A white paper from Active Thermal Management

*"**Cool** answers to **hot** problems…."*

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Thermal problems and the custom audio-video designer/installer

Section 1 – the technical stuff…..

There is a problem which has been facing the custom installation community for some time. Not a glamorous problem with a neat hi-tech solution, but one that's real, getting harder to solve and even harder to ignore.

It's heat.

Many of our industry's problems (such as how to integrate various home systems from lighting levels to spa temperatures, how to avoid having 23 remote controls on the coffee table, how to handle multi-room distribution, and others) have been addressed by the manufacturers; little attention has been paid to the problem of the heat generated by the equipment they make and you install. The problem grows worse as we add more equipment to installations; excess heat has become a problem we can't sweep under the rug much longer……unless it's made of asbestos!

It's a problem that the client is increasingly aware of.

With today's amplifiers with more channels (and more power per channel), devices that compete with the home heating system for "most BTUs generated", more power than ever is going into the home entertainment system. Yesterday's "stereo" is today's "home theater", with 5 full-range channels (frequently 7), and very high powered amplifiers to handle low-frequency effects (pronounced "ex-plo-sions").

In the past few years, we've added equipment consuming hundreds, sometimes thousands of watts to the typical installation; all we've eliminated is the ten watt turntable!

When the equipment is mounted in closed cabinets or racks, and the racks are tucked into recesses or closets, the heat generated by this equipment has nowhere to go, and temperatures can rise to levels that will shorten equipment life to a significant degree. In talking to installers, we've found that almost everyone has come up against this problem in more than one installation, knowing that despite the severity of the problem, little meaningful help was available. *In addition to knowing the theory and practice of audio and video, a basic knowledge of thermodynamics is becoming necessary, because the day when a muffin fan would solve the problem is long gone.*

You know when you have a heat problem; You don't have to burn your hand to know that most of the power that goes into home entertainment products is dissipated as heat.

But -----

- How do you get rid of the heat?
- How do you do it quietly?
- Where can you get <u>useful</u> information?
- Where can you go to get everything you need to do the job?
- Why do you think we wrote this paper?!

We know that designers and installers know practically everything from AMX to Xantech, but who knows about BTUs? CFM's? Convection and radiation? And who has the time to shop everywhere from Home Depot to Radio Shack looking for parts that might - *or might not* - do the job??

Every installation is different, there's no single approach that will work in every situation. Nice as it would be, we don't have a "cold" generator that you just put in the system and turn on. And any successful approach has to be quiet enough to be a <u>real</u> solution; and doesn't just turn a heat problem into a noise problem!

A few fundamentals:

- Fundamental #1 -- Electronic equipment "runs hot" because it's less than 100%

into heat, as with most signal sources. Naturally, power amps dissipate the most heat…….but the rest of a modern system frequently makes significant contributions to an overall heat load that could have the system operating in "sauna" mode, especially digital devices.

? Fundamental #2 -- In an enclosure, the basic relationship between "power in" and "temperature rise" for the system designer and installer is this:

As heat is dissipated by the equipment in an enclosure, the temperature of the air (and the other equipment within that enclosure) will rise until the heat leaving the enclosure equals the heat entering it.

There's only one way heat is generated inside an equipment enclosure (unless it's located next to a heating duct!): the electrical energy going into the equipment inside. There are several ways heat can leave:

1. Heat is transferred from a hot thing to a less-hot thing by one or more of three ways: conduction, convection, and radiation. Conduction describes the situation in which one end of a piece of metal is heated and the other end gets hot some time later because heat has traveled through the metal. Metals like copper and aluminum conduct heat very well; steel conducts it less well; air conducts heat poorly.

Little heat moves within or leaves an enclosure via conduction.

2. Placement of equipment in an enclosure can result in significant heat being radiated from hotter to cooler pieces of equipment. Radiation of infrared energy is what makes your face feel hot when you drive an air conditioned car on a sunny day. The air in the car is cool, but radiant energy from the sun passing through the windows is felt as heat on exposed skin. Similarly, a DVD player near (even below, if the shelving is the "mesh" type) a power amplifier may start feeling a bit toasty after a while, unless a barrier interrupts the flow of radiation.

Radiation will move heat around within an enclosure, but causes very little heat to leave; the problem of radiated heat in home entertainment systems has been largely ignored, while many a CD player has slowly baked to death……

The use of open shelving and cabinets without backs or doors can result in installations that are cool, but don't look cool.

4. In most applications, removing the heated air by using fans has been the most effective way to reduce the severity of the heat problem.

The system designer can use an air mover to exhaust hot air; the reduced pressure in the enclosure will pull cooler air in. Alternately, the fan can be turned around to push cooler air in, diluting the hot air and forcing it out of the enclosure. Both approaches are valid, but attention must be paid to get the "biggest bang for the buck".

If the equipment is in a room (or closet) with poor ventilation, it's only a matter of time before the air in the nearby environment is about as hot as the air in the cabinet, and all the exhaust or intake fans are doing is pushing hot air around in a circle.

There's also the matter of noise -- fans make noise in several ways.

- The cheaper ones vibrate, and send the resulting "buzz" into whatever they're fastened to. (If they're fastened to the thin back panel of a cabinet, that panel can act as a drumhead and amplify the noise.)

- If there are struts in front of or behind the fan blades (as with most of the "muffin" types), they produce a tone caused by the air column being chopped by the struts each time a blade passes.

- Another source of noise is the "whoosh" of air moving. The faster the air moves, the louder the "whoosh". As you move the same amount of air more slowly, the noise of the air moving drops rapidly.

So you pay for your thrills; a fast-turning fan moving air quickly can produce a strong cooling effect, but with the penalty of fan noise(s) to annoy the listener. Again, small fans were satisfactory for cooling yesterday's small systems, but can't do the job today.

Section 2 – the business stuff…..

We can recommend approaches that solve the fundamental problems. Don't just move the heat around in the cabinet or rack. Get rid of it. Get it completely out of the environment by moving it either into the room (almost always a satisfactory method), or move it far away; into a false ceiling, crawl space, attic, or outdoors, just as you do with the waste heat from a clothes dryer. It's not difficult in most situations, and it lets you put that fan away from the listening environment – move the heat and the noise away from the music; we'll show you how.

Have a piece of heat-sensitive equipment that has to be near an amplifier? Protect it with an active heat shield (they're not just for space shuttles anymore!) – we'll show you how to do that, too…..

In limited-ventilation situations, such as an enclosure open on one side, we offer quiet powered ventilators which are simply placed on top of, or beneath, the equipment to be cooled. Other products combine powered ventilation with a shelf, allowing a heat-sensitive preamp, DVD player, or other device to be placed directly above an amplifier or high-powered multichannel receiver -- without being cooked.

We see this as an opportunity both for us and for you, as this is a new and necessary product category with a common-sense, credible, easy-to-tell story behind it. The client KNOWS that heat is harmful to electronic equipment, even if he doesn't know the exact reason; you're going to solve that problem for him! (A rule of thumb is that for each 10 degree (C) rise in junction temperature, the expected life of a semiconductor is halved!) Heat is damaging to electrolytic capacitors, liquid crystal displays, and many other components; hot fuses blow at lower currents, and programming can be corrupted.

You'll probably avoid a number of nuisance service calls when equipment runs cool…..

> We think your clients will see the wisdom of investing in a simple system which protects their expensive audio-video installation, *just as they buy insurance to protect their valuable houses and cars. They know their car never broke down because it "overcooled"; sell them inexpensive insurance that will let their home theaters last for years.*

We know the custom installation business; we've been in it as designers, installers, and equipment manufacturers; we've pulled wires and we've hung projectors. We know what you need, and we know that practically every job is different; you need a place to go for advice as well as for specialized equipment. We offer products to the installation community which we have tested and found genuinely useful for the real-world