

Bonding and Grounding

A Review of Articles 820 and 830 of the National Electric Code

Presented by
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Thanks To:

- Howard (*Mr.* Bonding and Grounding) Hofferma, Thomas & Betts
- Larry Paul, AT&T Broadband
- Steve Johnson, Time Warner Cable
- Gary Donaldson, AT&T Broadband
- Larry Day, Cox Communications
- Steve Allen, Jonathan Kramer, Kramer.Firm
- ***NOTE!! All Errors contained herein are mine, and mine alone.***

Contents

- Article 820 - - CATV Drop Systems
- Article 830 - - Network Powered CATV Systems
- Changes: 1999 to 2002 Code

What is the NEC?

- First Published in 1911 for the purpose of “the practical safeguarding of persons and property from hazards arising from the use of electricity.”
- Published by the NFPA (National Fire Protection Association)
- It is a recommended set of Standards and Rules covering the installation of electric conductors and equipment within or on public and private buildings (or other structures)

What is the NEC?

- It is a SUGGESTED standard, does not have force of law until adopted (all, or in part) by the local governing authority (Cities, States, Counties, etc).
 - Each City, for instance, may work from an earlier version of the NEC, may adopt the current version in toto, or adopt with amendments and variations.

What Is The NEC?

- What it Covers-What it Doesn't:
 - Installation of electrical conductors (including communications cables) within a structure.
 - Begins essentially at the property line...From the tap outwards.
 - Does Not cover the Outside Plant, either buried or aerial, except as above, from the property line.
 - See National Electric Safety Code (NESC)

Tips to Live By:

- If the current (2002?) is More Strict than the local government's own standards, follow the rules of the NEC
 - It's Safer!
- If the local government's standards are more strict.....follow them.

Article 820

- Covers CATV Coax Drop
 - Begins essentially at the Tap
 - Only low voltage (60 volt max.), Non-Network-Powered Systems
 - See Article 830 for Network-Powered Systems
 - CATV Only
 - Telephony - - See Article 800
 - Antennas - - See Article 810

Article 820 Requirements

- 820-10 Cables Outside & Entering Buildings
 - 820-10(b) Aerial, Lead-In:
 - “....drop cables from a pole or other support....including point of initial attachment....shall be *kept away* from electric light, power....so as to avoid the possibility of accidental contact”
 - “Where proximity...cannot be avoided, shall provide clearances of not less than 12 in.....”

Article 820 Requirements

- 820-10(c) On Masts
 - “Aerial cable shall be permitted to be attached to an above-the-roof raceway mast *that does not enclose or support conductors of electric light or power circuits.*”
 - Exceptions: *NONE*
 - *Reaffirmed in 2002 NEC*

Article 820 Requirements

- 820-10(d) Above Roofs:
 - Vertical Clearance of not less than 8 feet “from all points of roof which they pass.”
 - Exceptions:
 - “Auxiliary buildings such as garages and the like.”
 - “A reduction in clearance of not less than 18”...if (1)not more than 4ft of the....drop....pass above the overhang, *and* (2) they are terminated at a raceway mast or other approved support.”
 - “Where the roof has a slope of *not less* than 4 in. in 12 in., a reduction in clearance of not less than 3ft shall be permitted.”

Article 820 Requirements

- 820-10(e) Between Buildings:
 - “Cables extending between buildings *and also* the supports or attachment fixtures *shall be acceptable for the purpose*, and have sufficient strength to withstand the loads to which they may be subjected.”

Article 820 Requirements

- Article 820-10(f) On Buildings:
 - “Where attached to buildings, cables shall be securely fastened in such a manner (to)...be separated from other conductors as follows:”
 - (1) “....coax shall have a separation of at least 4 in. from electric light, power, or nonpower-limited fire alarm conducts *not in* raceway or cable, or be permanently separated from conductors....by a continuous and firmly fixed nonconductor *in addition to the insulation on the wires.*”

Article 820 Requirements

- Article 820-10(f) continued....
 - (2) Other Communications Systems:
 - “no unnecessary interference in the maintenance of the separate systems. In no case shall the conductors, cables, messenger strand or equipment of one system cause abrasion to the conductors....(etc) of any other system.”
 - (3) Lightning Conductors:
 - “....a separation of at least 6ft *shall be* maintained....”

Article 820 Requirements

- Article 820-11. Entering Buildings
 - (a) Underground Systems:
 - Underground coaxial cables in a duct, pedestal, handhold or manhole that contains electric light or power or Class 1 circuits shall be a section permanently separated from such conductors by means of a *suitable barrier*.”

Article 820 Requirements

- 820-11. Entering Buildings (Cont..)
 - (b) Direct-Buried Cables & Raceways:
 - Separated at least 12 in. from conductors of any light or power or Class 1 circuit.
 - Exception: Where electric service conductors are installed in raceways or have metal cable armor.
 - Where electric conductors are installed in a raceway, or Type USE cables, *or coaxial cables have metal cable armor or are installed in a raceway.*”

Article 820 Requirements

- 820-33 Grounding
 - “The outer conductive shield of the coaxial cable *shall be grounded as close to the point of cable entry as practicable.*”
 - 1999 Code: No Maximum Distance specified.
 - 2002 Code Change: < 20ft, *“If Practicable”*

Article 820 Requirements

- 820-33 Grounding (cont..)
 - (a) Shield Grounding: Where the outer conductive shield....is grounded, *no other protective device is required.*”
 - (b) Shield Protection Devices: Grounding of a....drop cable shield by means of a protective device that does not interrupt the grounding system within the premises shall be permitted.”

Article 820 Requirements

- 820-40 Grounding Methods
 - (a) Grounding Conductor
 - (1) Insulation: Shall be insulated and “listed” (UL/CSA/?) as “suitable for the purpose.”
 - (2) Material: Shall be copper or “other corrosion-resistant material,” stranded or solid.
 - (3) Size: Shall not be smaller than No. 14 (14 awg). “It shall have a current carrying capacity *approximately equal* to that of the outer conductor of the coaxial cable.”

Article 820 Requirements

- 820-40 Grounding Methods (cont..)
- Current-Carrying Capacity of Drop Cable and Ground Conductors:

Cable Type	Current-Carrying Capacity (in Amps, 20 degrees C) Free Air	Equivalent Solid Cu Wire (AWG)	Current-Carrying Capacity (in Amps, 20 degrees C) in Free Air	Current-Carrying Capacity (in Amps, 20 degrees C) UG or Raceway
RG 6, 60%	21	12	25	20
RG 6 Tri-Shield	26	12	25	20
RG 6 Quad Shield	30	10	40	30
RG 11, 60%	29	10	40	30
RG11 Tri-Shield	35	10	40	30
RG 11 Quad Shield	41	8	70	50
P3/T10 500	148	4*	125	85
*Need to go to #2 (UG/Raceway: 115?)				
*Question: How much to de-rate coax in UG/Raceway?				

Article 820 Requirements

- 820-40 Grounding Methods (cont..)
 - (a) Grounding Conductor (cont..)
 - (4) Run in a straight Line: “....shall be run to the grounding electrode in as straight a line as possible.”
 - No coils. If found, take them out!
 - Use a 2” bend radius--no sharp bends

Article 820 Requirements

- 820-40 Grounding Methods (cont..)
 - (a) Grounding Conductor (cont..)
 - (5) Physical Protection: “Where subject to physical damage, the grounding conductor *shall be* adequately protected.”
 - Use good craft when locating the wire. Make sure there are no trip points or areas where the wire can be abraded.
 - If put in a metallic raceway, “*both ends shall be* bonded to the grounding conductor or the same terminal or electrode to which the grounding conductor is connected.”

Article 820 Requirements

- 820-40 Grounding Methods (cont..)
 - (b) Electrode
 - Where to attach your ground wire:
 - (1)” To the *nearest accessible location on the following:*”

Article 820 Requirements

- 820-40 Grounding Methods (cont..)
 - Where to Bond:
 - The Grounding Electrode System:
 - #6 Stub From Meter Box
 - “UFER” Ground (#6 Wire, Building Rebar, building neutral connection strip) Sometimes located behind a wallplate.
 - #6 Wire to Building Ground Rod, *Not Telco or CATV Ground Rod*

Article 820 Requirements

- 820-40 Grounding Methods (cont..)
 - Where to Bond:
 - The grounded interior metal water piping system...
 - *2002 Amendment: Only within 5ft of pipe's Entrance to the building*
 - Pipe must be metal!;
 - Must *already* be grounded;
 - Be sure to use proper strap....copper strap for copper pipe, galvanized strap for galvanized pipe.
 - SCTE, some MSO's, have a testing requirement to insure resistance is <25 Ohms.

Article 820 Requirements

- 820-40 Grounding Methods (cont..)
 - Building Ground Rod
 - Must use clamp approved for below-grade use;
 - Must ensure that the ground wire is “protected”
 - CATV clamp cannot be in contact with building/Telco/other clamps.
 - **Never** remove, loosen or move another service’s clamp.

Article 820 Requirements

- 820-40 Grounding Methods (cont..)
 - Where to Bond:
 - Power Mast
 - Be Sure to:
 - » Maintain distance limitations from power;
 - » Ensure the power mast is metal, not PVC/PE
 - » Get a clean contact (remove paint, rust)
 - » OK to bond above/below Electrical Panel/Meter Box

Article 820 Requirements

- 820-40 Grounding Requirements (cont..)
 - 820-40 Grounding Methods (cont..)
 - Meter Box
 - Be sure to:
 - » Not interfere with access to the box (for instance, don't use a corner clamp on the front corner).
 - » Not enter the box, or interfere with access to the interior of the box (don't use the screws holding the faceplate on).
 - » Ensure that you have proper metal to metal contact

Article 820 Requirements

- 820-40 Grounding Methods (cont..)
 - Where to Bond:
 - New Ground Rod - 8 foot (Art. 830 requires 5 ft.)
 - *2002 NEC Update: suggests use of ground rod where the distance from building entry of the coax is greater than 20ft.....must be bonded to structure grounding system with #6 wire.*
 - Use an approved below-grade clamp;
 - Top of rod should be 6” below grade;
 - Make sure ground wire is “protected”
 - Must be bonded to structure grounding system with #6 Wire

Article 820 Requirements

- 820-40 Grounding Methods (cont..)
 - Special Problems:
 - Mobile Homes
 - *If* electric service to Mobile Home is grounded *and* within 30ft of the home, *and* is visible from the mobile home, use standard bonding and grounding techniques.
 - If not (>30ft, powered by a plug, etc), bond to the Mobile Home's frame “with a copper grounding conductor not smaller than #12.” (820-42(b))

Article 820 Requirements

- 820-40 Grounding Methods (cont..)
 - Special Problems:
 - Independent CATV Ground Rods
 - Must either disconnect and establish bond in the normal manner, or bond CATV rod with #6 wire to building grounding system

Article 820 Requirements

- 820-40 Grounding Methods (cont..)
 - Special Problems:
 - Ungrounded Structure
 - Where you can't find *any* established path to ground:
 - » Inform customer you can't provide service until a ground/bonding point is established.
 - » Why not an independent ground rod?
 - » CATV system could become path to ground for entire structure...."hot drop" with CATV drop carrying all load.

Article 820 Requirements

- 820-40 Grounding Methods (cont..)
 - Special Problems:
 - MDU's
 - Note requirements for size of grounding conductor....must have roughly the same current carrying capacity of the outside shield of the drop.
 - Suppose multiple drops to MDU....each must be bonded to structure grounding system
 - All other NEC requirements (i.e., proximity to bonding point) are applicable.

Article 820 Requirements

- 820-40 Grounding Methods (cont..)
 - Special Problems:
 - The converted garage, the bus in the backyard:
 - Assuming Customer wants separate CATV service:
 - » How is power going to the structure?
 - » If garage/outbuilding, bond to closest point of power service ground;
 - » If a bus or trailer, bond to closest point of power service ground *and* bond to metal frame if distance >30ft.

Article 830 - Network Powered Broadband

- 830-1 “Covers network-powered broadband communications that provide *any* combination of voice, audio, video, data, and interactive services through a network interface unit.”

Article 830 - Network Powering

- Covers:
 - Coax-Power on Center Conductor
 - Coax with Twisted Pair-For Power
 - Fiber with Twisted Pair-For Power

Article 830 - Network Powering

- For the first time, requires that drop cable be UL rated for voltage, and for all but UG cables, flame retardant (UL VW-1 flame test).
 - Only exception is for “grand-fathered” (installed before 1/1/2000) *and* “low power.”

Article 830 - Network Powering

- Network Interface Unit (NIU)
 - “A device that converts a broadband signal into component voice, audio, video, data, and interactive services signals. The NIU provides *isolation* between the network power and the premises signal circuits. The NIU may also contain primary and secondary protectors.:

Article 830 - Network Powering

- 830-3 Locations and Other Articles:
 - (d) Output circuits: “As appropriate for the services provided, the output circuits....from the (NIU) shall comply....with the following:
 - Article 800 - Installation of Communications Circuits
 - Article 820 - CATV
 - Article 770 - Installation of F.O. cables
 - Article 725 - Installation of Class 2 & 3 circuits
 - Article 760 - Installation of power-limited fire alarm circuits.

Article 830 - Network Powering

- 830-4 Low/Medium Power Sources:
 - Low Power = Max. System Voltage of 100v
 - Low Power = Max. Power Rating of 100 volt-amperes.
 - Intended to service one NIU in a single family dwelling.

Article 830 - Network Powering

- 830-4 Low/Medium Power Sources:
 - Medium Power = Max. System Voltage of 150v
 - Medium Power = Max. Power Rating of 100 volt-amperes.
 - Intended to serve multiple NIU's

Article 830 - Network Powering

- 830-10 Aerial Cables:
 - Clearances
 - Other than over roof (8ft) requirements are much more specific in Article 830.

Article 830 - Network Powering

- Cable Type, Use and Listing (830-5)
 - BMU - Medium Power - Outdoor, Underground
 - BM - Medium Power - General Purpose - except Risers and Plenums.
 - BMR - Medium Power - Riser Applications
 - BLU - Low Power - Outdoor, Underground
 - BLX - Low Power - Limited Use Outside, in dwellings, or in raceways
 - BLP - Low Power - Ducts, Air Plenums

Article 830 - Network Powering

- Cable Types
 - Grandfathered:
 - Cables installed prior to January 1, 2000 in accordance with Article 820 *and* are used for *low power* network-powered communication circuits.

Article 830 - Network Powering

- 830-10(i)(4) Protection From Damage:
 - Above Ground:
 - IF coax is located within 8ft of finished grade, *shall be* protected by enclosures, raceways, or “other approved means....in no case shall the protection be required to exceed 18....below finished grade.”
 - *Exception: For both aerial and UG: If the network is “low power,” and the circuit is equipped with a “listed fault protection device” and located on the “network side” (i.e. at least at the tap), no “enclosures, raceways, etc. are required.*
 - Note change from Article 820, which does not require or discuss such protection.

Article 830 - Network Powering

- 830-11 Underground Circuits Entering Buildings
 - Tougher requirements than Article 820.
 - Note “Grandfather clause” (before 1/1/2000) for “low power” cable.

Article 830 - Network Powering

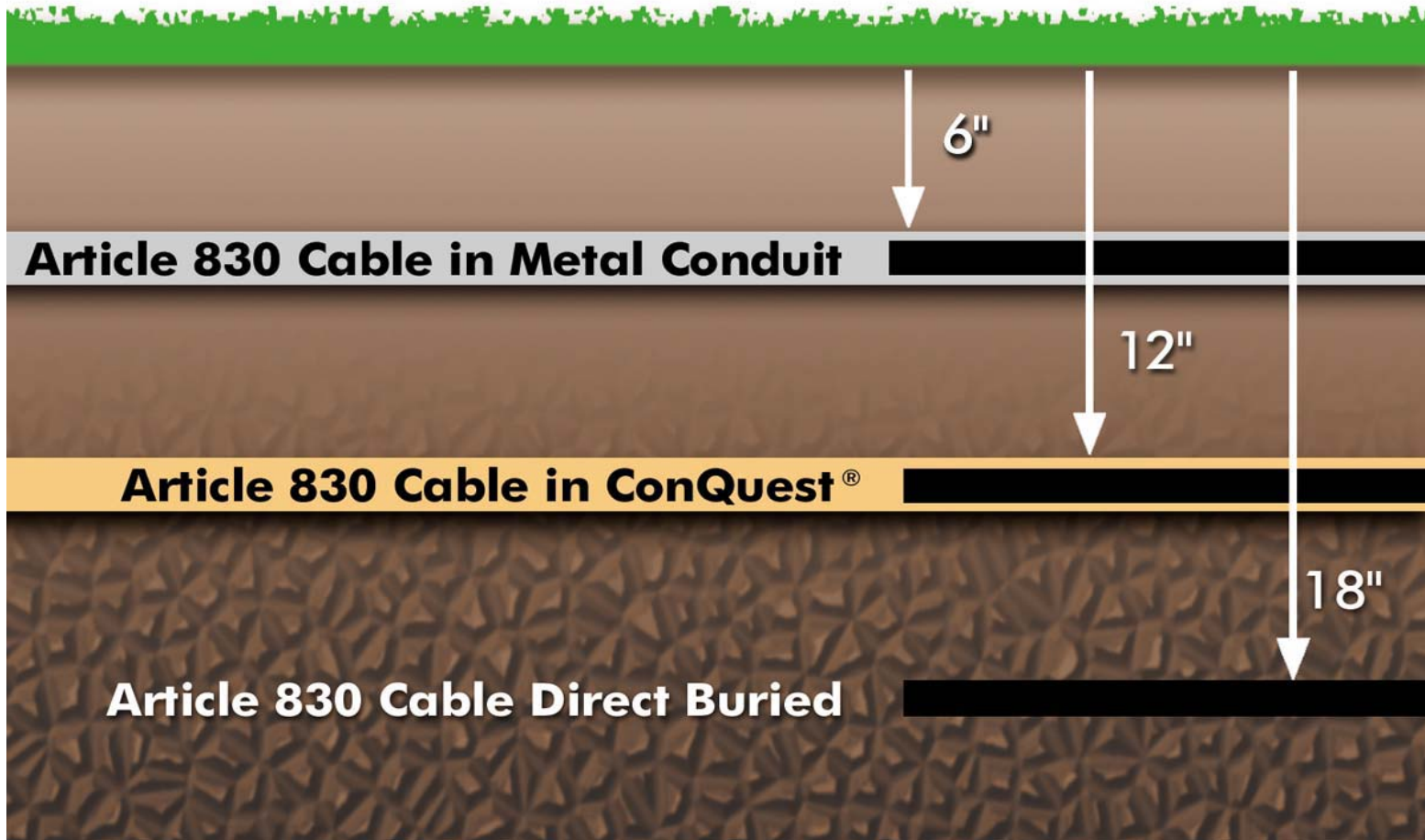


TABLE 2 MINIMUM COVER REQUIREMENTS

Location of wiring method or circuit	Direct burial cables (inches)	Rigid metal conduit or intermediate metal conduit (inches)	Non-metallic raceways listed for direct burial; w/o concrete encasement or other approved raceways (in)
All locations not specified below	18	6	12
In trench below 2-inch thick concrete or equivalent	12	6	6
Under a building (in raceway only)	0	0	0
Under minimum of 4-inch thick concrete exterior slab with no vehicular traffic and the slab extending not less than 6 inches beyond the underground installation	12	4	4
One- and two-family dwelling driveways and outdoor parking areas and used only for dwelling related purposes	12	12	12

Notes: 1) Cover is defined as the shortest distance measured between a point on the top surface of any direct-buried cable, conduit or other raceway and the top surface of finished grade, concrete or similar cover; 2) raceways approved for burial only where concrete encased shall require a concrete envelope not less than two-inches thick; 3) lesser depths shall be permitted where cables rise for terminations or splices, or where access is otherwise required; 4) where solid rock is encountered, all wiring shall be installed in metal or non-metallic raceway permitted for direct burial. The raceway shall be covered by a minimum of two inches of concrete extending down to rock; 5) low power network-powered broadband communications circuits using directly-buried community antenna television and radio distribution system coaxial cables that were installed outside and entering buildings prior to January 1, 2000, in accordance with Article 820 shall be permitted where buried to a minimum depth of 12-inches.

Source: Adapted from NEC Table 830-11

Article 830 - Network Powering

- 830-11 (cont..)– So, Network-Powered Cable (after 1/1/00) must:
 - Be buried differently (deeper) from Article 820;
 - Must be protected by conduit from the approved burial depth to a point at least 8ft above finished grade (remember exception for “low power” with fault protection device).

Article 830 - Network Powering

- 830-11 (cont..)

- *Exception:*

- “Low power circuit that is equipped with a listed fault protection device, appropriate to the network-powered....cable used, *and* located on the network side...of the cable being protected.
 - Seems to state that such a cable would only have to meet Article 820 (12” depth), with no “protection” (other than good craft) above ground.

Article 830 - Network Powering

- 830-30 Primary Electrical Protection:
 - Telephone-type requirements (See Article 800) included in Art. 830.
 - Protection Device may be located in one of three places (830-30(b)):
 - External to the NIU (input side)
 - Incorporated into the NIU (input side)
 - » NIU “shall be listed for the purpose *and* have external marking....that it contains primary electrical protection.
 - Incorporated into the NIU (output side).

Article 830 - Network Powering

- 830-30 Primary Electrical Protection:
 - Types & Function
 - Fuseless (gas type)
 - Increasing heat increases resistance, resets. (Most likely to be seen, most reliable).
 - Fused
 - “A primary protector....*shall be located* as close as possible to the point of entrance.” Art. 830-30(b)

Article 830 - Network Powering

- Current-Limiting Provisions:
 - Is required to fall below $1000/V_{max}$, where V_{max} is the maximum system voltage possible.
 - 90v supply has a limitation of 11 amps, with a fold-over possibility of up to 22.5 amps.
 - Code requires additional components to limit current to the NIU.
 - Power Passing Taps provide by use of a “PTC” (Positive Temperature Coefficient Device) which limits current.
 - Does not detect an open, can’t be used in place of a “listed fault protection device.”

Article 830 - Network Powering

- 830-30© Hazardous Locations
 - Can't locate equipment in “hazardous locations” (see Article 500) “or in the vicinity
 - of easily ignitable material.
 - Provision not in Article 820

Article 830 - Network Powering

- 830-33 Grounding/Interruption of metallic members
 - Controversial Article
 - “Metallic cable members not used for communications or powering (i.e. the drop messenger) *shall be* grounded or interrupted *by an insulating joint or equivalent device as close to the point of entrance as practicable.*”

Article 830 - Network Powering

- 830-33 Grounding/Interruption of metallic members (cont.)
 - Means messenger:
 - Must be grounded at the bonding block, or:
 - Must have an insulating joint (i.e., a ceramic insulator on the “P” hook) where the cable is anchored.
 - What about the insulation on the messenger? Isn’t that sufficient to “interrupt”?

Article 830 - Network Powering

- 830-40 Grounding Methods:
 - NIU's containing protectors, NIU's w/metallic enclosures, primary protectors and grounded metallic members of the....cable shall be grounded:

Article 830 - Network Powering

- Grounding Methods (cont..)
 - Conductor shall be insulated and listed (**same as Article 820**)
 - Conductor shall be copper, etc (**same as Article 820**)

Article 830 - Network Powering

- Grounding Methods (cont..)
- Grounding Conductor Size:
 - No smaller than #14 (**same as Article 820**)
 - Current-carrying capacity approximately equal to that of the grounded metallic members *and protected conductors*
 - **Means that current-carrying capacity must include both shield and center conductor.**
 - **But what about a grounded messenger?**
 - Not required to be larger than #6

Article 830 - Network Powering

- Coax shield + center conductor current-carrying capacity

Cable Type	Current-Carrying Capacity (in Amps, 20 degrees C) Free Air	Equivalent Solid Cu Wire (AWG)	Current-Carrying Capacity (in Amps, 20 degrees C) in Free Air	Current-Carrying Capacity (in Amps, 20 degrees C) UG or Raceway
RG 6, 60%	8	14	20	15
RG 6 Tri-Shield	8	14	20	15
RG 6 Quad Shield	8	14	20	15
RG 11, 60%	13	14	20	15
RG11 Tri-Shield	13	14	20	15
RG 11 Quad Shield	13	14	20	15
P3/T10 500	43	8	70	50
*Question: How much to de-rate coax in UG/Raceway?				

Compare w/Article 820:

Cable Type	Current-Carrying Capacity (in Amps, 20 degrees C) Free Air	Equivalent Solid Cu Wire (AWG)	Current-Carrying Capacity (in Amps, 20 degrees C) in Free Air	Current-Carrying Capacity (in Amps, 20 degrees C) UG or Raceway
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RG 11 Quad Shield	41	8	70	50
P3/T10 500	148	4*	125	85
*Need to go to #2 (UG/Raceway: 115?)				
*Question: How much to de-rate coax in UG/Raceway?				

Article 830 - Network Powering

- Grounding Methods (cont..)
 - Physical Protection
 - Where required (Same as 820)
 - Run in a Straight Line (Same as 820)

Article 830 - Network Powering

- Grounding Methods (cont.)
 - (5) Physical Protection: “Where subject to physical damage, the grounding conductor ***shall be*** adequately protected.”
 - Use good craft when locating the wire. Make sure there are no trip points or areas where the wire can be abraded.
 - If put in a metallic raceway, “***both ends shall be*** bonded to the grounding conductor or the same terminal or electrode to which the grounding conductor is connected.”
 - Same language as Article 820

Article 830 - Network Powering

- New Ground Rod - *5 ft., 1/2" min.* (Art. 820 requires 5/8", 8 ft.)
 - *2002 NEC Update: suggests use of ground rod where the distance from building entry of the coax is greater than 20ft.....must be bonded to structure grounding system with #6 wire.*
 - Use an approved below-grade clamp;
 - Top of rod should be 6" below grade;
 - Make sure ground wire is "protected"
 - Must be bonded to structure grounding system with #6 Wire

Article 830 - Network Powering

- 830-42 Bonding and Grounding at Mobile Homes
 - *If* electric service to Mobile Home is grounded *and* within 30ft of the home, *and* is visible from the mobile home, use standard bonding and grounding techniques.
 - If not (>30ft, powered by a plug, etc), bond to the Mobile Home's frame “with a copper grounding conductor not smaller than #12.” (Same as Article 820)
 - Bond all equipment (NIU, primary protector, etc.

Article 830 - Network Powering

- The End
- Questions/Comments?
- Thank you for your time.