The Science of Cable Design

Part III

The Sonic Differences Between Conductor and Dielectric Materials and Treatments.

In Part II, we discussed the conductor's own inductive reactance and its effect on the sound in an audio cable. In this installment, we'll examine conductor materials and treatments, as well as dielectric materials and their effect on the sound. Although it's important to note that these factors have a lesser effect on the sound than the design of the conductors themselves, when the conductor is more linear with frequency, these minor differences in materials do become more apparent.

Conductor diameter vs. frequency linearity

$$D = \frac{1.1}{\sqrt{\frac{2\mu f}{p}} \times (0.099346)}$$

D = Diameter of conductor

u = Permeability of material

f = Frequency at which HF attenuation occurs

p = Specific resistivity of material (u-ohm/cm)

The two most common conductor materials today are copper and silver. Is one inherently better than the other? Not necessarily. So much depends on the purity and treatment of the raw conductor material. The treatment process known as annealing softens and purifies the conductor material, affecting its specific resistivity. Proper annealing of copper conductors increases conductivity (lowers specific resistivity) by increasing the length and size of the crystals within the material. This results in fewer electrical discontinuities in the conductor, removing the distortion, brightness, or hashiness from the sound.

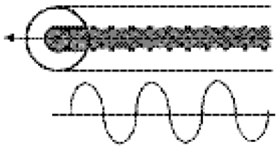
Conductors must also be properly designed to deliver maximum frequency linearity with any given material. The mathematical formula shown above shows a direct relationship between the diameter of the conductor and the specific resistivity of the material. We see that, for a given conductor material, there are different frequency response curves and different linearity with frequency. The sound of a properly designed and treated conductor is open, neutral and extended, yet smooth and without grain. Conductors which sound harsh or bright have not been properly designed, or treated, or both.

Insulating materials exposed to electric fields are called "dielectrics." Dielectrics are necessary components in any cable because they prevent oxidation and keep the conductors from touching one another. In audio cables, relatively low voltage and current levels mean that dielectric strength is not the most important factor. Far more significant in its effect on the sound is a material's dielectric absorption. This characteristic describes the way a dielectric may discharge a secondary signal into the conductor out of phase with the audio signal.

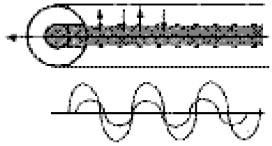
As a current is passed through a conductor, an electromagnetic field is created which interacts with the dielectric material and temporarily displaces the molecular structure. If the dielectric material has good elasticity and can return quickly to its normal state, then the material is said to have low dielectric hysteresis or loss and will have little audible effect on the signal.

Dielectric materials, then, sound different because of the different rates that the materials store and release energy at different frequencies. PVC, a common dielectric material, causes distortion and coloration mostly audible in the mid-bass and mid-range frequencies, whereas Teflon causes distortion in the lower treble frequencies, making coloration less noticeable.

TARA Labs uses a proprietary dielectric material called "Aerospace Polyethylene™" or "Aero-PE®." This material is chemically treated to have low dielectric absorption and high dielectric elasticity. Therefore, it reacts less and returns more quickly to its neutral state, making it more sonically neutral than other materials. Aero-PE is also extruded at a lower temperature than other insulating materials. Copper conductors insulated with Aero-PE are not exposed to high heat and therefore retain their specially annealed qualities.



Audio signal creates an electro-magnetic field around the conductor.



Dielectric materials absorb energy and release it back into the conductor out of phase with the audio signal.

In comparing lesser quality cables, you may never hear the difference between PVC and PE insulation, or hyper-pure vs. low grade copper. The limitations of the design itself will obscure these subtler effects. However, with high-quality cable designs, one can more readily hear the differences in materials, proper annealing and good quality insulation.

In Part IV, we'll examine the cable as an interface having the properties of a second-order low-pass filter.

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