Subject: Woofer cooling device - Destructive test
Posted by Wayne Parham on Wed, 24 Aug 2005 21:10:58 GMT
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This afternoon, I setup to test the cooling device for an extended duration. The initial tests were all for relatively short periods, and I wanted to run the LAB12 woofers for a couple of hours to see what happened. So I setup a woofer with a cooling system and another without, both driven with a 40V, 40Hz sine wave cycled 15 seconds on, 15 seconds off. Both woofers were in ambient free air of 72º Fahrenheit.This became a destructive test for the woofer without a cooling system.The woofer with the heat exchanger worked flawlessly and stayed cool. I ran it for 2 hours and measured the outside of the magnet at 114º Fahrenheit. The inside pole piece was 138º at the front, its hottest point. The woofer was working well, without strain and sounded good.I noticed the woofer without a heat exchanger began to make buzzing sounds at an hour and a half. I was pretty certain it had probably been damaged, so I reduced power and inserted the heat exchanger, hoping for the best. But it was already gone, and I terminated the test prematurely, at 1.5 hours. The magnet had reached an external temperature of 131º Fahrenheit and the inside pole piece was a scorching 195º. Looking into the cooling vent, I could see part of the voice coil wire, unwound and hanging behind the cone. The motor still functioned, so the voice coil was not open. It simply had started to come unglued at the edge and had separated from the former. The buzzing sound was made when it vibrated against the pole piece.I conclude from this that the heat exchanger has proven to be successful at reducing heat when the speaker is used for extended periods of time, and also successful at preventing thermal failures. To tell the truth, I was somewhat surprised at just how effective it is. I knew there would be a difference when using the heat exchanger, and the temperature measurements showed it too. But more than that, from a user's perspective, this is really significant. If you're running these kinds of speakers wide open for a few hours at a time, the addition of a heat exchanger makes a huge difference.

Subject: Re: Woofer cooling device - Destructive test - Ruminations
Posted by Wayne Parham on Thu, 25 Aug 2005 02:46:25 GMT
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The heat exchanger was originally intended as a improvement for basshorns where the rear chamber volume was very small. My thought was that probably the small chambers could easily superheat, and so the woofer motors inside might suffer from inadequate venting. But the more tests I performed, the more I realized that pretty much any loudspeaker used at power levels greater than about 100 watts could probably benefit from a heat exchanger like this.Certainly, the air in very small cabinets will heat more than larger ones. But even a free flowing vent (or preferably set of cooling vents on both sides of the gap) exposed to a free open area of cool air is only able to do so much. A lot of heat still saturates the magnet and metal surrounding the voice coil. As the power levels are increased, the amount of heat radiated is substantial. This makes a hellish environment for the voice coil, and the glue that binds the voice coil to the former can't take it.Think about how hot a 25 or 35 watt soldering iron gets. Or think about a light bulb. After you turn it on, the glass quickly becomes too hot to touch. 40 watt, 60 watt, 100 watt, they all get hot. Now think about surrounding the light bulb with 1/4" steel, and then surround that with a couple inches of ceramic. This really holds the heat inside. Sure, venting it and blowing some air back

and forth helps, and it helps quite a bit. But the little box of steel and ceramic still holds a lot of heat, even when vented. That's pretty close to what a loudspeaker motor has to deal with, except that the wire that generates the heat is glued onto a coil former. It doesn't glow white hot, but it does get hot enough to radiate. And the power levels are often ten times that of a light bulb or a soldering iron.Think about how many speakers you've heard that were blown. Most buzz. When a speaker buzzes after high power use, it is usually because the voice coil has come unglued and part of the winding is whipping against the pole piece as it moves, or is dragging inside the gap. Those are very common symptoms of a blown speaker. After a while, the mechanical stresses on the wire bending and scraping will eventually cause it to open. But it may work for quite a while, buzzing, before the wire breaks. The cause is a failure of the glue that holds the voice coil on the former, due to excessive heat.If the rush of current were extremely high, it would fuse the wire and open immediately. It would cause an open circuit condition that happens very rapidly, almost instantly. Those kinds of failures do happen, but it has been my experience that they are rare. They are usually the result of a defective amp sending high voltage out on the speaker line, or some kind of accident that causes AC power or some other extreme over-voltage condition.Thermal failure creeps up on you. The speaker in danger of thermal failure is being pushed pretty hard, so it is defintely taxed. Its distortion and compression levels are obviously higher than if it were being used at lower levels. But it doesn't usually give any obvious indication that the voice coil is coming undone, it sounds reasonably normal. In prosound environments, the speaker may see most of its use at these levels, or just under. But the heat generated under these conditions is incredible, and it's always working on that voice coil glue. One day, push it a little too hard and the voice coil rubs.Of all the blown speakers I've run across, the vast majority have fit this description. They've had rubbing voice coils. So I think it is probably pretty important to do whatever is possible to get the heat out, especially on speakers used at levels more than 100 watts. I don't care if it's a horn, a box or an open baffle, it can't hurt to remove heat from the motor.So it occurs to me as I consider today's test that a heat exchanger would probably be good on just about everything. Basshorns and small sealed cabinets aren't the only ones that will benefit. They're just the obvious canidates. But even bass-reflex and open baffled speakers would benefit, if power levels are moderate to high.Even just a 8" to 10" disk fastened to the heat tube will provide effective cooling. It doesn't have to be placed outside the cabinet either, although that will help. One could place a heat exchanger inside a cabinet, if it couldn't be easily installed to radiate outside. That won't get the heat out of the box, but it will get it out of the motor, where it's doing the most harm. Anything to get those temperatures down, and prevent voice coil glue failure.When the temperature inside the speaker magnet is cooking at 150º to 200º, the voice coil is even hotter. Temperature changes cause the voice coil to expand and contract, and when it's hottest, it expands the most, like a coil spring. That's also when the glue is the weakest, because it is being overheated. So it is really important to get the heat out, and I think it would be beneficial to use a heat exchanger like this in all high-power loudspeaker cabinets, not just basshorns with small sealed chambers.

Subject: Re: Woofer cooling device - Destructive test
Posted by GrantMarshall on Thu, 25 Aug 2005 20:56:21 GMT
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Congratulations on the positive test Wayne.My first thought while reading this was if you just ran a

speaker for a short period of time like 15 minutes what temperature does the pole piece go to? That is important because if the pole piece would normally go to 138 in a short time this would mean there had been no build up of heat after an hour and a half. That would suggest you could just keep pumping at that level with no additional heat buildup.The addition of the heat exchangers, crossovers with low end cutoffs and overload protection would make for a long lived speaker that would survive during concerts and from what I've read many don't make it now. Making "kits" to retrofit the most commonly used commercial speakers could be a new sideline in your spare time. Grant.

Subject: Re: Woofer cooling device - Destructive test - Ruminations
Posted by ToFo on Fri, 26 Aug 2005 01:20:44 GMT
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Hi Wayne,Great work! This heat spreader is the real deal.Thomas

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Subject: Re: Woofer cooling device - Destructive test - Ruminations
Posted by Wayne Parham on Fri, 26 Aug 2005 01:36:50 GMT
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Yes, it truly is. I'm surprised it isn't on everything, but maybe after word spreads, it will be.

Subject: Re: Woofer cooling device - Destructive test
Posted by Wayne Parham on Fri, 26 Aug 2005 03:11:55 GMT
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At 15 minutes, the magnet is pretty much heat soaked. Without a cooling device, it's about 165º - 170º Fahrenheit at the front pole piece. It actually rises to this level fairly quickly, over the course of a few minutes. But then the temperature rise is very slow, which is why I assumed it was done rising after 15 or 20 minutes.Initial test resultsWhat I realized yesterday, is that temperature wasn't done rising after 15 minutes, it just slowed down. When the test was run for a longer period, the temperature continued to rise until the voice coil separated from the former and it began to buzz.I didn't expect this to happen. I didn't think the woofer would fail at this signal level. What I expected was that temperature would hold constant. I was planning to confirm this with temperature measurements taken at two hours for both the stock woofer and the one with the heat exchanger installed. But the stock woofer didn't make it that long.I think there is a power level below which the woofer can be run indefinitely without a thermal failure. I expect there is a point which you run into a power verses time curve, and over that power level, the more power you apply, the less time it takes to reach a point of thermal failure. In other words, maybe the

woofer will take 35 volts forever without a thermal failure, but by 38 volts, maybe it will fail after 10 hours of continuous use. Then maybe 39 volts damages it in 5 hours and 40 volts kills it in two. That's the kind of power rating curve I think you can expect.The thing is, I expected that the 40 volt level was safe to run indefinitely. I didn't think this woofer would fail until it reached 42 or 45 volts. I thought maybe if I sent a continuous signal, it might be too much, and the voice coil might eventually fail. Then again, when the signal is removed, pumping action stops and there is no cooling airflow, so the temperature surges momentarily before it starts to drop. So perhaps a continuous signal would actually cause less thermal stress than one cycled 15 seconds on and 15 seconds off.It might be helpful to make more measurements, and I plan to do so as time permits. It would probably be good to plot temperatures by the minute, maybe reducing measurement intervals to every five minutes after a while. This could be done in ambient cool air, and perhaps in a small sealed box for comparison. Each of these will be done with and without the heat exchanger, in order to study the limits more closely.One thing is certain. The speaker with the heat exchanger stayed considerably cooler than the one without. There was a 57º difference at the pole piece, and this probably wasn't the most severe test that could have been performed. Putting the speaker inside a small box instead of a nice cool 72º room would probably have made the difference even greater.Then again, since the speaker failed, I'd say 190º or 195º pole piece temperature probably marks its red line. Without the heat exchanger, we crossed this line in less than an hour and a half. With the heat exchanger installed, it ran two hours at a relatively cool 138º inside at its hottest point. The back of the magnet was barely warm, at under 115º. So the heat exchanger did a great job of holding motor temperatures down and preventing voice coil failure.

Subject: Re: Woofer cooling device - Destructive test
Posted by GrantMarshall on Fri, 26 Aug 2005 19:18:45 GMT
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Thanks for the response about where a speaker would be after 15 minutes. Your findings show your implementation works great.I'm thinking there should be a LARGE market for this one that doesn't all belong to Pi speakers. Your comments about all speakers, not just subs benefiting from this suggests you're thinking the same way.It will be interesting to watch where this one goes.Grant.

Subject: Re: Woofer cooling device - Destructive test
Posted by Wayne Parham on Fri, 26 Aug 2005 21:44:01 GMT
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I agree. When I saw the initial tests of the cooling device, I was immediately impressed and knew at once this was something that could be used on lots of equipment. I thought it would be best to make it as compatible and wide-reaching as possible. So I laid out my horn to make compatibility possible. The heat exchanger can be used with either my horn or the LABhorn, and all that is required to retrofit an existing LABhorn is to drill a hole in the access panel and add the heat tube,

provided the existing access panel is aluminum. If not, replace the panel with one that is. We'll be putting them in the shopping cart shortly, at very attractive prices, less than half the cost of the woofer.It also fits other horns, and even other cabinet types. At most, all that is required to use it in loudspeaker is a few extra support braces. If the box is small, then the radiating panel of the heat exchanger can be mounted to the rear of the box. But if the cabinet is large, then braces can be added to the interior of the cabinet, which can then be used to mount the heat exchanger and hold it in place.Internally mounted heat exchangerI'll be working on heat tubes to fit several vent sizes so I'll have heat exchangers available for many speaker motors. It really works well, so I want to make them available for as many high power speakers as possible.

Subject: Re: Woofer cooling device - Destructive test
Posted by GrantMarshall on Sat, 27 Aug 2005 00:15:12 GMT
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With the internal mount I'd be concerned:1) the exchanger was messing with rear sound waves.2) it wouldn't be as effective as external.Grant.

Subject: Re: Woofer cooling device - Destructive test
Posted by Wayne Parham on Sat, 27 Aug 2005 06:02:37 GMT
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Surely having the heat exchanger outside the box would be preferable. But I think if the box is large enough that the heat tube wouldn't reach the back panel, having the exchanger inside would still do a good job. At least it would get the heat out of the motor. It's probably worth a test.

Subject: Re: Woofer cooling device - Destructive test
Posted by GrantMarshall on Sat, 27 Aug 2005 10:57:33 GMT
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It would be easy to protect the heat exchanger with a wood rail mounted on either side that sticks out further than the exchanger. This would allow laying the speaker on it's back without the exchanger being damaged.The internal test is worth trying, but I expect you've already got it right.Grant.

Subject: Re: Woofer cooling device - Destructive test

Posted by Wayne Parham on Sat, 27 Aug 2005 11:13:11 GMT
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Oh, yes, I agree. When installing the radiator panel, we routed the wood so the panel was flush. I wouldn't install the heat exchanger internally on a basshorn or other cabinet where the woofer magnet was close to a panel. It's better to mount the radiator outside.Internal installation of the device was really only meant for large front-loaded cabinets. If the speaker magnet is far from a cabinet panel, an externally mounted heat exchanger would be too far away. An example would be direct radiating subs in large 10ft3 cabinets. A person could install the heat exchanger internally, and I think it would still help remove heat from the motor.

Subject: Re: Woofer cooling device - Destructive test - Ruminations
Posted by Monomer on Sun, 28 Aug 2005 07:08:41 GMT
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it's going in all my boxes.

Subject: Re: Woofer cooling device - Destructive test - Ruminations
Posted by Sean on Thu, 01 Sep 2005 02:42:27 GMT
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I wonder how this effects the electrical parameters of the woofer as we all know that Q goes up as temperature rises. Might be interesting to see. My guess is that the electrical parameters become more stable over a wider temperature range, although i'm still expecting things to change going from stone cold to normal operating temp. Just not as much.... Sean>

Subject: Re: Woofer cooling device - Destructive test - Ruminations
Posted by Wayne Parham on Thu, 01 Sep 2005 03:01:08 GMT
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Yes, you're exactly right.

Subject: Re: Woofer cooling device - Test Cycle with Heat Exchanger Installed
Posted by Wayne Parham on Thu, 06 Oct 2005 09:07:26 GMT

Woofer and Heat Exchanger Under TestThe last several days, I performed a series of tests to find the limits of the LAB12 with the heat exchanger installed. I intended to push the driver to the point of failure, but after power was well above twice the level that caused it to fail without the heat exchanger, I realized that a destructive test was not really necessary. The LAB12 with a heat exchanger survived 2 hours at 60VRMS, which is approximately 840WRMS. At this point, I decided to end the test.To tell the truth, I expected a pretty serious power handling improvement, maybe 150% or so. But the measured improvement is at least 225%. At that point I terminated the test, but it could be as much as 250% or 300%.There is increased output up to about 150%, and above this, at extreme power levels the driver output is compressed but able to dissipate the heat without damage. Thermal failures are made extremely unlikely with the heat exchanger installed because the voice coil enters compression, increases resistance and in a sense, saves itself.An interesting thing happens above about 600 watts. The test signal I've been using is a 40Hz sine wave, cycled on for 15 seconds and then off for 15 seconds. What happens is that the woofer is very loud initially, when the signal is applied. It stays loud for about 10 seconds, and then begins to trail off, becoming noticeably quieter over the next 5 seconds when the signal shuts off. This doesn't happen below about 500 watts, but starts somewhere above 600 watts. These levels are with the heat exchanger, of course.The voice coil is obviously becoming very hot, increasing resistance, so power decreases as the driver enters heavy compression. The voice coil radiates heat into the pole piece and the heat exchanger carries it away. After several seconds, enough heat has been carried away that the voice coil is cool enough to lose resistance, and compression goes away. Once the signal has been applied for another ten seconds continuously, it enters compresion again and the process repeats itself.The heat exchanger provides a significant increase of long-term power capability, and that this improvement translates to increased sound output. It also increases short-term output, because the long-term heat-soaking energy is wicked away by the heat exchanger, allowing the voice coil to remain cool and track transients. It can provide very high output levels for short bursts, under ten seconds or so.Extended duration high-power signals lasting longer than ten seconds start to cause compression enough to reduce output. But the driver is protected by the heat exchanger, and signals that are in excess of twice the level that would destroy a LAB12 do not harm the driver with the heat exchanger installed. So the advantage of having the heat exchanger is more than providing additional output, it also serves to improve durability. With the heat exchanger installed, the loudspeaker is much more robust, and can handle 800 watts continuously. This helps prevent thermal failures in the field.Voltage Input Power Level Duration Temp at back of magnet Temp inside at pole piece==========42VRMS 410WRMS 2 hours 108º F 134.2º F44VRMS 450WRMS 2 hours 110º F 136.5º F46VRMS 490WRMS 2 hours 113º F 138.7º F48VRMS 540WRMS 2 hours 116º F 140.5º F50VRMS 580WRMS 2 hours 118º F 142.6º F52VRMS 630WRMS 2 hours 120º F 144.7º F54VRMS 680WRMS 2 hours 122º F 147.2º F56VRMS 730WRMS 2 hours 123º F 151.7º F58VRMS 780WRMS 2 hours 125º F 154.6º F60VRMS 840WRMS 2 hours 127º F 160.1º F==========Compare these values with the driver run without a heat exchanger.

With 40VRMS input, it reached 195º F after an hour and a half, and the voice coil had failed. All other conditions were the same.