Maintaining An Effectively Bonded and Grounded Network in an Age of Copper Theft

Keeping the bad guys from copping your copper

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Abstract

The confluence of extraordinary commodity prices for copper and an employment market approaching a depth of gloom not seen in America since the Great Depression of the 1930's, has resulted in a significant uptick in thefts of valuable metal infrastructure. Building markets are suffering the stripping of copper wiring and air conditioning coils from homes and commercial buildings that is nearly pandemic in scope and scale. Often hard hit are farmers, whose irrigation systems are being stripped of wiring. Such thefts net only small amounts of copper that sells for $2 to $3 a pound but often costs thousands of dollars to replace and in many cases, the temporary loss of an irrigation system results in crop failure. So, a thief nets a hundred dollars or so while the farmer's losses might be in the hundreds of thousands of dollars.

Ditto the telecommunications industry where copper thieves frequently target unattended facilities such as cell and microwave sites. Especially vulnerable are ground bars and bonding and grounding wires. These crimes of opportunity typically reward the thief with fifty or sixty dollars from a scrap metals dealer per site that he's pillaged. The site owner however is stuck with thousands of dollars in repair and replacement costs and the very real threat that lightning striking a now ungrounded system may cause damages in the tens or even hundreds of thousands of dollars. This paper will explore a number of copper theft deterrent schemes that have been explored over the past couple years, some of which worked while others didn't.

What kinds of telecom sites are being attacked?

For the most part, remote locations are being pillaged, obviously because they are unmanned sites with no one present to catch the thieves. Most Cell and microwave sites have approximately 200 pounds of copper outside the shelter between the ground wiring and bars, the refrigeration coils in the HVAC system and the generator and associated wiring. Of that quantity, probably 75% is either buried or up on a tower out of reach. Opportunistic criminals are there to pick 'low hanging fruit' and therefore typical material thefts are splice plate ground bars at the shelter waveguide hatch and another one mounted fairly low on the tower, and whatever #2 AWG and #6 AWG copper leads that bond the coaxial cables and waveguides to those bars, and the conductors bonding the bars to the buried electrode system. Generally, thieves don't climb the towers to steal the ground bars high on the tower and generally they don't dig up the buried conductors. While most copper thefts are made with cable cutters, in the case of farm irrigation thefts thieves have begun cutting conduits and then tying off cabling to a rope attached to their vehicle and driving off to yank whatever wiring as will pull out and then stop a-ways down the road to coil up their booty and leave. If this little bit of criminal innovation takes hold, we may begin seeing buried copper wiring disappear this way. Additionally, while almost any ne'er do well drug addict with a wire cutter or a hacksaw might steal copper, increasingly, there is evidence to suggest that in some cases the same contractors who install these grounding systems are tearing them out to make a quick buck from the scrap and to make an even bigger buck by creating a market for replacing the booty.

Figure 1 depicts four cut copper ribbons that once connected the hatch plate and the ground bar just inside the hatch plate to the buried Ground ring.

While ground level cell and microwave sites experience significant thefts, rooftop sites are even more tempting to thieves because there is more copper available there. Many workmen have access to the roofs of the hotels, apartment houses and office buildings where cell and microwave sites are placed on roofs and increasingly these sites are being plundered.

Figure 2 Rooftop cell and microwave sites have larger quantities of easily stolen copper wiring than do ground level sites, and increasingly these rooftops are being targeted by metals bandits.

What's a guy to do?

Across the various copper-intense industries, many initiatives are being tried with varying levels of success.

Some folks are dealing with the issue by deploying signage that claims there is no copper on the site. Remarkably, this dirt cheap solution has deterred a fair number of would-be copper thieves even though the copper components are easily visible. Obviously some of these thieves aren't the brightest bulbs on the string.

One approach that I like is finding solutions that protect copper or eliminate it altogether. Probably the densest copper element at a cell or microwave site is the ground bars. Typically these are a solid copper bar weighing roughly 9 or 10 pounds. Given that the telecommunications outside plant network mostly is bonded to a messenger strand of galvanized steel, why can't a galvanized steel ground bar do the job? With that in mind, a couple of vendors were approached and one built some sample bars and ran them by UL. This bar (Figure 3) was accepted by UL and at least one of the wireless carriers is making good use of them and has seen copper theft reduce drastically.

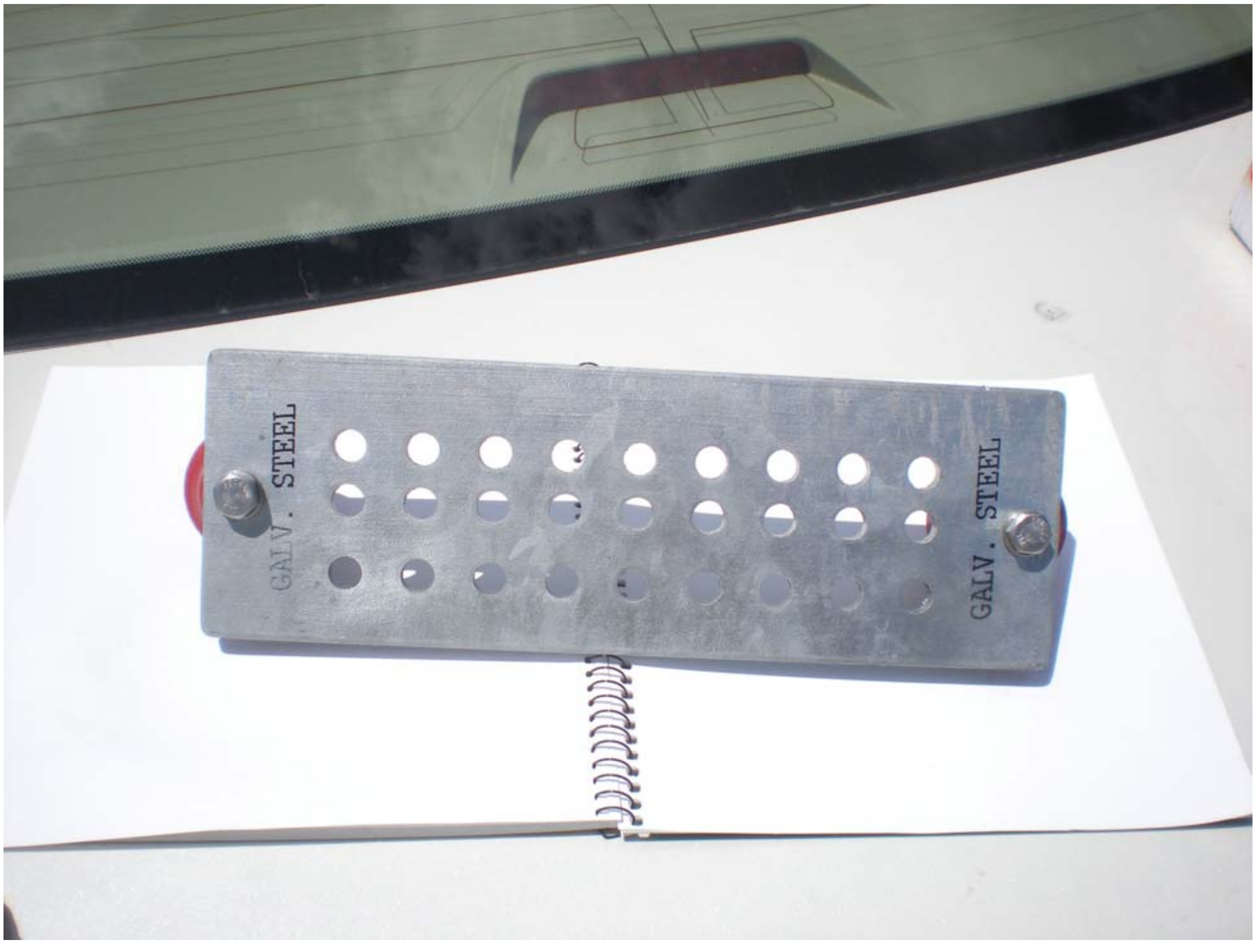

Figure 3 the galvanized steel ground bar splice plate has made a significant improvement in reducing copper theft.

Another approach is to make the copper difficult to separate from other materials such as insulation that might surround it. To that end a crimped armor was applied to #2 AWG solid bare tinned copper wire (Figure 4) and this too has improved copper retention. The crimps are on 8 inch centers and the thief would have to make so many cuts to get to the copper that the workload is a deterrent. This approach has been used for about two years now and has been effective at reducing copper theft. Another approach is making the copper too nasty to touch and one company has produced a sticky, tar-like substance that one paints onto assembled copper components. The material (Figure 5) is disgustingly pasty and difficult to remove from hands and clothing,

Figure 4 Crimped, armored #2 AWG BTCU wire.

Figure 5 Theft deterrent compound

Next, if galvanized steel is an acceptable ground bar, is it an acceptable bonding conductor? The short answer is yes, some railroads and electric utilities have begun using a copper power wire that has copper strands surrounded by galvanized steel ones? While such cable (Figure 6) is a little more inductive than its copper cousins, the fact is that when sized and run correctly, the product does a credible job of Grounding protection.

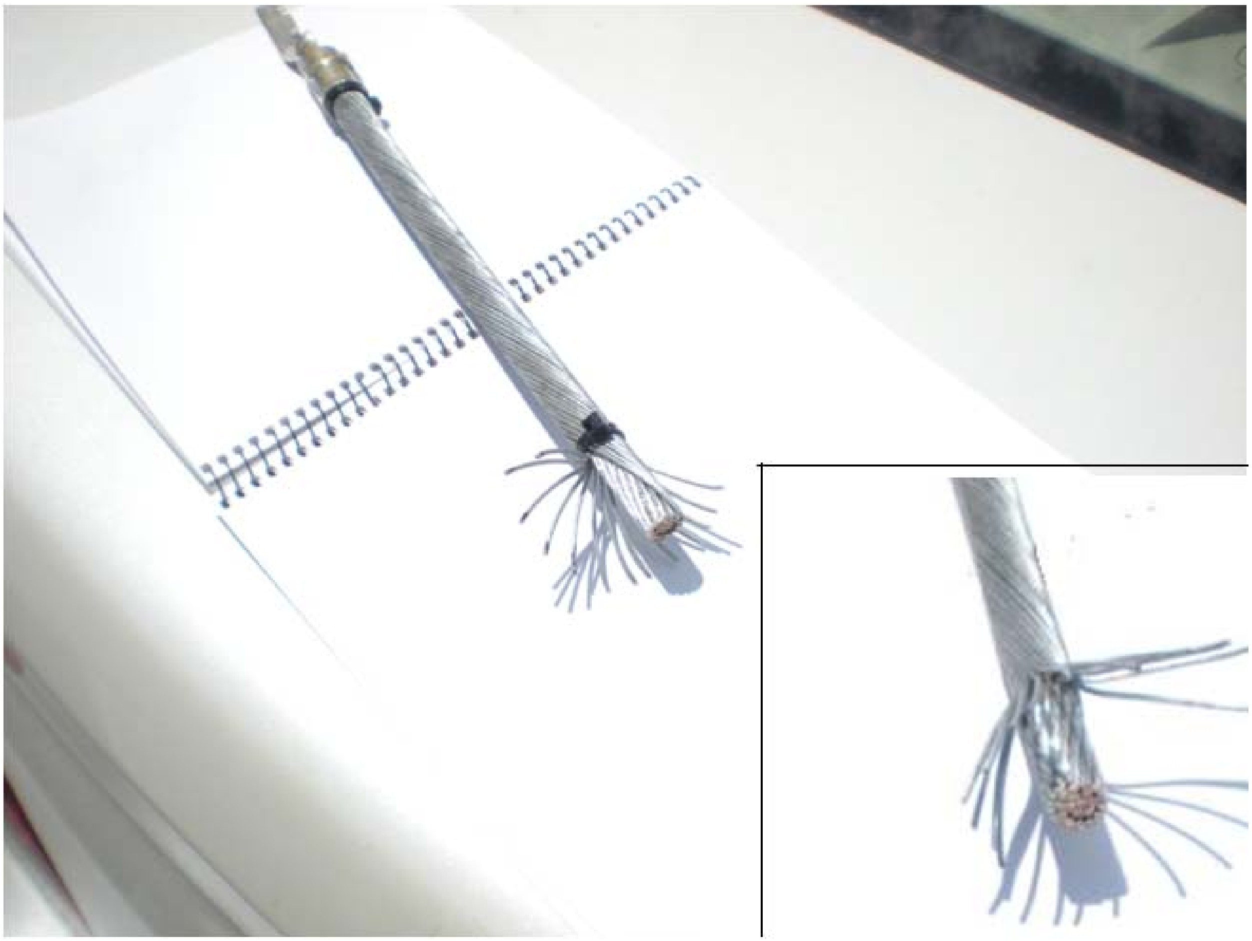

Figure 6 a composite grounding wire with galvanized steel strands wound concentrically around a core of copper strands.

Yet another approach is aluminum wire. As a practical matter, most of the US power grid is comprised of long haul high tension electrical transmission lines using aluminum conductors. Further, the lightning protection systems on buildings protected by lightning rods use either copper or aluminum depending on a number of factors, one of which is what other metals exist on the roof. Aluminum lightning protection system conductors are UL listed for the purpose and do a credible job. This situation begs the question: if aluminum conductors are perfectly adequate to protect a building from lightning, why then shouldn't aluminum conductors also suffice to bond and ground the systems and subsystems for a rooftop cell or microwave site?

Figure 7 if aluminum wiring is adequate to provide lightning protection for a building, why then shouldn't aluminum conductors also suffice to bond and ground the systems and subsystems for a rooftop cell or microwave site? (Note: the system shown here is still being constructed; hence some of the connector bases aren't tightened yet, nor are the anchor plates cemented down with silicon sealer.)

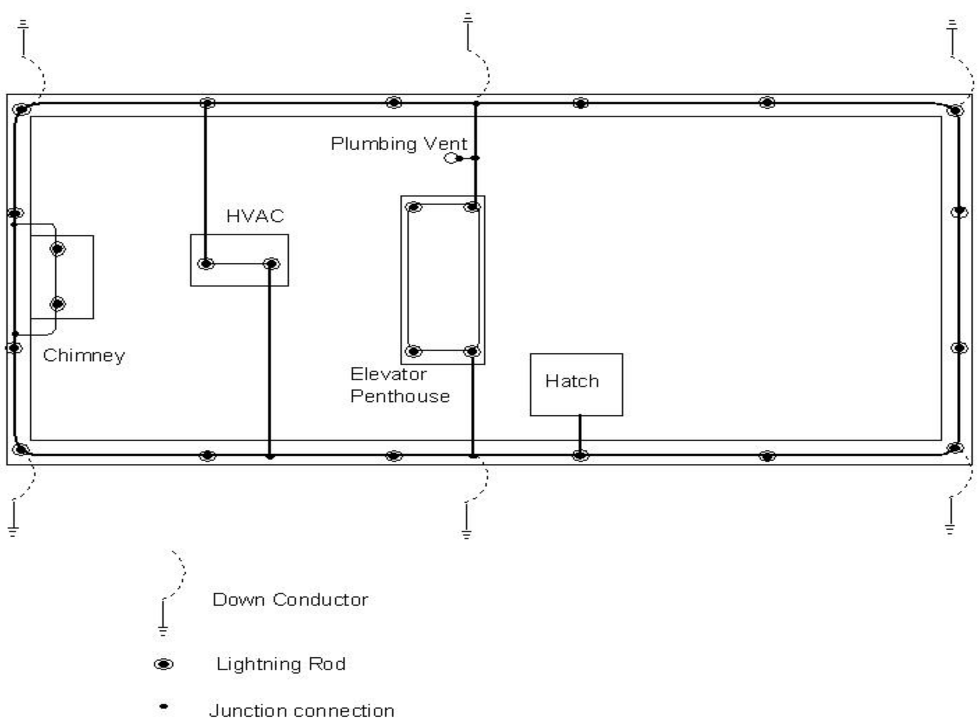

Figure 8 depicts a typical rooftop lightning protection system

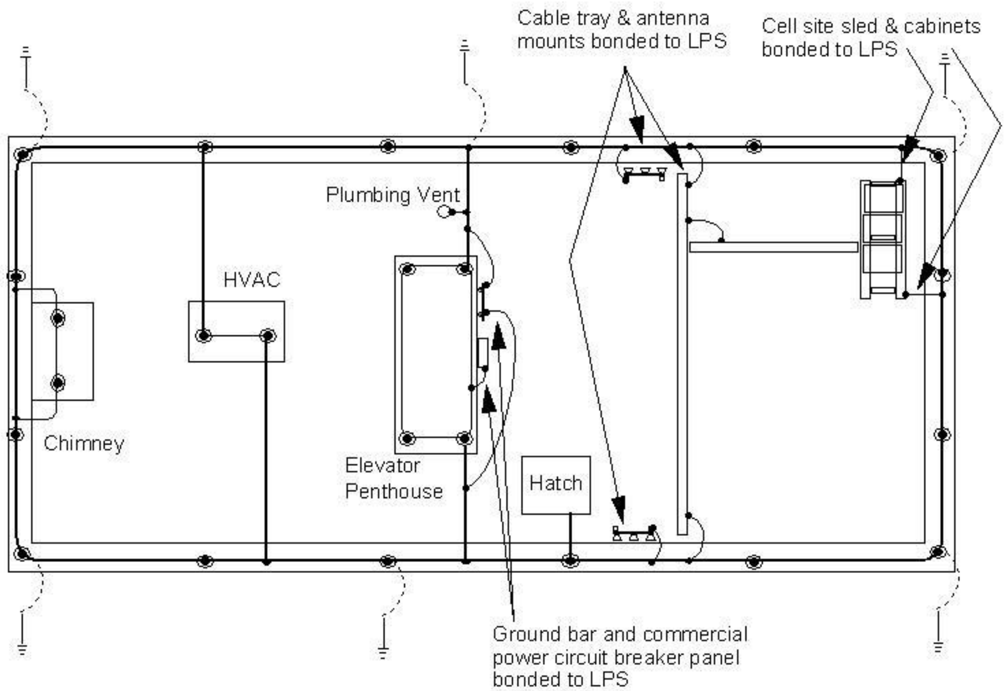

Figure 9 is the same sketch as Figure 8 with the addition of a cell site bonded to the lightning protection system.

If the roof has no lightning protection in place a perimeter ring must be established. The ring need not encompass the entire roof, just the area where the carrier will be adding cell or microwave site equipment as shown in the figure 10.

The recommended material for the perimeter ring is either the aluminum Class II lightning system conductor as is described herein and widely available or the theft deterrent galvanized steel over copper wire. Note that when running the wire, it is important that aluminum wire not come into intentional or accidental contact with steel elements without proper interfacing. If the wire must route close enough to touch a steel element a length of nonmetallic electrical tubing such as PVC conduit or nonmetallic liquid-tight flexible conduit (Seal-Tite®) shall be used to prevent contact. Similarly, if the galvanized steel theft deterrent cable is used; nonmetallic conduits must be used where the wire could come into contact with aluminum elements. Silicone sealer shall close each end of the conduit to prevent water entry.

Physical supports and clamps for the perimeter wiring must be compatible with the metallurgy of the wire and in no case shall the clamps encircle the conductor with ferrous iron or steel (See figure).

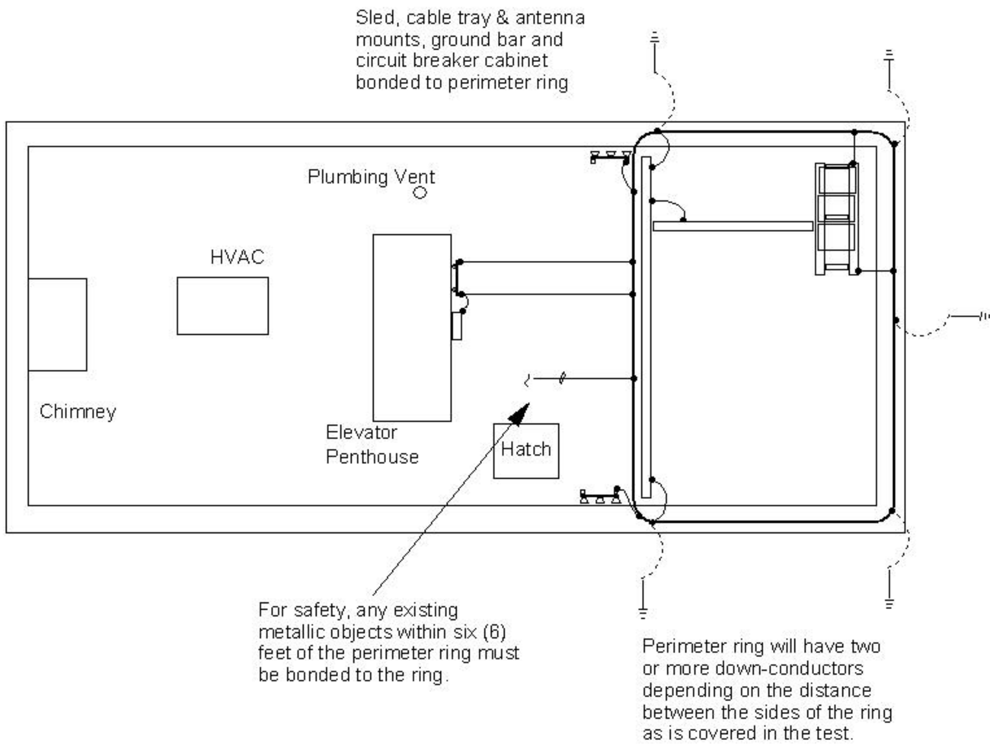

Figure 11 is a cell or microwave site atop a roof that does not have a lightning protection system and incorporates two or more down-conductors or the building structural framework itself for connection to earth ground.

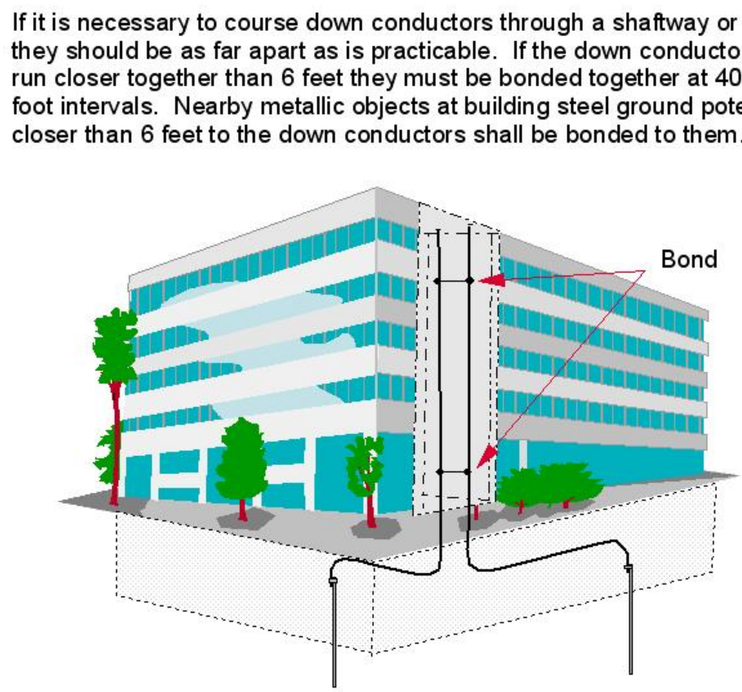

Figure 12 shows down conductors in a shaftway or wiring chase in a building. Note that aluminum wire cannot be run below grade and so if aluminum is used for this application one should transition to copper for the buried portion.

When bonding and grounding rooftop sites it is critical that equipments be well bonded together or else personnel safety and equipment reliability could be severely compromised. It's possible for very large electrical differences in potential to exist during lightning events and the only effective way to minimize those potentials is with effective bonding to hold the differences in potential to tolerable levels as is illustrated in Figure 13.

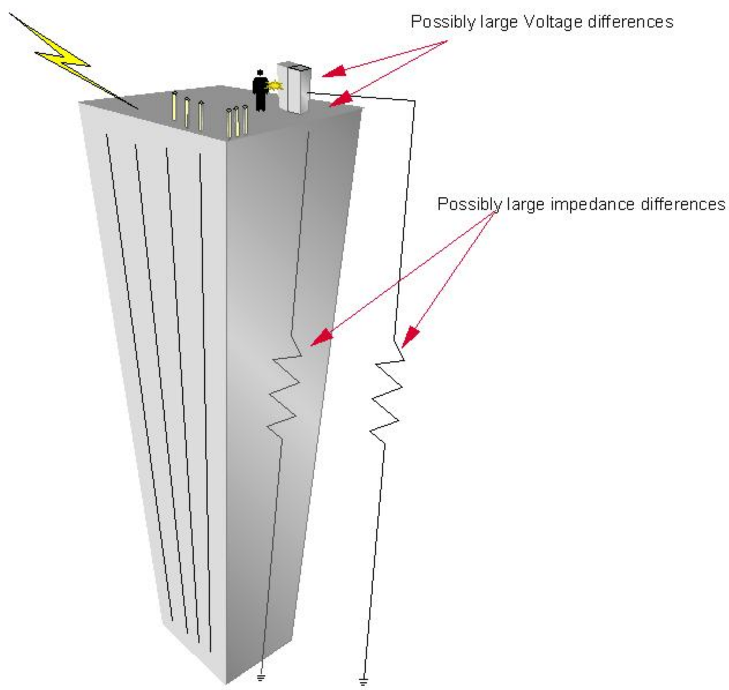

Figure 13 shows the potential for large voltages at the rooftop systems due to the overall impedance of the down conductor paths and the impedance of the building framework. Accordingly, effective bonding to building structural steel is critical.

Bonding the cell or microwave components together is critical and aluminum can be used for that purpose so long as attention is paid to the interface with steel cabinetry, frameworks or other conductive elements. The use of connectors or lugs intended for bimetal connections and a good antioxidation compound must be used. Figure 14 depicts such an application.

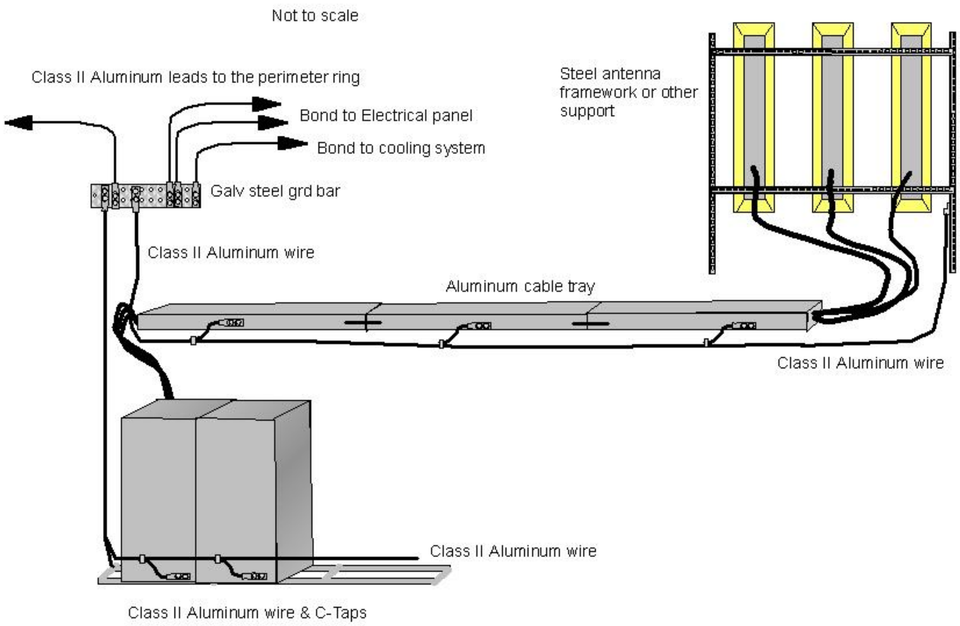

Figure 14, aluminum wire used to bond a rooftop cell site.

What about surveillance?

The cost of video surveillance is steadily coming down and there are a number of ways to do it. Some companies already use cellular Modems and routers to monitor their fuel status and flag a reminder when a refill is needed (Figure 15). A camera plugged into a spare port of the router could be used to monitor the site.

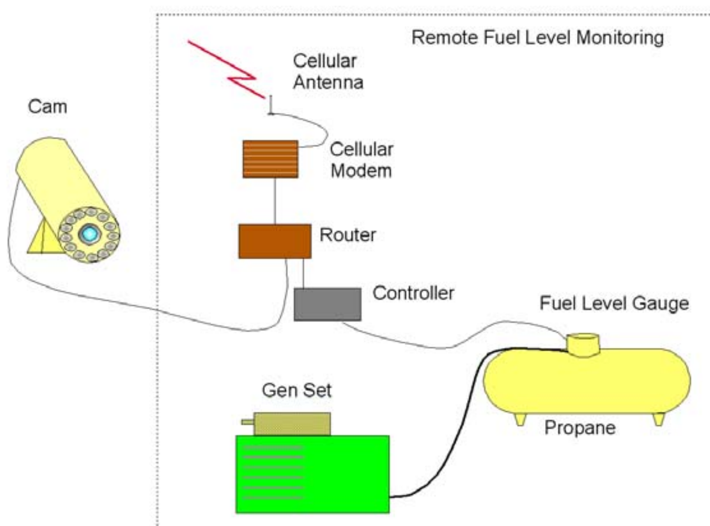

Figure 15, a camera could share a virtual circuit used for fuel or other monitoring at a cell or microwave site.

Another interesting approach has been offered by a company that combines a camera and IR light source with a motion sensor and a built in replaceable battery.

Figure 16 a motion detecting camera that reports events over the cellular network.

What makes video surveillance useful is that police departments are more likely to prioritize a crime in progress and catch the thieves. Plus, the images have solid evidentiary value when the thief is prosecuted.

Alarming the ground bar is an approach that some areas have tried with a fair level of success. Some simply loop a wire through a spare hole in the bar and then monitor the wire for continuity. Other designs are more complex. One shown in Figure 17 is essentially a plastic pipe that occupies a space on the unit. The bar can't be taken without compromising the wiring in the pipe and that wiring is conveyed into the shelter via a short length of Sealtite at the bottom of the unit. If taking any of the bar alarm approaches it's important to remember that lightning currents might enter the facility on the alarm leads and therefore it's prudent to use some sort of a primary protector on those leads to take overstress voltages safely to ground.

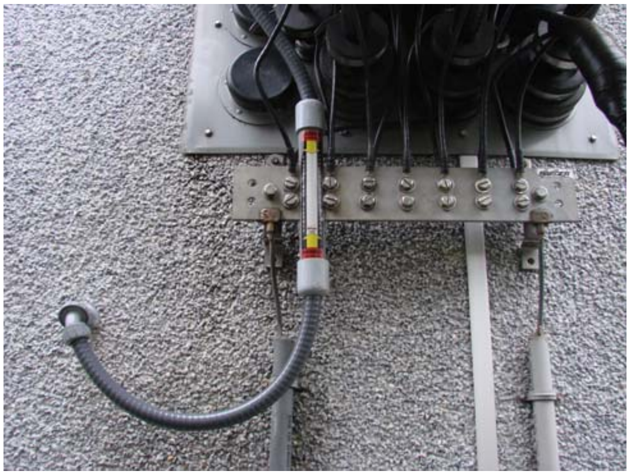

Figure 17, one method of alarming a ground bar.

Other approaches have included clamping heavy gauge steel boxes around the Ground bar(s) or other locking mechanisms. Some of these methods seem more destined to become birdhouses than anything else. Still others involve unusual connection arrangements. One well-intentioned vendor has produced a product that doesn't have a ground bar per se, but rather stacks up lugs between tinned copper spacers. This approach uses about half as much copper in the spacers as there would be in a ground bar. One risk with this connection method is that a loose connection invalidates all connections instead of only one or two as would be the case with bar arrangements. Finally, one would need to use lugs or other space maintainers or else the assembly wouldn't have room for growth if additional terminations were needed in the future.

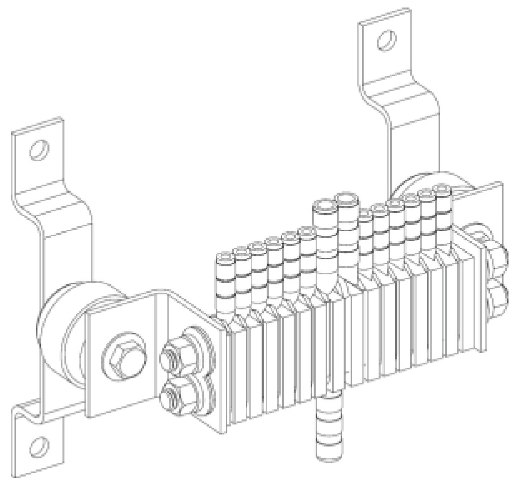

Figure 18 a stacked lug and spacer approach to ground connections (Duley Electric BARNONE sold through Harger)

Conclusions

Whether one owns a cell site, a farm or a jewelry store, loss prevention is a combination of well integrated security measures and diligence. Most of the methods discussed herein have a niche and the potential to reduce losses if used. Also, legislation is producing more effective screening requirements for scrap dealers including photo ID and other means of thwarting or identifying dishonest 'customers'.

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