# Grounding and Bonding

*Georgia Power*

# Why Ground?

Following up after a major storm event Field Meter Tech arrived on site to investigate Form 2S meter reporting low phase to phase voltage (124 volts). The meter should normally report 240 volts.

Upon arrival he noted that recently a tree had fallen and possibly pulled down the service. (he found out later an out of state crew had pulled the cut in back up and re-attached the service)

While performing a socket check-out he found 119 volts from left hot leg to neutral

He found 242 volts from right hot leg to neutral.


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At that point he had an uneasy feeling something was very wrong. He stuck a piece of #6 solid copper wire into the ground and measured from neutral to the copper wire and got 84.2 volts. THE SOCKET ENCLOSURE WAS ENERGIZED!

When the crew pulled the service back up they squeezed the socket neutral conductor to a hot leg at the mast. And it held! No fuses were blown.


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The neutral and one energized phase had been mistakenly crossed. This created a very unsafe situation as the socket and mast were energized at 120 volts. The home was vacant at the time.

We do not know if the premise suffered any property damage due to the voltage issue. As you can see, the socket has grounding to a driven ground rod. This was in a coastal area with very sandy soil. Evidently the grounding was not good enough to blow a fuse and clear this up.

# Why Ground?

**Safety**

Protecting person and property from injury and damage

Equipment and Protection

Facilitate the operation of protective devices before damage occurs

Digital Stability

Ensure the integrity of digital systems and reliability of data

# True or False?

- *Electrons take the path of least resistance.*

  The truth is that electrons will take every available path. (i.e. the human body, the surface of meter enclosures, etc.)

- *Electrons leaving a power supply are trying to flow to earth.*

  The truth is that electrons are trying to return to the power supply, not the earth. Electrons will use the earth as one path if given the opportunity.

- *The earth is a good conductor.*

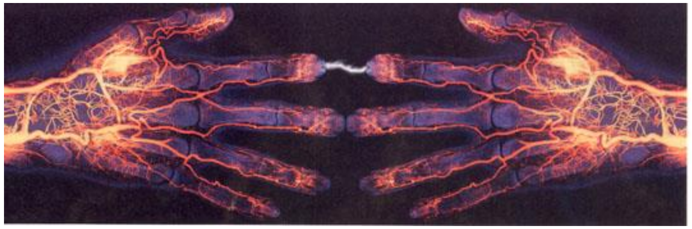
  The truth is that the earth is often a very poor conductor. It is difficult for the earth to conduct enough current to clear a phase to ground fault.

# FACTS

- *Current will always return to the source*

- *Current will return in all paths that are available*

- *The amount of Current on a particular path depends on the impedance of that path*



## Shock

***Current*, *Not Voltage* causes Electric Shock**

- **0.5 - 3 mA** - Tingling sensations
- **3 - 10 mA** - Muscle contractions and pain
- **10 - 40 mA** - “Let-go” threshold
- **30 - 75 mA** - Respiratory paralysis
- **100 - 200 mA** - Ventricular fibrillation
- **200 - 500 mA** - Heart clamps tight
- **1500 + mA** - Tissue and Organs start to burn

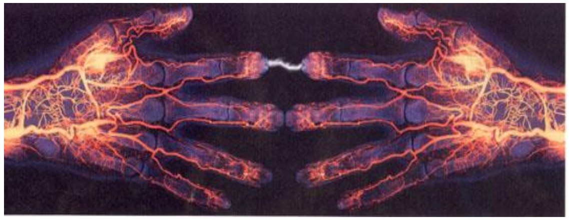
Electrical Hazards

***Note: Reaction will vary with frequency and time of exposure***

# Safety BASICs ™

By Bussmann

Electrical Hazards



## Shock

- **Human body resistance (hand to hand) across the body is about 1000Ω**

**Ohms Law: I = V / R (Amps.)**

I = 480 volts / 1000 Ω

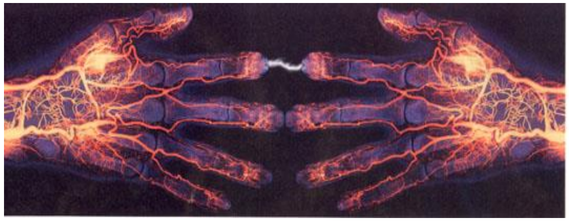
= **0.48 amps (480 mA)**

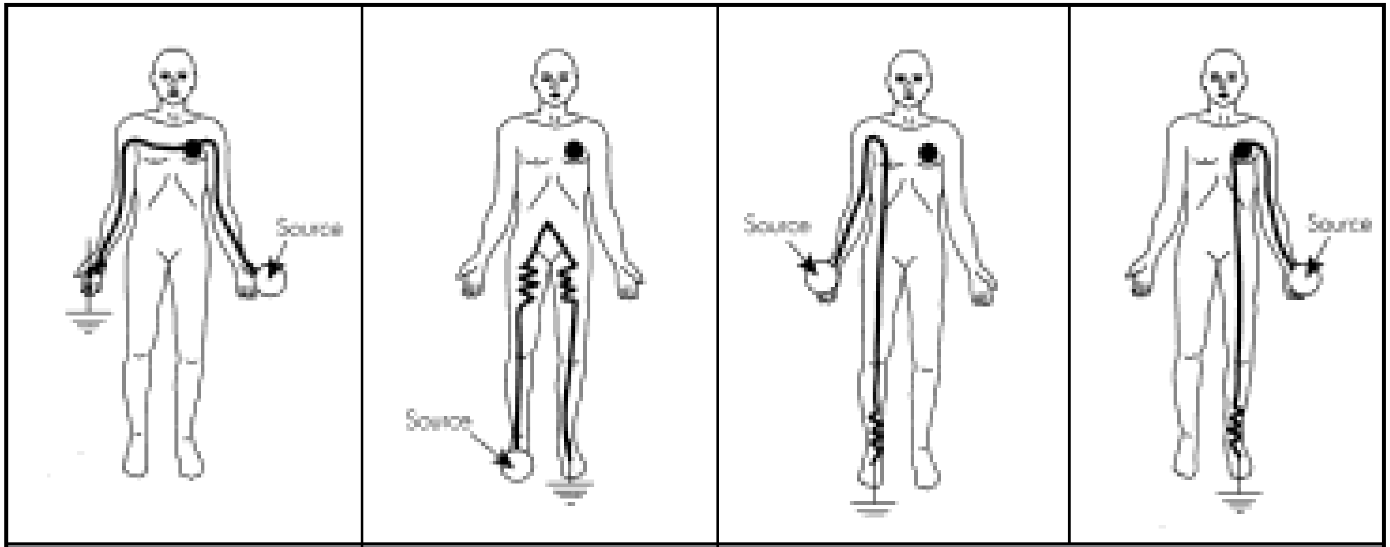
**The National Electrical Code® considers 5 mA to be the safe upper limit for children and adults.**

# Safety BASICs ™

Electrical Hazards

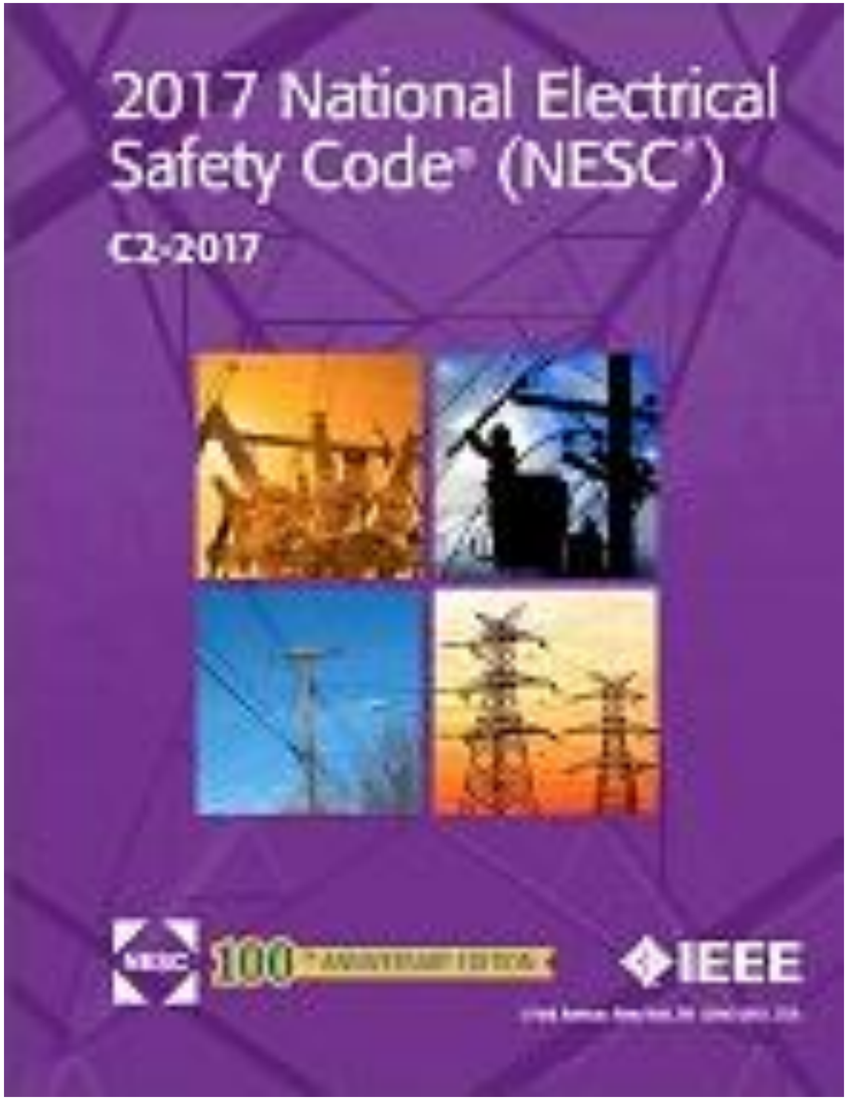
## Current Pathways



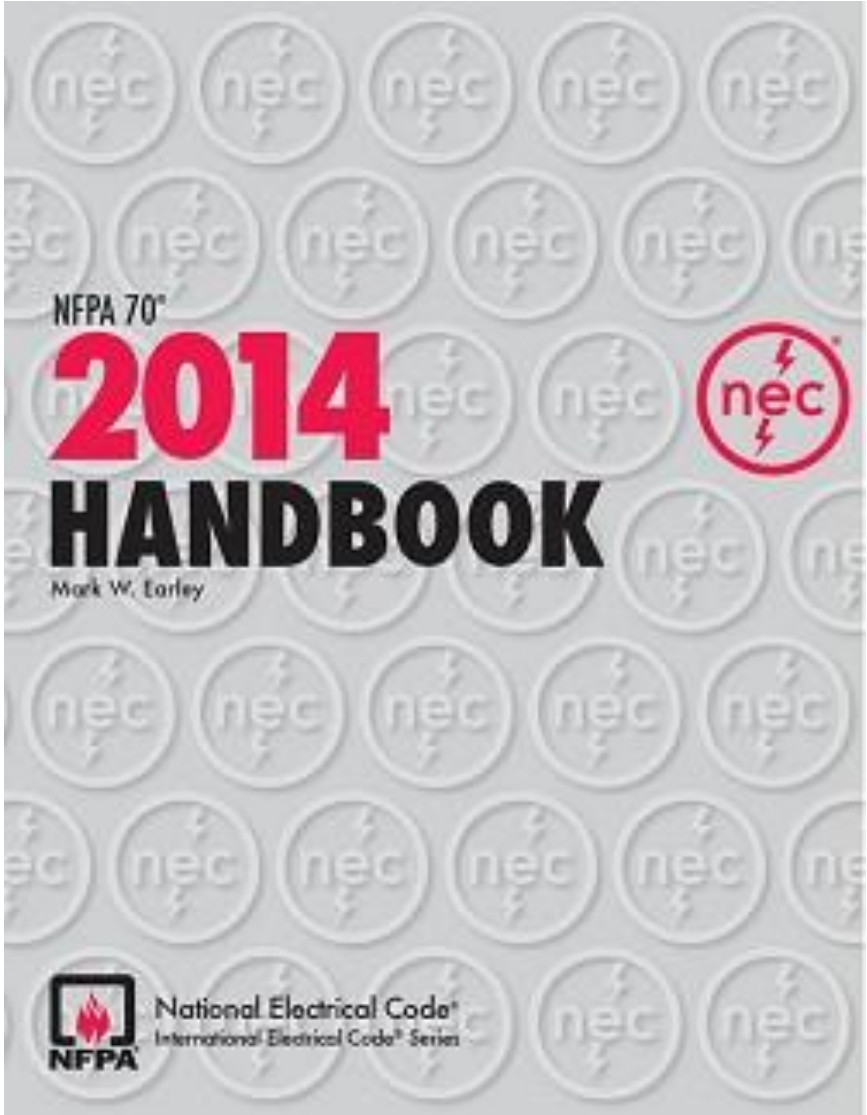



| (A) Touch Potential | (B) Step Potential | (C and D) Touch / Step Potential |
|---|---|---|

***Current passing through the heart and lungs is the most serious***




- **Published by IEEE**
- **Revised on a 5 year cycle**
- **Covers utility facilities and functions up to the service point**
- **Purpose is the safeguarding of persons** (employees & public) during the installation, operation, or maintenance of electric supply and communication lines and associated equipment
- **Grounding Requirements:**
    - Primary & Secondary Neutrals Connected
    - Neutral connected to Ground Rod at every Transformer and sufficient other points to have at least 4 grounds per mile.




- Published by NFPA
- Revised on a 3 year cycle
- Covers Customer wiring systems
- Article 250 covers the grounding and bonding requirements for protection against fire hazards and to assure personnel safety from electrocution.
- Requirements include the Equipment Grounding (bonding) System, and the Grounding Electrode System (earth ground)

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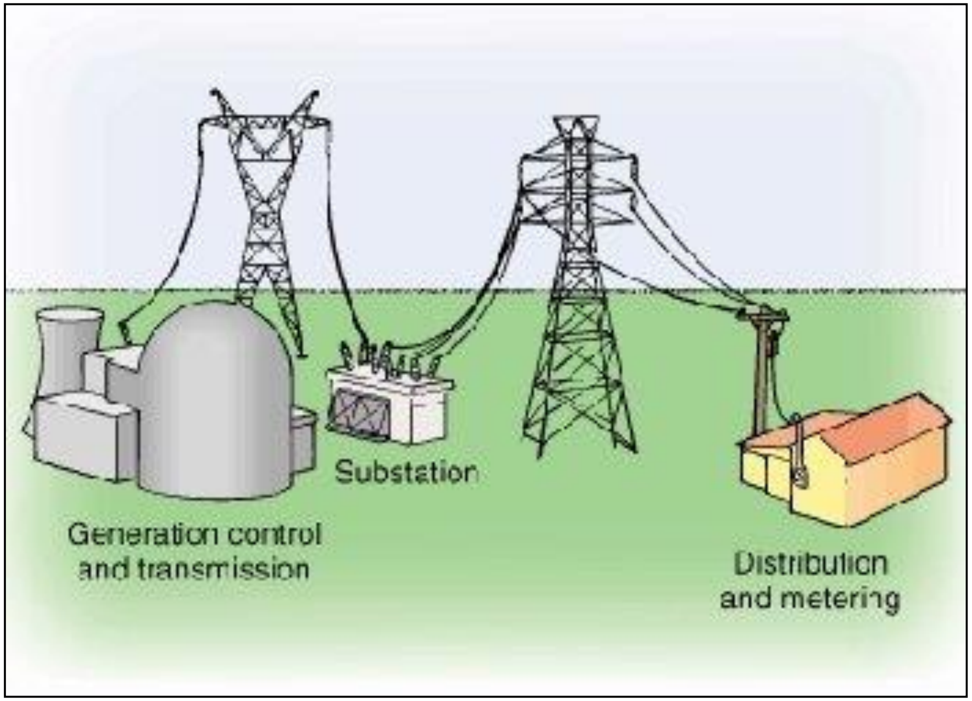
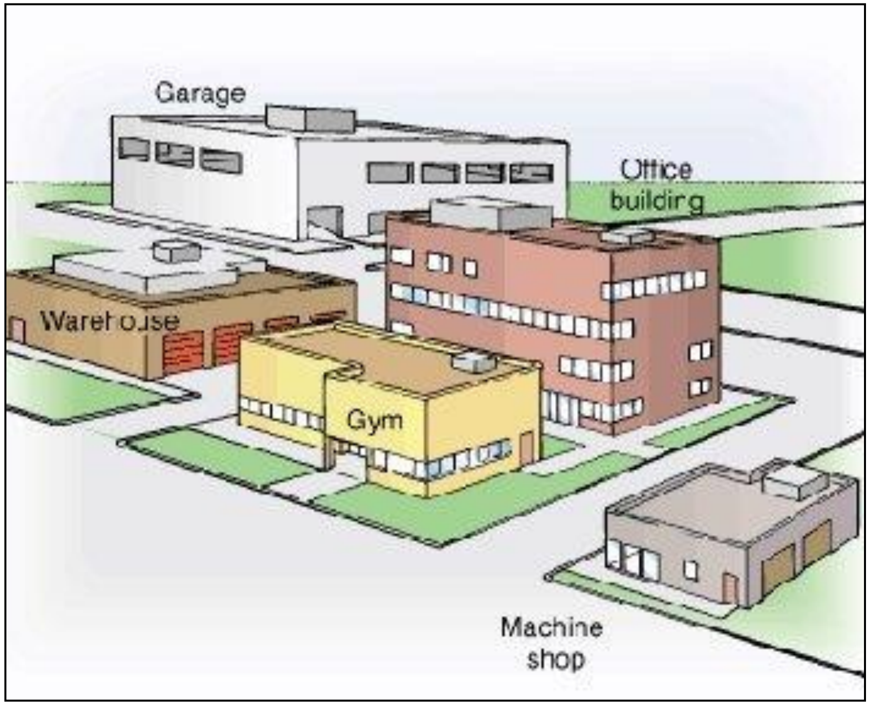
# NESC vs. NEC




**Utility System**
**Covered by NESC**

(The electrical system in the USA is a solidly multi-grounded system.)

**Customer Wiring Systems**
**Covered by NEC**

(Most customer wiring systems are solidly grounded systems, but may also be ungrounded or high impedance grounded.)

(Both NEC and NESC may apply in industrial complex or multi-building complex)

# Definitions

(NEC, Article 100 – Definitions)

Bonding (Bonded). "Connected to establish electrical continuity and conductivity."

Grounded. "Connected to earth or to some conducting body that serves in place of the earth."

Ground. "The earth."

Bonding Jumper. "A reliable conductor to ensure the required electrical conductivity between metal parts required to be electrically connected."

Grounded Conductor. "A system or circuit conductor that is intentionally grounded." *(Commonly referred to as the neutral conductor. It should be white or identified with white markings.)*

Equipment Grounding Conductor. "The conductor used to connect the non-current–carrying metal parts of equipment, raceways, and other enclosures to the system grounded *(neutral)* conductor, the grounding electrode conductor, or both, at the service equipment." *(Sometimes referred to as the Bond wire. It should be green or identified with green markings.)*

Grounding Electrode Conductor. "A conductor used to connect the system grounded conductor or the equipment to a grounding electrode or to a point on the grounding electrode system."

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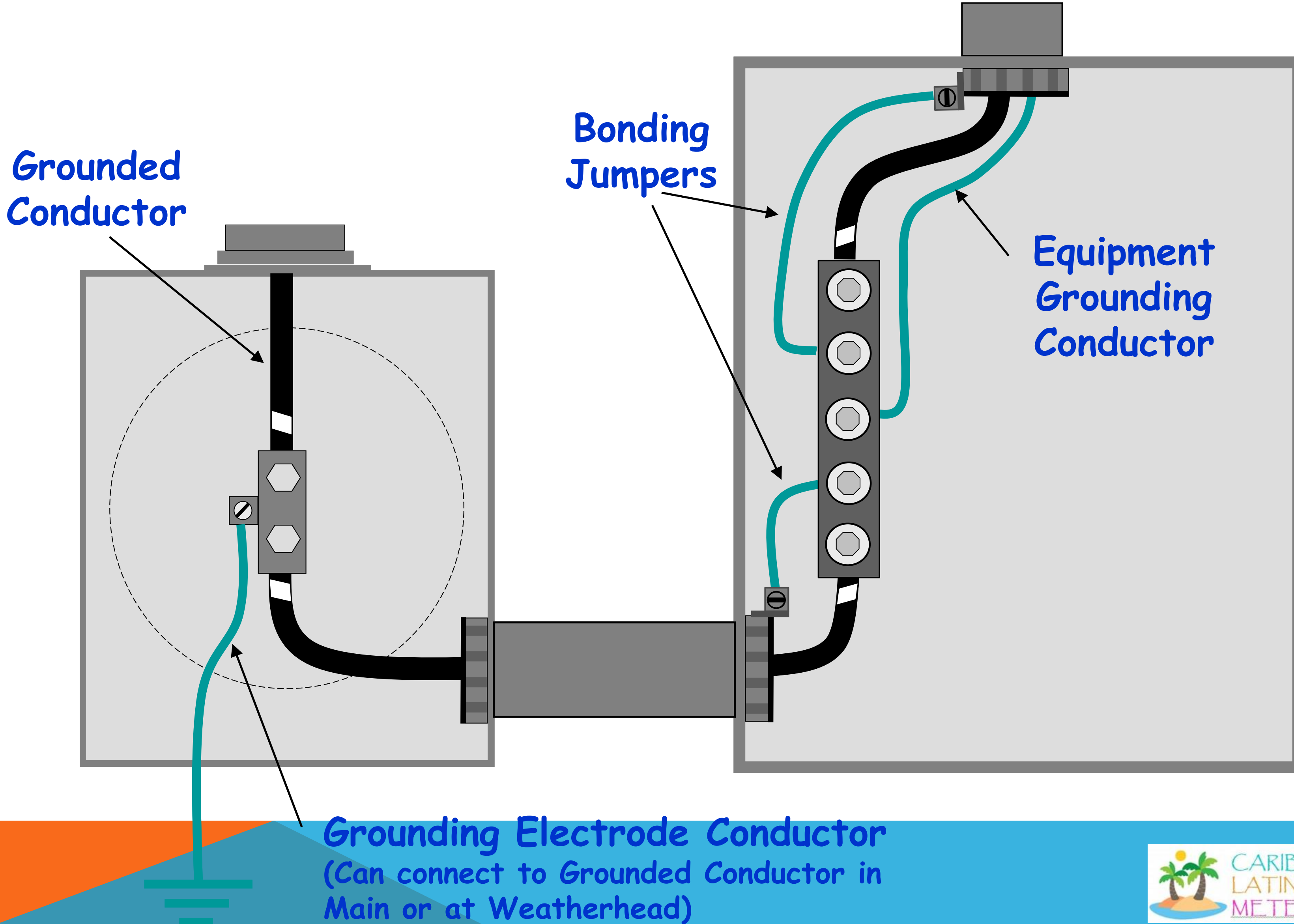
# Definitions



# The NEC differentiates between "System" and "Equipment" Grounding

- System Ground: A system ground is a connection to ground from one of the current-carrying conductors of a premises wiring system.
- Equipment Ground: An equipment ground is a connection to ground from the non-current-carrying metal parts of the wiring system and the equipment connected to the system. (Includes such metal parts as conduits, raceways, metal armor of cables, outlet boxes, cabinets, motor frames, etc.) All metal parts must be bonded together in a manner to provide an effective ground-fault current path.

NOTE: Not all systems are required to be grounded, but all systems must have equipment grounding.

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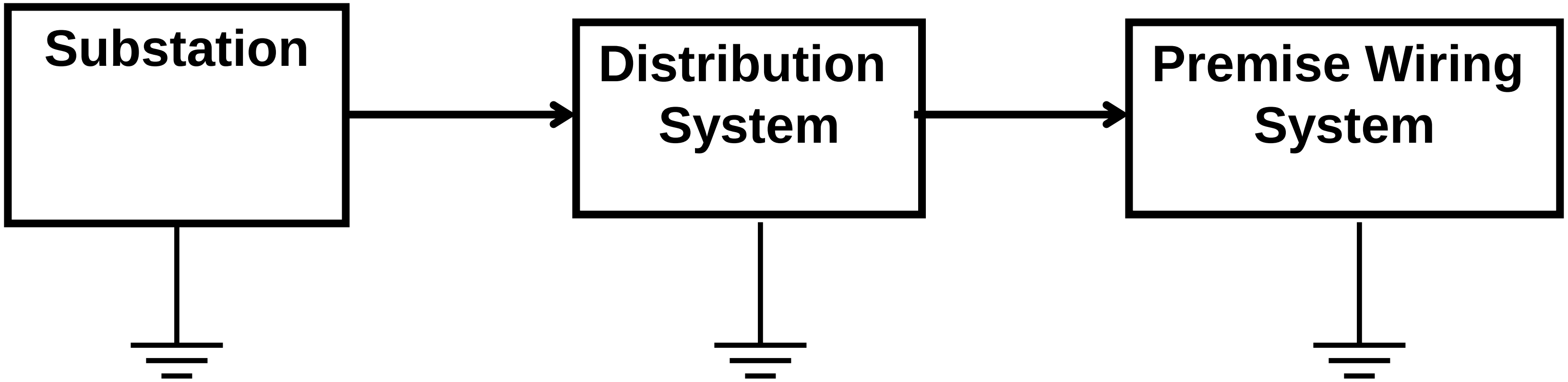
# Multi-Grounded System in the United States




**The utility can serve customer with either of 3 systems at the service point:**

**(1) solidly grounded system**

**(2) ungrounded system**

**(3) impedance grounded system**

**<u>NOTE</u>: Regardless of the type system, the customer always has a grounding electrode system plus equipment grounding!**

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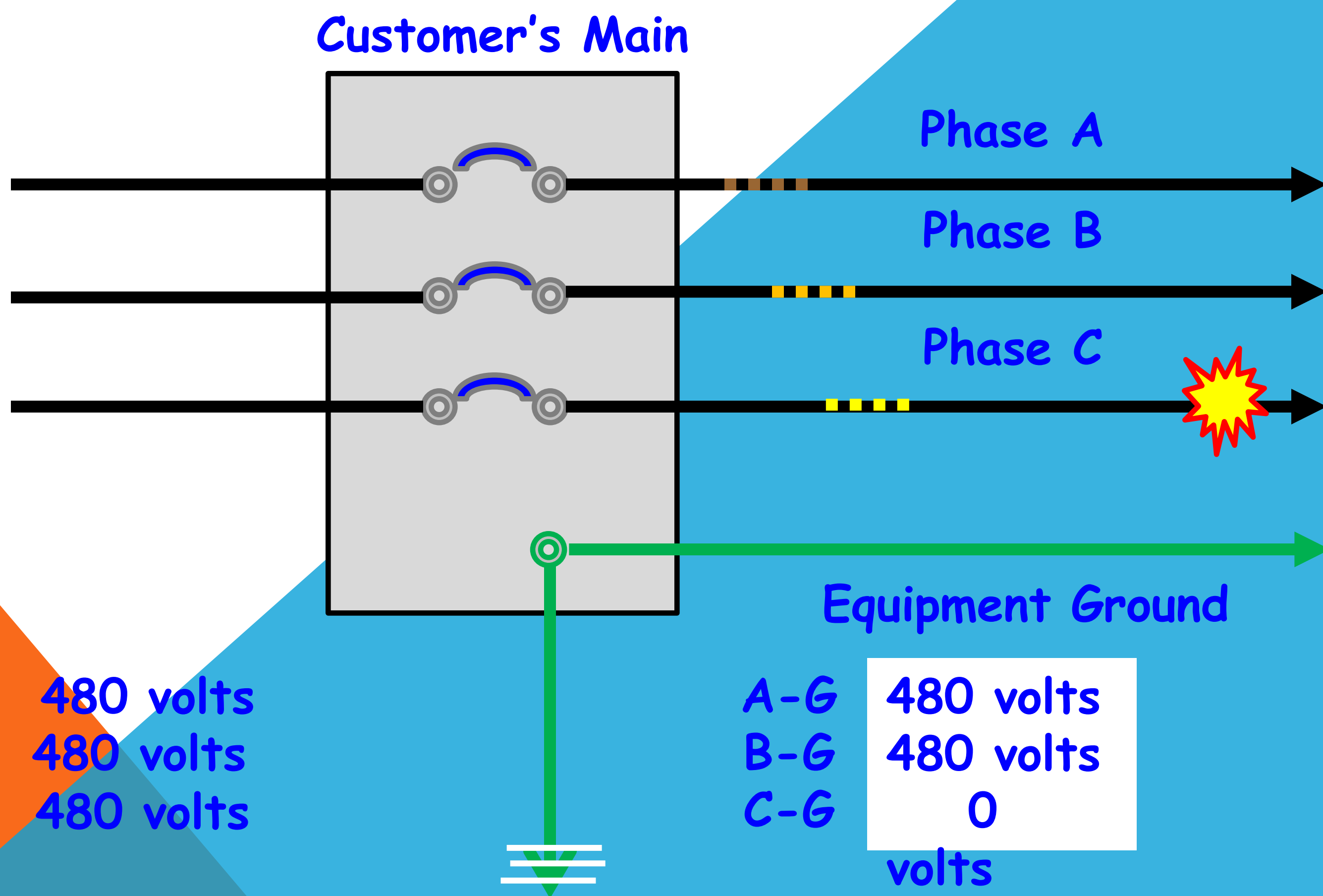
# UNGROUNDED SYSTEMS

- Definition: An ungrounded system is one in which there is no intentional connection between the conductors and earth ground.
- Advantages: The circuit may continue in operation after a ground-fault on one phase conductor. Production can continue until a convenient shutdown can be scheduled for maintenance.
- Disadvantages: A number of problems can arise when a ground-fault occurs on one phase conductor:
  - Ground-faults are difficult to locate.
  - Full line-to-line voltage will appear on the other two phases. A voltage 1.732 times the normal voltage will be present on the ungrounded phases.
  - Transient over-voltages (6 to 8 times normal) may appear from line to ground during normal switching of a circuit having a ground-fault.
  - These over-voltages may cause insulation failures at points other than the original fault which could cause a second ground-fault on another phase to occur before the first fault can be cleared. The result would be a phase-to-phase fault.

# 3 WIRE 3 PHASE UNGROUNDED SERVICE




A-B 480 volts
B-C 480 volts
C-A 480 volts

A-G 480 volts
B-G 480 volts
C-G 0 volts

# HIGH IMPEDANCE GROUNDED SYSTEMS

- Definition: A high impedance grounded system is one that has the neutral connected to ground through a resistance that will limit ground-fault current to a very low level. (Typically under 10 amps)
- Advantages: As in ungrounded systems, the circuit may continue in operation after a ground-fault on one phase conductor. By limiting the ground-fault current, the fault can be tolerated on the system until it can be located and removed. Transient over-voltages are limited during ground-faults, and faults are easier to locate.
- Disadvantages: As in ungrounded systems, the two un-faulted phases rise to the line-to-line voltage creating an increase in voltage stress on the insulation of the system. Also, as in ungrounded systems, should a second ground-fault occur on another phase before the first ground-fault is removed, a line-to-line fault is created.

# IMPEDANCE GROUNDED SYSTEMS (250.36 & 250.187)

Large industrial customers have grounding resistor banks in utility substation

Installations in 1500 - 2500 kVA range have resistors in main switchboard

Installations served from padmount transformer have to be modified

Identify transformers with special tag for maintenance/safety reasons

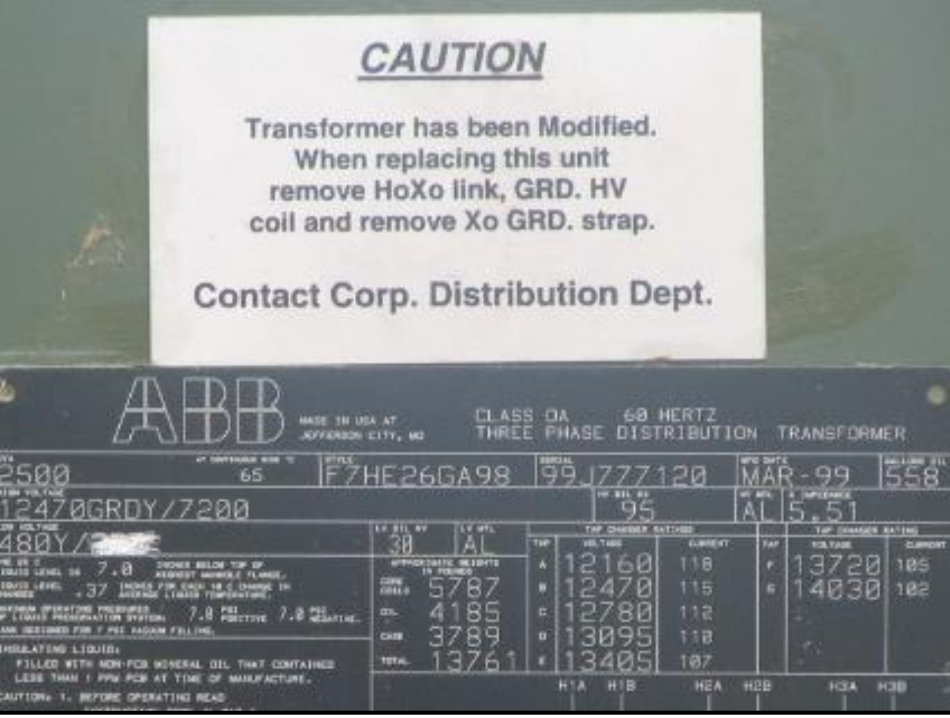
# PADMOUNT TRANSFORMERS MUST BE MODIFIED

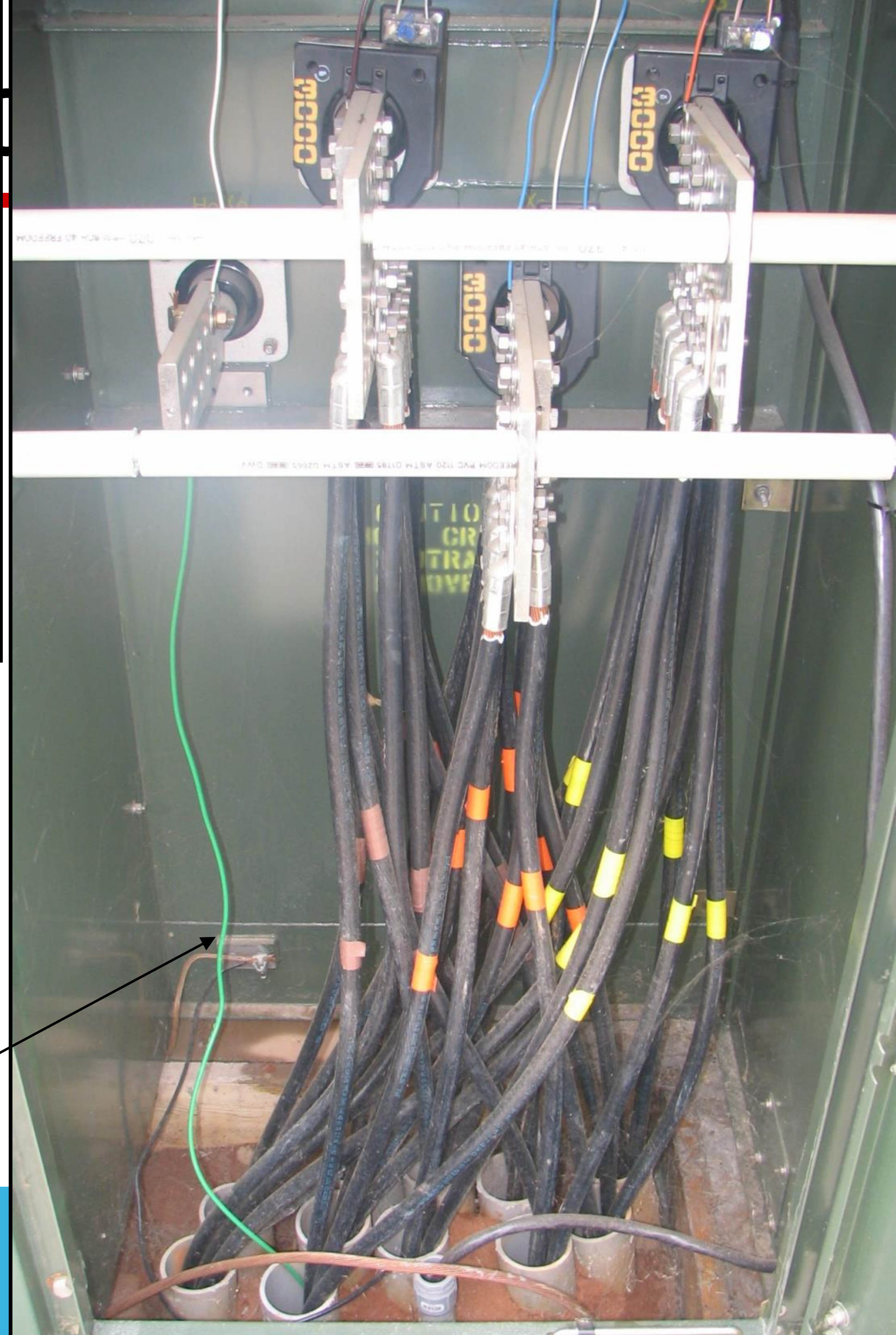
A Typical Caution Sticker is Illustrated Below

*CAUTION*

Transformer has been modified.
When replacing this unit
remove $H_oX_o$ link, GRD HV
coil and remove
$X_o$ GRD strap.

Contact Corp. Distribution Dept.



Note the small neutral conductor

**IEEE Std 242-1986 Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems**

**7.2.5** Ungrounded systems offer no advantage over high-resistance grounded systems in terms of continuity of service, and have the disadvantage of transient over-voltages, difficulty locating the first ground fault, and burn downs from a second ground fault.  For these reasons, they are being used less frequently today than high-resistance grounded systems, and existing ungrounded systems are often converted to high resistance grounded systems.

# SOLIDLY GROUNDED SYSTEMS

**A solidly grounded system is one in which the neutral points have been intentionally connected to earth ground with a conductor having no intentional impedance.**

(*Solidly grounded systems are the most common type, and the remainder of this presentation will focus on solidly ground systems.)*

**SOLIDLY GROUNDED SYSTEM** - The most common system

single phase
120/240 V

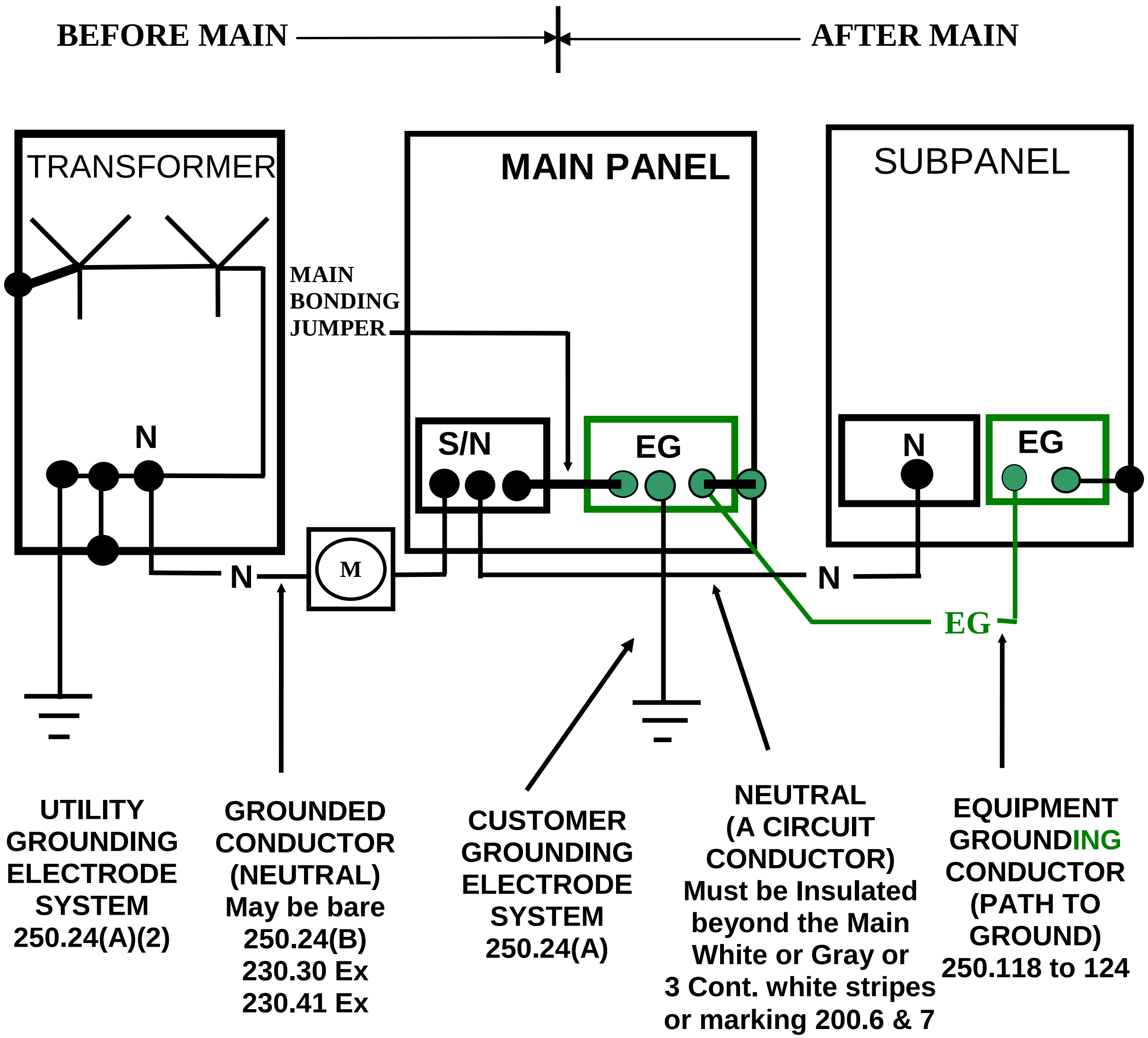
three-phase
240/120 V
208Y/120 V
480Y/277 V

special cases
600Y/346 V

Medium Voltage
4160Y2400 V

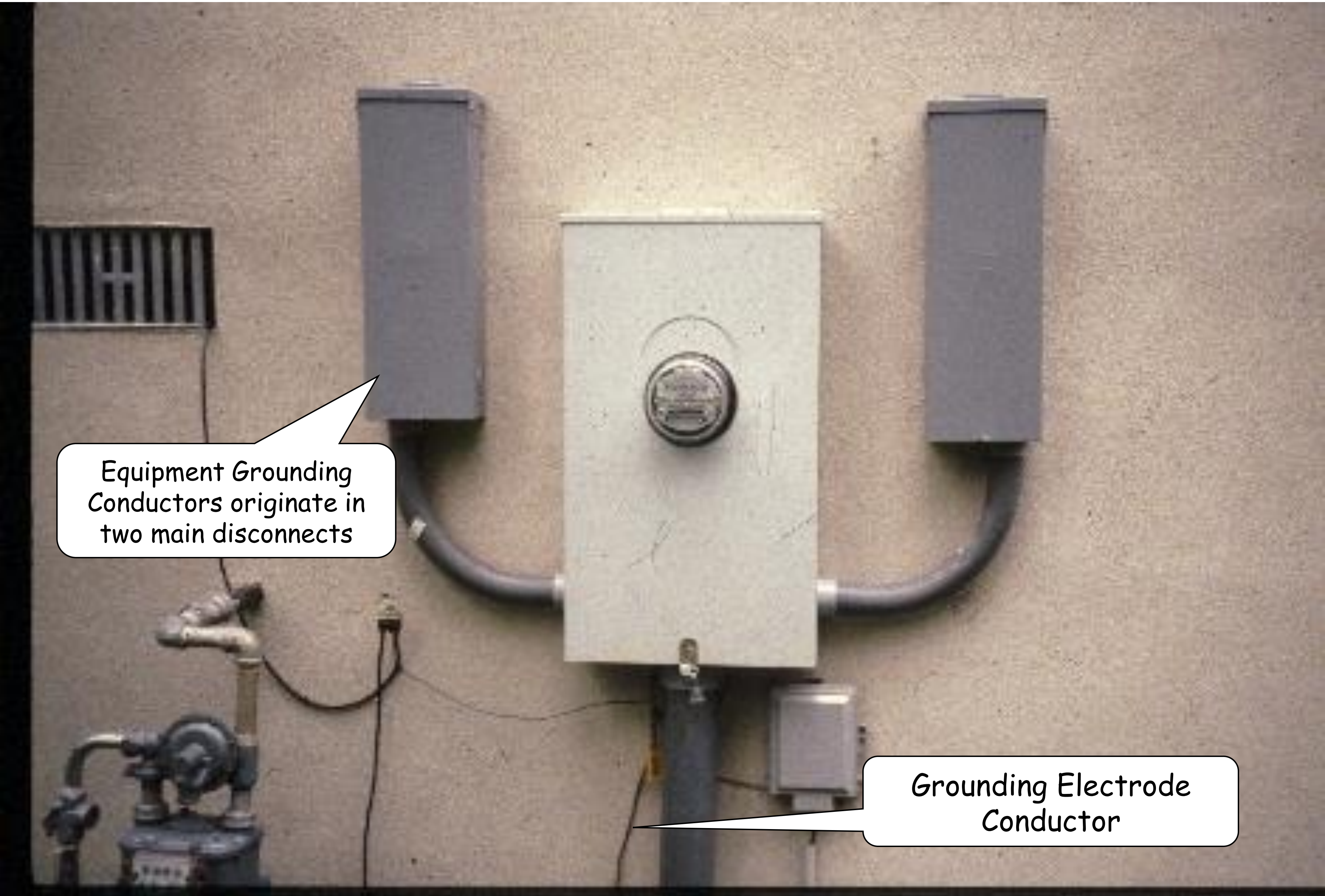
See IEEE
Red Book

GROUND*ED* AND GROUND*ING* CONDUCTORS




**Note: The grounding electrode system may be connected to the grounded conductor at *either* the Main Panel (S/N bus and EG bus are bonded together) or at the meter base when the appropriate lug is provided , or at the weatherhead for overhead services.**

## Common Grounding when there is a lug in the Meter Base and the Grounding Electrode Conductor originates from the Meter



# Sub-panels fed from two outside "Mains"

## Service Feeder Cable to "Main lugs only" Panels

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***250.4 General Requirements for Grounding and Bonding.***

***(A) Grounded Systems.***

> ***(5) Effective Ground-Fault Current Path.*** *Electrical equipment and wiring and other electrically conductive material likely to become energized shall be installed in a manner that creates a permanent, low-impedance circuit facilitating the operation of the overcurrent device or ground detector for high-impedance grounded systems. It shall be capable of safely carrying the maximum ground-fault current likely to be imposed on it from any point on the wiring system where a ground fault may occur to the electrical supply source.* ***The earth shall not be used as the sole equipment grounding conductor or effective ground-fault current path.***

What does this mean in terms of grounding metering equipment?

All metering equipment (sockets, cabinets, conduits, etc.) must be effectively bonded to the system neutral to prevent the equipment from becoming energized in the case of a line to ground fault.

Grounding to the earth only (ground rod) may not allow enough current flow to clear the fault.

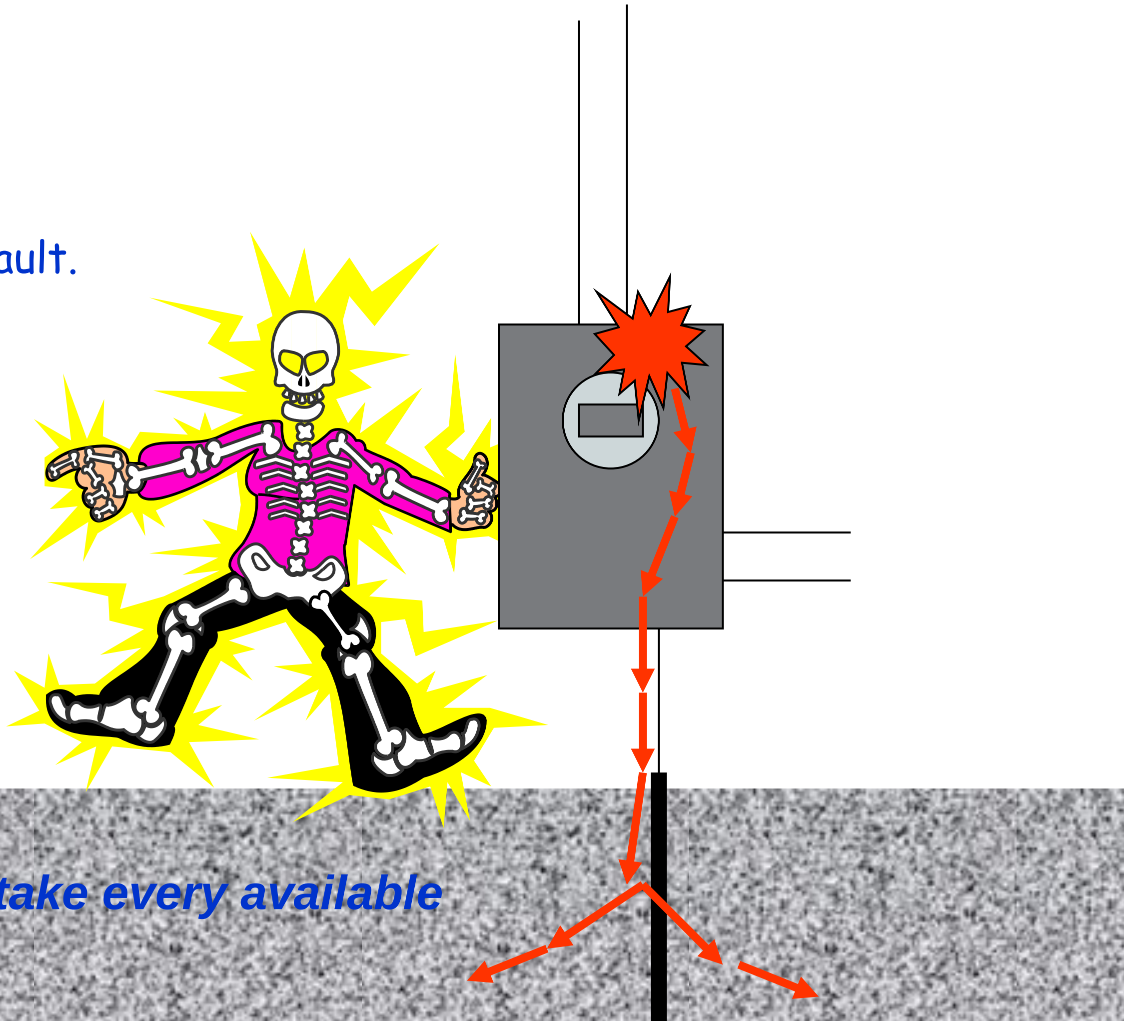
# Effective Ground Fault Current Path

## Earth Grounding alone will not Remove Dangerous Voltage Caused by Line-to-Case Faults

A ground rod with 25 ohms of resistance would only allow 4.8 amperes of current flow in the event of a 120 volt to ground fault.

$$I = \frac{E}{R}$$

$$\frac{120\text{ V}}{25\text{ ohms}} = 4.8\text{ A}$$

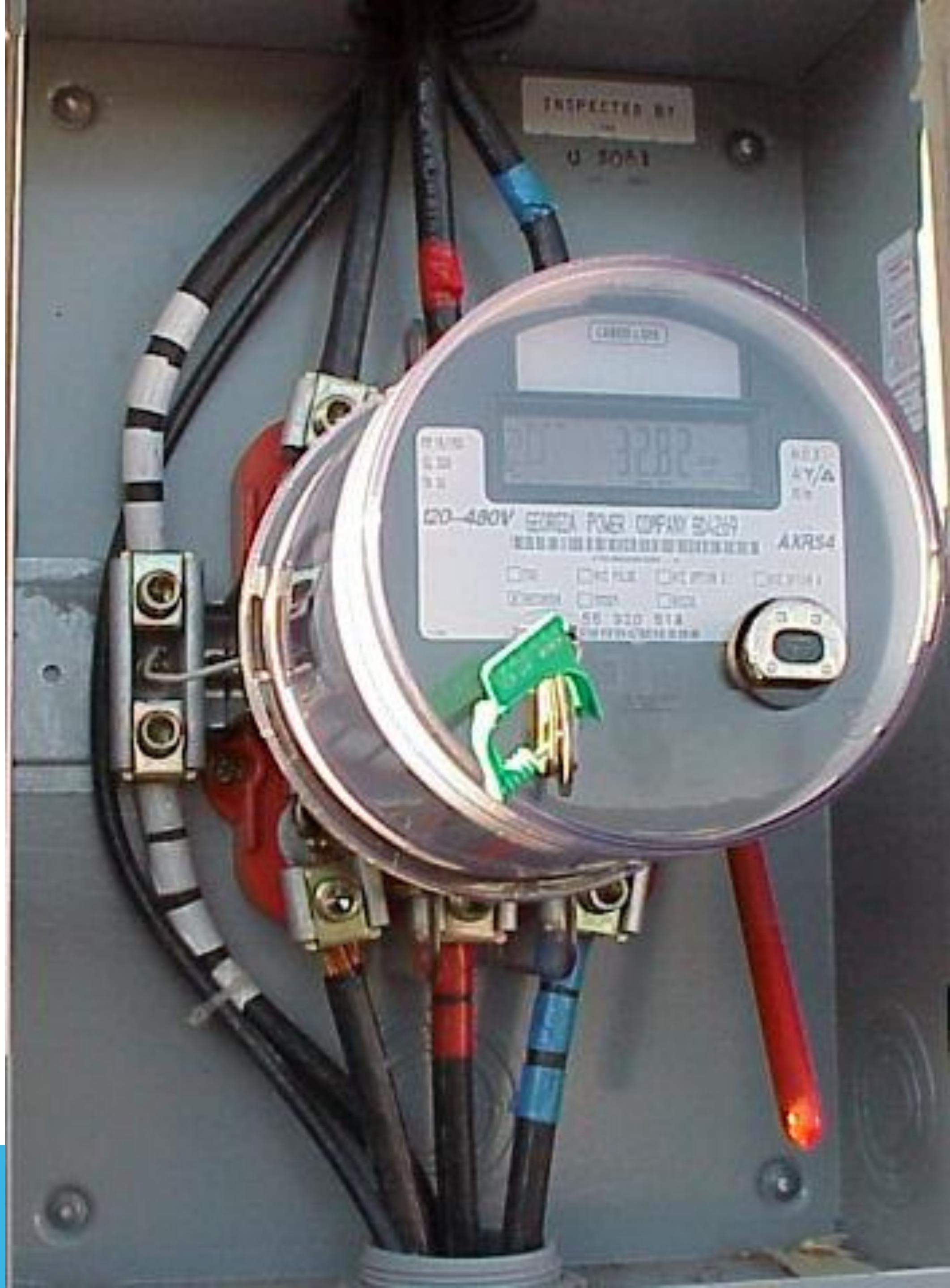


***Remember: current will take every available path, including you!***

# Effective Ground Fault Current Path

## Self-contained Sockets

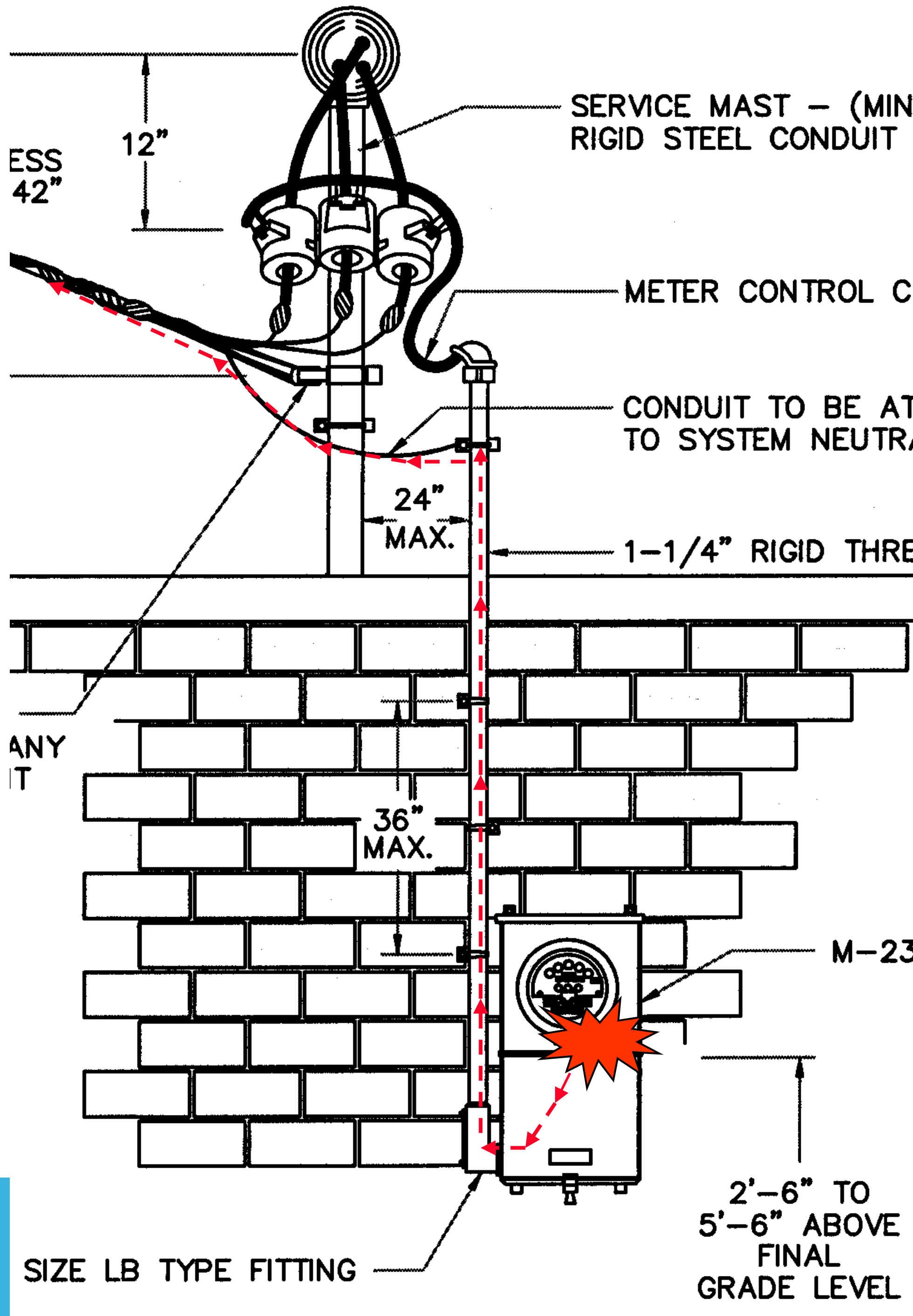
- Self-contained meter enclosures are typically bonded to the grounded conductor (neutral) by design.
- No other grounding conductors or bonding jumpers are required to provide an effective ground fault current path.

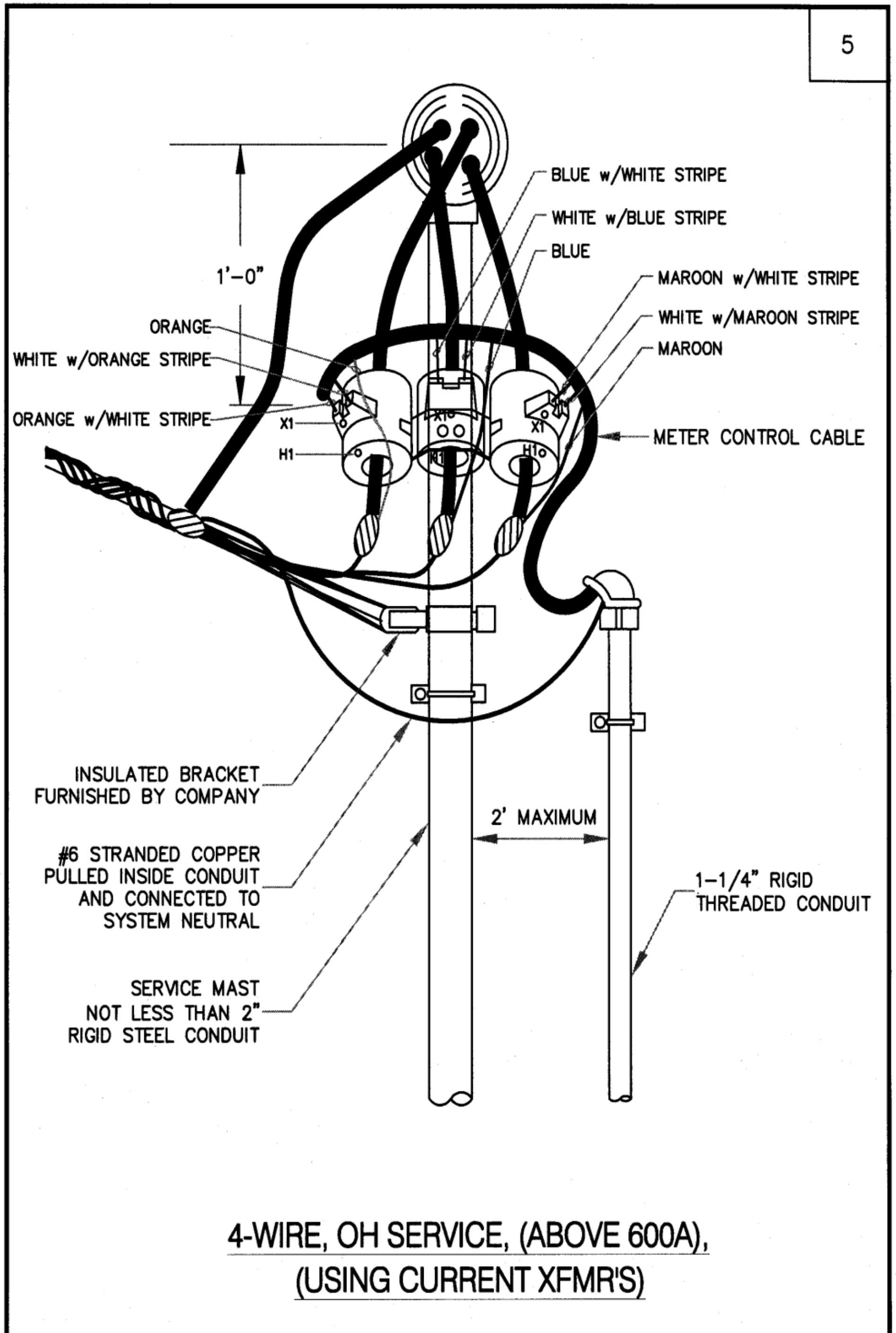


# Effective Ground Fault Current Path

## Transformer Rated Meter Installations

- All metal enclosures and conduits must be bonded with a good low impedance path to the system neutral.
- If the meter control cable conduit is used for the bonding path, a proper bond must exist between the conduit and the meter enclosure.






# Effective Ground Fault Current Path

If the conduit is not used for the bonding path, a bond wire can be pulled inside the conduit.

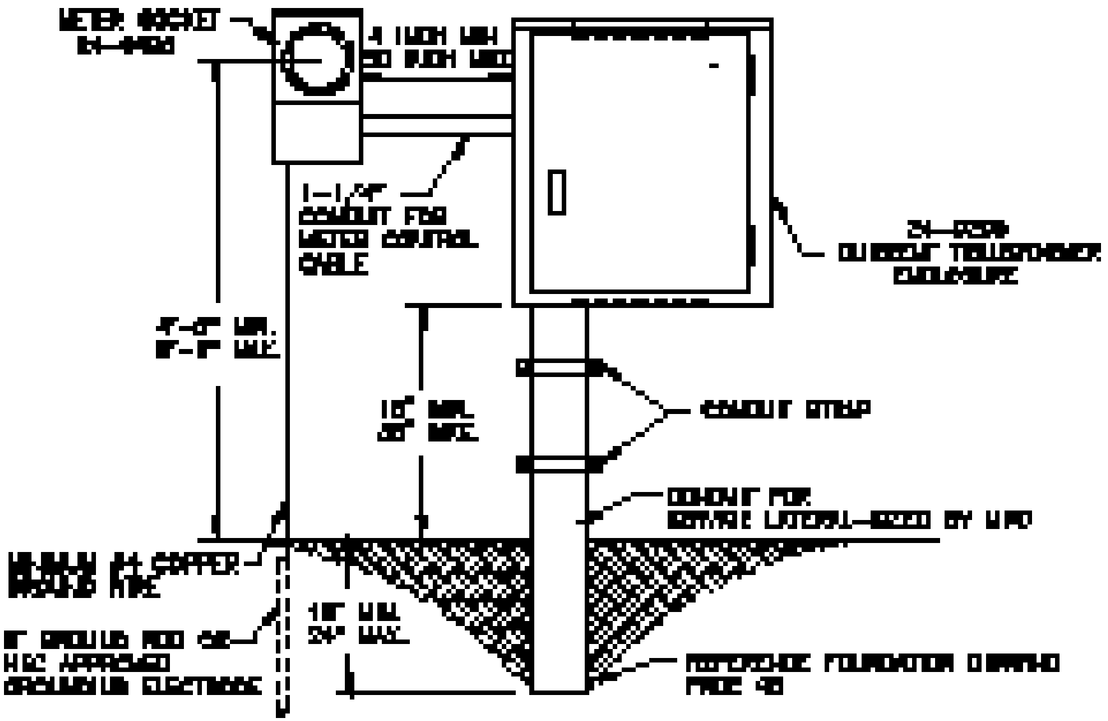
This will be necessary if using PVC conduit for the meter control cable.

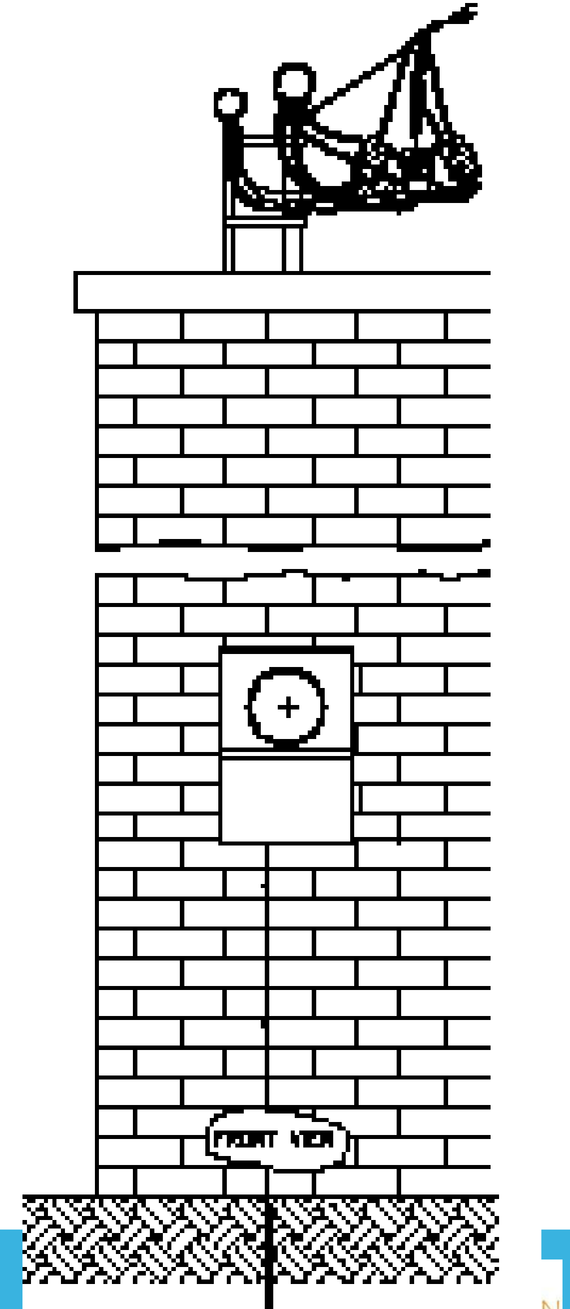
The bond wire should be larger than the size of the meter control wires.

If pulling a bond wire inside metal conduit, bond the wire to one end of the conduit. Preferably the meter end.

# Some Utilities specify a Ground Rod at all meter installations.

This Ground Rod must not be depended upon for clearing dangerous voltage which may result from a line to ground fault within the metering equipment.

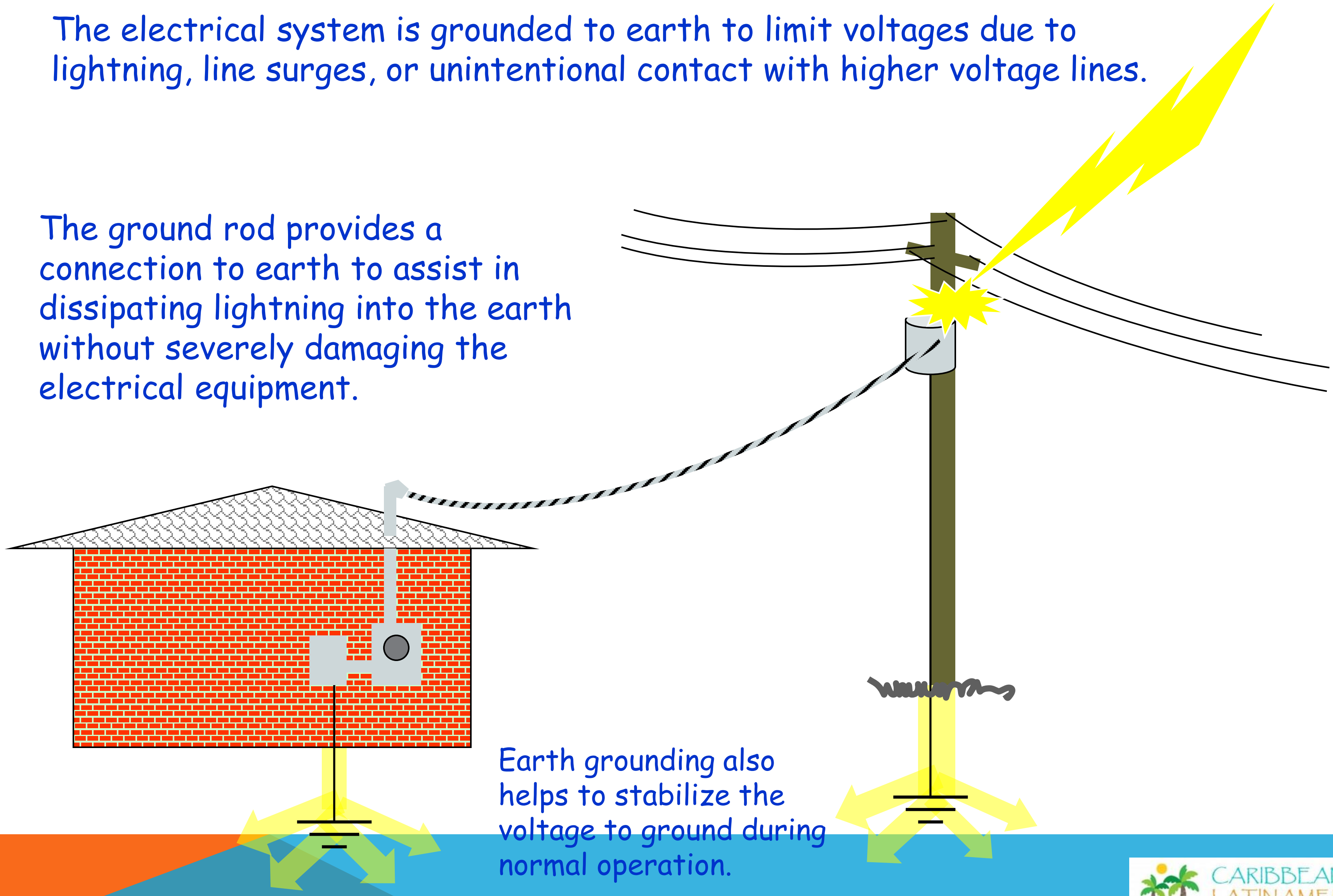




# If not for fault protection, what is the purpose of Ground Rods?

The electrical system is grounded to earth to limit voltages due to lightning, line surges, or unintentional contact with higher voltage lines.

The ground rod provides a connection to earth to assist in dissipating lightning into the earth without severely damaging the electrical equipment.

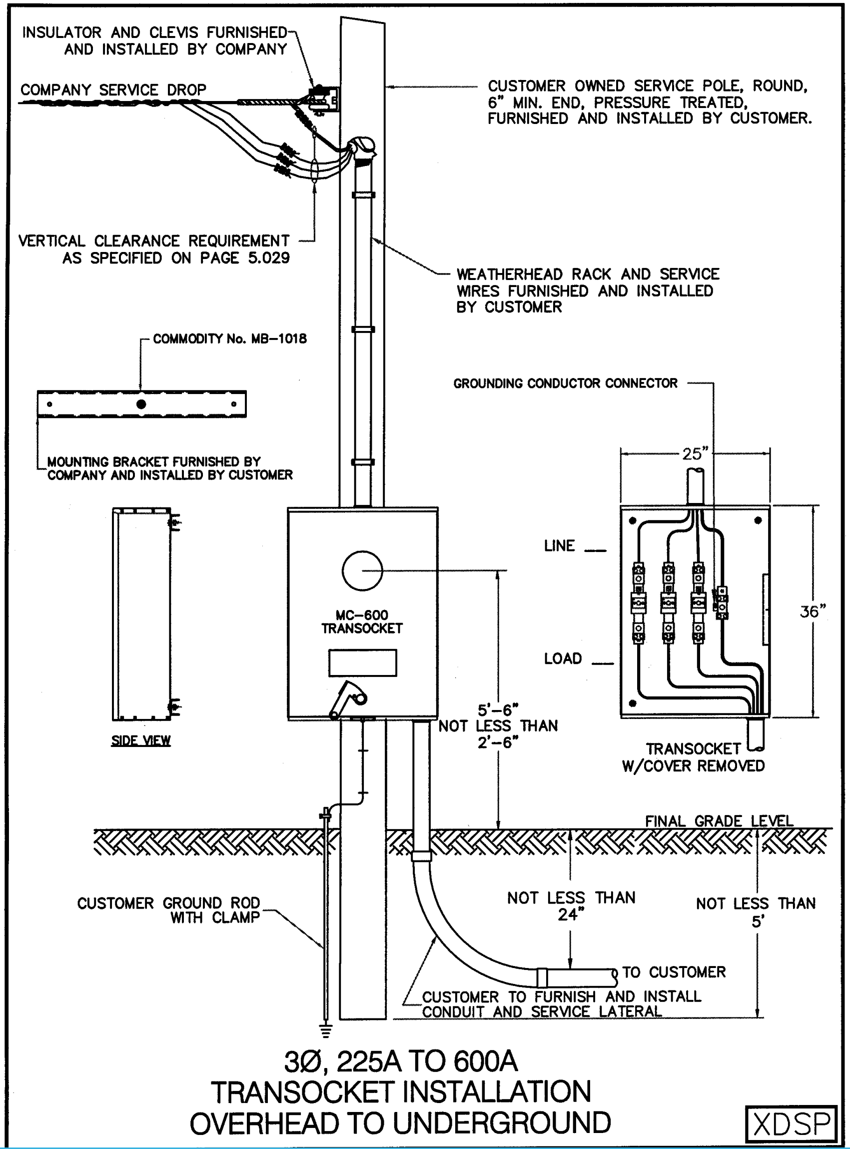


Earth grounding also helps to stabilize the voltage to ground during normal operation.

Typically a meter will be located in close proximity to the utility's grounded transformer or the customer's grounded service entrance, and a separate ground rod for the meter is not needed.

However, if the meter is located some distance from the transformer and some distance from the customer's service entrance, an additional ground rod at the meter will be a good idea.

This ground rod will serve to equalize any difference in potential that might arise between the ground and the meter enclosure that is bonded to the system neutral.



# Equipment Grounding Conductors

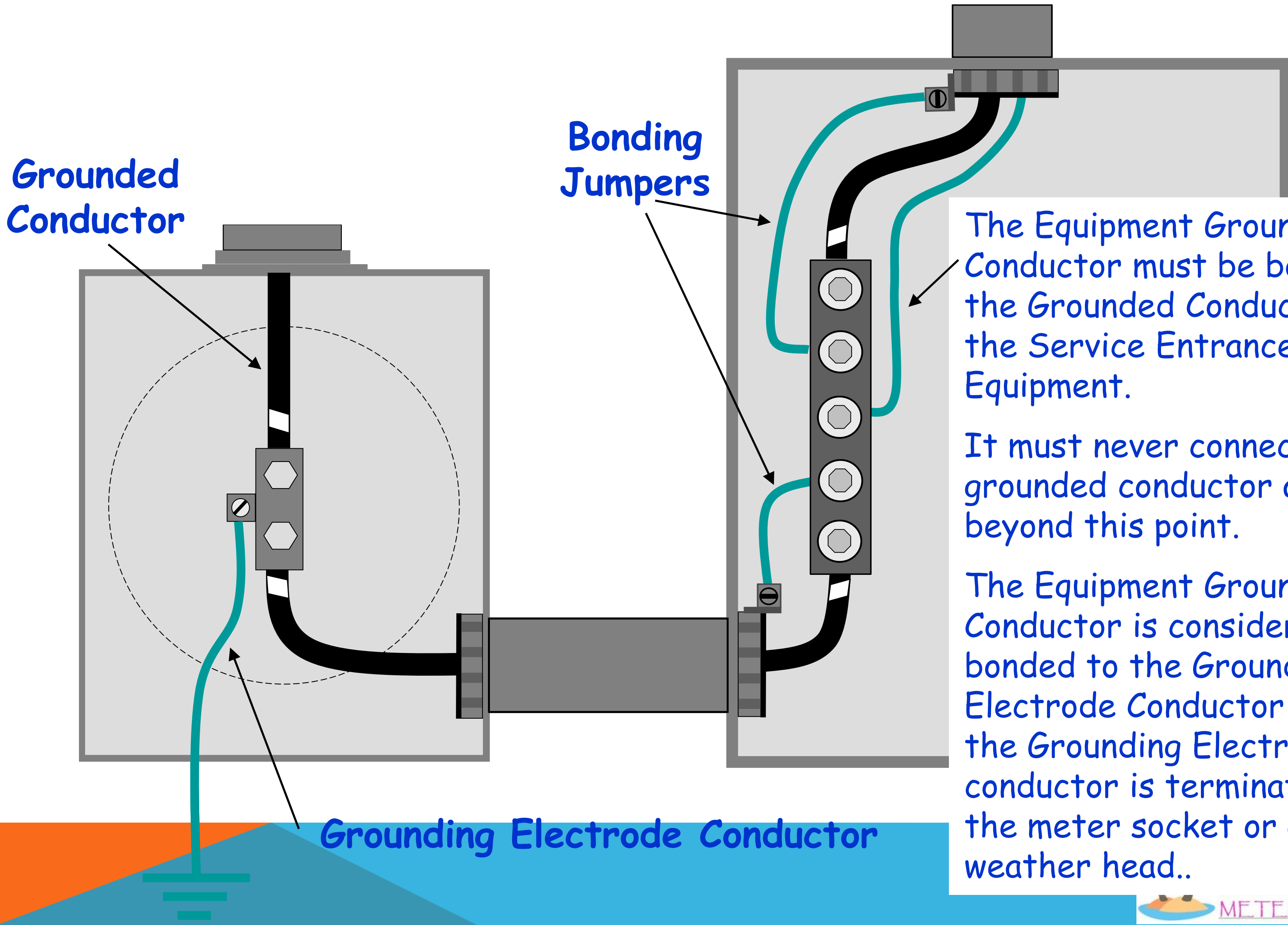
**2014 National Electrical Code**

***250.130 Equipment Grounding Conductor Connections.*** *…Equipment grounding conductor connections at service equipment shall be made as indicated in 250.130(A) or (B)...*

***(A) For Grounded Systems.*** *The connection shall be made by bonding the equipment grounding conductor to the grounded service conductor and the grounding electrode conductor.*

- The Equipment Grounding Conductor is bonded to the Neutral Conductor and the Grounding Electrode Conductor at the service entrance equipment.
- There should be only one point of connection between the Equipment Grounding Conductor and the Neutral Conductor.
- The Equipment Grounding Conductor is <u>not</u> a current carrying conductor under normal operating conditions.
- The Equipment Grounding Conductor should only carry current in the event of temporary fault currents.
- The primary purpose of the Equipment Grounding Conductor is protection from electrical shock and fire hazard.
- The secondary purpose is to provide a stable reference for electronic equipment.

# The Equipment Grounding Conductor



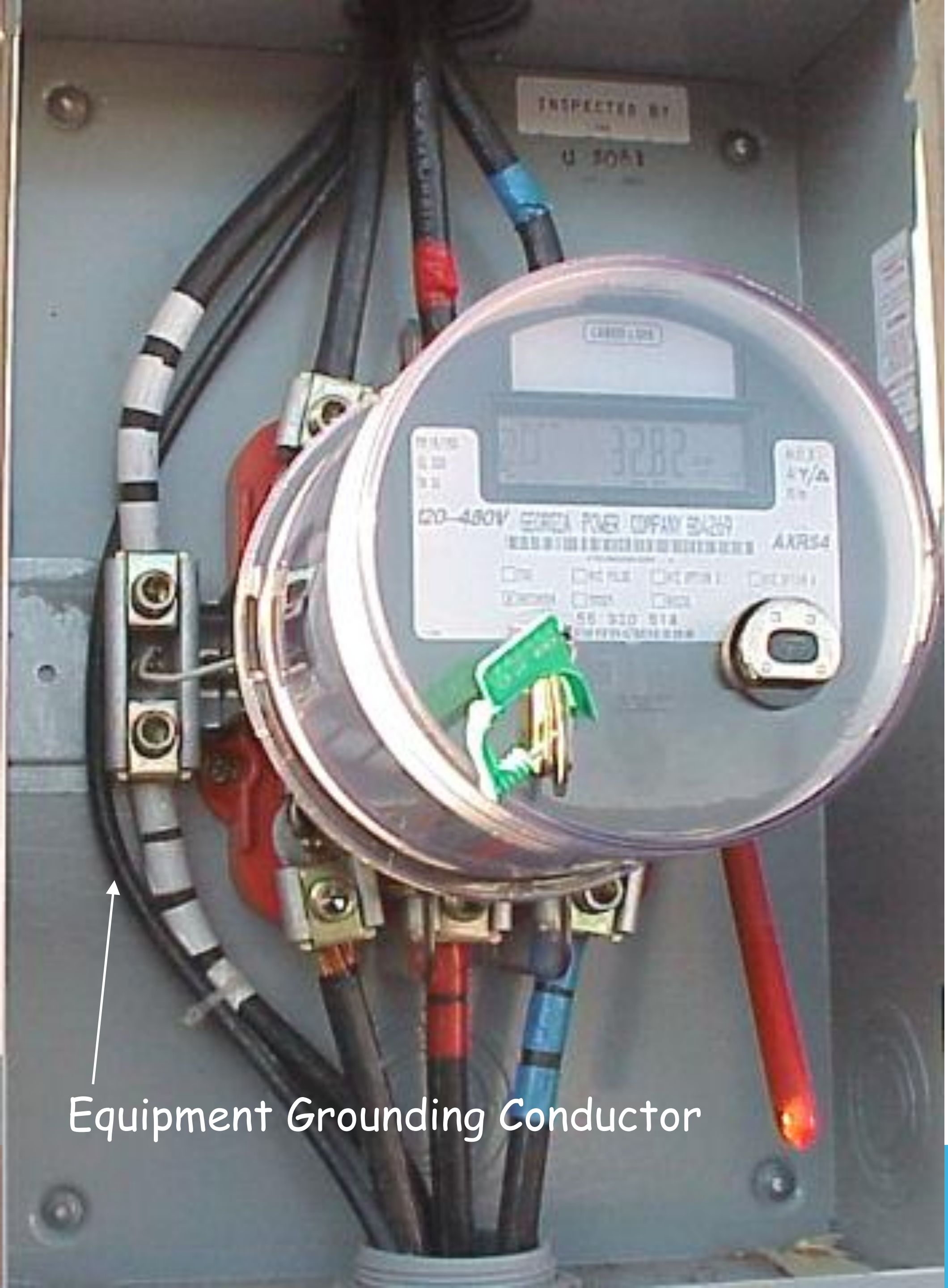

The Equipment Grounding Conductor must be bonded to the Grounded Conductor at the Service Entrance Equipment.

It must never connect to the grounded conductor again beyond this point.

The Equipment Grounding Conductor is considered bonded to the Grounding Electrode Conductor even if the Grounding Electrode conductor is terminated in the meter socket or at the weather head..

# Equipment Grounding Conductors & Metering Equipment

- **The preferred method of grounding meter equipment is always by bonding to the system neutral inside the enclosure.**
- It may be necessary to use the Equipment Grounding Conductor for grounding if:
  - The meter is located on the load side of ground-fault protection.
  - The meter is located on the load side of the service disconnect and a long distance away from the disconnect.
- Meter equipment should never be bonded to both the Equipment Grounding Conductor and the Grounded Conductor (neutral).
- Connecting Equipment Grounding Conductors to meter equipment that is bonded to the system neutral will create parallel paths for neutral current to flow on the Equipment Grounding Conductor between the meter equipment and the service disconnect. In some cases, neutral current can flow across the surfaces of meter sockets and enclosures.
- The NEC refers to this undesirable current flow as "Objectionable Current."




Self-Contained Sockets are typically bonded to the Neutral by design.

An Equipment Grounding Conductor should not attach to a meter enclosure when the enclosure is bonded to the system neutral.

Exception: If the meter is installed on the load side of ground-fault protection, the enclosure may need to be grounded by the equipment grounding conductor, rather than the system neutral.

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***250.6 Objectionable Current over Grounding Conductors.***

***(A) Arrangement to Prevent Objectionable Current.*** *The grounding of electrical systems, circuit conductors, surge arresters, surge-protection devices, and conductive normally non-current-carrying metal parts of equipment shall be installed and arranged in a manner that will prevent objectionable current.*

***(B) Alterations to Stop Objectionable Current.*** *If the use of multiple grounding connections results in objectionable current, one or more of the following alterations shall be permitted to be made, provided that the requirements of 250.4(A)(5) or (B)(4) are met:*

*(1) Discontinue one or more but not all of such grounding connections.*

*(2) Change the locations of the grounding connections.*

*(3) Interrupt the continuity of the conductor or conductive path causing the objectionable current.*

*(4) Take other suitable remedial and approved action.*

## What does this mean in respect to metering equipment?

Parallel paths for the flow of neutral current should not exist across the surface of meter equipment, or be allowed to flow through equipment grounding conductors inside metering enclosures.

# Danger of Objectionable Current on the Grounding Path

- **Electric Shock.** Electric shock can occur if a person gets in series with a grounding path that is carrying objectionable current. We do not normally expect current to be on ground wires. A grounding conductor carrying objectionable current can be especially dangerous in the event of a loose or broken neutral connection. The grounding conductor carrying objectionable current could be a metal raceway, and a person opening the raceway could be killed.

- **Fire Hazard.** Neutral current on the grounding path can cause temperature to build up on the grounding conductor and/or at loose connections. A poor connection on the system neutral could cause excessive current and heating or arcing on the grounding path.

- **Power Quality Issues.** Currents flowing on the grounding path and across the surfaces of equipment can cause electrical noise that may adversely effect sensitive electronic equipment.

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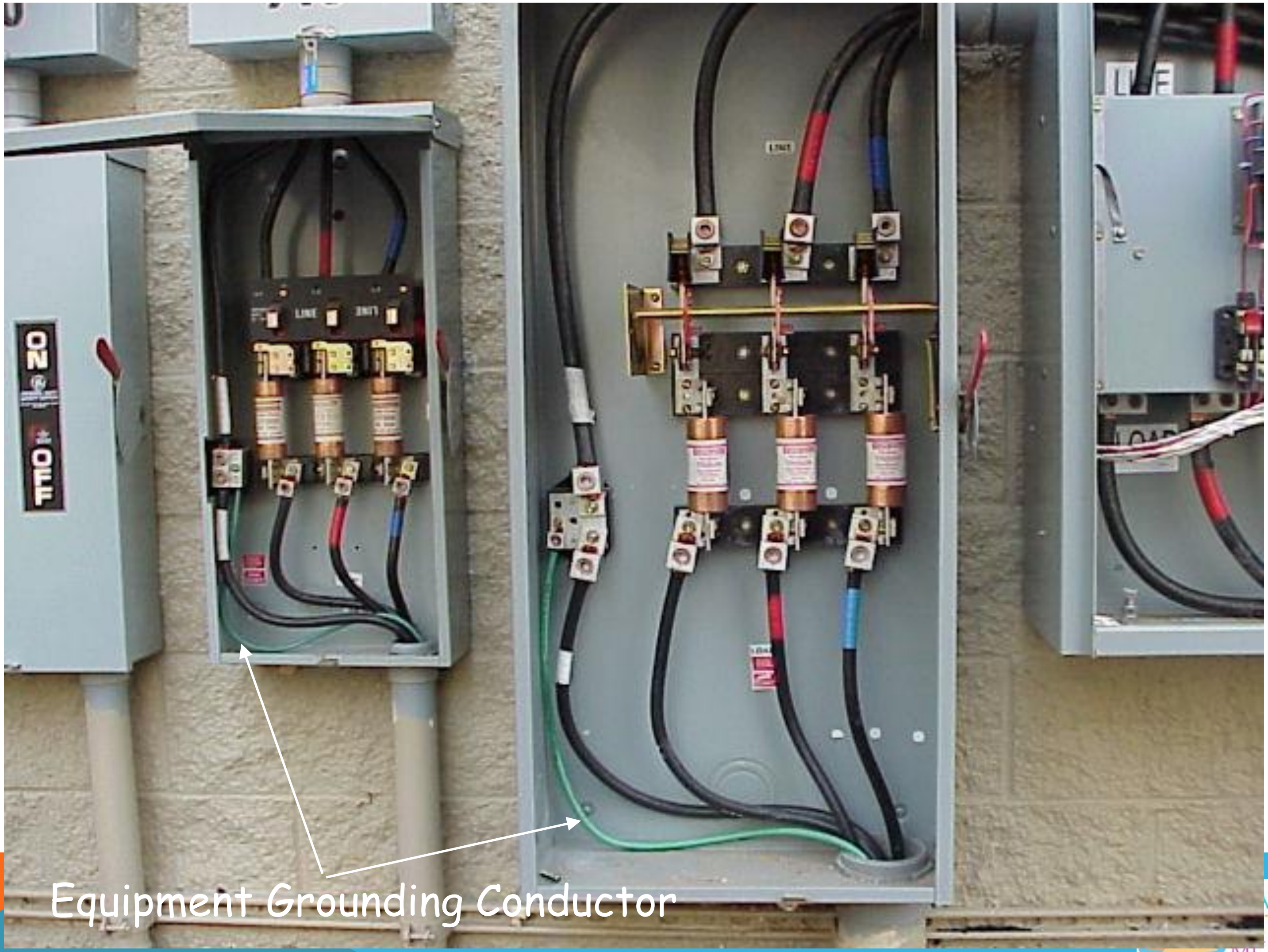
Objectionable currents due to multiple neutral-to-ground connections are often present at installations with multiple meters, especially when there is a main disconnect ahead of the meters.

The NEC permits meter sockets to be grounded by connecting to the Grounded Service Conductor (neutral), even if on the load side of a main service disconnect.  All of the Equipment Grounding Conductors on this installation originate in the disconnects on the load side of the meters.

All Equipment Grounding Conductors at this location correctly originate in the service disconnect enclosures on the load side of the meters.

There is no danger of Objectionable Current at the meter sockets.



The NEC allows for the grounding of Metering Equipment by bonding the Meter Enclosure to the Grounded Conductor (neutral) inside the Enclosure, Even when the Meter Enclosure is on the Load Side of a Main Service Disconnect.

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***250.142 Use of Grounded Circuit Conductor for Grounding Equipment***

***(A) Supply-Side Equipment.*** *A grounded circuit conductor shall be permitted to ground non-current-carrying metal parts of equipment, raceways, and other enclosures at any of the following locations:*

*(1) On the supply side or within the enclosure of the ac service-disconnecting means.*

***(B) Load-Side Equipment.*** *…a grounded circuit conductor shall not be used for grounding non-current-carrying metal parts of equipment on the load side of the service disconnecting means…*

*Exception No. 2: It shall be permissible to ground meter enclosures by connection to the grounded circuit conductor on the load side of the service disconnect where all of the following conditions apply:*

*(a) No service ground-fault protection is installed.*

*(b) All meter enclosures are located immediately adjacent to the service disconnecting means.*

*(c) The size of the grounded circuit conductor is not smaller than the size specified in Table 250.122 for equipment grounding conductors.*

# Bonding of Service Equipment

Section 250.92 of the NEC, which addresses the bonding together of all service entrance equipment, also allows for Meter Enclosures to be grounded by bonding to the Grounded Conductor (neutral) inside the enclosure without the need for any additional grounding conductors or bonding jumpers.

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***250.92 (A) Bonding of Services.*** *The normally non-current-carrying metal parts of equipment indicated in 250.92(A)(1) and (A)(2) shall be bonded together.*

*(1) All raceways, cables trays, cablebus framework, auxiliary gutters, or service cable armor or sheath that enclose, contain, or support service conductors, except as permitted in 250.80.*

*(2) All enclosures containing service conductors, including meter fittings, boxes, or the like, interposed in the service raceway or armor.*

***(B) Method of Bonding at the Service.*** *Electrical continuity at service equipment, service raceways, and service conductor enclosures shall be ensured by one of the following methods:*

***(1) Bonding equipment to the grounded service conductor*** *in a manner provided in 250.8*

# Effective Ground Fault Current Path

## Earth Grounding alone will not Remove Dangerous Voltage Caused by Line-to-Case Faults

- Copper thieves had already stripped out equipment grounding conductors and bonding jumpers.
- This left the installation without an effective low impedance ground fault current path.
- When the thieves attempted to cut the energized phase conductors, the cable cutters welded against the metal enclosure.
- The fault current's only path back to the transformer was through the ground.

- *The customer had not operated this plant for several years and there had been no electrical energy consumption.*
- *The customer suddenly received a bill for over 30,000 kWH of energy consumption.*
- *It was determined that the cable cutters were carrying a 27 kW load. (approx. 97 amps)*

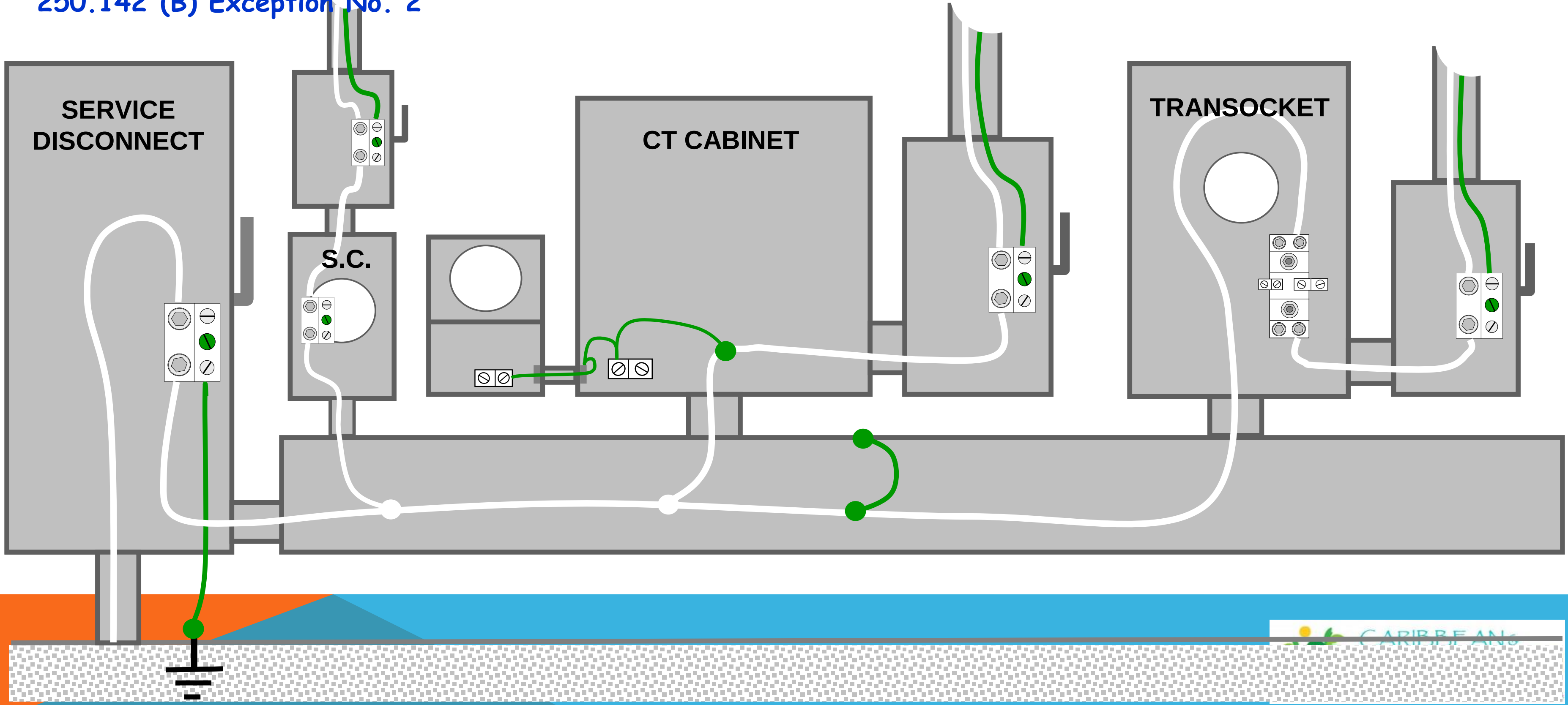
## With a few rare exceptions, customer equipment grounding conductors should not connect to or pass through meter enclosures – even when a service disconnect is ahead of the meters.

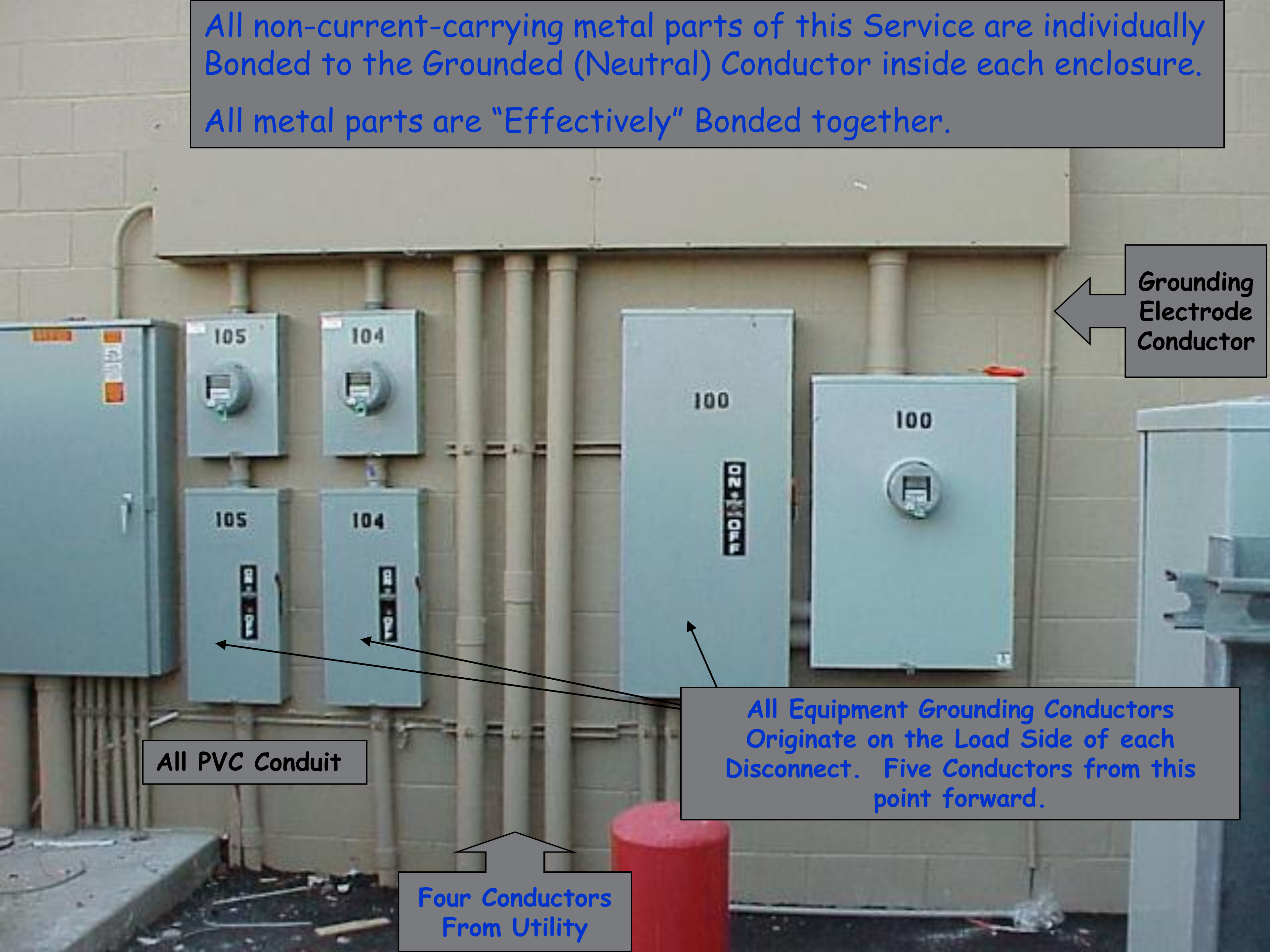
*"It shall be permissible to ground meter enclosures by connection to the grounded circuit conductor on the load side of the service disconnect if*

*(a) No service ground-fault protection is installed, and*

*(b) All meter enclosures are located immediately adjacent to the service disconnecting means"*

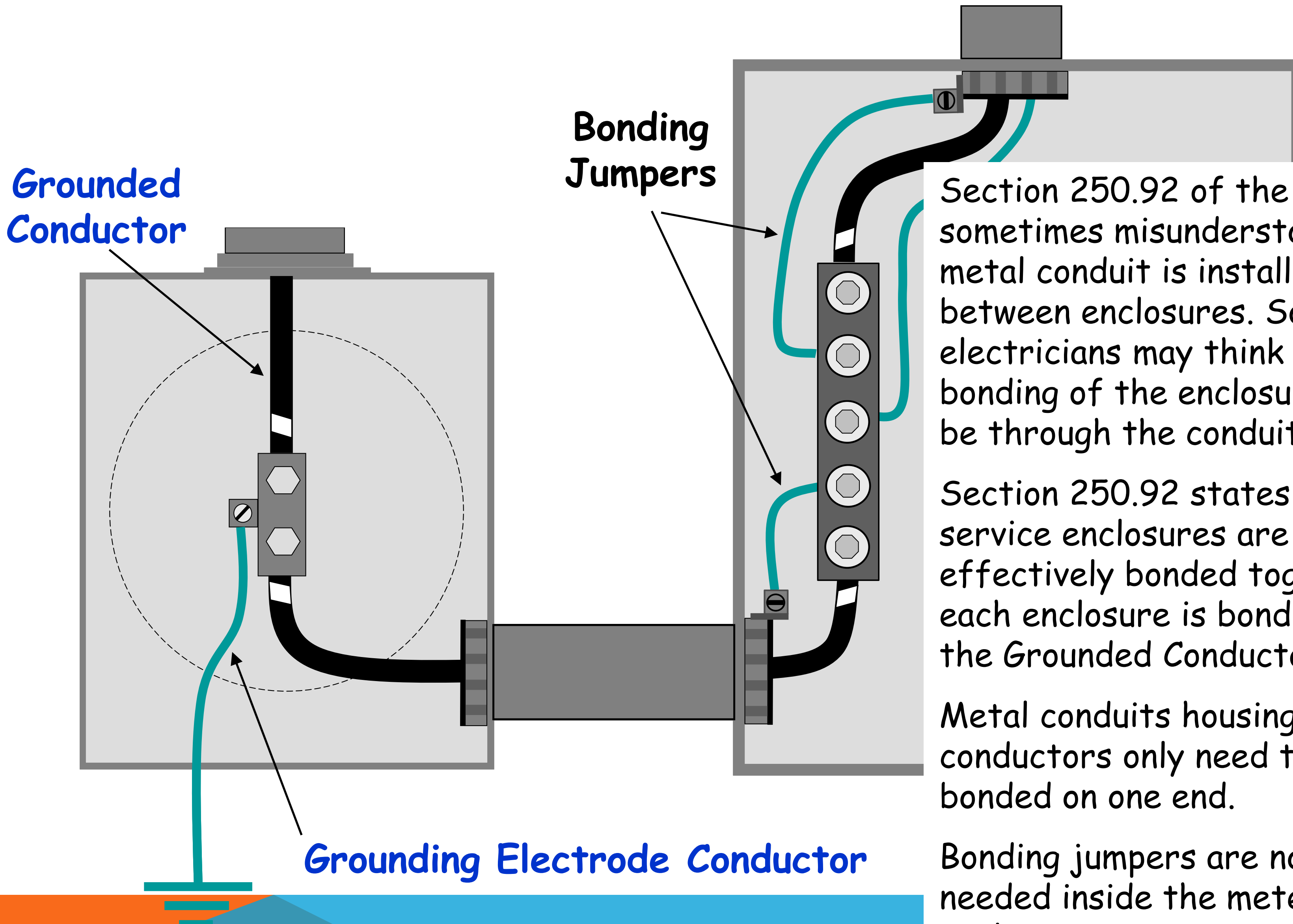
NEC Section 250.142 (B) Exception No. 2




All non-current-carrying metal parts of this Service are individually Bonded to the Grounded (Neutral) Conductor inside each enclosure.
All metal parts are "Effectively" Bonded together.
Grounding Electrode Conductor
105
104
105
104
100
100
All PVC Conduit
All Equipment Grounding Conductors Originate on the Load Side of each Disconnect. Five Conductors from this point forward.
Four Conductors From Utility

All Equipment Grounding Conductors Originate on the Load Side of each Disconnect.  Five Conductors from this point forward.

# Bonding of Service Equipment




Section 250.92 of the NEC is sometimes misunderstood when metal conduit is installed between enclosures. Some electricians may think that the bonding of the enclosures must be through the conduit.

Section 250.92 states that all service enclosures are effectively bonded together if each enclosure is bonded to the Grounded Conductor.

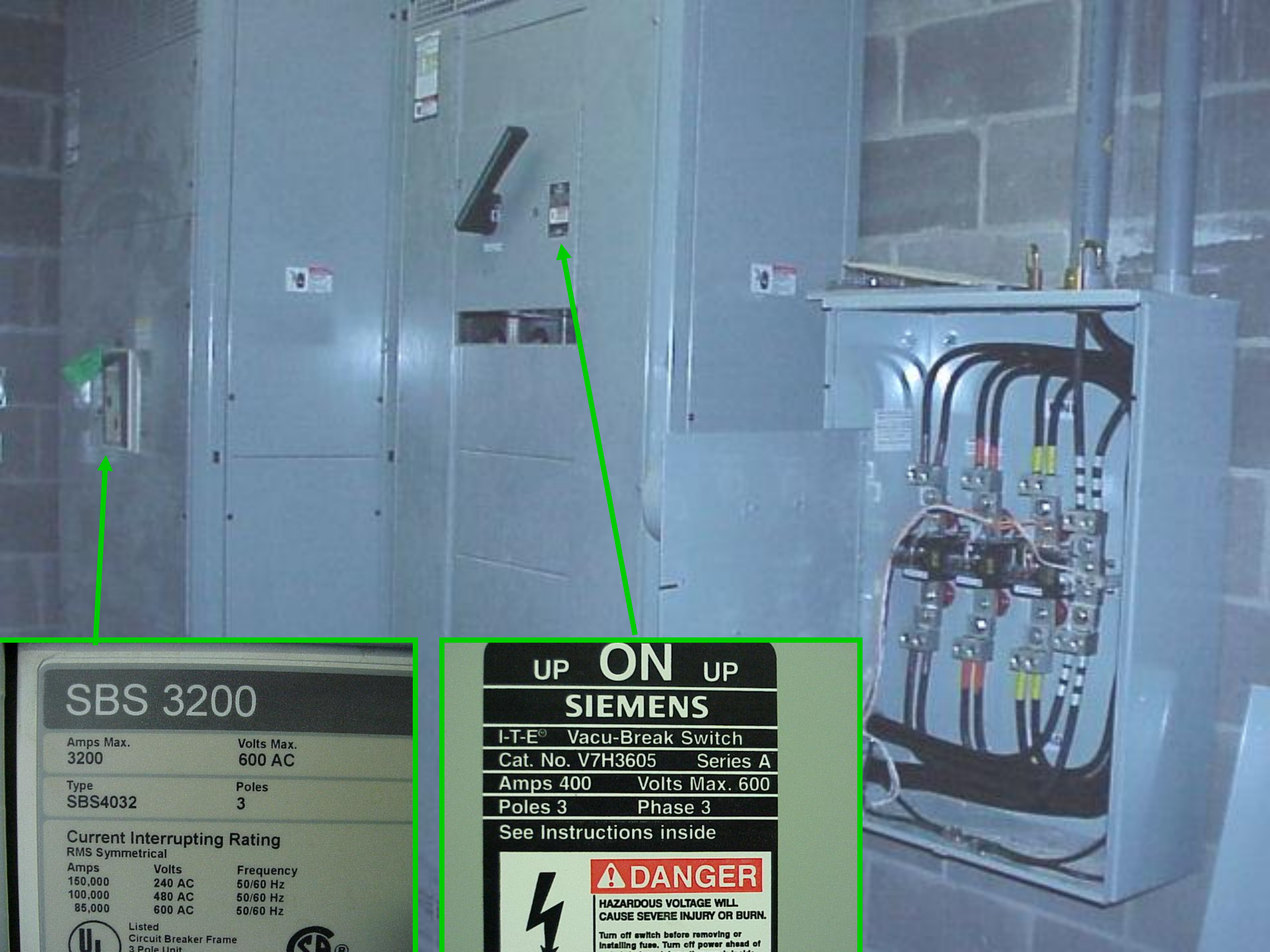
Metal conduits housing service conductors only need to be bonded on one end.

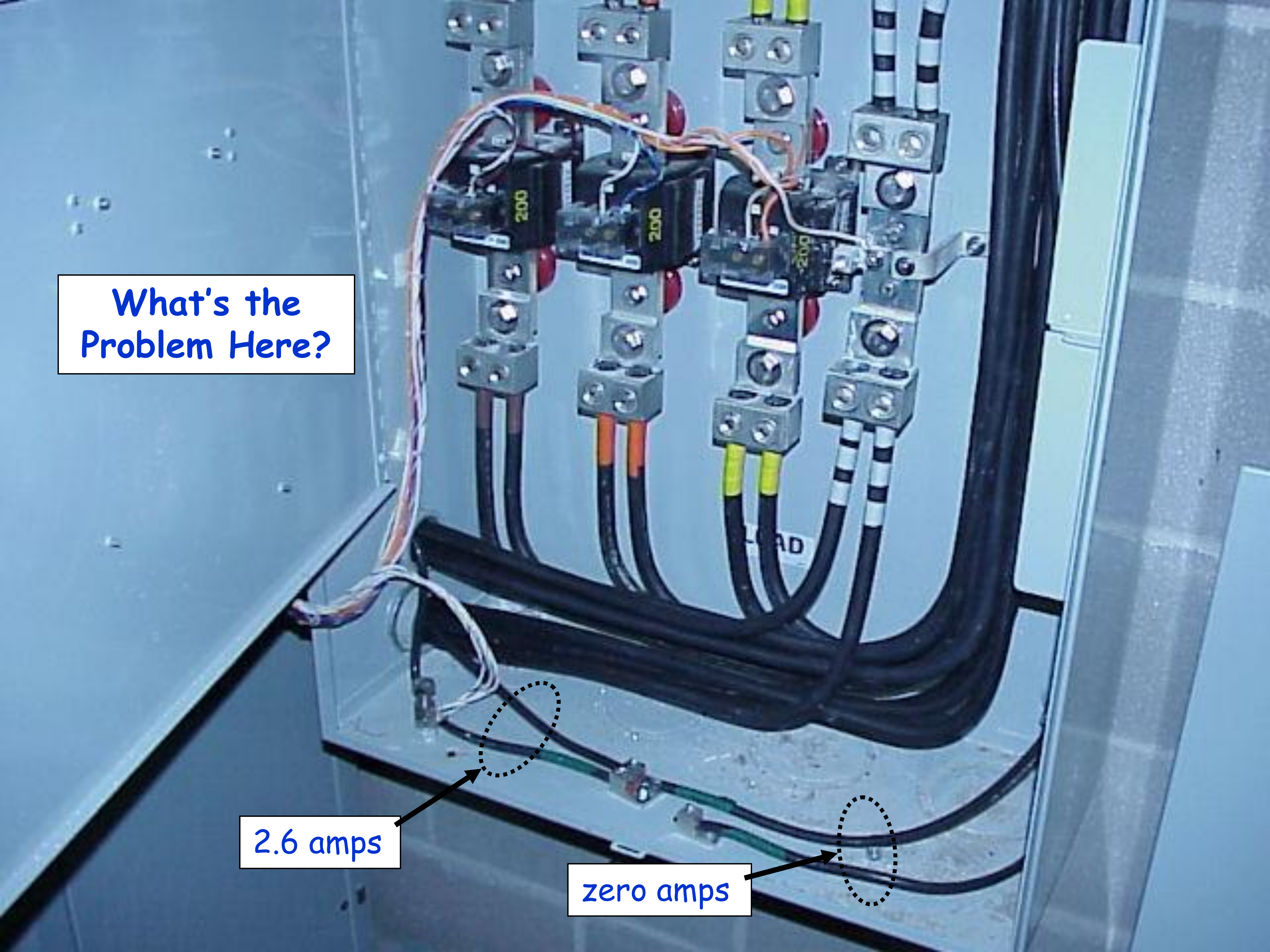
Bonding jumpers are not needed inside the meter enclosure.

Equipment Grounding Conductor originates in Transocket.  Parallel neutral paths exist due to multiple neutral to ground connections.


200
200
200
LOAD


Neutral Current on Equipment Grounding Conductor due to Neutral to Ground connection in Transocket
GOULD
GOULD


SBS 3200
Amps Max.
3200
Volts Max.
600 AC
Type
SBS4032
Poles
3
Current Interrupting Rating
RMS Symmetrical
Amps
150,000
100,000
85,000
Volts
240 AC
480 AC
600 AC
Frequency
50/60 Hz
50/60 Hz
50/60 Hz
Listed
Circuit Breaker Frame
UP ON UP
SIEMENS
I-T-E Vacu-Break Switch
Cat. No. V7H3605 Series A
Amps 400 Volts Max. 600
Poles 3 Phase 3
See Instructions inside
DANGER
HAZARDOUS VOLTAGE WILL
CAUSE SEVERE INJURY OR BURN.
Turn off switch before removing or
installing fuse. Turn off power ahead of


What's the Problem Here?
2.6 amps
zero amps


FLUKE
2.613
mV
OFF


2.649
RANGE
V
mV
Hz
Ω
OFF
A
COM
200


13.28


200
200
FLUKE
1.192

# *ENERGIZED METER SOCKET*

## METERMAN RECEIVED SHOCK WHILE TOUCHING YELLOW POST & METER CABINET. MEASURED 160 VOLTS BETWEEN POST & CABINET. MEASURED 277 VOLTS BETWEEN CABINET & TRANSFORMER.

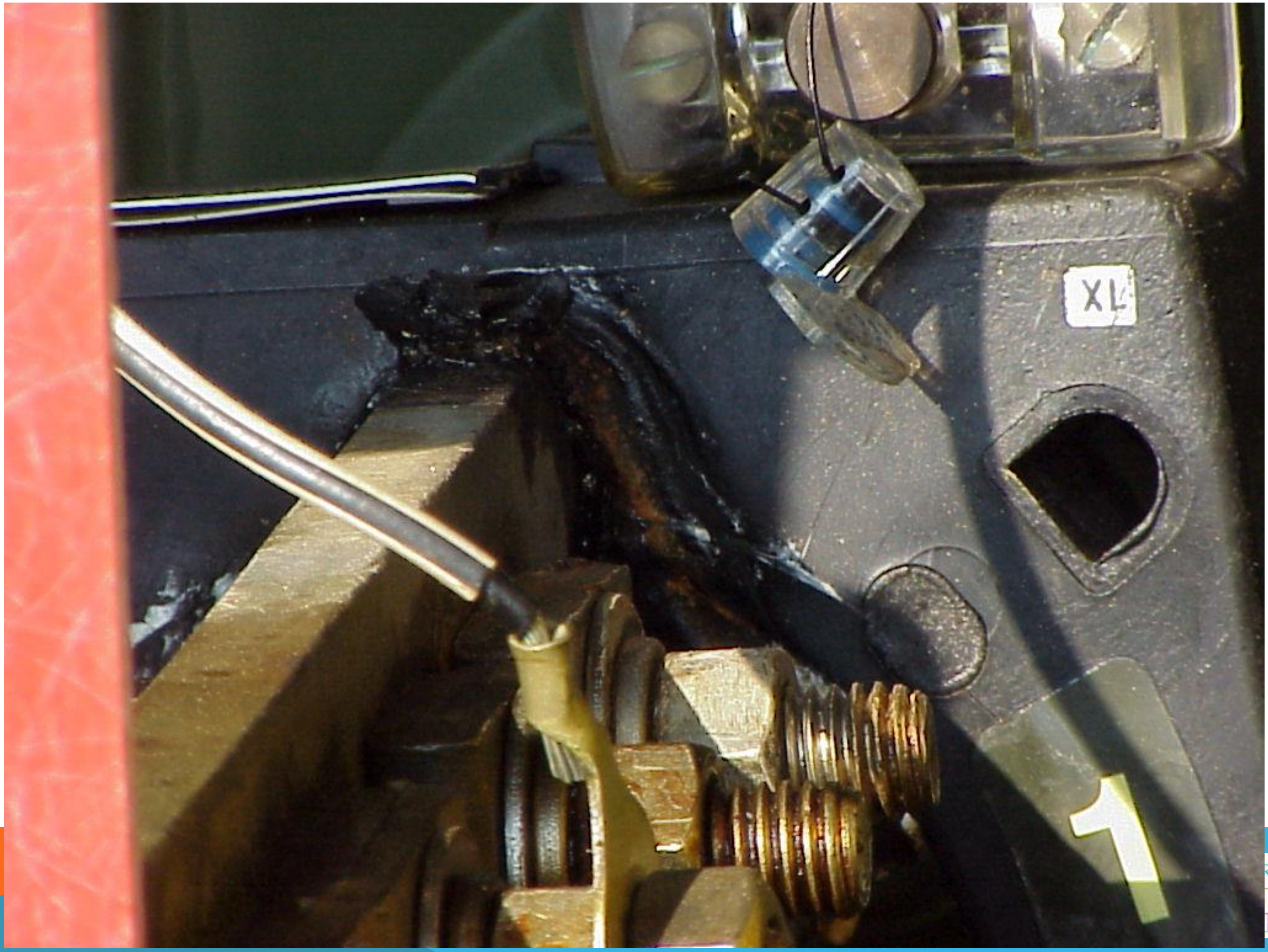
# ***ENERGIZED METER SOCKET***

## SECONDARY BUSHING IN TRANSFORMER WAS LOOSE.


| | |
|---|---|
| **Substation Name** | CEDAR MOUNTAIN |
| **Circuit Number** | A1642 |
| **Equipment Number** | T# 375824 |
| **Location** | WAL-MART, DOUGLASVILLE |

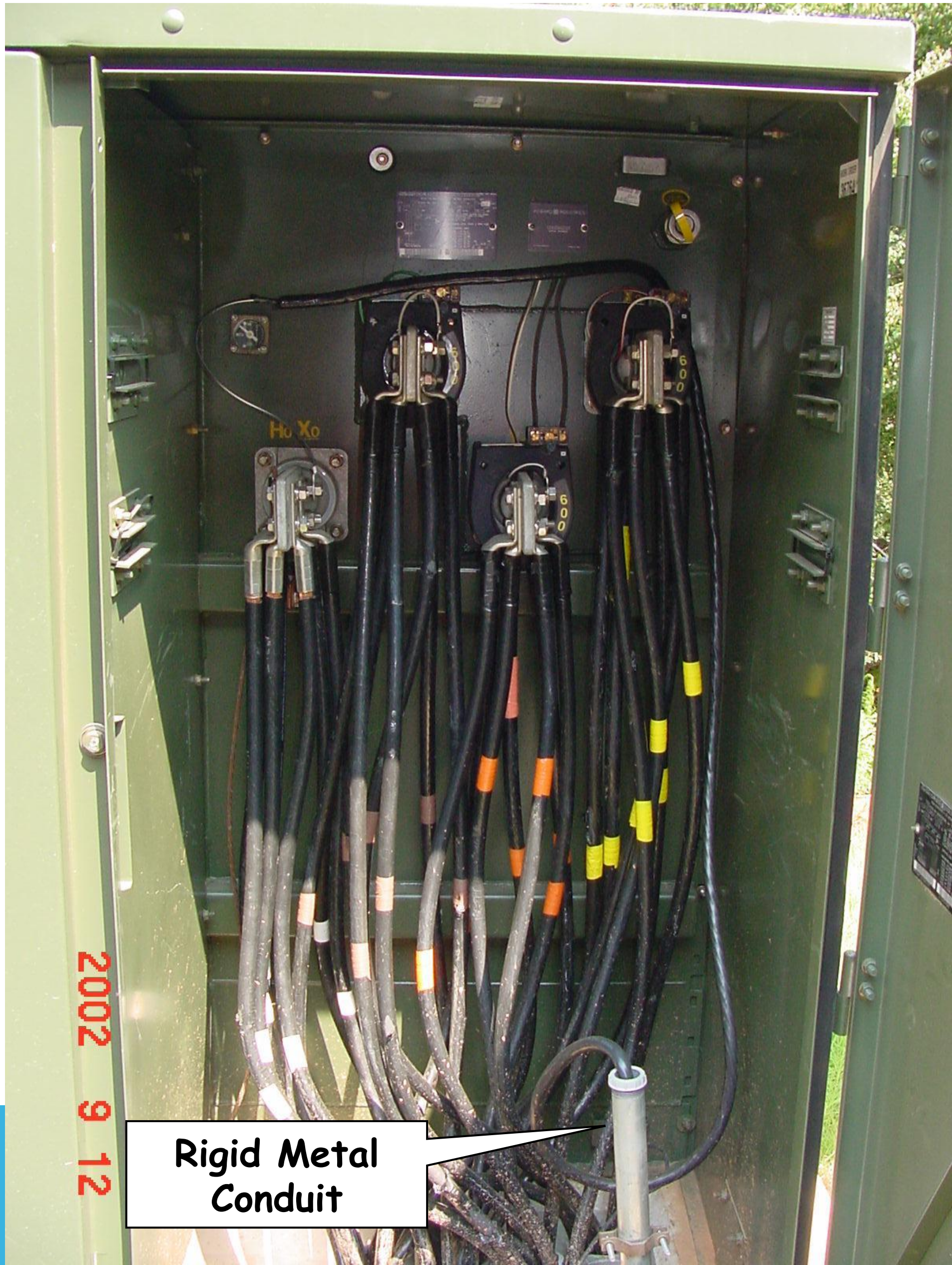
# *ENERGIZED METER SOCKET*

## THE SECONDARY WINDING OF THE CT BECAME ENERGIZED WHICH ENERGIZED THE METER CABINET.



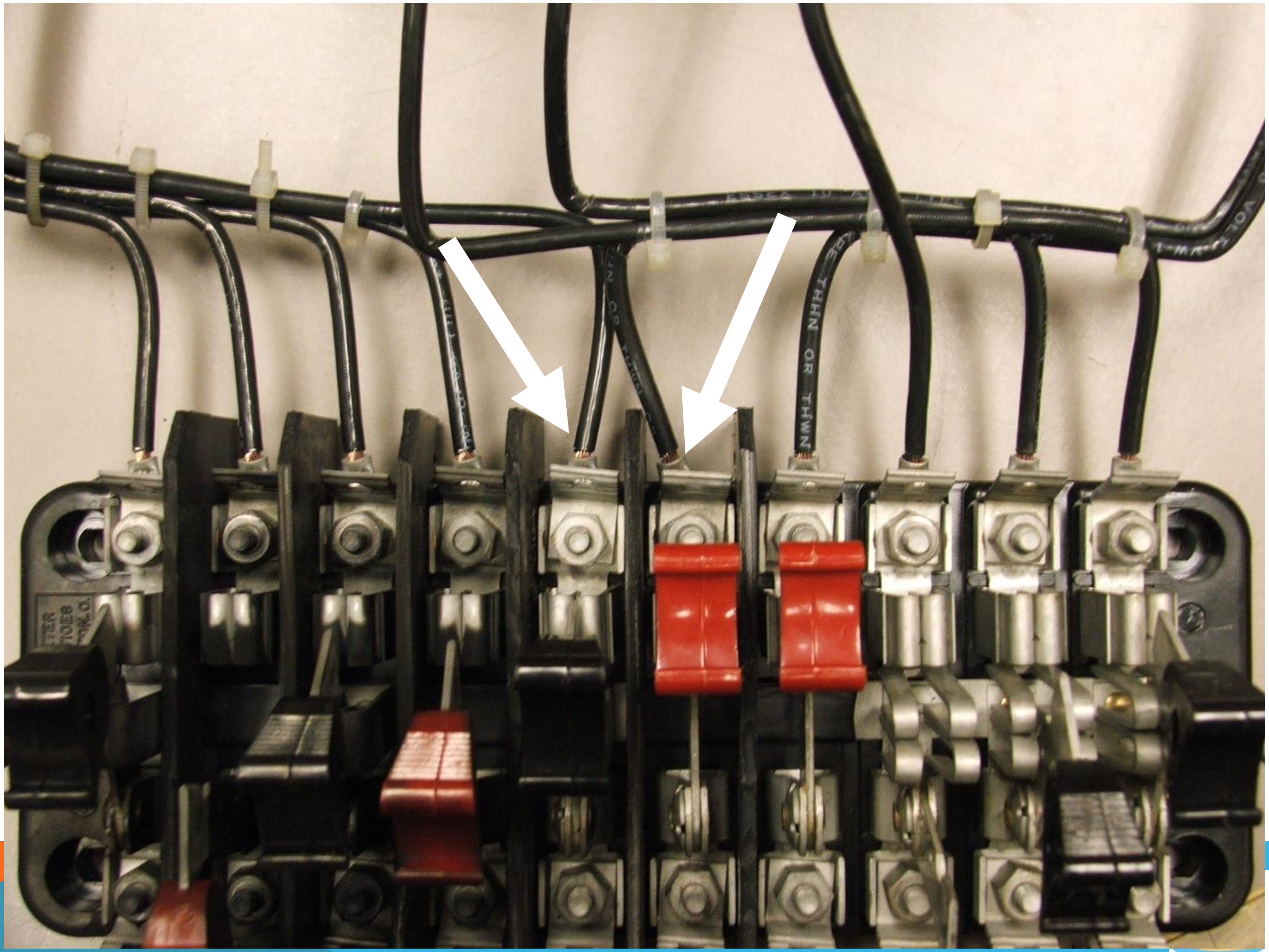
# ENERGIZED METER SOCKET

- There was no effective ground fault current path bonding the meter cabinet back to the system neutral.
- The meter control cable conduit was bonded to the transformer case.
- The rigid metal conduit was not continuous between the transformer and the meter cabinet.
- The ground resistance was too high for the fault to clear itself.



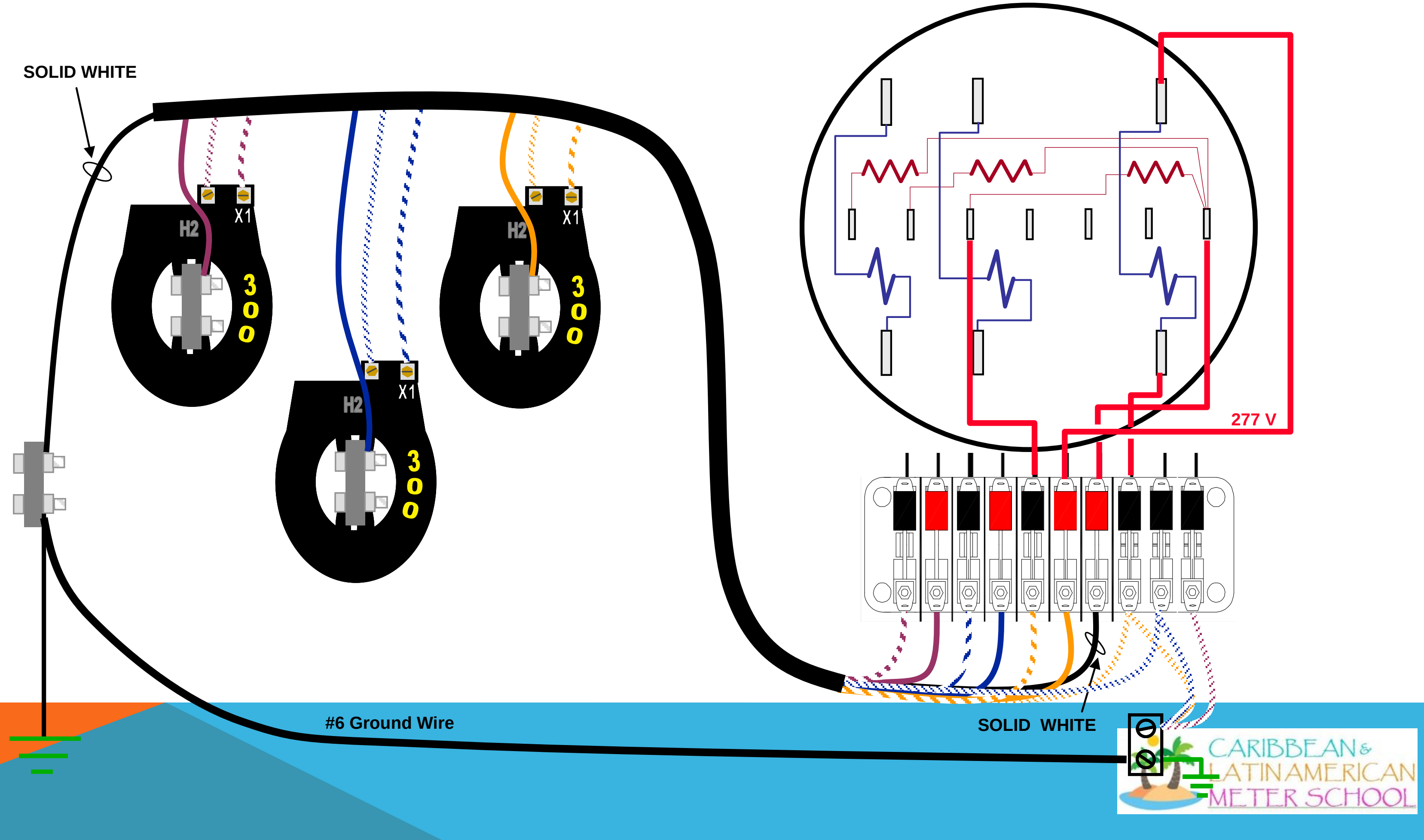
# CLOSE CALL

**When a Meterman was changing out a damaged meter block, he accidentally swapped a current wire and a potential wire on the top of the test switch block.**



The current and voltage wires were crossed on the third phase. The right-hand current coil in the meter was energized at 277 volts. Because the current returns are grounded, the meter socket was momentarily energized before the fault cleared itself.

*This installation had an Effective Ground Fault Current Path!*



# THE #6 GROUND WIRE DID ITS JOB

**When the meterman closed the test switches, the orange potential wire in the meter control cable quickly heated, melting its insulation along the entire length. The individual strands were actually welded together.**

**The meter control wires shorted phase-to-phase inside the pad-mount transformer and cleared the fault so that the meter socket was not left energized.**

***Note: These are two good examples of why we ground the secondary side of instrument transformers.***

Equipment Grounding Conductor attaches to and passes through CT cabinet back to UG Transformer. A parallel neutral path exists from the GPC transformer to the main disconnect.


Amps on Grounding Conductor

Amps on Neutral

The Equipment Grounding Conductor is correctly connected to the Grounded Conductor inside the service disconnect on the load side of the meter.

There should be no other neutral-to-ground connection beyond this point.

Grounding conductor passes through CT Cabinet to Neutral Spade in Transformer. Parallel neutral path exists from transformer to main disconnect inside.

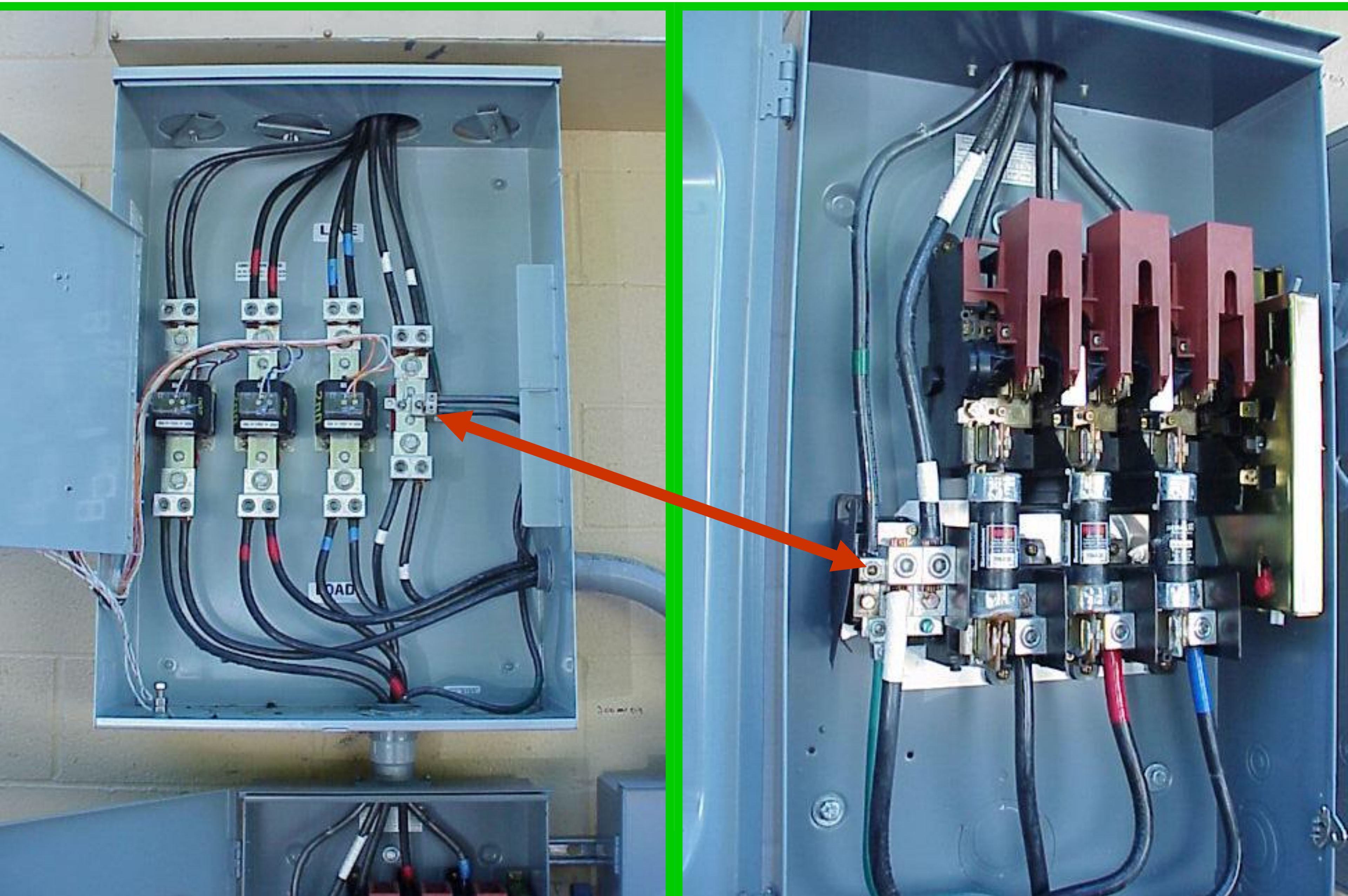

Grounding conductor originates in Trough.
Passes through and connects to CT Cabinet and Self-contained meter socket.
Service


Cabinet Bonded
To Neutral
By Meterman
Grounding conductor parallels
neutral from CT cabinet to Main


120/208 Y

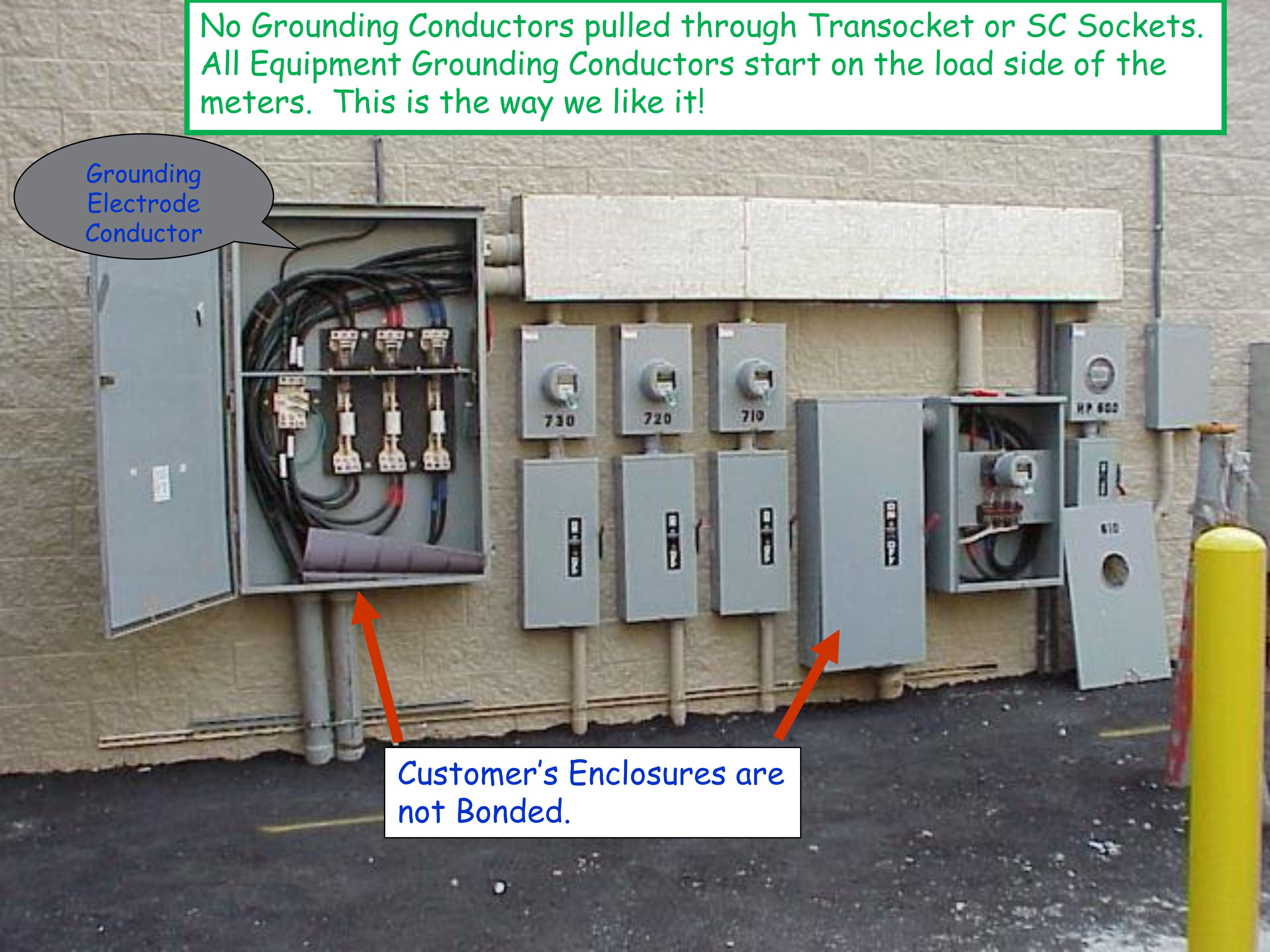

VECTRON
02.01
METER TYPE

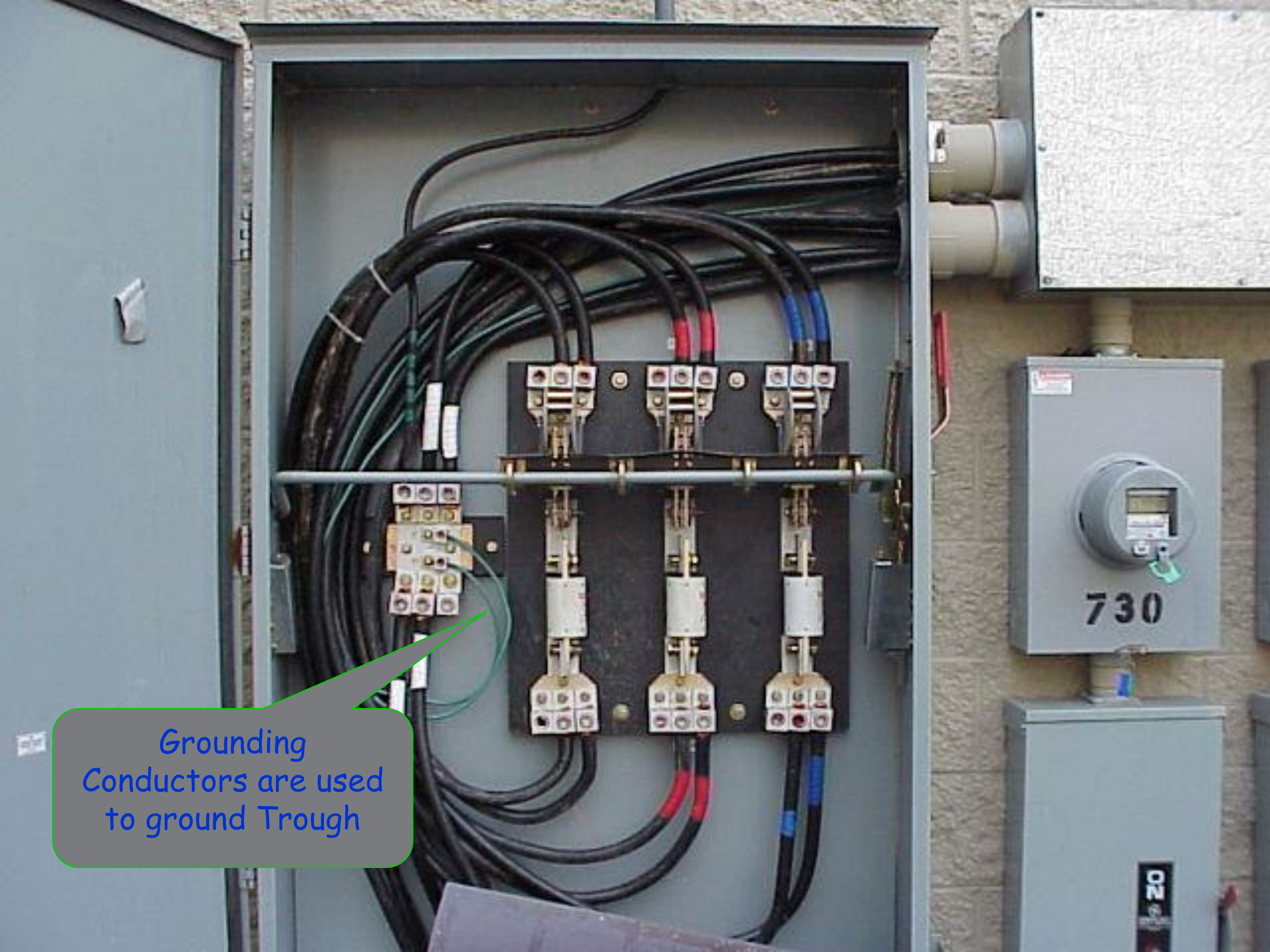
Parallel Neutral path exists between the Transocket and the two Disconnects.


LOAD

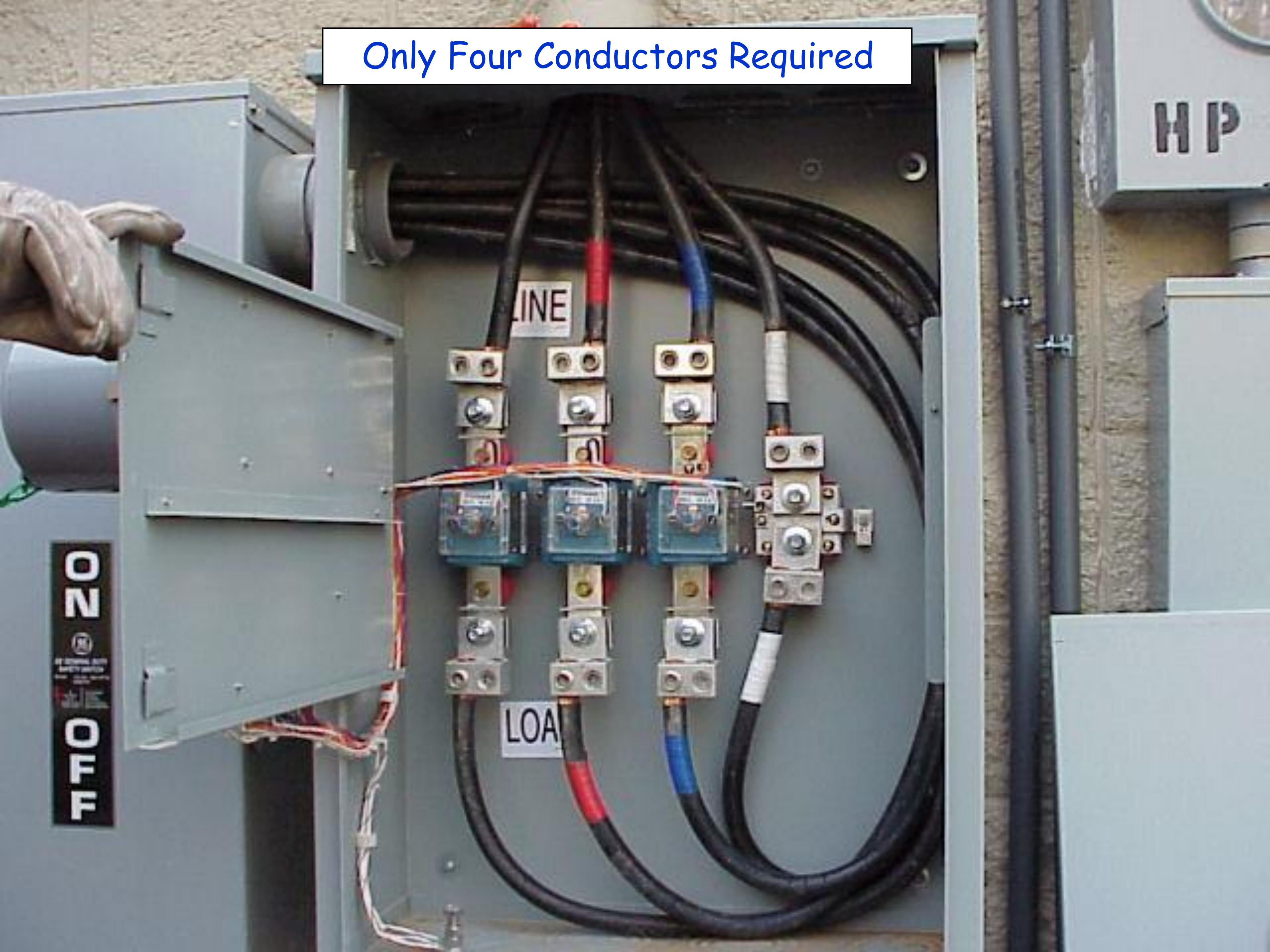

08.13

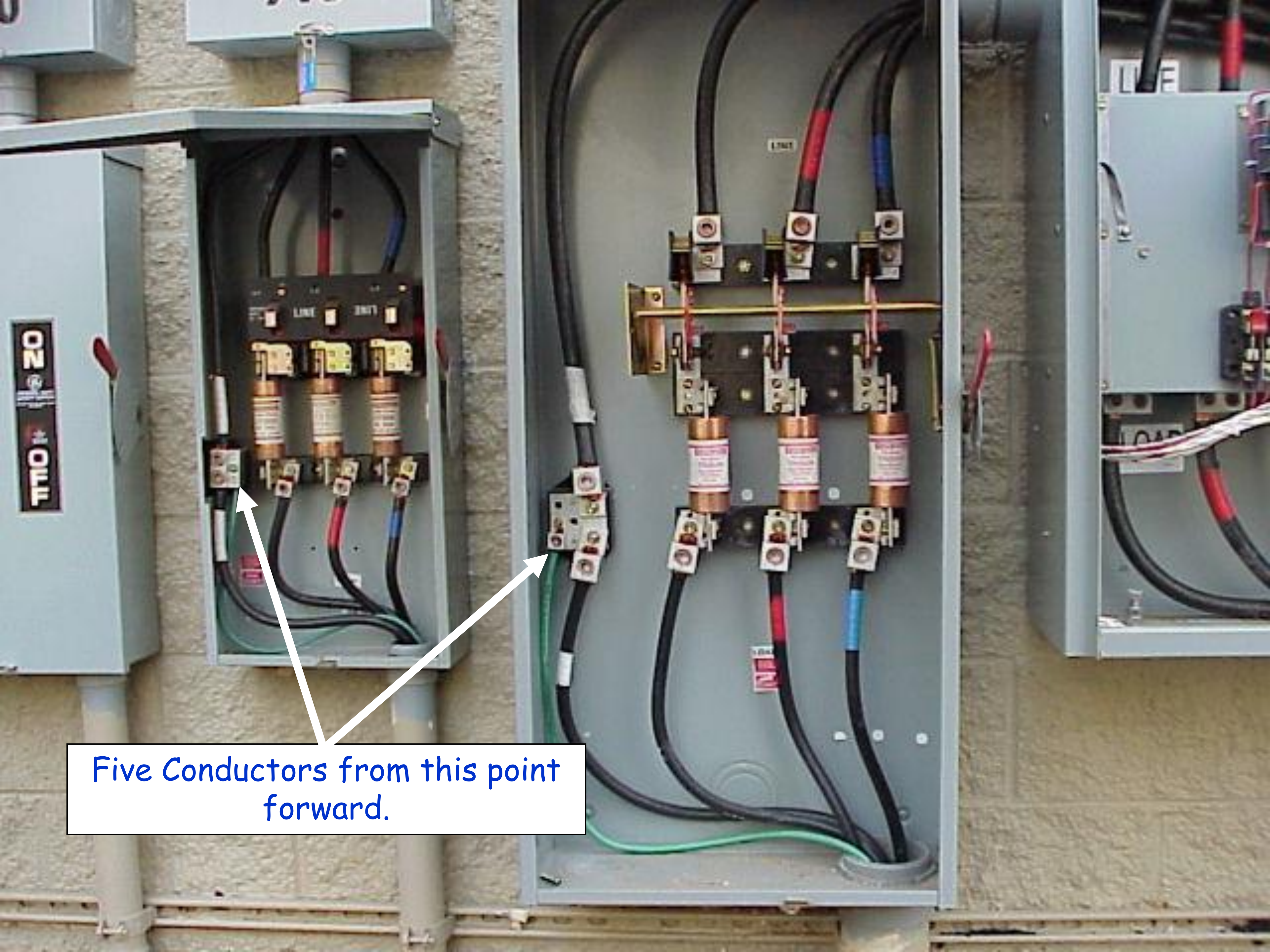

3.443


No Grounding Conductors pulled through Transocket or SC Sockets. All Equipment Grounding Conductors start on the load side of the meters. This is the way we like it!
Grounding Electrode Conductor
730
720
710
Customer's Enclosures are not Bonded.

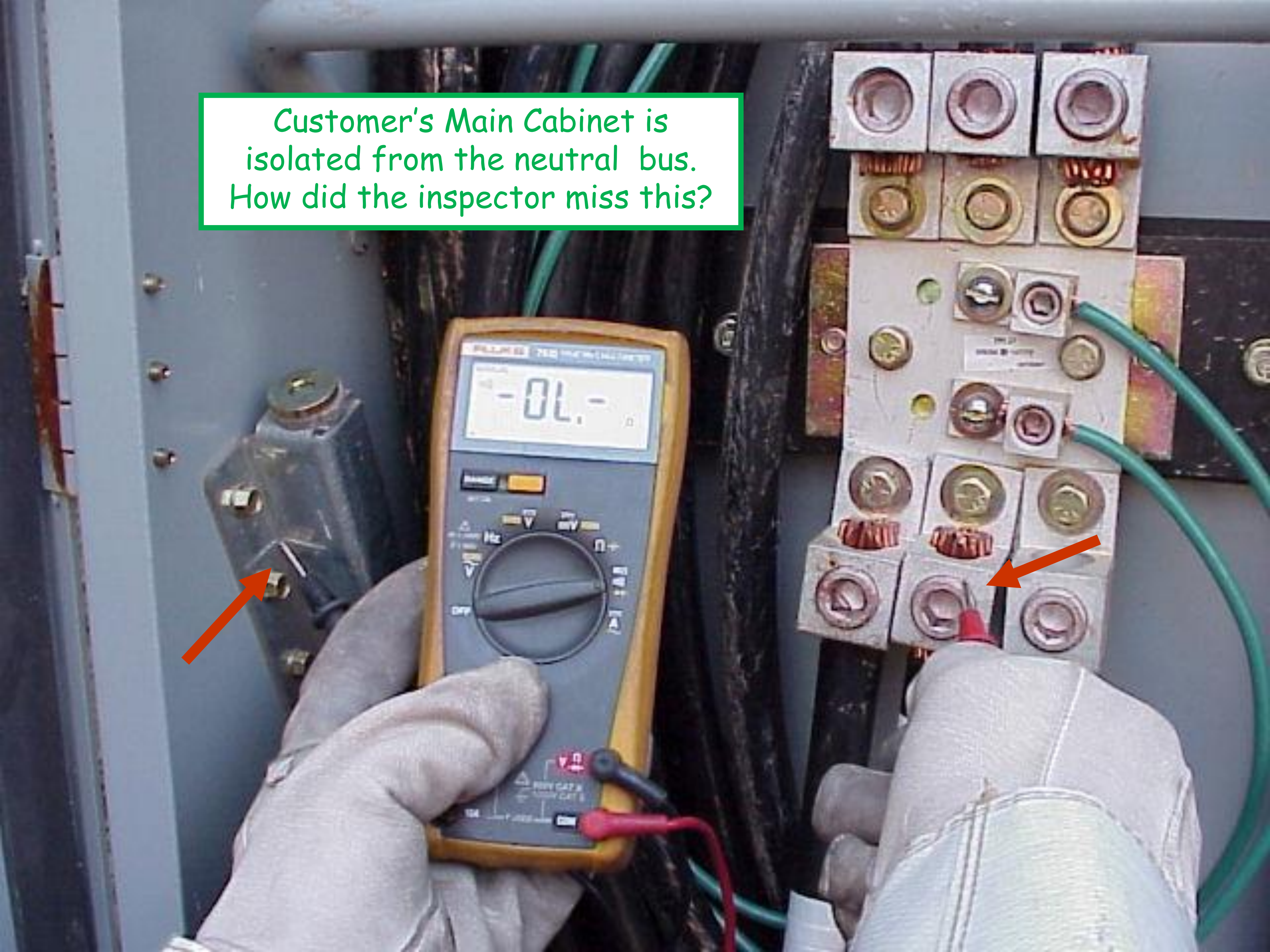

Grounding
Conductors are used
to ground Trough
730
ON

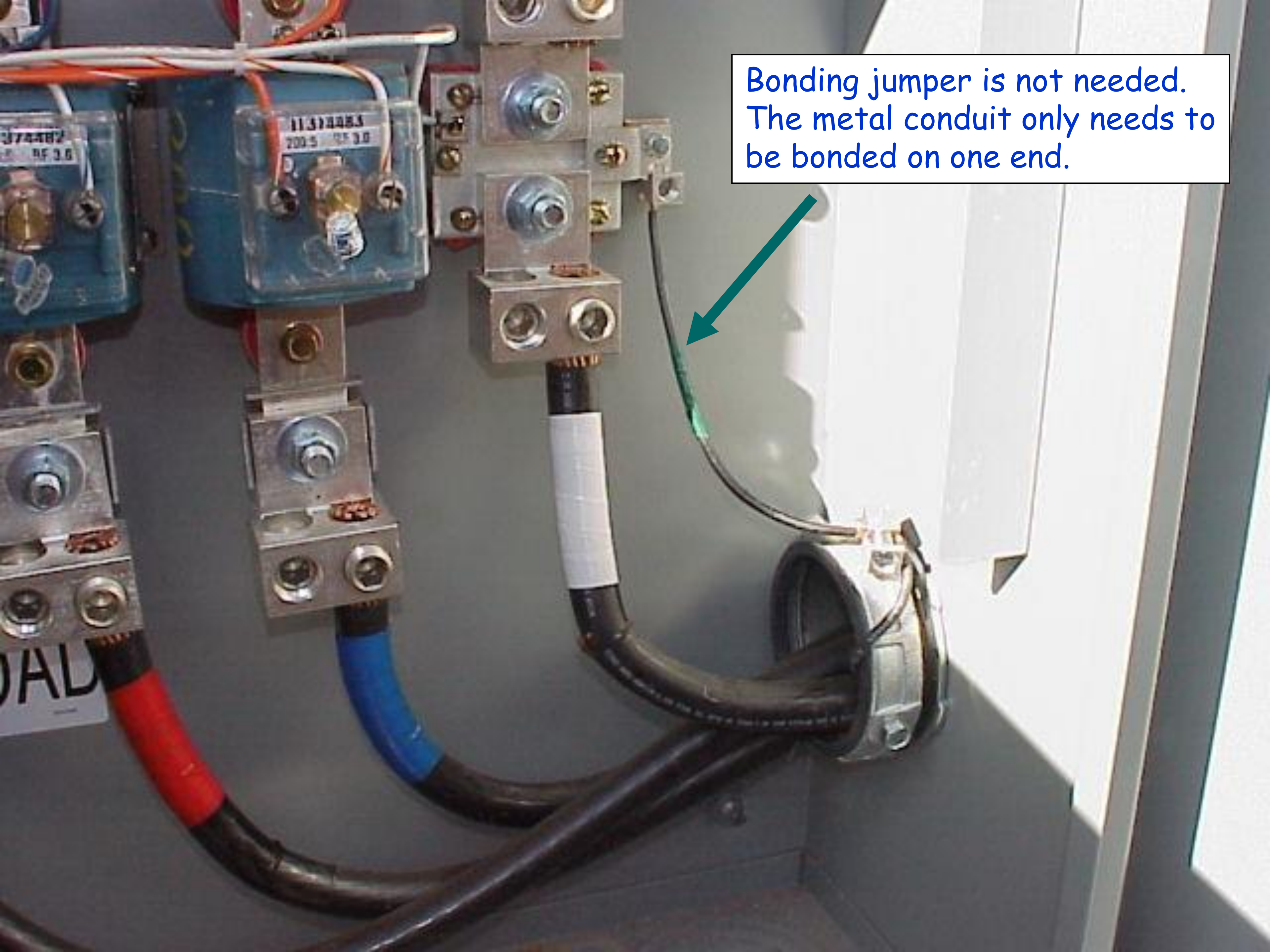
# Only Four Conductors Required




ON
OFF
Five Conductors from this point forward.


Bonding Screw, Cabinet is not Grounded
TR250R
TR250R

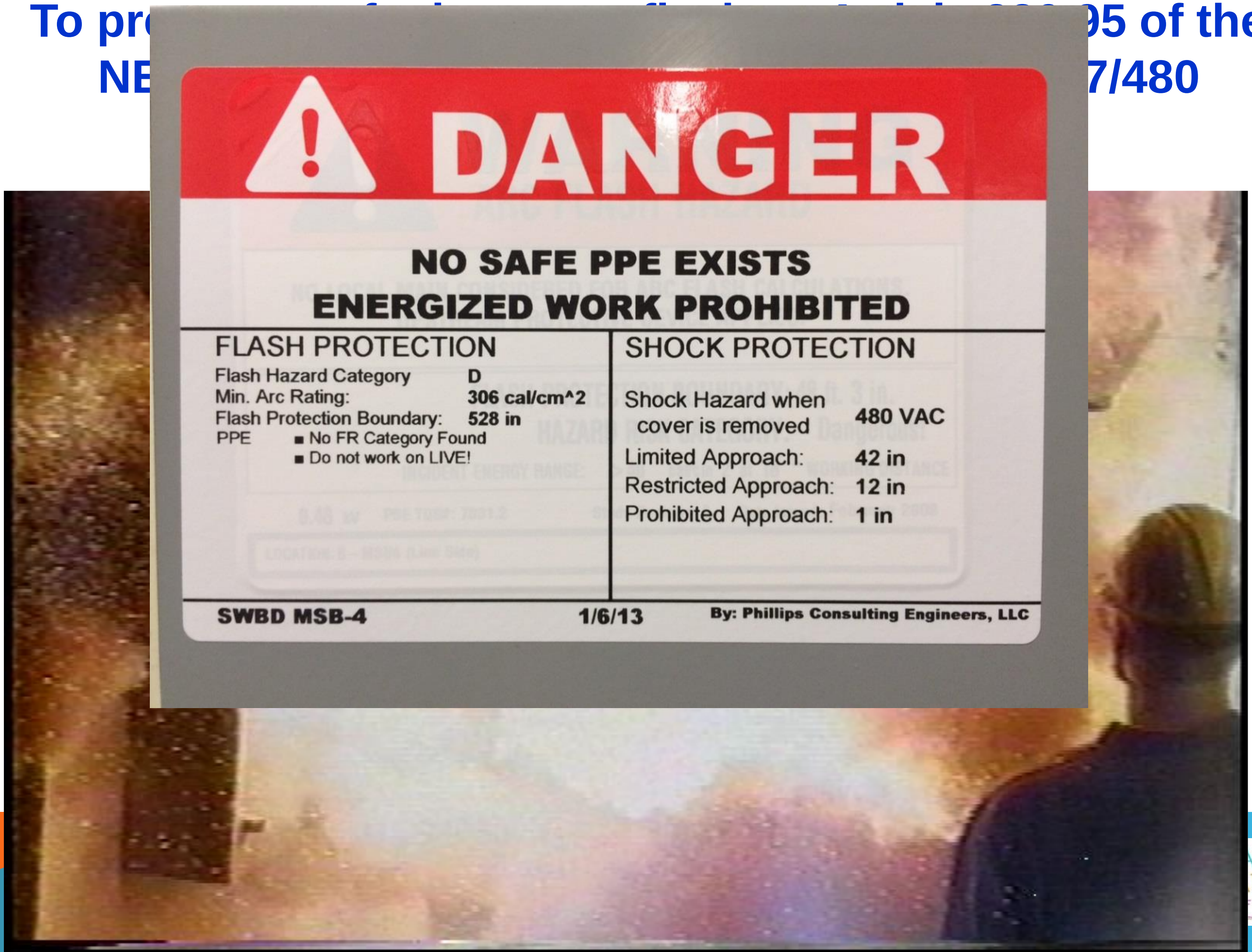

Customer's Main Cabinet is
isolated from the neutral bus.
How did the inspector miss this?
-0L.-


Bonding jumper is not needed.
The metal conduit only needs to be bonded on one end.

# Ground-Fault Protection of Equipment

**The NEC recognizes a great difference in Safety between 277/480 volt and 120/208 volt systems.**

**To pr 95 of the NE 7/480**



# What does IEEE say?

***IEEE Std 242-1986 Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems.***

***7.2.2*** *One disadvantage of the solidly grounded 480 V systems involves the high magnitude of ground-fault currents that can occur, and the destructive nature of arcing ground faults.*

***IEEE Std 141-1993 Recommended Practice for Electric Power Distribution for Industrial Plants***

***7.2.4*** *The solidly grounded system has the highest probability of escalating into a phase-to-phase or three-phase arcing fault, particularly for the 480 and 600V systems. A safety hazard exists for solidly grounded systems from the severe flash, arc burning and blast hazard from any phase-to-ground fault.*

**NEC Article 230.95    Ground-Fault Protection of Equipment**

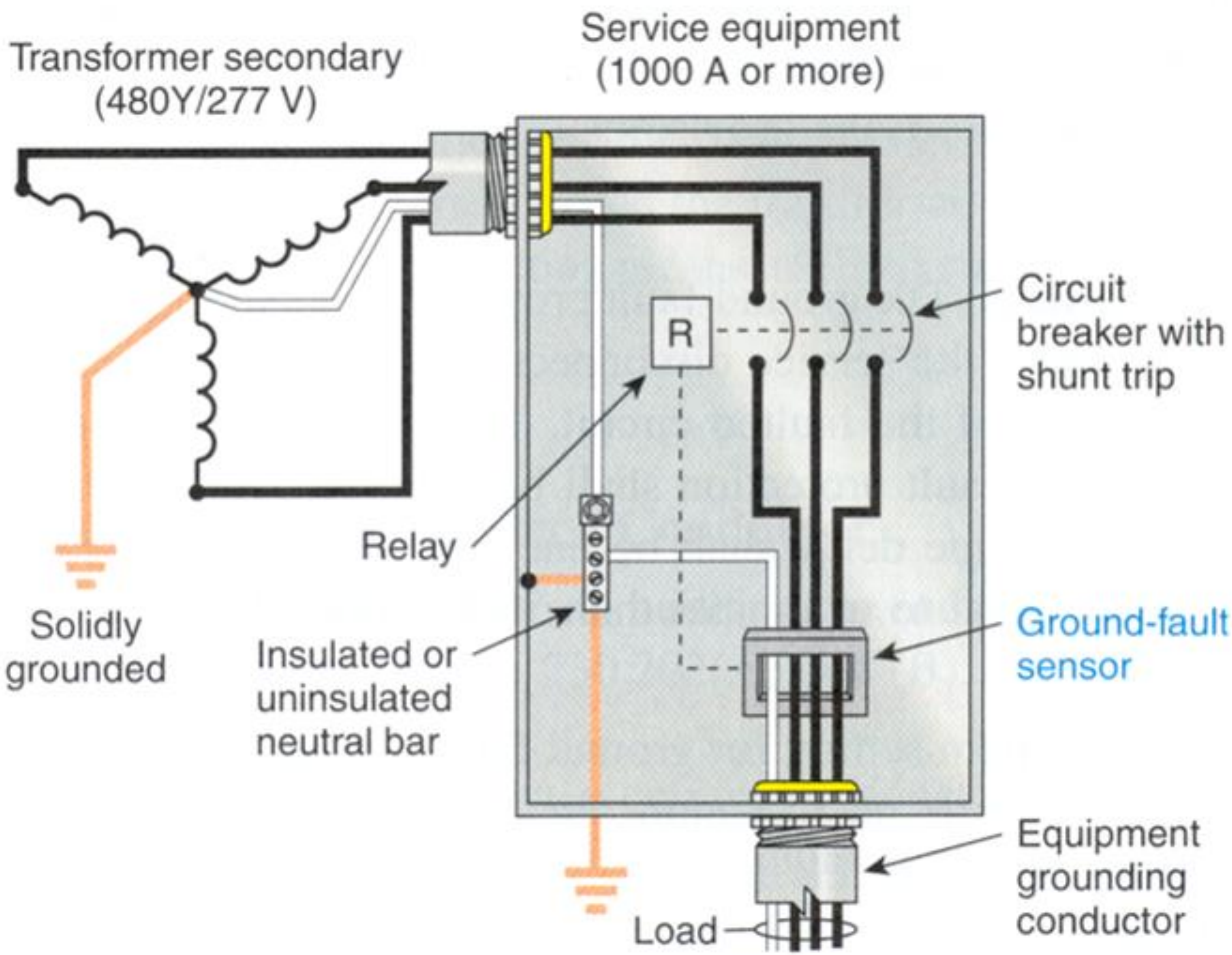
*"Ground-fault protection of equipment shall be provided for solidly grounded wye electrical services of more than 150 volts to ground but not exceeding 1000 volts phase-to-phase for each service disconnect rated 1000 amperes or more."*

**NEC Article 100 - Definitions: Ground-Fault Protection of Equipment**

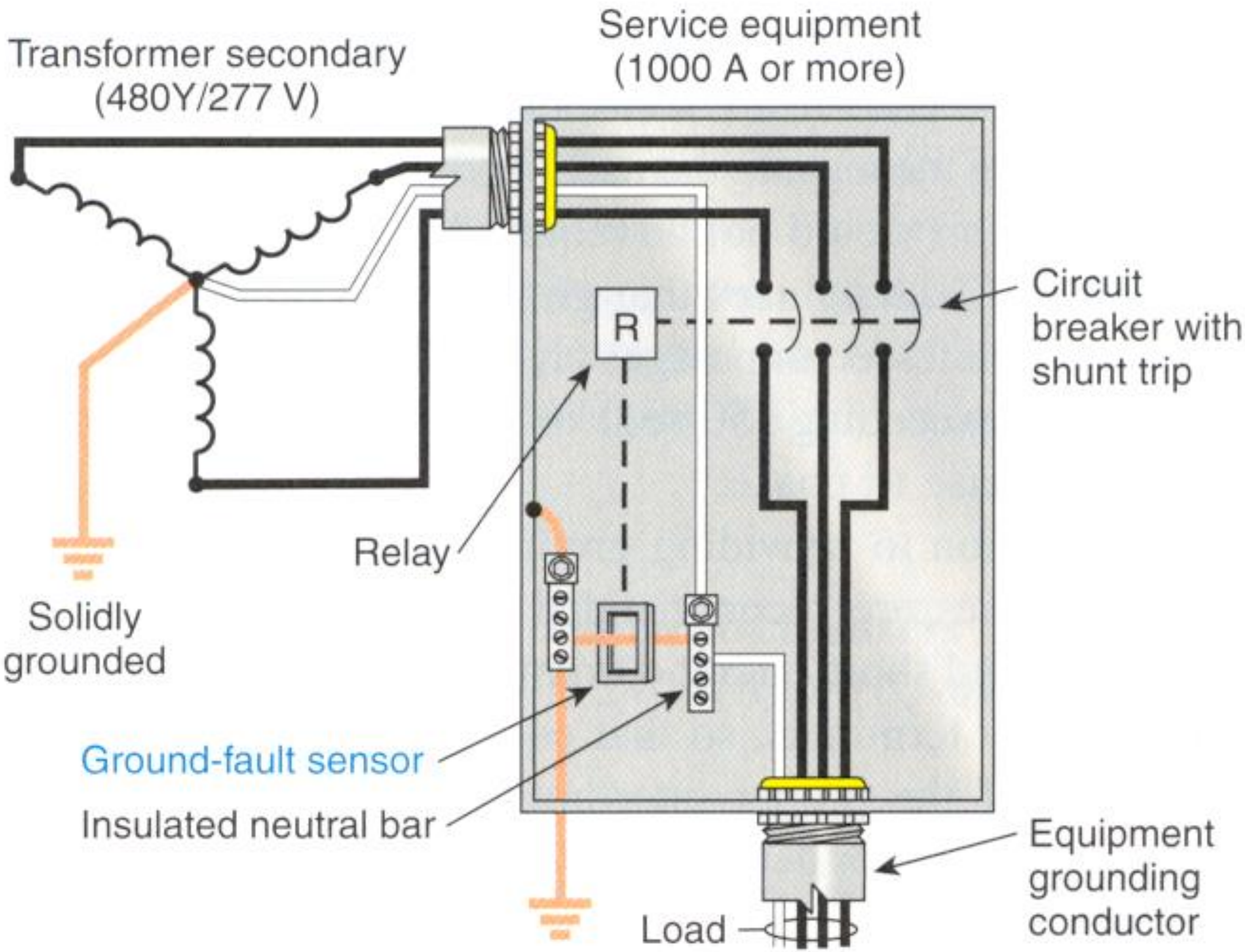
*"A system intended to provide protection of equipment from damaging line-to-ground fault currents by operating to cause a disconnecting means to open all ungrounded conductors of the faulted circuit. This protection is provided at current levels less than those required to protect conductors from damage through the operation of a supply circuit overcurrent device."*

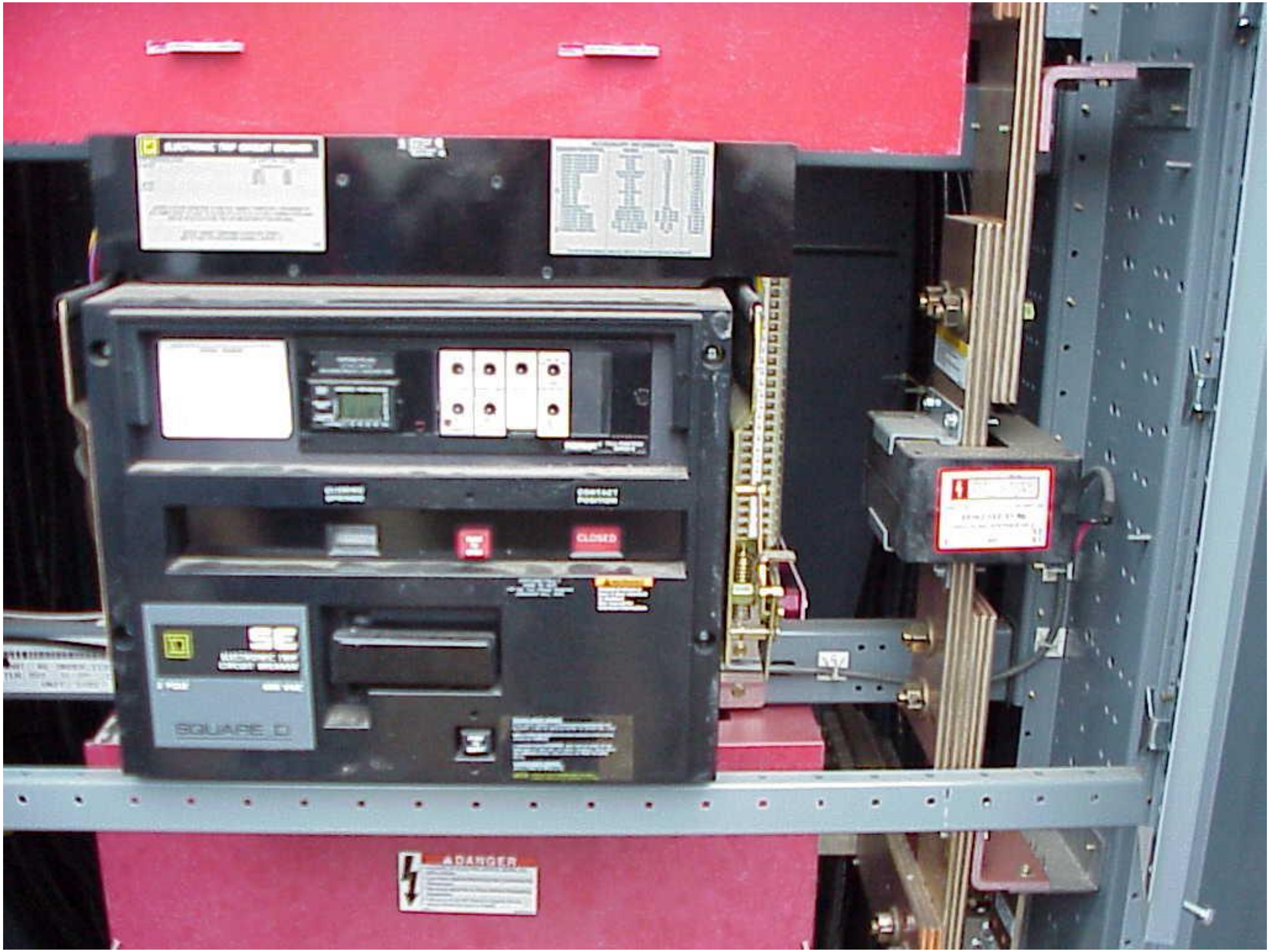
- ***The reason behind this requirement was an awareness of the danger of arc faults on grounded 277/480 volt systems.***
- ***On larger services, the current required to sustain the arc may be less than the rating of the circuit breakers.***
- ***On smaller services (below 1000 amps), the overcurrent devices would be expected to clear the fault in sufficient time to limit damage, however, ground-fault protection may sometimes be desirable on services below 1000 amps.***
- ***Up to six 800 amp mains may be installed without GFP.***

## The Ground-fault sensor is installed around all the circuit conductors, including the neutral.



## The Ground-fault sensor is installed around the bonding jumper only.






Residual Type Ground Fault Protection


The End
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