Grounding and Bonding in Communications Systems

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This talk concentrates on:

Interconnection of equipment and connection to earth

April 15 is coming

- **The only difference between a tax man and a taxidermist is that the taxidermist leaves the skin.**

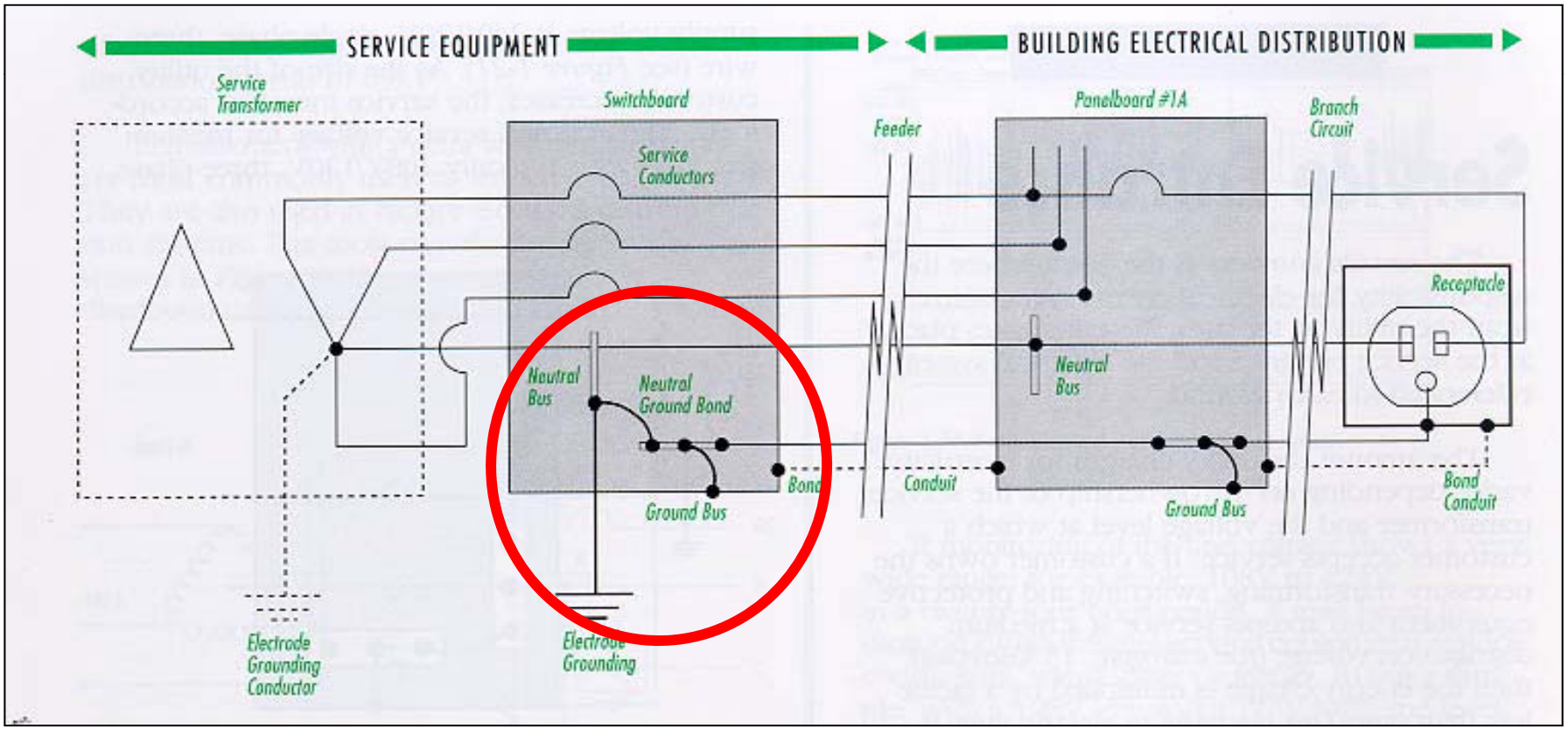
-- Mark Twain

Grounding and Bonding

Grounding and bonding are fundamental components of power quality and reliability, and should be robust before you do anything else

Grounding

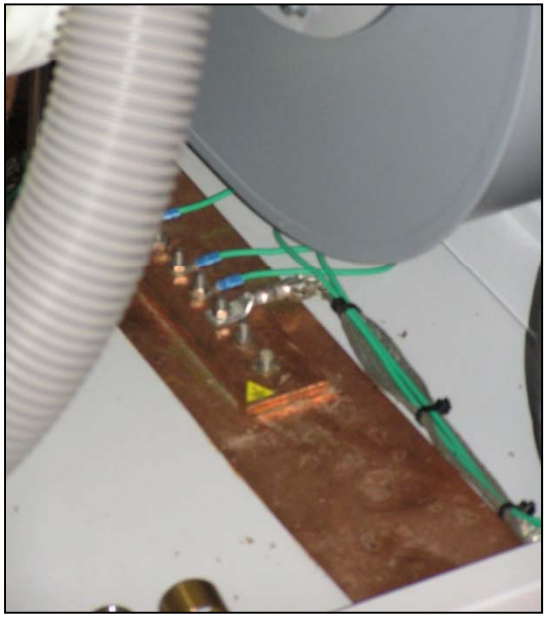
Grounding is the intentional connection of the electrical system to the "earth" or a body that serves in place of the earth



Bonding

Bonding is the intentional interconnection of normally non-current-carrying parts of electrical equipment to prevent shock and voltage differences in the event of a fault

The terms “grounding” and “bonding” are sometimes used incorrectly and often interchanged.

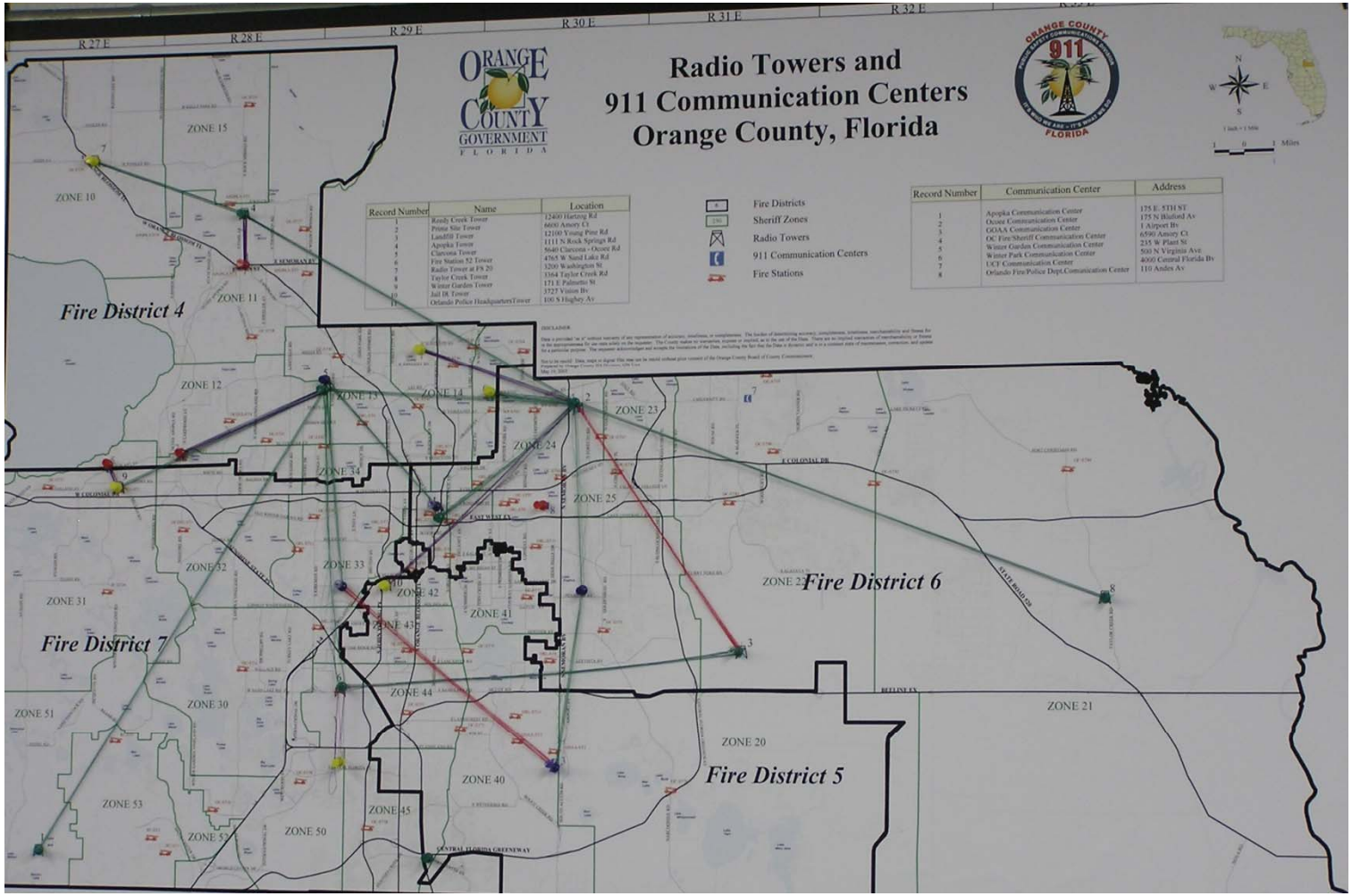


Orange County, FL 9-1-1 system

Retrofit of existing sites

Orange County, FL 9-1-1

11 transmitter sites



Orange County, FL 9-1-1

Headquarters
Apopka, FL

- **Source: Power & System Innovations, Inc., Orlando**

Orange County 9-1-1 - Apopka

280 foot tower

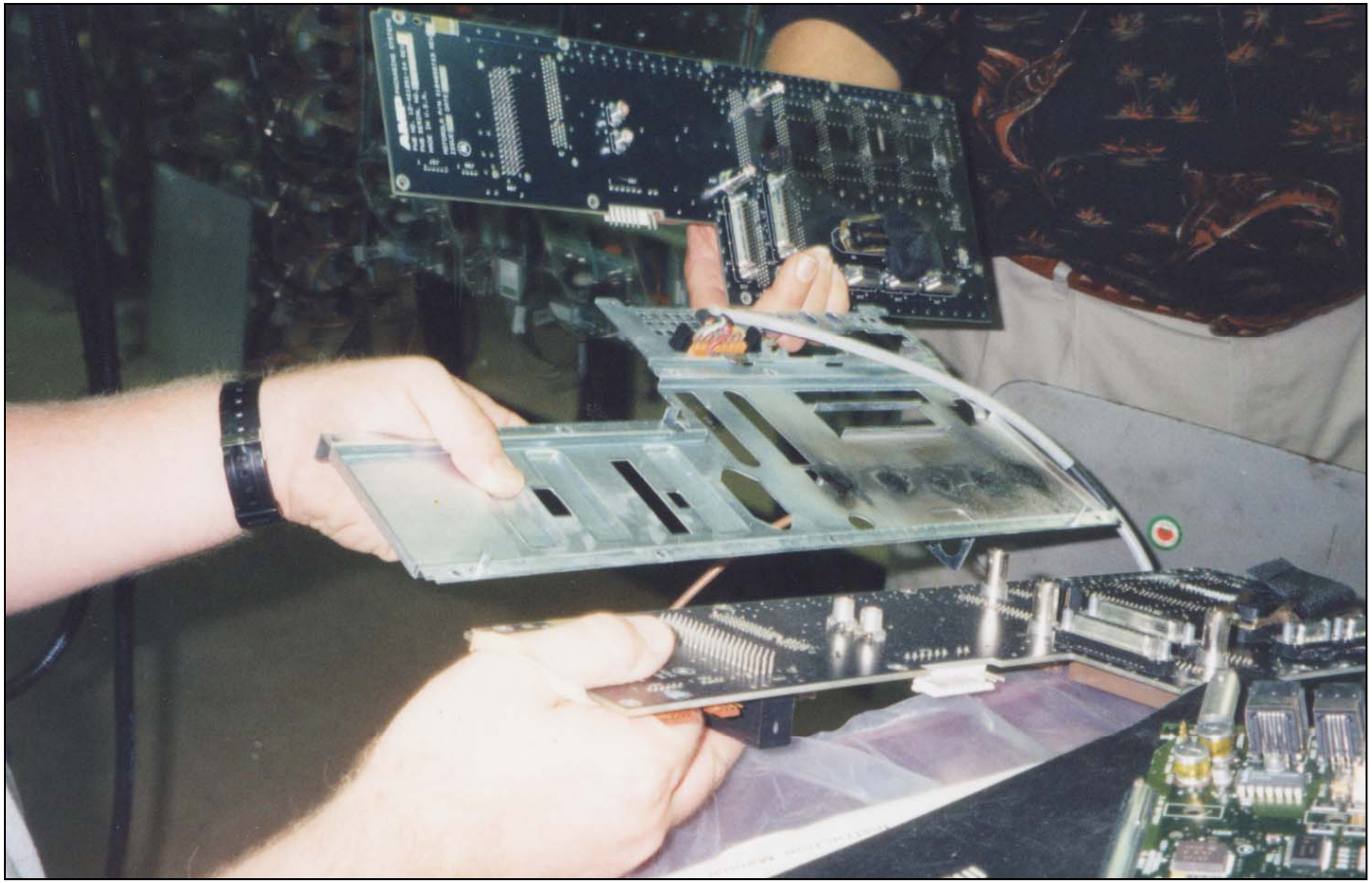
3 sets of 5 guys

Orange County 9-1-1 - Apopka

$100 K/yr. damage at Apopka alone

Orange County 9-1-1 System

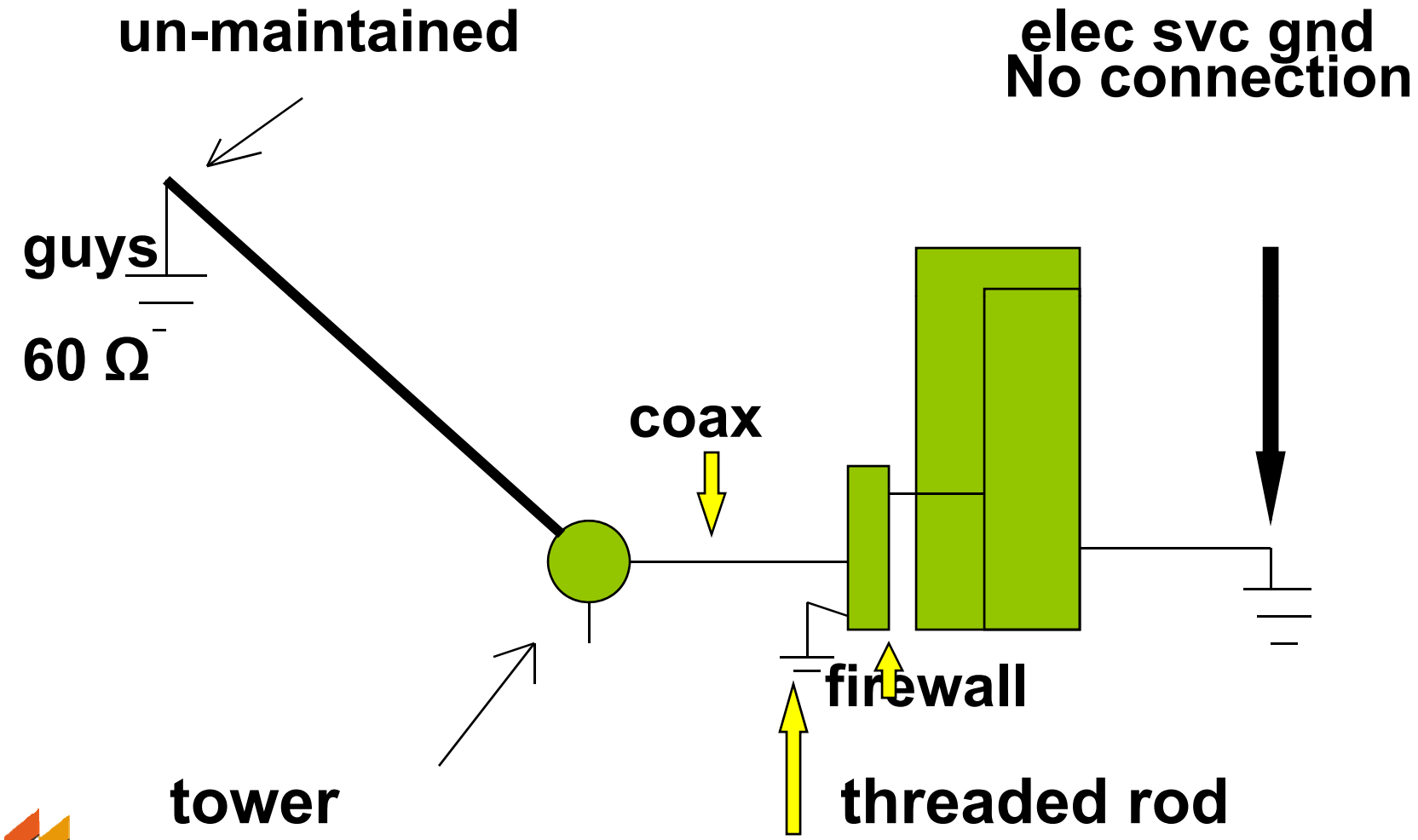
$1-2 million equipment losses system-wide /year



Step 1

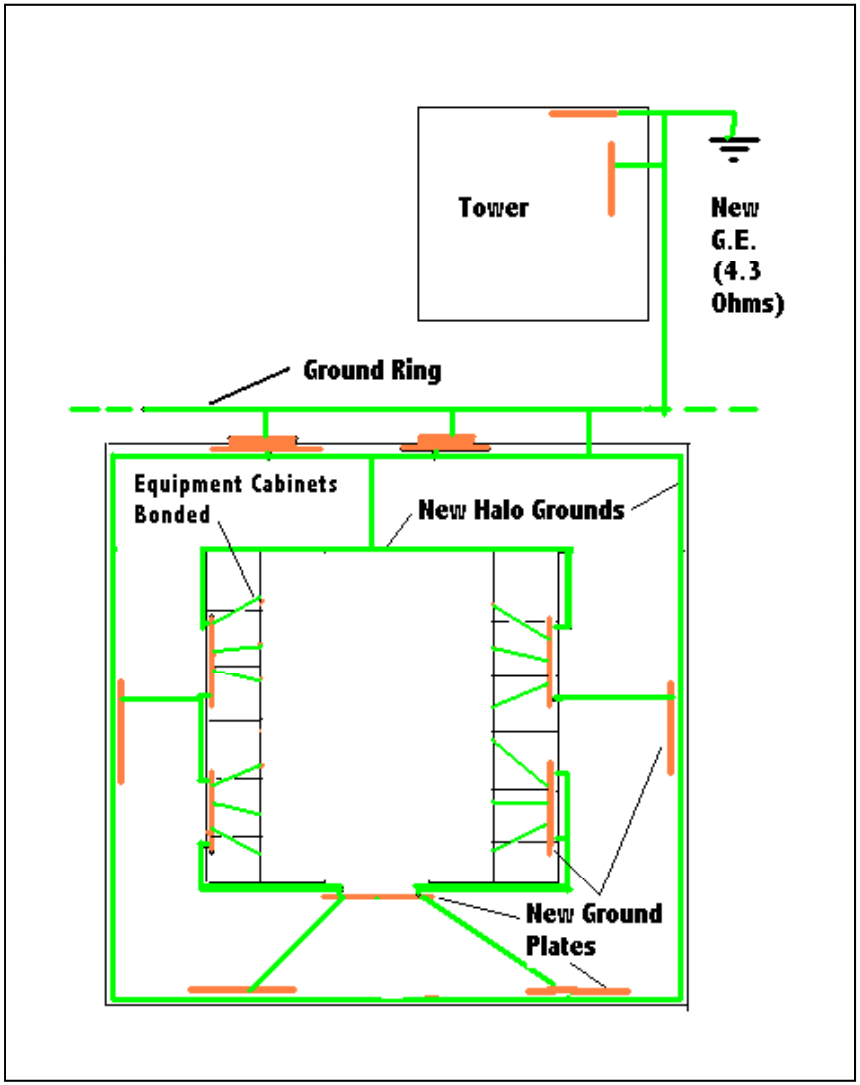
Staff was not expert in power quality, called in knowledgeable professional

3 Independent grounds



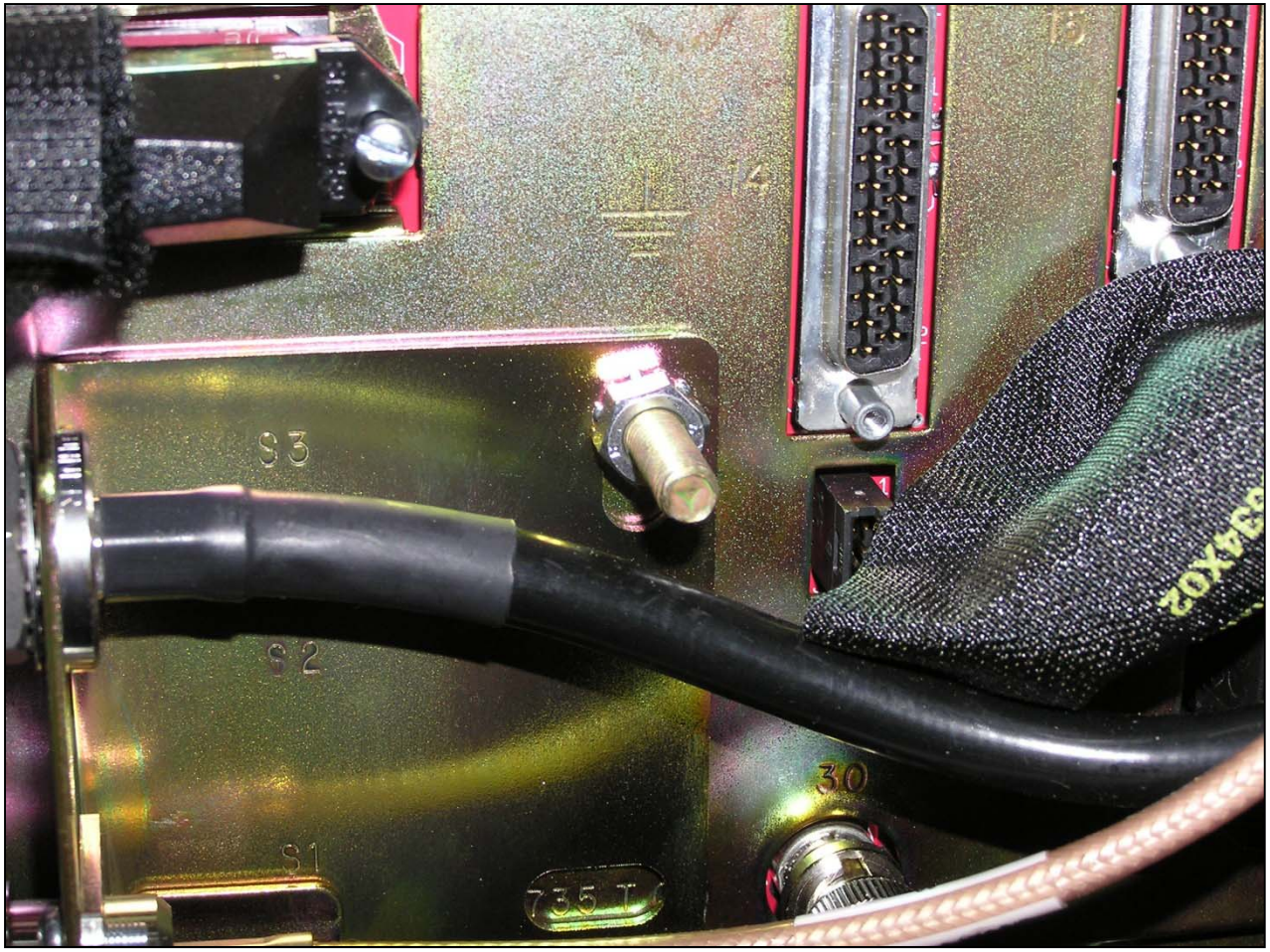
Refitted site

Everything bonded together



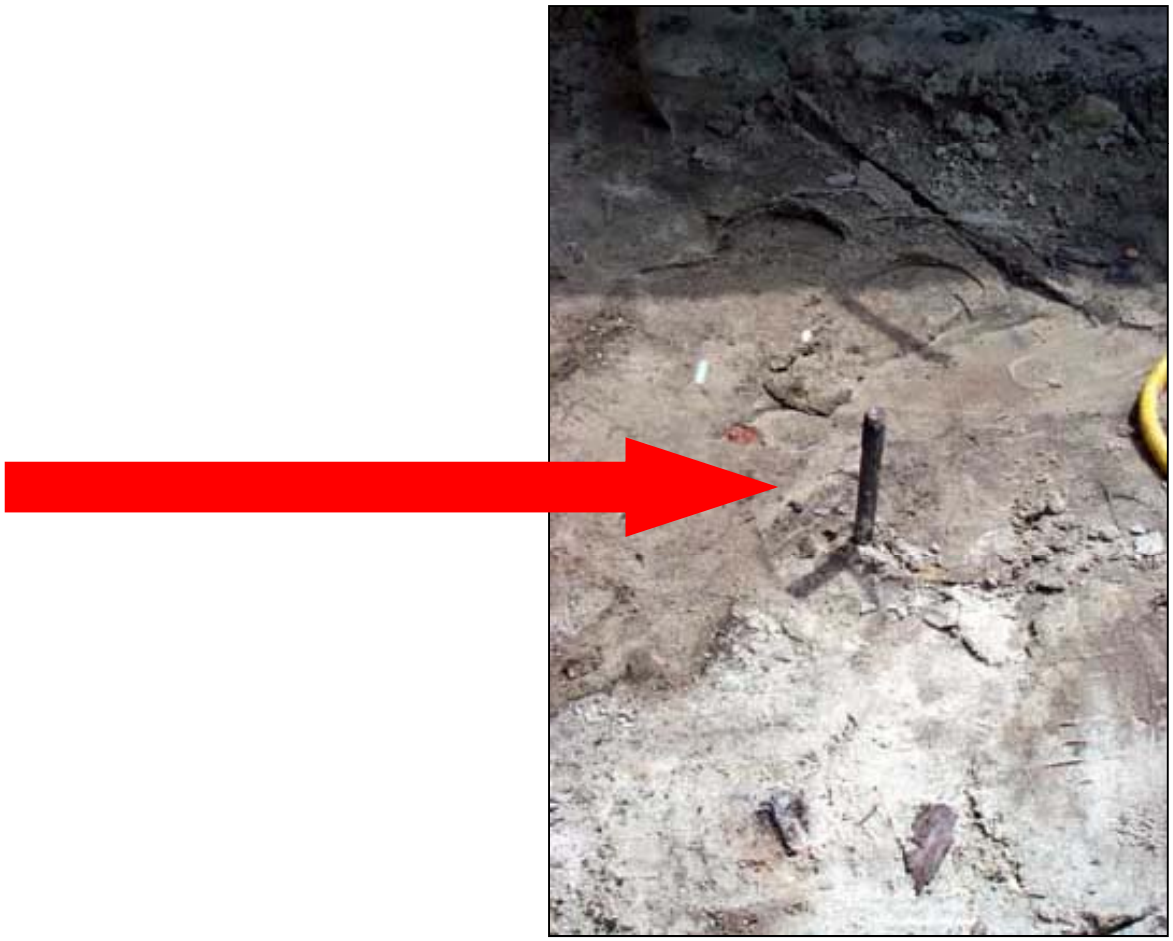
Throughout The System

Ungrounded equipment cabinets



Facility ground at Apopka

Main electrode was all-thread rod



Old Apopka ground rod

Measured 550 ohms

Apopka Tower Grounding

Retrofits:

Deep (60 ft) electrode supplements tower

Proper coax shield grounds:

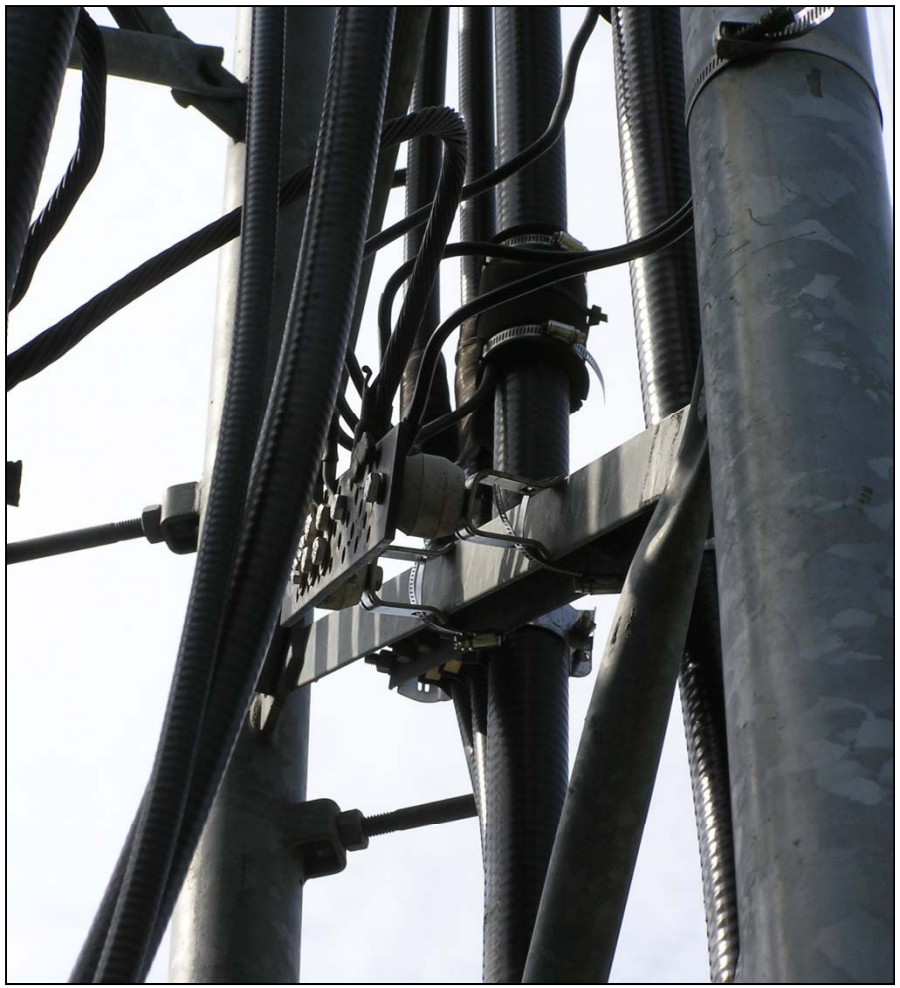
New bus on tower

For coax grounds then 4/0 to electrode

Coax Shields

Coax shield bonded to bus,

to electrode system

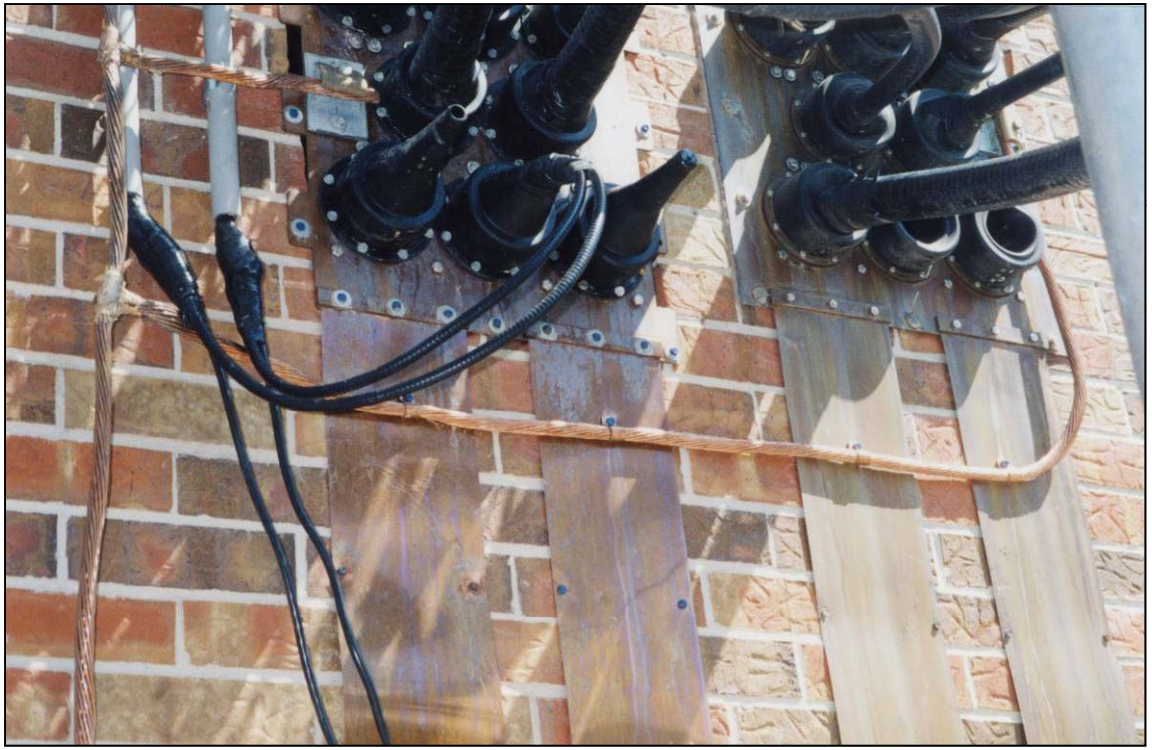


Outside Firewall

Only ONE Cu strip connected to electrode

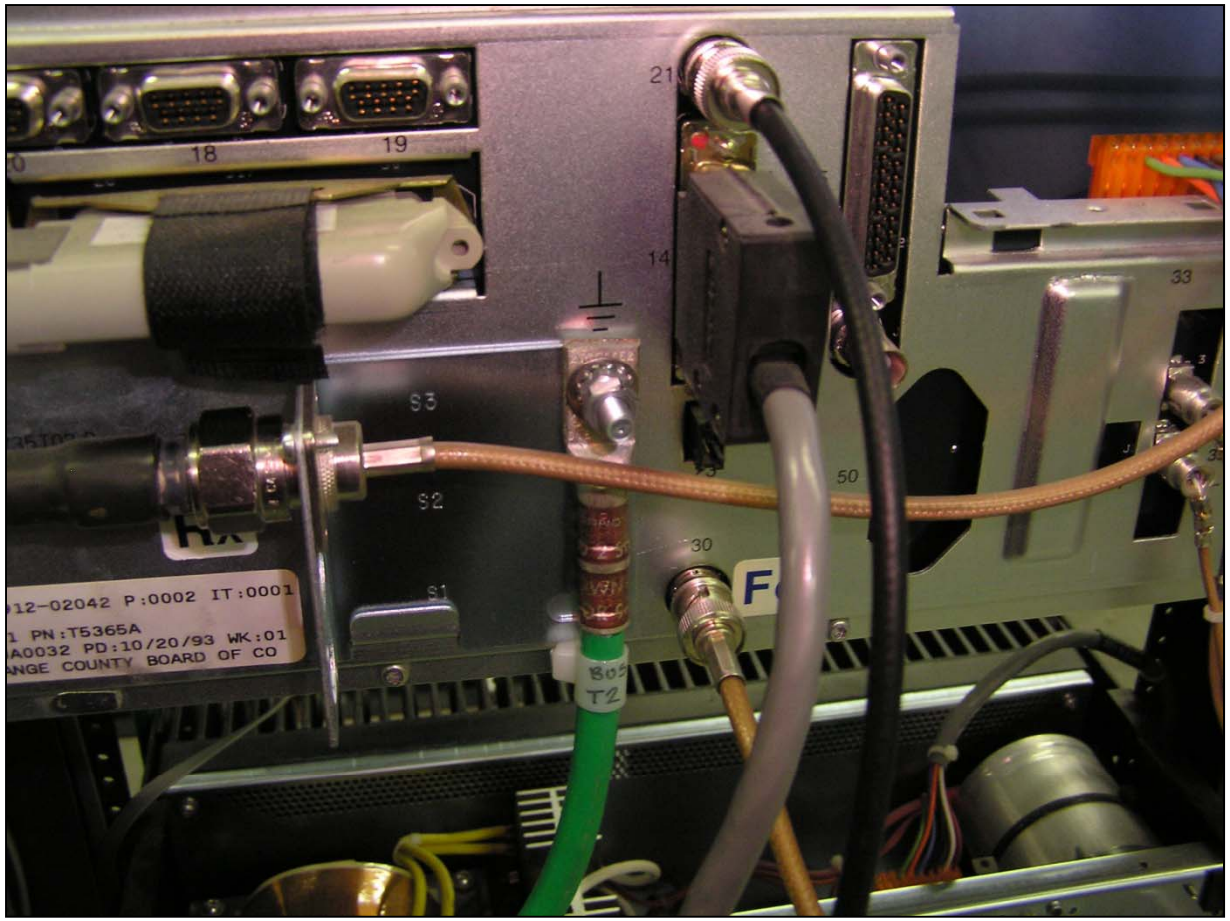
Outside Firewall

Strip bonded together and to ring with 4/0



At all Equipment Cabinets

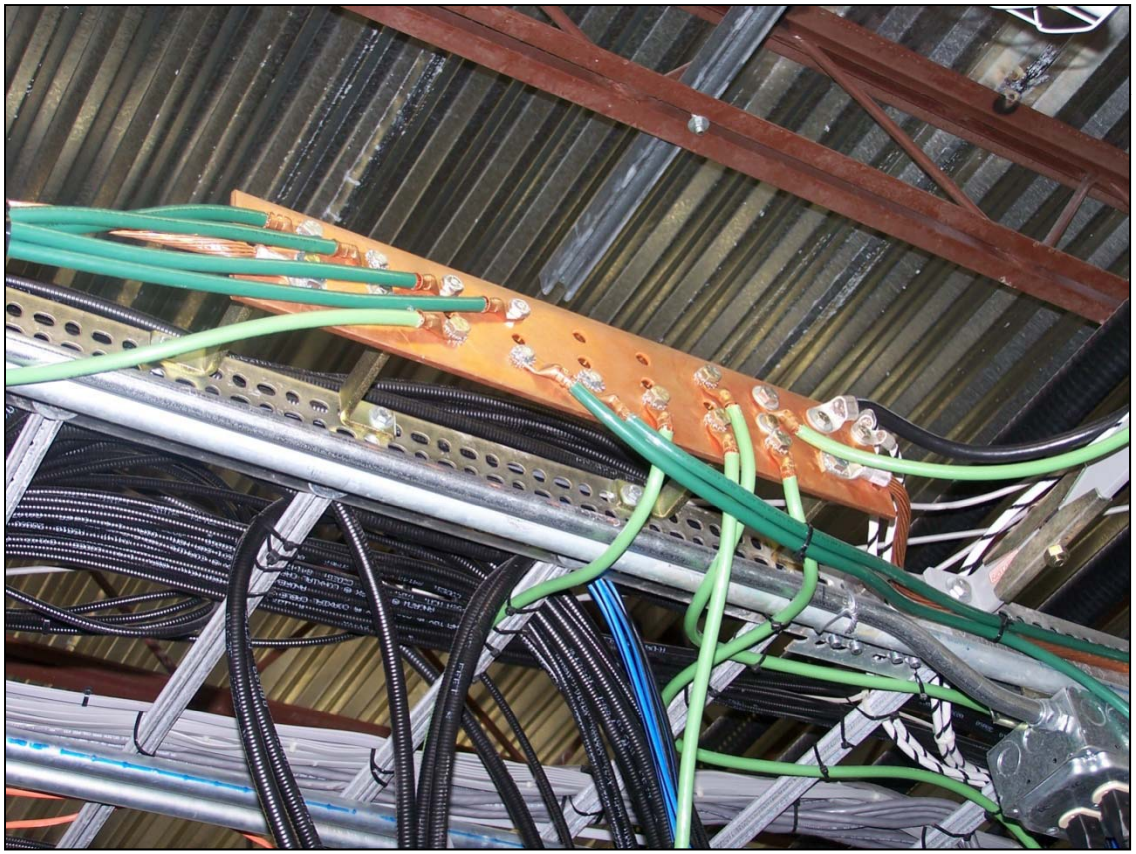
Bond equipment properly



Separate Bonding

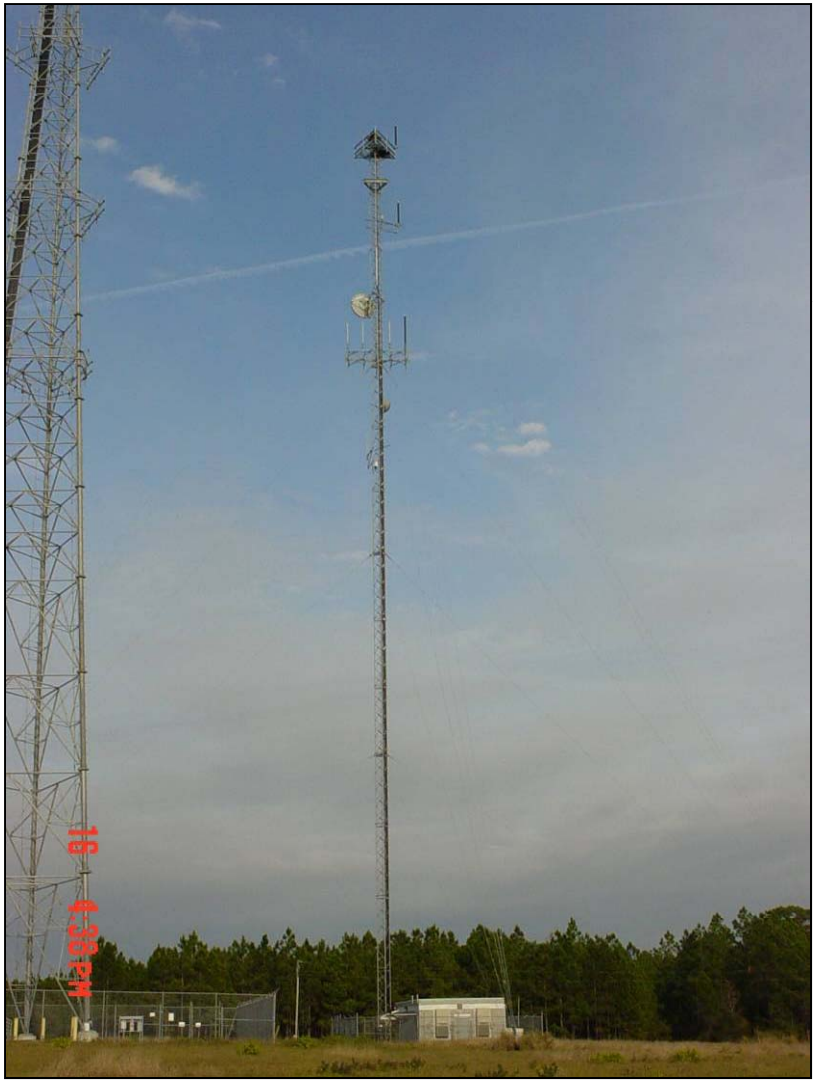
All equipment bonds brought to buses

Buses tied to halo rings



Reedy Creek

Remote repeater near Disney World

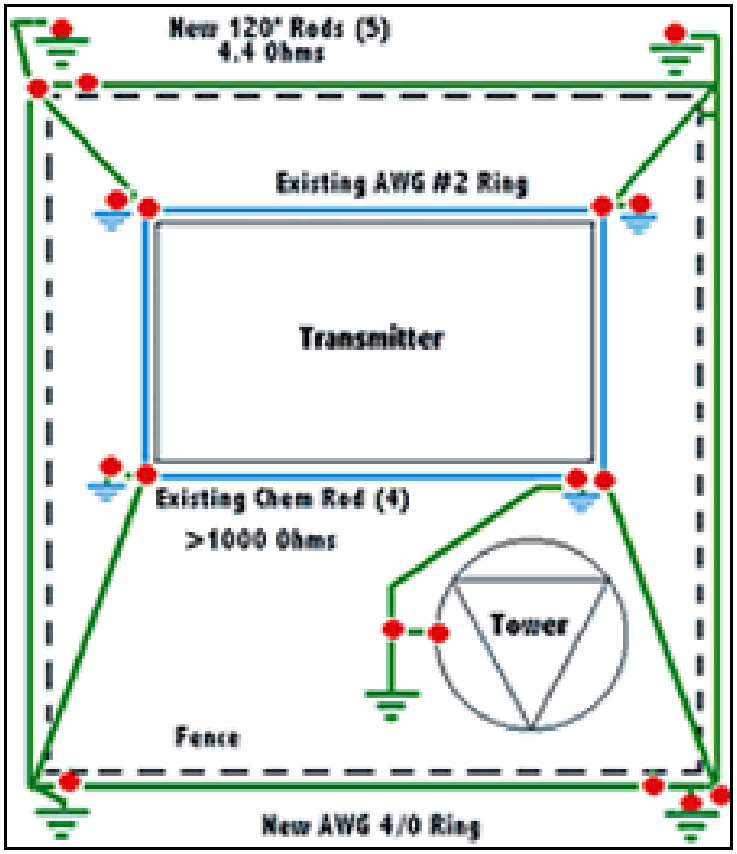


Reedy Creek

More real estate to work with

Reedy Creek Layout

double rings plus deep electrodes

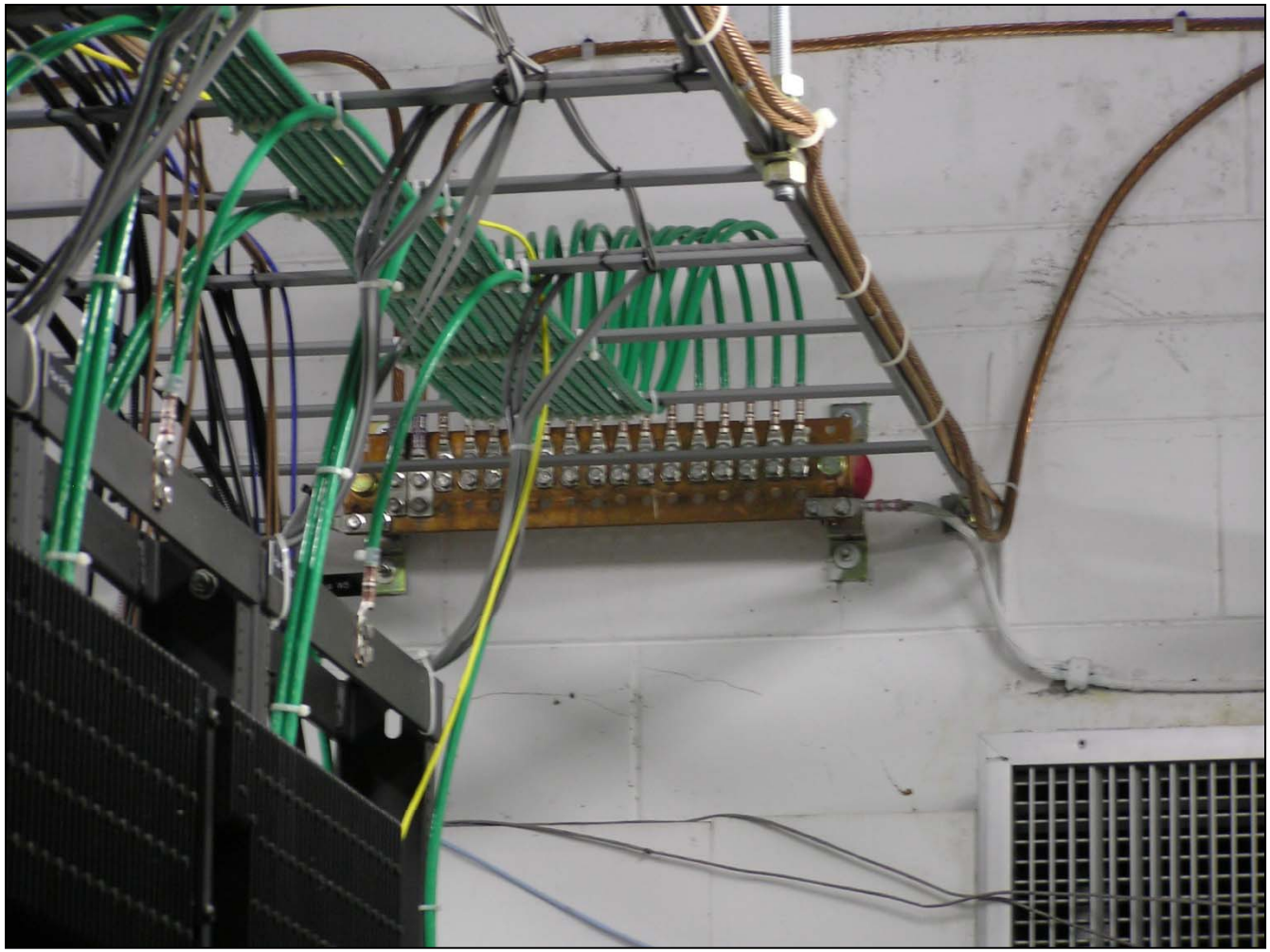


Deep ground rods

Each rod was driven deep enough to achieve < 5 ohms independently

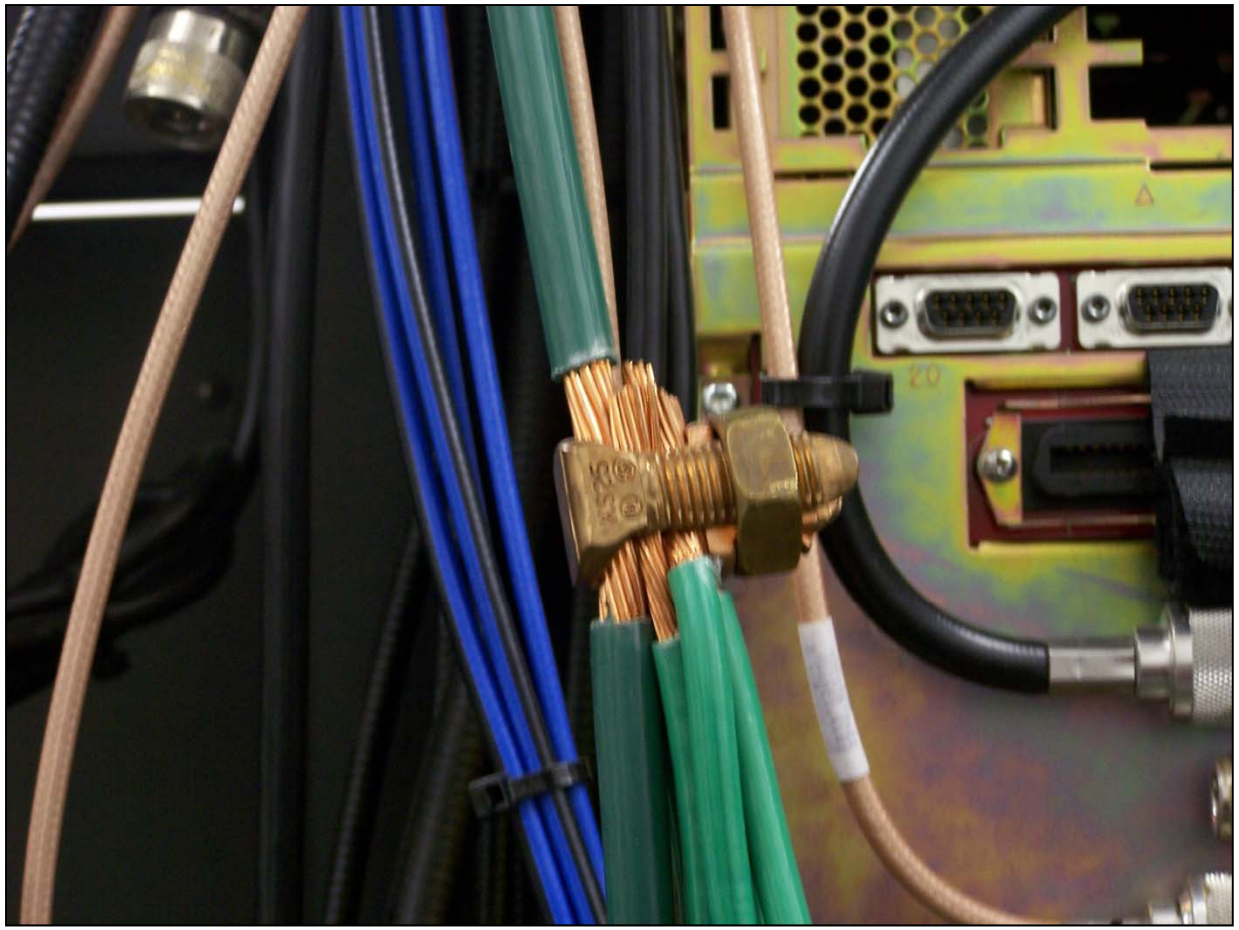
Note wide turns

Lightning doesn't like right angles



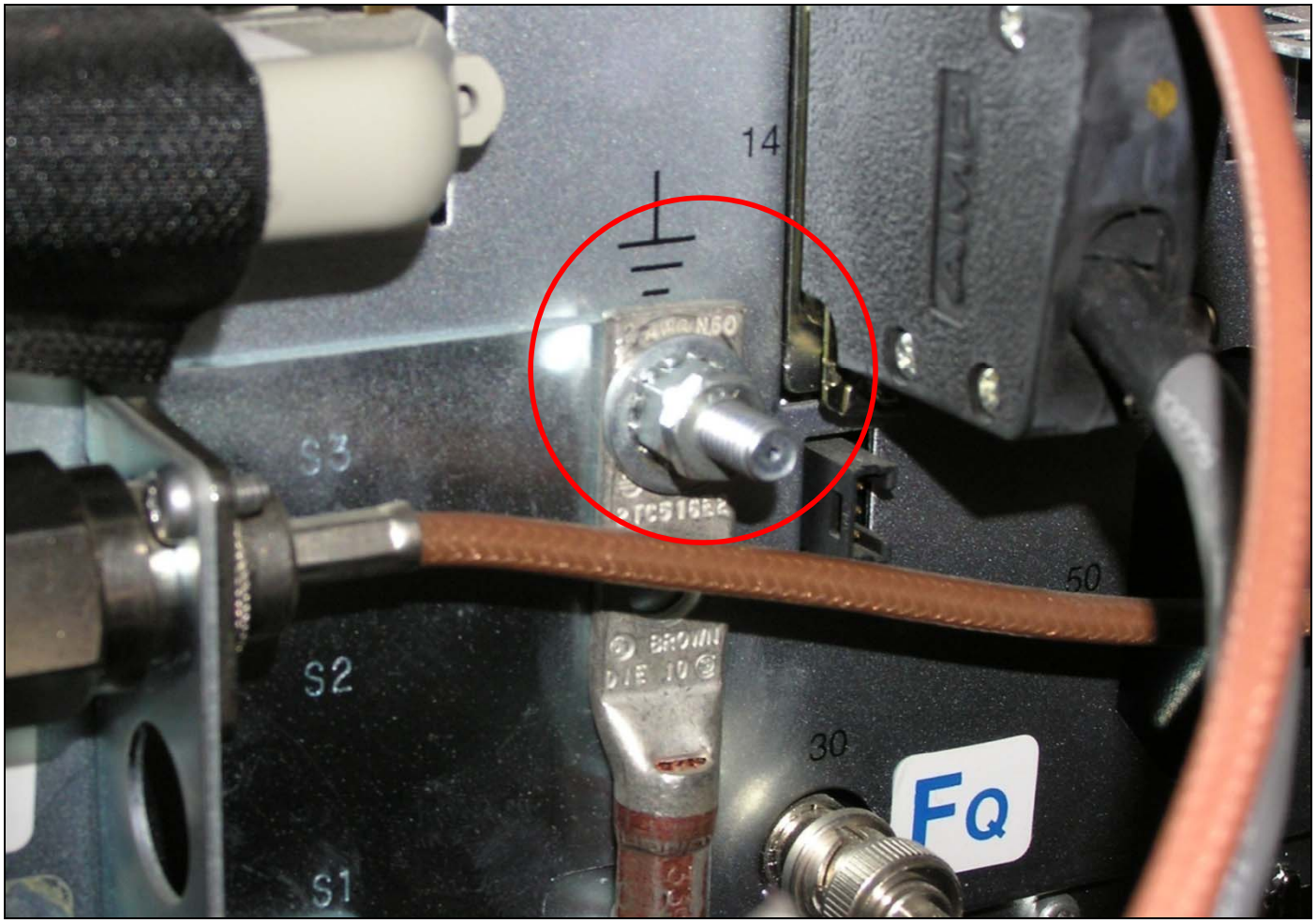
Equipment incorrectly bonded

Replacing connections like this



Equipment connections

Note lock washer, double nuts



SPD's (TVSS)

SPD's on main service entrance

Experience

- **Thousands of events recorded**
- **One strike witnessed**

- **NO Downtime! No equipment damage.**

Major lessons from OC 9-1-1

3 different contractors

electrical

- **radio room**
- **tower**

No one party had

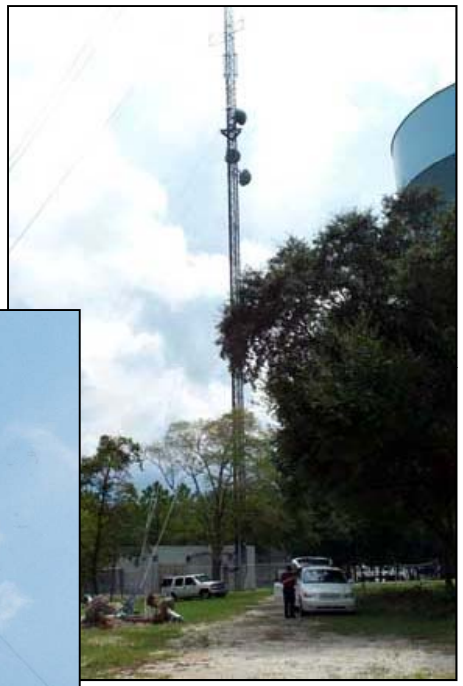
- **responsibility**

Major lessons from OC 911

Low bid

No maintenance

Minimal design



Power Quality is Cost-effective

OC 911:

<$100,000 cured $1 million damages

6-mos. to 1 year paybacks common

Case Study: Winter Park, FL Comm. Ctr.

- **4/0 AWG ring ground completely surrounds building**

Tower alongside building

- **Tower now has four 50 ft. vertical electrodes in**
- **X-pattern, connected to ring ground**

Was Ufer ground even connected?

- **Original phone #2 AWG tower Ufer grounding**

Cellular side of site

- **Original coax ground on**
- **horizontal run**

- **#2 Cu. conductor**

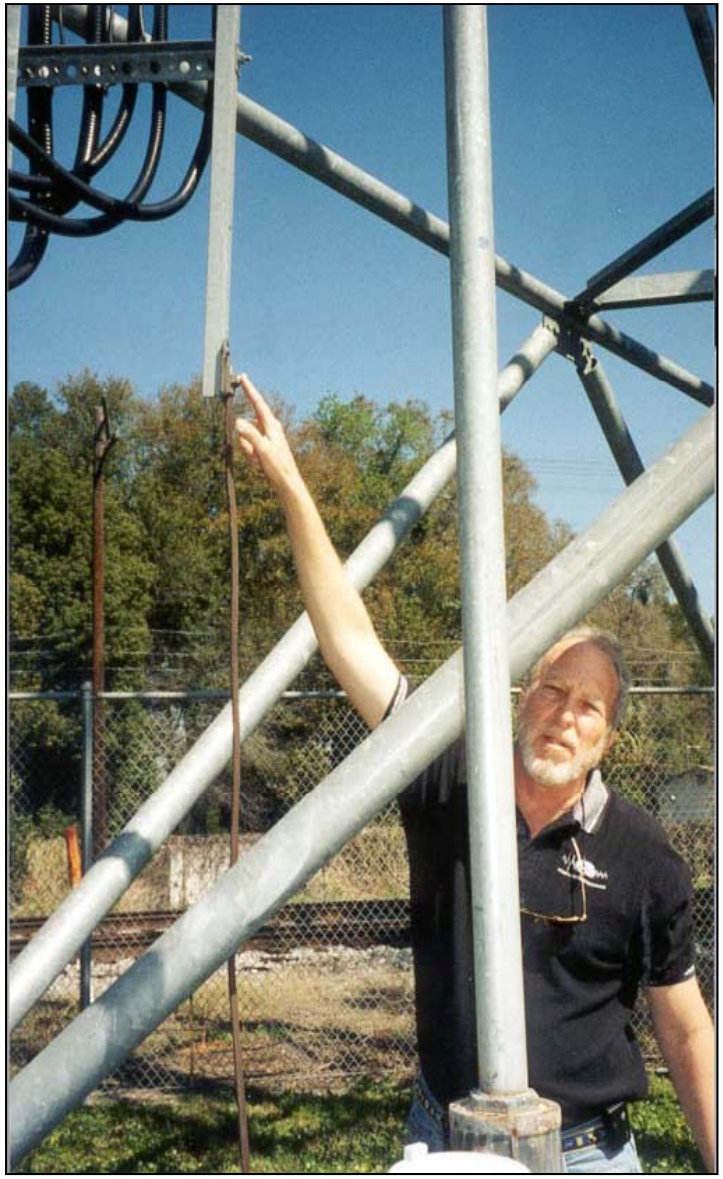
Coax bonding

- **Coax braid has 29X**
- **Lightning cable clamped,**
- **re-wrapped**

- **Note location on vertical run**

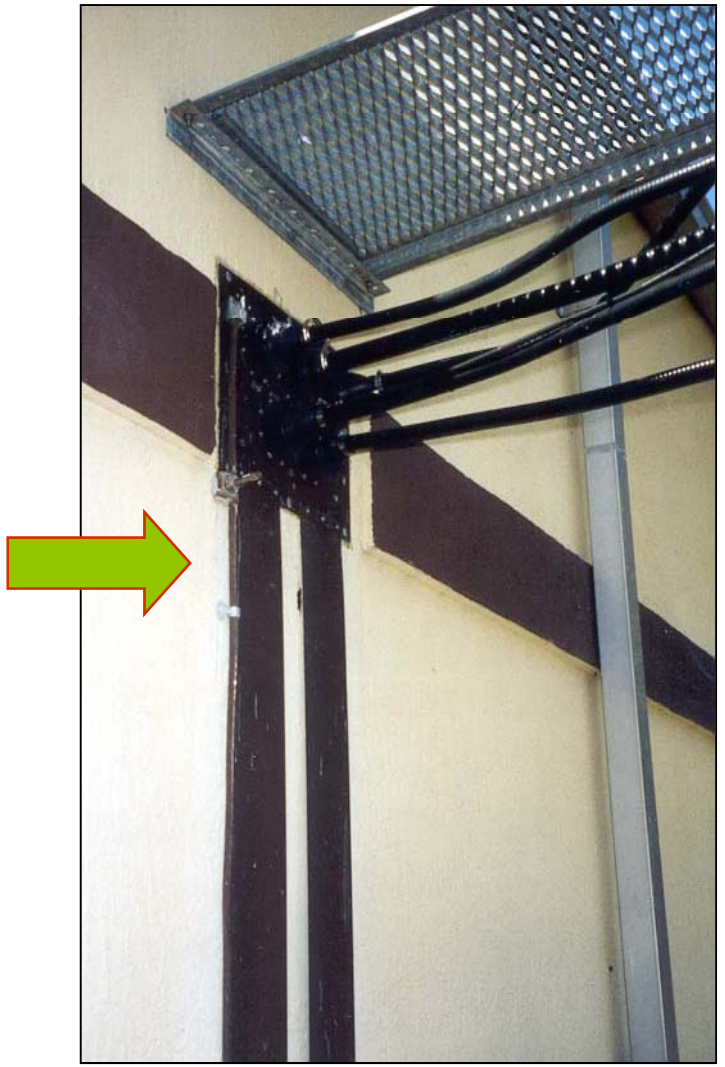
Straight vertical runs

- **29X lightning cable then**
- **connects to 4/0 vertical**
- **to 5- 50 ft. electrodes**
- **under tower**



Outside firewall

- **Outside copper firewall**
- **4/0 vertical to**
- **ring ground**

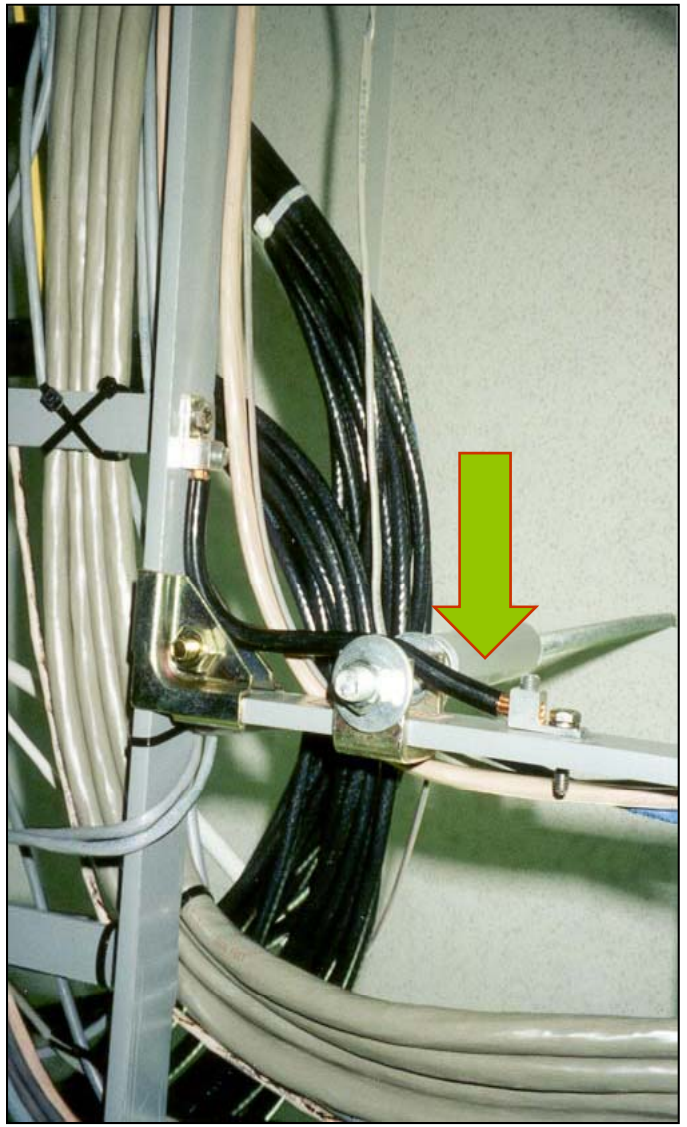


Inside firewall

- **Inside copper firewall**
- **4/0 connects to “halo” and grounding electrode system**
- **Note large radii**

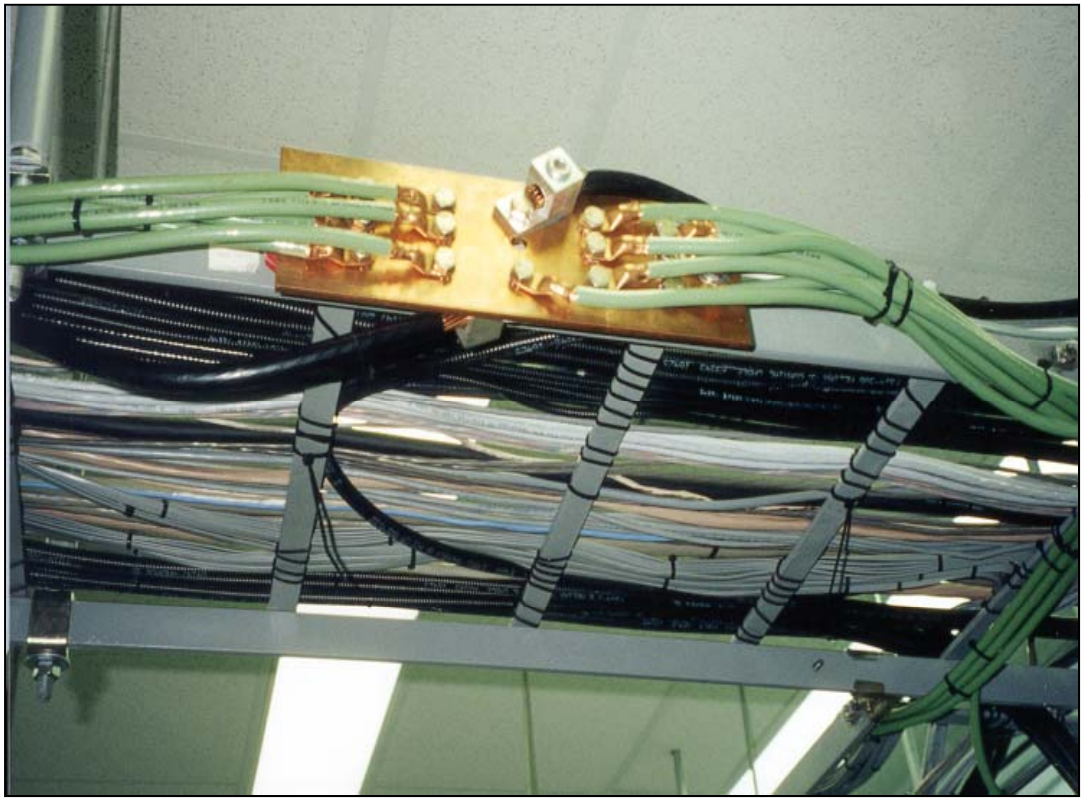
Rack bonding

- **Every steel joint jumpered with #2 copper**



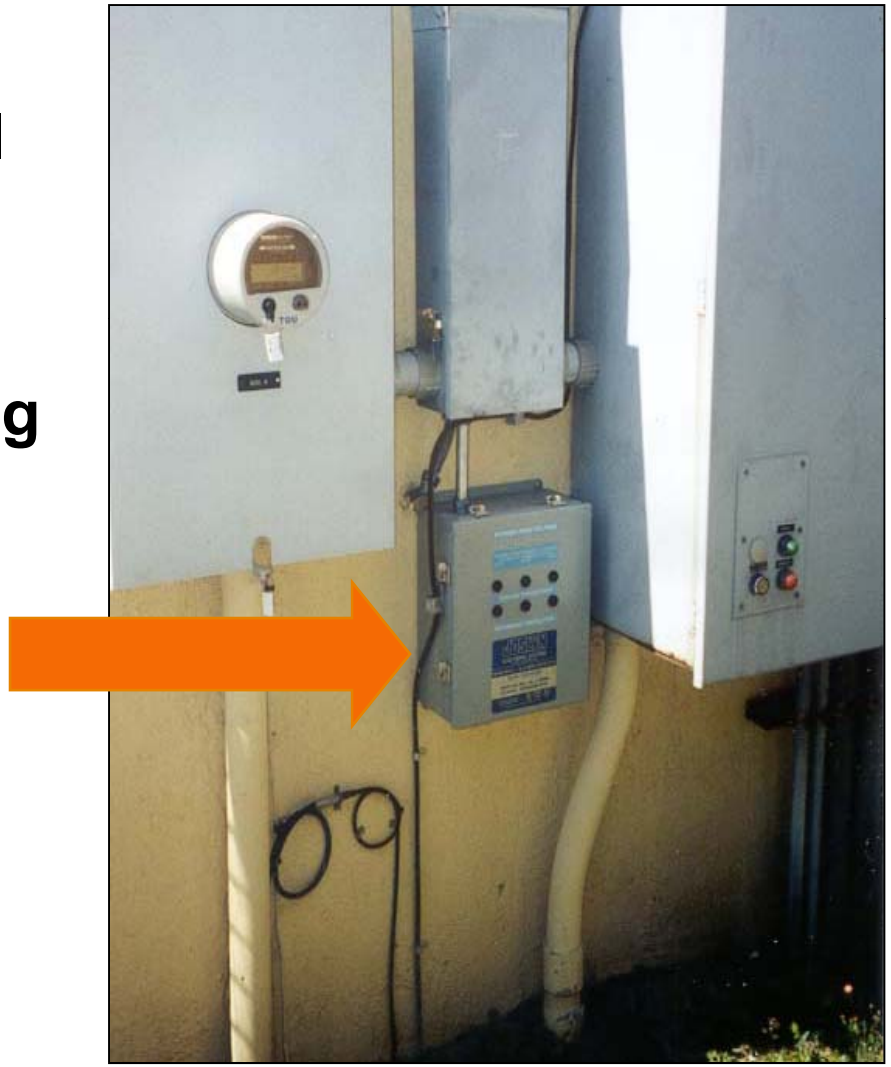
Busbars for connections

- **Every joint, tray and cabinet bonded and jumped with #2 to plate, then 4/0 connects to “halo”**



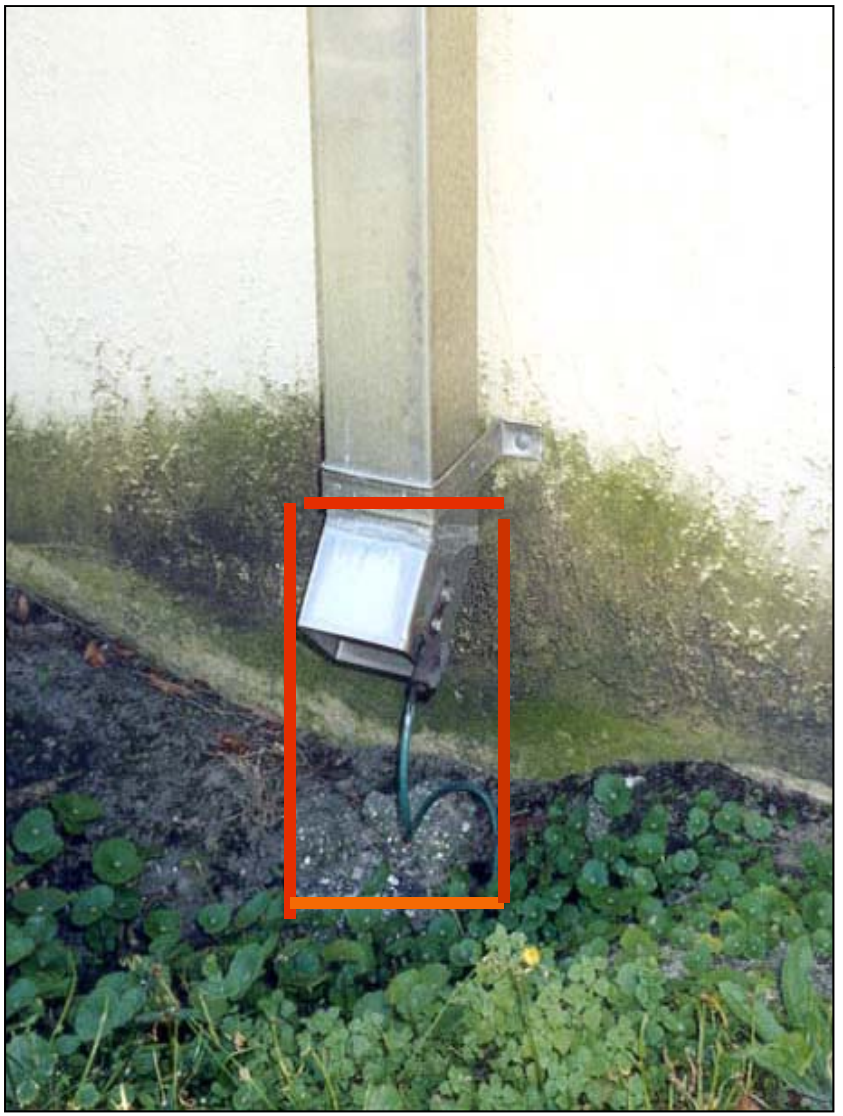
SPD at electric service

- **TVSS at the service and all branch panels**
- **All cabinets bonded with copper jumpers then to ring ground with 4/0 copper**



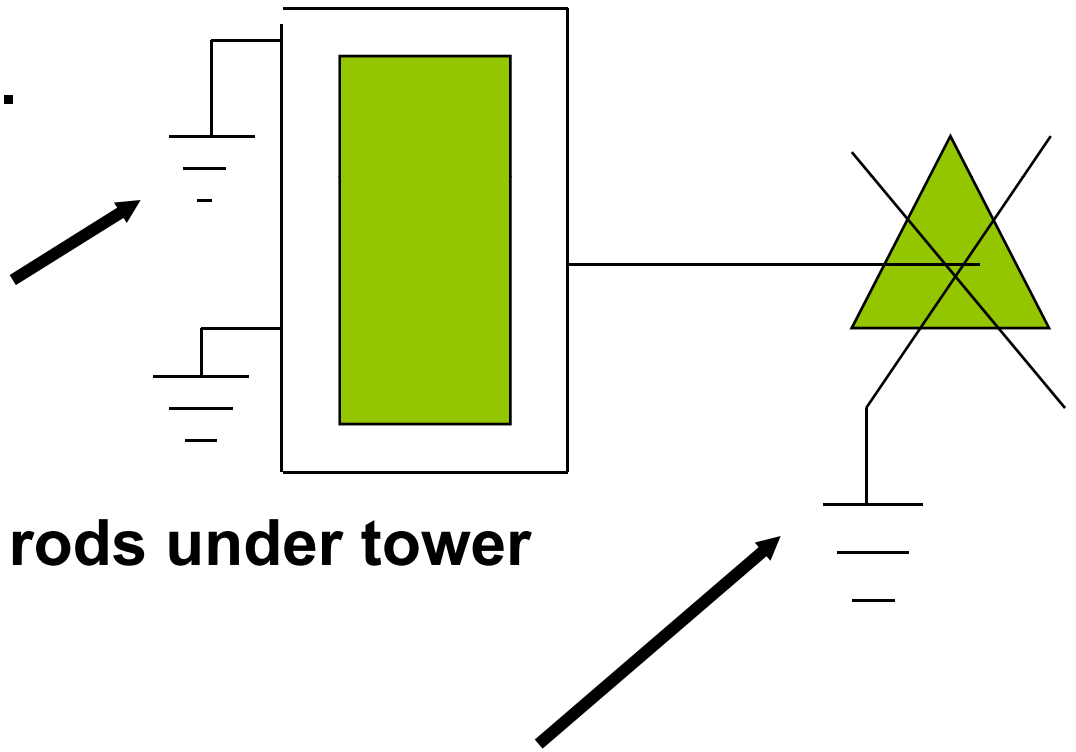
Everything bonded

- **Even the downspout is bonded to the ring ground**



Resultant layout

- **4/0 ring**
- **20 ft rod every 20 ft.**



- **5- 50 rods under tower**

Sumter County, FL 9-1-1

2004 lightning strike took out entire facility

Tower had separate grounding

121 foot tower erected in 2007

Separate ground independent from building

230 Ohms to ground

Building had single galvanized rod

Independent grounds

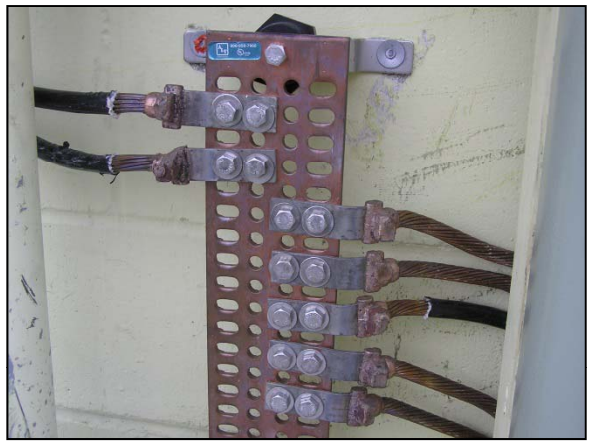
2 emergency generators each had independent ground

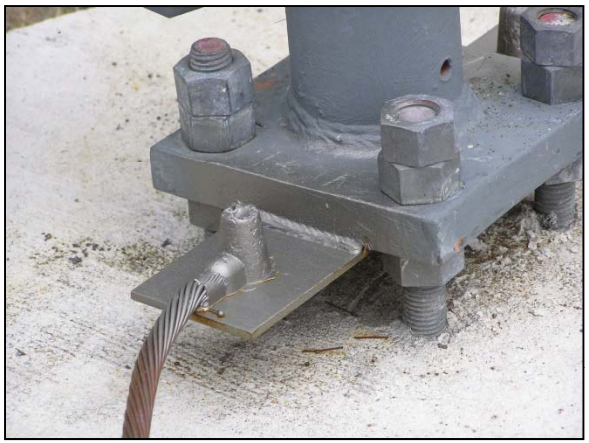
Hose clamp connection

Steel was not grounded

2 transformers were grounded to building steel, but steel was not bonded to ground electrode

Sumter County 911





Sumter County 911

Complete renovation of bonding and grounding

- **Removed daisy-chained grounds**
- **Ground system supplemented and tied together**
- **Building steel bonded to electrode**

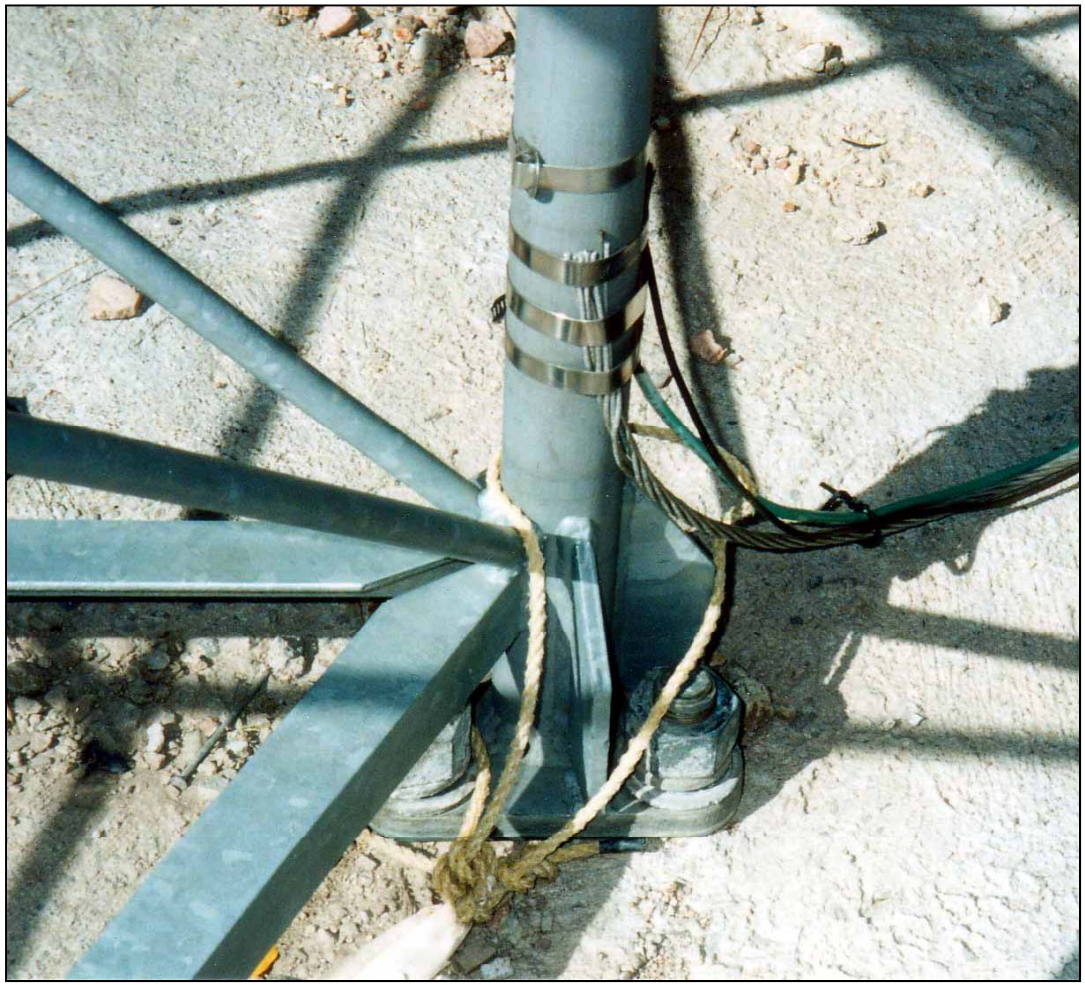
No outages since retrofit

KKIT - FM

Angel Fire, NM

Actual tower grounding

Proper connection methods?



KKIT-FM

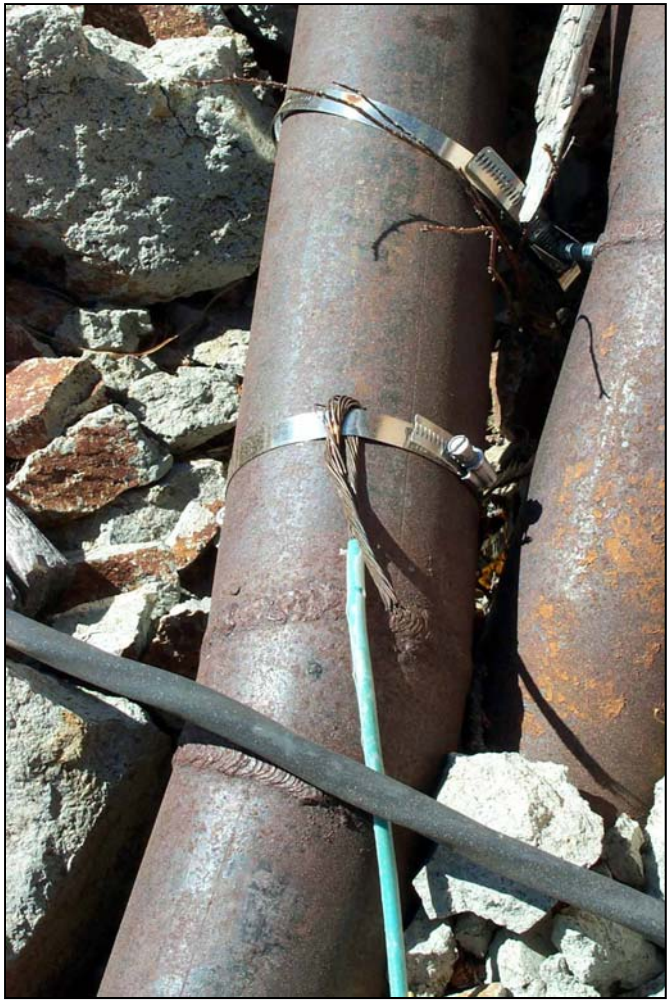
Actual connection to ground rod

Proper connection methods?

KKIT-FM

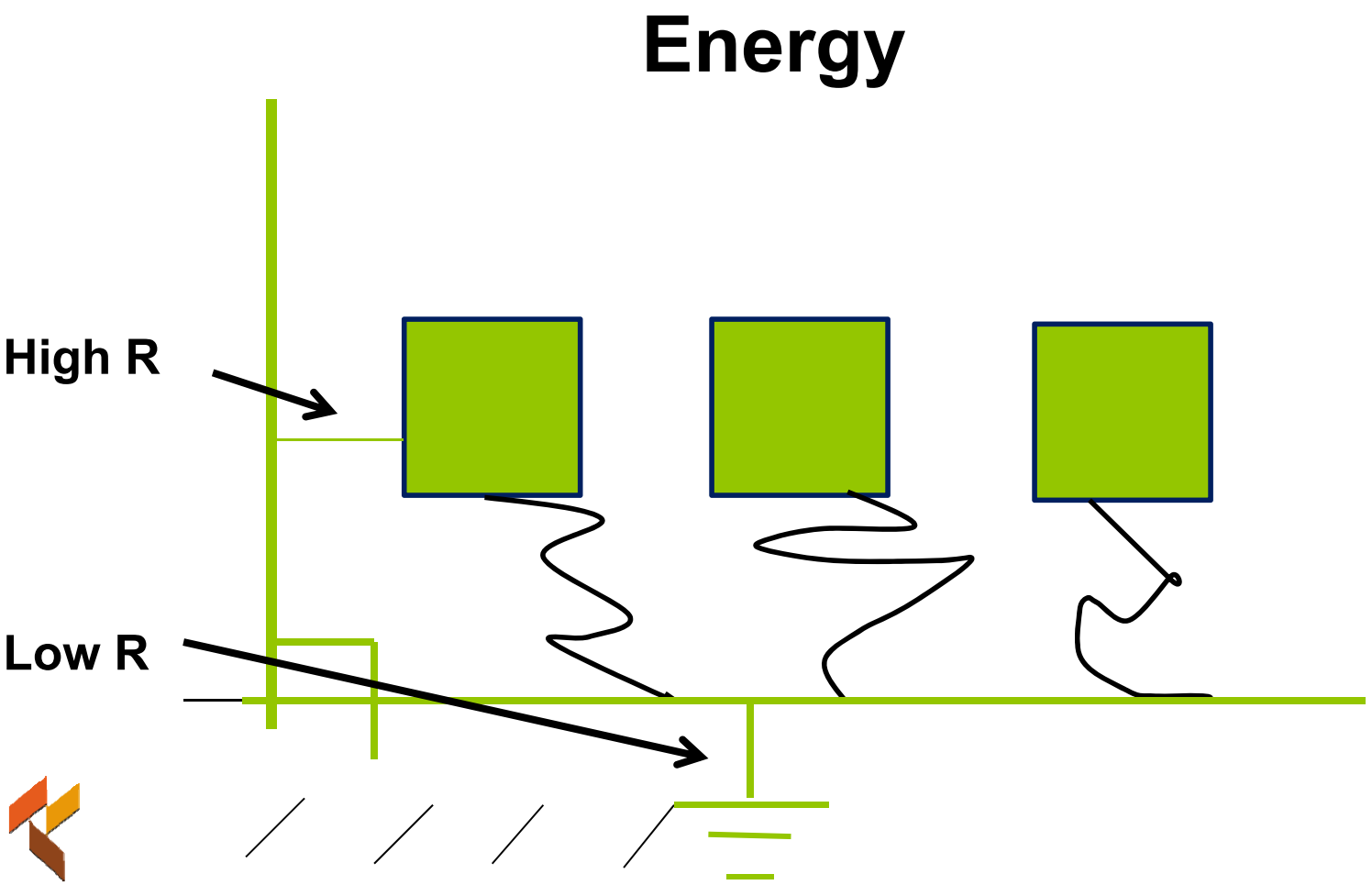
Actual water pipe bonding

Corrosion and connection errors.

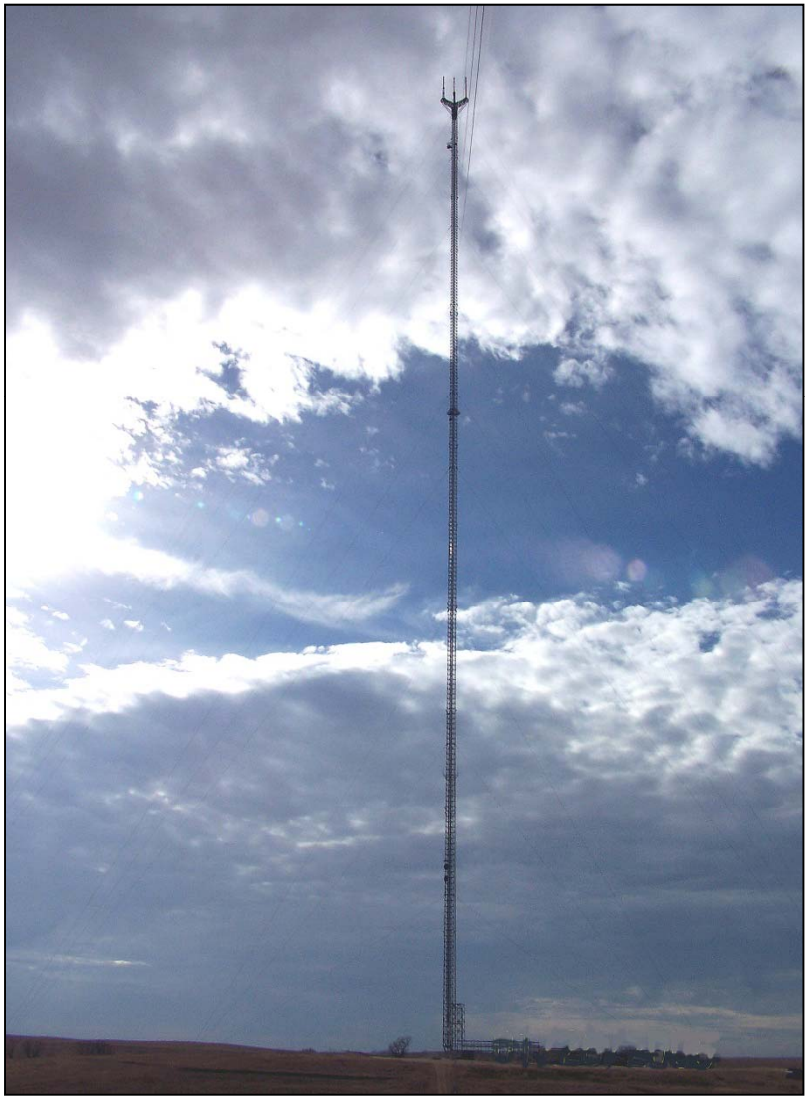


KKIT-FM

Think of “current divider”



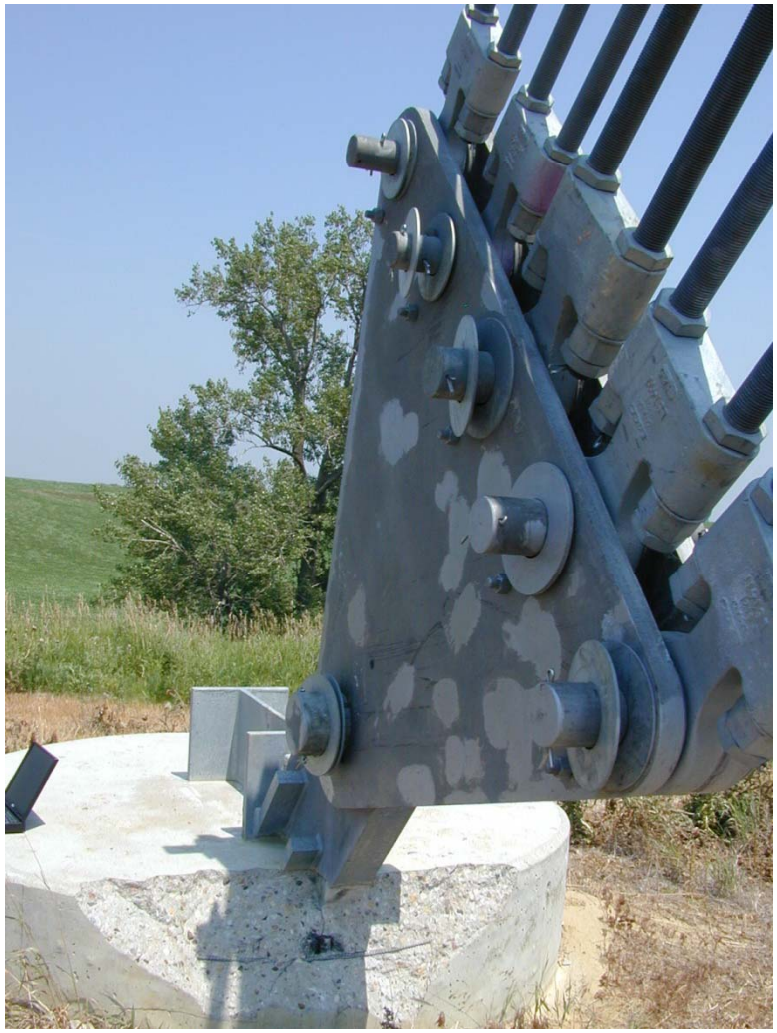
KPTH - KMEG



1988 ft. tower

Near S. Sioux City, NE

Ufer ground after lightning



At tower base

2- 8 ft. ground rods

190 Ω

Ice bridge

#2 AWG connected to same rods

Guy wires

Note double U-bolts

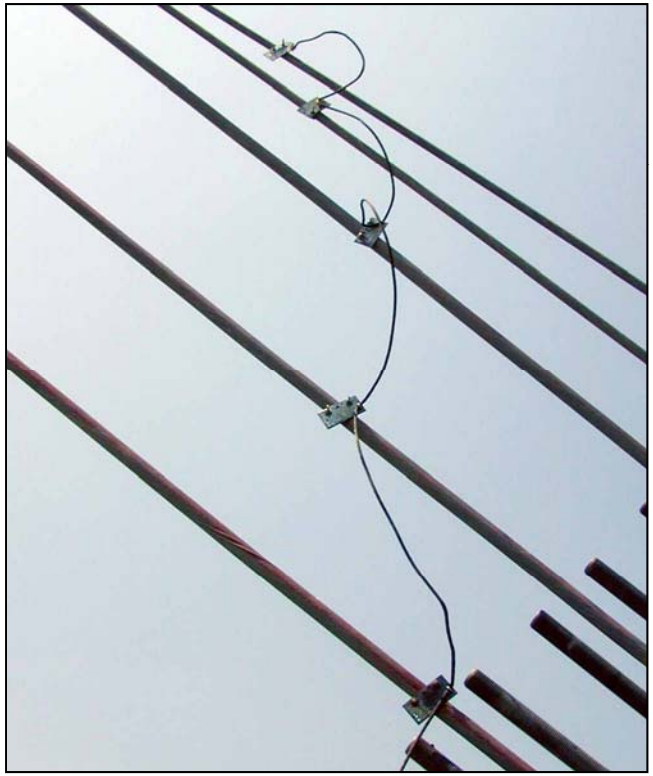
Connectors not listed

90° angles

Vibration

Guy grounding

Note right angles



Guy grounding

New “listed” tin-plated silicon-bronze connectors

Parallel to guy wires

Guy grounding

3-80 ft. deep SS rods

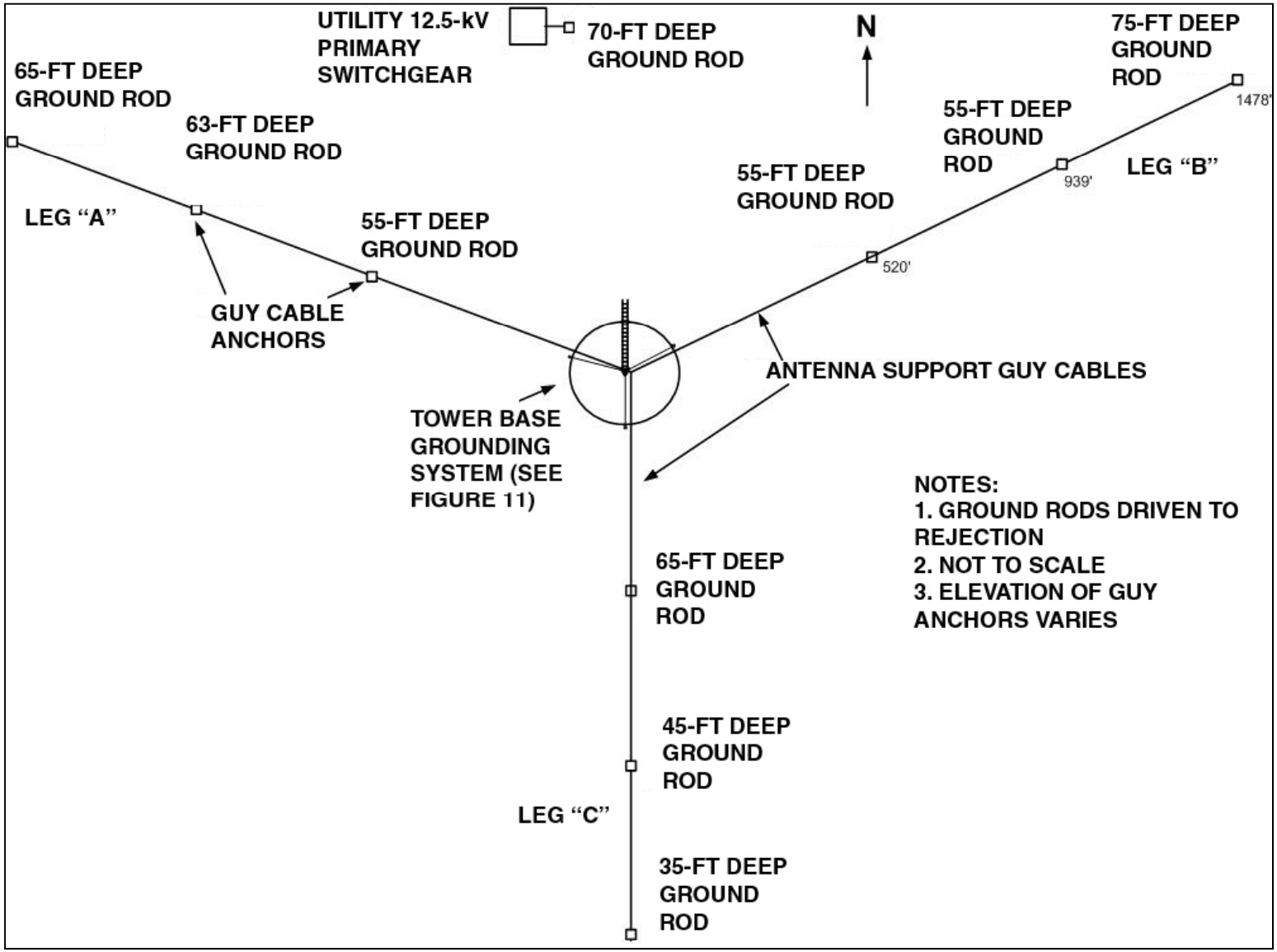
250 kcmil to ring

Ice bridge

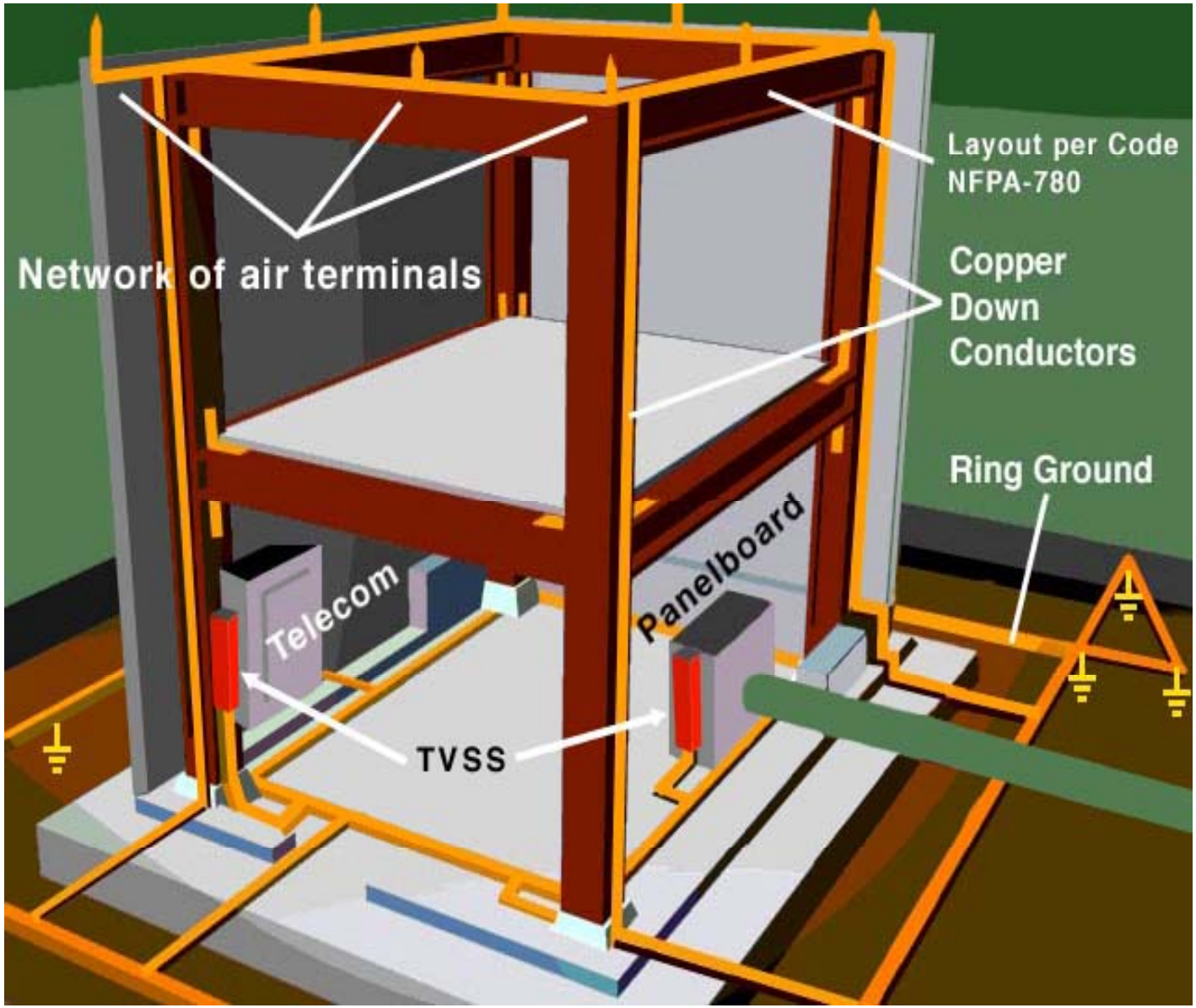
Note rust

Strap has lower impedance

Result

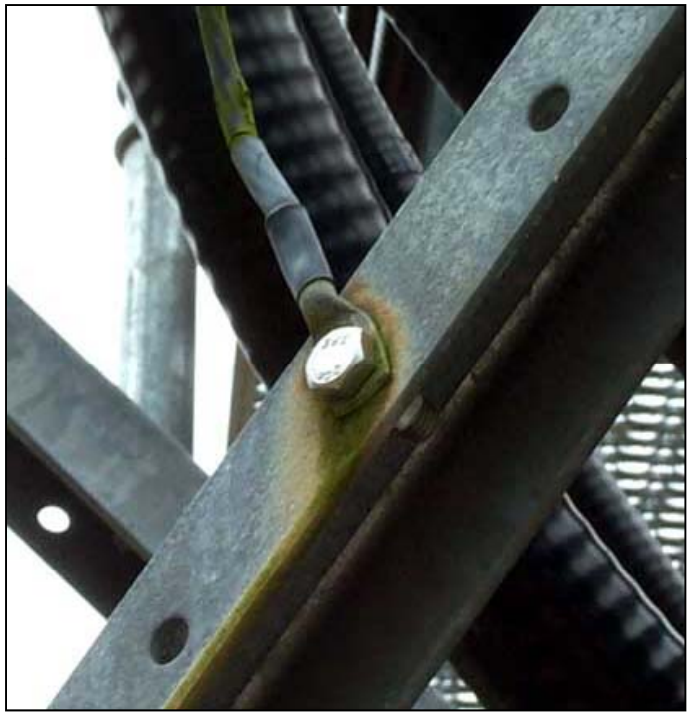

UTILITY 12.5-kV PRIMARY SWITCHGEAR
70-FT DEEP GROUND ROD
N
75-FT DEEP GROUND ROD
1478'
65-FT DEEP GROUND ROD
63-FT DEEP GROUND ROD
55-FT DEEP GROUND ROD
55-FT DEEP GROUND ROD
939'
LEG "B"
LEG "A"
55-FT DEEP GROUND ROD
520'
GUY CABLE ANCHORS
ANTENNA SUPPORT GUY CABLES
TOWER BASE GROUNDING SYSTEM (SEE FIGURE 11)
NOTES:
1. GROUND RODS DRIVEN TO REJECTION
2. NOT TO SCALE
3. ELEVATION OF GUY ANCHORS VARIES
65-FT DEEP GROUND ROD
45-FT DEEP GROUND ROD
LEG "C"
35-FT DEEP GROUND ROD

One ground system



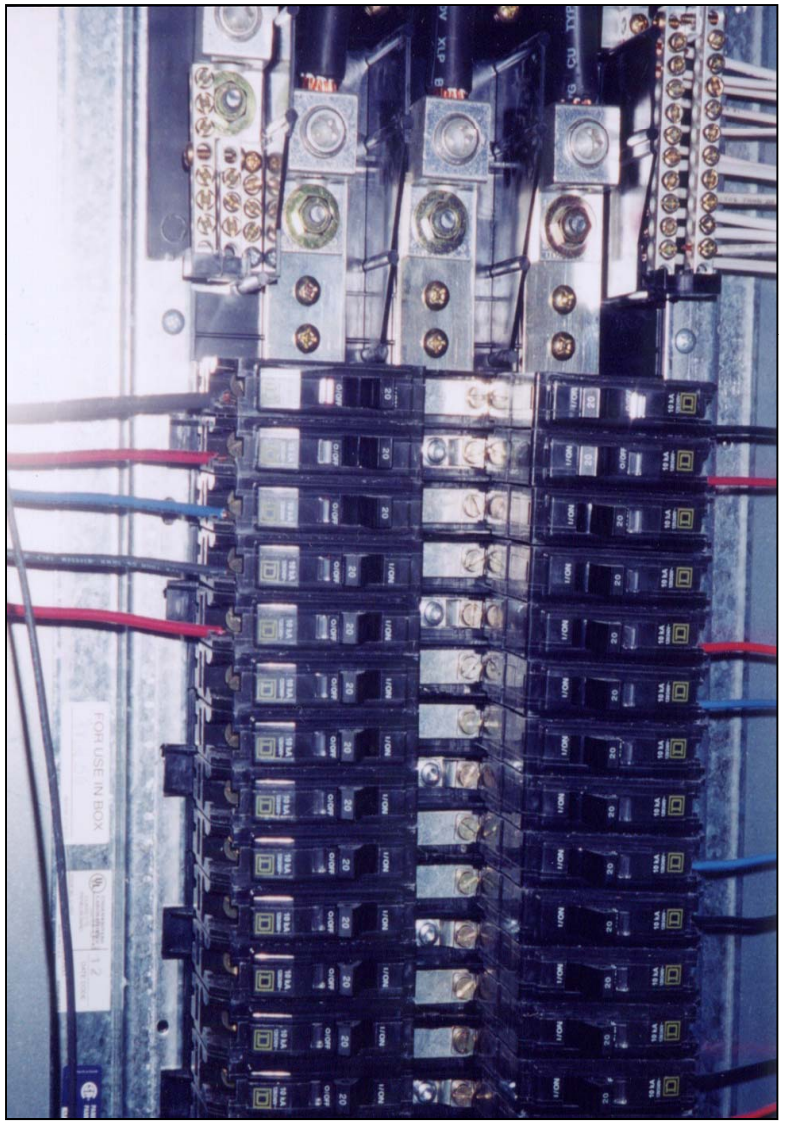
Recommended Practice

Correct corrosion issues



Recommended Practice

***Use bolt-in CB's*, not snap-in**



Inadequate Tower Grounding

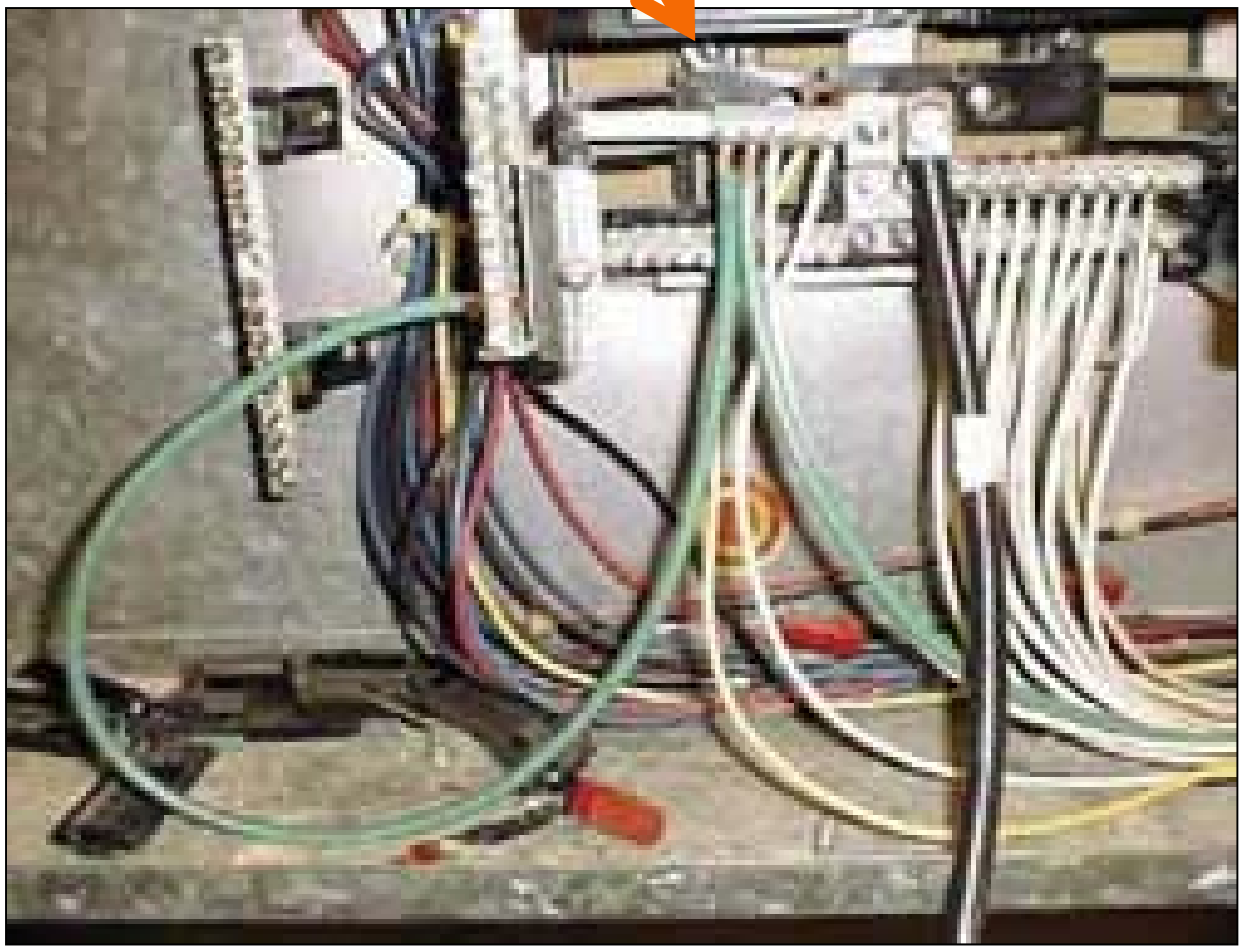
Is Ufer EGC actually bonded to rebar?

Ground wire outside conduit

Proper wiring methods?

Separate Neutral and Ground

Improper N-G bonds



Are connections proper?

Look for paint or other insulation

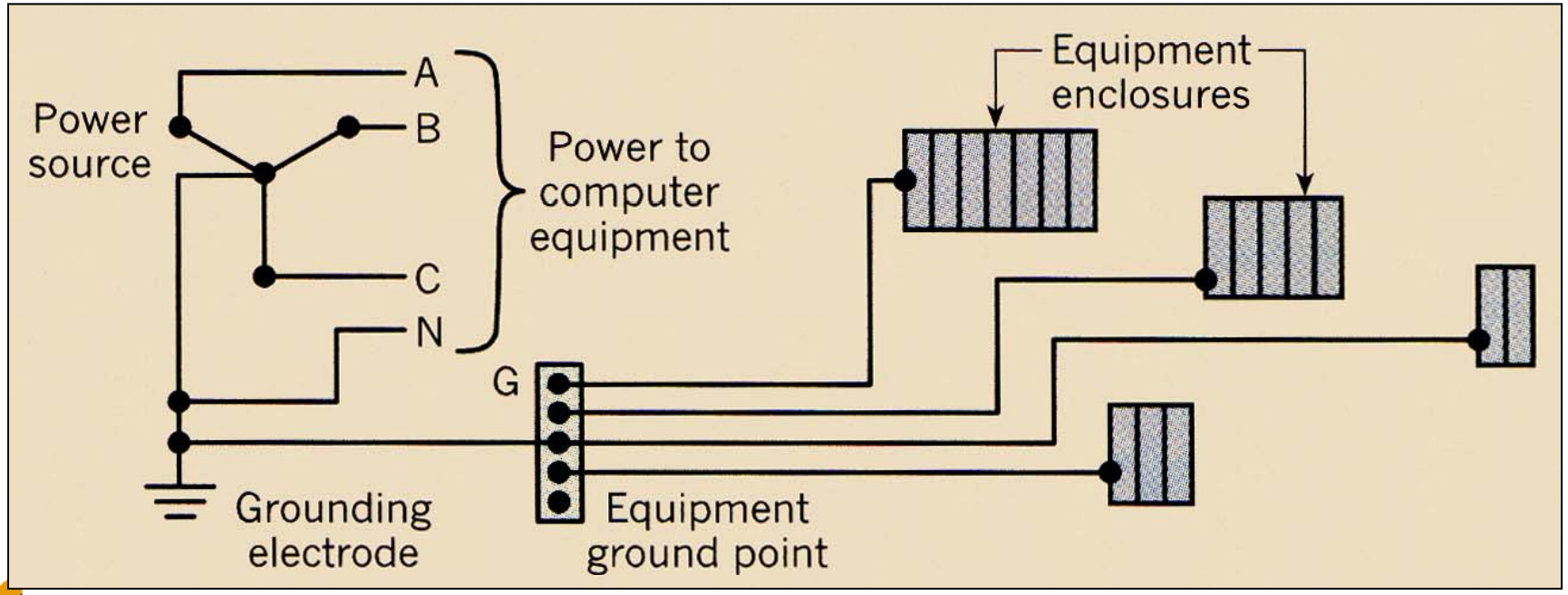
After commissioning

Check resistance to earth annually

Under 5 ohms is desirable

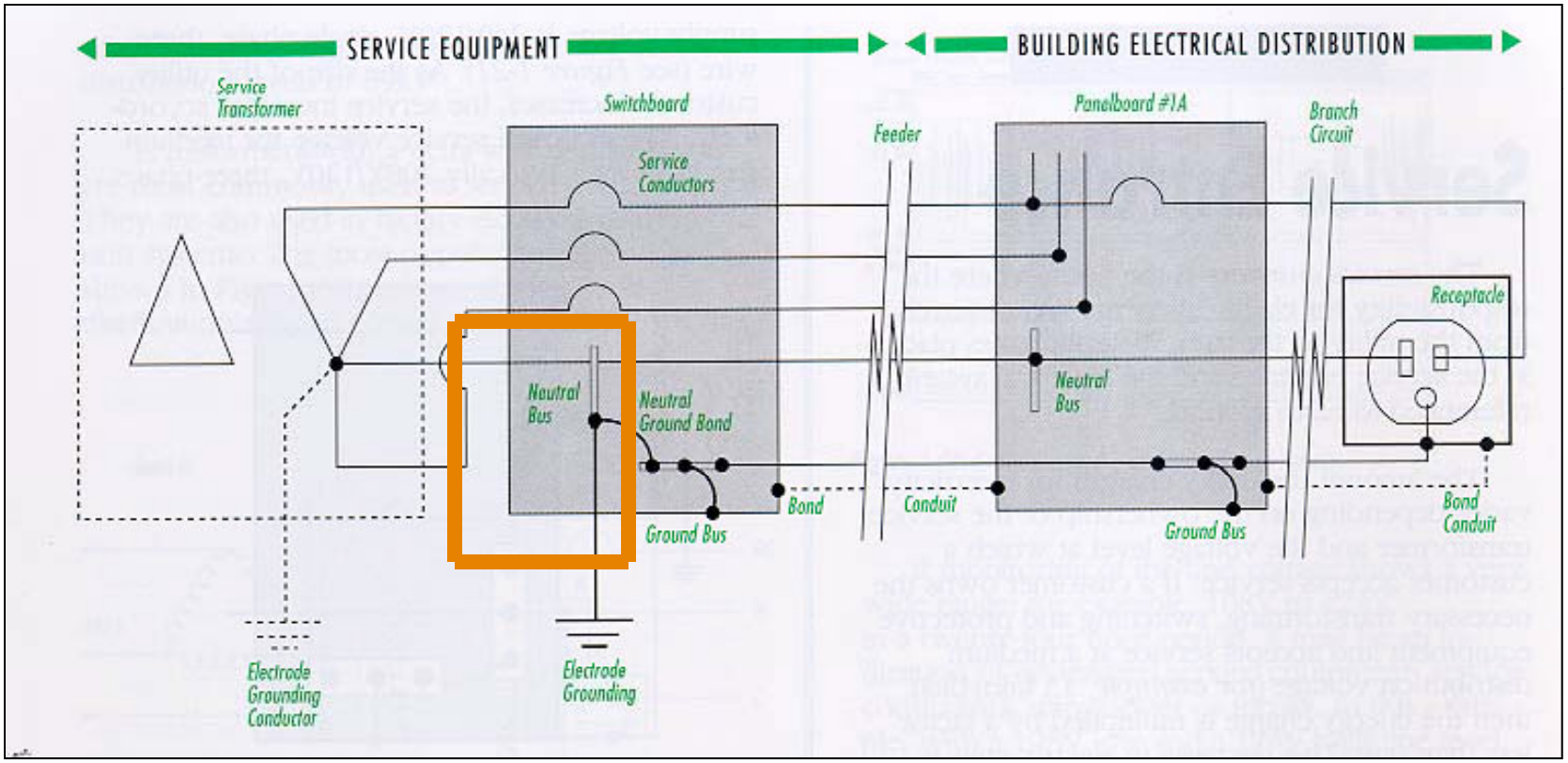
Do not “daisy-chain” equipment

“Radial” bonding to a ground bus avoids ground loops



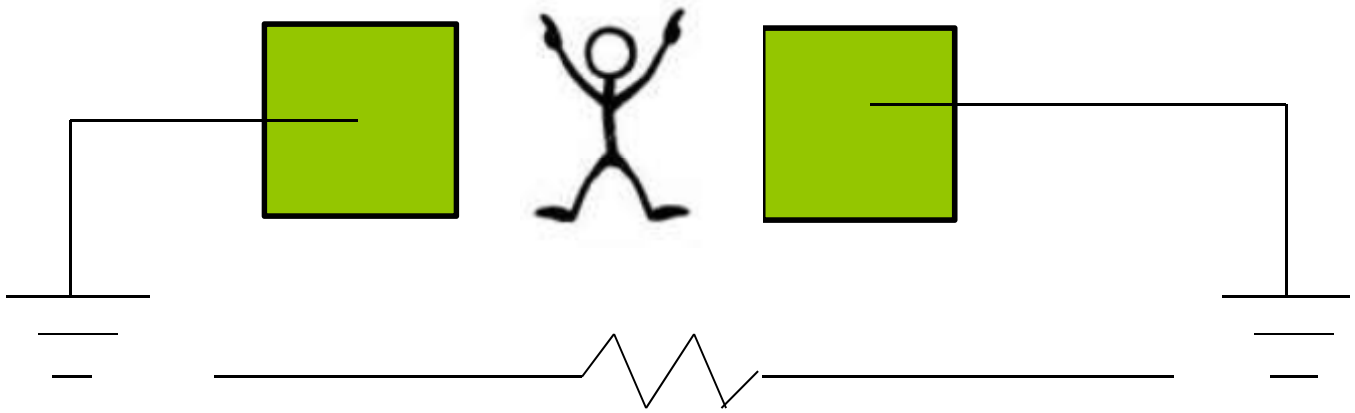
Interior Grounding

There should be ONE central point connecting the neutral to the ONE exterior grounding electrode <u>system</u>



Earth is not a current path

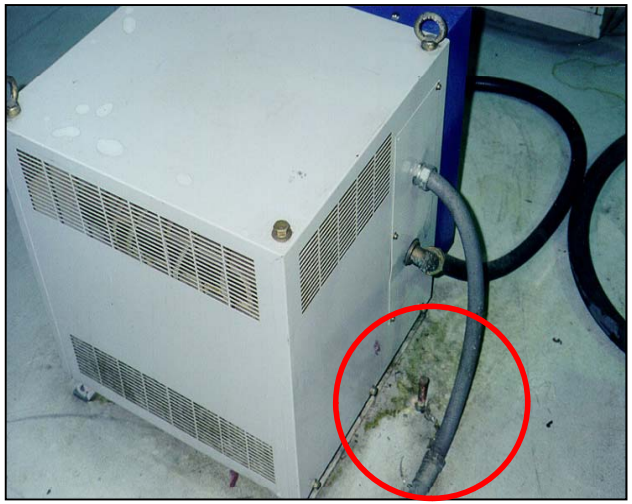
No separate grounds – one grounding system

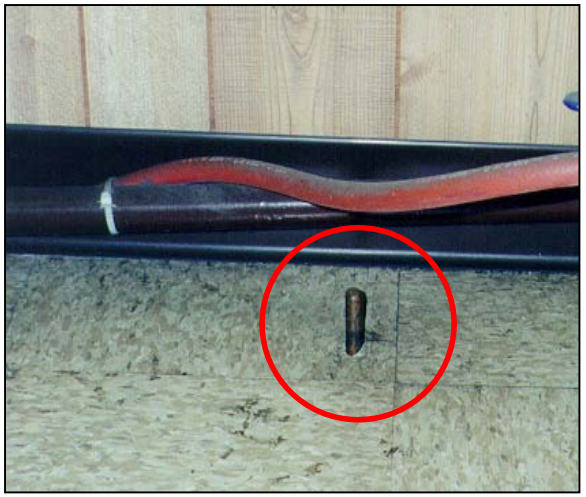


Examples of “clean” grounds

Be wary of the term

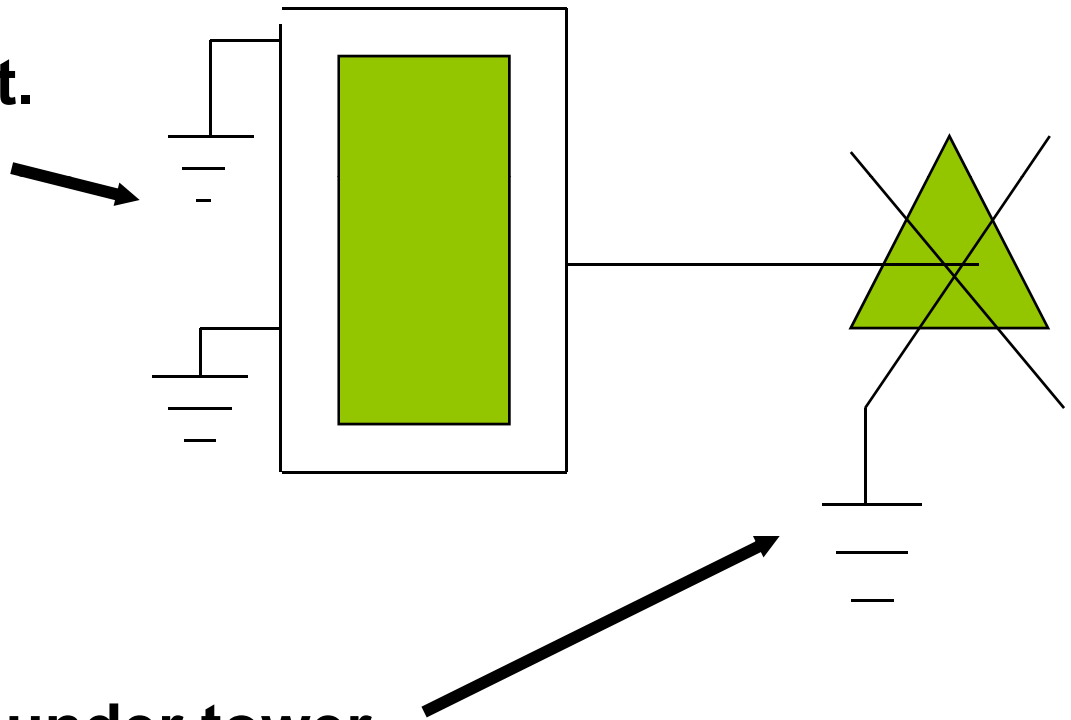
“clean ground”





Resultant layout

- **4/0 ring**
- **20 ft. rod**
  every 20 ft.



- **5- 50 rods under tower**

Desired grounding

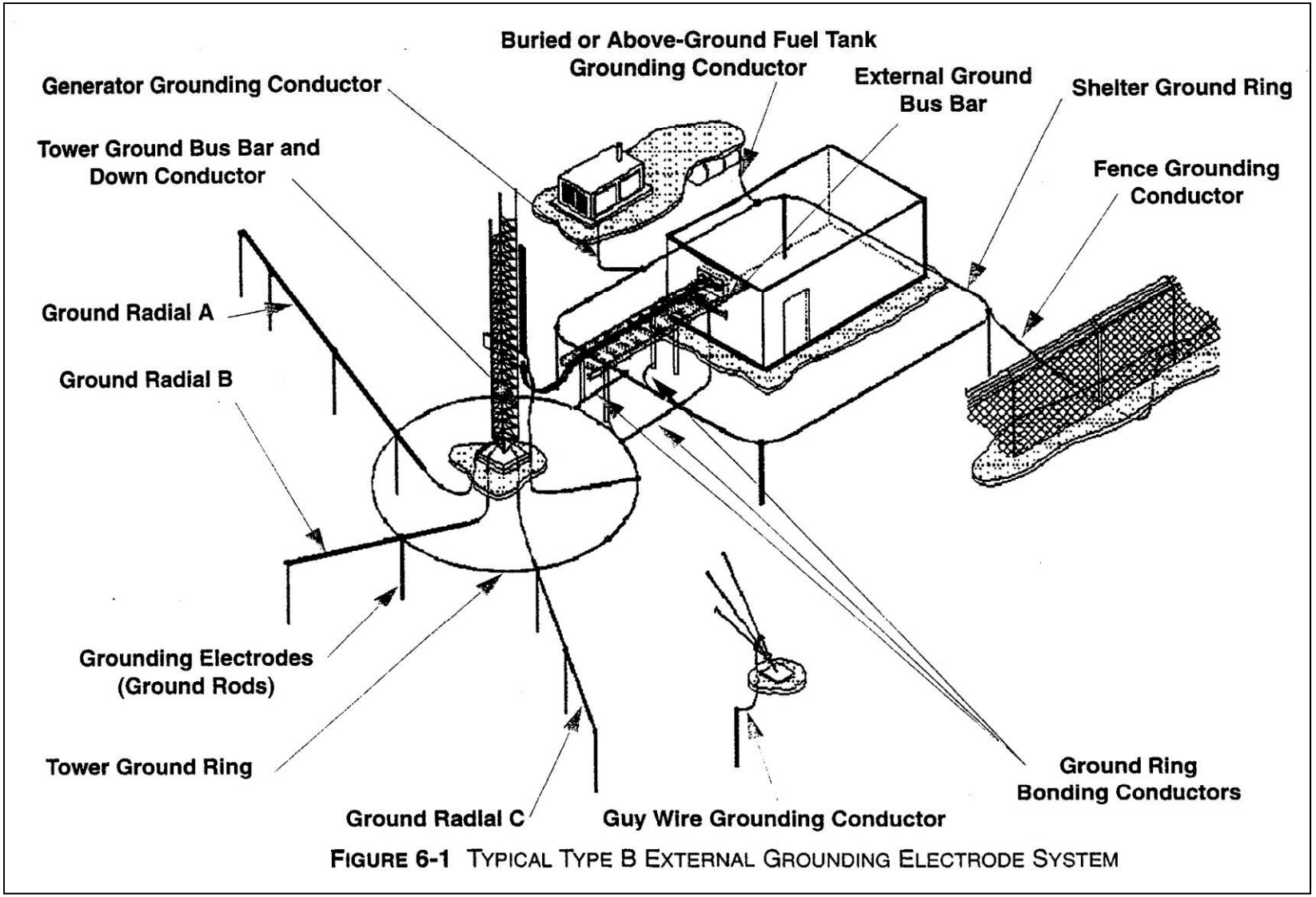


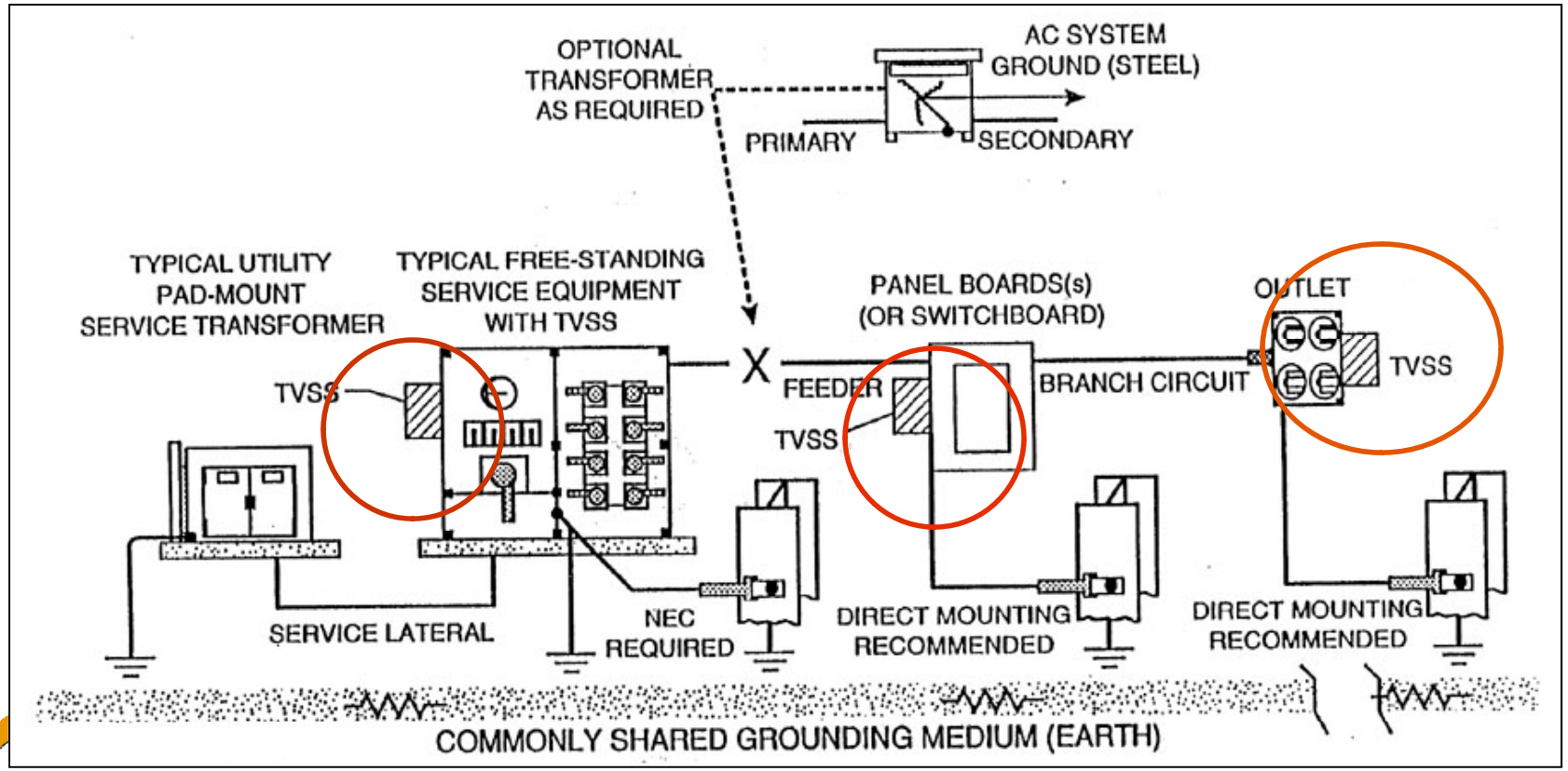
FIGURE 6-1 TYPICAL TYPE B EXTERNAL GROUNDING ELECTRODE SYSTEM

All equipment needs SPD's

at service, at panelboards

SPD Sizes

Type C	Type B	Type A
150 kA	75 kA	25 kA /mode



leads as short as possible

Takeaways

1. Exceed the Code, but don't violate the Code!
(Code minimum is one step above "illegal")

2. You don't get what you <u>expect</u>,
you only get what you <u>inspect</u>.

3. Have a written plan and procedures.
Insist contractors follow it.

3. Get the grounding and bonding right before anything else. Most lightning and transient problems can be cured at minimal cost.

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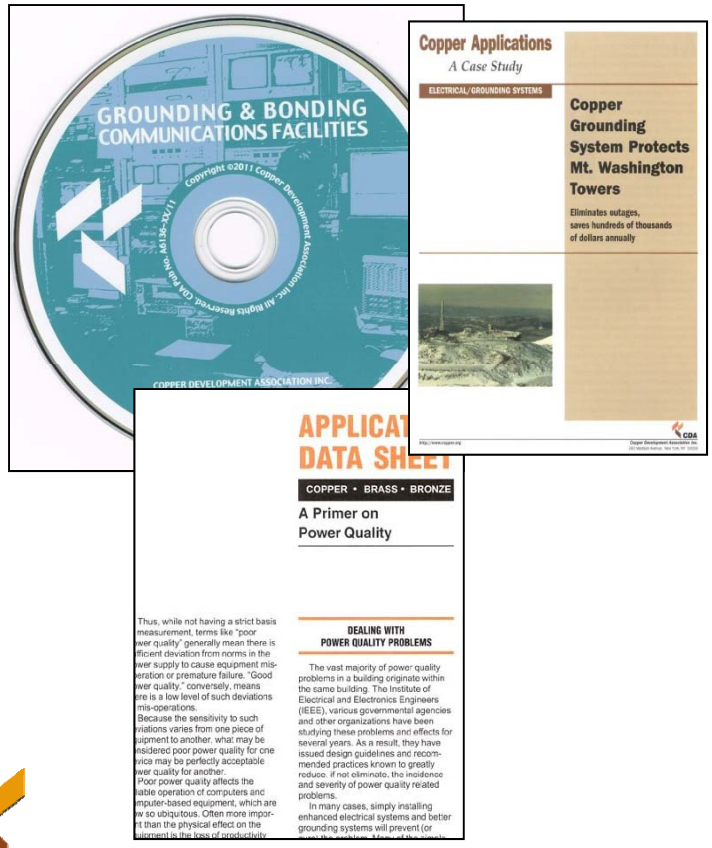

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