Telecommunication Grounding & Bonding

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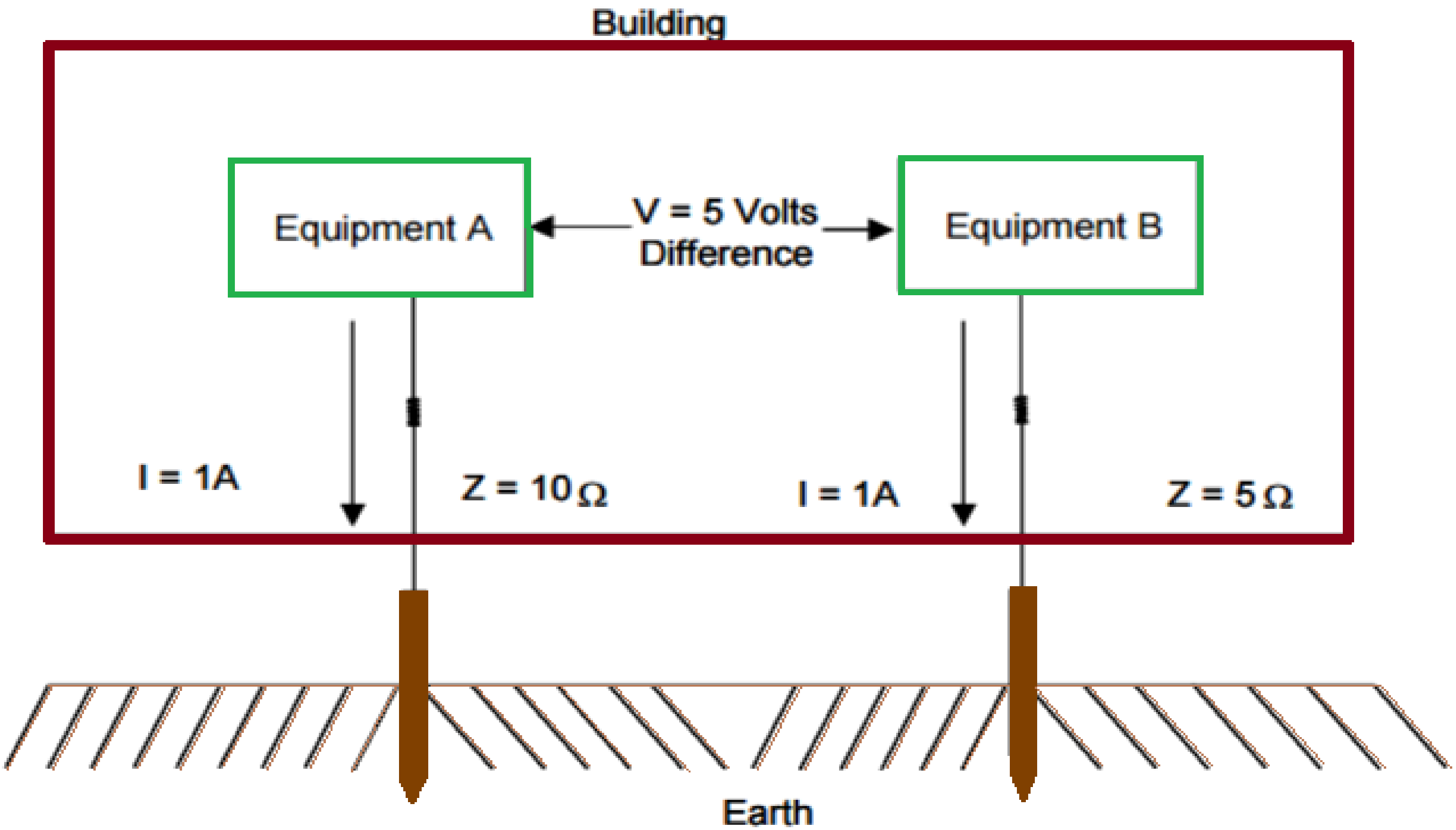
Codes and Standard References

- ANSI J-STD 607B
- ANSI/NECA/BICSI 607:2011
- ANSI/TIA 607B: 2011
- BICSI TDMM 13th Edition:2014
- BS 7430:2011
- IEEE 1100:2005
- IEEE 81:2012
- ISO/IEC 30129:10.2015
- NFPA 70:2014 (NEC)
- Motorola R56:2005

Why the need for Grounding and Bonding

- Equipment Protection
- Satisfy Warranty Requirement
- System Performance
- Service Protection
- Personnel Safety
  (code requirement – NEC/CSA/BS/IEC)

Case: Two Ground Reference Points



Effect of Two Earth Reference Points

(voltage difference between two equipment)

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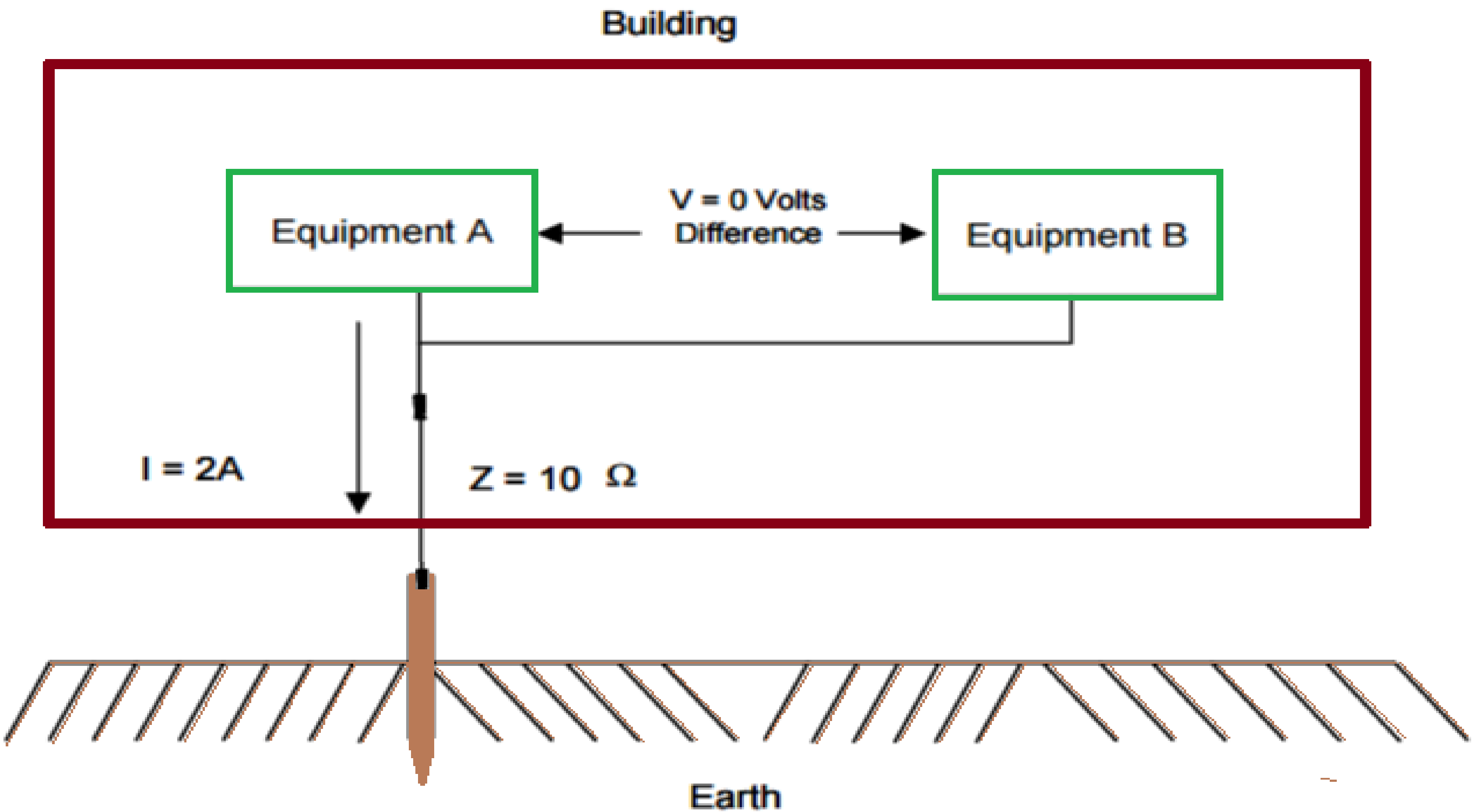
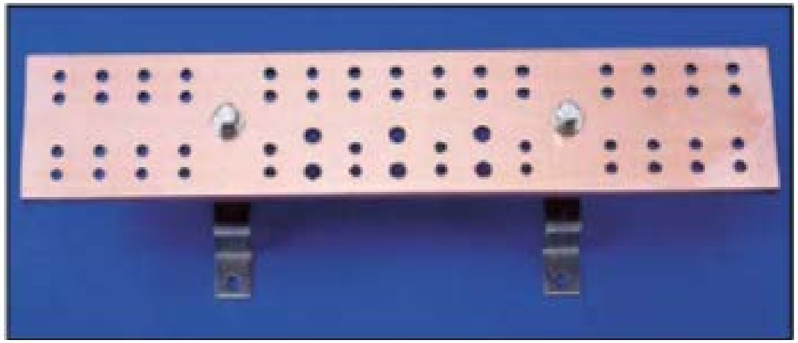
Case: Single Equipotential Plane



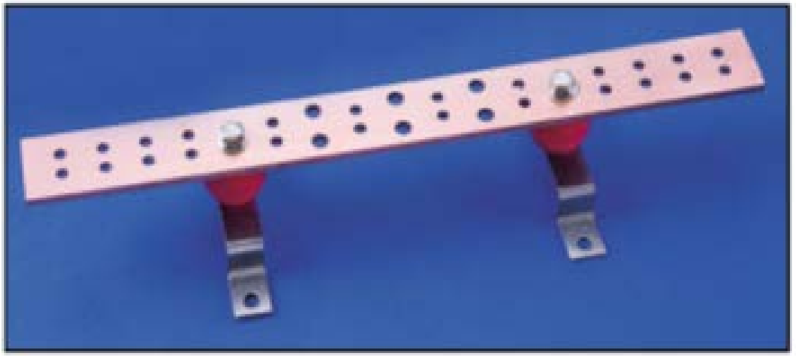
Effect of Single-point Reference of all Equipment (0 volts Difference)

1. Grounding & Bonding Components

Main Telecommunication Grounding Busbar (TMGBB)

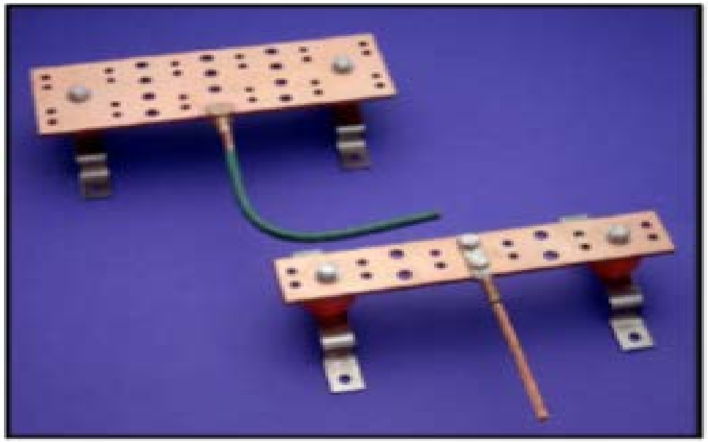


Telecommunication Grounding Busbar (TGBB)

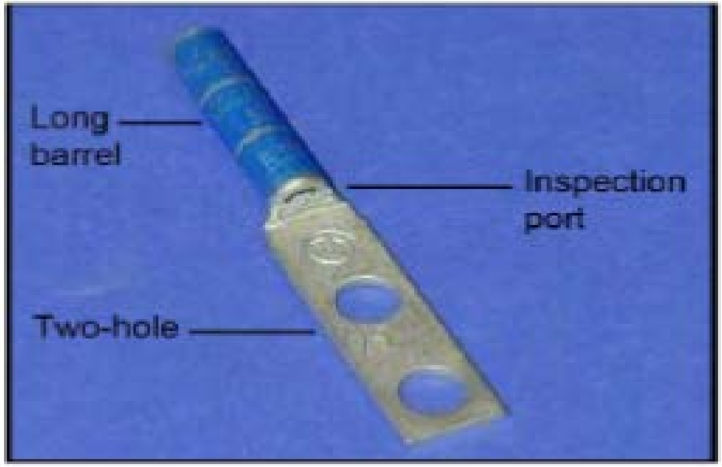


2-Hole Long Barrel Terminal Lugs & Compression Type Connectors

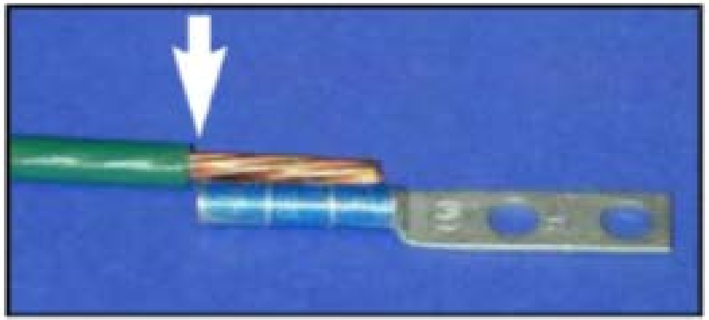
1. Grounding & Bonding Components



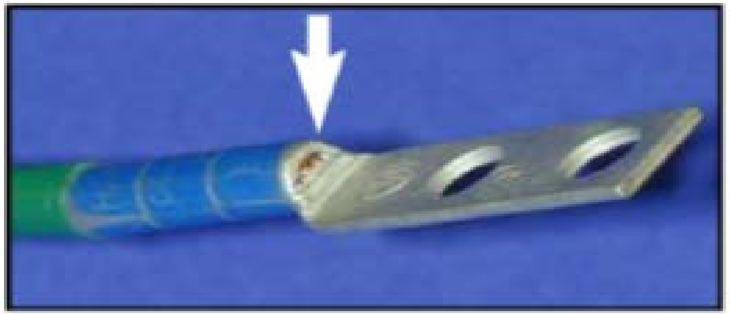
Exothermic connection & a 2-hole lug connection to a busbar



2-Hole Terminal Lug

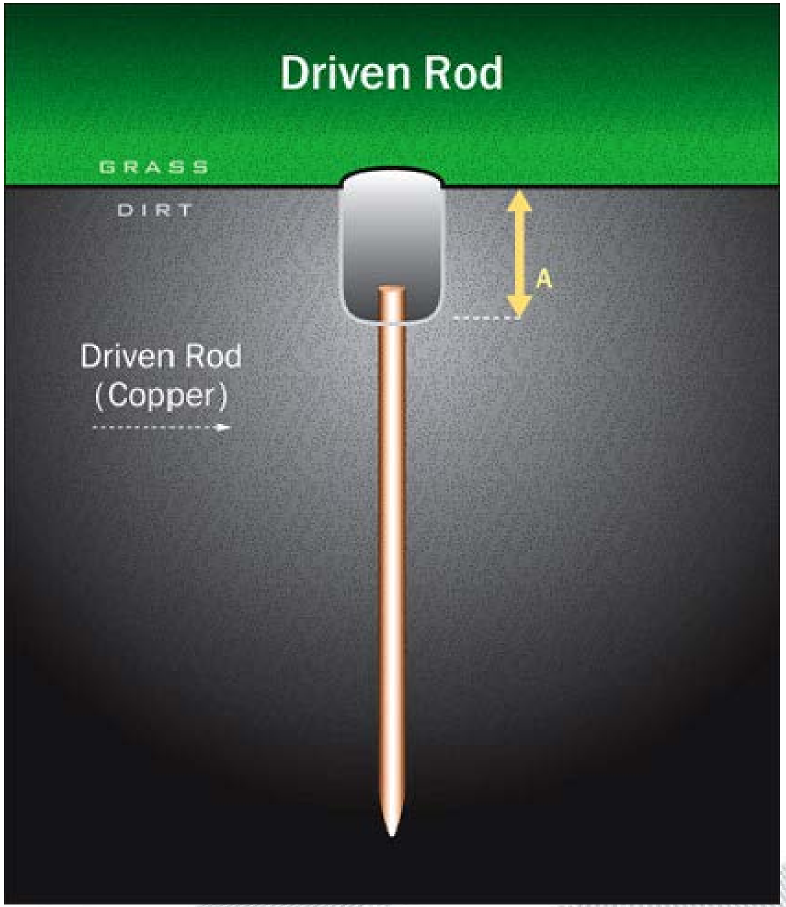


Trimmed Insulation from a conductor

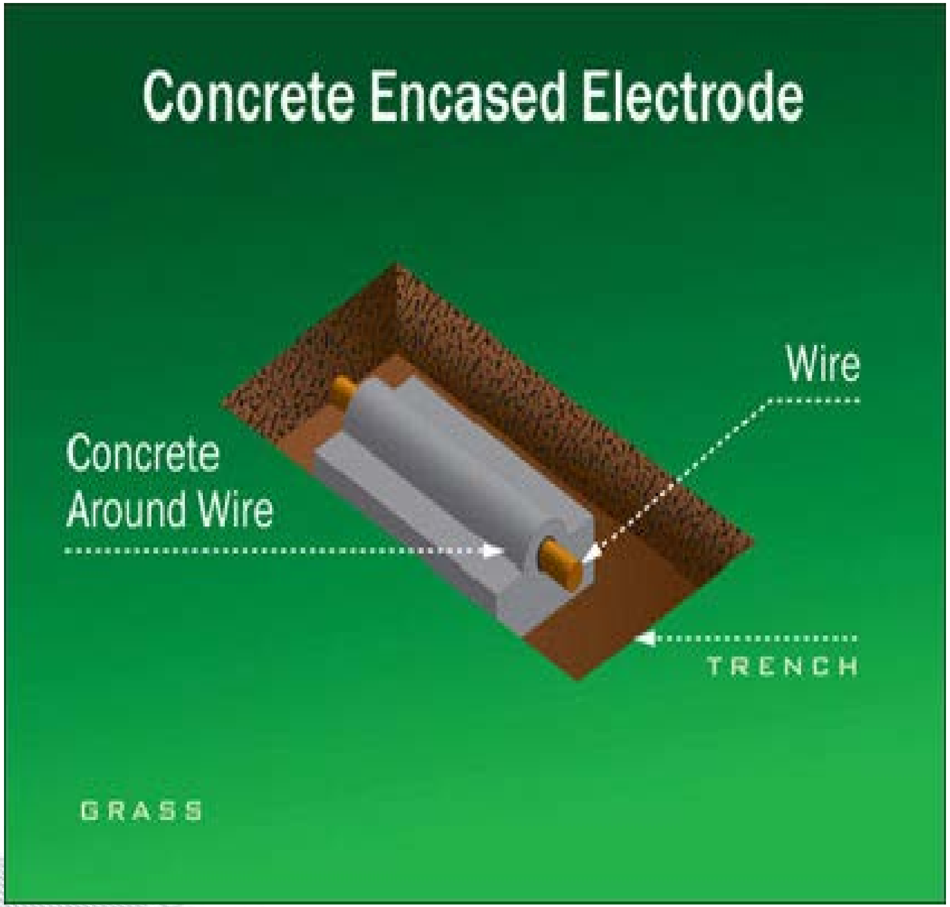


Conductor seen Through the inspection port (window)

1. Grounding Rods Plates & Pipes

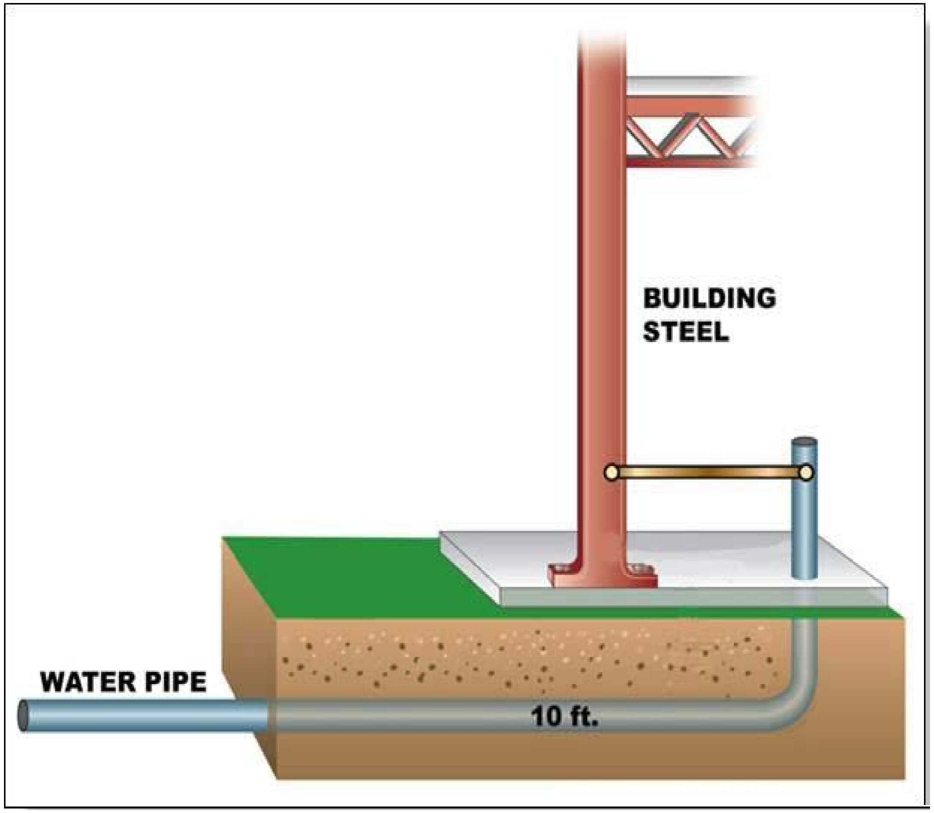


Copper Ground Rod

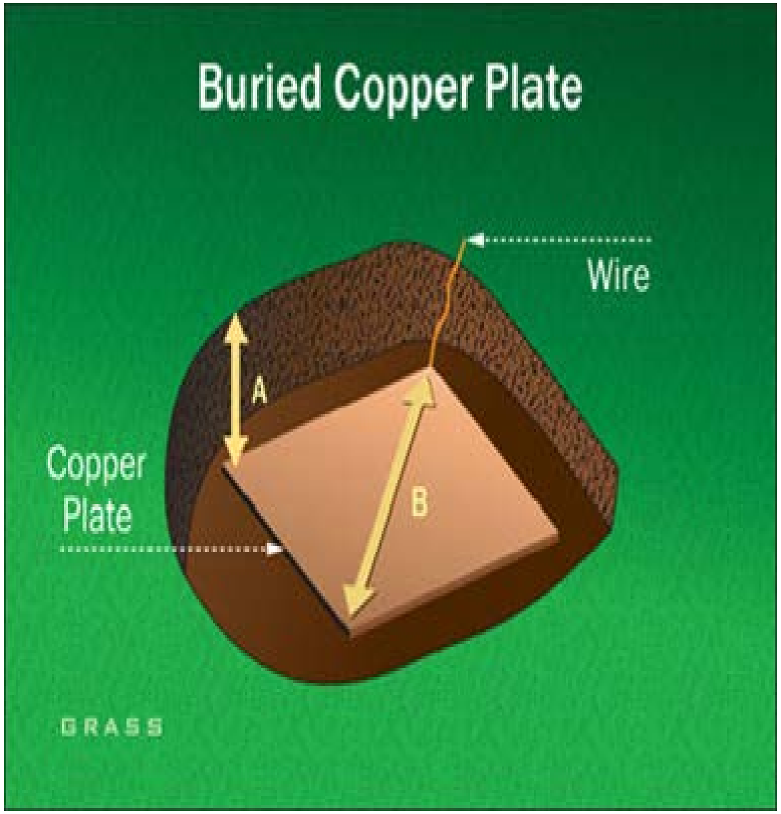


Ufer Grounding Method

1. Grounding Rods Plates & Pipes

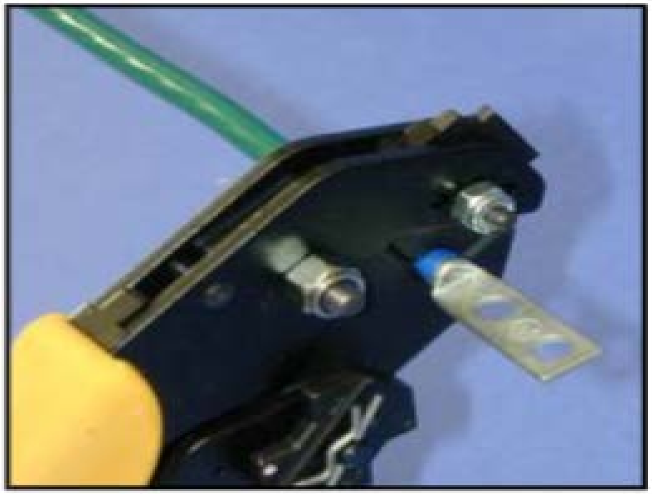


Building Frame & Water Pipe Bonding



Copper Plate Grounding

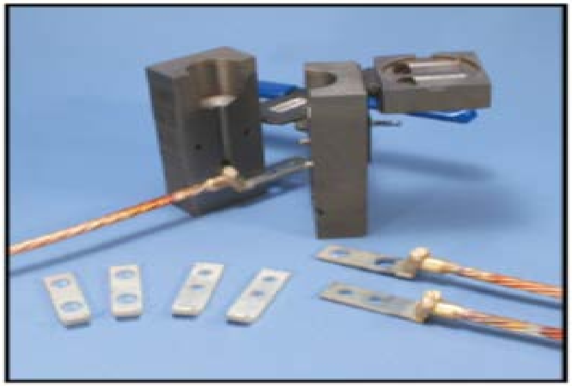
2. Preparations - Crimping & Exothermic Welding



Crimping a conductor in the barrel of the lug

Mold being locked and disk inserted

Finished Barrel with 3-crimps



Example of a mold for an exothermic weld

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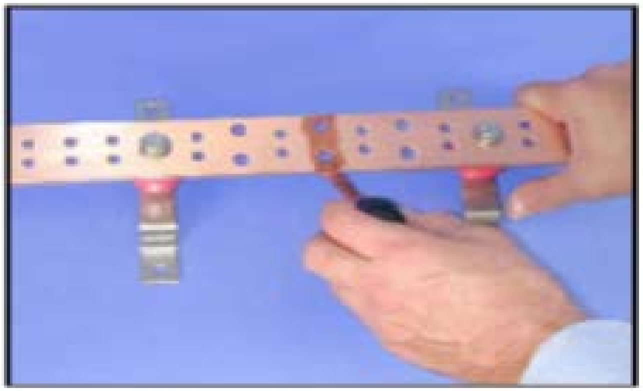
2. Preparation - Exothermic Welding & Busbar

Pouring Weld metal powder into a mold

Removing oxidation from the grounding busbar

Igniting the accelerant



Applying an antioxidant to the cleaned area of the grounding busbar

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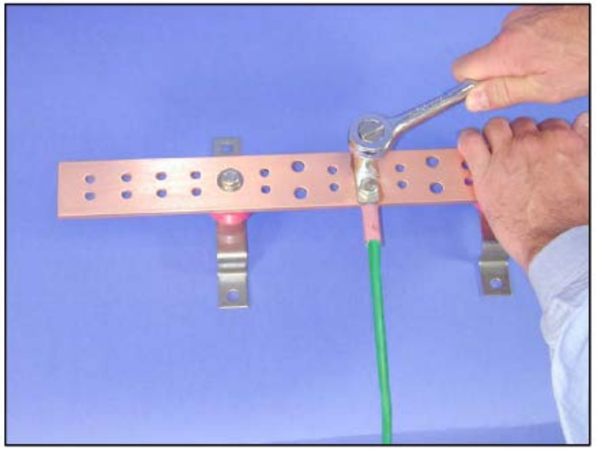
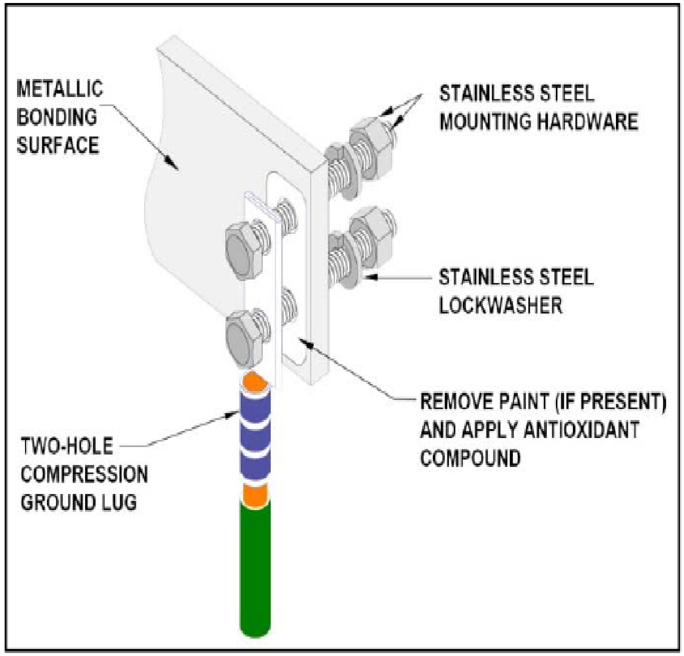
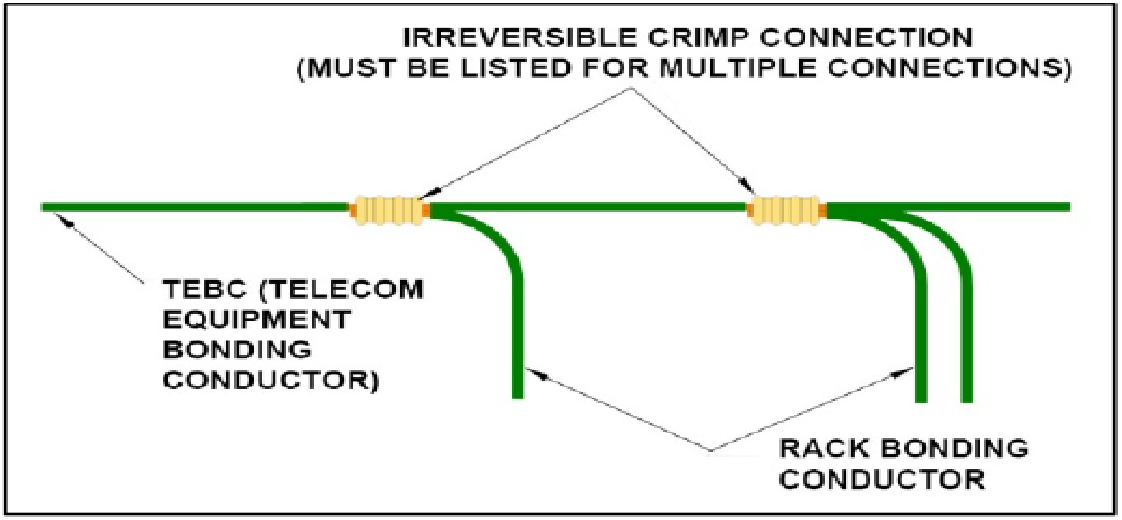
2. Preparation - Busbar Lug Connection



Attaching a lug to the grounding busbar



Lug mounting configuration



Example of a TEBC to Rack bonding conductor connection

3. Sample - Bonding Connection with Rack Cabinet Door System

Illustration of a bond connection from a cabinet to the cabinet door & side panel

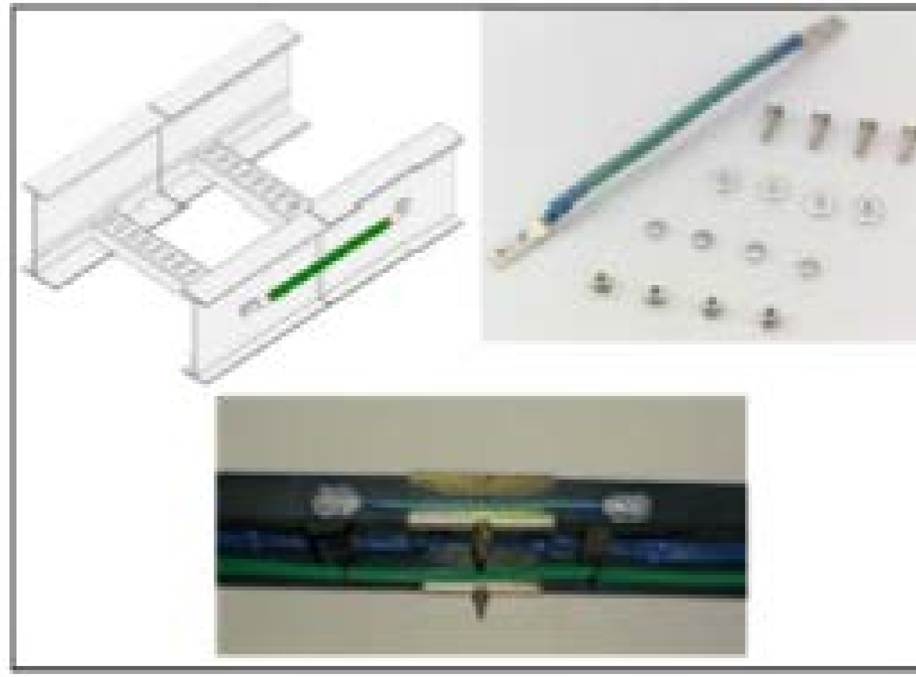
3. Sample - Mechanical & Exothermic Bonding Connection

Example of Mechanical Connector Shall Be UL listed for the purpose - Always

Example of Exothermic Welding

3. Sample - Mechanical Bonding on Trays

Example of 2-hole lugs and a ground terminal block & Clips



Example of bonding jumper and its installation between cable tray segments

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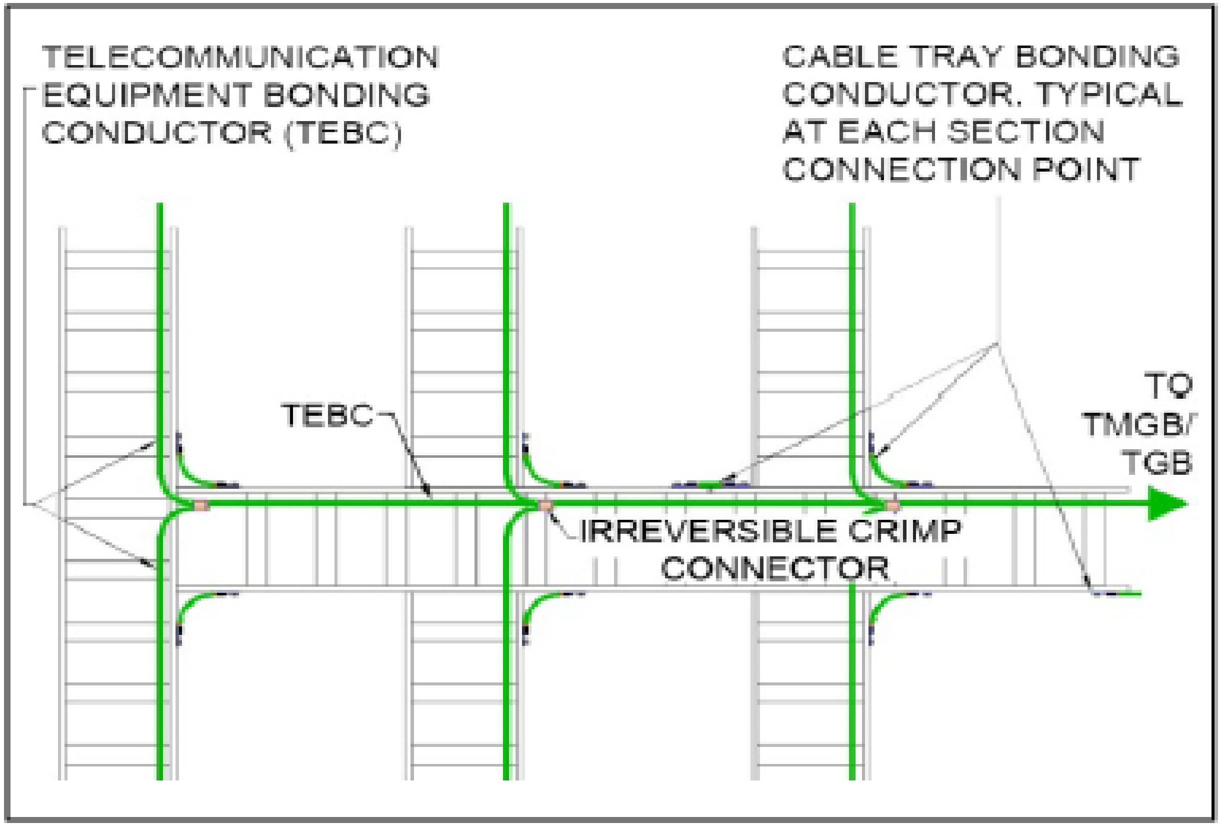
3. Sample - Tray Bonding Routing & Radius



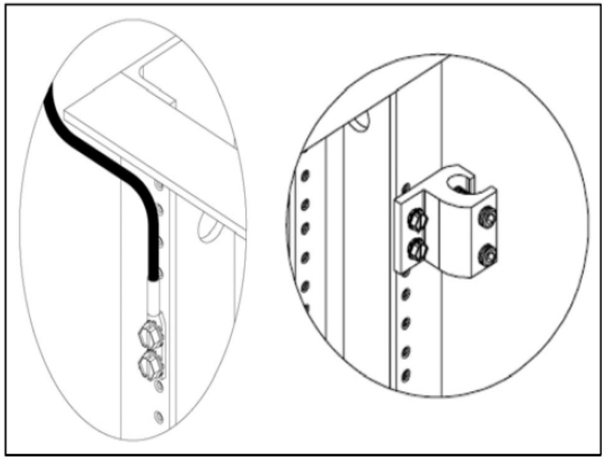
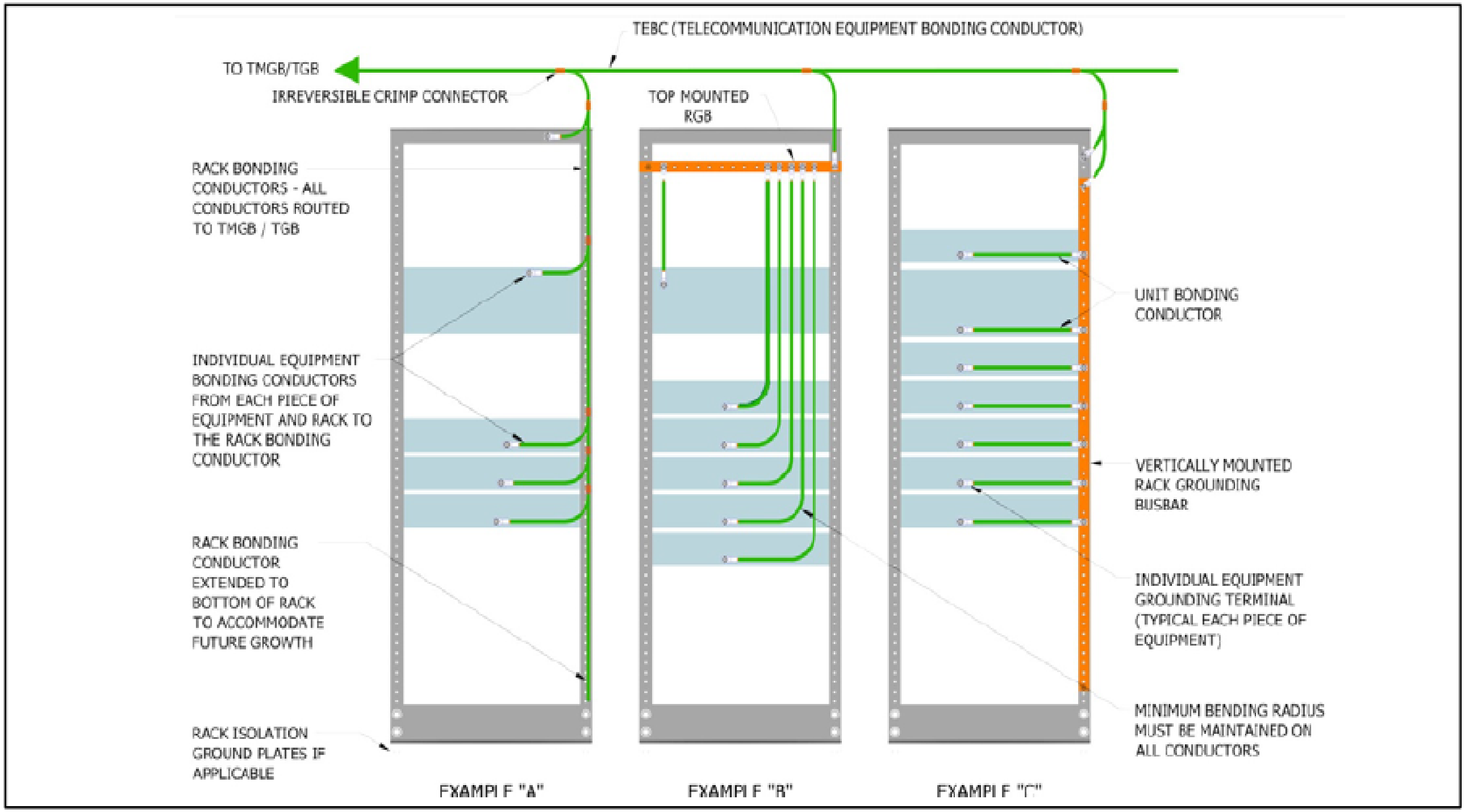


Illustration of a connection point to a rack from a TECB

Example of a TEBC routed on a cable tray - bend radius shall not be less than 200mm & 90 degrees minimum

3. Sample - Rack Bonding Configurations



Three methods to bond equipment & racks to ground

3. Sample - Rack Bonding Configuration

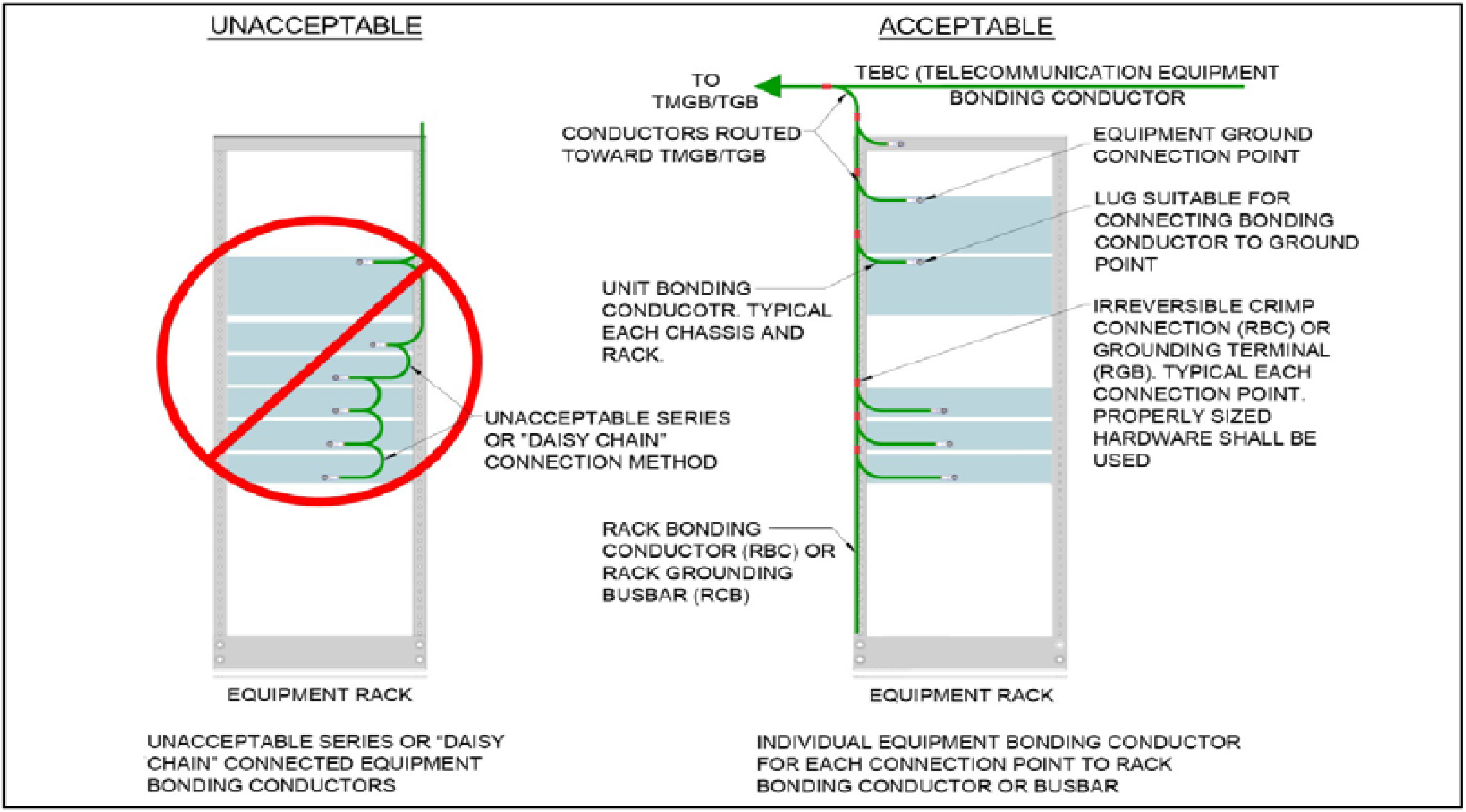
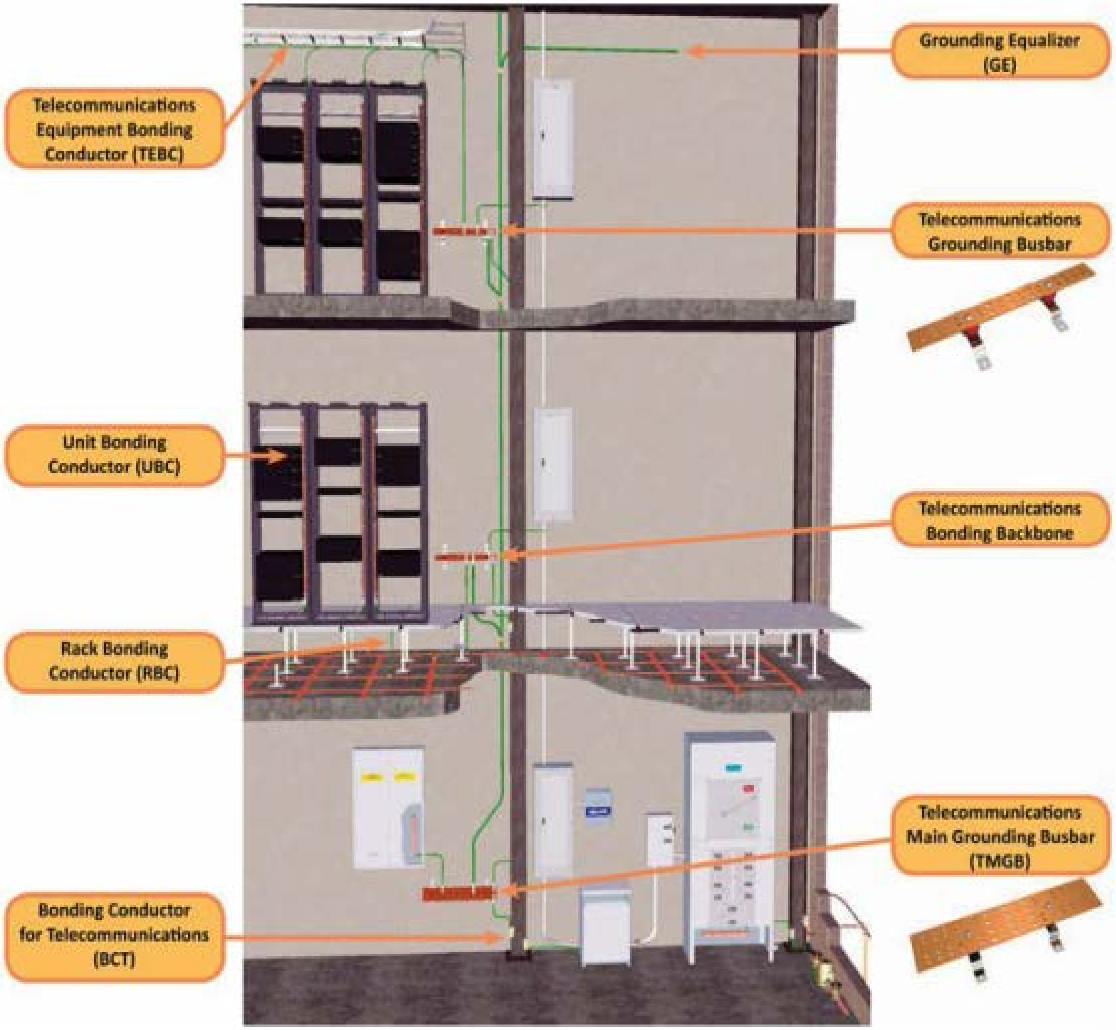


Illustration of acceptable and Unacceptable equipment bonding

4. Set Up - TGBB Grounding in an IT Room

TGBB should be closest possible to the Electrical Panels – Bond Everything!!

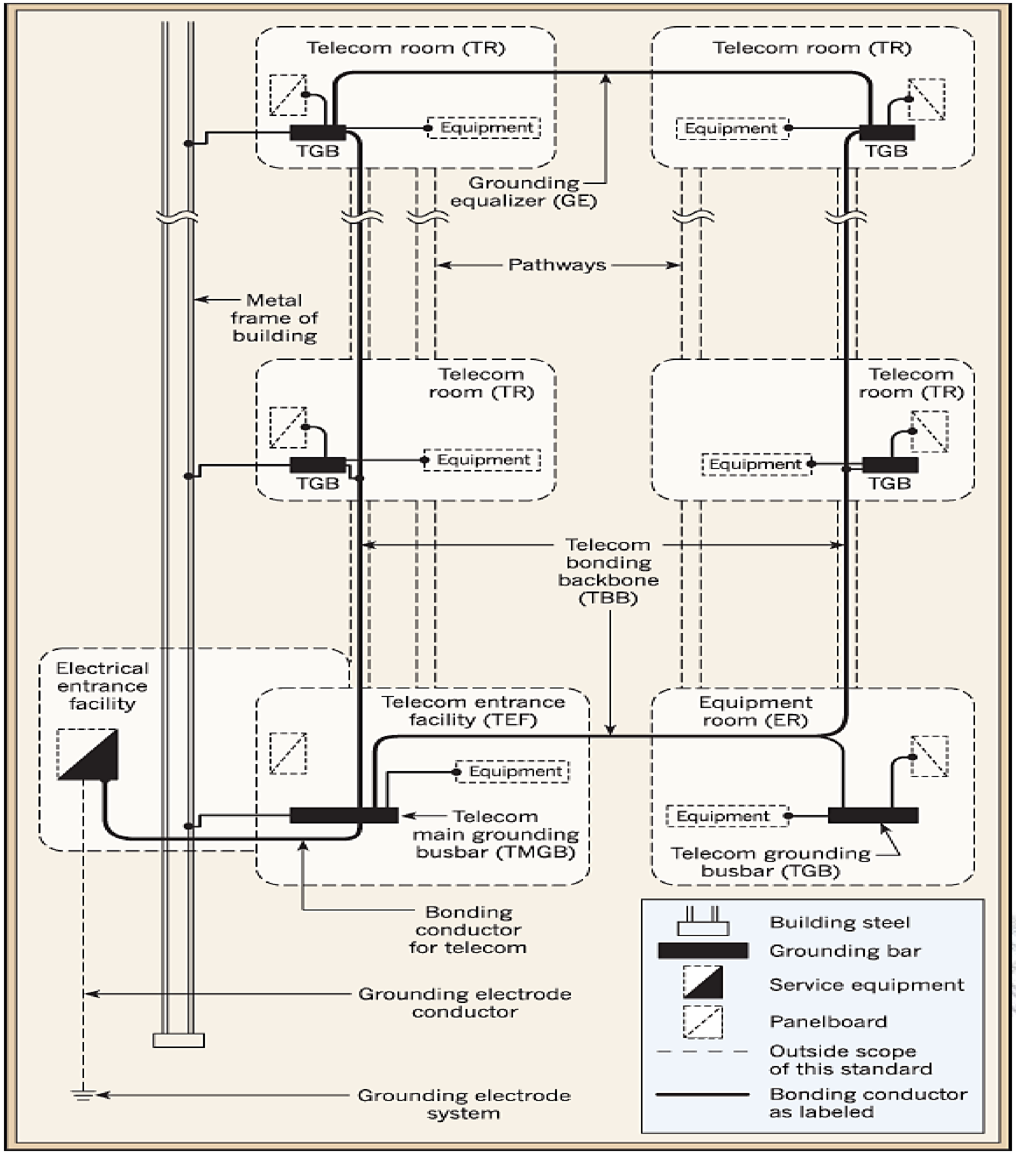
4. Set up - Components of grounding & Bonding System



Main components of the telecommunications bonding and grounding system

Supplemental bonding grid, or signal reference grid, found in raised-floor systems

4. Set up - Components of grounding & Bonding System ISO/IEC Referenced



Note that on the ISO/IEC 30129 (released Oct 2015) Standard for Information Technology : Telecommunications Bonding Networks for Buildings and other structures – GEs (Also known as Bonding Equalizer) must be made every other 3 floors and the top floor.

5. Sizing Up all Conductors – Main Bonding Conductors & Bonding Jumpers

TIA 607-B & ISO/IEC 30129

Maximum TMGBB (PBB) to TGBB (SBB) Length (L) meters (feet)	Conductor cross-sectional area (minimum)	
	Nominal Int'l Conductor (mm2)	Nominal AWG Conductor
L ≤ 4m (13ft)	16	6
4 < L ≤ 6m (14 – 20ft)	25	4
6 < L ≤ 8m (21 – 26ft)	35	3
8 < L ≤ 10m (27 – 33ft)	35	2
10 < L ≤ 13m (34 – 41ft)	50	1
13 < L ≤ 16m (42 – 52ft)	60	1/0
16 < L ≤ 20m (53 – 66ft)	70	2/0
20 < L ≤ 26m (67 – 84ft)	95	3/0
26 < L ≤ 32m (85 – 105ft)	120	4/0
32 < L ≤ 38m (106 – 125ft)	150	250 kcmil
38 < L ≤ 46m (126 – 150ft)	150	300 kcmil
46 < L ≤ 53m (151 – 175ft)	185	350 kcmil
53 < L ≤ 76m (176 – 250ft)	250	500 kcmil
76 < L ≤ 91m (251 – 300ft)	300	600 kcmil
Greater than 91m (301ft)	400	750kcmil
For lengths in excess of those shown above, the conductor cross-sectional area should be calculated as 3.3mm2/m or 2kcmil/ft.		

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5. Sizing Up all Conductors – Bonding Conductors or Bonding Jumpers

Main incoming circuit-breaker rating (Amps)	Minimum number of Earth Electrodes	Minimum size of main Earth Conductor (mm^2)
60/100	1	16
200	1	50
300	1	50
400	1	70
500	2	70
600	2	70
800	2	70
1000	2	70
1600	2	70
2000	2	150
2500	2	150

5. Sizing Up all Conductors – Bonding Conductors or Bonding Jumpers

Cross sectional area of phase and neutral conductors (S) (mm²)	Minimum cross-sectional area of Earth conductors [see note 1] (mm²)	Minimum cross-sectional area of equipotential bonding conductors (mm²)
S <= 16	S (not less than 1.5 see note 2)	S / 2 (not less than 4 or 6, see note 3)
16 < S <= 35	16	10
S > 35	S / 2	S / 4 (but not exceeding 25)

A5 (j) Sizing of Earth Conductors and Equipotential Bonding Conductors

[from table 54.7 of BS 7671]

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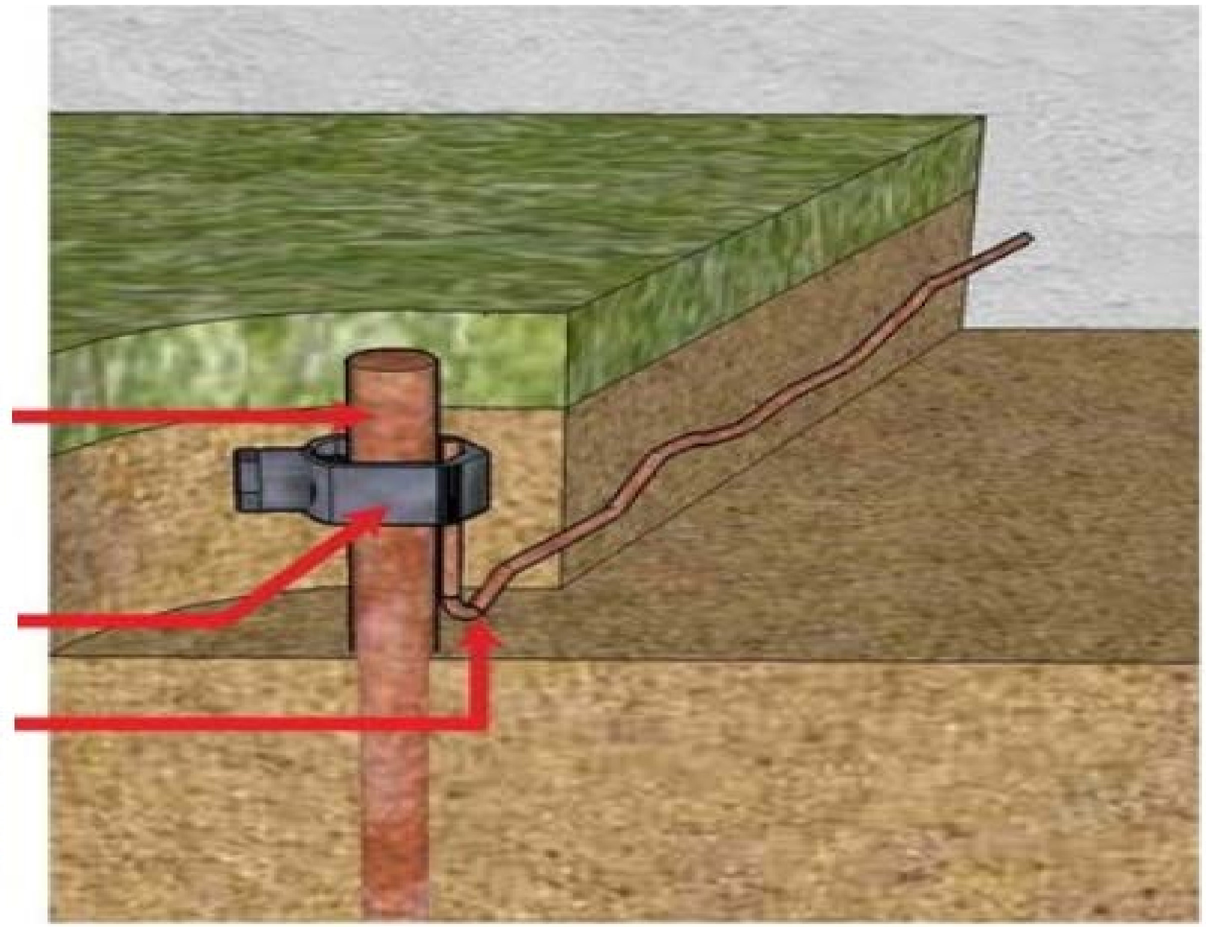
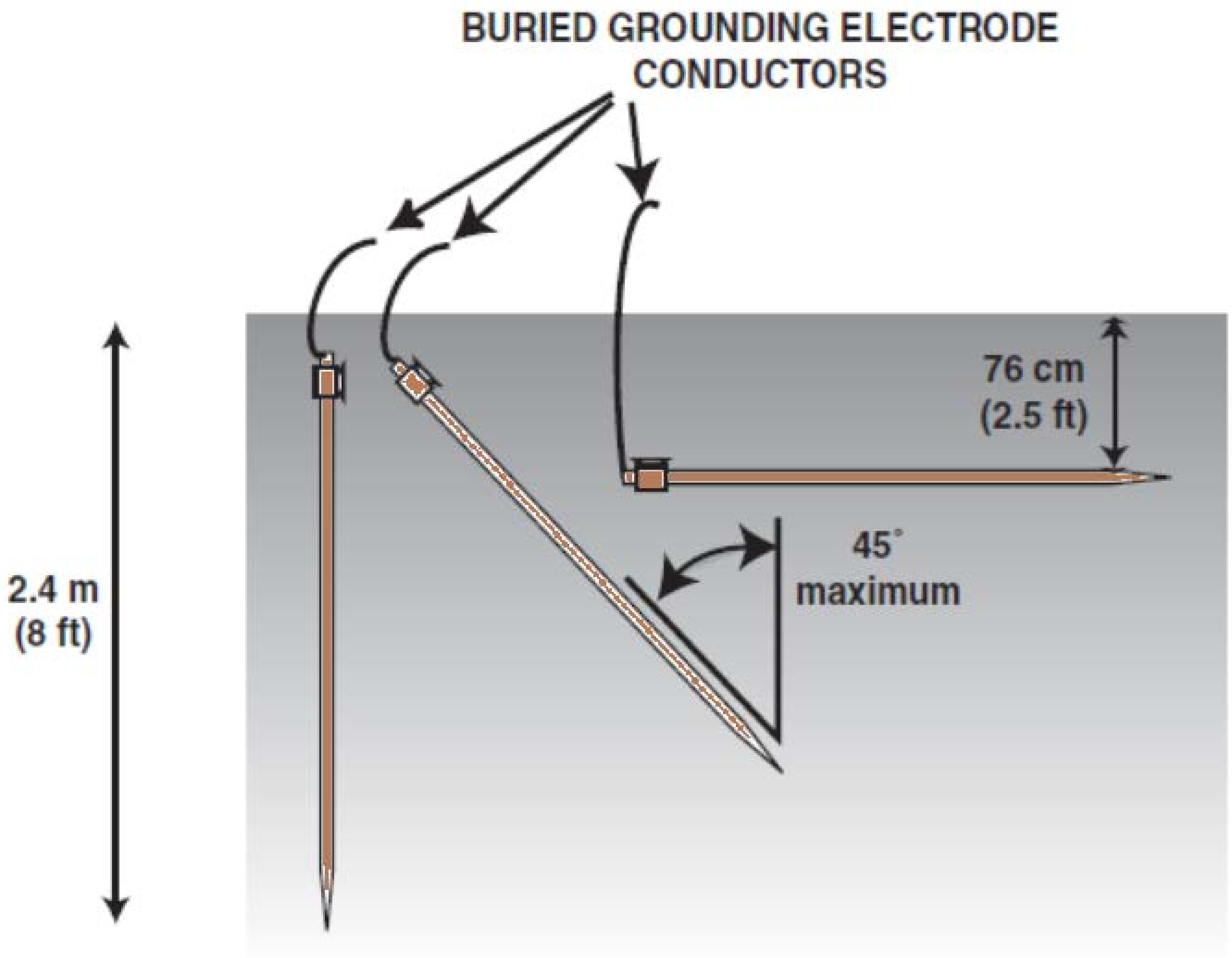
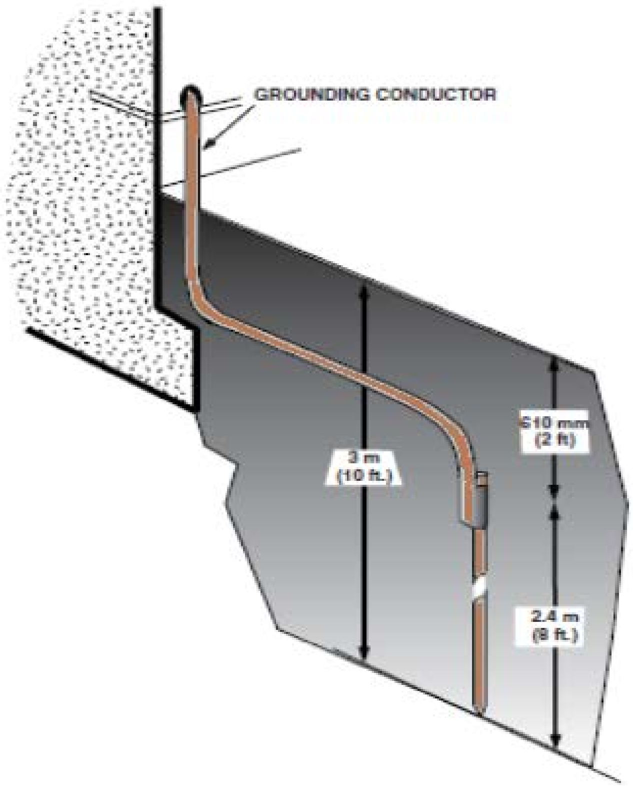
5. Sample Conductor – Main Grounding Electrode Conductor



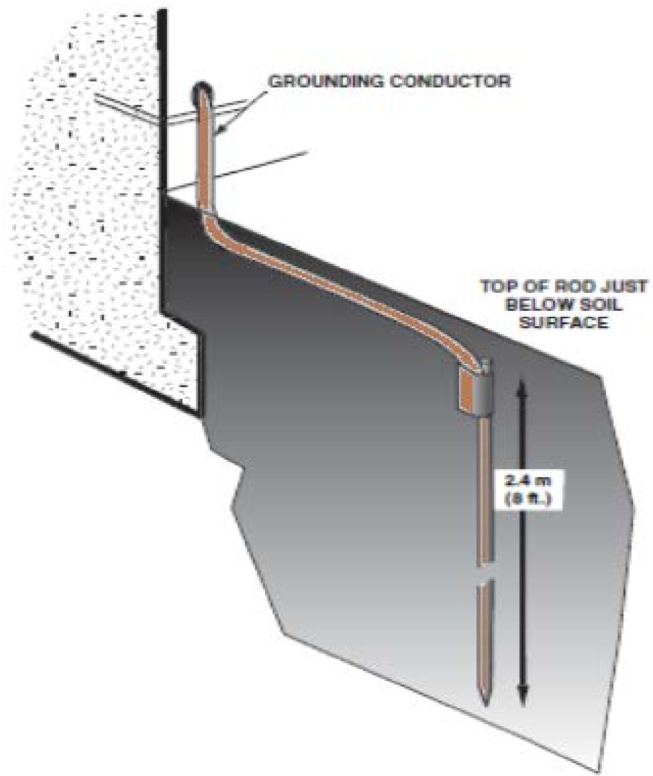
5. How to do It :
Main Grounding Electrode - Position



5. How to do It :
Main Grounding Electrode - Depth

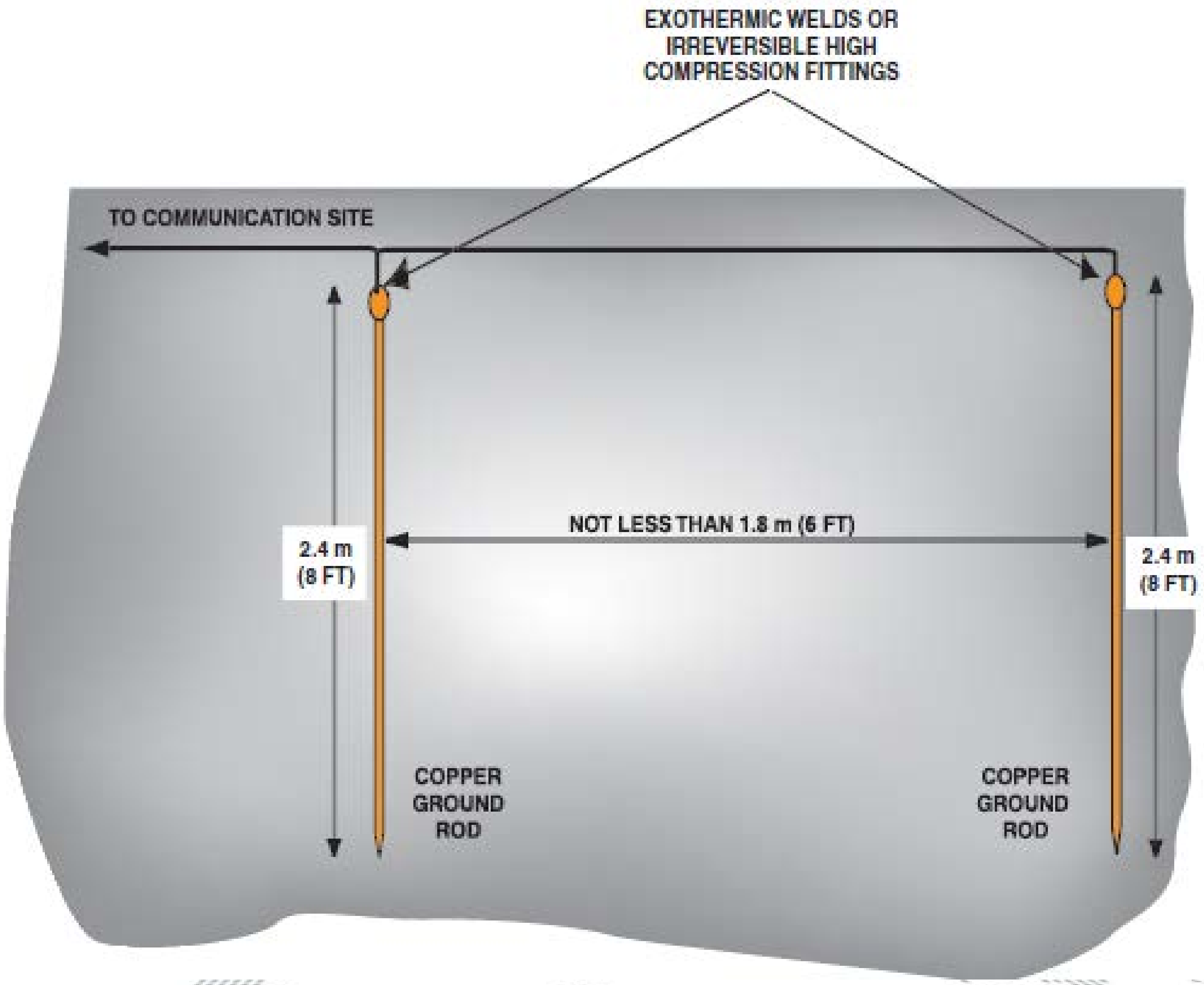


RECOMMENDED DEPTH



MINIMUM DEPTH

5. How to do It :
Main Grounding Electrode - Spacing



DEWA = 6 meters apart Minimum

NPFA 70 = equal to the length of the Rod – minimum, with recommended spacing of <u>twice the length</u> of the Rod

DEWA = Dubai Electric & Water Authority

6. Testing – What numbers to look at?

Typical Ground Resistance Requirements – Which one to Follow!

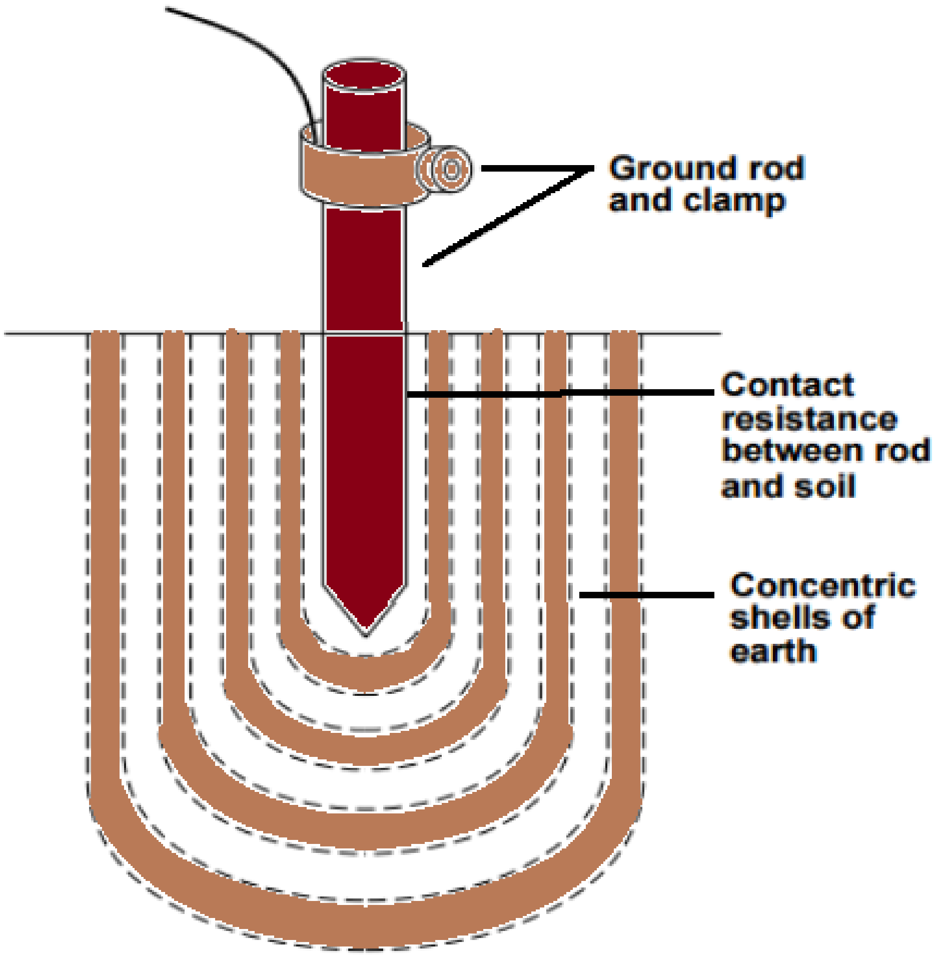
Type "A" Sites: (One Rod or Two Rods Grounding Systems)

- NFPA 70:2017 (NEC) = 25 Ohms or use two rods or more

Type "B" Sites: (Two or more Rods Grounding Systems in ring/radial or special set up)

- IEEE Standard 1100 = 1 Ohm (125Vac L-G) USA
  = 0.8 Ohm (277Vac L-G) USA
  = 0.8 Ohm (347Vac L-G) Canada
- Motorola Standard R56 = 10 Ohms (Design Goal – 5 Ohms Recommended)
- Telecommunications Cos = 3 to 5 Ohms, Regional TELCOs Less than 10 Ohms
- GE & Other Medical Systems = 2 Ohms
- ANSI/BICSI 002:2014 = 5 Ohms Maximum, but recommends
  3 Ohms for Class F2 & F3 DC, and
  1 Ohm for Class F4 Data Centers Design
- DEWA - Dubai = 1 Ohm (Section 5.2.4 – 1997Ed)
- TEWR - Abu Dhabi = 10 Ohms (Section 6.2.1a – 2014ed)

6. Testing - Option 1 = Fall Of Potential Method



(Effective Resistance Area)

Components of resistances in an earth Electrode

6. Testing - Option 1 = Fall Of Potential Method

Reference: IEEE 81:2012 = Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Grounding System

How to Space the Current Probe from Electrode to be Tested?..... How Far!

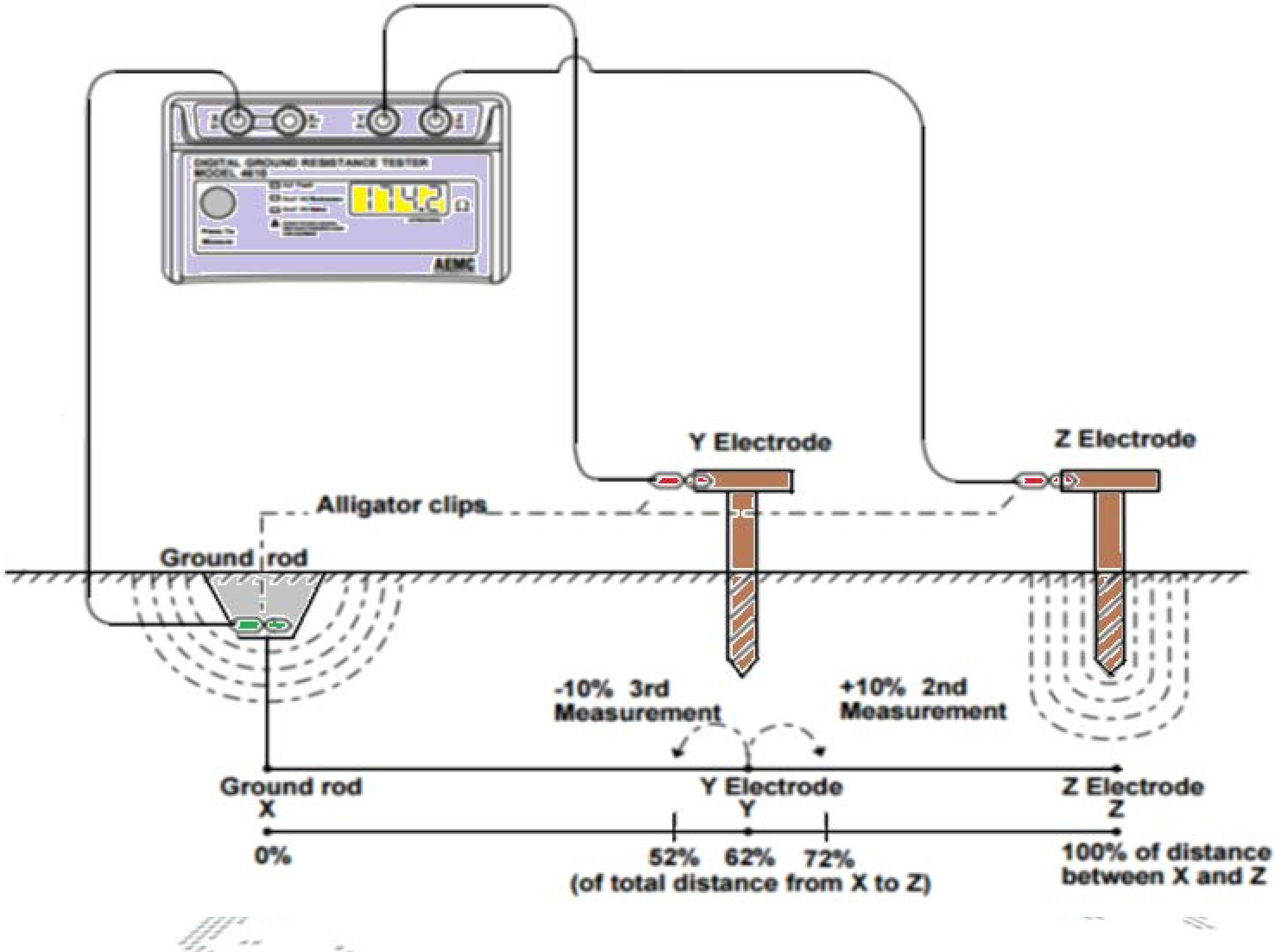
On a Single Electrode

* **Minimum Distance = 5 Times the Length of the Rod**
* **Ideal? = 10 Times the Length of the Rod**

@ 10FT Rod, Current Probe = 100Feet Away

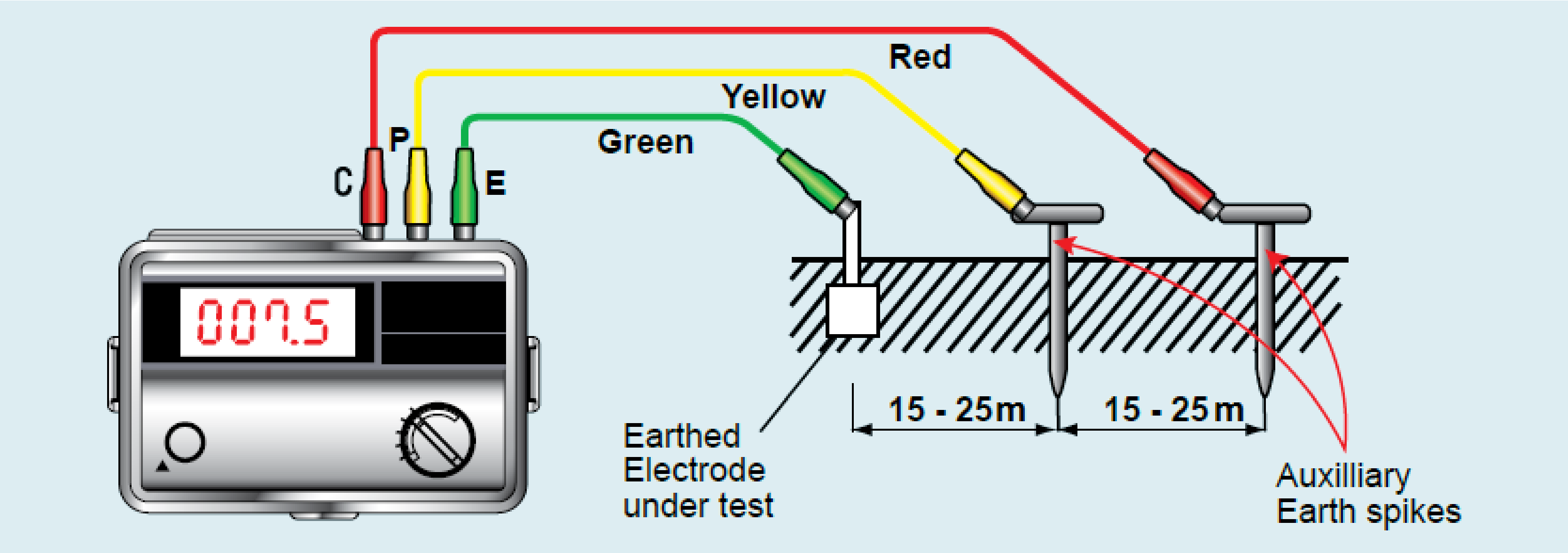
Note: In numerous test on soil with uniform soil resistivity it has been found that ground's resistance is at around 62% (some documents says at 61.8%) away from the rod under test!! **Hence Fall of Potential Method is also known as 62% Method of Ground Resistance Testing.**

6. Testing - Option 1 = Fall Of Potential Method



6. Testing - Option 1 = Fall Of Potential Method

Method 1: measurement using dedicated Earth Electrode tester



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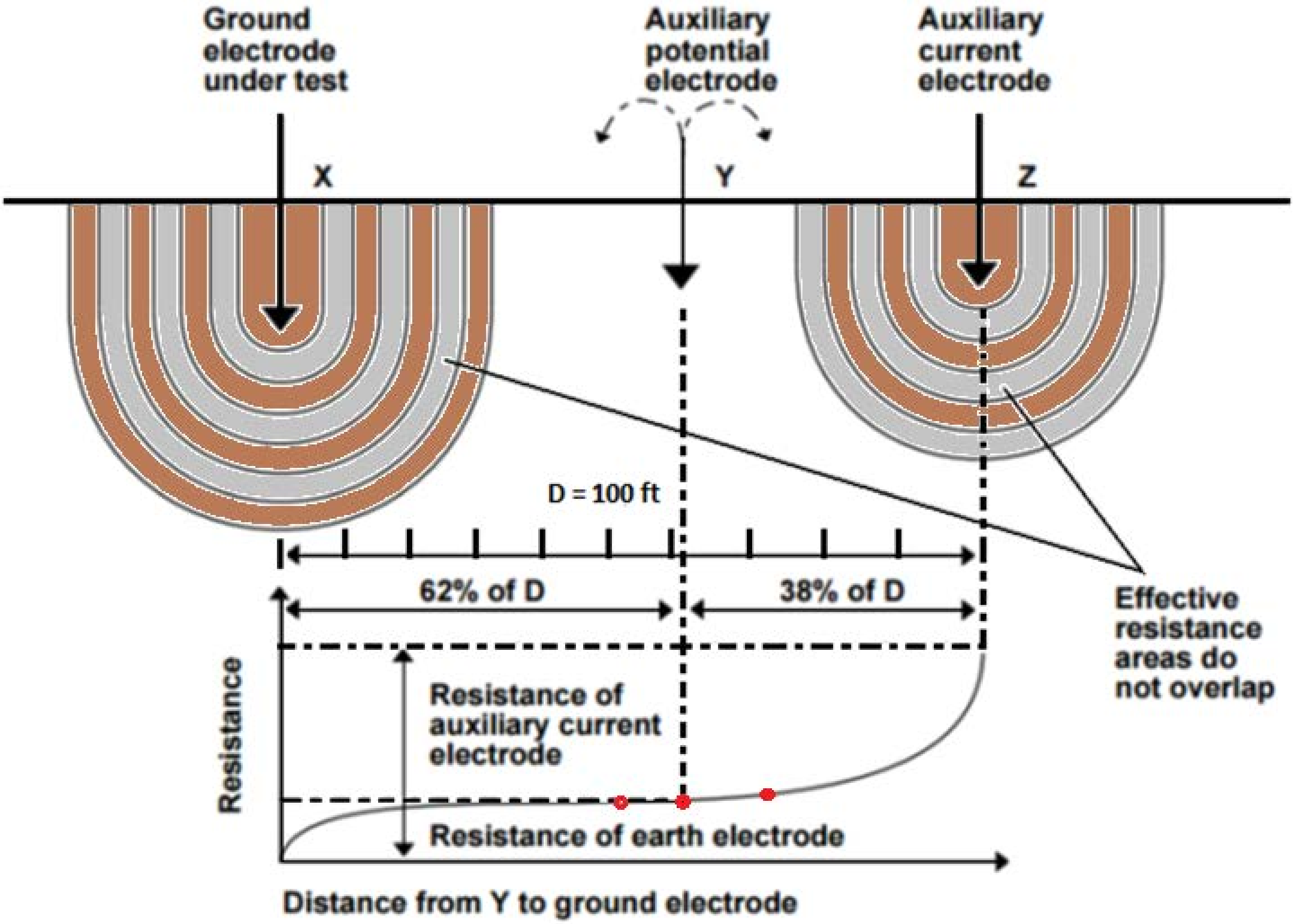

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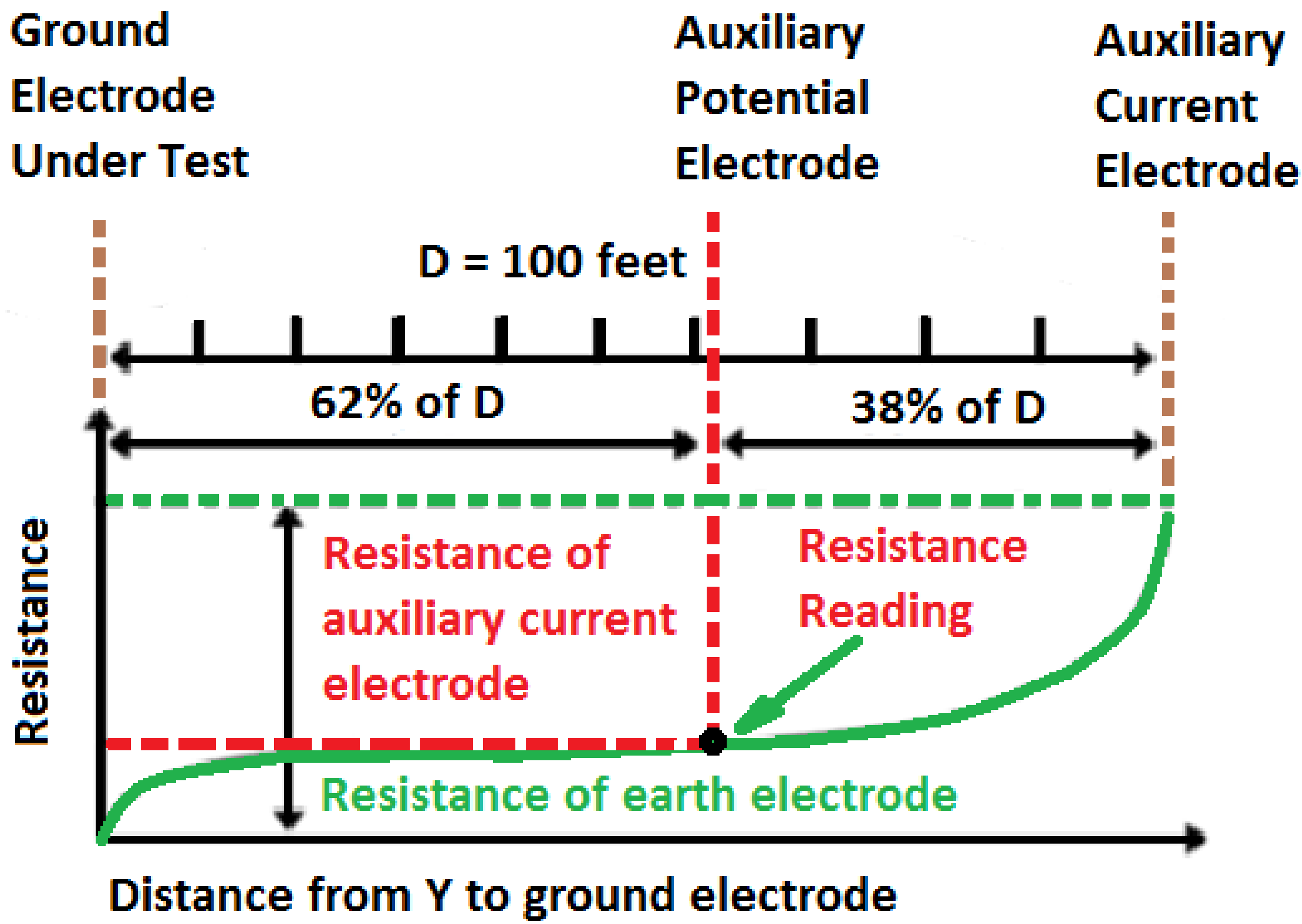

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6. Testing - Option 2 = Clamp-on Testing

Clamp-on Ground Resistance Meter

* Does Not Require Disconnecting Equipment
* Measures Current on the Ground to get Ground Resistance,
* Referenced with Pole Butt Proper and consistent resistance, and
* Very Convenient, Quick & Easy

However, it may read Ground Loops instead of Ground Resistance!!

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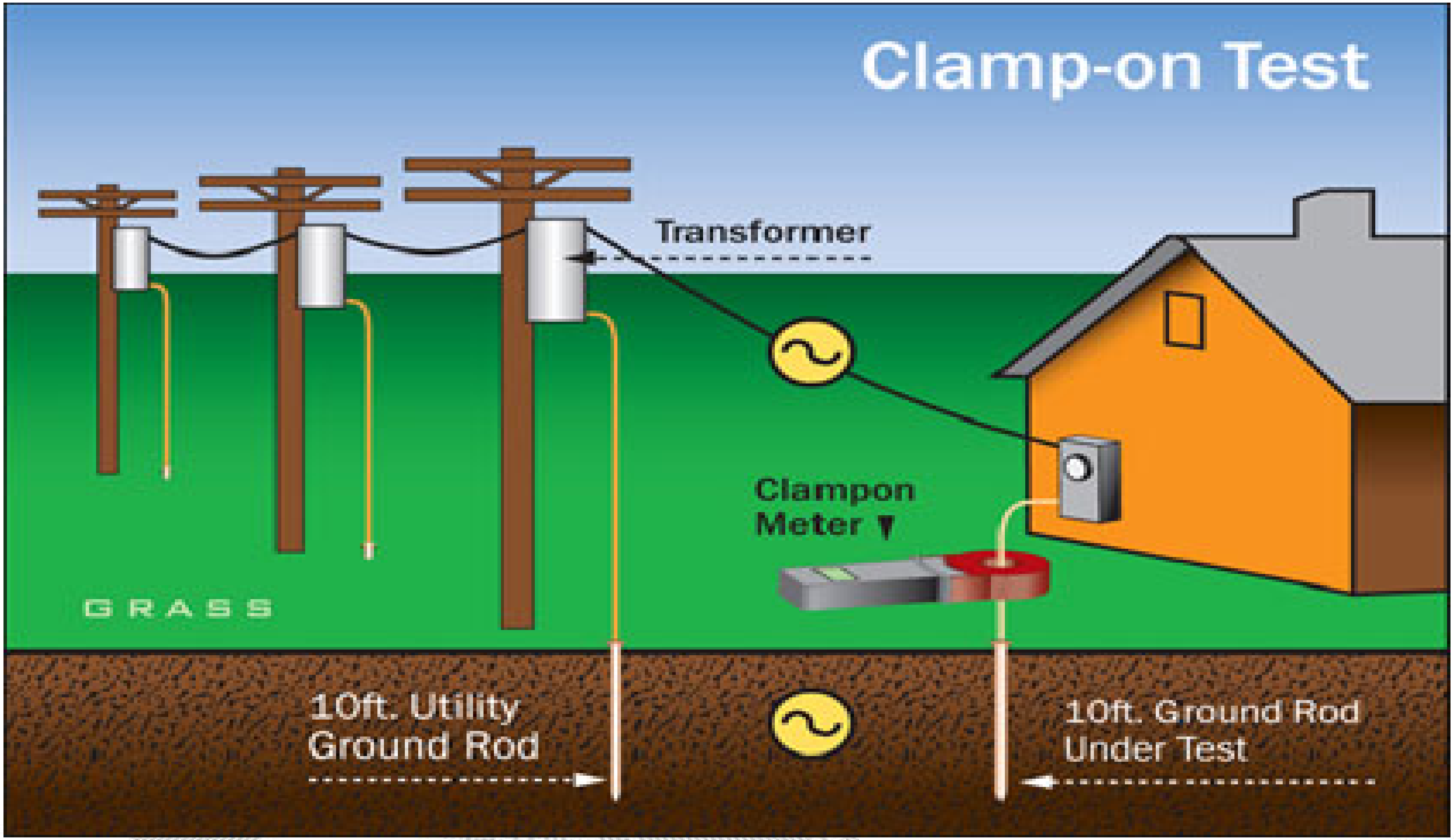
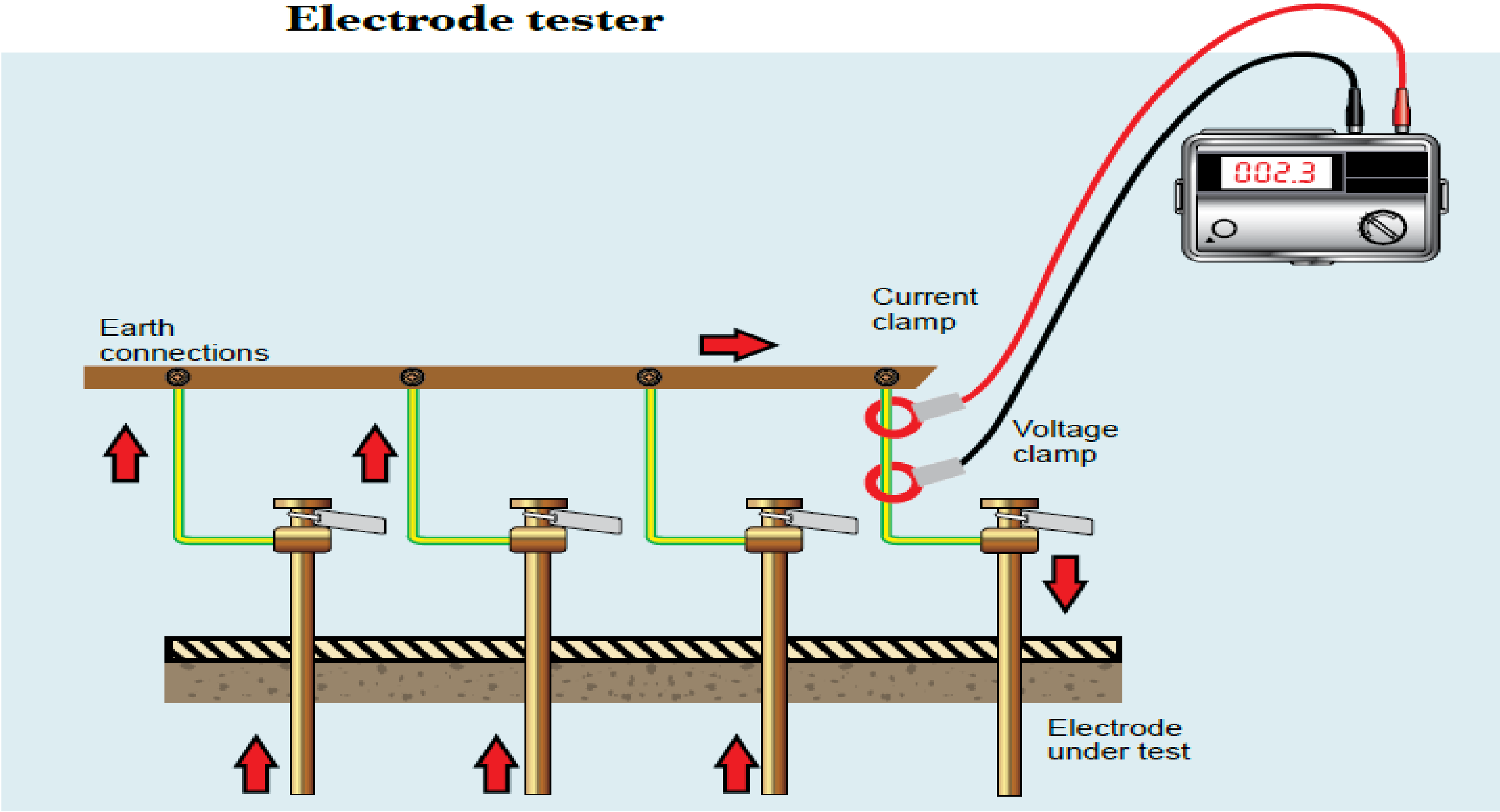
6. Testing - Option 2 = Clamp-on Testing



6. Testing - Option 2 = Clamp-on Testing

Method 2: measurement using dedicated stakeless Earth Electrode tester



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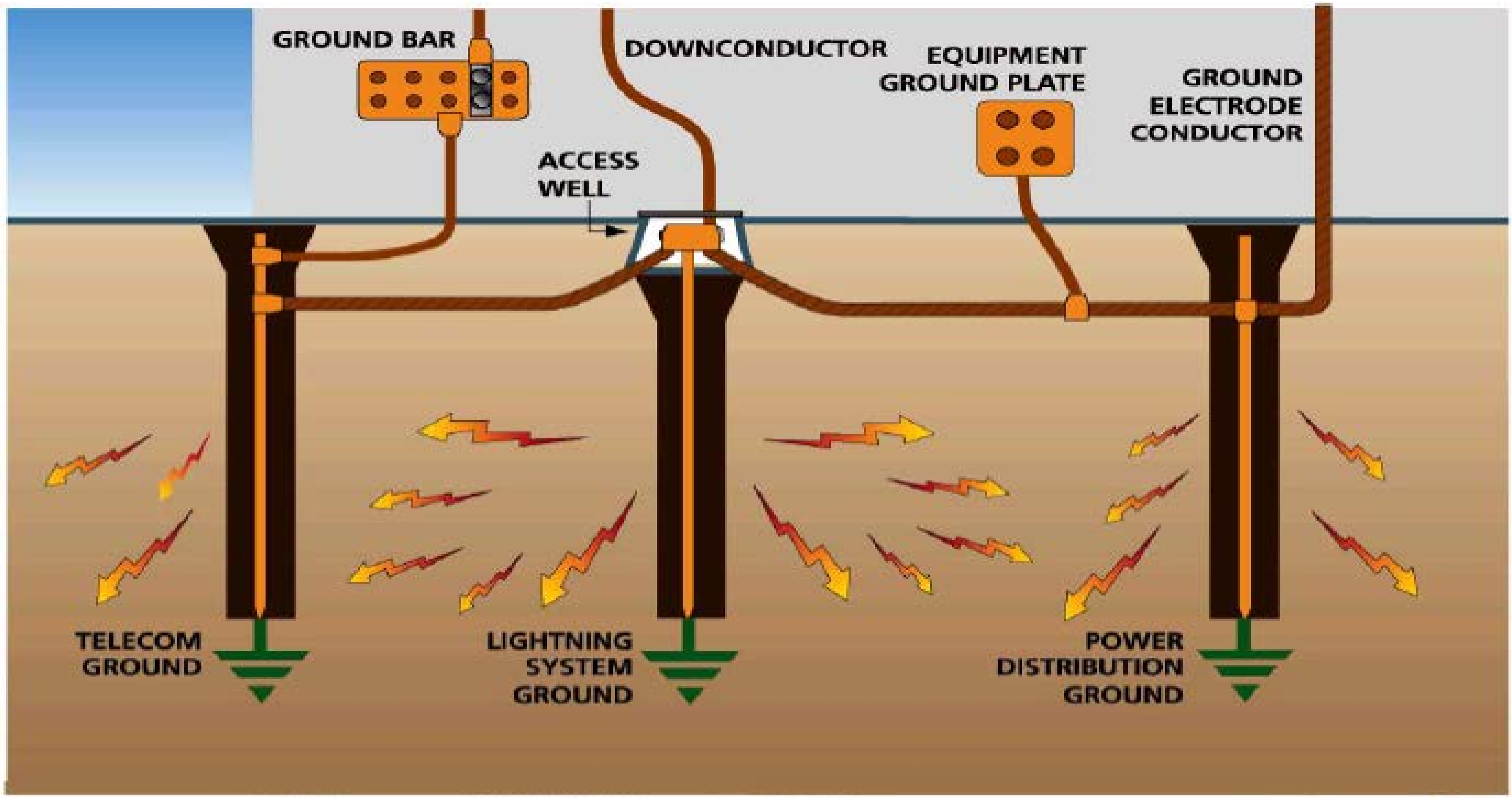
7. Bond it Together - Follow the Codes

NFPA 70:2017
Art 800 Communication Circuits
Section: 800.100(D)

Bonding of Electrodes. A bonding jumper not smaller than **6AWG (14mm2)** copper or equivalent shall be connected between the communications grounding electrode and power grounding electrode system at the building or structure served where separate electrodes are used.

7. The Key? – Just Bond It Together!



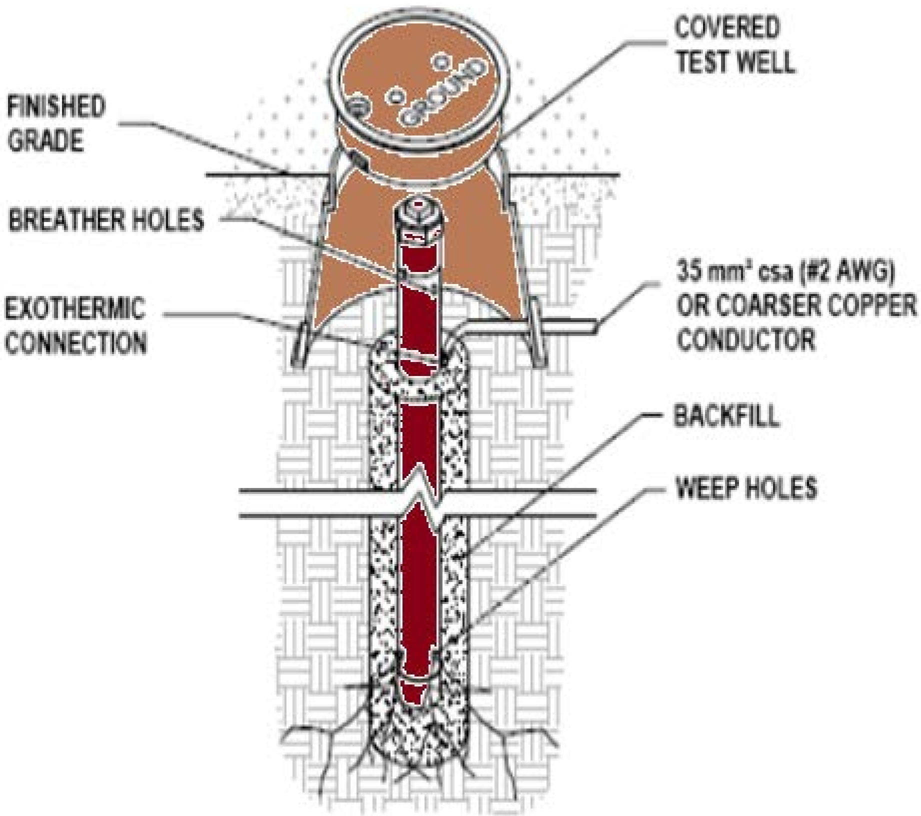
8. Area with Poor Soil Conductivity

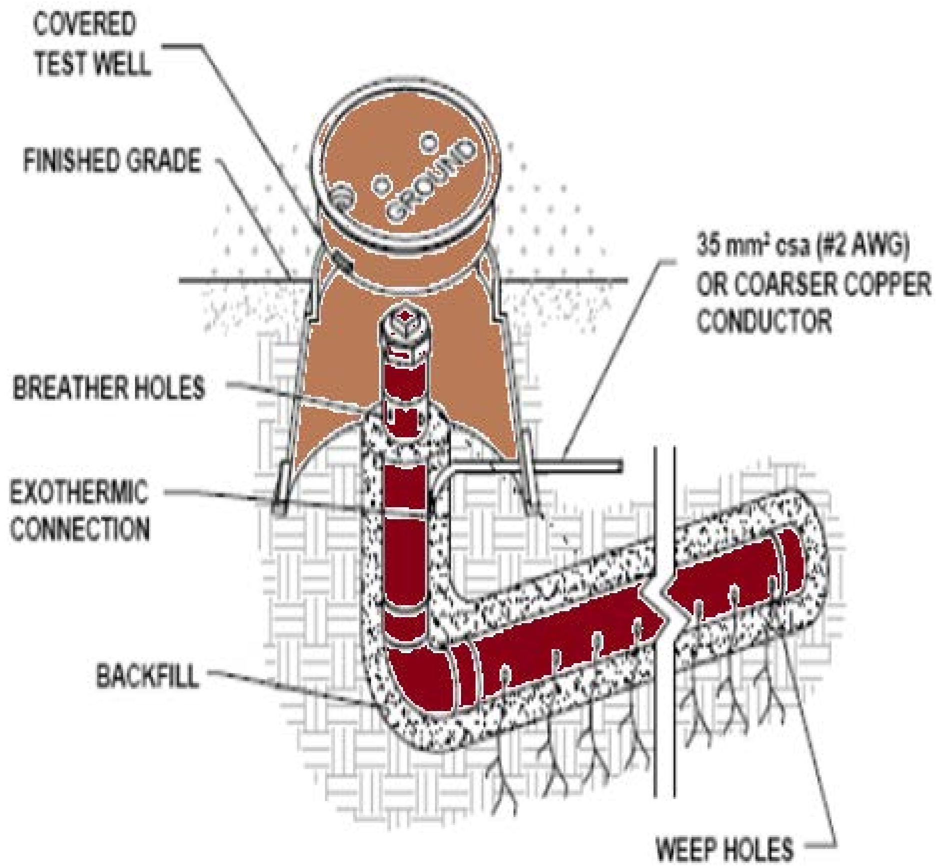
Option 1: Electrolytic Grounding Rod Systems

- **Commercially available electrolytic ground rods should be considered.** (MIL-HDBK-419A Volume I, and UL 467-2013)
- **These are in straight or L-shaped versions. Generally constructed of 54 mm (2.125 in.) dia. hollow copper pipe and filled with a mixture of non-hazardous natural earth salts.**
- **Holes on the pipe allow moisture to be hygroscopically extracted from the air into the salt within the pipe, hence forming conductive electrolytes and leach out from the pipe into the soil, thus improving soil conductivity.**
- **Electrolytic ground rods are inserted into a pre-drilled hole, or in the case of L-shaped rods, placed into a trench at least 762 mm (30 in.) deep, and encased in a grounding electrode encasement material.**

8. Area with Poor Soil Conductivity

Option 1: Electrolytic Grounding Rod Systems





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8. Area with Poor Soil Conductivity

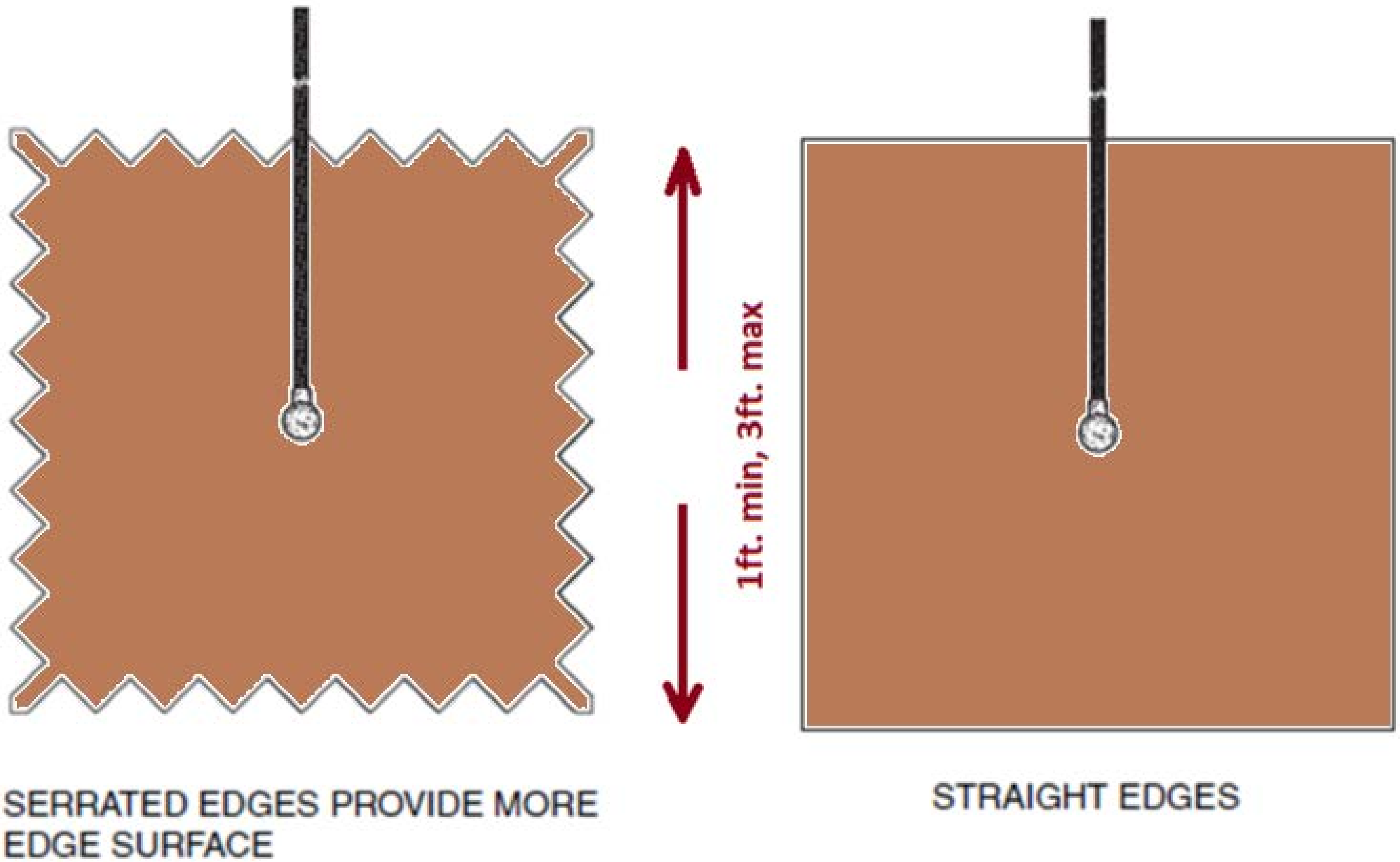
Option 2: Copper Plates Grounding Systems

Requirements and use of ground plate electrodes are as follows:

- Ground Plates shall be UL listed using copper or copper-clad steel plates.
- It shall expose not less than 0.37 m2 (2 sq.ft.) of surface to exterior soil (MIL-HDBK-419A, NFPA 70-2017, & NFPA 780-2017).
- It shall have a minimum thickness of 1.5 mm (0.06 in.) (MIL-HDBK-419A, & NFPA 70-2017).
- Ground plates shall be free of paint or other nonconductive coatings (NFPA 70-2017, & NFPA 780-2017).
- It shall be buried not less than 762 mm (30 in.) below the surface of the earth (NFPA 70-2017).
- Where practical, a ground plate shall be embedded below permanent moisture level (BS 7430:1998, & NFPA 70-2017).
- Ground plates should be installed vertically to allow for minimum excavation and better contact with the soil when backfilling (BS 7430:1998 and IEEE STD 142-1991)

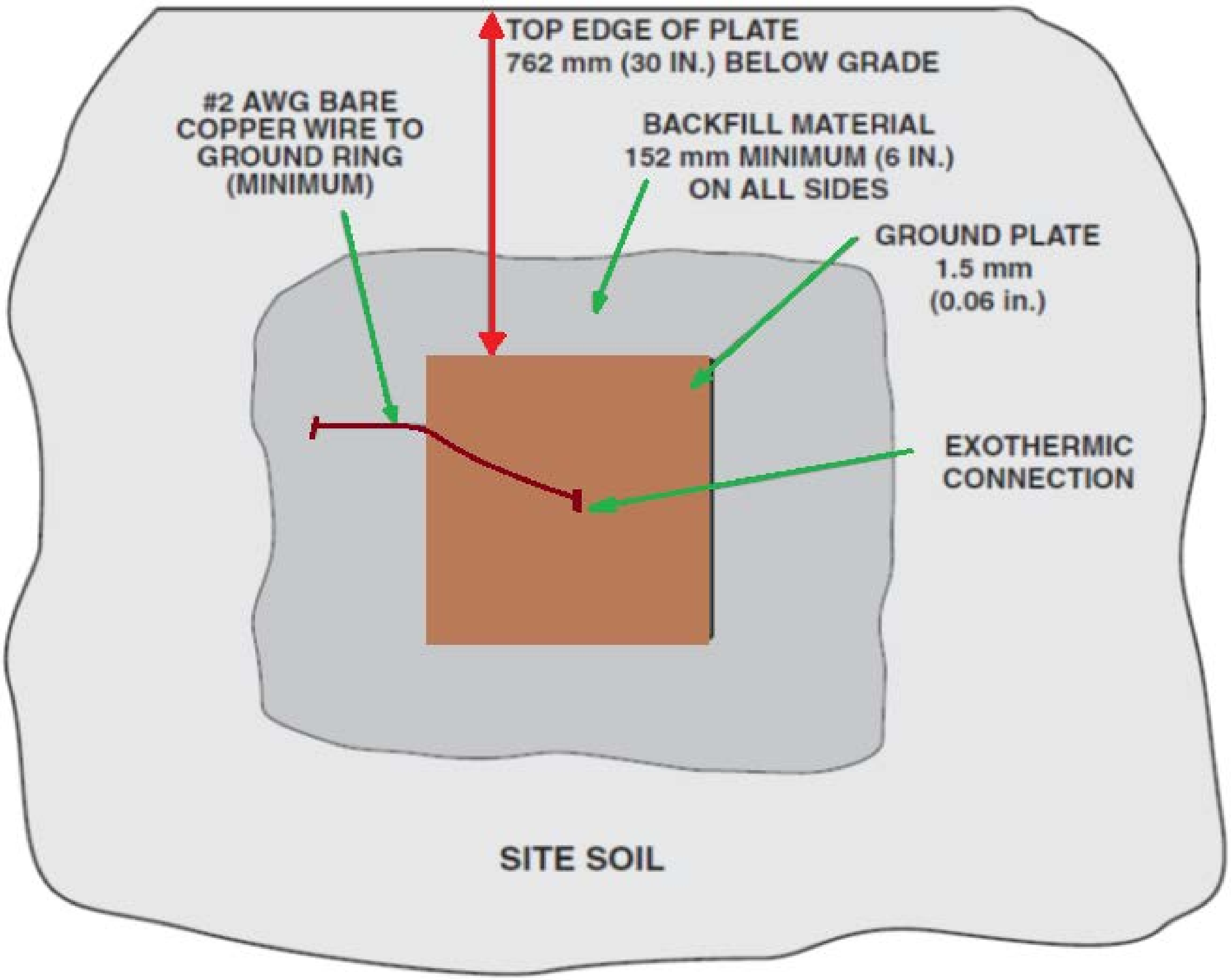
8. Area with Poor Soil Conductivity

Option 2: Copper Plates Grounding Systems



8. Area with Poor Soil Conductivity

Option 2: Copper Plates Grounding Systems



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8. Area with Poor Soil Conductivity

Option 3: Ufer Grounding Systems

- Though concrete-encased electrodes (also known as Ufer electrodes, or foundation earth electrodes - named after Herbert G. Ufer,), they should be used in new construction as a method of supplementing the grounding electrode system (IEC 62305-3).

- It enhance the effectiveness of the grounding electrode system in two ways:

  * the concrete absorbs and retains moisture from the surrounding soil, and
  * the concrete provides a much larger surface area in direct contact with the surrounding soil. (This is especially helpful at sites with limited area for installing a grounding electrode system).

- See IEEE STD 142-1991 section 4.2.3, and the International Association of Electrical Inspectors publication, Soares Book on Grounding and Bonding, 9th Edition, for added information.

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8. Area with Poor Soil Conductivity

Option 3: Ufer Grounding Systems

Requirements for a concrete encased electrode, if used, are listed as follows (IEC 62305-3, NFPA 70-2017, and NFPA 780-2017):

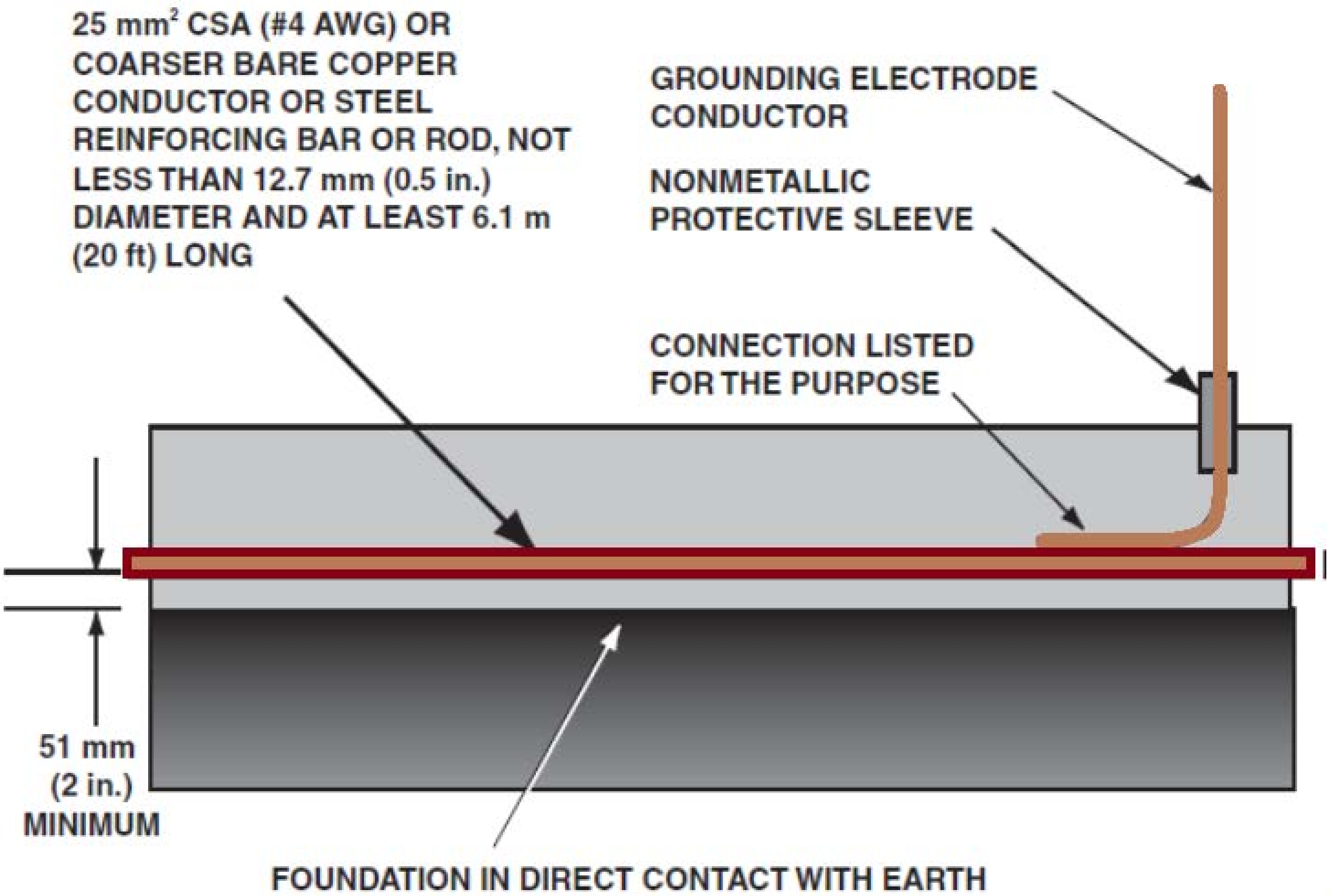
- Concrete-encased electrodes shall be encased by at least 51 mm (2 in.) of concrete, located within and near the bottom of a concrete foundation or footing that is in direct contact with the earth (or ground).

- It shall be at least 6.1 m (20 ft.) of bare copper conductor not smaller than 25 mm2 (#4 AWG) or at least 6.1 m (20 ft.) of one or more bare or zinc galvanized or other conductive coated steel reinforcing bars, or rods at least 12.7 mm (0.5 in.) in diameter.

- And, shall be bonded to any other grounding electrode system at the site as per NFPA 70-2017.

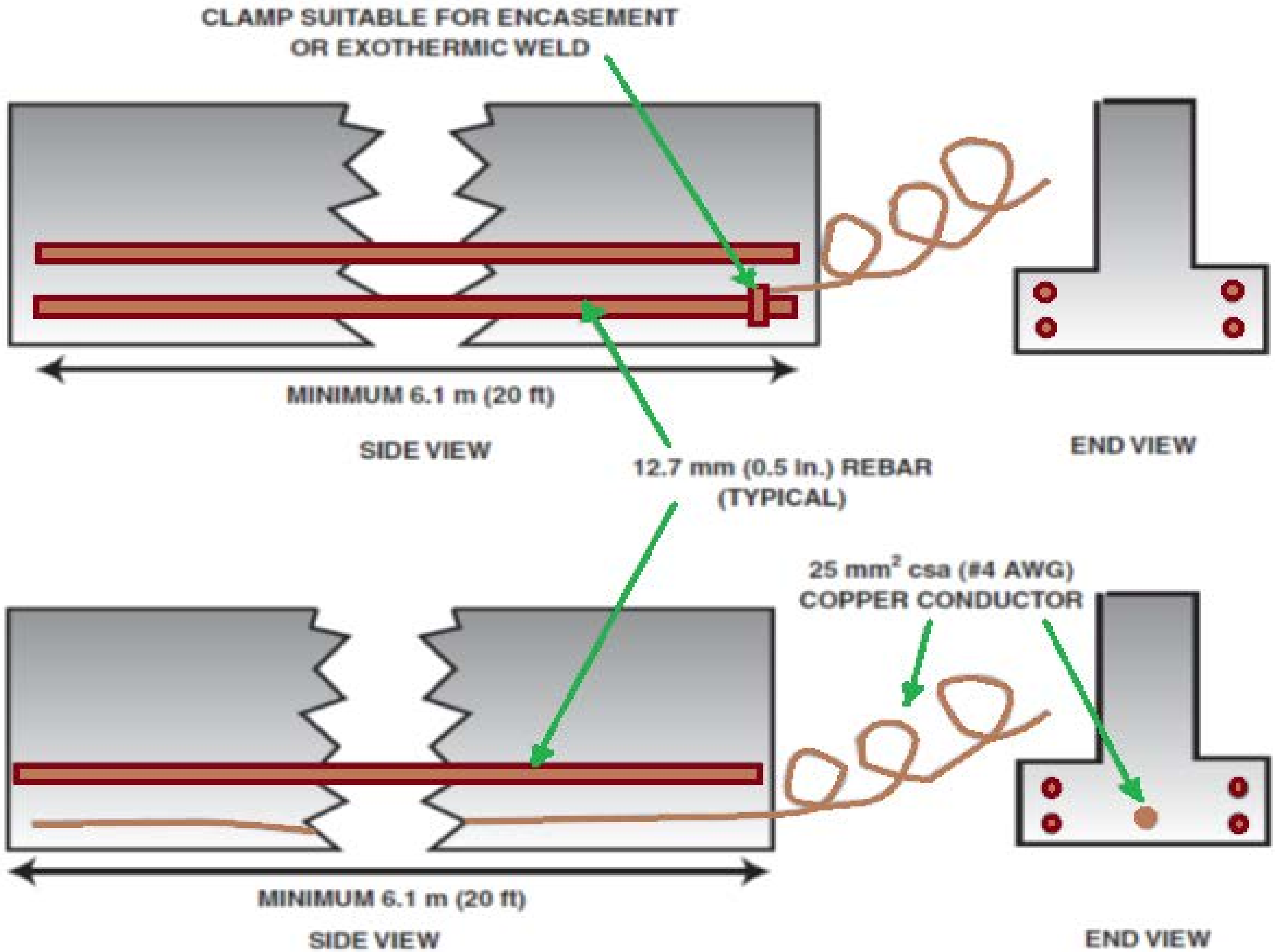
8. Area with Poor Soil Conductivity

Option 3: Ufer Grounding Systems



8. Area with Poor Soil Conductivity

Option 3: Ufer Grounding Systems



9. Reading References for Grounding & Bonding Specially on Areas with Poor Conductivity Soil Conditions

BS 7430:2011 (Code of Practice for Protective Earthing of Electrical Installations)

ISO/IEC 62305-3 (Protection of Structure Against Lightning)

IEEE 142:2007 (Green Book – Grounding of Industrial & Commercial Power Systems)

Motorola R56 (Standards & Guidelines for Communication Sites)

MIL-HDBK-419A (Military Handbook Grounding, Bonding & Shielding for Electronic Equipment & Facilities)

MIL-UFC-3-580-01:2016 (Military Unified Facility Command Telecommunications Interior Infrastructure Planning & Design)

MIL-I3A Standard 2010 (Military Technical Criteria for the Installation Information Infrastructure & Architecture)

UL – 469:2013 (Grounding & Bonding Equipment)

10. Where to Buy Codes and Manuals mentioned

www.bicsi.org

www.iso.org

www.global.ihs.com

www.tiaonline.org

Thanks a lot

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