Chemistry Class: Debunking a Widespread Myth

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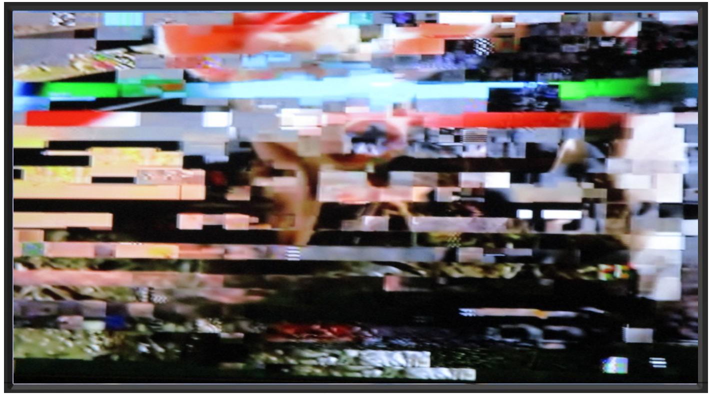
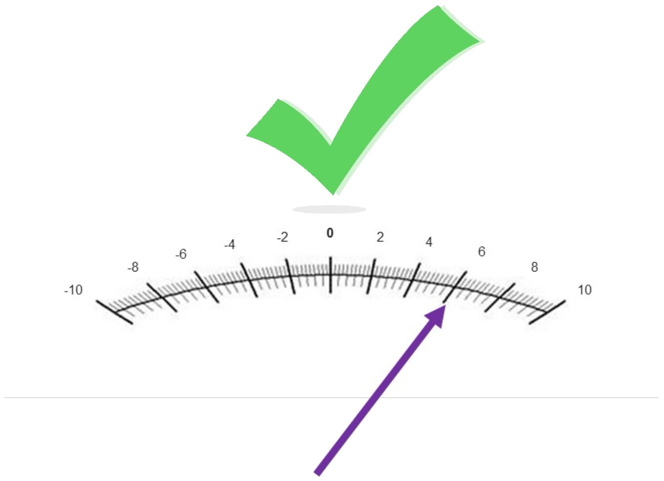
The Problem …

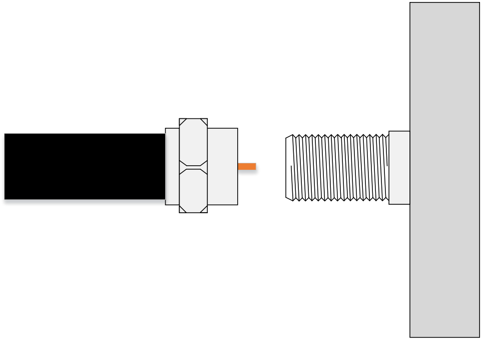
How many times have you or someone you work with visited a subscriber's home in response to a service call about snowy pictures on some or all of the analog channels, and perhaps problems with some or all of the digital channels?

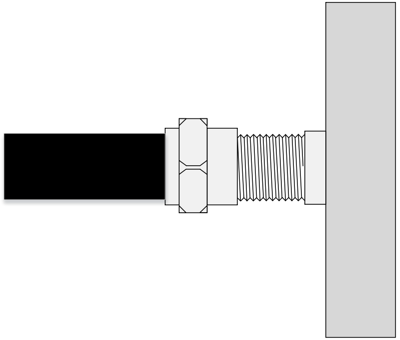


Troubleshooting …



The drop is disconnected from the ground block or splitter on the side of the home, and connected to a signal level meter or other instrument. Signal levels are fine, so the drop cable is reconnected.





It’s “Fixed”!

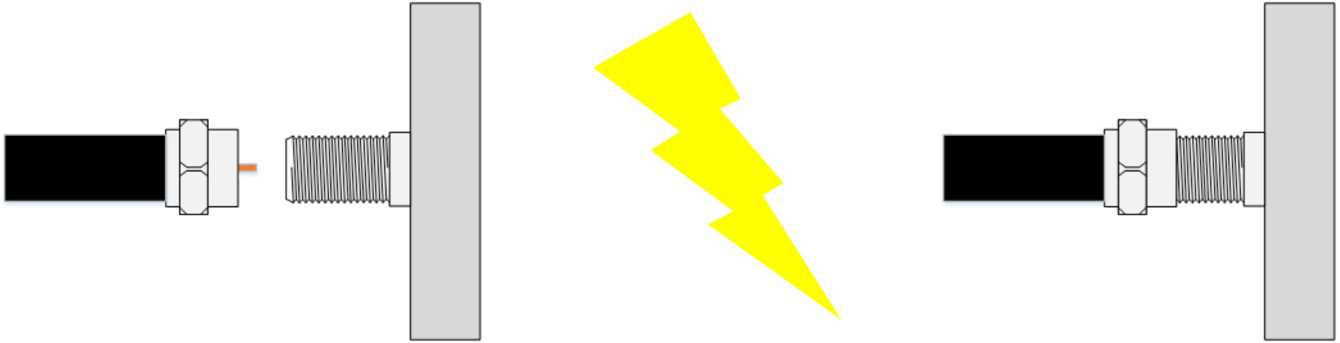
Amazingly, the snowy pictures are snowy no more, and any digital problems stopped being problems.

What the heck is going on here?

The Myth

One explanation that has been the subject of lengthy discussions is the so-called "capacitance effect."

- Disconnecting the drop and hooking it up to the test equipment *somehow discharged a static or other mysterious charge buildup in the drop cable, solving the problem!*




WRONG


NONSENSE


STOP

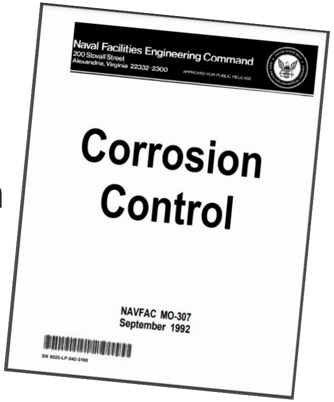
What’s Happening?

What’s really going on isn’t quite so mysterious as some undefined capacitance effect. This is nothing more than the basic chemistry of corrosion.

Question: What is Corrosion?

Answer: "…the destructive attack of a metal through interaction with its environment."

(Source: Naval Facilities Engineering Command 1992 document *Corrosion Control*)


Naval Facilities Engineering Command
200 Stovall Street
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APPROVED FOR PUBLIC RELEASE

Corrosion Control

NAVFAC MO-307
September 1992

Question: What is Corrosion?

Answer: "…the destructive attack of a metal through interaction with its environment."

(Source: Naval Facilities Engineering Command 1992 document *Corrosion Control*)

Most of us have at least some experience with corrosion:

A rusty bolt or nut …

A tarnished penny …

Why Does Corrosion Happen?

Most metals exist in nature in chemical combination with other elements. We refine various ores to get relatively pure metals and alloys.

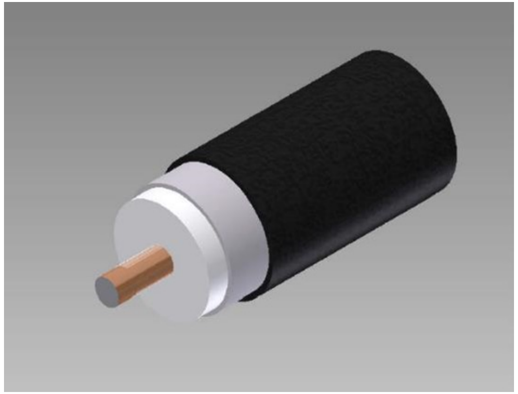
The energy content of refined metals and alloys is higher than that of the original ores, so metals and alloys are constantly trying to change back into lower energy ores or ore-like compounds. This is what we call corrosion.

The Chemistry

The center conductor of most drop cables is copper-clad steel. Let's look at the copper cladding of a drop's center conductor as it oxidizes (the same thing happens with solid copper center conductors). Here's the basic chemical reaction:

$$2\mathrm{Cu}(s) + \mathrm{O}_2(g) \rightarrow 2\mathrm{CuO}(s)$$

The term on the right side of the equation is copper oxide.



The Chemistry

In practice, there are two forms of copper oxide when copper oxidizes in the air. The first is copper (I) oxide, also known as cuprous oxide. This is Cu_2O, which often has a reddish or reddish brown color. The second is copper (II) oxide, or cupric oxide. Its chemical designation is CuO, and it has a blackish color.

Metal oxides in general are not good conductors. Cu_2O, for instance, is considered a p-type semiconductor.

See where this is headed?

The Chemistry

So far I’ve talked about what happens when copper is exposed to oxygen, but copper may be exposed to many things. Copper in moist air often takes on a green patina – the Statue of Liberty is a good example. That green color is a 1:1 mole mixture of $Cu(OH)_2$ and $CuCO_3$:

$$2Cu(s) + H_2O(g) \rightarrow Cu(OH)_2(s) + CuCO_3(s)$$

But Wait; There's More!

*Let's look at natural patina formation on clean copper in marine, urban, and rural environments.**

The copper's corrosion comprises multiple oxide layers. In all three environments, immediately adjacent to the clean copper surface is copper sulphide, followed by a layer of the mineral cuprite (Cu_2O). Next is atacamite, or copper chloride hydroxide – $Cu_2Cl(OH)_3$ – a halide mineral; and posnjakite, or copper sulphate hydroxide hydrate: $Cu_4(SO_4)(OH)_6 \cdot (H_2O)$.

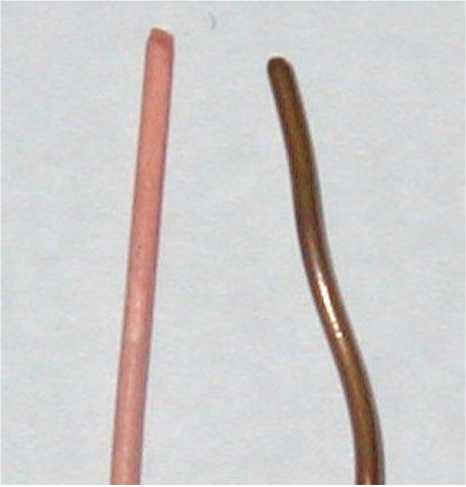
Depending upon the specific environment, other things that show up in the patina may include malachite, antlerite, brochantite, gerhardtite, and organic compounds.

*Source: "Modeling and Rendering of Metallic Patinas" (Dorsey, P. and P. Hanrahan, Proceedings of ACM SIGGRAPH 1996)

Tarnished!

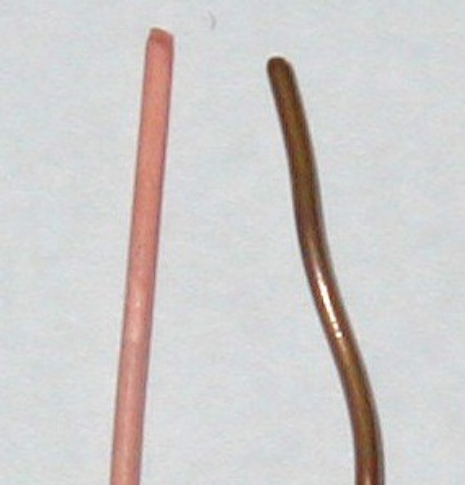
The patinas just discussed are **very thin**, on the order of a few tenths of a micrometer (micron) to perhaps a few microns.

The formation of copper sulphide (a brown tarnish) and cuprite (a reddish brown color) may happen relatively quickly, but the other layers generally take a fair amount of time.



Tarnished!

Over time, the exposed bare copper center conductor (*yes, the center conductor is considered exposed even when it's inside of a mating connector*) will oxidize. That brownish or reddish brown color means the originally clean copper now has a very thin patina of copper sulphide and/or cuprite, and perhaps other stuff depending on the environment and whether or not dissimilar metals are present in the mating interface.



Cuprite, or copper (I) oxide, is not a particularly good conductor. Hmm, sounds like an ATTENUATOR!

The Real Fix

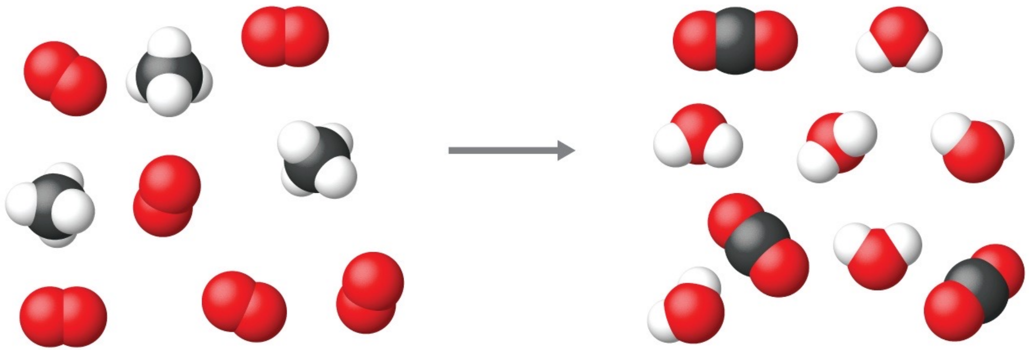
Disconnect the drop from the mating interface, hook it up to a signal level meter, and what happens?

The scrubbing action of disconnecting the drop, connecting it to a piece of test equipment, then reconnecting it to the ground block or whatever, removes some of the center conductor's patina, exposing fresh copper. *Remember, the patina is at most a few microns thick, probably less than a micron! It doesn't take much to scrape away some of the microscopically thin patina to get down to the copper.*

The result? Proper signal levels.

Now What?

What can be done to prevent oxidation of the center conductor? Not much, really. It’s possible to significantly slow down the process, but it’s tough to stop it altogether.



Some Tips

- ✓ Cap the exposed ends of those reels of drop cable in the truck or van (the warehouse, too). This will reduce the likelihood of moisture being wicked into the end of the cable. Whenever a length of coax is removed from the reel, replace the cap on the end of the remaining cable on the reel.

- ✓ Don’t touch the exposed center conductor with bare fingers, and ensure that no visible dirt or other contaminants are present. Don’t cut or scrape the center conductor with a knife or other sharp object.

- ✓ Torque the properly installed connector to 20 to 30 pound-inches (lb-in) on the tap spigot, ground block, splitter/coupler, and drop amp mating interfaces (don’t tighten connectors this tight on CPE).

Some Tips

- ✓ Weatherproof the interfaces on all outdoor connectors, even those inside of pedestals, vaults, and boxes on the sides of customers' homes. Most compression F connectors have one or more integral o-rings to enhance weatherproofing, and the compression crimp provides a 360 degree seal on the jacket. Don't rule out the use of sealing sleeves on the threads, or protective boots in harsh environments.

- ✓ Use ground blocks, drop passives and actives, and so forth that are made of materials that will not result in a dissimilar metals interface. Dissimilar metals mean galvanic corrosion. Discuss the center conductor seizing mechanism with the manufacturer. One that has a large contact surface area relative to the exposed center conductor – preferably with high contact force – is desirable.

Some Tips

- ✓ Use connectors and drop components whose physical interfaces meet relevant SCTE standards.

- ? A potentially controversial idea is to abandon the feed-through drop connector design in favor of pin-type F connectors. We already use pin-type F connectors on Series 11 drop cables, so why not also on Series 59 and Series 6 cables? Pin-type F connectors are more expensive to be sure, but would the added materials cost be offset by a reduction in service calls and truck rolls? More research needs to be done here.

Wrapping Up

There is no **mysterious capacitance or static build-up** that causes signal levels to drop, resulting in snowy analog TV pictures, tiling in digital video channels, or FEC errors in high-speed data service.

It's good ol' corrosion.

When the drop is disconnected from the mating interface (tap, ground block, etc.), plugged into a test instrument, disconnected from the test instrument, and reconnected to the original mating interface, the scraping action on the center conductor removes some of the copper's corrosion patina, exposing fresh copper. That's what causes the signal levels to return to normal.