AUDIO BASICS

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What Can Electronics Bench Tests Tell Us?

Last month, with "Tire Testing Without a Pressure Gauge," we began an essay showing the fallacies of contemporary methodologies of high fidelity equipment evaluation. We wish that the review process in general could become more objective. The following are our suggestions as to how this might be accomplished using some of the techniques that have evolved here to help keep us honest in the design evaluation process.

"I Like It" Isn't Good Enough!

We have a great deal of trouble getting this concept across to audiophiles. Everybody seems to think that if they have heard hi-fi equipment that they "really like," then that particular equipment must be really good. Every do-it-by-ear designer seems to think that his newest and latest and greatest product design that he really likes a lot better than ever must be really good. Every do-it-yourselfer who has ever blindly attacked an audio component with new "better sounding" parts and wires has always found that any audible changes he has made have made the equipment better.

Sorry, but in the absence of any objective evidence that the equipment really is better, we refuse to totally rely upon unverified subjective impressions. It is altogether possible to "really like" something really awful.

Time Out! We need to back up and define what "good and bad" really are in relation to high fidelity audio equipment. There is not much point debating which direction is an advancement when we do not know where we are going!

Thus I am going to etch a few points in granite (actually set them in bricks like our masthead).

- **The audio system is a *reproducer*, not a *producer*. The goal is a perfect Xerox machine; the goal is not a musical instrument. We are not trying to get out a print that is really lovely to look at. We are trying to get a print that is so unchanged from the original that we cannot tell them apart.**

  Thus, the goal is never "good sounding woods or cabinets" for speakers. The cabinets should have no sound at all. The goal is never good sounding wires or parts. The wires or parts, independent of their real electronic characteristics and thus their real effect on the transfer characteristics of the system, have no sound at all.

- **"High Fidelity" means being as faithful to the source material as possible. It does not necessarily mean "sounds really good." Thus, vastly expanded vocabularies and subjective terms requiring multi-page essays to subjectively relate "how a hi-fi component sounds" are for the benefit of the writer (upping his word count and filling the pages) and not for you. All of the long winded subjective impressions can be much more succinctly and accurately conveyed if the purveyor of purple prose has some real knowledge of what is going on - or remember Shakespeare's famous line in *Macbeth.***

- **The best high fidelity equipment is that which least screws up the source material. It cannot be better than the source**

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material, *it cannot add musicality*. It can only be an absolutely transparent window to the performance.

- **Any difference between input and output is distortion. It does not matter that you like it if it was not in the score of the music, or it was not performed by the musicians. However, the distortion is only important if we can hear it, or if a manifestation of it disturbs the music that we can hear.**
- **Any difference between input and output that we can observe on the test bench is bad. But not all differences are audible and not all audible differences are easy to detect on the bench.**

  To the best of our knowledge, the measurement process is not refined enough at this time to tell us everything we need to know about the audio component. We can still hear differences that we cannot pin down on the test bench. But we can always separate out the wheat from the chaff so we do not have to waste our time agonizing about subjective significant distortions that we might happen to like that day.
- **To find out what is really going on you have to measure. Most important, *you have to measure first*. Our "I like it better" is no more valid than anyone else's. We can just as easily be persuaded that our own newest and greatest design idea is a wonderful step forward when it really is not. Everybody thinks their own new baby is just wonderful. Thus, we measure first and listen only after being reasonably sure that what we are going to subjectively evaluate is not really bad.**
- **Thus the main reason to measure first is to keep us honest – to insure that we never start liking euphonic colorations best, and to allow us to learn how to objectively identify the causes of some of those colorations. Once you have knowledge, superstitions and soothsayers become much less convincing.**

The Basic Measurements Are Easy to Do.

Let's go through our process with you, step by step. Note that the process is different when we are evaluating alien, never seen before components brought in for us to inspect. Then we have to start from square one each time. With our own circuit designs, we usually have some unchanged foundation to build upon so we don't have to re-invent unnecessary wheels. We will describe the process first assuming this is our initial look at a component that has not passed our way before.

It does not go into the system or get plugged in on the test bench until we know it is safe.

You would be astonished to see how much unsafe and/or defective equipment is tossed our way with the offhand comment "please check this out for me" when the output is full DC offset, the AC power line is shorted to the chassis, or internal components have been dislodged and launched by the grossly excessive shock loads of bad handling in shipping combined with inadequate packing. Our own new and rebuilt equipment hardly ever takes outgoing shipping damage because we do follow our own advice, "pack so the contents will survive being kicked down a flight of stairs."

We take off the cover and give the unit a thorough mechanical inspection.

We are looking first for loose or wrong connections. Often giant wires are gob soldered to solder lugs held onto the output terminals by the last screw thread before the nut falls off. Oversized capacitors break loose from circuit boards. Power transformers shift in their moorings and mash wires and parts. In particular, everything to do with the AC wiring had better be safely done. One amplifier, proudly brought to us because it imaged better than anything else the owner had ever heard was easy to explain - it had the wiring to one channel erroneously internally connected out of phase. It certainly was different from anything else, but hardly better.

We look for obviously wrong parts, not only in user built kits but in factory wired units too.

We do not assume that factory wired equipment was properly built, because far too often it was not.

For example, a factory wired Hafler DH-100 preamplifier was recently sent to us to inspect and for possible upgrade because the owner thought that “one channel might not sound quite right.” This is a unit that had been in service for several years. I guess it didn’t sound quite right! Its balance control pot and treble control pot had been mistakenly swapped internally during the original factory production. This caused the channel balance to always be off and for that control action to misbehave. Worse, the balance control in the treble location caused a huge frequency response error (one channel with a large high frequency cut, the other with a horrendous high frequency boost and impossible to set flat). Worse yet, the unintended high frequency boost caused one channel to go into hard oscillations, which had damaged one of the IC amplifiers. The client had one other lament – that the LED on indicator blinked. We discovered that this was because the AC power wiring had never been soldered at the AC power switch – it was held on only by a loosely crimped bare wire, arcing and sparking. If this factory wired unit had ever been inspected or tested at all at the factory or by the selling dealer it would never have gotten out. And how the customer could have used it for years with these gross problems is beyond us. After we see enough of these (and we do) we are even more suspect of “I like it” than ever. This client “really liked” his Hafler preamp, channel imbalance, high frequency peaks, oscillations, arcing AC power and all, for years.

We look for overheated parts.

One aspect of bad design (and poor reliability) is the use of parts that are thermally underrated for the circuit application (they get too hot).

Often these are easy to spot because they are scorched brown. It does not matter how good performing or sounding a component is right now if is being pushed beyond reasonable thermal limits. Electronic parts change value with heat and age. The hotter you run them the more they change and the quicker they fail. A just wonderful unit, run so hot that the circuit values are changing rapidly, won’t be just wonderful for long. Once many things have drifted out of specification it becomes almost impossible to make the unit run correctly again. The cost of measuring and replacing everything that might have overheated out of specification will likely be higher than the replacement cost of the unit.

Interestingly enough, thermal problems sometimes are easier to spot on overall decent equipment than on bad. When a mass-produced low-priced plastic Walkman or boombox fails after a few years, it is simply pitched and replaced. Nobody seriously investigates why. But because the original Dyna units, for example, were mechanically durable enough to keep for years, their “hot spots” show up like sore thumbs now.

Inadequate thermal dissipation from output transistors can produce obvious bass distortion. Years ago Aado and I observed that high energy low frequency signals create enough thermal error in output transistors to significantly affect the feedback correction signal unless the heat sinks can stabilize the die temperature really well. In other words, if the heat sinks are scummy, the bass is likely to be scummy too. The boom and mud you hear may simply be an aspect of your output transistors changing temperature (and linearity) due to the demands of the music.

We watch out for magic parts.

We observe that it would probably be nice if a capacitor (for example) was just a capacitor, not an inductor and a reverb generating machine too. We would like the circuit to do what we designed it to do, not to go its own way making lots of other cute little tunes that are unfortunately not part of the musical source. Thus we have this old fashioned concept that the best capacitor for a given application is one that is very temperature stable, is non-microphonic, is non-inductive, is long term value stable, is from a known high reliability source, is of the correct value and voltage for the circuit application, and is matched very closely with its twin in the other channel of a stereo unit (we would like both channels to be the same). Thus we give a fishy eyed stare to the use of antiquated large soft film spiral wound capacitors, produced in the third world for repairing obsolete vacuum tube table radios but re-branded "just wonderful sounding magic parts" here. We usually give these parts the "thump test" after actually turning the equipment on, and they usually respond with a "boing" from the output much like a microphonic vacuum tube. They fail. The equipment that uses them fails. We are interested in audio amplifiers and preamplifiers, not reverb machines (unless they are so labeled and you can turn them off).

Likewise we reject units wired with highly reactive braided oversized gonzo wires and similar. If the designer doesn't know the values and locations of the capacitors he has in his circuits (and each of these multi-stranded braided wires is a significant capacitor) then he does not know what his circuit is doing and it likely isn't doing too much good. In contrast, you might notice that in our power amplifiers, every power supply feed and ground and output feed to every output transistor is individually terminated at each transistor with a critically damped circuit to ensure that each circuit connection is simply a totally stable connection, not an underdamped resonant circuit. Thus our amplifiers amplify rather than do their own thing. They tend to be very rugged and durable too, another aspect of superior design stability.

We look for bad repair work.

Good designs are often ruined by incompetent repairs. A major culprit is improper substitution of transistors. The repair shops have substitution guide handbooks which tell them what general purpose repair grade transistor they can substitute for OEM parts. Unfortunately, the guides are inadequate. For example, the original Dyna St-120 used 2N3055 power transistors, selected and especially purchased by Dynaco with a 90 volt rating. A normal off the shelf 2N3055 power transistor (or any general purpose substitution for it) has a 60 volt rating. The Dyna circuit operates at 70 volts. Guess what blows up a lot? I have never ever seen a Dyna St-120 come here for service or rebuild that had been correctly repaired with general purpose parts (transistors of an adequate voltage rating for the application). The batting average we observe is zero.

Brand new equipment is often produced with built-in failure modes too. In a plus and minus supply amplifier, for example, the voltage across each half of the amplifier at idle and during normal operation is no more than the measured supply voltage. For example, in a Dyna St-400, with plus and minus 75 volt supplies, the voltage across each half is 75 volts. The original output and driver transistors are rated at 120 volts. This is just fine, right? Wrong! When the amplifier is pushed beyond maximum power (into clipping) then one half of the amplifier is turned on hard while the other half is turned off. There is very little voltage drop across the half turned on, while the entire rail-to-rail power supply voltage is now summed across the half that was turned off. Let's see – 75 plus 75 equals 150 volts across half the amplifier. What was the voltage ratings of those transistors again? 120 volts? Whoops, bang! The repair shops are full of amplifiers that never would have died if they had been built with parts that were correct for the application (voltage rating in excess of full rail-to-rail clipping). We look, we measure, and if the parts are underrated, we quit right there. We will reserve our musical judgements for units free of overstressed parts that are rapidly aging and deteriorating. The designer of just wonderful stuff should know better.

Did the repair shop or manufacturer understand that it would be nice if both channels were the same? Repairs or updates to one channel had better be reflected in matched performance with the other channel. We have seen factory upgrades where a whole new channel module was sent out to replace a defective one. Unfortunately, then the client had two different amplifiers, for the two channels were then of different vintage and performance. Which did he like best? Would better interconnect cables help? Perhaps this was the place for the green felt marker or magic dots.

We look for proper fuses and circuit protection.

If something goes wrong (and it sometimes does with everything built by relatively fallible human beings and their machines) then a graceful exit from the problem is desirable.

We consider it more desirable to replace a fuse if the consumer or a part screws up than to replace transistors and speaker voice coils. We consider a power supply fuse to be more desirable than a fire. We understand that fuses replaced with buss-bars are not fuses at all. We also understand that fuses do not "sound bad." What sounds bad is the siren on the emergency vehicle coming to put out the fire!

We look for bad and silly design details.

An unshielded toroid power transformer stuffed close to an audio circuit board will almost always produce a spiky low level hum signature in the audio output. Shielding or space to separate the transformer from the circuits solves that problem; an amp with neither probably isn't a serious design. Some observations require a bit more engineering knowledge. For example we know the drive current and impedance requirements for the often used Hitachi power V-Mos-Fet output transistors. We also know the maximum drive current available from typical small signal vacuum tubes and little TO-92 plastic signal transistors. When the current available in the drive devices is far less than the minimum demanded to drive the output transistors, then the amplifier simply cannot work correctly. At this point one could have Niagara Falls for a power supply and all the wiring made of unobtainum blessed by the whoever and it still would not work. It may put out impressive sounds, but these will be the sounds of the drive stage saturating, not the sounds of the music. In this case it matters not a whit what the quality of the parts are or the pedigree of the designer or the thickness of the faceplate or the subjective impressions of the amplifier. It is not reproducing music, it is only producing its own thing. If you like that "thing" best, fine, but please don't fool yourself into calling it high fidelity and don't pay extra for it.

We reject unsafe connections. We have informed you before that large all metal speaker posts should never be used on a large power amplifier. A big amplifier can put out much of the energy of your AC power line, and metal exposed speaker terminals are just about as hazardous on the amplifier as on your toaster. We wish audiophiles (and the purveyors of bangles and beads for them) would use a bit of common sense. The circuit from the power supply terminals of an amplifier through the output transistors (or tubes), through the speaker terminals, the speaker wire, through the speaker crossover parts and voice coils, and back to the ground side of the speaker terminal to the power supply ground in the amplifier is essentially one great big series loop. In a series circuit, the amount of energy that can pass is limited to the most resistive element of the circuit (which will get the hottest and eventually burn out first if it is the most limited in power dissipation).

If we ran a test of a typical ordinary run of the mill inexpensive little system with typical little 18 gauge speaker wires, push-on speaker connections, and typical little two way speakers by dumping current into the loop until something let go, what do you think will let go first? Assuming any protection fuses had been jumped out, then the first to go would be either the output transistors or the speaker voice coils. So we need bigger speaker wires and terminals, right? Sure. Let's make the voice coils much heavier or parallel them to share the power and build the amp with lots of paralleled transistors to share the power (or with much heavier transistors) and run the tests again. The speaker wires still are only a small fraction of an ohm and the speaker terminals, even standard ones, are more substantial and much shorter than the speaker wires. No matter what we do, we will lose the speaker coils, the output transistors, and perhaps even speaker crossover capacitors and circuit board foil paths before we manage to overheat or damage the speaker wires or terminals. So then why do the audiophlakes think that the first thing that needs to be beefed up is that which has the most capacity in the first place? They are busy putting diamond studs on the brass rails on the Titanic. What is really funny is to observe the insides of an amplifier made "just for show" to impress the audiophlakes. Then we find huge speaker studs on the outside, and tiny little ribbon cables and unreliable push-on connectors on the inside, all cluttered about off-shore phenolic circuit boards held together with plastic hardware. Take the cover off first before deciding what is good quality and good engineering and what is not.

We are not a bit impressed with circuit board layouts presenting all of the parts lined up in tidy little rows. Inevitably, this is done to impress amateur inspectors (or to make it easier for automatic machinery to stuff the parts on the boards) instead of for good electrical engineering layout reasons. Often over-emphasis on the presentation of the parts show on top results in more torturous foil trace paths for the circuits on the bottom. Good engineering keeps ground and power supply feeds as short and direct as possible, routes inputs away from outputs, and provides proper shielding for high speed devices. A degraded layout will have more noise, stray resonances, poorer stability, poorer reliability, poorer repairability, and poorer musicality. However good marketing may demand just that to impress the fools. If form interferes with function, the unit gets the boot from us.

We look for "whoopses."

We look to see how many cuts, hacks, and patches the manufacturer has made to make his circuit boards usable. A while back we counted over 100 "patches" on one preamp design that came here for evaluation. That certainly made one wonder about the stability of the design. A clean consistent layout free of reworks probably indicates that some care was used to get the design right the first time. Certainly design improvements over time might require minor changes to a PC board to adapt the improvements economically, but sometimes one can read the board fixes and understand that there had been much hair pulling before they got that sucker to work properly.

Well gee, look how much we have learned about the unit under test and we haven't even turned it on yet! To be continued next month (in about two weeks actually, we *will* catch up).

Used Equipment

Super 70i Vacuum Tube Amplifier with new AVA jack set, and all new signal tubes. This is as nice as a small vacuum tube amplifier gets and is a great match for speakers such as our B&W DM640i with AVA upgraded crossovers. We have several good chassis and can offer this package with our new insides for $645.00 plus $15 shipping in the continental USA. These units have a two year parts and labor warranty on our circuits, six months on the chassis and mechanical bits, and 30 days on the tubes. Add $100 for the AVA power transformer and solid state rectifier installed too.

Big Power Amplifiers! We have two decent Dyna 400 based chassis with which we can build you a killer amplifier at an advantageous price. One is a mediocre Dyna 416 (silver rack mount faceplate, grab handles, an led blinking power display, cooling fan and all). We can build a 220 watt per channel Ωmega II power amplifier in this chassis with either four, six, or eight big-die power mos-fets per channel. With four mos-fets per channel the amplifier is rated for 8 ohm and 4 ohm loads. With six mos-fets per channel it is safe into 2 ohm loads. With eight mos-fets per channel it becomes the ideal Apogee driver – great gobs of power and safe one ohm load drive capability. One client tells us this made his Infinity 4.5s sound the best ever. Pay $895 for the basic four mos-fet per channel Ωmega II circuit set installed, $125 extra for six mos-fets per channel, or $250 extra for eight mos-fets per channel, and we will charge you only $100 more for the Dyna 416 chassis! You get a two year parts and labor warranty on our circuits and six months on the original Dyna parts (cosmetic wear and tear not included). The other chassis is our own Double 400 version of this design. It has a very attractive black VA Double 400 faceplate with power meters. The meters work, but are not illuminated. The heat sink is identical so we can offer the same options at the same price. It is cleaner overall, but does not have grab handles or a full rack mount width on the faceplate. Add $25 for shipping on either in the continental USA.

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