About the Technical Speaker

ENGR. JUSTO MA. J LOPEZ JR., PEE no.1834

Fellow IIEE , ASEAN Engineer, ACPE Engineer

- **Convenor PEC1-IEC Sub Committee**
- **Vice-Chair BPS TC-77 Committee**
- **Member IIEE College of Fellow Committee**
- **Former Vice-Chair : IIEE IAG (Advocacy) Committee**
- **Former Vice-Chair IIEE Electrical Safety Committee**

- BS in Electrical Engineering, University of Santo Tomas (1974)

- Diploma in Electronic Technology, Cleveland Institute of Electronics (1973)

ACHIEVEMENTS & AWARDS:

-2010 - Most Outstanding Electrical Engineer for Construction & Project Management

-2011 - **Most Outstanding Alumnus awarded by Don Bosco College, Mandaluyong City**

- 2019 - ONE of 3 Nominees for PRC Most Outstanding Electrical Engineer

- 1st Electrical Contracting Practitioner who did the tallest building : 54 Story located in Ortigas Business Center in the Philippines in 2002, The One San Miguel Building

WORK EXPERIENCE

President- Drosvil Engineering Services 2012-2014

Exec. VP- Drosvil Engineering Services 1974-2011

Electrical Consultant - City of Manila 2003 -2007

Electrical Consultant- Dept of Environment & National Resources (DENR NCR) 2007 -2009

Electrical Consultant- North Matrix Development Corporation / LMPRESS 2014 - present

COMMON BASIC ERRORS
in Electrical installations

- *Raceway Issues*
- *Wiring Issues*
- *Boxes Issues*
- *Termination Issues*
- *Phase Balancing Issues*

COMMON Basic Concerns

- Correct Interpretation of the plans and diagram
- Site Inspection and familiarization of the place
- Availability of proper Tools needed in installation
- Right type of raceway to be used and it's approved accessories
- Proper type of boxes and accessories to be used
- Proper size and type of Cables/Wires to be used for the installation.
- Correct type and ratings of circuit protections
- Proper rated Wiring devices should be suited for the installation.
- Testing and Commissioning of the installation using the proper testing devices
- Termination and Splicing of wires and cables (source of overheating)
- Implementation of "Grounding" per requirement of the PEC

Wires and Cables Concerns

I. **Use Correct wire size to carry the <u>maximum electrical load</u> (consider Temperature limitation 100A 0r less)**

II. **Use Wires and Cables suited for the area of installation (Dry, damp, wet, in Cable tray, underground locations)**

III. **Use the correct size of wires to address the Voltage drop PEC requirements.**

I: Maximum Ampacities of Wires

Maximum Ampacities

A Ampacities for conductors rated 0 to 2000 volts are specified in the Allowable Ampacity Table 310.15(B)(16) through Table 310.15(B)(19), and Ampacity Table 310.15(B)(20) and Table 310.15(B)(21) as modified by 310.15(B)(1) through (B)(7) »*310.15(B)*«.

B Table 310.104(A) contains specific conductor information, such as trade name, type letter, maximum operating temperature, application provisions, insulation, size, and outer covering.

C Tables 310.15(B)(16) through 310.15(B)(21) list aluminum (or copper-clad aluminum) as well as copper conductors.

D Maximum ampacities are listed in Tables 310.15(B)(16) through 310.15(B)(21). Other factors must be considered before using these ampacities: temperature limitations »*110.14(C)*«, continuous loads »*210.19(A)* and *215.2(A)*«, ambient temperature »*Tables 310.15(B)(2)(a)* and *(b)*«, and the number of current-carrying conductors »*310.15(B)(3)(a)*«, to name a few.

A	60°C (140°F)	75°C (167°F)	90°C (194°F)	D
	70 amperes	85 amperes	95 amperes	
B	TW	THW	THHN	
				
C	4 AWG Copper	4 AWG Copper	4 AWG Copper	

I: Conductor Temperature Limitations

A Equipment termination provisions for circuits rated 100 amperes or less or marked for 14 AWG through 1 AWG conductors are used only for conductors rated 60°C (140°F) »*110.14(C)(1)(a)*«. Because the lowest temperature (weakest link) is 60°C (140°F), the ampacity of this conductor shall not exceed 70 amperes.

B A 4 AWG copper conductor with a temperature rating of 60°C (140°F) has an ampacity of 70 amperes »*Table 310.15(B)(16)*«.

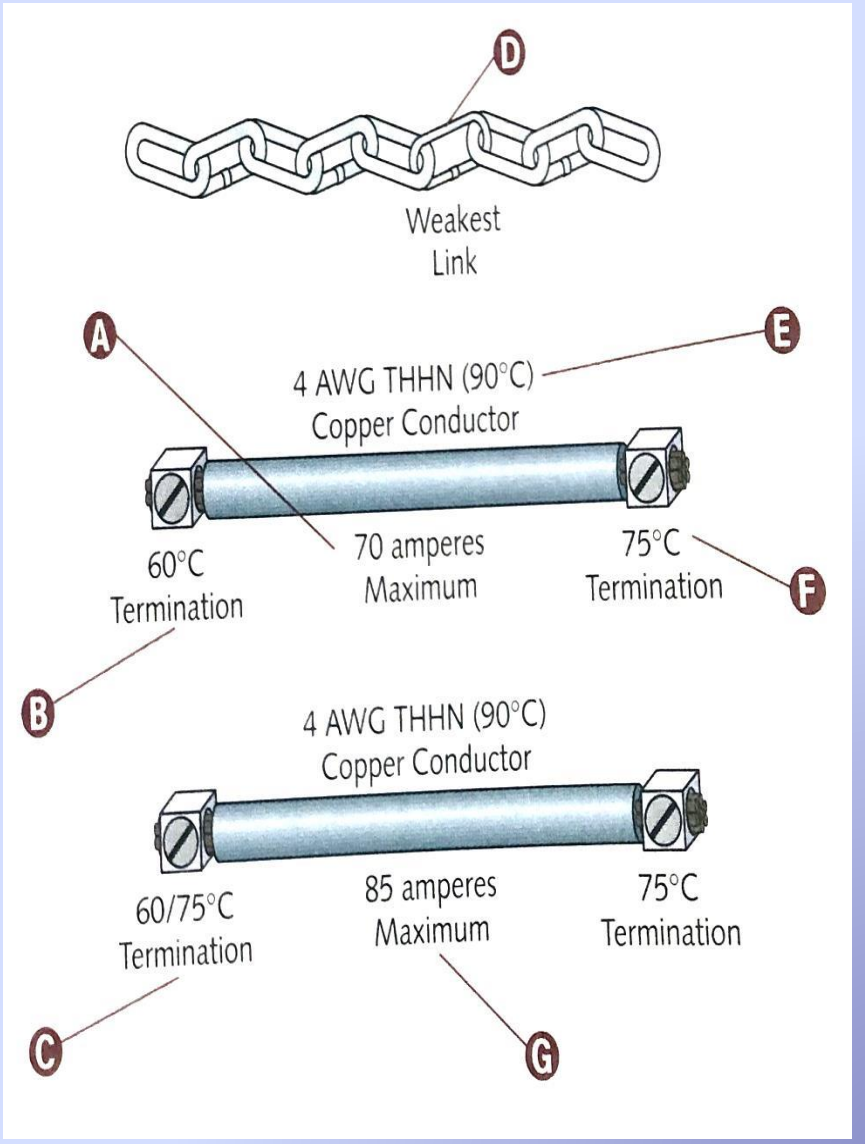
C A temperature rating of 60/75°C means that the termination is suitable for 60°C (140°F) or 75°C (167°F) conductors.

D Conductor temperature limitations can be compared to the strength of a chain. A chain is only as strong as its weakest link. One potential weak link for conductors is the termination (connection) point. The conductor ampacity shall not be higher than the lowest temperature rating of any connected termination, conductor, or device »*110.14(C)*«.

E The ampacity of a 4 AWG THHN copper conductor is 95 amperes »*Table 310.15(B)(16)*«.

F A 4 AWG copper conductor with a temperature rating of 75°C (167°F) has an ampacity of 85 amperes »*Table 310.15(B)(16)*«.

G Equipment termination provisions for circuits rated 100 amperes or less or marked for 14 AWG through 1 AWG conductors can be used for conductors up to their maximum ampacities if the equipment is listed and identified for use with such conductors »*110.14(C)(1)(a)(3)*«. The ampacity of this conductor now has a rating of 85 amperes because the lowest temperature (weakest link) is 75°C (167°F).



Conductors in Parallel

Conductors in Parallel

A Conductors of one phase, polarity, neutral, grounded-circuit conductors, or equipment grounding conductors can have different physical characteristics from those of another phase, neutral, grounded-circuit conductors, or equipment grounding conductors and still achieve balance. For example, neutral conductors do not have to be the same length as Phase A conductors, and Phase A conductors do not have to be the same length as Phase B conductors, etc. »*310.10(H)(2)*«.

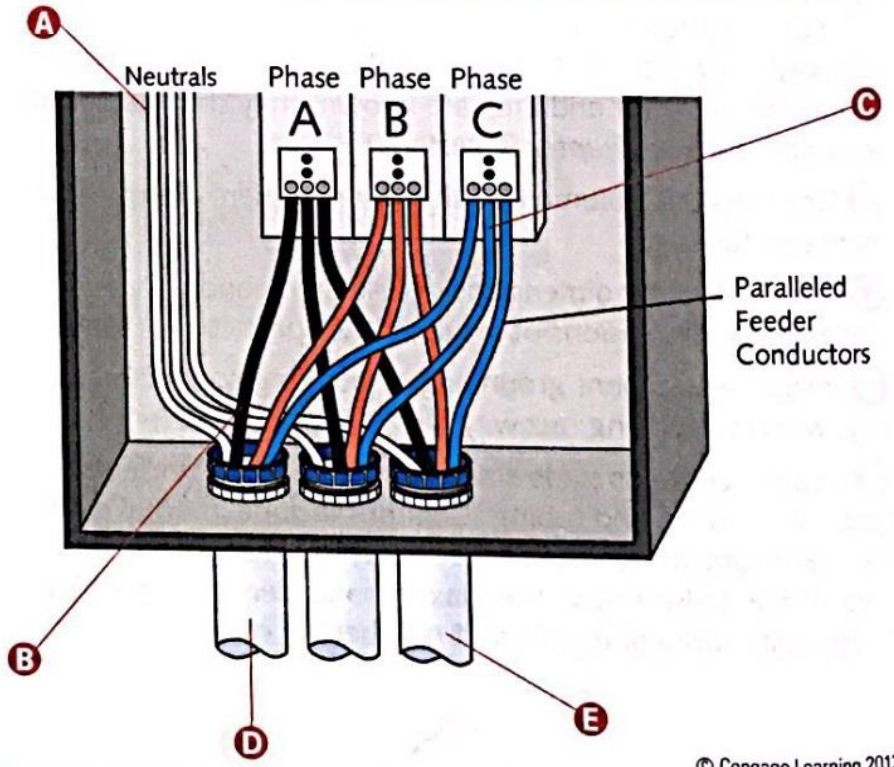
B As a general rule, 1/0 AWG and larger size conductors can be connected in parallel (electrically joined at both ends to form a single conductor) »*310.10(H)(1)*«.

C The paralleled conductors in each phase, polarity, neutral, grounded-circuit conductor, equipment grounding conductors, or equipment bonding jumper must have the same characteristics »*310.10(H)(2)*«. For example, all paralleled, Phase C conductors must:

(1) be the same length,
(2) consist of the same conductor material,
(3) be the same size in circular mil area,
(4) have the same insulation type, and
(5) be terminated in the same manner.

D Conductors carrying alternating current, installed in ferrous metal enclosures or ferrous metal raceways, must be so arranged as to avoid heating the surrounding metal by induction »*300.20(A)*«.

E If run in separate raceways (or cables), the raceways (or cables) must have the same physical characteristics. Where conductors are in separate raceways or cables, the same number of conductors must be used in each raceway or cable »*310.10(H)(3)*«.



WARNING

Each ferrous metal raceway (housing paralleled conductors) must contain all phase conductors, the grounded conductor (where used), and all equipment grounding conductors »*300.20(A)*«. For example, a Phase A conductor, a Phase B conductor, a Phase C conductor, and, if used, a neutral (or grounded) conductor and an equipment grounding conductor must be in each raceway.

NOTE

Equipment grounding conductors used with conductors in parallel must comply with 310.10(H) requirements, applying the sizing requirements of 250.122.

II: Wire Types & It's Insulations & Characteristics

	PRODUCT TYPE	DESIGNATION	MAXIMUM OPERATING TEMP.	REMARKS (APPLICATION)
	**TW**	**(LEAD FREE)** MOISTURE-RESISTANT THERMOPLASTIC WIRE	**60° C**	FLAME RETARDANT MOISTURE RESISTANT BUILDING WIRE WET OR DRY LOCATION
	**THW**	**(LEAD FREE)** HEAT AND MOISTURE RESISTANT THERMOPLASTIC WIRE	**75° C**	FLAME RETARDANT HEAT & MOISTURE RESISTANT BUILDING WIRE WET OR DRY LOCATION
	**THHN/THWN**	**(LEAD FREE)** THERMOPLASTIC HEAT-RESISTANT WIRE WITH NYLON JACKET	**90° C**	FOR CONDUIT WIRING FLAME RETARDANT MOISTURE & HEAT RESISTANT BUILDING WIRES
	**CT-RATED THHN/THWN**	**(LEAD FREE)** CT-RATED THERMOPLASTIC HEAT RESISTANT WIRE WITH NYLON JACKET	**90° C**	CABLE TRAY FLAME RETARDANT MOISTURE & HEAT RESISTANT BUILDING WIRES
	**DUREX**	**(LEAD FREE)** FLAT NON-METALLIC SHEATHED CABLE 2C OR 2C W/ GROUNDWIRE	**60° C**	FOR EXPOSED OR CONCEALED INSTALLATIONS

Wire Types & It's Insulations & Characteristics

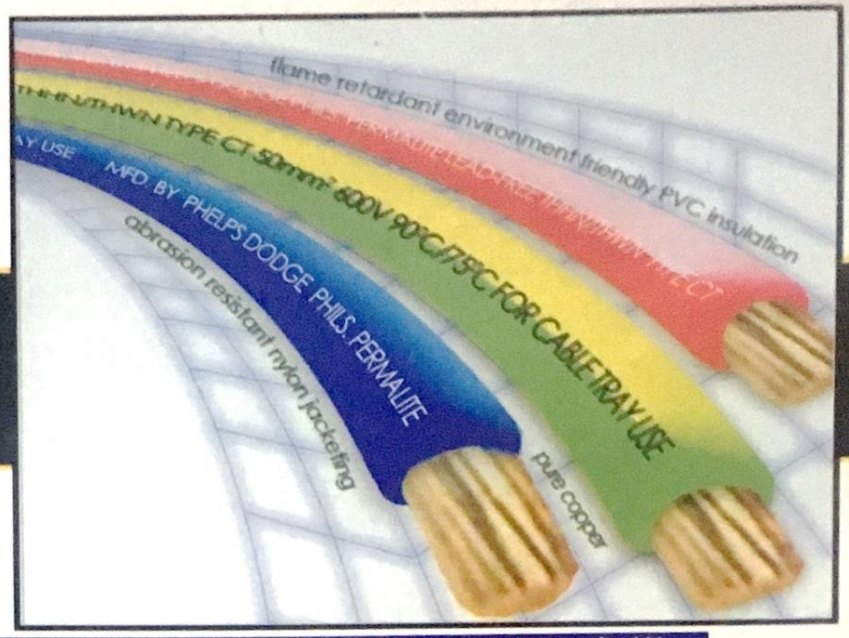
	**DUREX**	**(LEAD FREE)** FLAT NON-METALLIC SHEATHED CABLE (UV JACKET) 2C OR 2C W/ GROUNDWIRE	**60° C**	OUTDOOR APPLICATION OR SERVICE ENTRANCE
	**TF**	**(LEAD FREE)** THERMOPLASTIC FIXTURE	**60° C**	FIXTURE WIRE WITH NYLON SOLID OR STRANDED 300V
	**TFN**	**(LEAD FREE)** THERMOPLASTIC FIXTURE WITH NYLON JACKET	**90° C**	FIXTURE WIRE WITH NYLON SOLID OR STRANDED 300V
	**FLAT CORD**	**(LEAD FREE)** ALL PLASTIC PARALLEL CORD, SPT (FLAT CORD)	**60° C**	PENDANT OR PORTABLE (JUNIOR SERVICE)
	**BARE COPPER SOLID/ STRANDED SOFT DRAWN/ HARD DRAWN**	BARE COPPER		TRANSMISSION WIRE/ GROUNDWIRE

CABLE TRAY RATED WIRES and CABLES

phelps dodge

Over 50 years of undisputed leadership.

Phelps Dodge Lead-Free Cable Tray Rated THHN/THWN Building Wire (PDCT) Technical Specifications



PNS SIZE	Nearest Equivalent AWG/MCM Size	Cable Diameter (mm)	Cable Weight (Kg/m)	Ampacity** (Amperes)		Ampacity*** (Amperes)	
				75°C	90°C	75°C	90°C
50 MM²	# 1/0 AWG	11.8	0.514	220	235	165	193
60 MM²	# 2/0 AWG	12.7	0.625	250	260	187	218
80 MM²	# 3/0 AWG	14.2	0.813	300	320	227	266
100 MM²	# 4/0 AWG	15.7	1.030	325	370	270	315
*125 MM²	# 250 MCM	17.9	1.300	400	420	316	369
*150 MM²	# 300 MCM	19.3	1.560	440	475	363	423
200 MM²	# 400 MCM	21.4	1.970	510	570	416	486
*250 MM²	# 500 MCM	23.8	2.520	620	655	496	581
325 MM²	# 650 MCM	26.9	3.220	720	770	576	674
*400 MM²	# 800 MCM	29.6	3.970	810	875	659	771
500 MM²	# 1000 MCM	32.2	4.810	930	995	741	870

*Complies with UL 83 specifications for conductor sizes under UL File E 54448
**For single conductors installed in single layer with maintained free air spacing of not less than one cable diameter as per PEC 3.18.1.11(b)3 at 30°C ambient temperature.
***For Single conductors installed in triangular configuration with maintained free air spacing of 2.15 x cable diameter as per PEC 3.18.11(b)4 at 40°C ambient temperature.

CABLE TRAY RATED WIRES

PNS SIZE	Nearest Equivalent AWG/MCM Size	Cable Diameter (mm)	Cable Weight (Kg/m)	Ampacity** (Amperes)		Ampacity*** (Amperes)	
				75°C	90°C	75°C	90°C
50 MM²	# 1/0 AWG	11.8	0.514	220	235	165	193
60 MM²	# 2/0 AWG	12.7	0.625	250	260	187	218
80 MM²	# 3/0 AWG	14.2	0.813	300	320	227	266
100 MM²	# 4/0 AWG	15.7	1.030	325	370	270	315
*125 MM²	# 250 MCM	17.9	1.300	400	420	316	369
*150 MM²	# 300 MCM	19.3	1.560	440	475	363	423
200 MM²	# 400 MCM	21.4	1.970	510	570	416	486
*250 MM²	# 500 MCM	23.8	2.520	620	655	496	581
325 MM²	# 650 MCM	26.9	3.220	720	770	576	674
*400 MM²	# 800 MCM	29.6	3.970	810	875	659	771
500 MM²	# 1000 MCM	32.2	4.810	930	995	741	870

*Complies with UL 83 specifications for conductor sizes under UL File E 54448

**For single conductors installed in single layer with maintained free air spacing of not less than one cable diameter as per PEC 3.18.1.11(b)3 at 30°C ambient temperature.

***For Single conductors installed in triangular configuration with maintained free air spacing of 2.15 x cable diameter as per PEC 3.18.11(b)4 at 40°C ambient temperature.

Cable Tray Rated Wires

What are Cable Tray (CT) Rated Building Wires?

The Cable Tray Wiring System is a proven safe and cost-effective way to manage cables. Electrical designers and contractors worldwide have already proven the benefits of using the cable tray wiring system, which include easier electrical design, lesser materials needed, easier installation and maintenance, and flexibility for future expansion or alteration.

When using the Cable Tray System, the Philippine Electrical Code requires that Cable Tray Rated building wires be used. These wires are specially designed to fit the needs of the cable tray wiring system because of their superior flame retardant capability.

How Do You Know if a Building Wire is CT Rated?

To know if a building wire is cable tray rated, simply look at the wire marking which must state that it is suitable for cable tray use.

The marking means that it complies with the Philippine Electrical Code's requirement that CT Rated wires must pass the 'vertical tray flame test' first before being marked with the inscription 'for cable tray use'. The vertical tray flame test, which must be done by an independent laboratory, will ensure that the wire does not propagate flames to other areas in case of fire.

PDCT

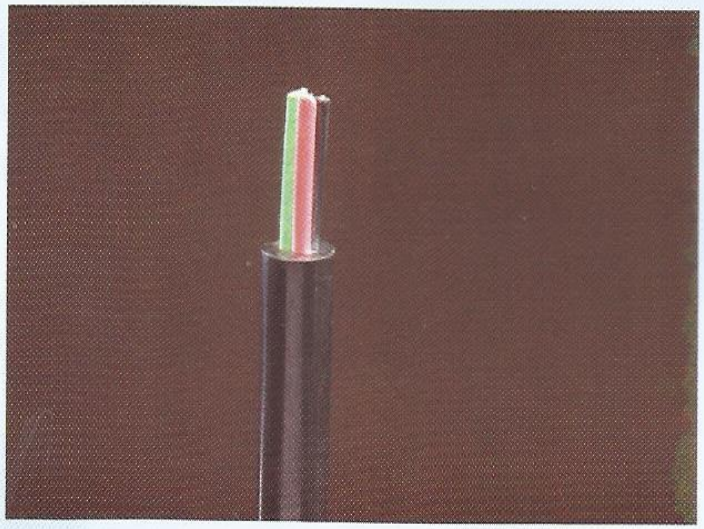
In the Philippines, only Phelps Dodge Lead-Free Cable Tray Rated Building Wires (PDCT) has such marking (for 50mm^2 size to 500mm^2). PDCT was tested by Underwriters Laboratories, the leading certifications and standards organizations in the US, and was certified to be suitable for cable tray installations.

PDCT's enhanced and more effective flame retardant capability protects it from fire and its tough abrasion resistant nylon jacketing protects it from mechanical damage.

With its lead-free insulation, PDCT cables have the added bonus of being environment friendly, eliminating the hazard risk brought about by lead.

Fire-Smoke Rated Wires & Cables

Low Smoke Cables



Low-Smoke Halogen-Free Cables (LSHF - Copper or Aluminum)

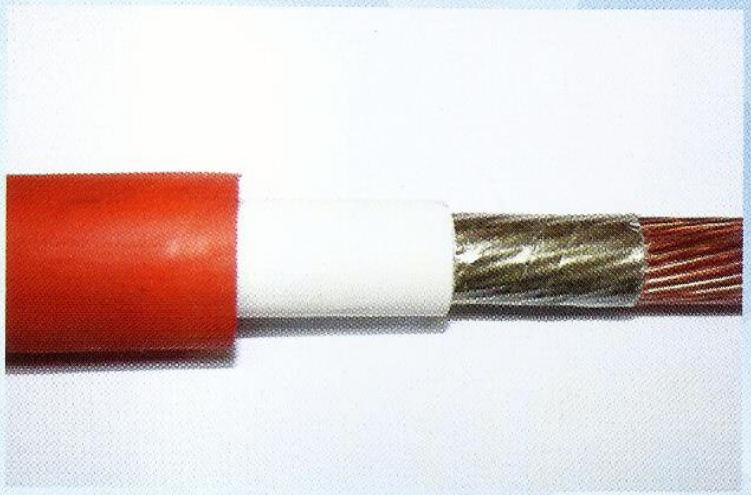
DESCRIPTION:
Single-core or multi-core with low-smoke halogen-free insulation and jacket

CABLE STANDARD:
IEC 60502 - 1 (power cable)
ICEA S - 73 - 532 (control cable)

SIZE RANGE:
2.0mm² - 500mm² (14AWG - 1000MCM)
14mm² - 500mm² (6AWG - 1000MCM) for aluminum conductors

USE OR APPLICATION:
Installed in highly congested and critical areas to prevent smoke suffocation in cases of fire

Fire-Rated Cables



Fire-Rated Cables Single Core or Multi-core – Armored

DESCRIPTION:
Stranded conductor Mica tape, LSHF insulated, LSHF jacketed with temperature of 90°C and for use in 1kV application

CABLE STANDARD:
IEC 60331 and BS 6387

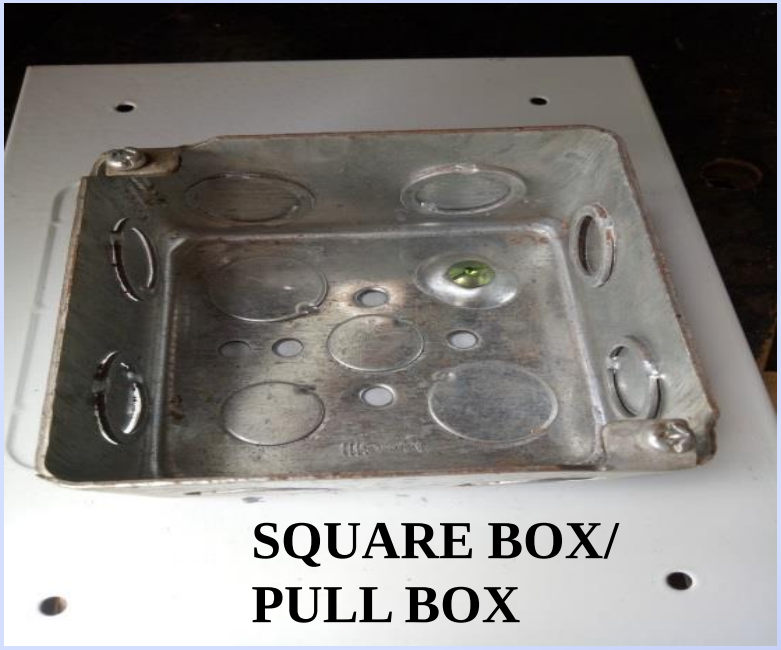
SIZE RANGE:
2.5mm² up to 500mm²

USE OR APPLICATION:
Applicable for use in emergency lighting and exit signs, life support equipment, fire pumps, fire alarms and voice communication systems, fire fighters' elevators, smoke extraction fans

COMMONLY Used BOXES

Commonly Used Boxes

UTILITY BOX



SQUARE BOX/
PULL BOX

JUNCTION
BOX

NEMA 3R Enclosures

Commonly Used Raceways

- **Rigid metal conduit (*RMC).* Can be made of heavy-wall steel or aluminum.**
- **Intermediate metal conduit *(IMC)*. Normally made of steel conduit.**
- **Electrometallic tubing (EMT). Thin-walled steel conduit.**
- ***Electric nonmetallic tubing (ENT)*. Corrugated plastic flexible raceway.**
- ***Nonmetallic underground conduit (PVC)*. Schedule 40 (heavy wall) or schedule 20 [called EB, for "encased burial" (in concrete)].**
- ***Flexible metallic tubing, Greenfield, spiral metal flexible conduit*.**
- ***Liquidtite flexible metallic conduit, Sealtite, flexible metal conduit with an overall PVC waterproofing covering*.**
- ***Surface metal and nonmetallic raceways, Wiremold*.**

Conduits


Ø1" Arrow pipe EMT WHITE CONDUIT
Ø1" Arrow pipe IMC WHITE CONDUIT
Ø1" Arrow pipe RSC WHITE CONDUIT
Protective Coating
Steel
galvanized process
PRODUCT OF QUALITY

ELECTRICAL CONDUITS

PVC CONDUIT

FLEXIBLE METALIC CONDUIT

FITTINGS AND CONNECTORS

ADAPTERS

LOCKNUTS

BUSHINGS

SAMPLE INSTALLATION of Locknut & Bushing

ELBOW

PVC ELBOW

EMT ELBOW

CONDULETS

Condulet T

Condulet LL

Condulet LR
type

Condulet LB

COUPLING

EMT COUPLING

IMC COUPLING

CLAMPS

SERVICE ENTRANCE CAP

CONDUIT INSTALLATIONS

Raceways Fill Percentage

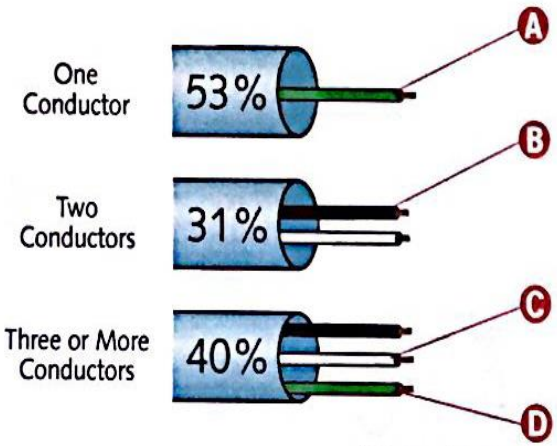
Raceway Fill Percentage

A A conduit having a single conductor or cable can be filled to 53% of the conduit's cross-sectional area.

B A conduit containing exactly two conductors and/or cables can only be filled to 31% of the cross-sectional area of the conduit or tubing.

C A conduit containing three or more conductors and/or cables can be filled to 40% of its cross-sectional area.

D When pulling three conductors or cables into a raceway, if the ratio of the raceway (inside diameter) to the conductor or cable (outside diameter) is between 2.8 and 3.2, jamming can occur. Jamming is less likely to occur when pulling four or more conductors or cables into a raceway »*Chapter 9, Table 1, Informational Note No. 2*«.



NOTE

Tables 1 and 4 (in Chapter 9) list maximum fill percentages for conduits and tubing.

CAUTION

Table 1 is based on common conditions of proper cabling and alignment of conductors where the length of the pull and the number of bends are within reasonable limits. Be advised that a larger size conduit (or fewer conductors) should be considered for certain conditions »*Chapter 9, Table 1, Informational Note No. 1*«.

NOTE

To perform the calculation ratio of the raceway to the conductor or cable, divide the total (100%) cross-sectional area of the conduit or tubing by the approximate area of the three conductors and/or cables.

For example, three 3 AWG THHN conductors will be installed in a 1-inch EMT raceway. Find the ratio of the raceway to the conductors.

The total cross-sectional area of 1-inch EMT is 0.864 in.^{2}.

The approximate area for three 3 AWG THHN conductors is 0.2919 in.^{2} (0.0973 × 3 = 0.2919).

The ratio of the raceway to the conductors is 2.96 (0.864 ÷ 0.2919 = 2.9599 = 2.96).

Because 2.96 is between 2.8 and 3.2, there is a higher probability that jamming will occur.

Maximum Bends Radius of Bends in Conduit Runs

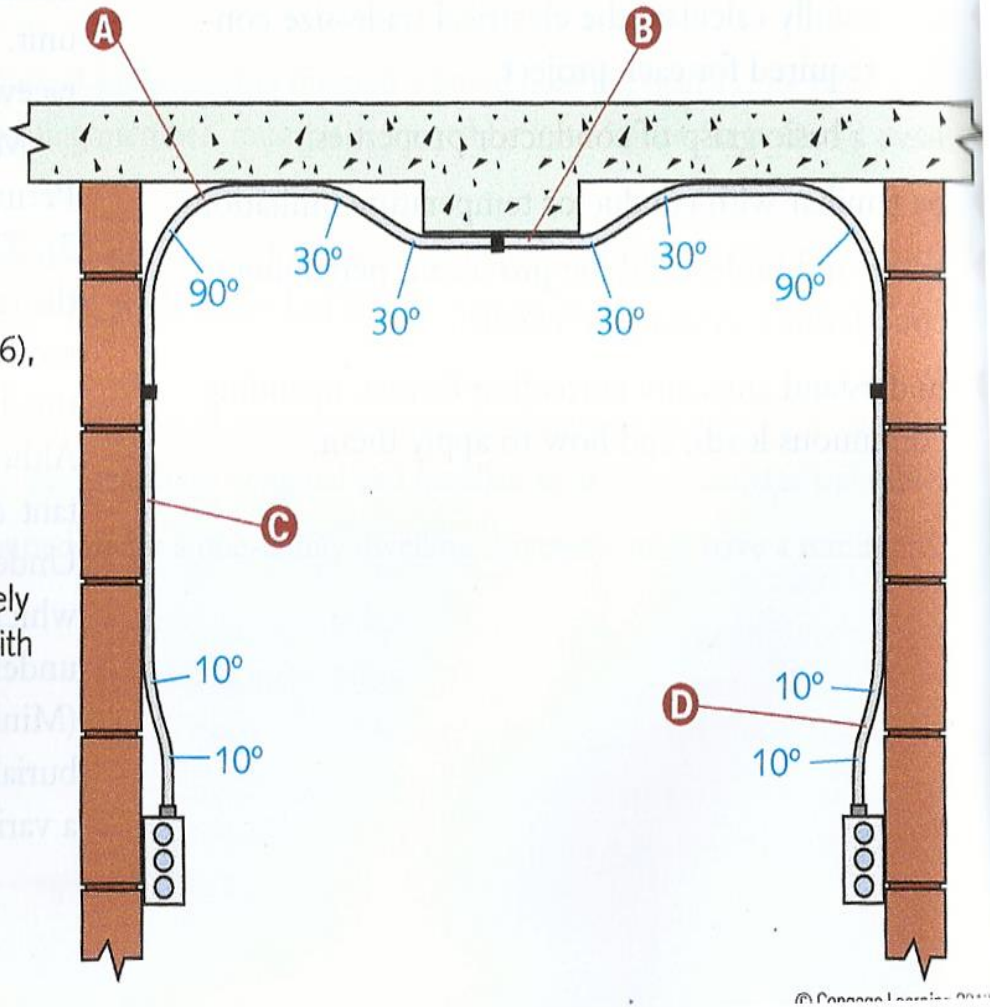
Maximum Bends in One Run

A The equivalent of four quarter bends (360° total) is the maximum allowed between pull points, for example, conduit bodies and boxes. Because the total bends in this conduit run is 340°, this installation falls within *NEC* specifications.

B The bend maximum of 360° applies to the following raceways: IGS (326.26), IMC (342.26), RMC (344.26), FMC (348.26), LFMC (350.26), PVC (352.26), HDPE (353.26), NUCC (354.26), RTRC (355.26), LFNC (356.26), EMT (358.26), and ENT (362.26).

C Generally, raceway installation must be complete between outlet, junction, or splicing points prior to the installation of conductors »*300.18(A)*«.

D All bends are counted, even those located immediately adjacent to the pull box (or termination). A box offset with two 10° bends counts as 20°.



NOTE

Metal raceways must not be supported, terminated, or connected by welding unless specifically permitted by design or *Code* specifications »*300.18(B)*«.

Bending Radius

(A) Bends must be made so that the conduit or tubing remains undamaged with its internal diameter basically undiminished. For any field bend, the radius of the curve to the centerline of the conduit must not be less than indicated in Table 2 of Chapter 9. Raceways permitted to use the "One Shot and Full Shoe Benders" column include IMC »*342.24*«, RMC »*344.24*«, and EMT »*358.24*«.

(B) The bending radius of certain other raceways must not be less than shown in the column titled "Other Bends." They include
FMC »*348.24*«,
LFMC »*350.24*«,
PVC »*352.24*«,
LFNC »*356.24*«, and
ENT »*362.24*«.

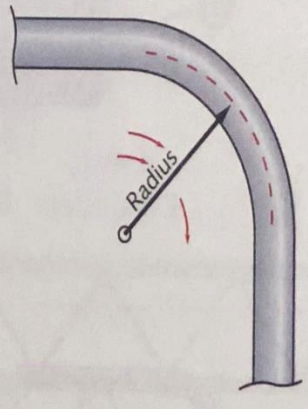


Table 2 (Chapter 9) Radius of Conduit and Tubing Bends

Conduit Size	One Shot and Full Shoe Benders	Other Bends
Trade Size	Bending Radius (in in.)	Bending Radius (in in.)
1/2	4	4
3/4	4 1/2	5
1	5 3/4	6
1 1/4	7 1/4	8
1 1/2	8 1/4	10
2	9 1/2	12
2 1/2	10 1/2	15
3	13	18
3 1/2	15	21
4	16	24
5	24	30
6	30	36

(A) (B)

JUNCTION & PULL BOX SIZING

Straight Pull—Two Raceways

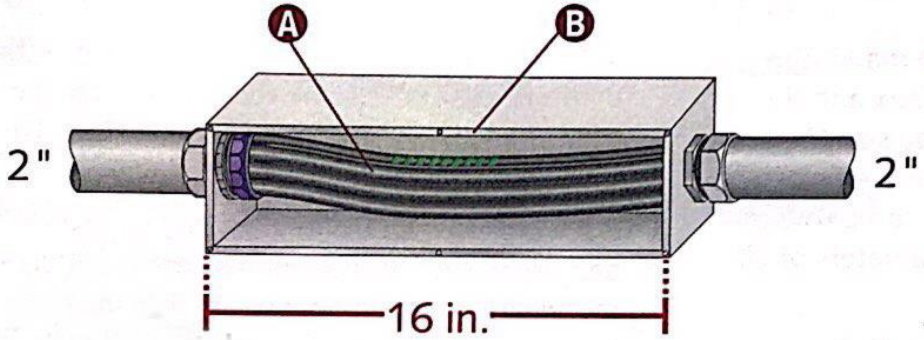
Section 314.16 is used to determine box size requirements for 6 AWG and smaller conductors. Calculations are based on the sizes and numbers of *conductors*. Section 314.28 is used to determine the box size requirements for 4 AWG and larger conductors (under 600 volts). Calculations here are based on the sizes and numbers of *raceways*.

Ⓐ Box calculations for 4 AWG and larger conductors (under 600 volts) are performed based on the size and numbers of raceways »*314.28*«.

Ⓑ Boxes or conduit bodies containing straight pulls are sized according to the largest raceway entering the box. The length must be at least eight times the trade size (metric designator) of the largest raceway »*314.28(A)(1)*«.

NOTE

Use the trade dimension that is applicable to the installation. For example, if millimeters or centimeters are needed to size the junction or pull box, use the metric designator in millimeters instead of the trade size in inches. A junction box is needed for a straight pull with two metric designator 53 raceways. (A 2-in. trade size raceway has a metric designator of 53 mm.) Calculate the minimum length by multiplying the metric designation by eight (53 mm × 8 = 424 mm = 42.4 cm). The minimum size pull box required is 424 mm or 42.4 cm.



Straight Pull

$$\frac{2}{\text{(trade size of largest raceway)}} \times 8 = \underline{16}\ \text{in.}$$

Raceways Enclosing the Same Conductors

The distance between raceway entries enclosing the same conductor shall not be less than six times the trade size (metric designator) of the largest raceway *» 314.28(A)(2) «*. This provision is applicable even if the raceway entries are on different walls.

A Because no other raceways enter on the same wall of the box, no additional raceway diameters are added.

B The minimum dimension required for this box is 12 in. × 12 in. The distance between the raceway entries must not be less than six times the trade size of the larger raceway. Because each raceway is located in the center of the wall of the box, the distance between the raceway entries is less than 12 in. Therefore, this installation is not permitted.

C This 12 in. × 12 in. junction (or pull) box is permitted if the raceways can be installed so the distance between the raceway entries is at least 12 in. Because the distance between the raceway entries is 12 in., this installation is permitted.

Angle Pull for "X" Dimension

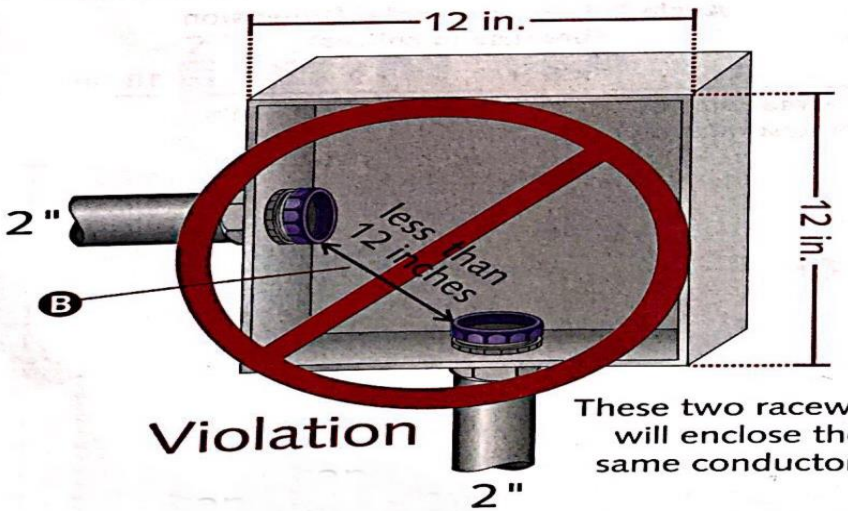
2 (trade size of largest raceway) × 6 + 0 (all other raceways in the same row, on the same wall) = 12 in.

Angle Pull for "Y" Dimension

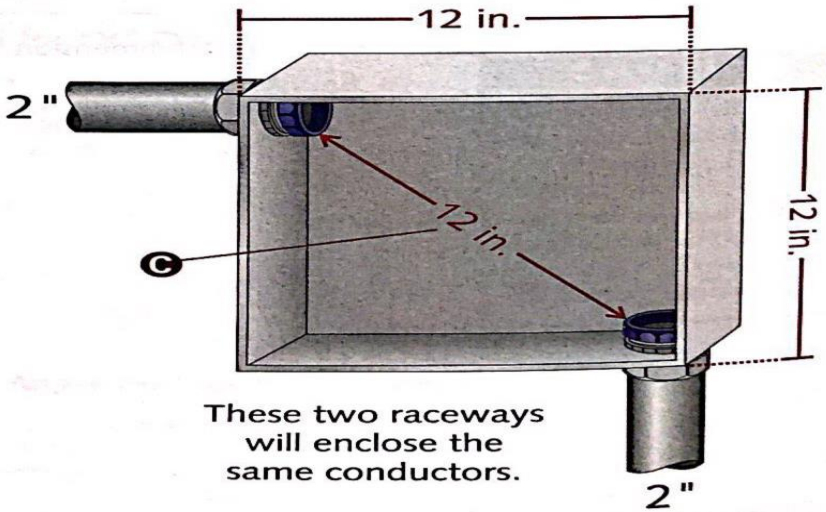
2 (trade size of largest raceway) × 6 + 0 (all other raceways in the same row, on the same wall) = 12 in.

Raceways Enclosing the Same Conductors

2 (trade size of larger raceway) × 6 = 12 in.



These two raceways will enclose the same conductors.



These two raceways will enclose the same conductors.

Conductors in these boxes will be larger than 6 AWG.

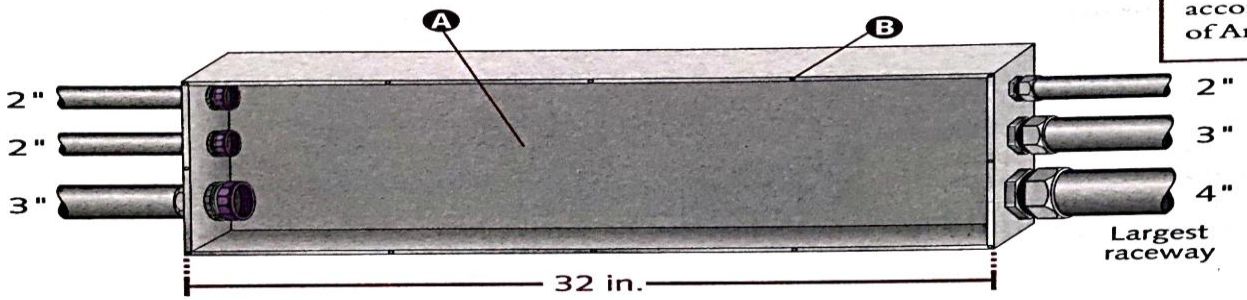
Straight Pull—Multiple Raceways

Ⓐ The length must be at least eight times the trade size (metric designator) of the largest single raceway. No extra space is required for additional raceways when calculating the minimum length of straight pulls. However, additional space is needed for the width of additional raceways, including locknuts and bushings »*314.28(A)(1)*«.

Ⓑ Conduit bodies and boxes (junction, pull, and outlet) must be installed so that the wiring they contain can be made accessible without removing any part of the building or structure »*314.29*«.

CAUTION

Except as permitted in 250.112(I), all metal boxes shall be grounded and bonded in accordance with Parts I, IV, V, VI, VII, and X of Article 250 as applicable »*314.4*«.



Straight Pull

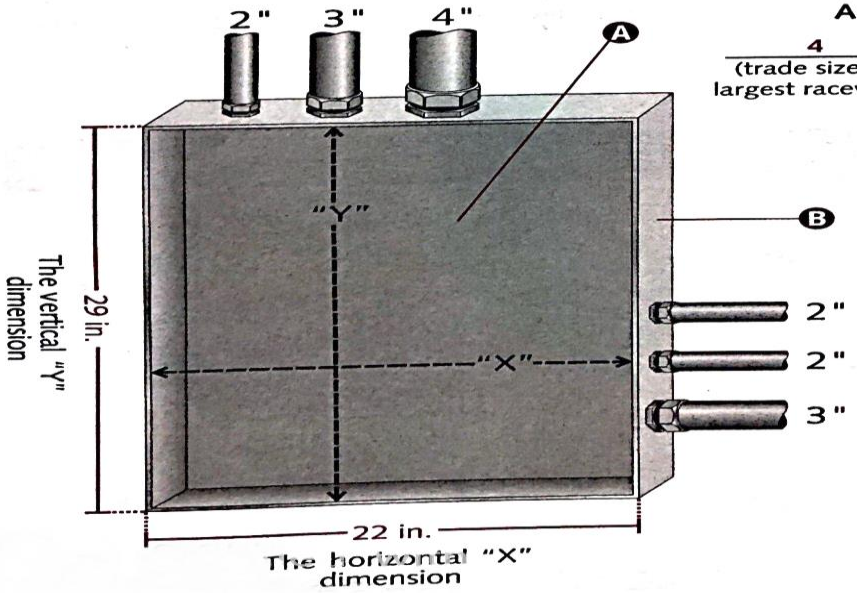
$\frac{4}{\text{(trade size of largest raceway)}} \times 8 = \underline{32}$ in.

Angle or U Pulls (or Splices)—Multiple Raceways

Ⓐ Where splices or where angle or U pulls are made, the distance between each raceway entry into the box and the opposite wall must be at least six times the trade size (metric designator) of the largest raceway in a row. This distance is increased for additional raceway entries (in the same row on the same wall of the box) by the sum of the diameters of all other raceway entries »*314.28(A)(2)*«.

Ⓑ To calculate the dimension of a box with angle pulls, start with one wall where the raceways enter the box, and find the distance to the opposite wall of the box. The path of the conductors is irrelevant to this calculation.

Ⓒ Pick one wall and multiply the largest raceway (trade diameter) by 6. Add to that number the trade diameter of all other raceway(s) in the same row, on the same side of the box.



Angle Pull for "Y" Dimension

$\frac{4}{\text{(trade size of largest raceway)}} \times 6 + \frac{3+2}{\text{(all other raceways in the same row, on the same wall)}} = \underline{29}$ in.

CAUTION

Where a box contains both straight and angle (or U) pulls, or straight pulls and splices, calculate each type of pull individually to find the dimension. Always select the largest dimensions.

Ⓒ

Angle Pull for "X" Dimension

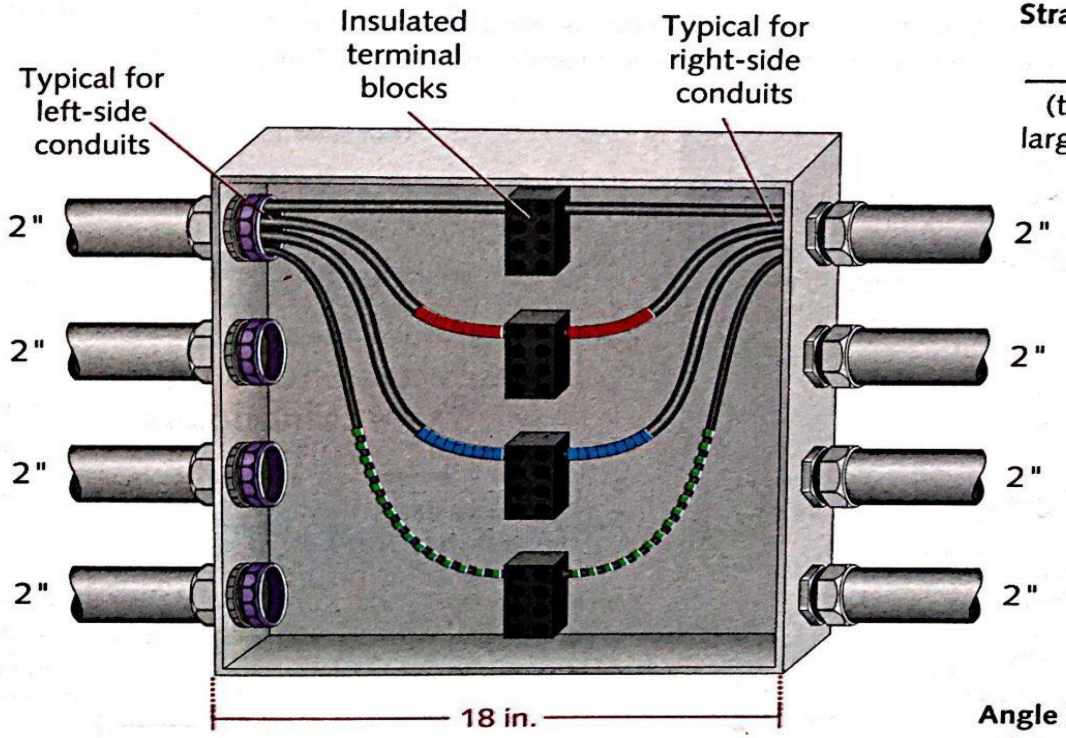
$\frac{3}{\text{(trade size of largest raceway)}} \times 6 + \frac{2+2}{\text{(all other raceways in the same row, on the same wall)}} = \underline{22}$ in.

NOTE

All pull boxes, junction boxes, and conduit bodies must have covers that are compatible with the box or conduit body construction and must be suitable for the conditions of use. Where used, metal covers shall comply with the grounding requirements of 250.110 »*314.28(C)*«.

Straight Pulls with Splices—Multiple Raceways

Where a junction box contains 4 AWG or larger conductors that are spliced and the box contains only straight pulls, compliance with 314.28(A)(1) and (A)(2) is required. Perform both the straight pull calculation and the angle pull calculation and then compare the results. The minimum dimension will be the larger of the two calculations.



Minimum horizontal dimension

Straight Pull for Horizontal Dimension

$$\frac{2}{\text{(trade size of largest raceway)}} \times 8 = \underline{16} \text{ inches}$$

Angle Pull for Horizontal Dimension (because of splices)

$$\frac{2}{\text{(trade size of largest raceway)}} \times 6 + \frac{2+2+2}{\text{(all other raceways in the same row, on the same wall)}} = \underline{18} \text{ in.}$$

Raceways Entering Opposite Removable Covers

Raceways Entering Opposite Removable Covers

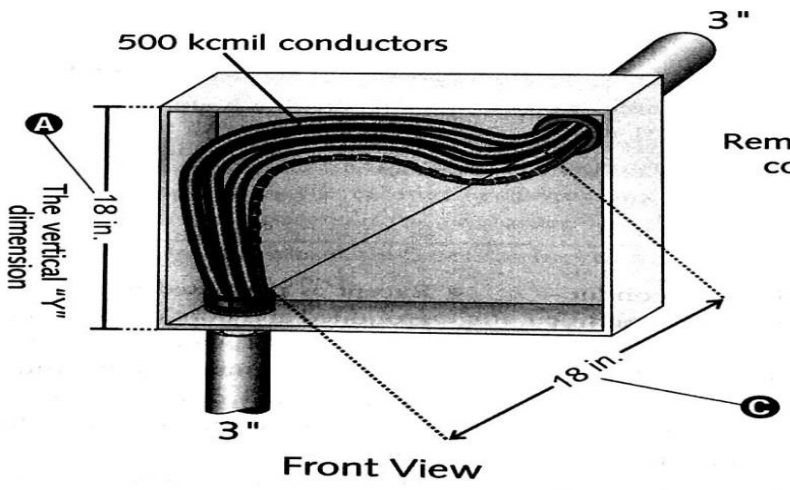
(A) Where angle pulls are made, the distance between each raceway entry into the box and the opposite wall of the box must be at least six times the trade size (metric designator) of the largest raceway >> *314.28(A)(2)* <<. Where no other raceways enter the same wall of the box, no additional raceway diameters are added.

(B) Where a raceway or cable enters the wall of a box (or conduit body) opposite a removable cover, the distance from the entry wall to the cover can be determined by the distance requirements for one wire per terminal found in Table 312.6(A) >> *314.28(A)(2) Exception* <<.

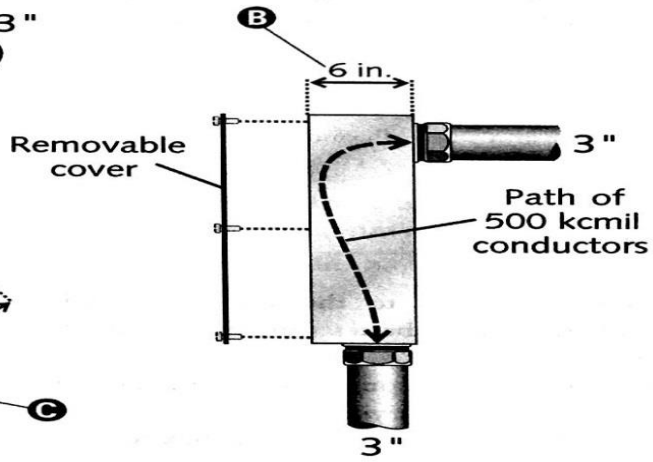
(C) The minimum distance between raceways enclosing the same conductor(s) is six times the trade size (metric designator) of the largest raceway >> *314.28(A)(2)* <<.

Raceways or Cables Entering Boxes Opposite from Removable Covers

Wire Size (AWG or kcmil)	*Minimum Distance from Wall to Cover*	
	in.	*mm*
4–3	2	50.8
2	2½	63.5
1	3	76.2
1/0–2/0	3½	88.9
3/0–4/0	4	102
250	4½	114
300–350	5	127
400–500	6	152
600–700	8	203
750–900	8	203
1000–1250	10	254
1500–2000	12	305



Front View



Side View

Angle Pull for "Y" Dimension

$$\frac{3}{\text{(trade size of largest raceway)}} \times 6 + \frac{0}{\text{(all other raceways in the same row, on the same wall)}} = \frac{18}{} \text{ in.}$$

Raceways Enclosing the Same Conductors

$$\frac{3}{\text{(trade size of larger raceway)}} \times 6 = \frac{18}{} \text{ in.}$$

U Pull—Two Raceways

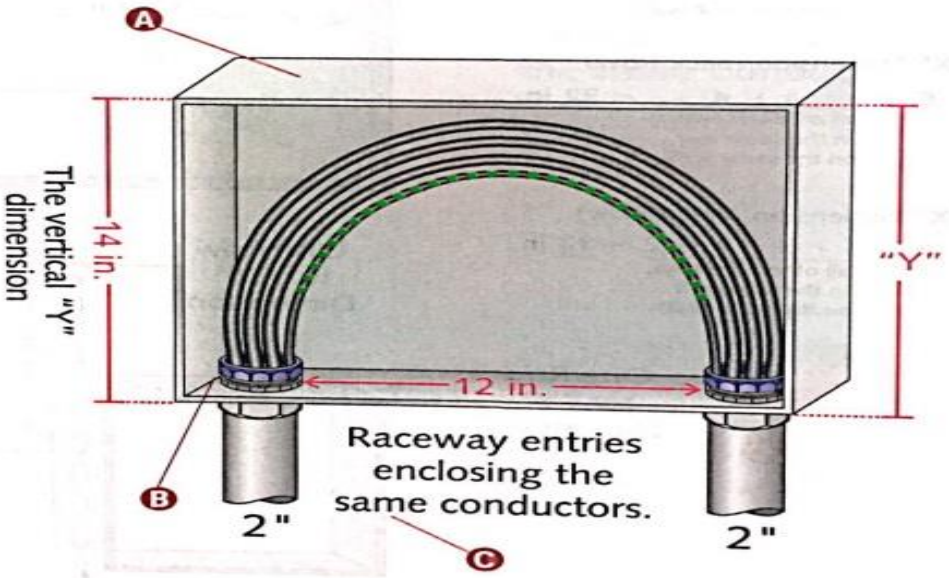
A Use the angle pull method to calculate U pulls. A box with conduit entries only on one wall has a minimum distance to the opposite wall. Multiply the largest raceway by six and add the sum of the trade size (metric designator) of the other raceway(s) entering the same wall »*314.28(A)(2)*«.

B The minimum box width must include 12 in. between raceways plus the thickness of the two raceways (including enough area to provide proper installation of locknuts and bushings).

C The distance between raceways enclosing the same conductor(s) must be at least six times the trade size (metric designator) of the largest raceway »*314.28(A)(2)*«.

NOTE

Insulated circuit conductors (4 AWG and larger) entering a cabinet, box, enclosure, or raceway from another raceway must be fitted with a substantial, smoothly rounded insulating surface, except where the conductors are insulated from the fitting or raceway by a securely fastened-in-place material (such as a plastic bushing) »*300.4(G)*«.



U Pull for "Y" Dimension

$$\frac{2}{\text{(trade size of largest raceway)}} \times 6 + \frac{2}{\text{(all other raceways in the same row, on the same wall)}} = \underline{14}\ \text{in.}$$

Raceways Enclosing the Same Conductors

$$\frac{2}{\text{(trade size of larger raceway)}} \times 6 = \underline{12}\ \text{in.}$$

Angle Pull—Multiple Rows

Ⓐ Where multiple rows of raceways enter a box, calculate each row separately. Use the single row that provides the maximum distance 314.28(A)(2).

Ⓑ Create an imaginary divider line separating each row.

Ⓒ Perform each row calculation as if in a separate box.

Angle Pull for "Y" Dimension (Back Row)

$$\underset{\text{(trade size of largest raceway)}}{4} \times 6 + \underset{\text{(all other raceways, in the same row, on the same wall)}}{3\tfrac{1}{2} + 3\tfrac{1}{2}} = \underline{31}\ \textbf{in.}$$

Angle Pull for "Y" Dimension (Front Row)

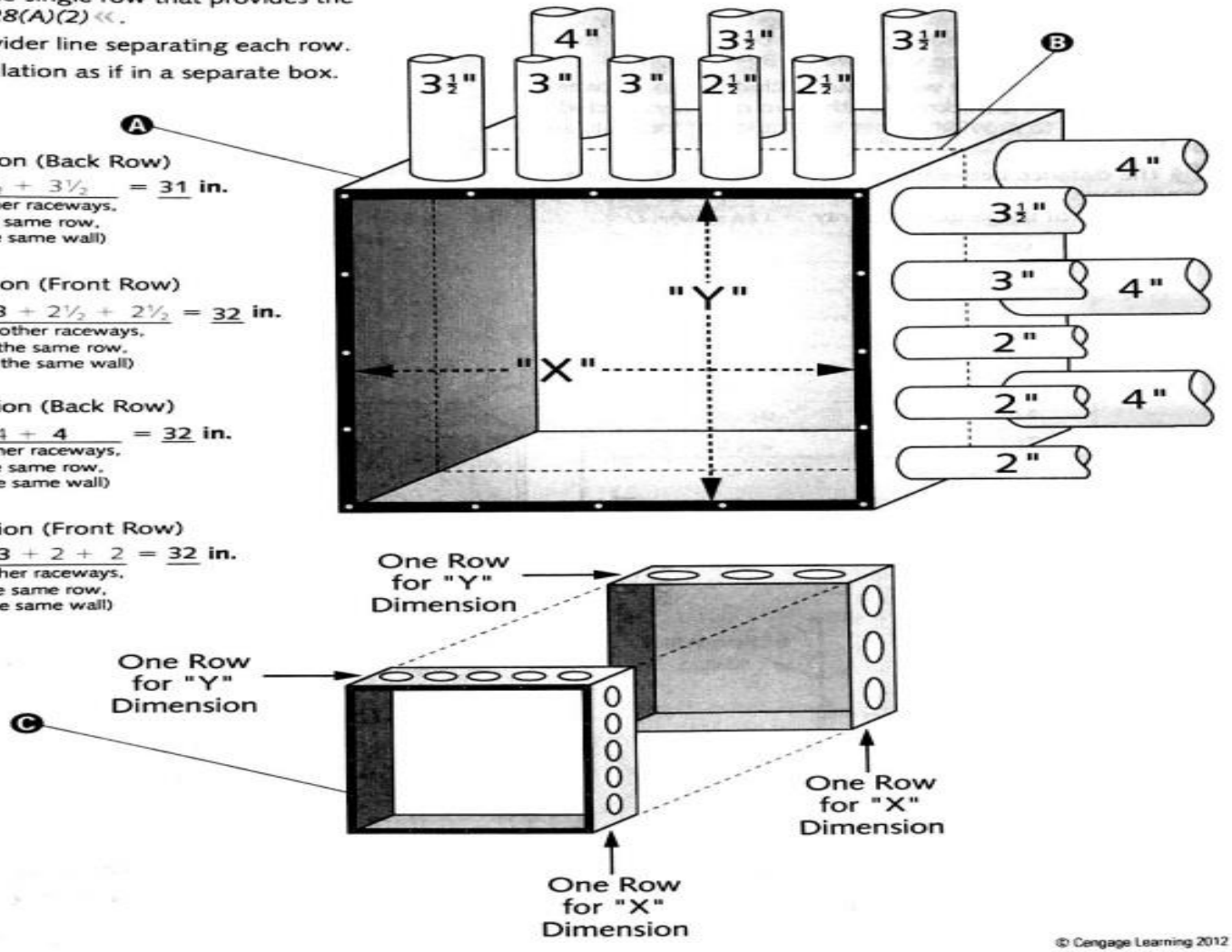
$$\underset{\text{(trade size of largest raceway)}}{3\tfrac{1}{2}} \times 6 + \underset{\text{(all other raceways, in the same row, on the same wall)}}{3 + 3 + 2\tfrac{1}{2} + 2\tfrac{1}{2}} = \underline{32}\ \textbf{in.}$$

Angle Pull for "X" Dimension (Back Row)

$$\underset{\text{(trade size of largest raceway)}}{4} \times 6 + \underset{\text{(all other raceways, in the same row, on the same wall)}}{4 + 4} = \underline{32}\ \textbf{in.}$$

Angle Pull for "X" Dimension (Front Row)

$$\underset{\text{(trade size of largest raceway)}}{3\tfrac{1}{2}} \times 6 + \underset{\text{(all other raceways, in the same row, on the same wall)}}{3 + 3 + 2 + 2} = \underline{32}\ \textbf{in.}$$



NOTE

In pull or junction boxes having any dimension over 6 ft (1.8 m), all conductors shall be cabled (or racked) in an

FEEDER TAPS

PEC ARTICLE 240

A A 200-ampere rated conductor is the minimum size allowed if the overcurrent protection on the tap conductor's line side is 600 amperes (600 ÷ 3 = 200) »*240.21(B)(2)(1)*«.

B The tap conductors shall terminate in a single circuit breaker (or single set of fuses) that will limit the load of the tap conductor's ampacity. This device can supply unlimited additional load side overcurrent devices »*240.21(B)(2)(2)*«.

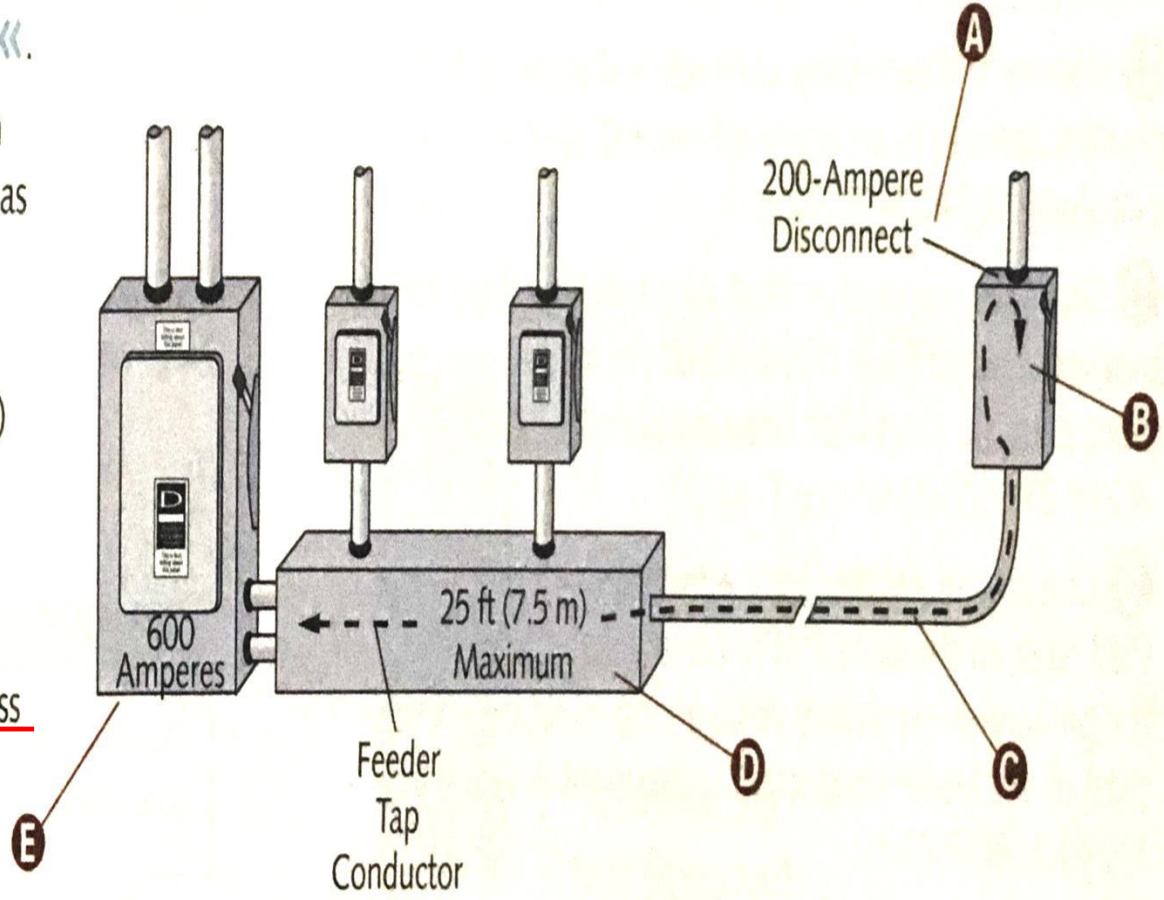
C The tap conductors shall be protected from physical damage in an approved manner, such as enclosed in a raceway »*240.21(B)(2)(3)*«.

D If the tap conductor's length does not exceed 25 ft (7.5 m) and all of 240.21(B)(2)(1) through (3) stipulations are satisfied, overcurrent protection at the tap to the feeder is not required »*240.21(B)(2)*«.

E The tap conductors' ampacity shall not be less than one-third of the feeder conductor's overcurrent device rating »*240.21(B)(2)(1)*«.

NOTE

Tap conductors longer than 25 ft (7.5 m) shall comply with 240.21(B)(4) specifications.



10-ft (3.0-m) Feeder Tap Rule

A A 60-ampere rated conductor is the minimum size allowed if the overcurrent protection on the tap conductor's line side is 600 amperes (600 ÷ 10 = 60) »240.21(B)(1)(4)«.

B The tap conductor's ampacity shall not be less than the rating of the equipment containing an overcurrent device(s) supplied by the tap conductors or less than the overcurrent-protective device rating at the tap conductor's termination »240.21(B)(1)(1)(b)«.

C In addition to the requirement of 408.30, a panelboard shall be protected by an overcurrent protective device having a rating not greater than that of the panelboard. This overcurrent protective device shall be located within or at any point on the supply side of the panelboard »408.36«.

D The tap conductor's ampacity shall not be less than the combined calculated loads on the circuits it supplies »240.21(B)(1)(1)(a)«.

E The tap conductors shall not extend beyond the switchboard, switchgear, panelboard, disconnecting means, or control devices they supply »240.21(B)(1)(2)«.

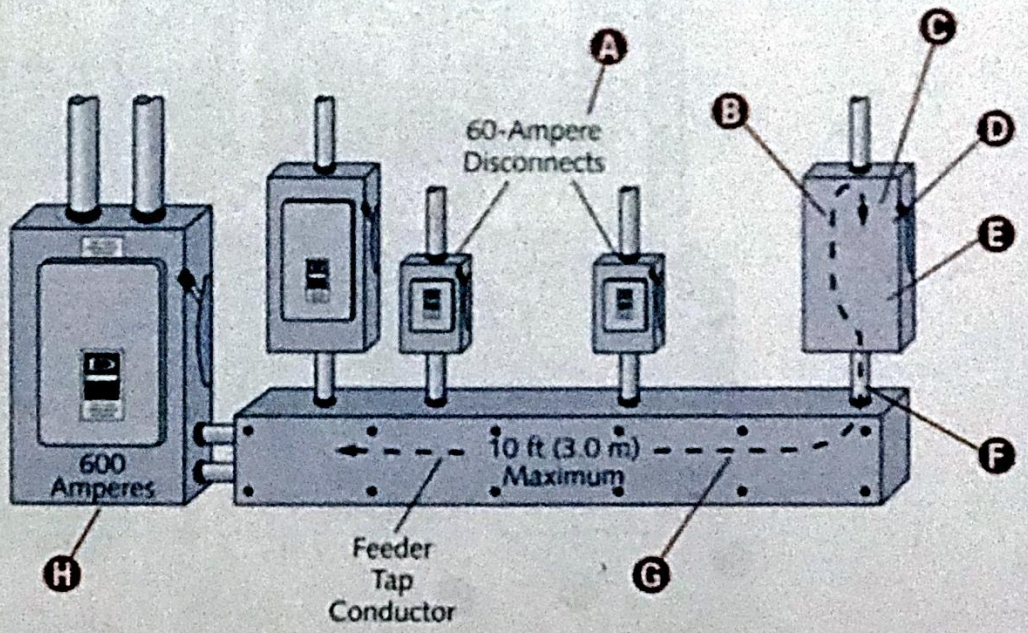
F Except where connected to the feeder, tap conductors shall be enclosed in a raceway extending from the tap to the enclosure of an enclosed switchboard, switchgear, panelboard, or control device, or to the back of an open switchboard »240.21(B)(1)(3)«.

G If the tap conductor's length does not exceed 10 ft (3 m) and all of 240.21(B)(1)(1) through (4) stipulations are satisfied, overcurrent protection at the tap to the feeder is not required »240.21(B)(1)«.

H Field installations with the tap conductors exiting the enclosure (or vault) where the tap is made require that the ampacity of the tap conductors be not less than one-tenth of the rating of the overcurrent device protecting the feeder conductors »240.21(B)(1)(4)«.

NOTE

Branch-circuit tap conductors meeting the requirements specified in 210.19 shall be permitted to have overcurrent protection as specified in 210.20 **»240.21(A)«**.



Terminals

Connection of conductors to terminal parts shall ensure a thoroughly good connection without damaging the conductors and shall be made by means of pressure connectors (including set-screw type), solder lugs, or splices to flexible leads.

Connection by means of wire-binding screws or studs and nuts that have upturned lugs or the equivalent shall be permitted for 5.5 mm2 (2.6 mm dia.) or smaller conductors.

Terminals for more than one conductor and terminals used to connect aluminum shall be so identified.

TERMINAL LUGS

Terminal Lugs

SPLICES

Conductors shall be spliced or joined with splicing devices identified for the use or by brazing, welding, or soldering with a fusible metal or alloy.

Soldered splices shall first be spliced or joined so as to be mechanically and electrically secure without solder and then be soldered.

All splices and joints and the free ends of conductors shall be covered with an insulation equivalent to that of the conductors or with an insulating device identified for the purpose.

Wire connectors or splicing means installed on conductors for direct burial shall be listed for such use.

MOTOR ISTALLATION CONCERNS

MOTOR INSTALLATION CONCERNS

PEC ARTICLE 430

A As an approved method of protecting a motor against overload, 430.32(A)(1) lists a separate overload device responsive to motor current. This device must be selected to trip or shall be rated at no more than the percentage of the motor nameplate full-load current rating shown here:

Motors with a marked service factor not less than 1.15 . . . . . 125%

Motors with a marked temperature rise not over 40°C. 125%

All other motors 115%

B Controllers must be marked according to 430.8 provisions.

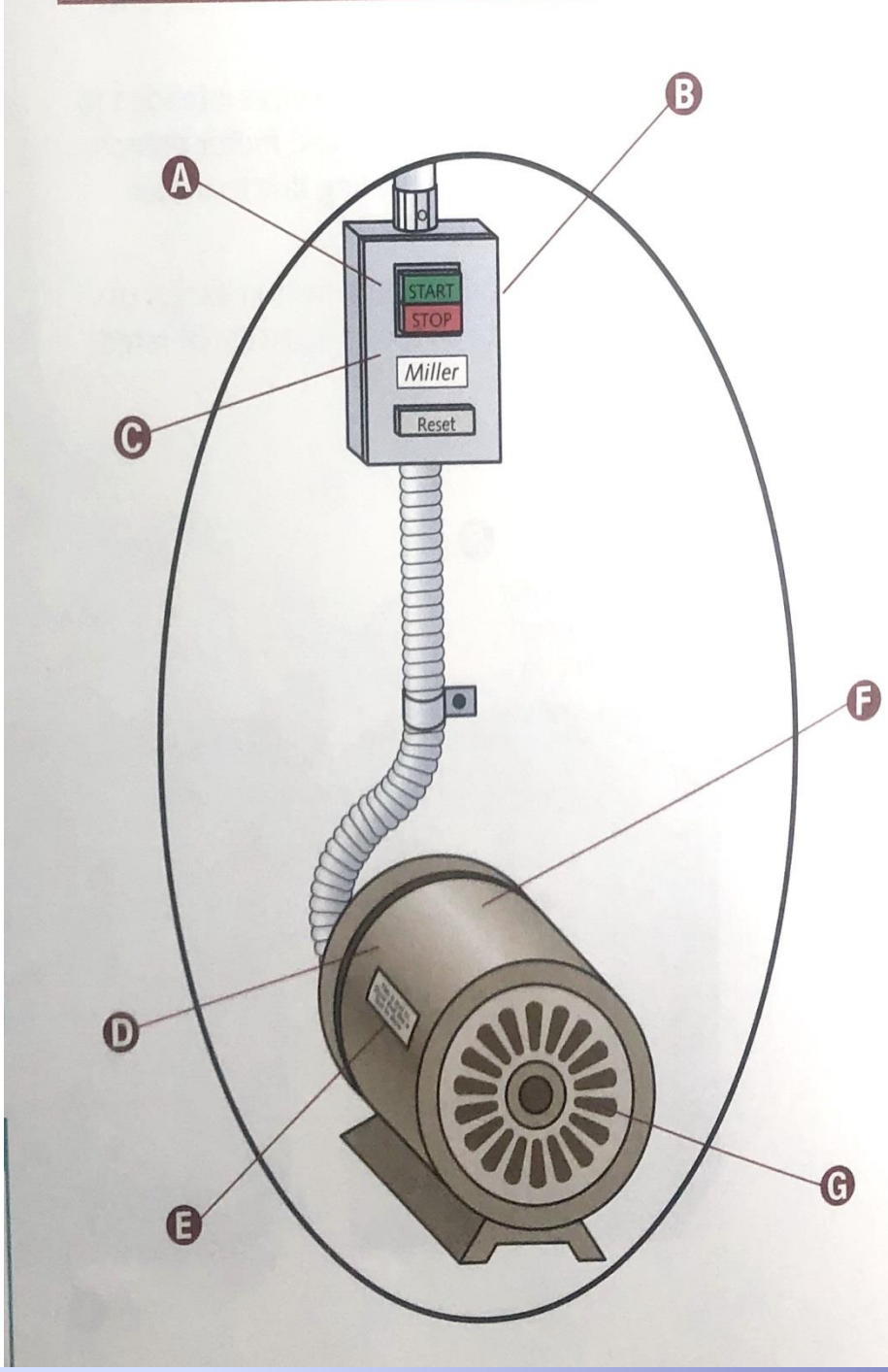
C Article 430, Part III lists overload devices intended to protect motors, motor-control apparatus, and motor branch-circuit conductors against excessive heating due to motor overloads and failure to start »*430.31*«.

D Separate motor overload protection shall be based on the actual motor nameplate current rating, not on the ratings listed in Tables 430.247 through 430.250 »*430.6(A)(2)*«.

E Motors (in usual applications) must be marked with the information listed in 430.7(A)(1) through (15).

F Each motor used in a continuous-duty application rated more than 1 hp must be protected against overload by a means listed in 430.32(A)(1) through (4).

G **Overload** is defined as operation of equipment in excess of normal, full-load rating, or of a conductor in excess of rated ampacity that, when it persists for a sufficient length of time, would cause damage or dangerous overheating. A fault, such as a short circuit or ground fault, is not an overload »*Article 100*«.



A Motor circuits rated 1000 volts, nominal, or less, shall have a disconnecting means with an ampere rating of at least 115% of the motor's full-load current rating »*430.110(A)*«.

B According to Article 430, a controller is any switch (or device) normally used to start and stop a motor by making and breaking motor circuit current »*430.2*«.

C An individual, fully functional disconnecting means shall be provided for each controller. The disconnecting means shall be located in sight from the controller, unless an exception is met »*430.102(A)*«. The controller disconnecting means required in accordance with 430.102(A) shall be permitted to serve as the disconnecting means for the motor if it is in sight from the motor location and the driven machinery location »*430.102(B)(2)*«.

D A disconnecting means shall be located in sight from the motor and driven machinery location »*430.102(B)(1)*«.

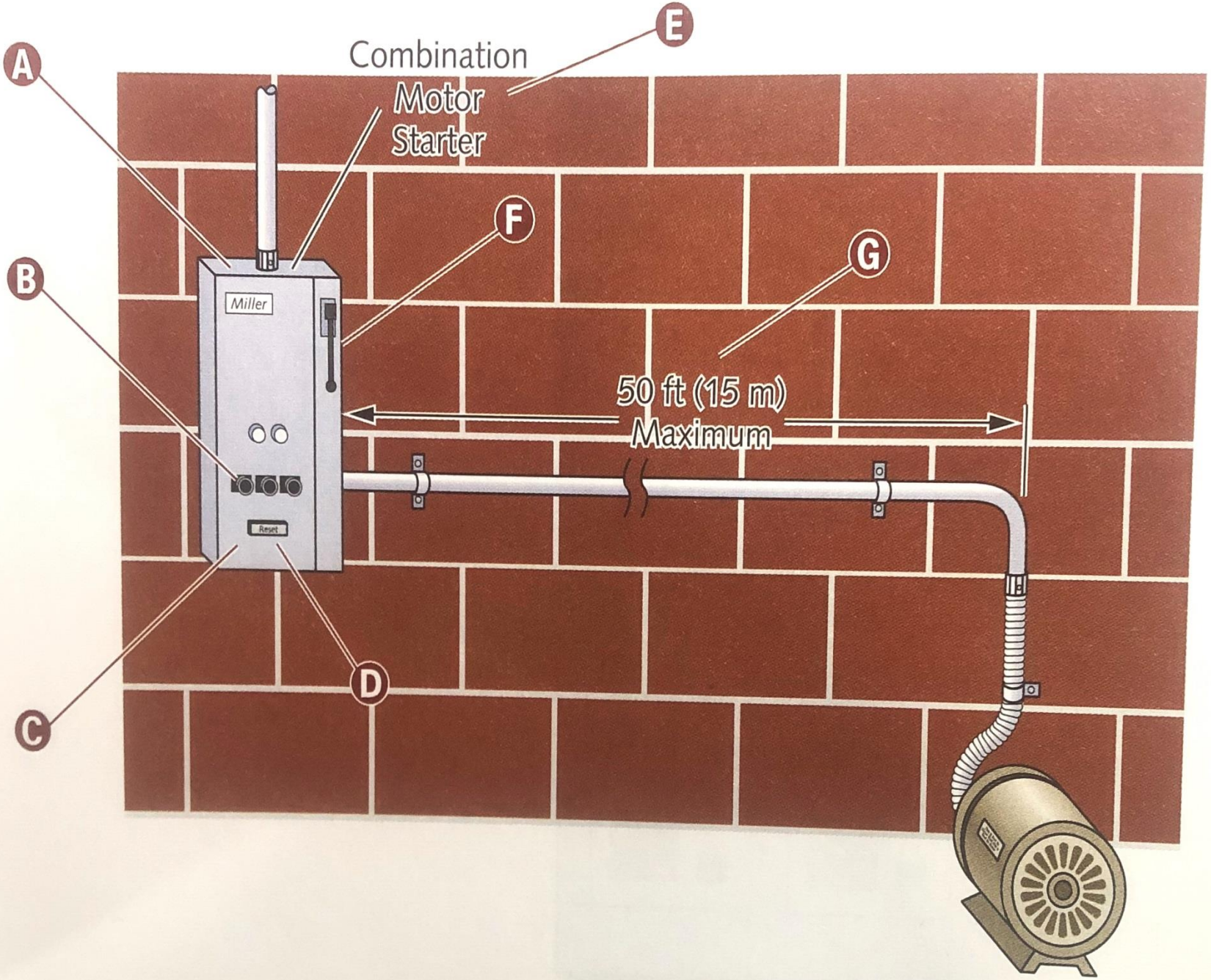
E Motor branch-circuit and ground-fault protection and motor overload protection can be combined into a single device, where the device's rating (or setting) provides the overload protection required by 430.32 »*430.55*«.

F Article 430, Part IX requires a disconnecting means capable of breaking the connection between the motors/controllers and the circuit »*430.101*«.

G The phrase "in sight from" indicates that specified items of equipment are visible and are no more than 50 ft (15 m) apart »*Article 100*«.

NOTE

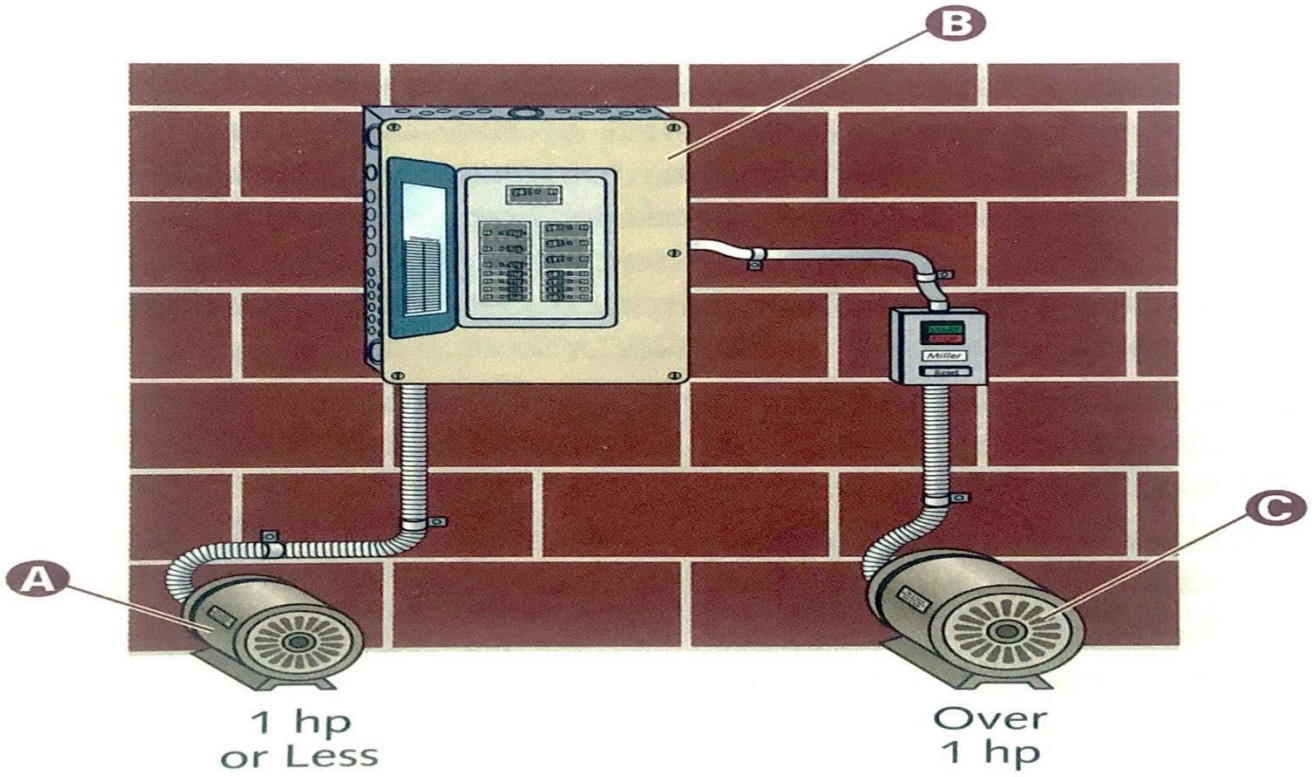
At least one of the disconnecting means shall be **readily** accessible »***430.107***«.


A
B
C
D
E
Combination
Motor
Starter
F
G
Miller
Reset
50 ft (15 m)
Maximum

A One or more motors without individual overload protection can be connected to a general-purpose branch circuit only if the installation complies with the limiting conditions of 430.32(B) and (D) and 430.53(A)(1) and (A)(2) »*430.42(A)*«.

B Motors used on general-purpose branch circuits (as permitted in Article 210) require overload protection per 430.42(A), (B), (C), or (D) specifications »*430.42*«

C Motors of larger ratings than specified in 430.53(A) can be connected to general-purpose branch circuits only if each motor has overload protection specifically listed for that motor as specified in 430.32. In the case of more than one motor, both the controller and the motor overload device shall be approved for group installation, and the short-circuit and ground-fault protective device shall be selected according to 430.53 »*430.42(B)*«.

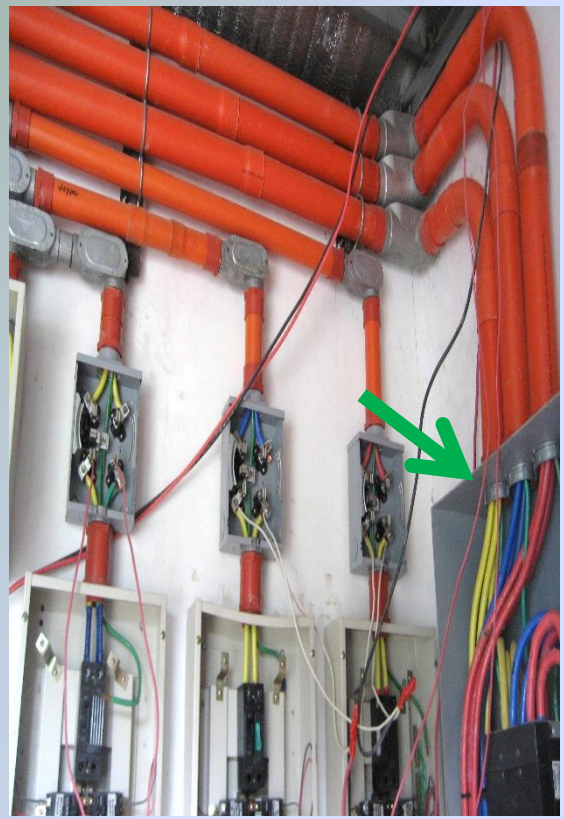


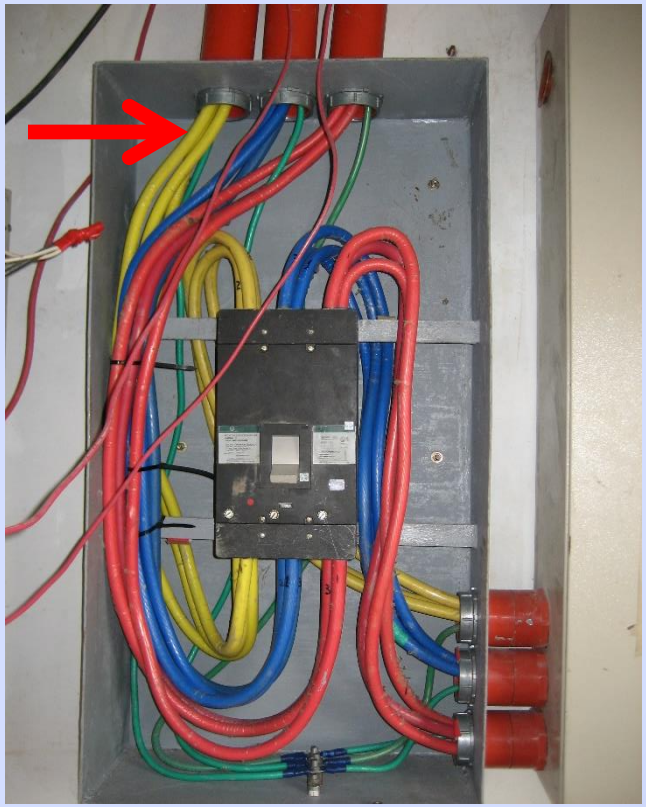
INSTALLATIONS WITH CODE VIOLATIONS

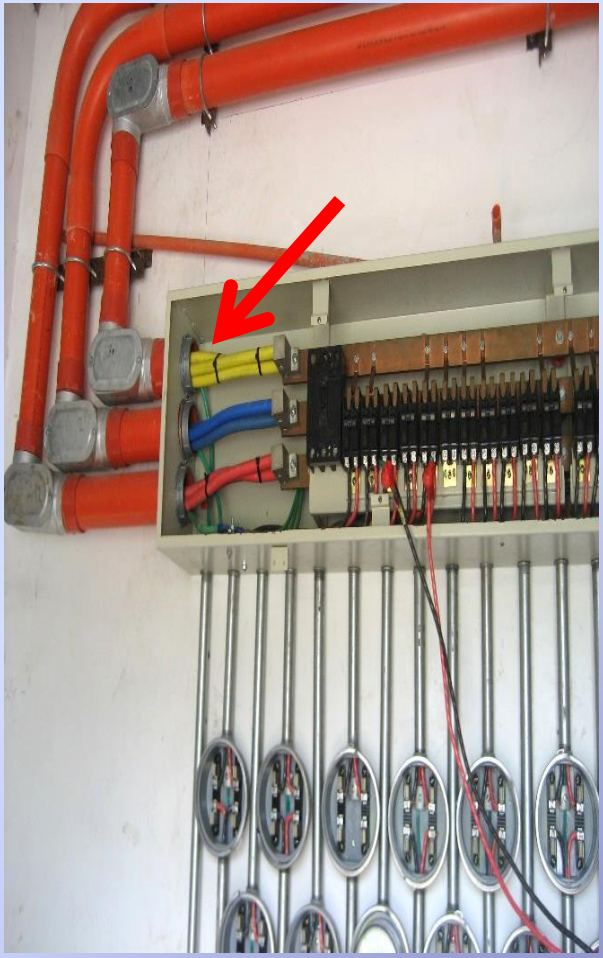
INSDIDE AND OUTSIDE INSTALLATIONS

CODE VIOLATION

Parallel Conductors of the same phase are installed inside a common conduit

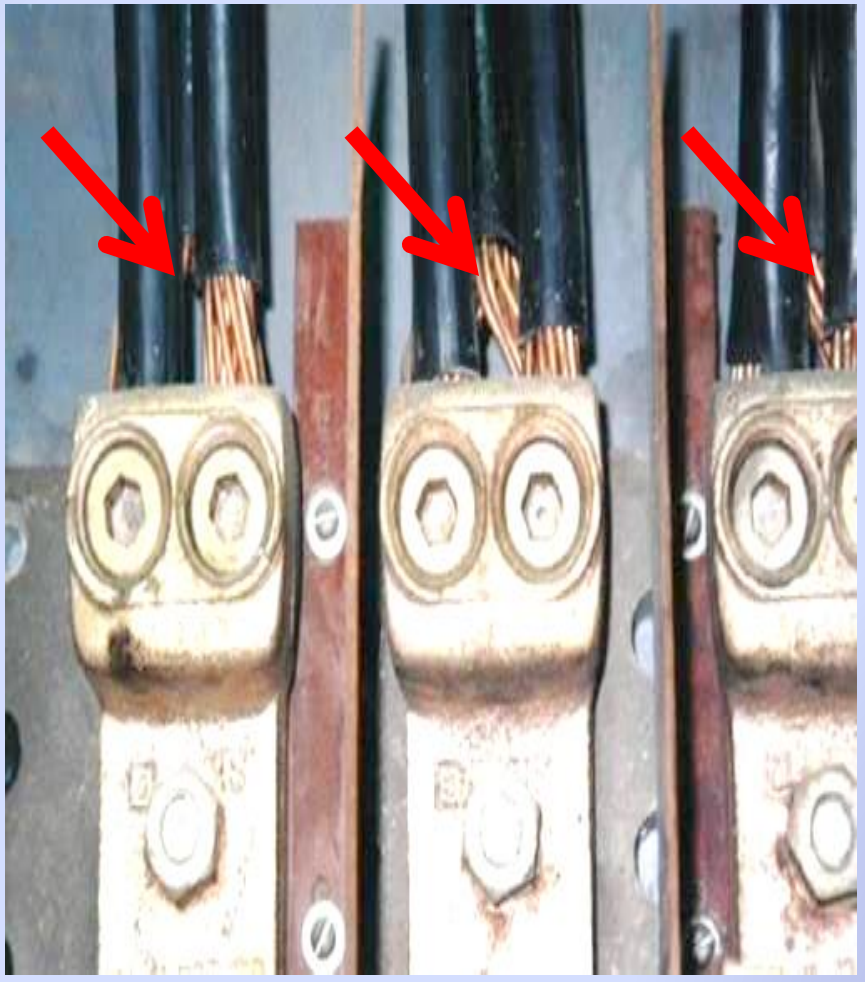






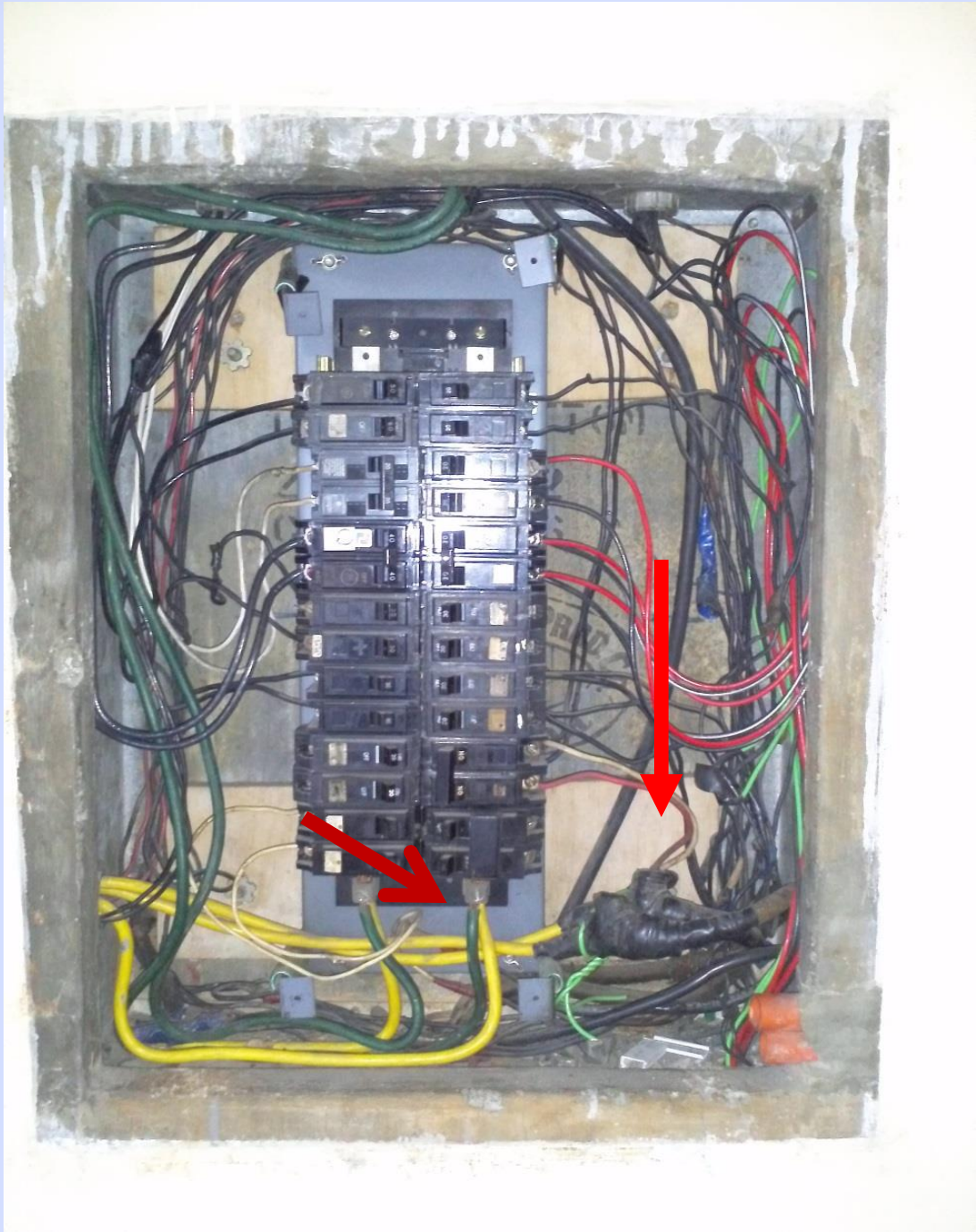
Water Pipes Used as Electrical Raceways

Termination Issues

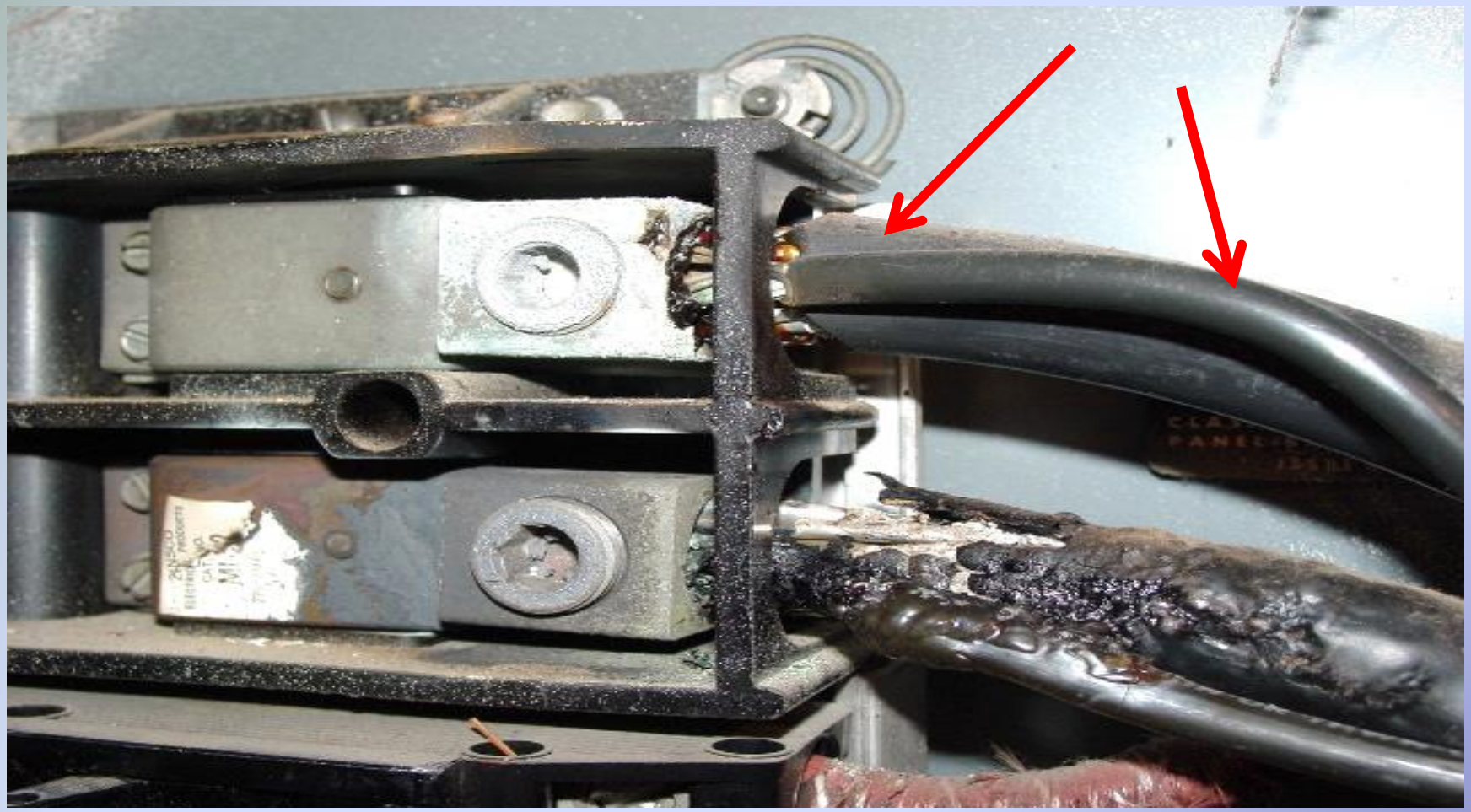


CODE Violation:
Multiple taps inside panel board enclosure

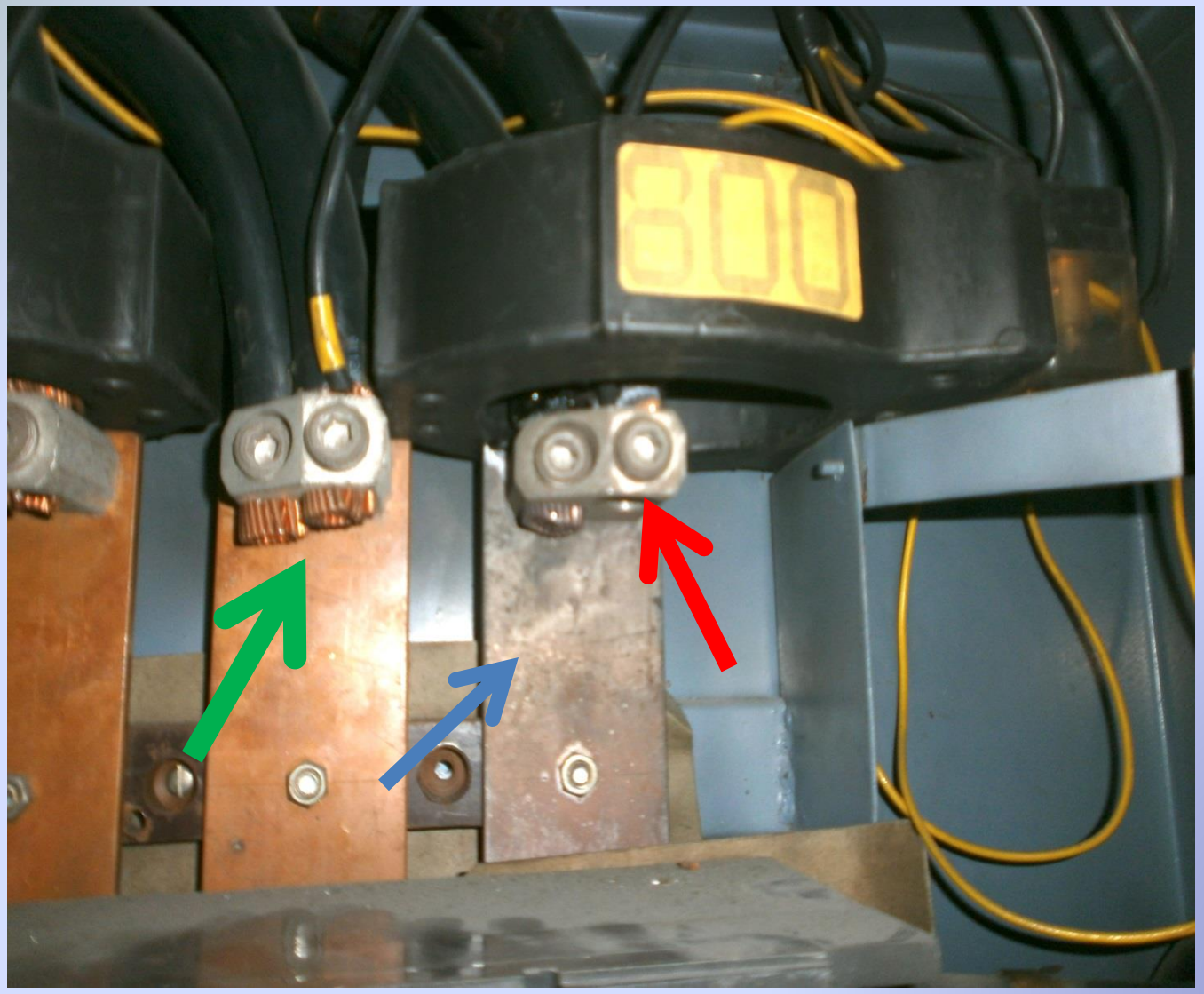
PEC art. 3.12.1.8
Enclosures for switches or overcurrent devices shall not be used as junction boxes, auxiliary gutters, or raceways for conductors feeding through or tapping off to other switches or overcurrent devices unless adequate space for this purpose is provided



Two dissimilar sized wires in one Terminal

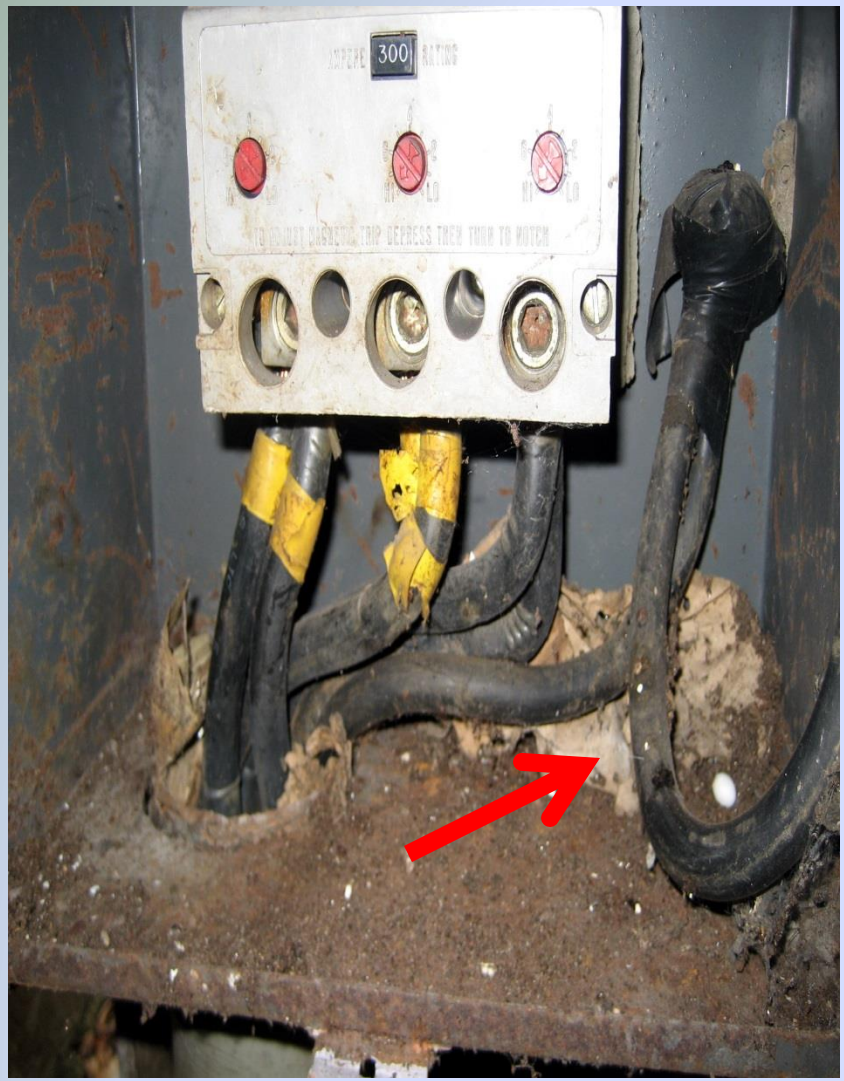


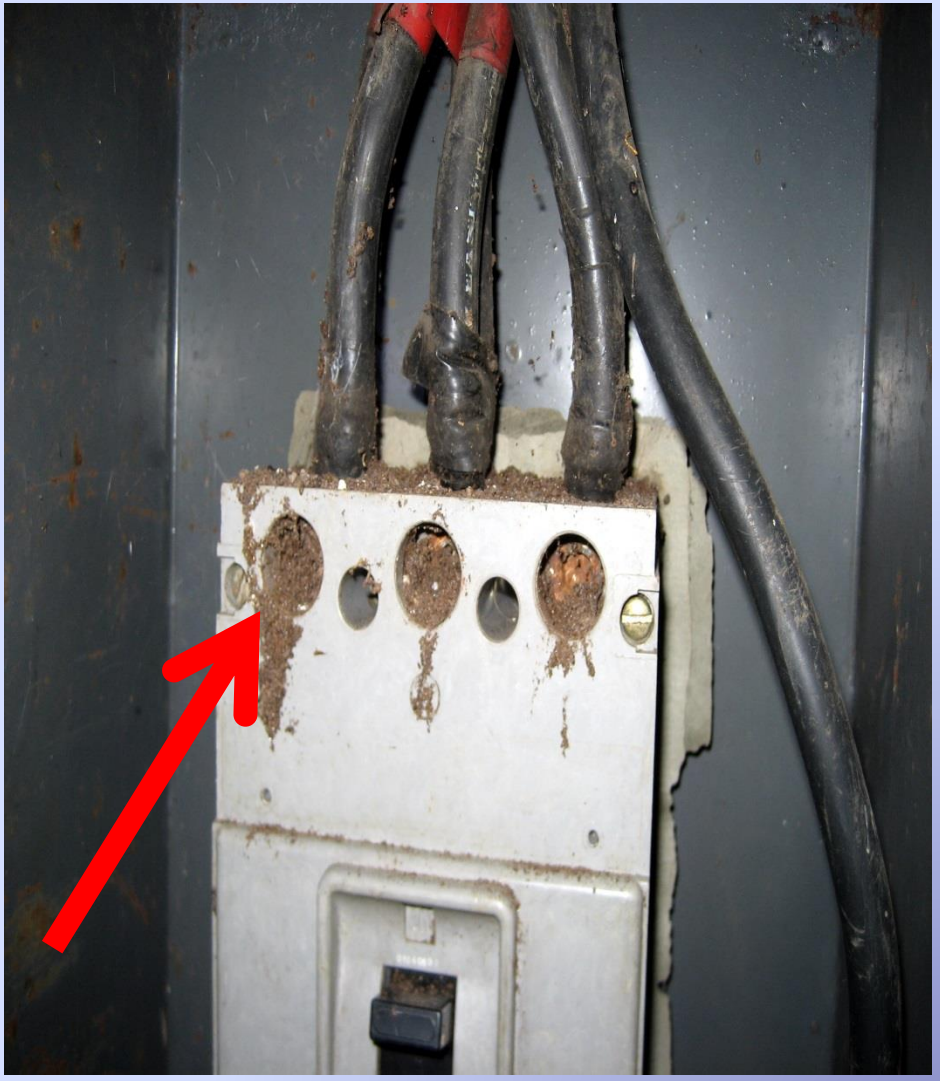
Over heated bus bar due to Termination issues



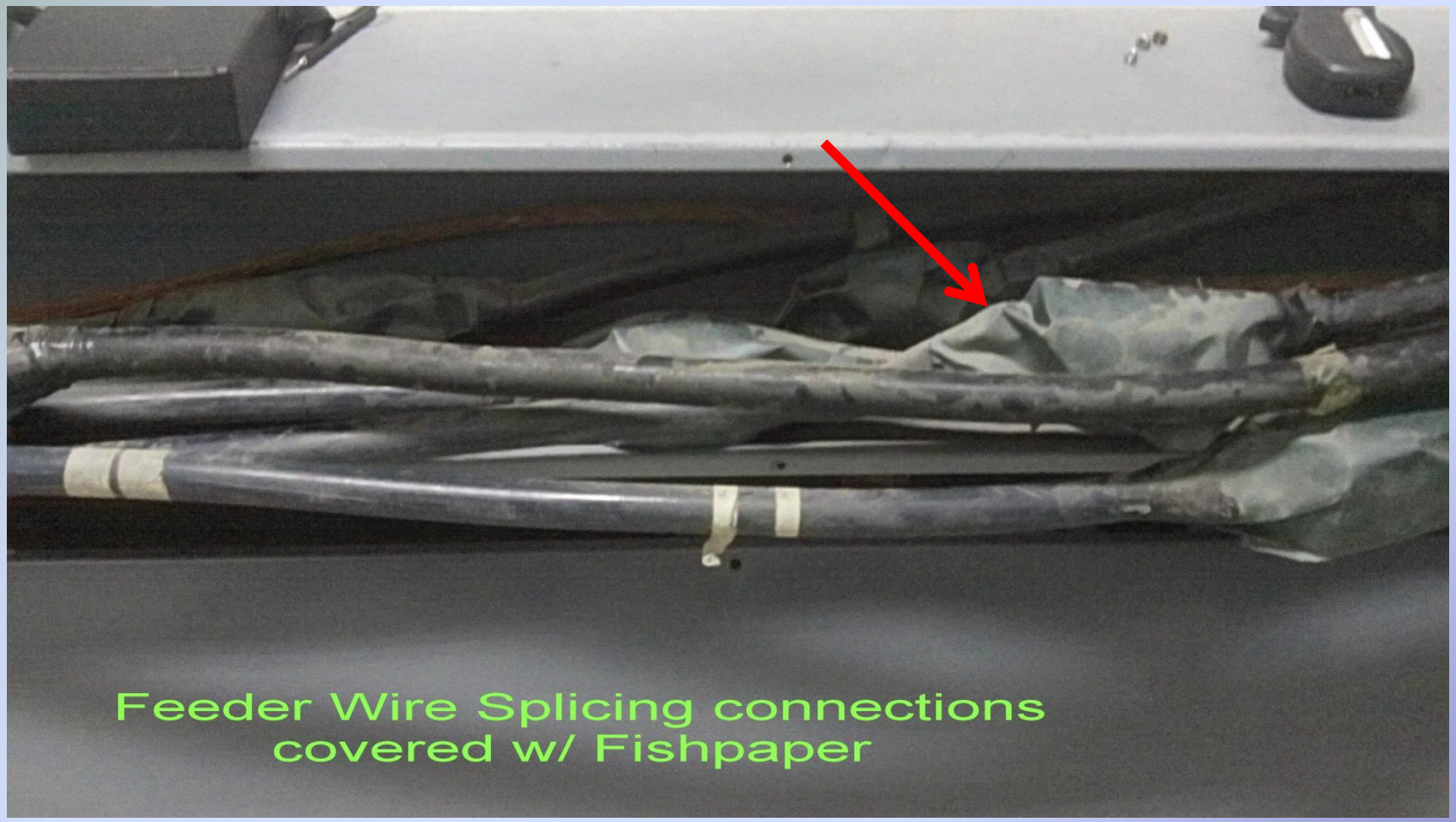
BUS BAR & CB Terminal Issues

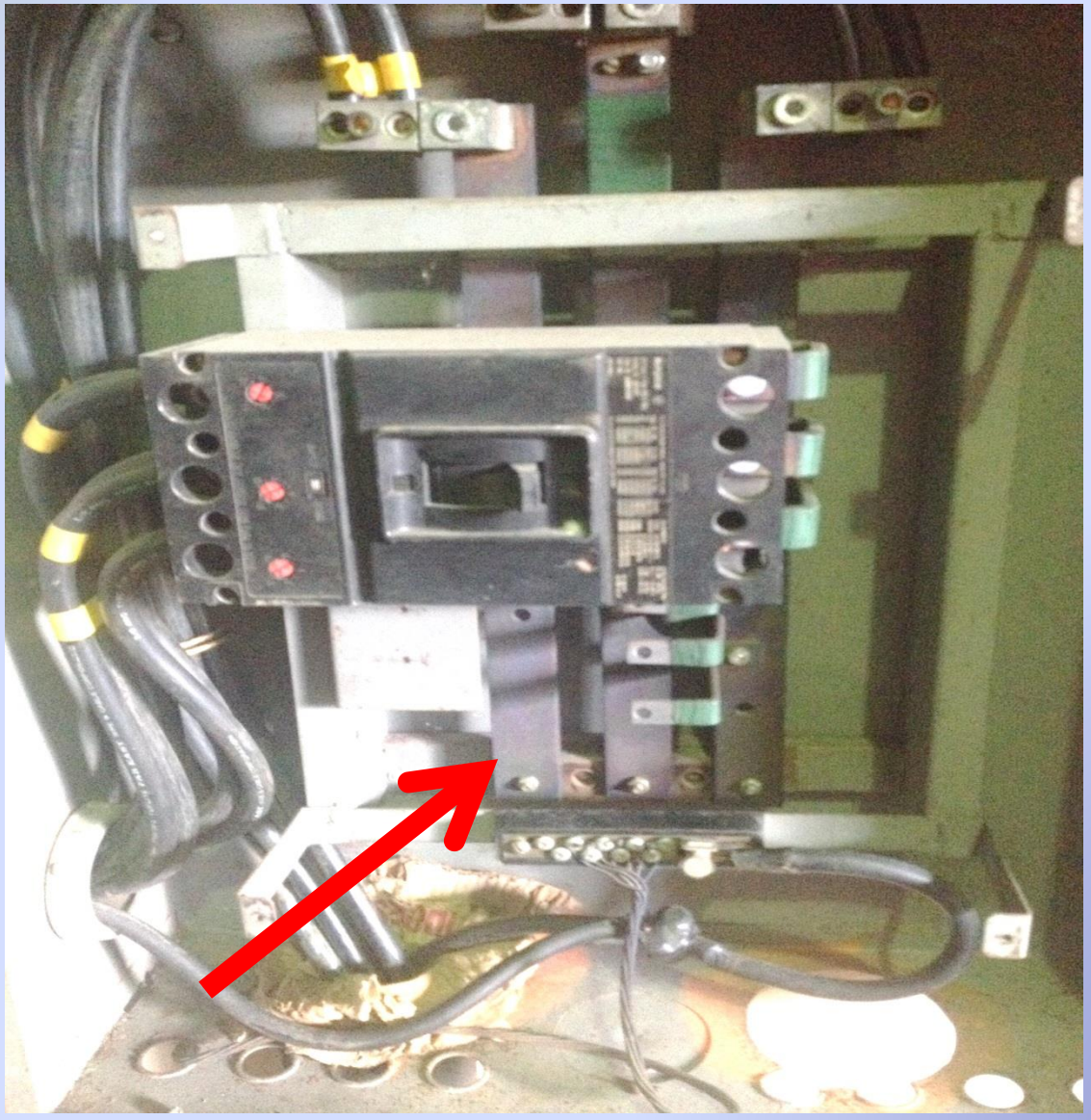
Lack of Maintenance Work



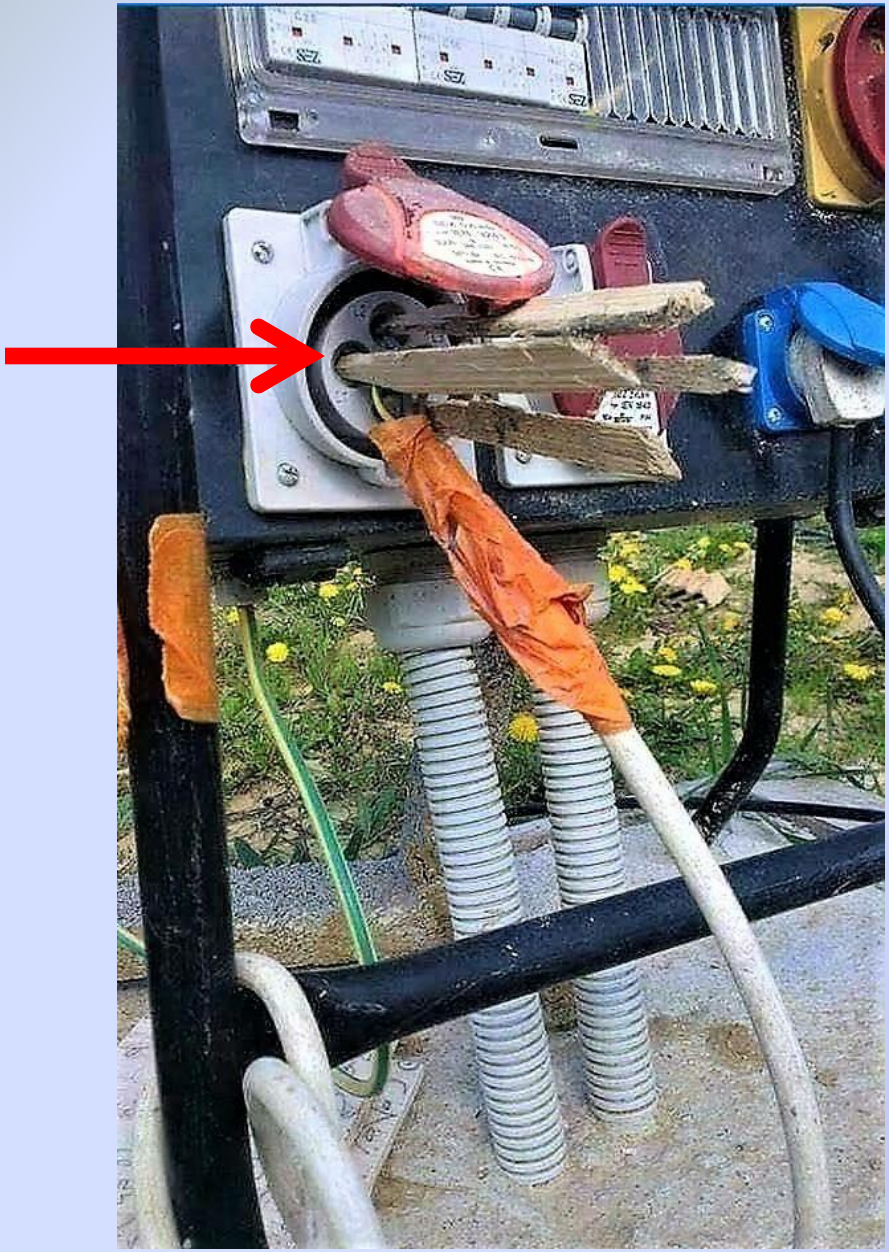


Wire Gutter Terminations

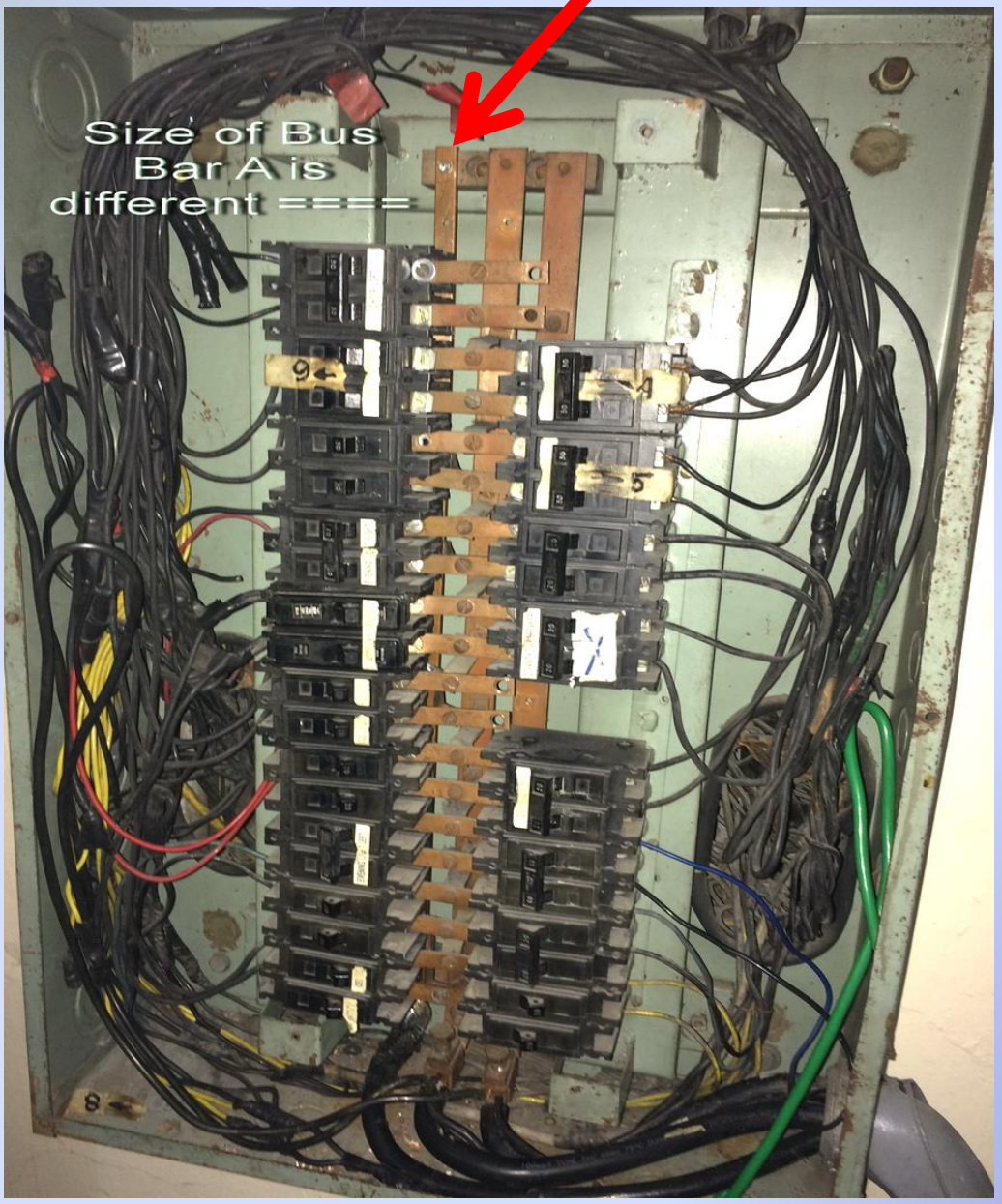




Proper Rated WP Male device needed



BUS Bar of Dissimilar Sizes

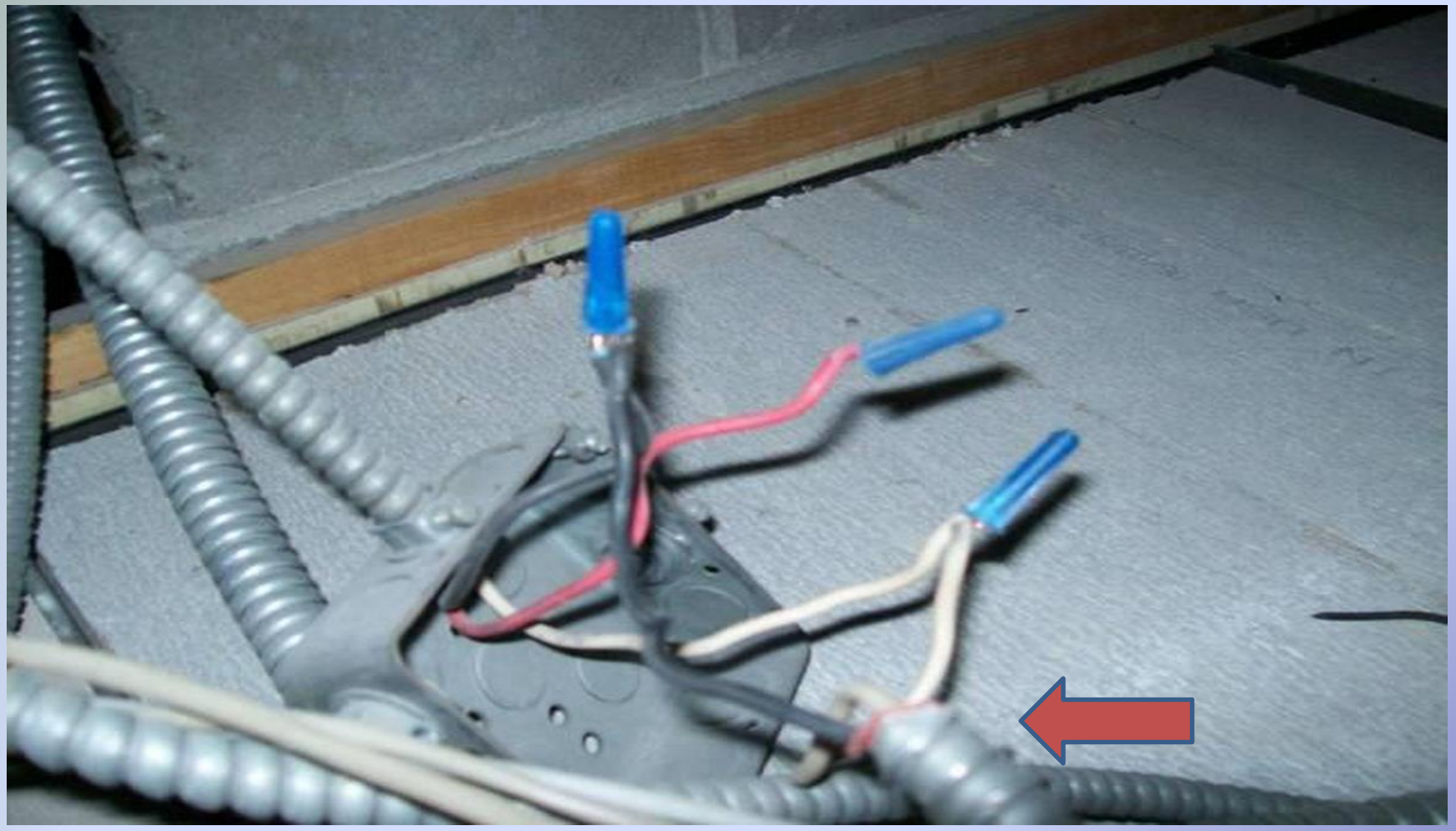


Photos - PEC Violation

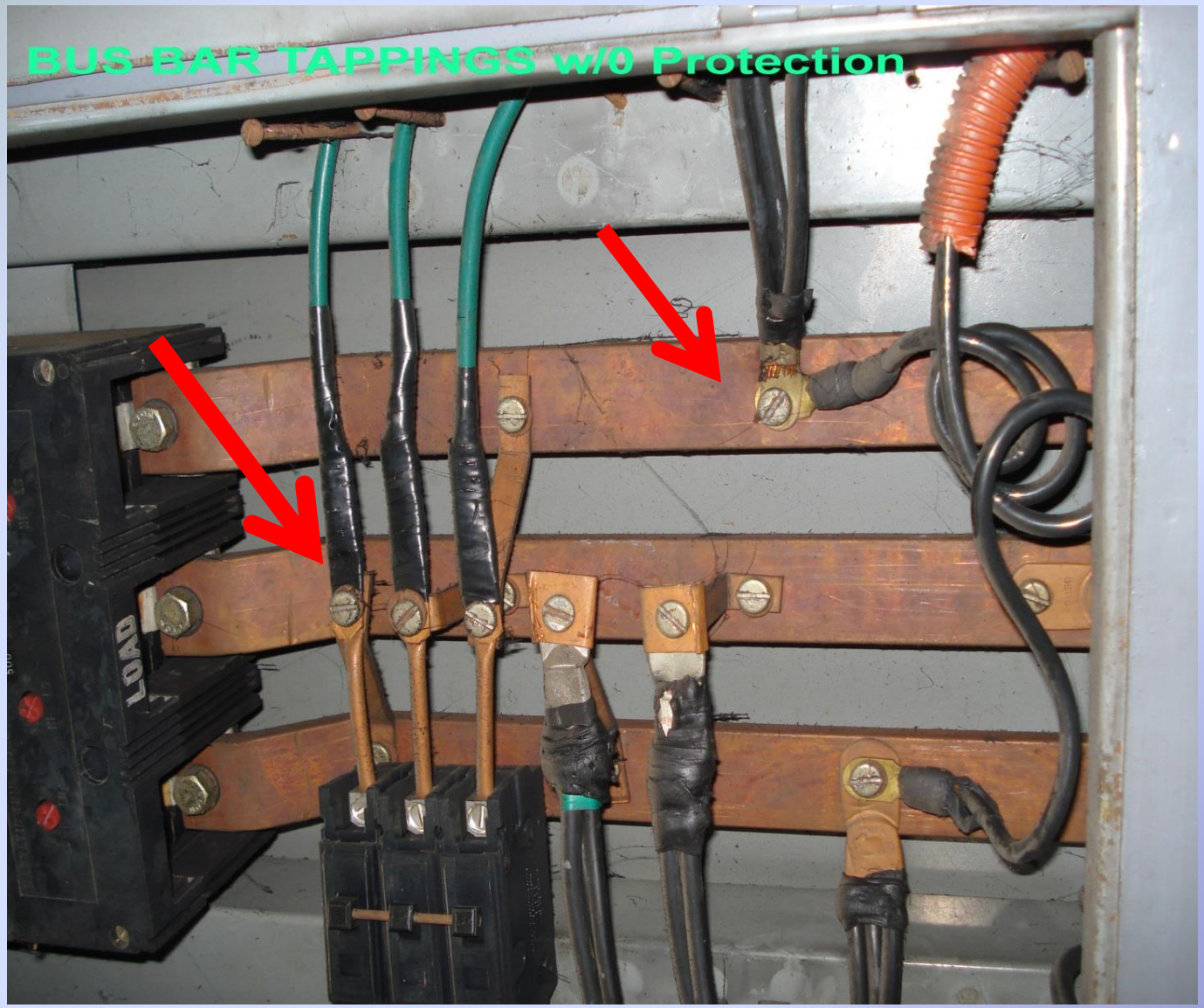
Underground Installation Violations

Underground Installed Conduit w/0 Concrete Encasement

Violation:
Branch feeder wires without cover and crowded
In-appropriate locknut & bushing to protect the wires from direct contact with the enclosure

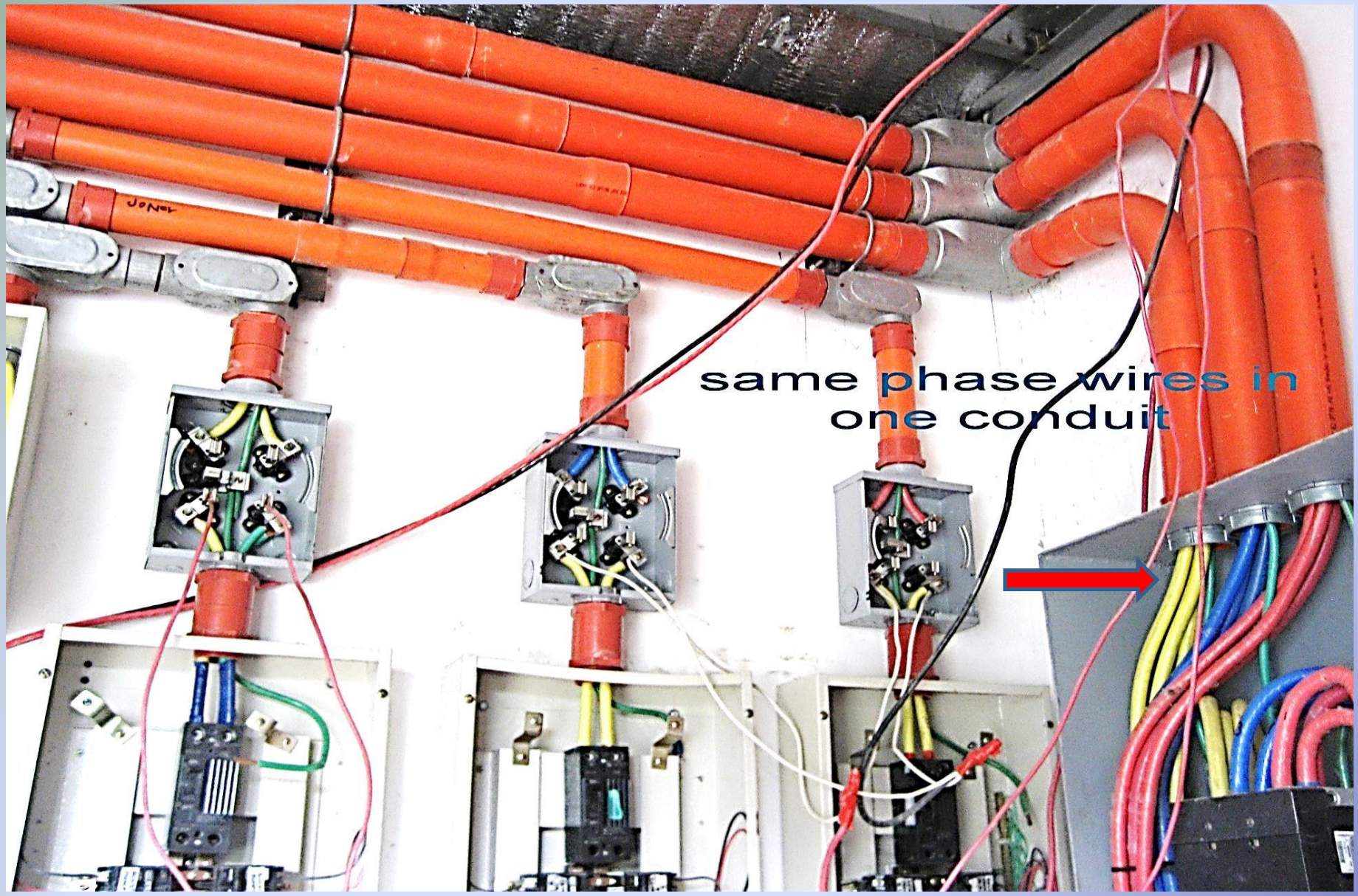


Bus Bar Tapings w/o Protections



Line side of CB has bigger size of wires, smaller size of wires at the load terminals. CB size should be coordinated with the Load Wires.

Metal conduit fittings heat up due to magnetic flux around the conductors. Never place same phase conductors in one conduit.

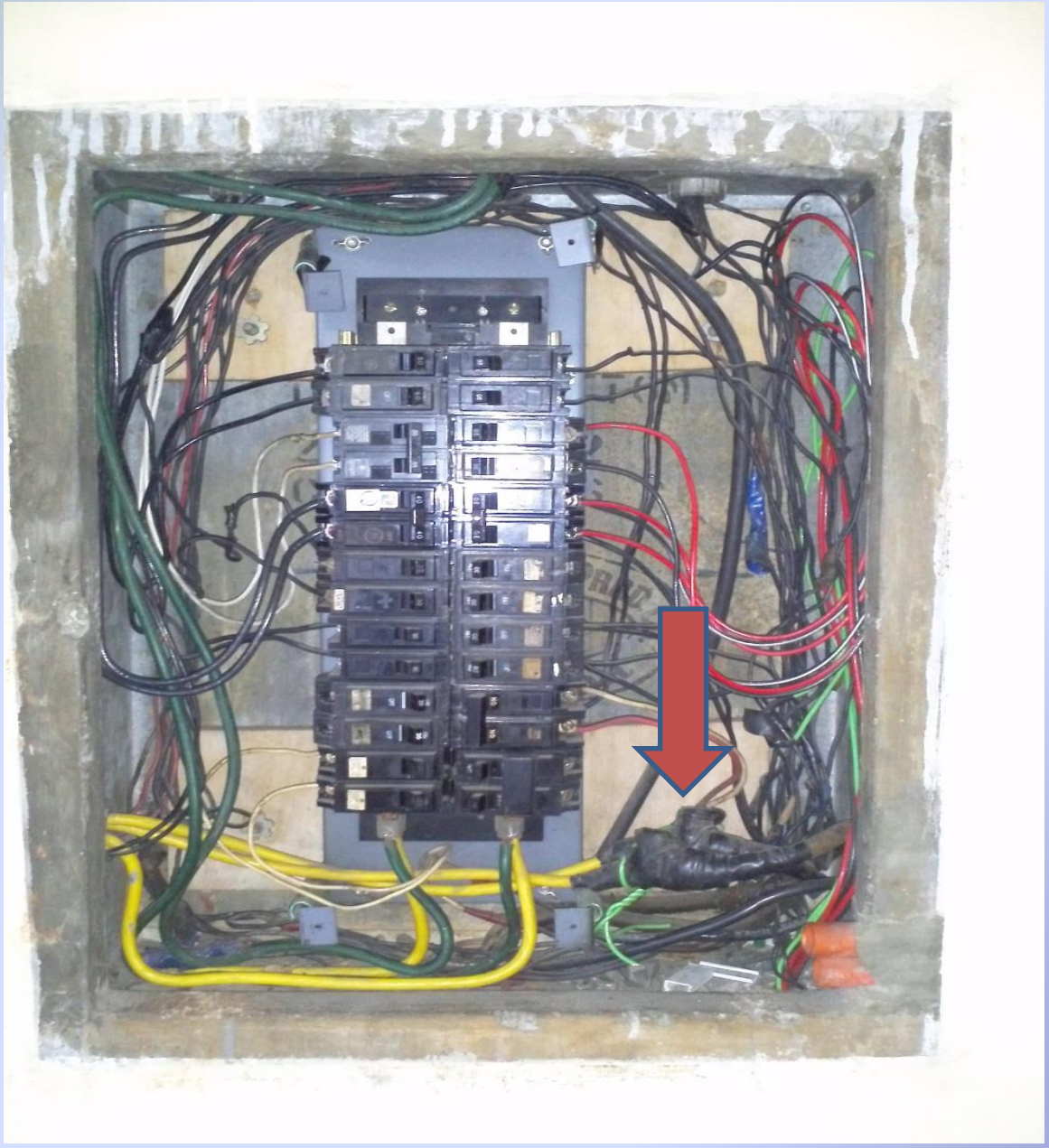


PEC Violation:
No service entrance conduits with Cap

Panel Board used as pull box

Multiple taps inside panel board enclosure – Paralleling of Wires Wires should be 50mm2 and above

Panel Enclosure used as splice/Pull Box



PEC Violation:

Art. 1.1 - Accessible/ Readily – Capable of being reached without having to climb or without obstruction to enter inside electrical control room.

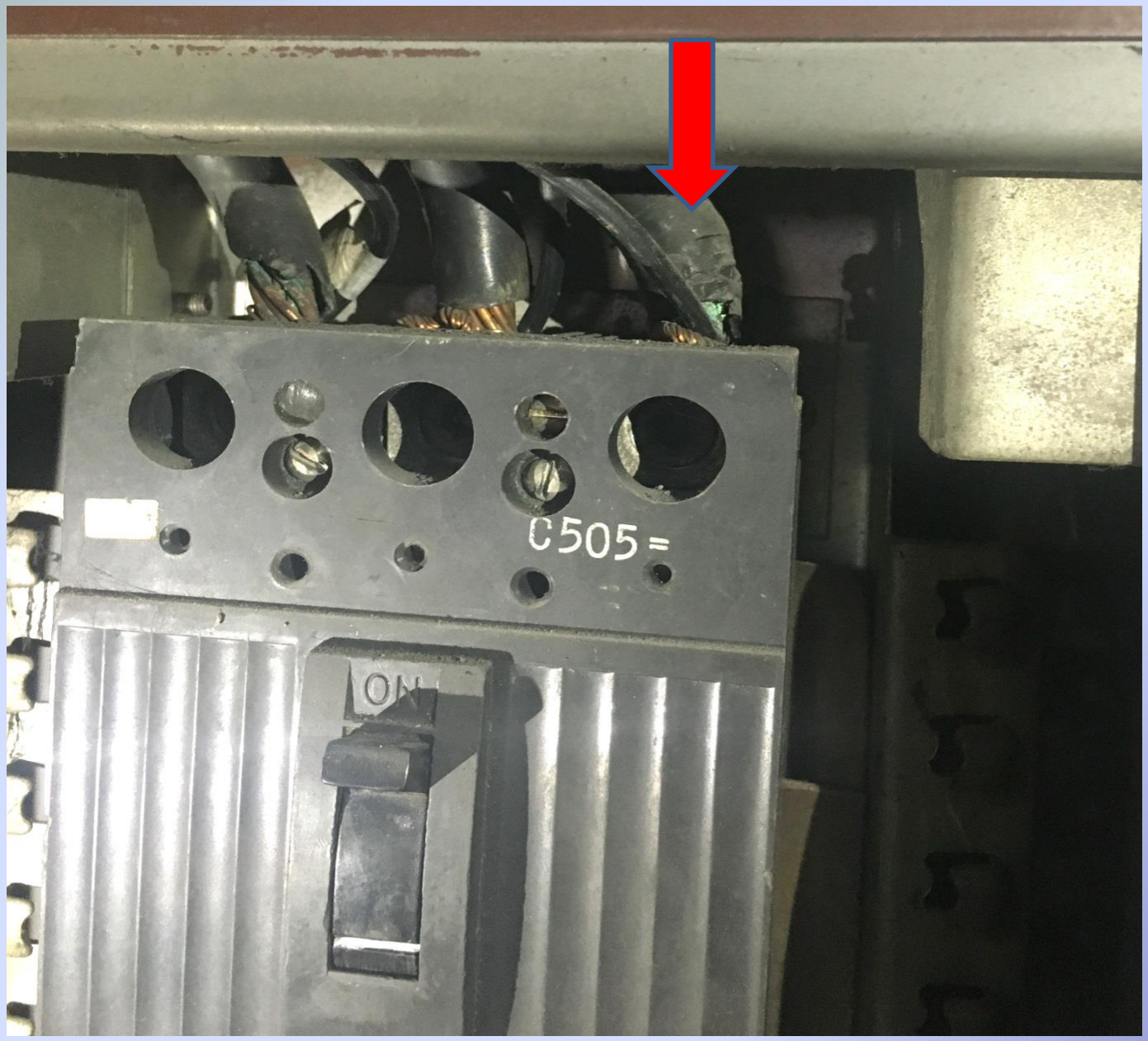
Disconnecting means/ Panel board shall be readily accessible

PEC Violation:

Installation outside the building exposed to heat and wet shall be done in NEMA 3R.4R etc…

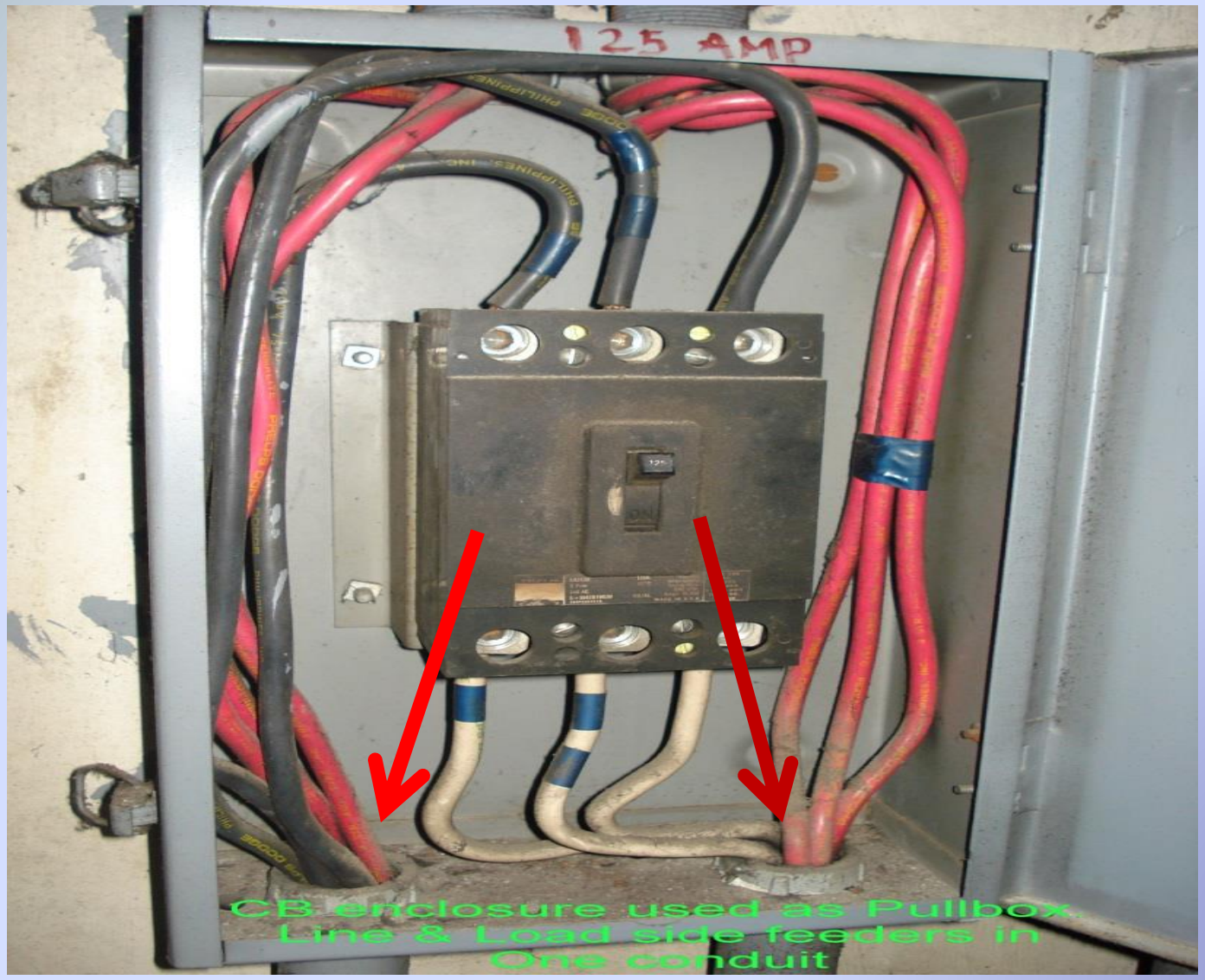
Lack of Top Gutter Space

Lack of Gutter Space



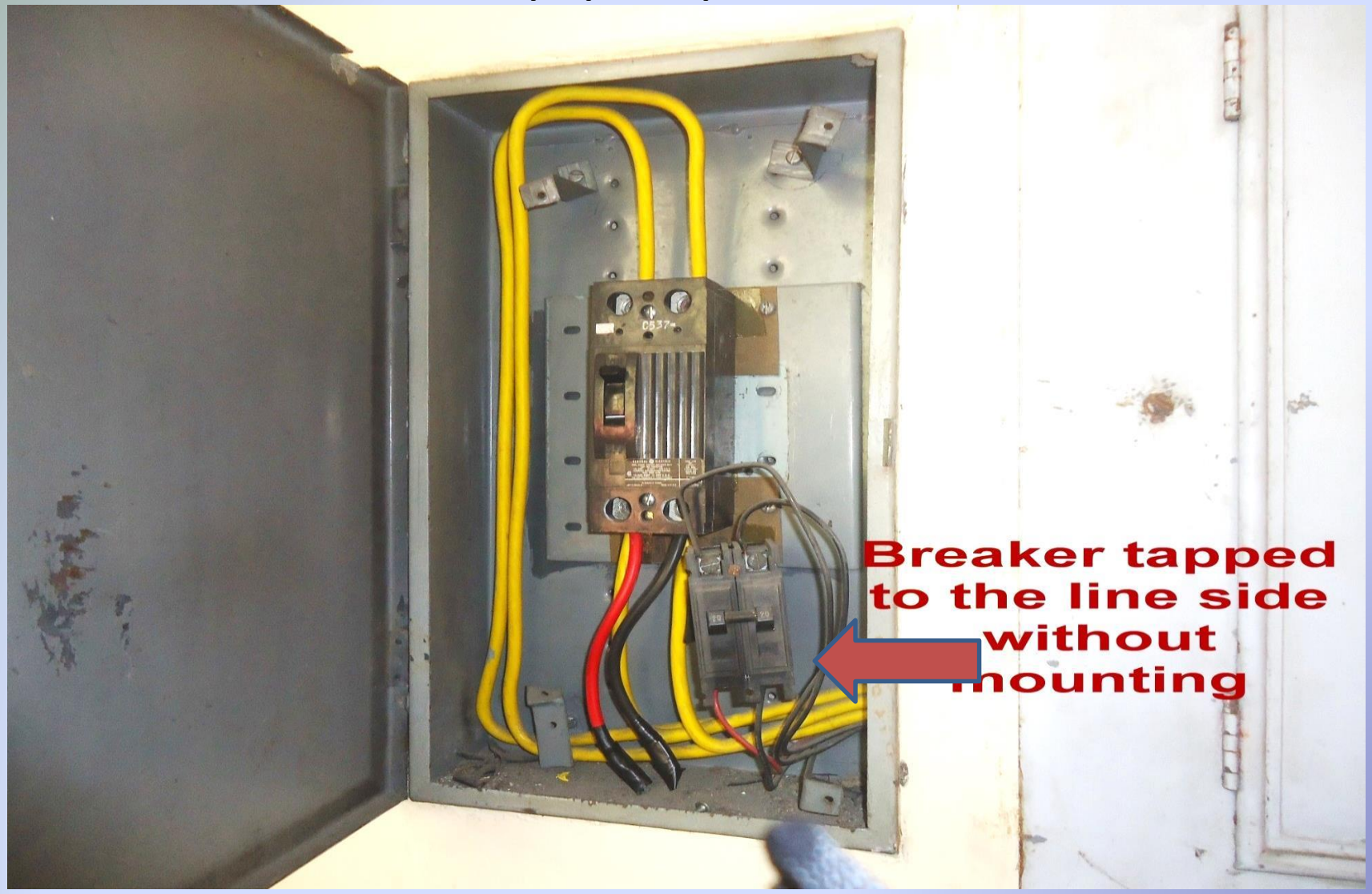
Line side and load side wires are joined in one conduit. Multiple Wires in a conduit- De-rating of ampacity needed

Use of Panel as Pull Box

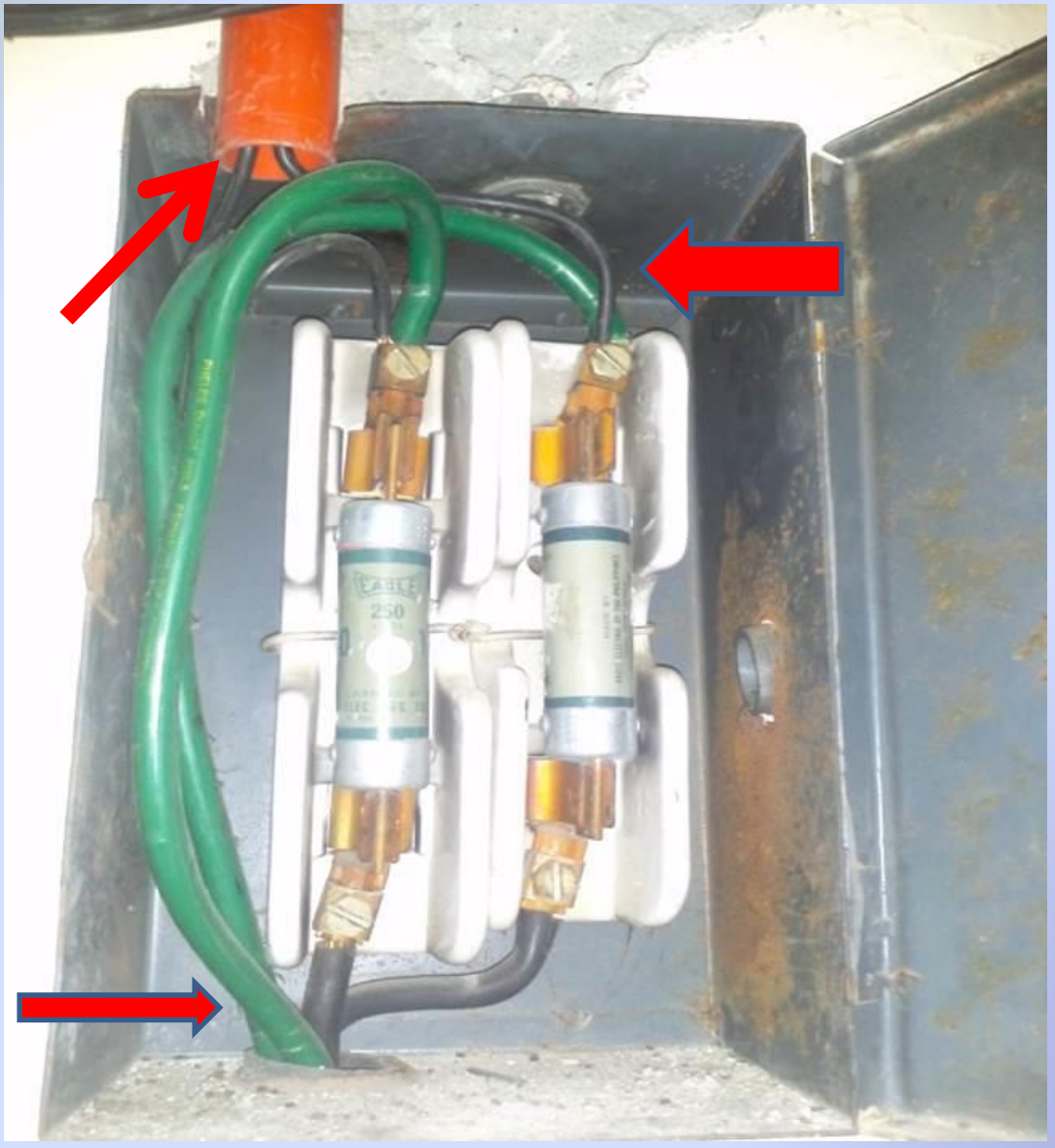


PEC Violation:

Art. 3.12.1.8 Enclosures for switches or overcurrent devices shall not be used as junction boxes, auxiliary gutters, or raceways for conductors feeding through or tapping off to other switches or overcurrent devices unless adequate space for this purpose is provided



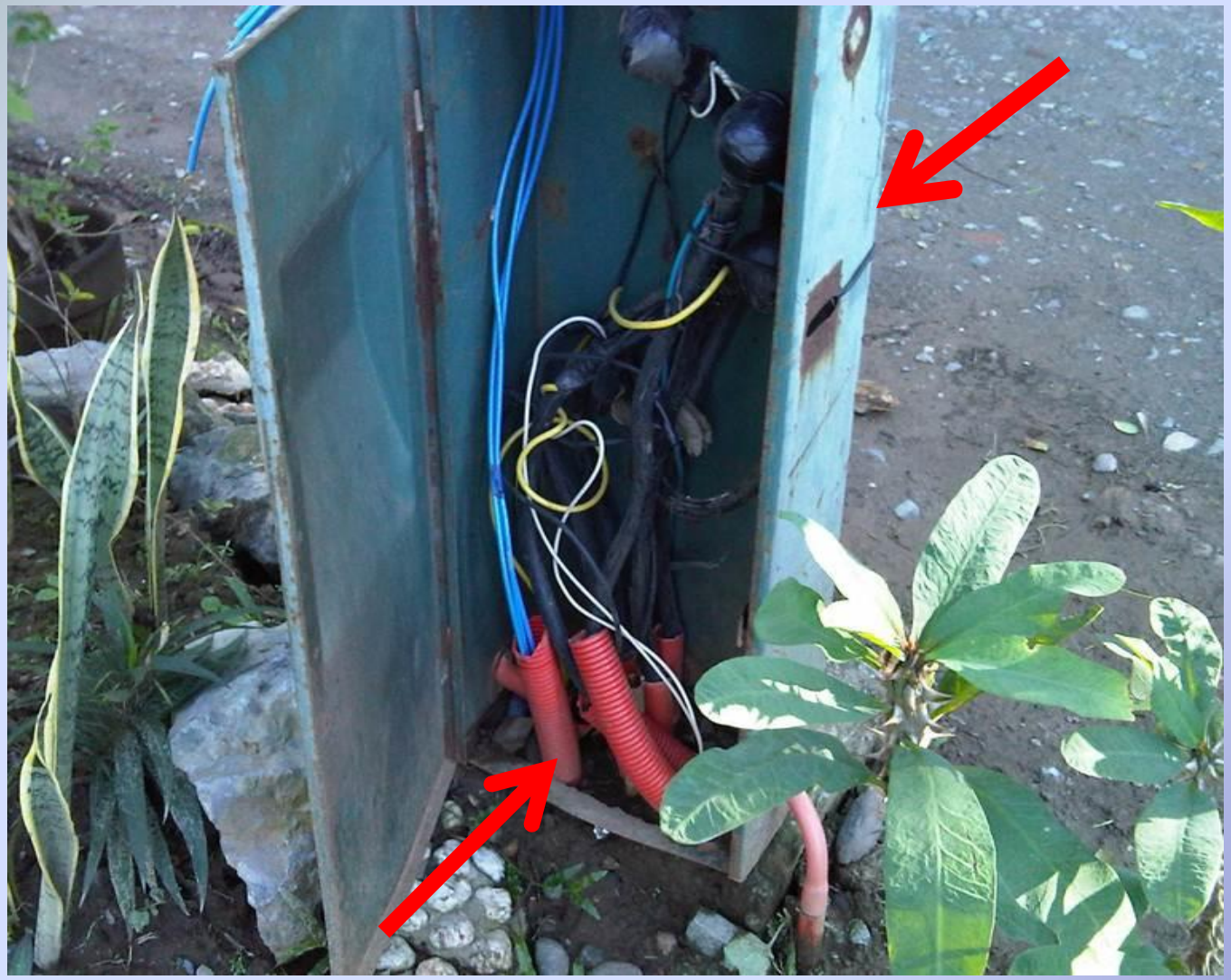
Line & Load Side in common raceway; Smaller Wire tapped to Line Side Unprotected and will add burden to main feeder



MANUAL TRANSFER SWITCH
LOAD SIDE & GEN-SET Feeders in same conduit
Paralleling of Wires Smaller than 50mm2 mot allowed by PEC

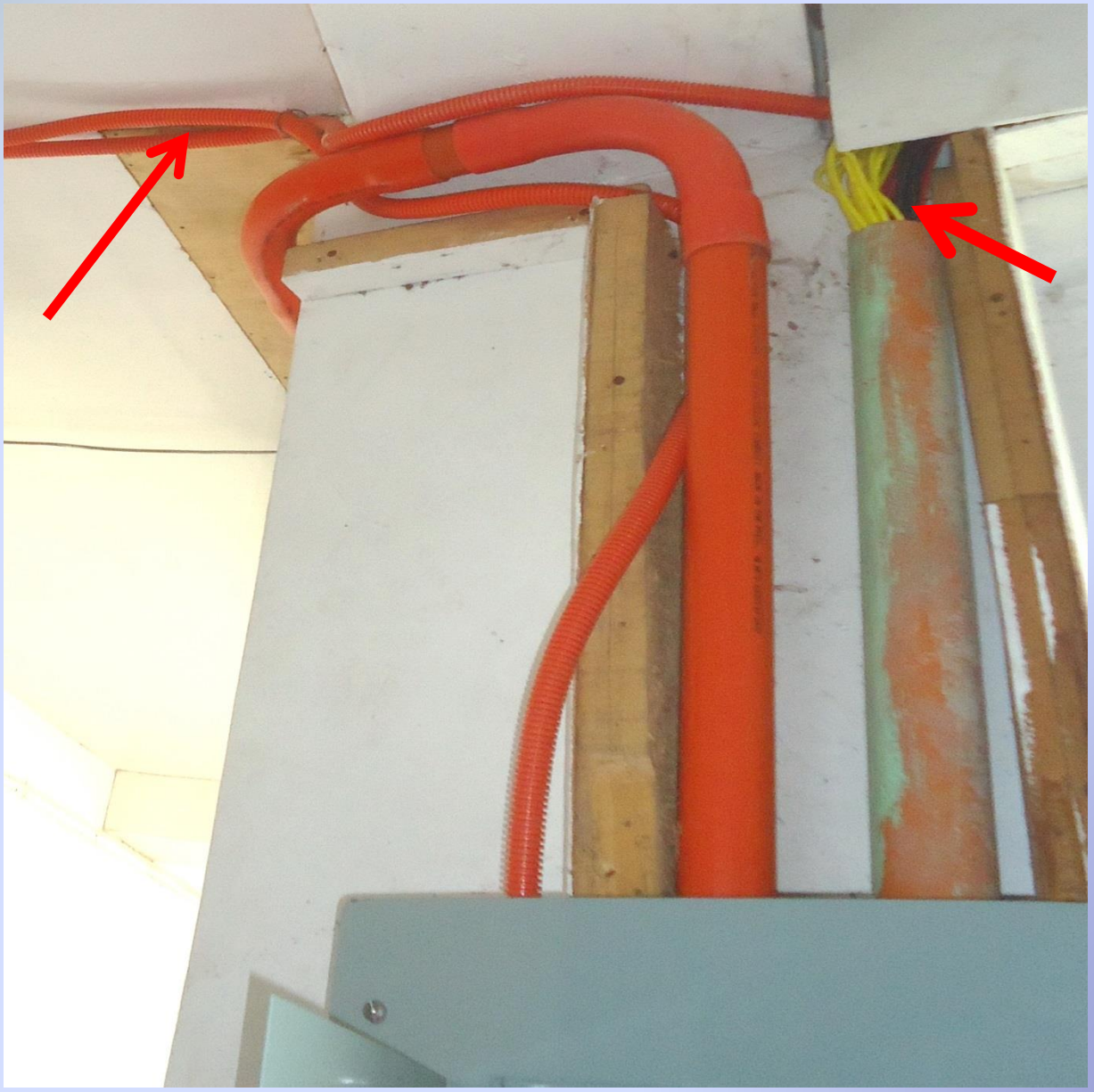
Wiring Installation Issues

Box needs to be replaced to Nema3R



Use Of Flexible PVC in Open Spaces

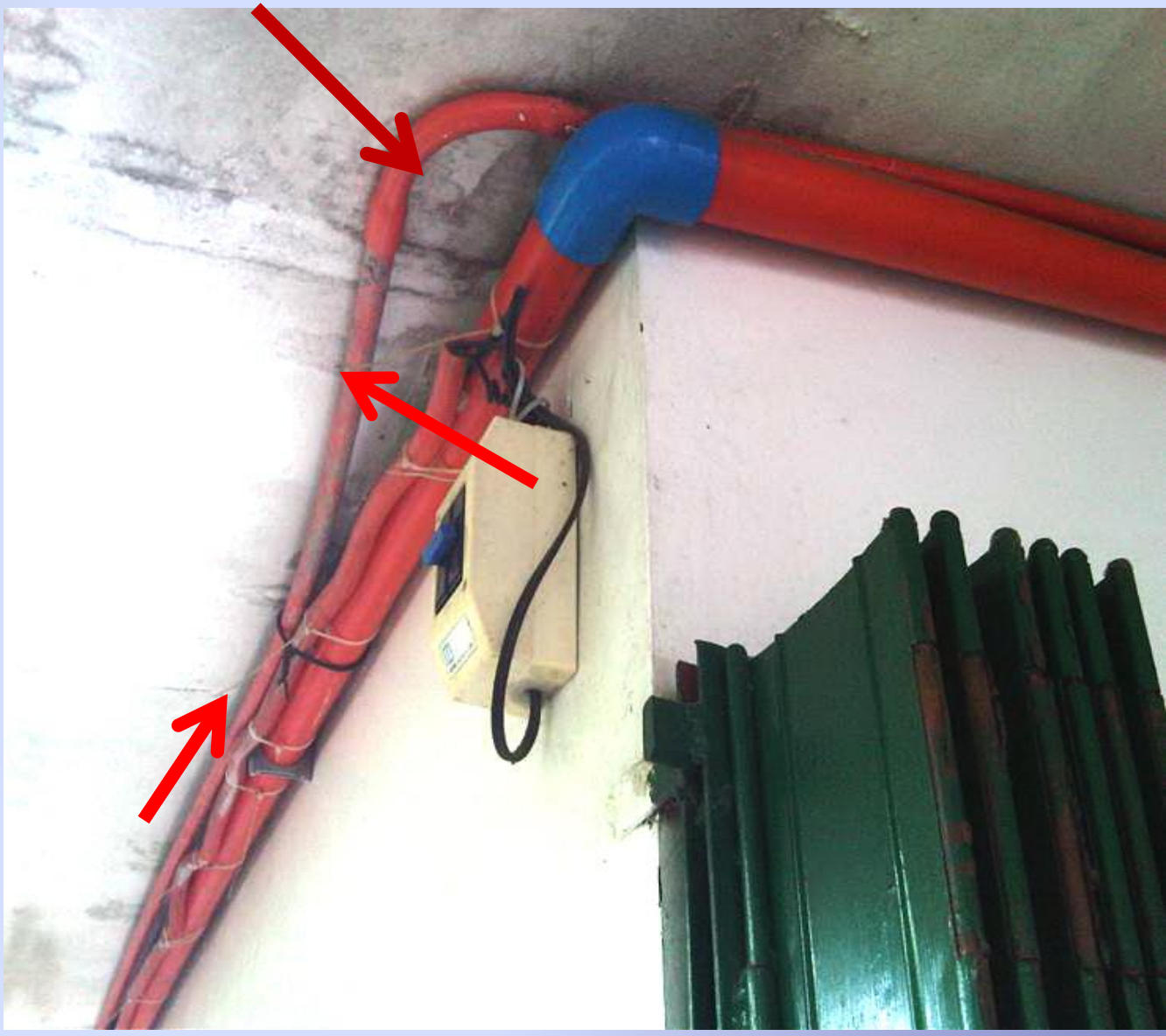
Raceway Issues



Raceway Issues and SE Cap

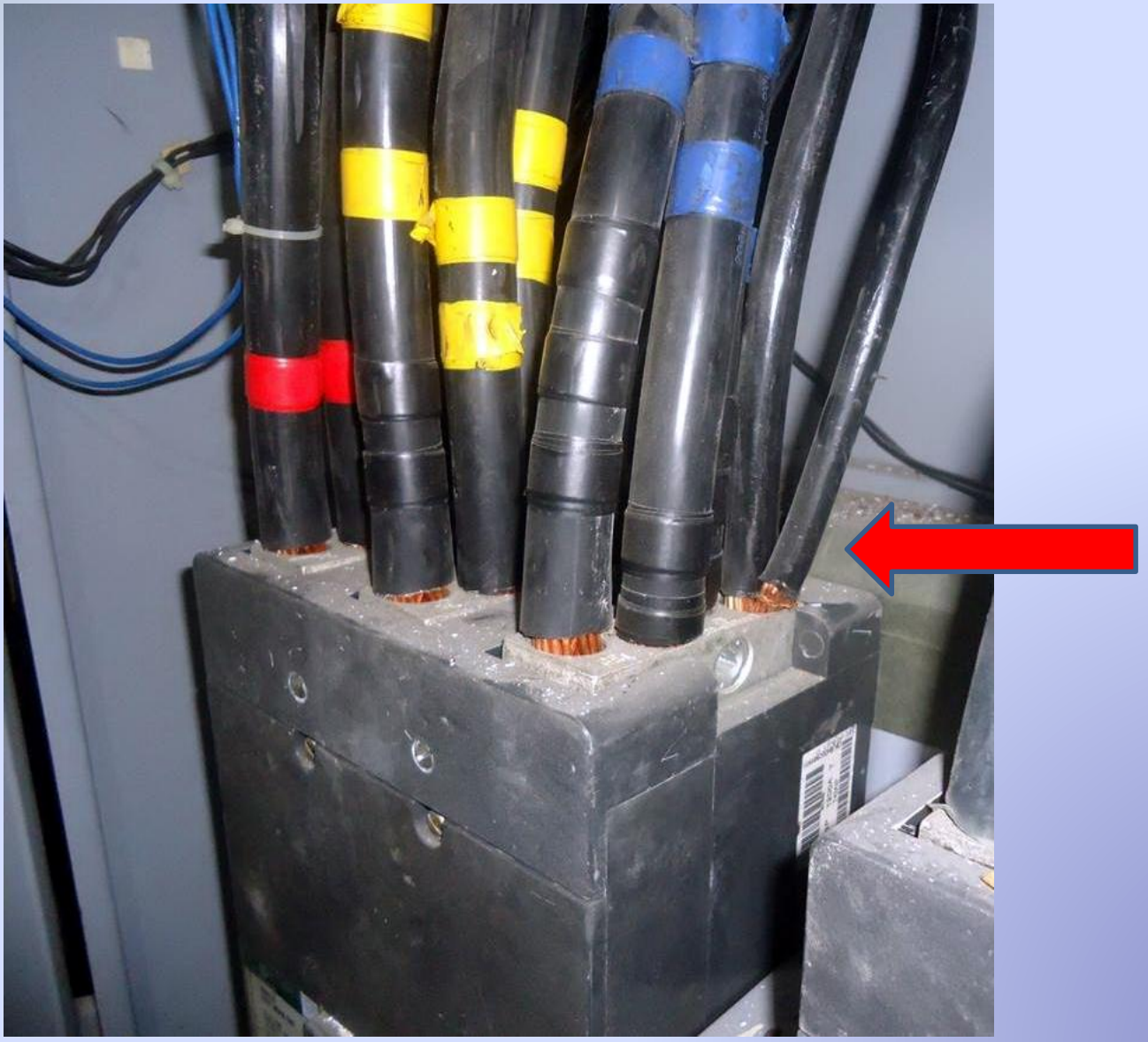
Raceway, Spice Box & Clearances Issues

Plumbing elbow used: CB and wiring issues

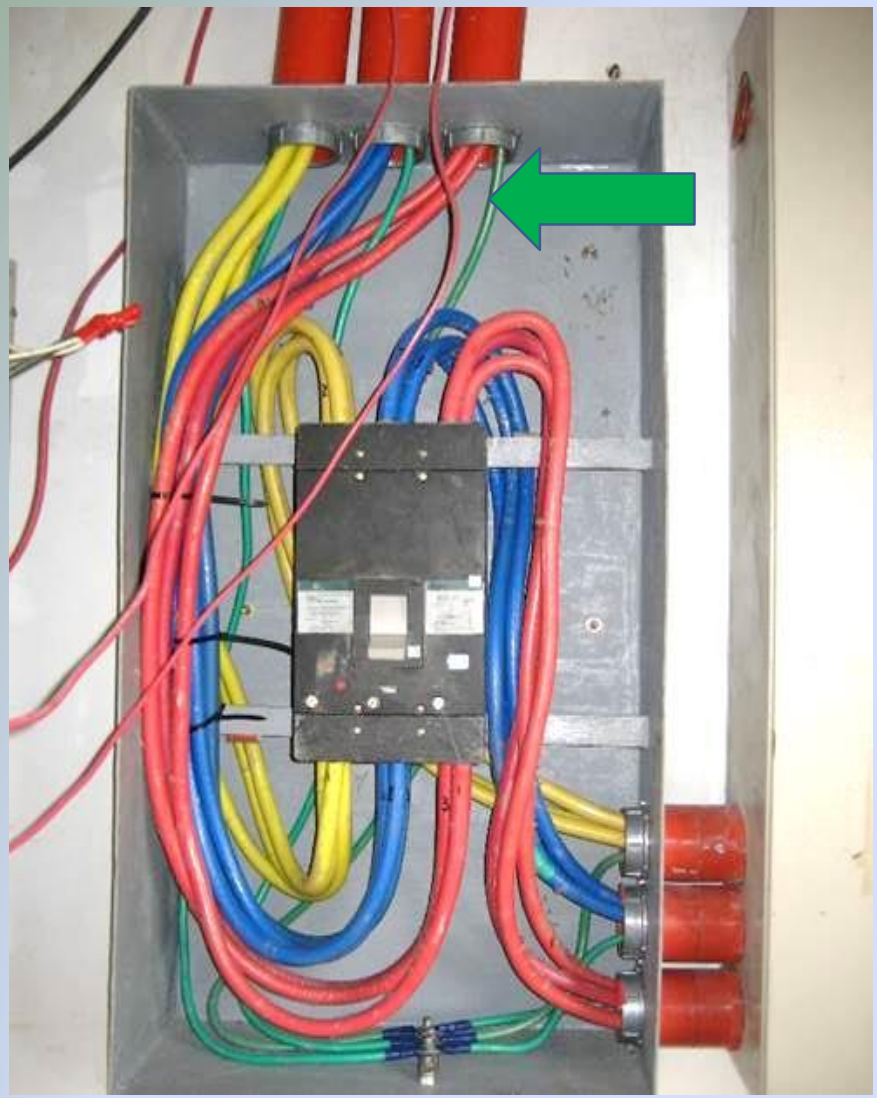


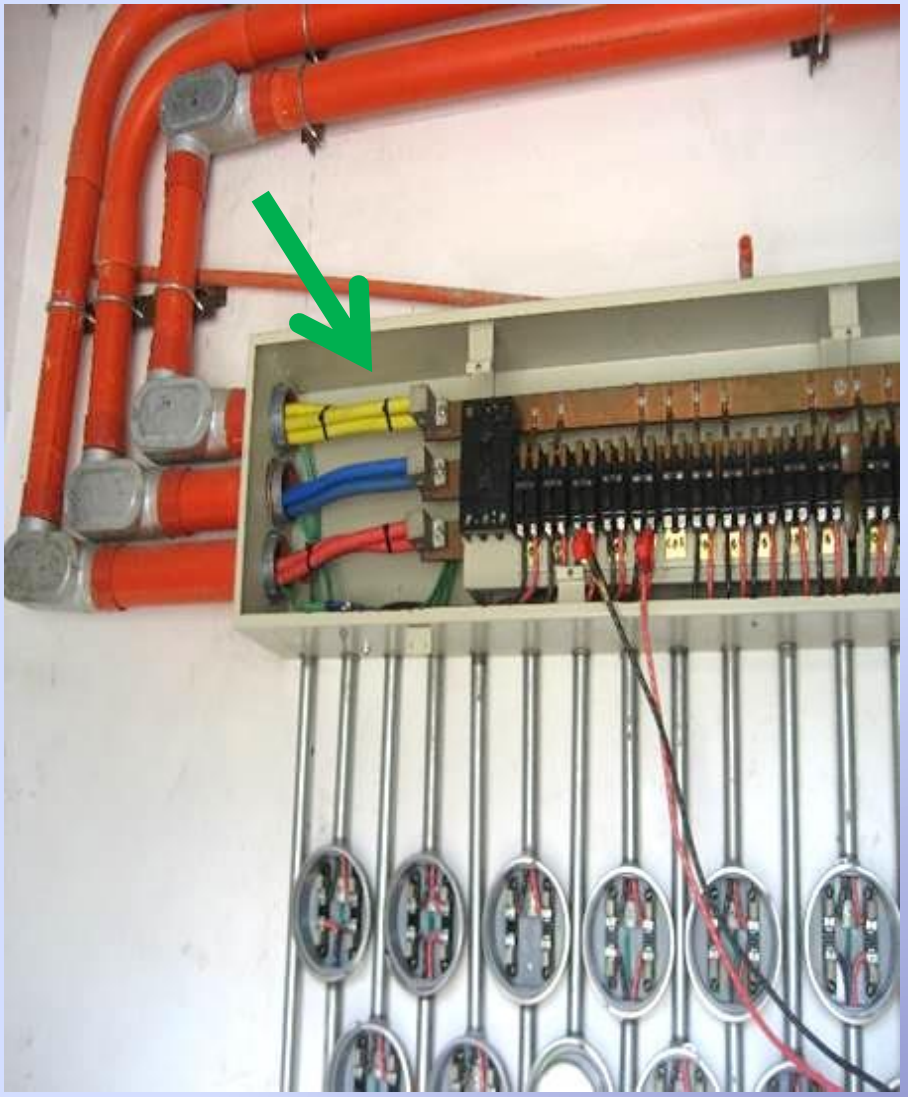
Different Sizes Of Feeder Wires at LINE SIDE

All Wires should be of the same size and should be 50mm2 or greater



Same Phase Wires in Conduits





Line and Load Side in common Raceway; No Grounding Provisions

Branch feeder line wires & load wires were installed in one conduit. Endangers maintenance personnel specifically during trouble shooting.

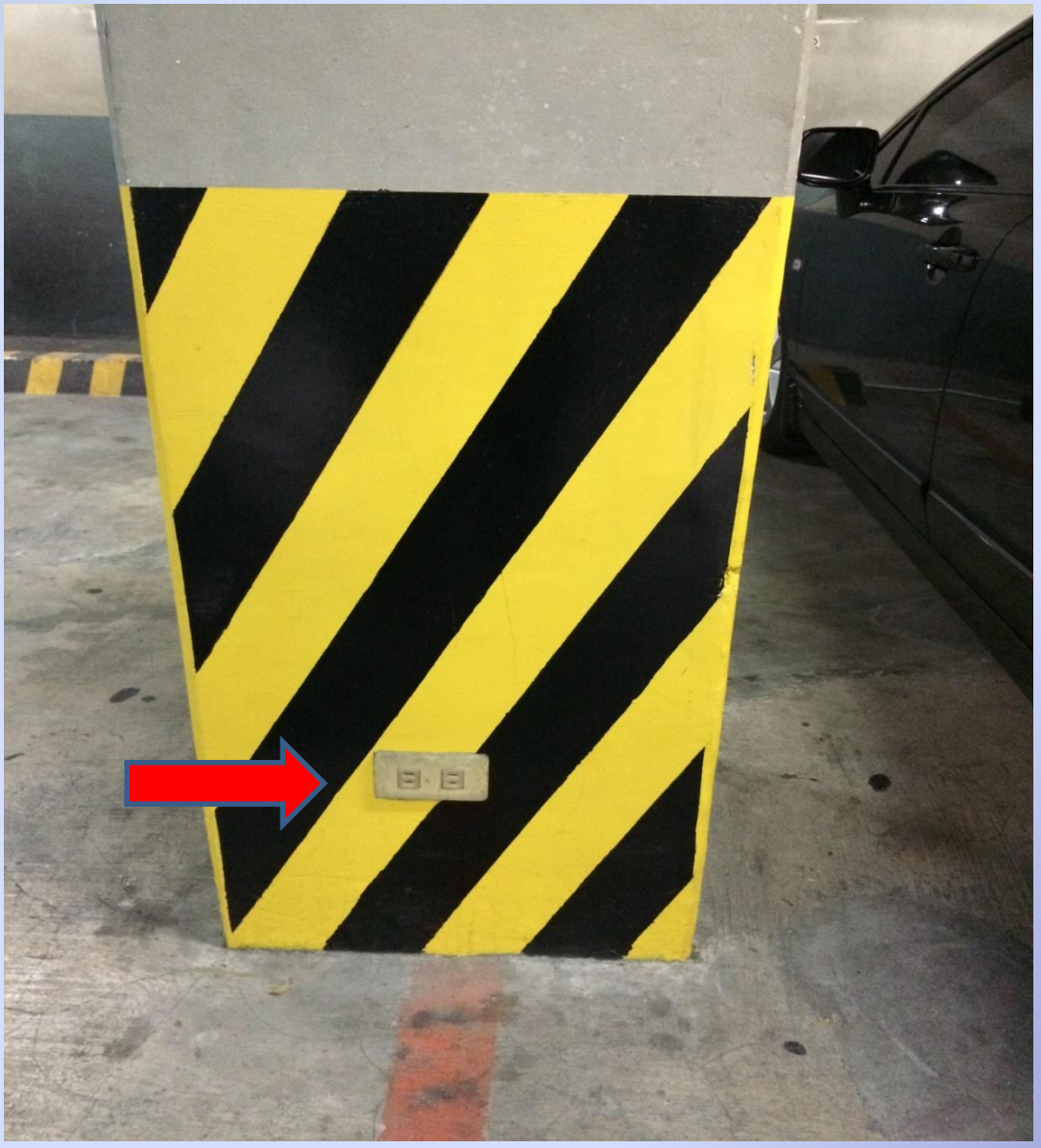
Segregate line side wires with load side wires, each set with conduit.

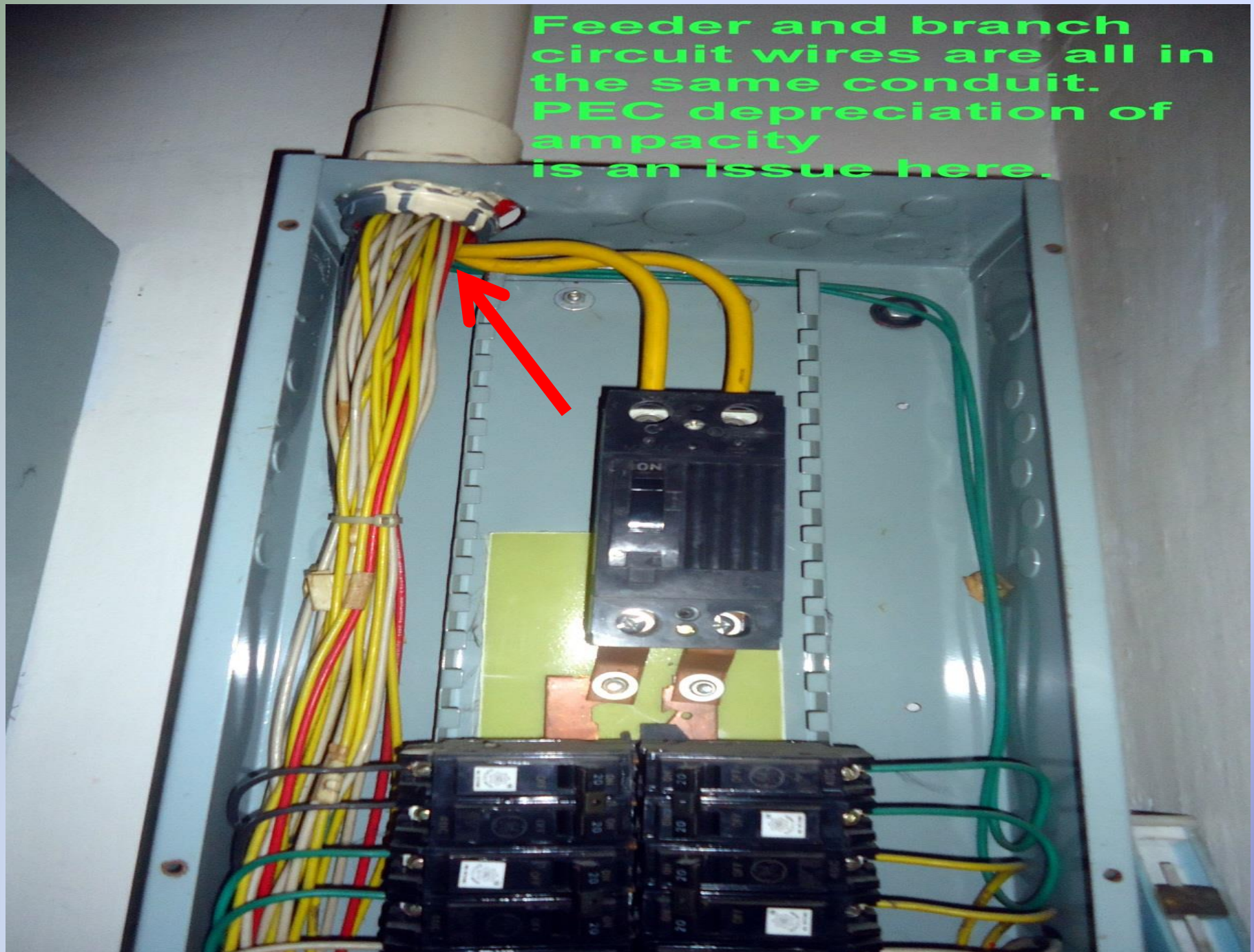
CODE Violation:

Not within approved clearance requirements

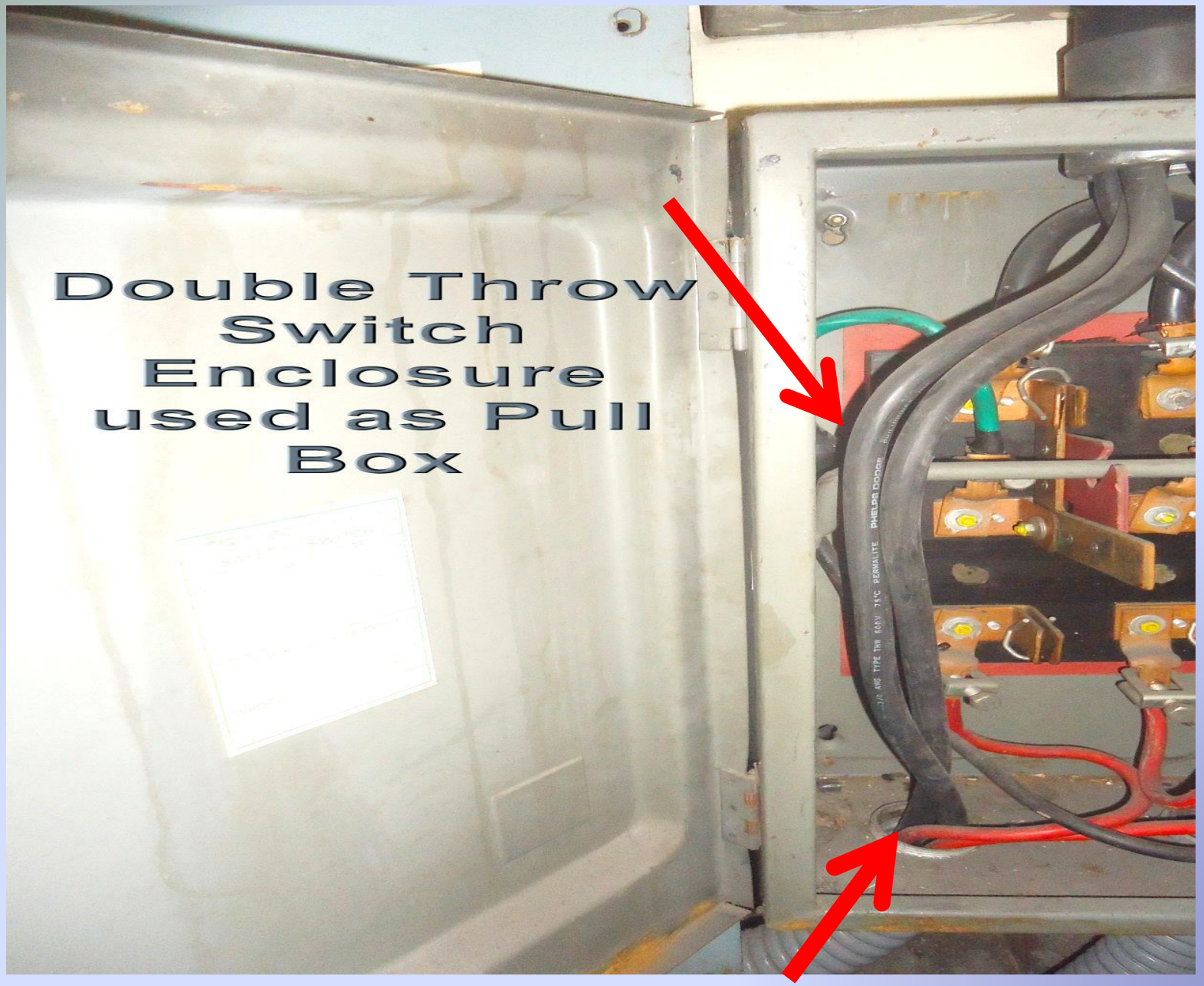
Violation:
PEC Art 2.10.1.8(b) – Ground Fault Circuit Interrupter (GFCI) Protection for Personnel required for wet location or installation outside the building.

Outlets in Commercial Garages: Mounting Height should be at least 18” or 46 cm due to Gas presence



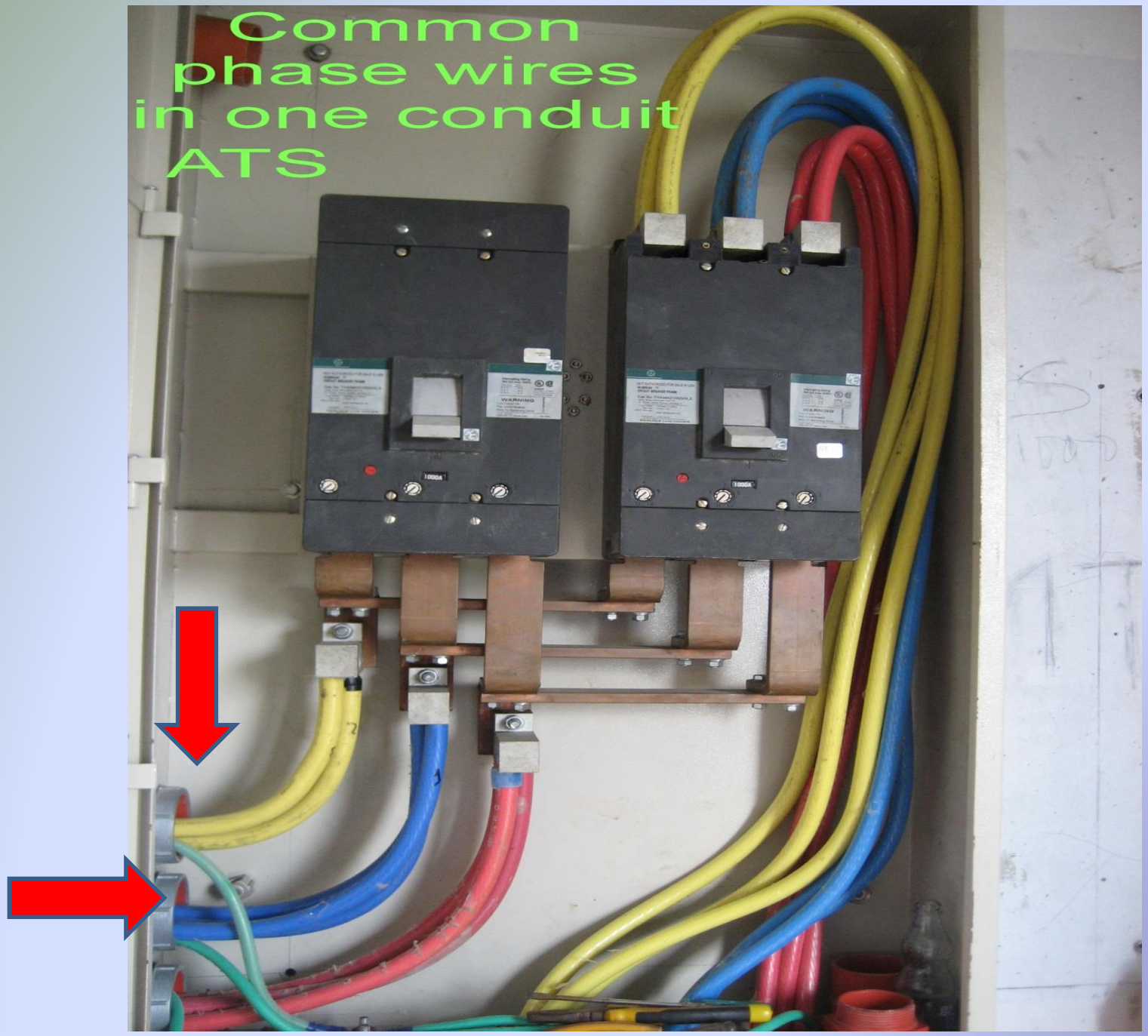

Feeder and branch
circuit wires are all in
the same conduit.
PEC depreciation of
ampacity
is an issue here.

BATHROOM INSTALLATIONS


Double Throw
Switch
Enclosure
used as Pull
Box

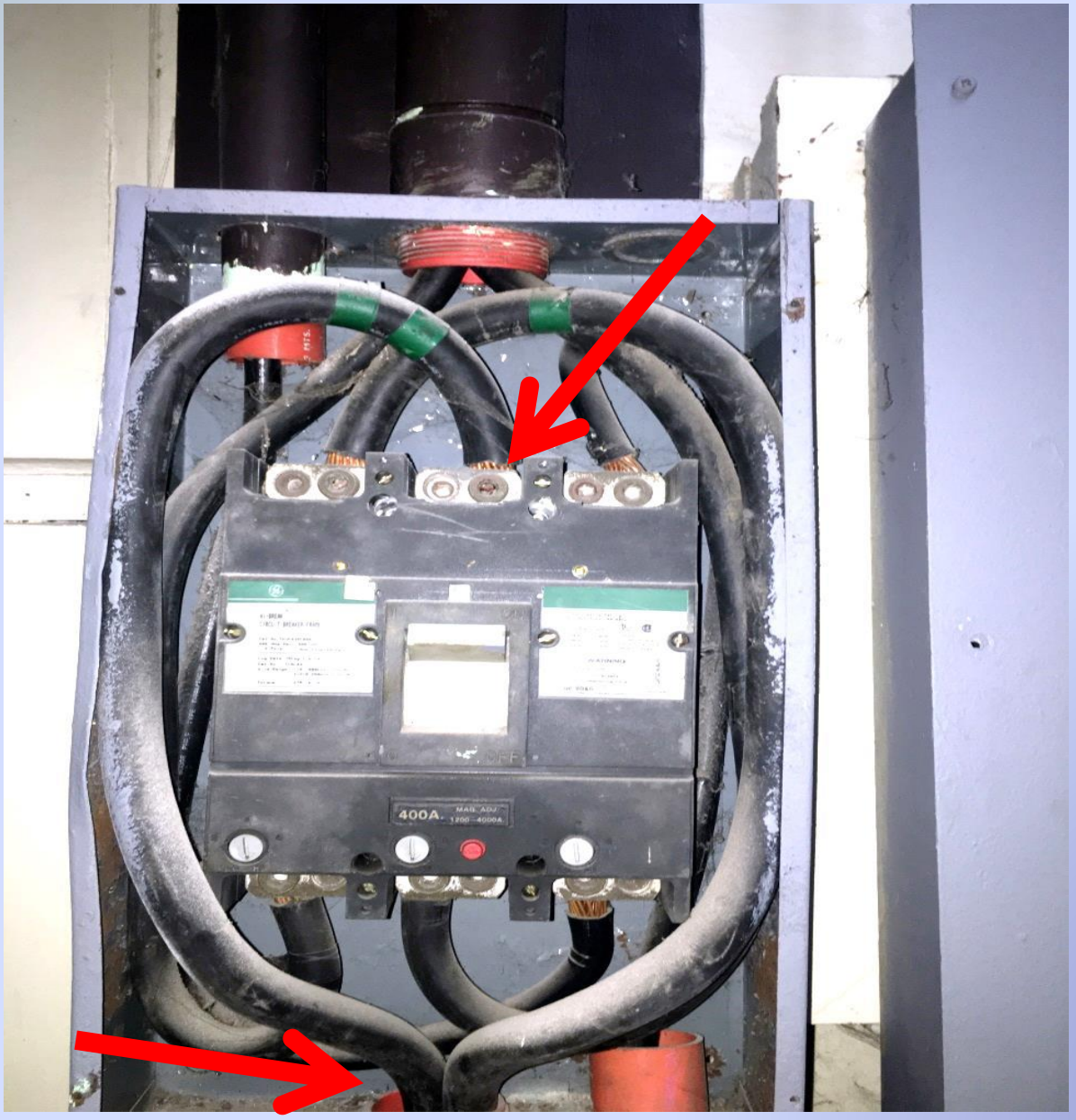
Issue with Mounting Height of Main CB


125 AMP
CB enclosure used as Pullbox.
Line & Load side feeders in
One conduit

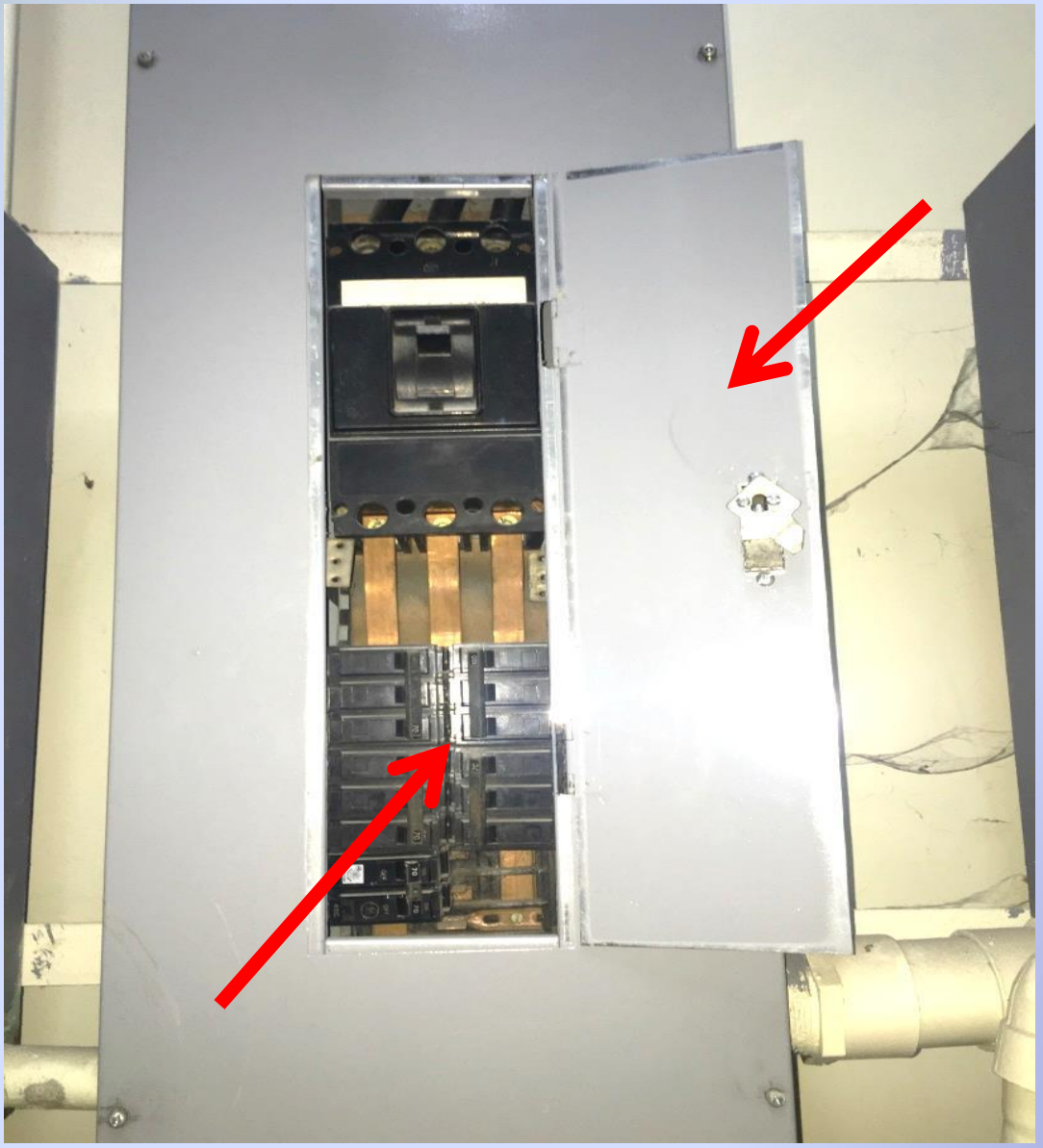

Common
phase wires
in one conduit
ATS

Multiple/parallel Wires at the Load side Less than 50mm2

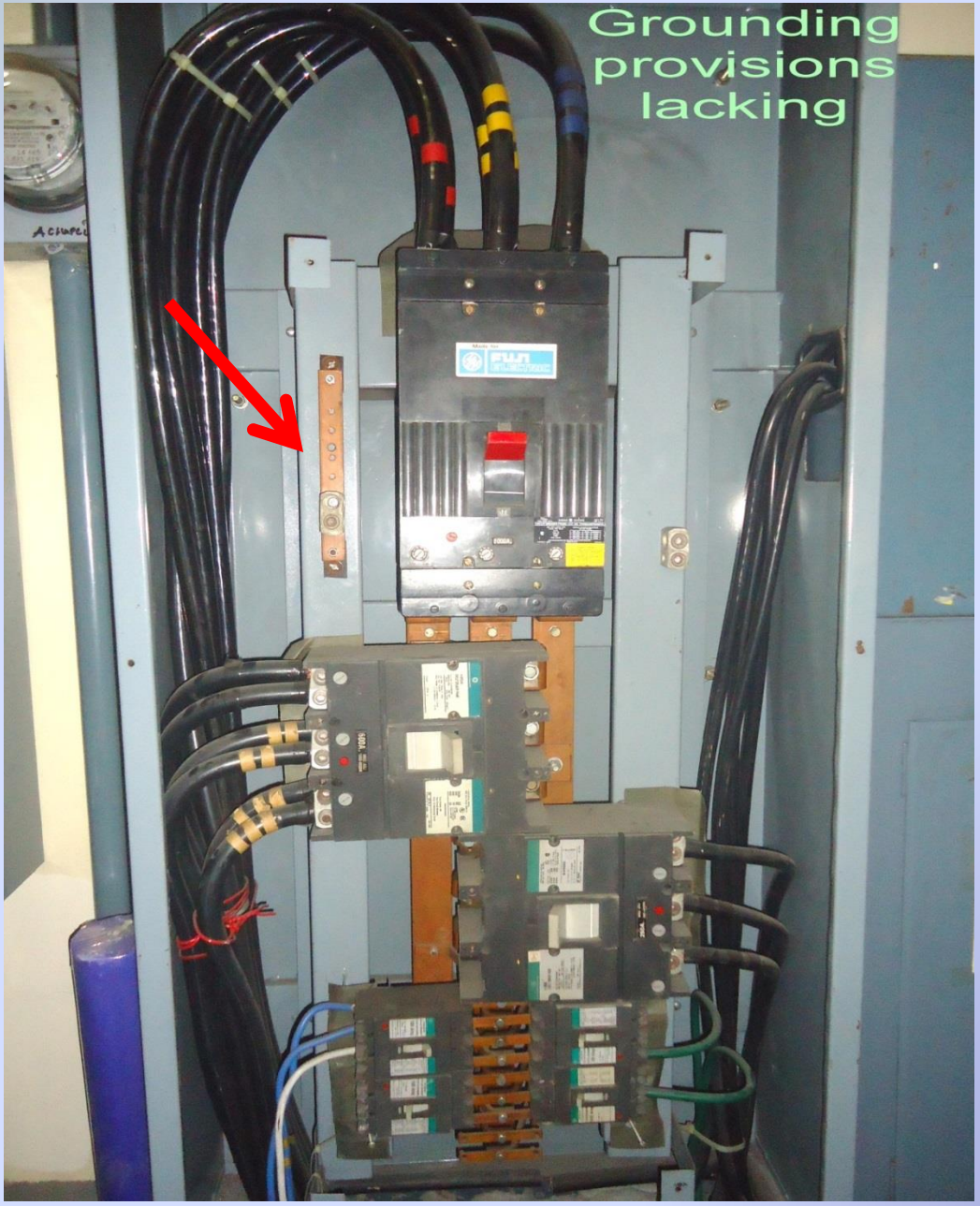
Line side used as termination of other feeder wires



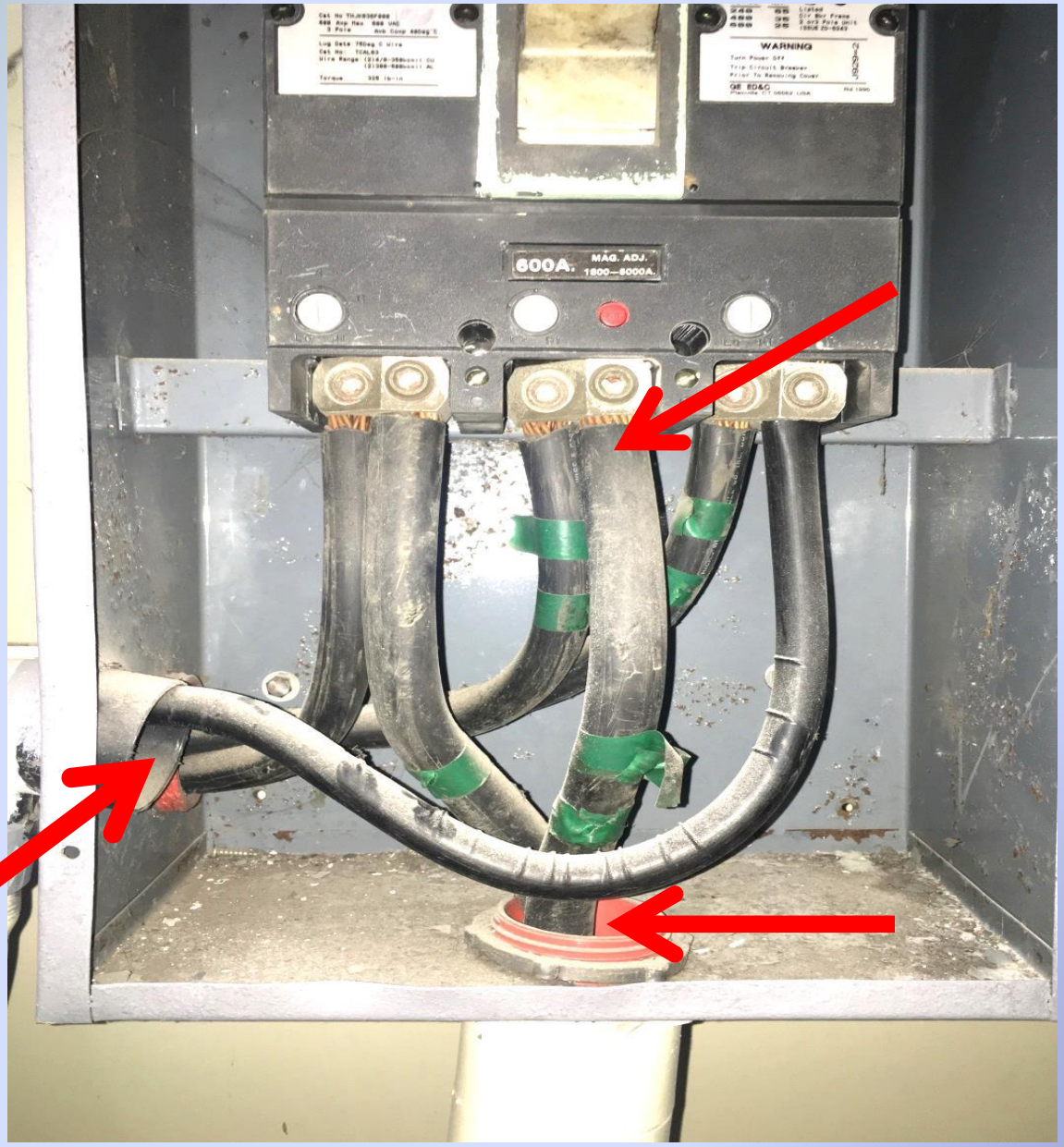
No dead front end cover and panel directory



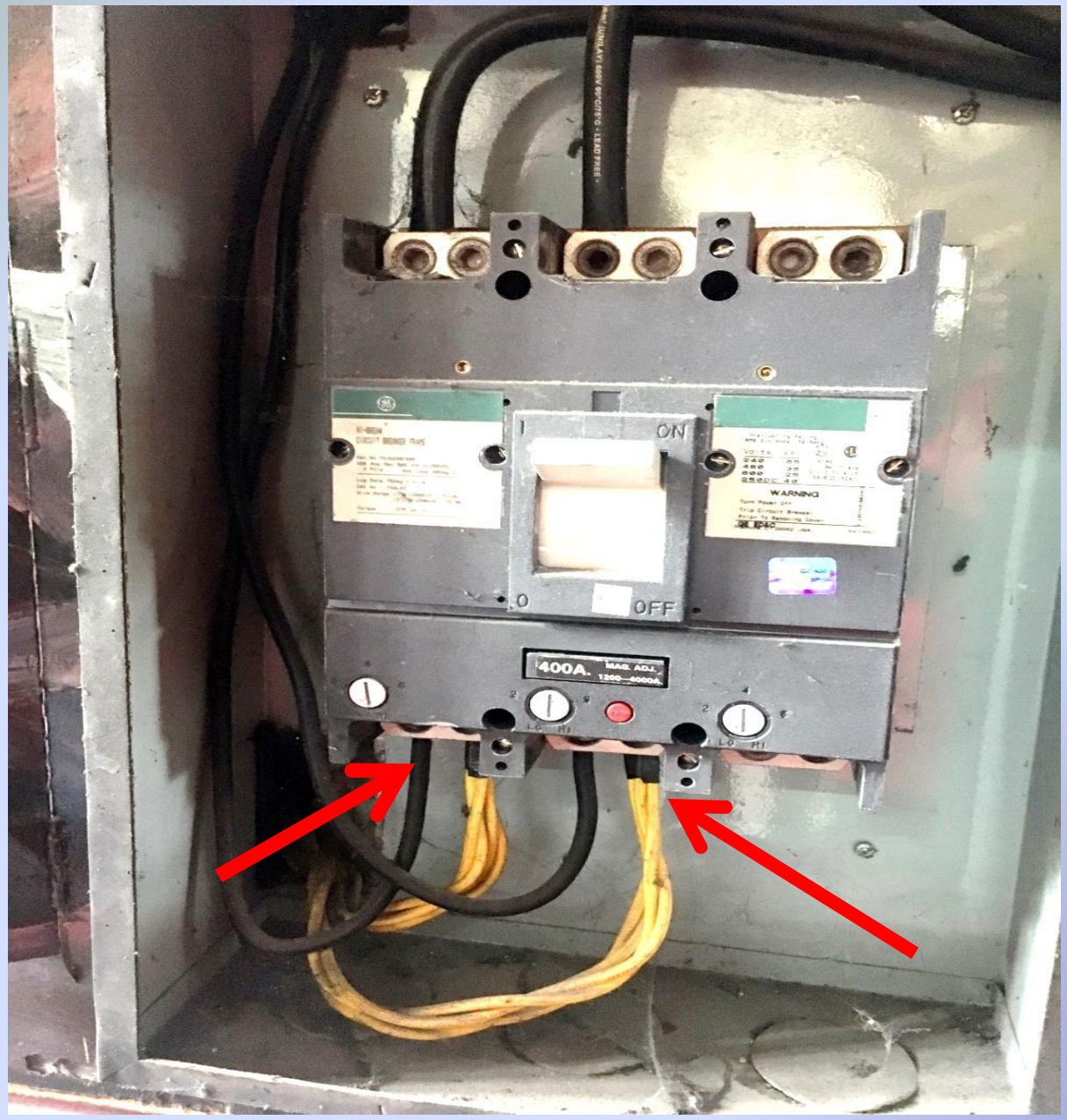
Enclosure needs to be Nema3R/4R


Grounding
provisions
lacking

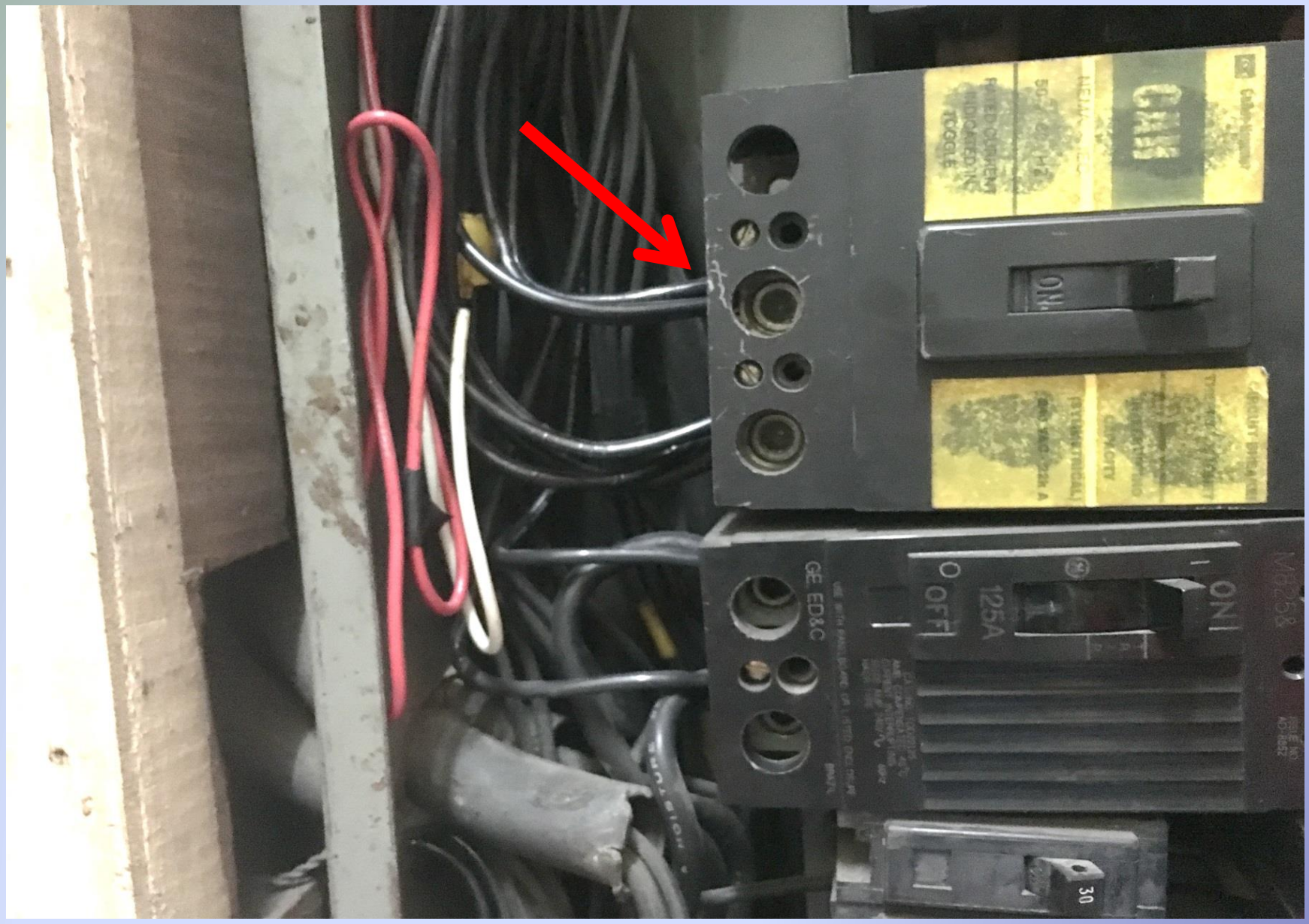
Different sizes of Load side wires



Load side feeders in parallel. Multiple load side feeders connected

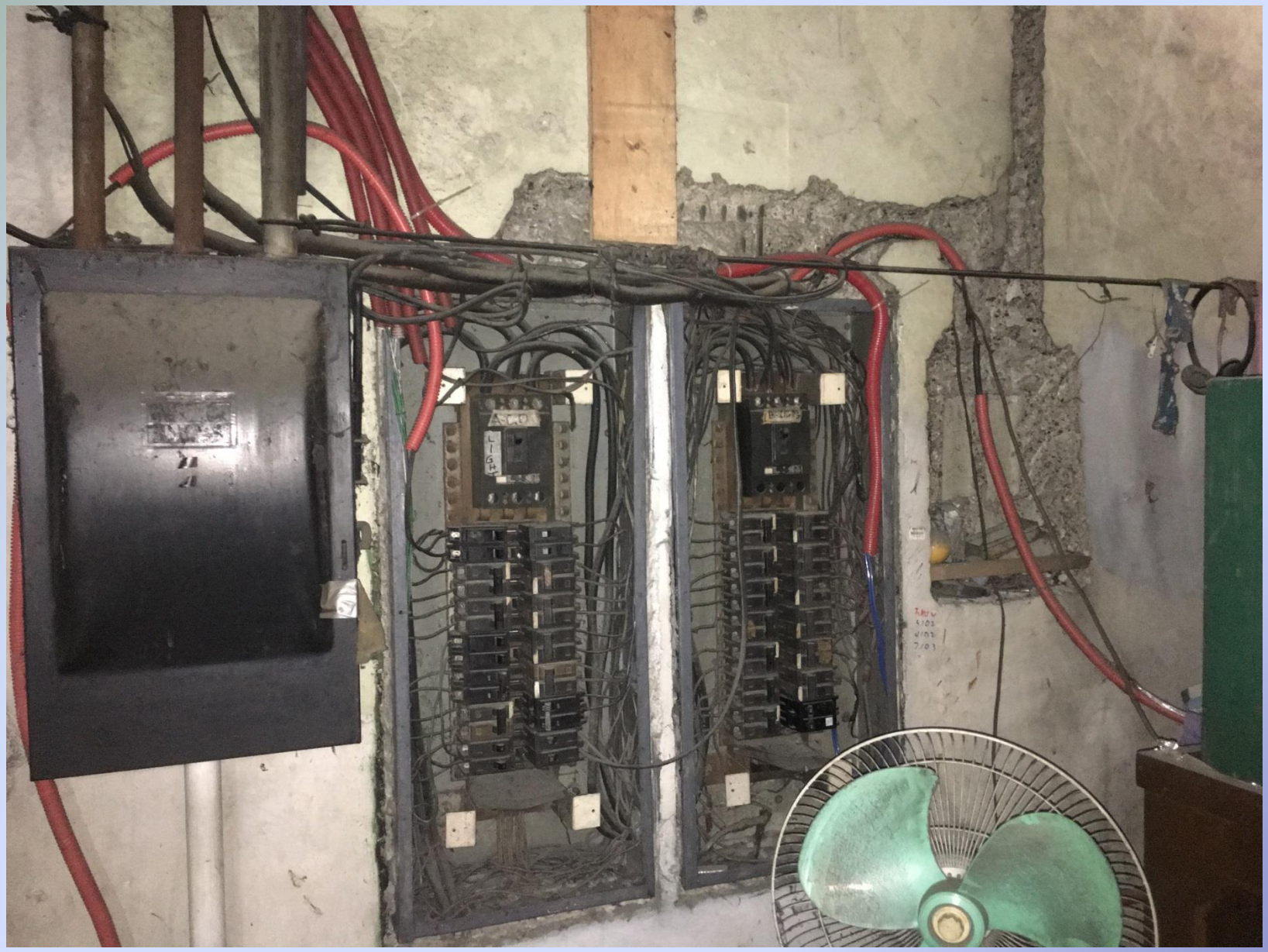


Multiple conductors on the branch CB



Lack of Service Entrance weather Caps

Needs Rewiring Work

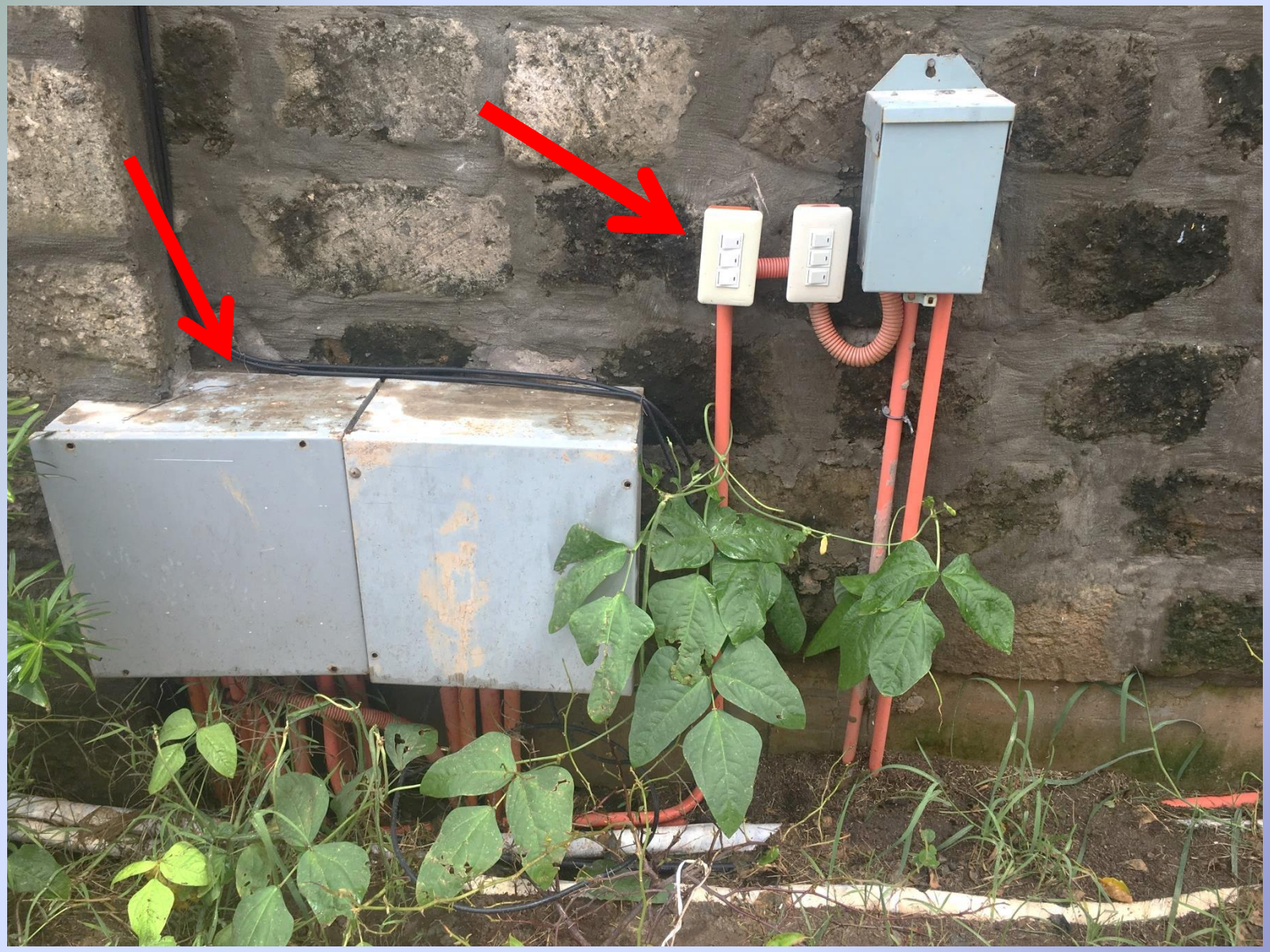


GFCI Outlet Needed

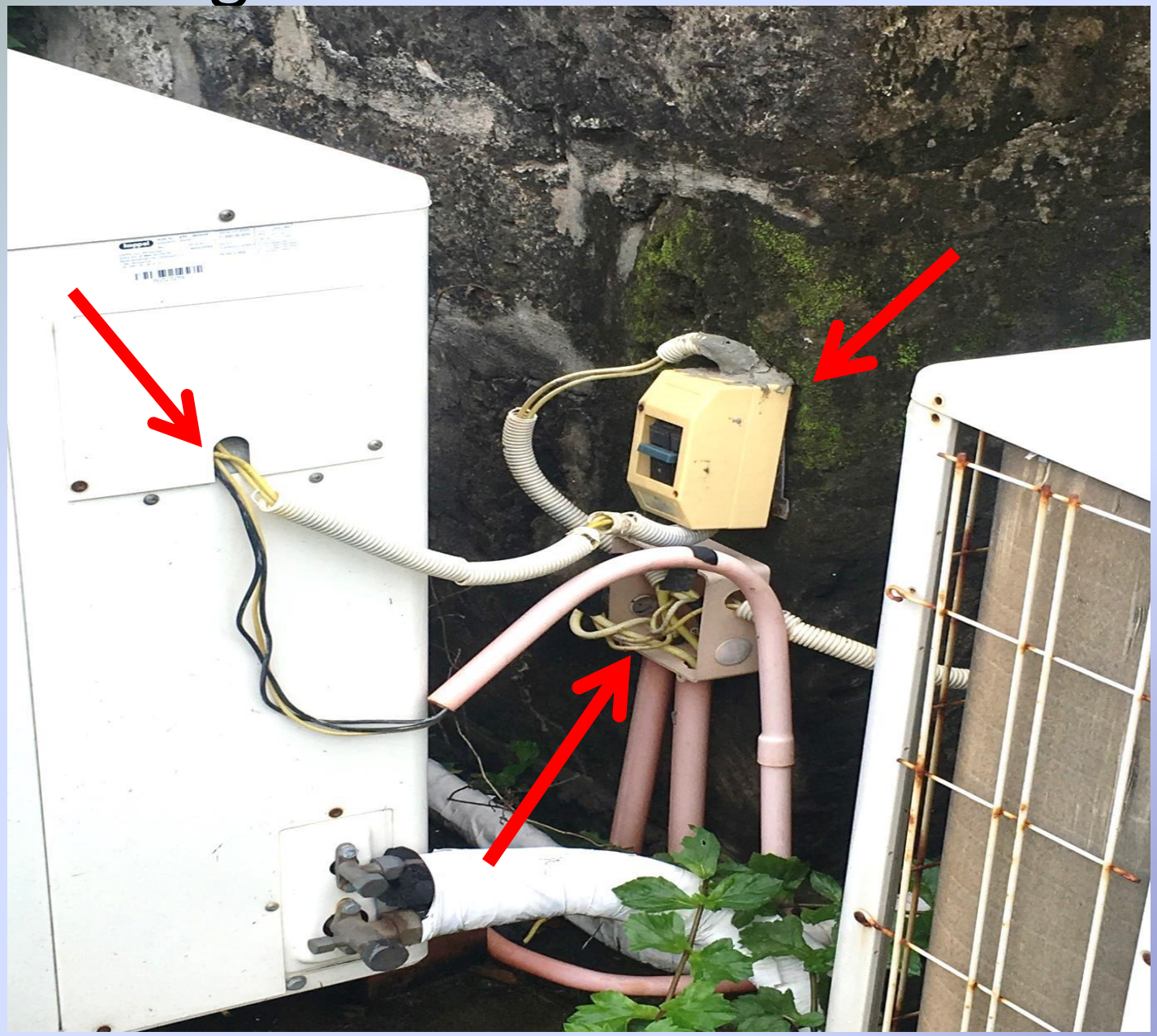
Wire Gutter - Tagging Needed

Nema 3R Enclosure Required

Nema 3R Boxes and WP Switches needed



Rewiring Needed on this Installation



BUS WAY

Due to Poor Maintenance

Damaged Bus way Due to Poor Maintenance

Damage due to Water Drip

Humidity and Dirt Accumulation

Neglect of Cleaning and Proper Maintenance

Dirt Accumulation

Arcing Damage Due to Poor Maintenance

ARC FLASH

ARC FLASH DAMAGE DUE TO POOR MAINTENANCE

ARC FLASH DAMAGE DUE TO POOR MAINTENANCE

USE PROPER PPE

USE OF PROPER PPE WHEN CONDUCTING TESTS

PROPER PPE AND PROPER SIGNS AND BARRIERS

BASIC PERSONNel PROTECTIVE EQUIPMENT (PPE'S)

REFLECTORIZED VEST

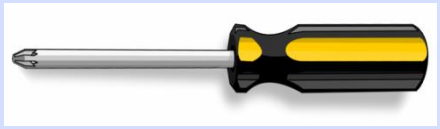
SAFETY GLOVES

HARD HAT

SAFETY SHOES

Common TOOLS

PHILIPS SCREW

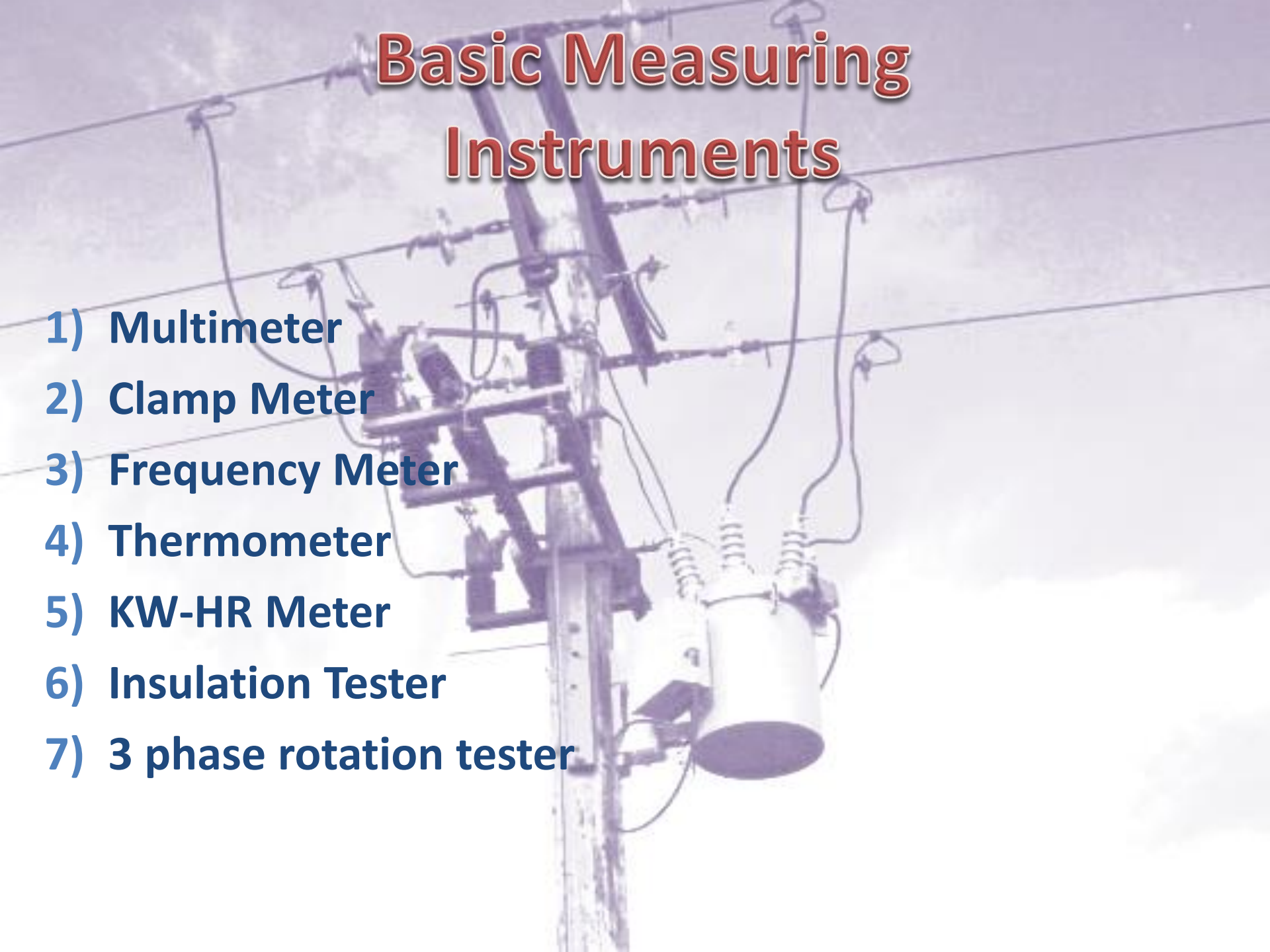


SCREW DRIVER

PLIERS

LONG NOSE PLIERS

Basic Measuring Instruments



1) Multimeter
2) Clamp Meter
3) Frequency Meter
4) Thermometer
5) KW-HR Meter
6) Insulation Tester
7) 3 phase rotation tester

Multimeter or a **Multitester**, also known as a **VOM** (Volt-Ohm meter), is an electronic measuring instrument that combines several measurement functions in one unit.

Multimeter can be a hand-held device useful for basic fault finding and field service work, or a bench instrument which can measure to a very high degree of accuracy. They can be used to troubleshoot electrical problems in a wide array of industrial and household devices such as electronic equipment, motor controls, domestic appliances, power supplies, and wiring systems.

Clamp Meter is an electrical tester that combines a basic digital multimeter with a current sensor. **Clamps** measure current. Probes measure voltage.

Having a hinged “clamp” jaw integrated into an electrical meter allows users to simply clamp around wire, cables and other conductors at any point in the electrical system and measure its current, without disconnecting it.

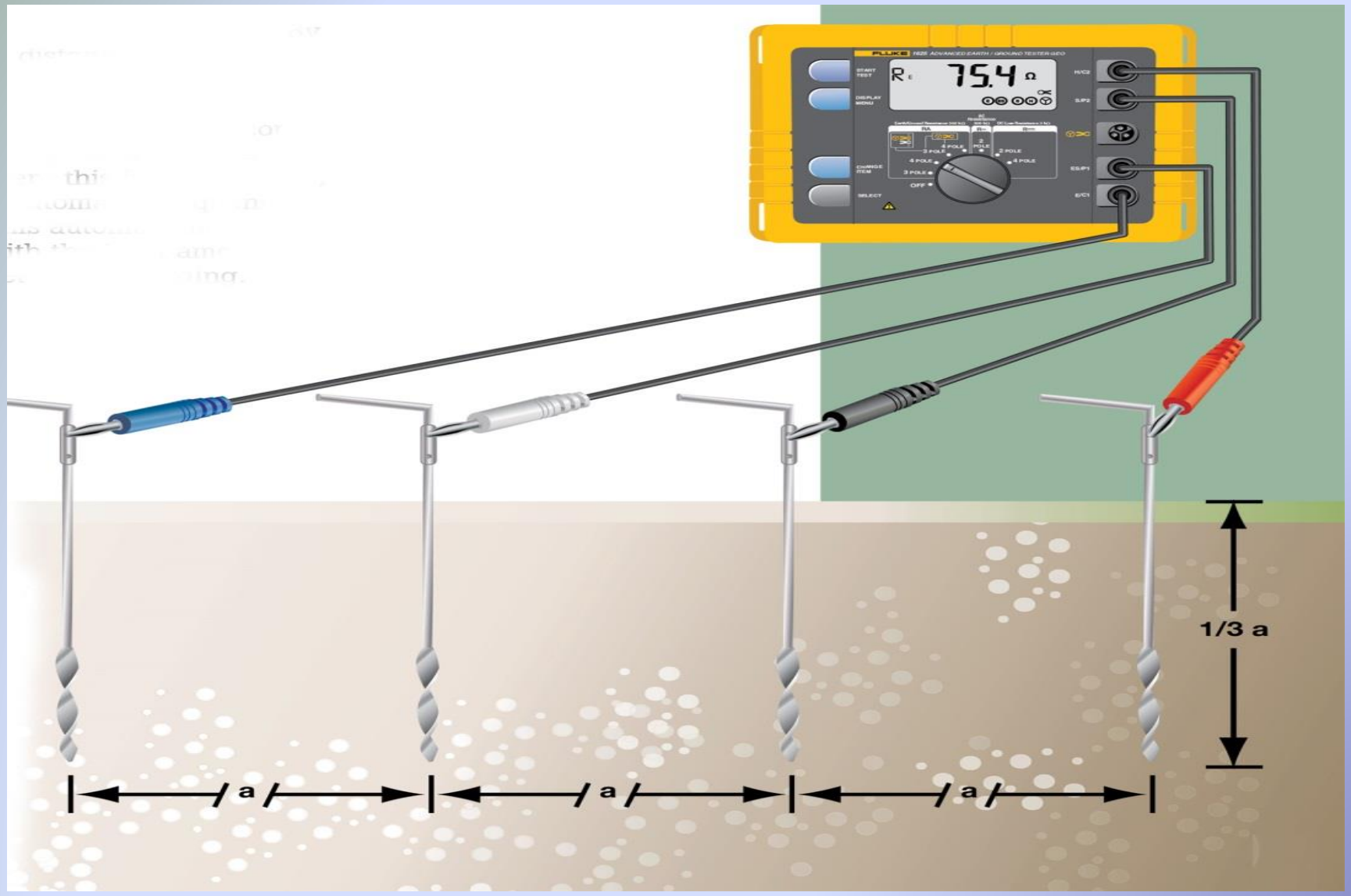
Frequency meter is an electronic instrument that displays the frequency of a periodic electrical signal.

Frequency meter, device for measuring the repetitions per unit of time (customarily, a second) of a complete electromagnetic waveform.

Insulation Tester – This test is to measure insulation resistance of wires and equipment (500VDC 0r 1000VDC)

Earth Resistance Tester

Earth Resistance Measurement



3 Phase Rotation Testers

Thermometer is a device that measures temperature or a temperature gradient using a variety of different principles.

A thermometer has two important elements: the temperature sensor (e.g. the bulb on a mercury-in-glass thermometer) in which some physical change occurs with temperature, plus some means of converting this physical change into a numerical value (e.g. the visible scale that is marked on a mercury-in-glass thermometer).

Samples Of Proper Installation

Meter Centers with Gutters & Bus Bars

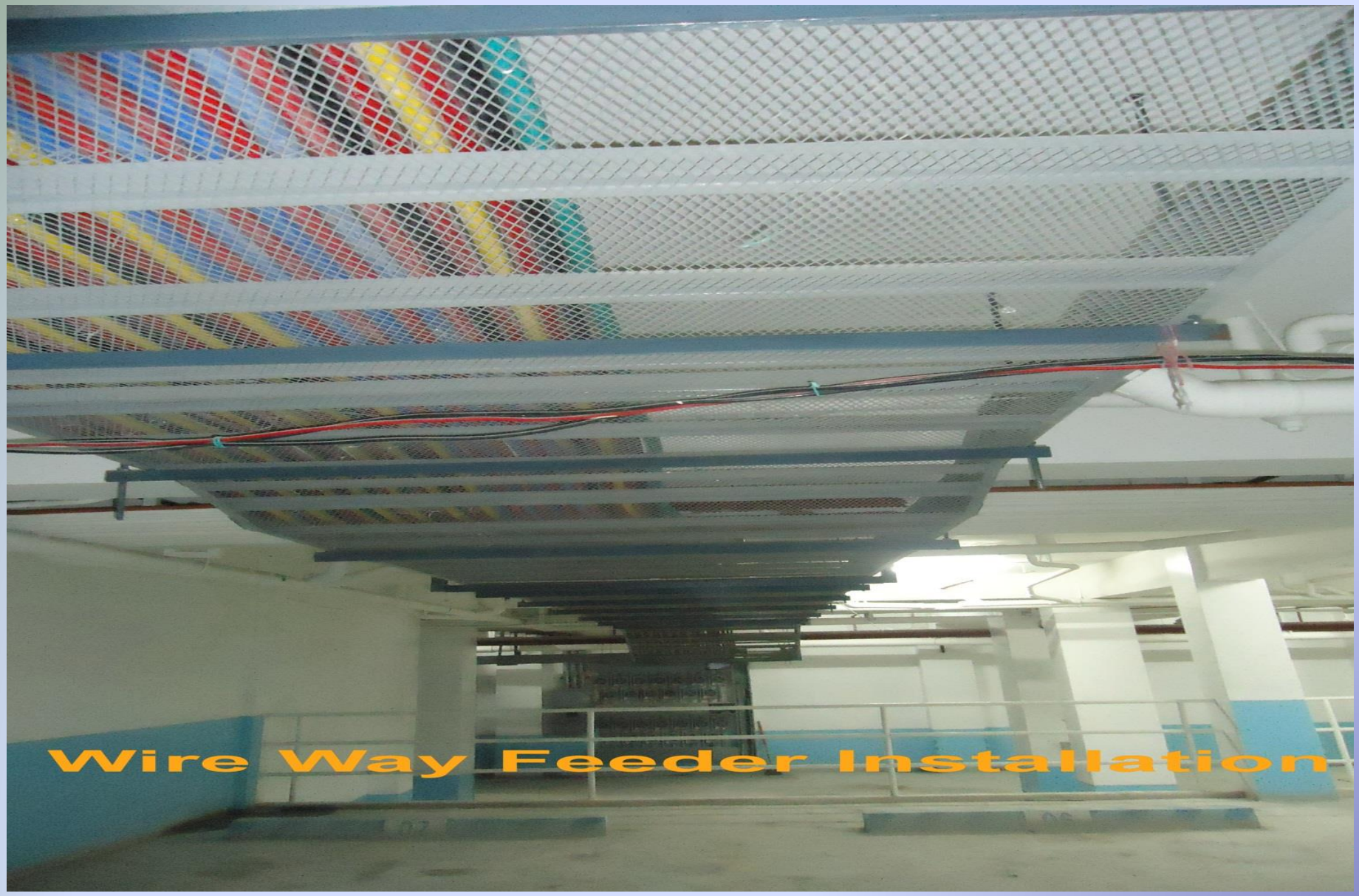
Wire Meshed /Wire Gutter Layout

Wire Gutter Layout & Metering Center

Wire Way /Gutter wiring installation for Feeders

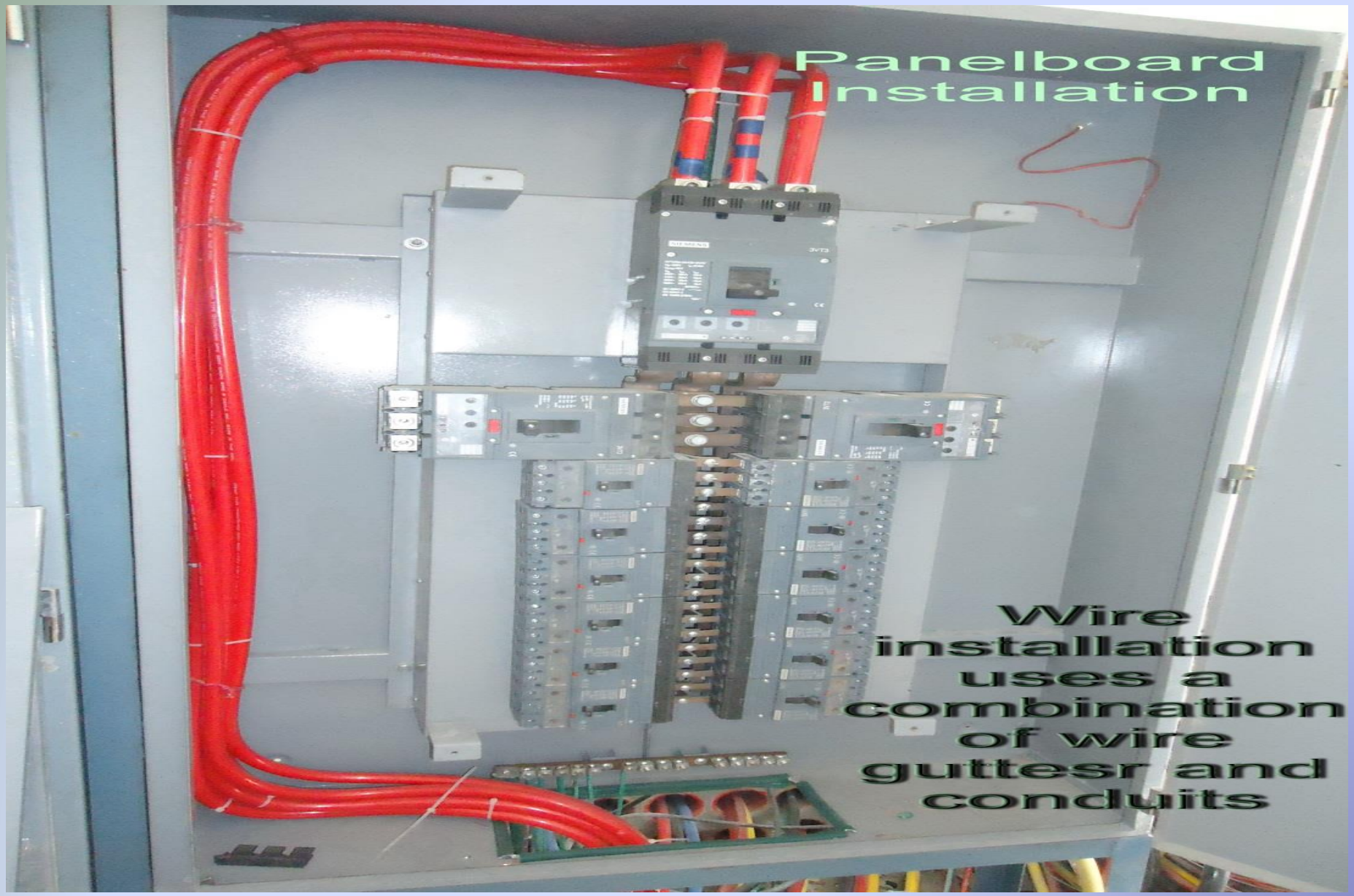
Wireway Layout to Conduit Risers

CABLE TRAY Feeder Installation

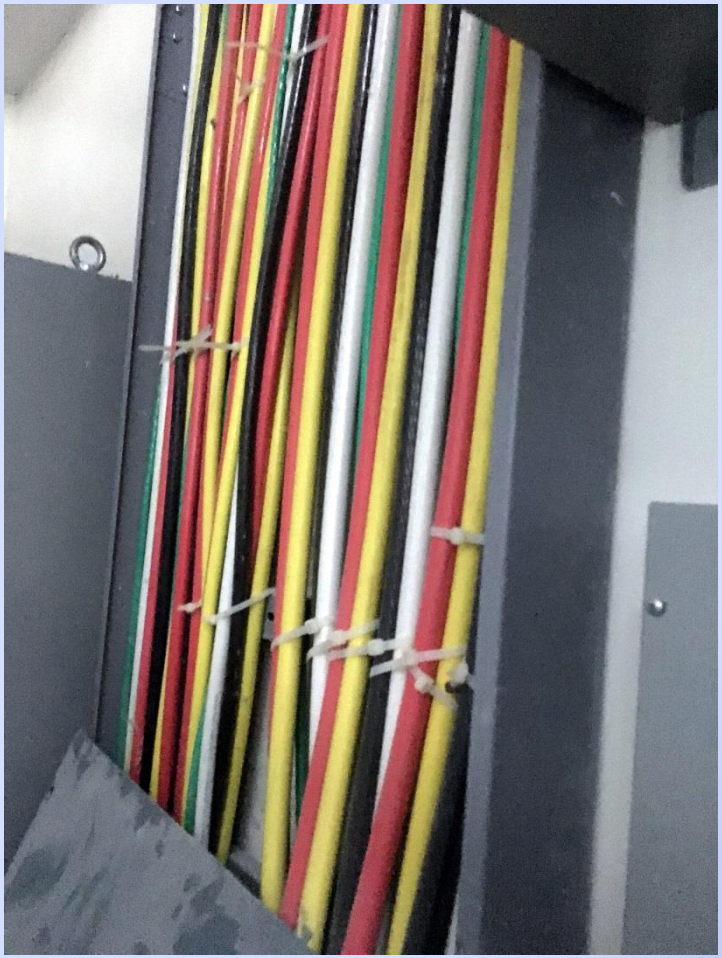


MERALCO Crew Installation of 2-2 MVA Pad Mounted Transformers

Panel Board & Feeder Wire Installation



Wire Gutter Layout with tie binders



Bus way Installation

Panel Board with proper Tagging an Directory

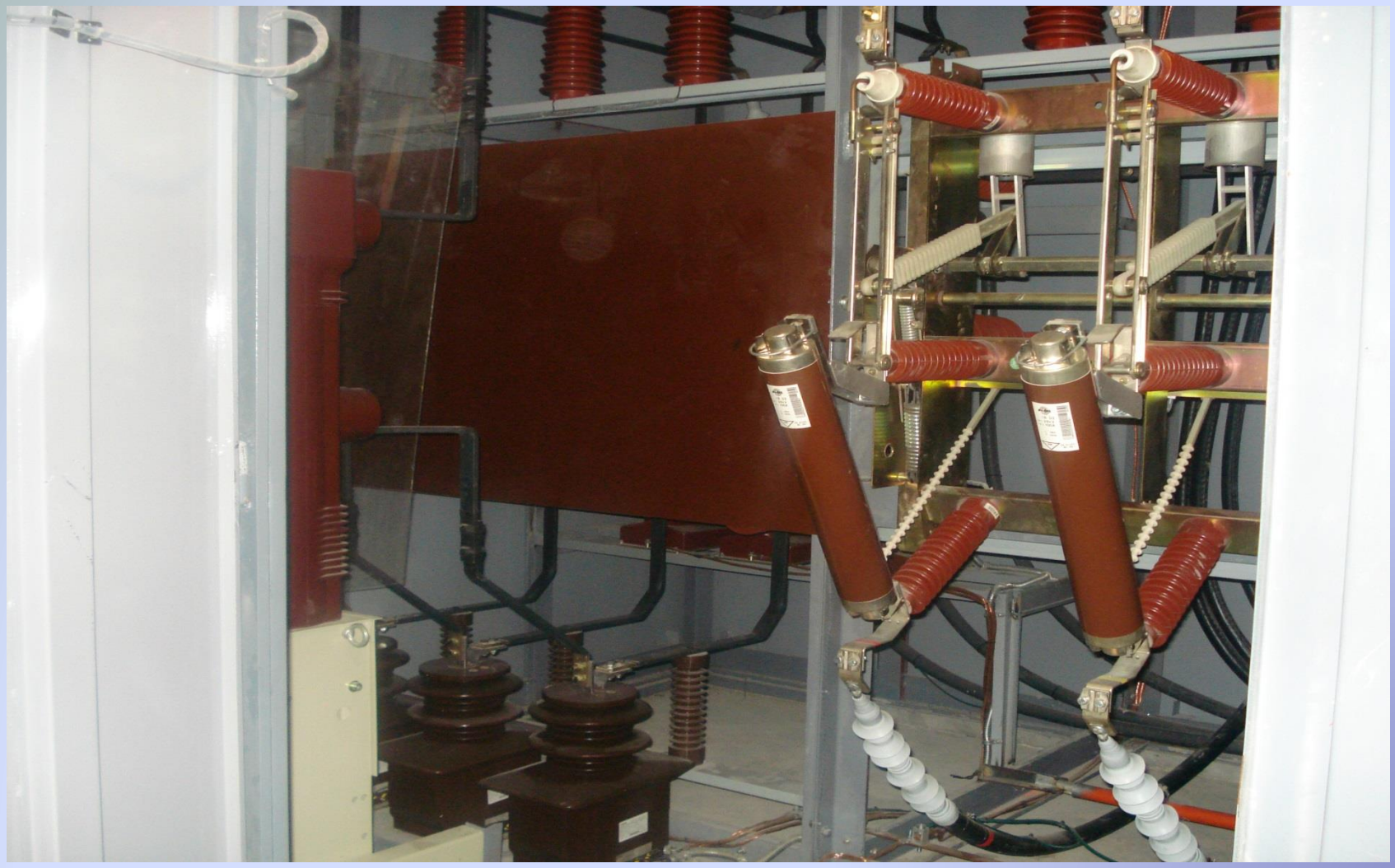
SWITCHGEAR CB and CABLE LAYOUT

Motor Control Panel

Pump Layout and Installation

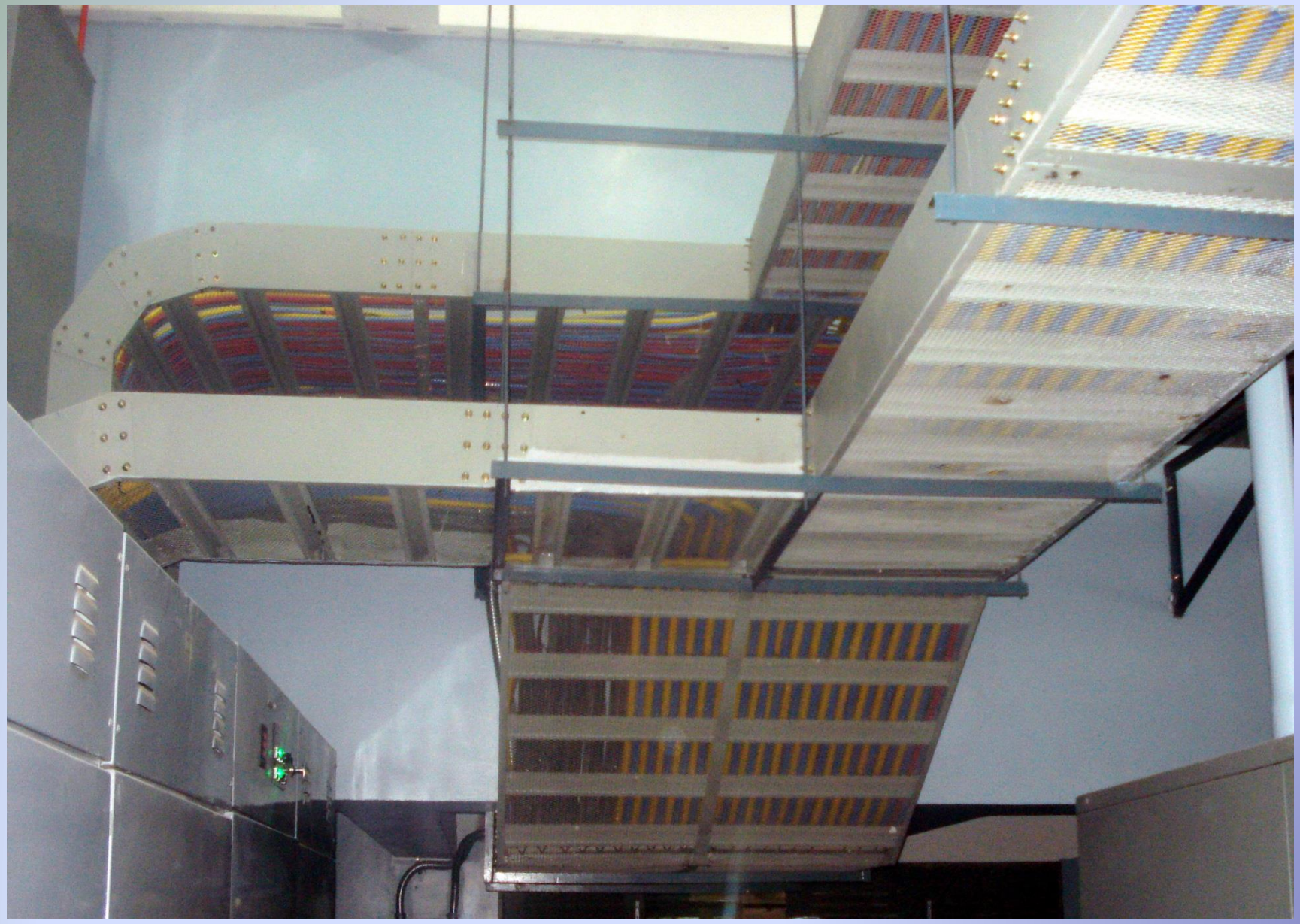
Fire Pump Layout Installation

Primary Fuse Assembly 34.5 KV 2MVA




0
40
80
120

CABLE RACEWAYS



Sources of Presentation

- Philippine Electrical Code part one 2017 Edition
- Illustrated Guide to the 2017 National Electrical Code, by Charles R. Miller 7th Edition
- American Electricians Handbook 14th Edition by Terrell Croft and Wilford Summers
- Various Catalogues of Phelps Dodge and Duraflex wires and cable

THANK YOU !

Engr. Justo Ma. J Lopez Jr.

Professional Electrical Engineer, ASEAN Engineer, ACPE

FELLOW – IIEE

2019 - BPS-TC 77 Vice Chairman

2019 Convenor PEC1-IEC Sub Committee

2019 – PRC Nominee for Outstanding Professional, Electrical Eng.

2010 Most Outstanding EE for Construction & Project Management

2018 IIEE Vice-Chairman – Advocacy Committee

Former Vice Chairman-IIEE Electrical Safety Committee (2013-17)