Seminar on:
"Philippine Electrical Code Provisions and its Proper Applications for Common Electrical Installation Practices."

Topic: COMMON WIRING METHODS

by: Engr. Raulito C. Baldonado Jr.
Engr. Jaime D. Magsayo

May 1 & 2, 2015
@Hotel Pier Cuatro, North Reclamation Area, Cebu City

Wiring Methods

IIEE – Cebu Chapter

Electrical system designing involves dealing with great ***wiring methods.***

This presentation aims to describe the common wiring methods in electrical system as being used to provide power in buildings, structures, industrial plants, among others.

Wiring Methods

IIEE – Cebu Chapter

These wiring methods involves three basic (3) parameters:

1.) *Wires and Cables*

2.) *Conduits, raceways, wire ways and cable trays*

3.) *Pull boxes, enclosures and hand holes*

Wiring Methods

IIEE – Cebu Chapter

1.) What is ***wire***?

The term "***wire***" refers primarily to the slender copper or aluminum metal*; wire* is understood to include the insulation.

Wiring Methods

IIEE – Cebu Chapter

- On the other hand, a "**cable"** is composed of two or more *small wires* running side by side, stranded and bonded, twisted or braided together to form a single conductor assembly and is used to carry electrical currents.
- The term ***cable*** is a general one, and in practice, it is usually applied only to the larger sizes.

Wiring Methods

IIEE – Cebu Chapter

The term ***"cable"*** also applies to a combination of conductors insulated from one another, multi-core in construction and packaged with an overall jacket as in a multi-conductor cable. As this picture shows an *ALPETH CABLE* which is 12 pairs.

Wiring Methods

IIEE – Cebu Chapter

What are the examples of wires/cables that are commonly used in our practice here in the Philippines?

Low voltage Building Wires & Cables rated at 600 V which include:
TW, THW, THHN

Wiring Methods

IIEE – Cebu Chapter

TW, THW, THHN building wires are used in residential, commercial and industrial buildings for general-purpose power, lighting, appliance, motor circuits & sometimes in controls applications.

TW, THW, THHN

"T" in these wire designations stands for thermoplastic insulation,
"H" for heat resistant,
"N" for nylon,
"W" stands for water-resistant.

Wiring Methods

IIEE – Cebu Chapter

Insulation/Temperature rating

TW (60°C) : Thermoplastic, Water-Resistant
THW (75°C) : Thermoplastic, Heat-Resistant, Water-Resistant
THHN (90°C) : Thermoplastic High Heat-Resistant, Nylon Coated
THWN (75°C): Thermoplastic High Water-resistant, Nylon Coated

Wiring Methods

IIEE – Cebu Chapter

PEC Section 3.10.1.8 (B) **Locations**

Insulated conductors and cables used in *dry and damp locations*

- Shall be Types, THHN, THW, THW-2, THHW, THHW-2,THWN, TW, XHH, XHHW, X, HHW-2, Z or ZW

PEC Section 3.10.1.8 (C) **Locations**

Insulated conductors and cables used in *wet locations*

- Moisture-impervious metal-sheathed
- Shall be Types, MTW, RHW, RHW-2, TW, THW, THW-2, THHW, THHW-2, THWN, THWN-2, XHW, XHHW, XHHW-2, ZW

Wiring Methods

IIEE – Cebu Chapter

PEC Section 3.10.1.8 (d) **Locations**
Insulated conductors where used exposed direct to rays of the sun shall be:

- Cable listed, or listed and marked, and being *sunlight resistant.*
- Conductors listed and marked as being *sunlight resistant.*

Wiring Methods

IIEE – Cebu Chapter

PEC Section 3.10.1.5 ***Minimum Size of Conductors***

The minimum size of conductor's shall be shown in Table 3.10.1.5, except as permitted elsewhere in this code.

Table 3.10.1.5 Minimum Size of Conductors

Conductor Voltage Rating (Volts)	Minimum Conductor Size mm^2(mm dia.)	
	Copper	Aluminum or Copper-Clad Aluminum
0–2000	2.0(1.6)	3.5(2.0)
2001–8000	8.0(3.2)	8.0(3.2)
8001–15,000	30	30
15,001–28,000	38	38
28,001–35,000	50	50

2.) Types of Conduit

Common used ***type of conduits*** in the Philippines are the following:

- Intermediate Metal Conduit (Type IMC)
- Rigid Metal Conduit(Type RMC)
- Flexible Metal Conduit (Type FMC)
- Liquidtight Flexible Metal Conduit (Type FLMC)
- Rigid NonMetallic Conduit (Type RNC)
- Electric Metallic Tubing (Type EMT)
- Electrical Nonmetallic Tubing (Type ENT)

PEC Article 3.42 **Intermediate Metal Conduit (IMC)**

3.42.2.1 *Uses Permitted*

- uses under all atmospheric condition and environment

3.42.2.11 *Sizes*

- *Minimum (15mmØ)*
- *Maximum (150mmØ)*

3.42.2.13 Number of Conductors

- Refer to PEC Table 9.1.1.1

3.42.2.17 *Bends*

- No more than four (4) quarter bends

Wiring Methods

IIEE – Cebu Chapter

PEC Article 3.44 **Rigid Metal Conduit (RMC)**

3.44.2.1 *Uses Permitted*

- uses under all atmospheric condition; except for *severe corrosive environment*

3.44.2.11 *Sizes*

- *Minimum (15mmØ)*
- *Maximum (150mmØ)*

3.44.2.13 Number of Conductors

- Refer to PEC Table 9.1.1.1

3.44.2.17 *Bends*

- No more than four (4) quarter bends

Wiring Methods

IIEE – Cebu Chapter

PEC Article 3.42 **Flexible Metal Conduit (FMC)**

3.48.2.1 *Uses Permitted*

- exposed and concealed locations

3.48.2.3 Uses Not Permitted

- Wet locations
- In hoistways
- Hazardous locations
- Storage battery rooms
- Underground/embedded in concrete or aggregate
- Subject to physical damaged

PEC Article 3.50 **Liquidtight Flexible Metal Conduit (LFMC)**

3.50.2.1 *Uses Permitted*

- exposed and concealed locations

3.50.2.3 Uses Not Permitted

- Wet locations
- In hoistways
- Hazardous locations
- Storage battery rooms
- Underground/embedded in concrete or aggregate
- Subject to physical damaged

Wiring Methods

IIEE – Cebu Chapter

PEC Article 3.52 **Rigid NonMetallic Conduit (RNC)**

A Sample for this type of conduit is the ***PVC pipes***

3.52.2.1 *Uses Permitted*

- Concealed
- *Corrosive Influences*
- *Cinders*
- *Wet Location*
- *Dry and Damp Locations*
- *Exposed (Shall not be subject for physical damaged)*

PEC Article 3.52 **Rigid NonMetallic Conduit (RNC)**

3.52.2.3 *Uses Not Permitted*

- Hazardous Locations
- Support of Luminaires
- Physical Damaged
- Ambient Temperature (not to excess in 50°C environment unless listed otherwise.

3.52.2.11 *Size*

(a) Minimum: 15mm Ø

(b)Maximum: 150mm Ø

Wiring Methods

IIEE – Cebu Chapter

PEC Article 3.58 **Electrical Metallic Tubing (EMT)**

3.58.2.1 *Uses Permitted*

- Exposed and Concealed

3.58.2.11 *Sizes*

- Minimum (15mmØ)
- Maximum (100mmØ)

3.58.2.13 Number of Conductors

- Refer to PEC Table 9.1.1.1

3.58.2.17 *Bends*

- No more than four (4) quarter bends

Wiring Methods

IIEE – Cebu Chapter

PEC Article 3.92 ***Cable Trays***

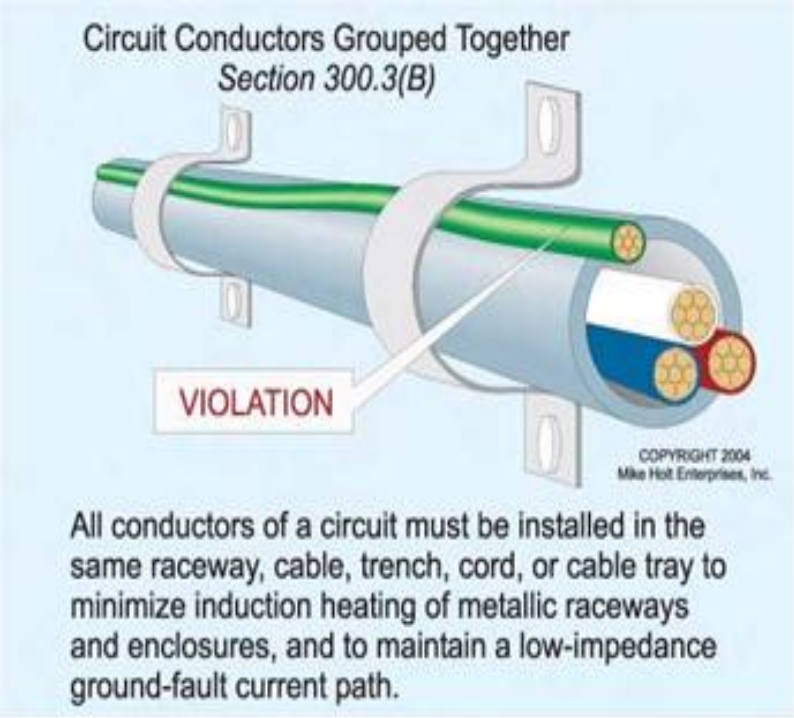
PEC Section 3.92.1.3(b)(1) @page 525.

- Single-conductor cable shall be 50mm² or larger shall be "type CT" for cable tray use.
- The maximum allowable rung spacing for the ladder-type cable tray shall be 230 mm.

3.) Common Wiring Methods using conduits

PEC Section 3.0.1.3 (b)
Conductors of the Same Circuit @page 306

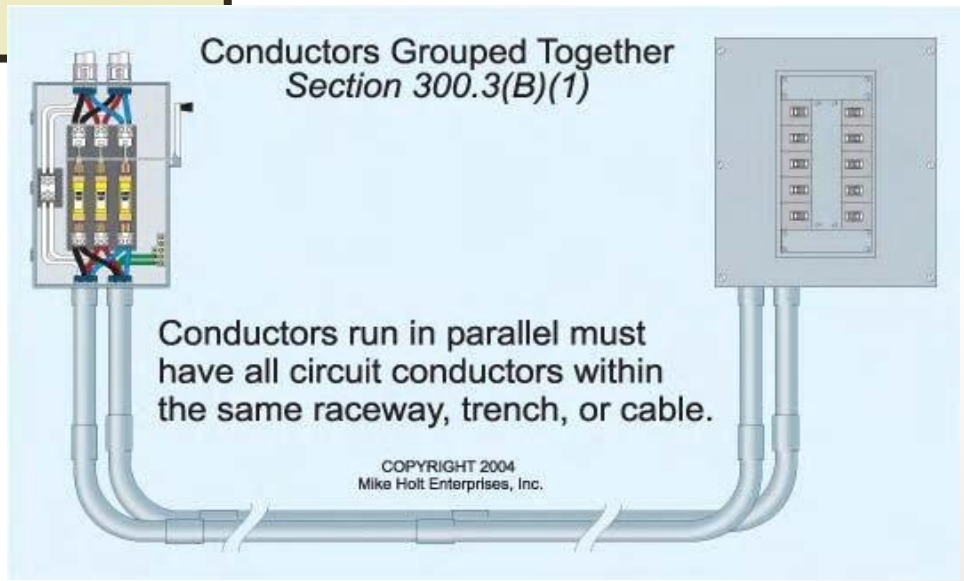
All conductors of the same circuit and, where used, the grounded conductor and all equipment grounding conductors and bonding conductors shall be contained within the same raceway, auxiliary gutter, cable tray, cable bus assembly, trench, cable, or cord, unless otherwise permitted in accordance with 3.0.1.3(b)(10 through (b)(4).



Wiring Methods

IIEE – Cebu Chapter

(1)Paralleled Installations.
Conductors can be run in parallel, in accordance with *PEC 3.10.1.4 @page 333*, and must have all circuit conductors within the same raceway, auxiliary gutter, cable tray, trench, or cable.



Wiring Methods

IIEE – Cebu Chapter

PEC Section 3.10.1.4 Conductors in Parallel

Aluminum, copper-clad aluminum, or copper conductors of size 50 mm^2 and larger

The parallel conductors in each phase, polarity, neutral, or grounded circuit conductors shall comply with all of the following:

(1) Be the same length

(2) Have the same conductor material

(3) Be the same cross sectional area of the conducting material

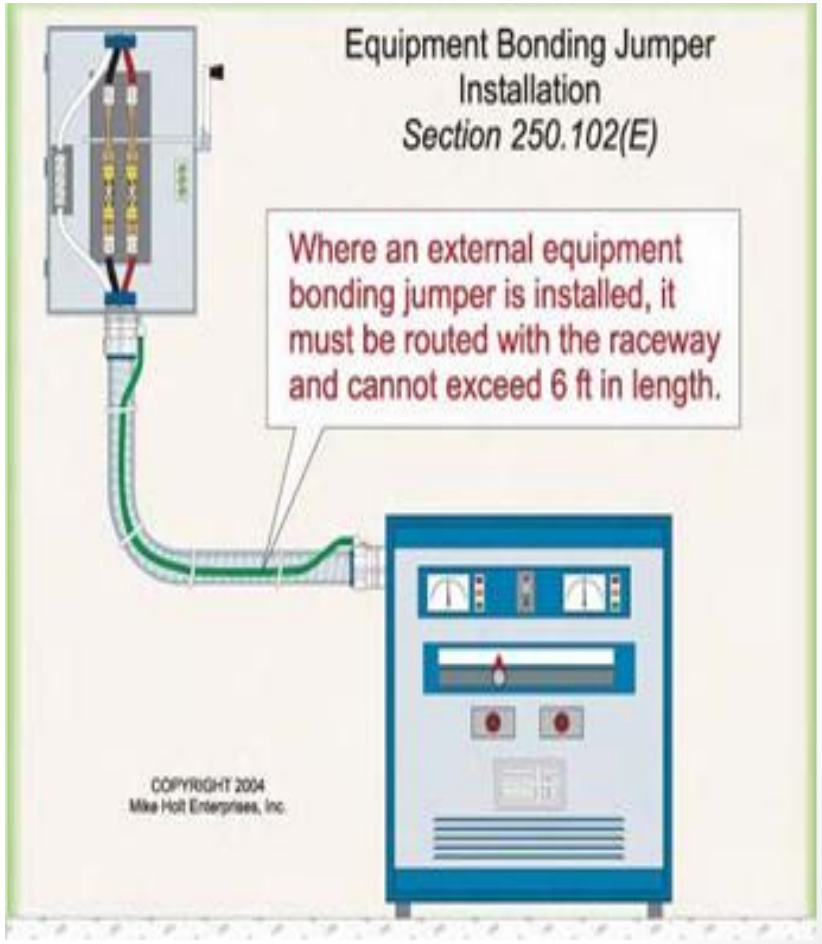
(4) Have the same insulation type

(5) Be terminated in the same manner

Wiring Methods

IIEE – Cebu Chapter

(2) Grounding and Bonding Conductors. Equipment grounding (bonding) conductors can be installed outside a raceway or cable assembly for certain existing installations. See 250.7.1(C). Equipment grounding (bonding) jumpers can be located outside a flexible raceway if the bonding jumper is installed in accordance with 250.5.3(E).



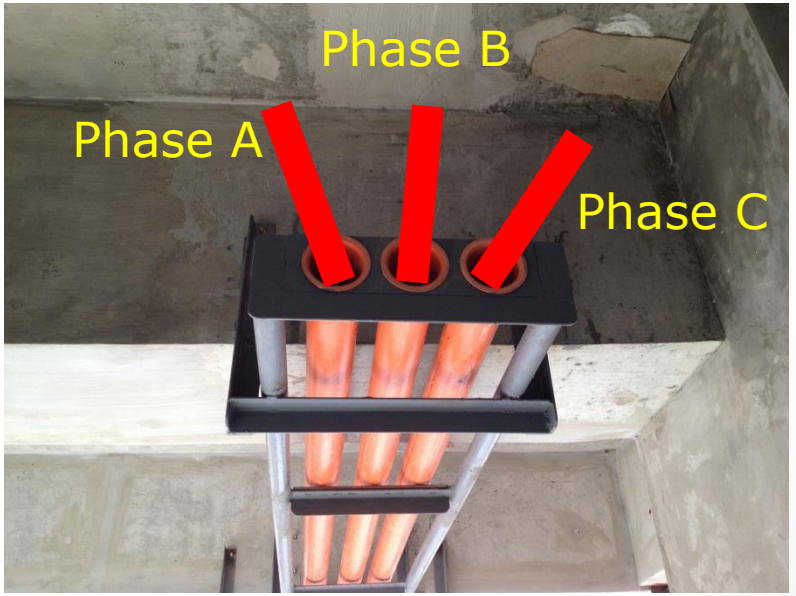
Wiring Methods

IIEE – Cebu Chapter

PEC Section 3.0.1.3(b)(1) @page 306

Nonferrous Wiring Methods.

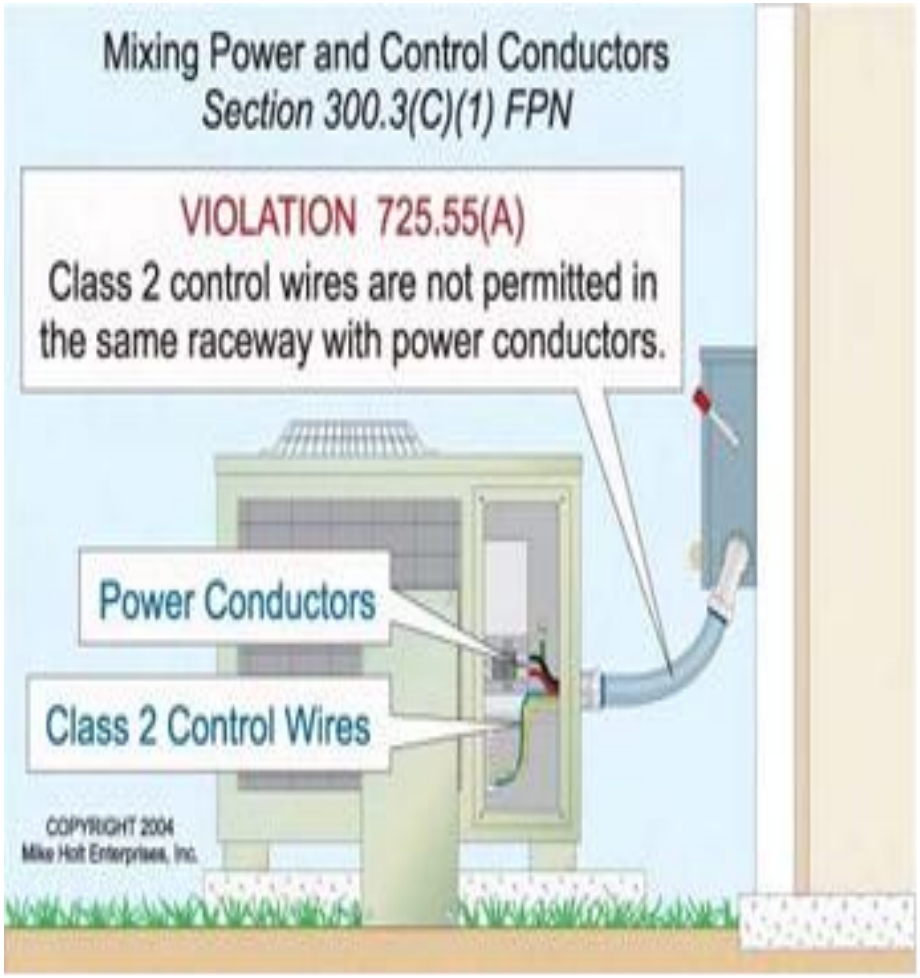
Circuit conductors can be run in different raceways (Phase A in raceway 1, Phase B in raceway 2, etc.) if, in order to reduce or eliminate inductive heating, *the raceway is nonmetallic or nonmagnetic* and the installation complies with 3.0.1.20(b).



Wiring Methods

IIEE – Cebu Chapter

(C) Conductors of Different Systems.

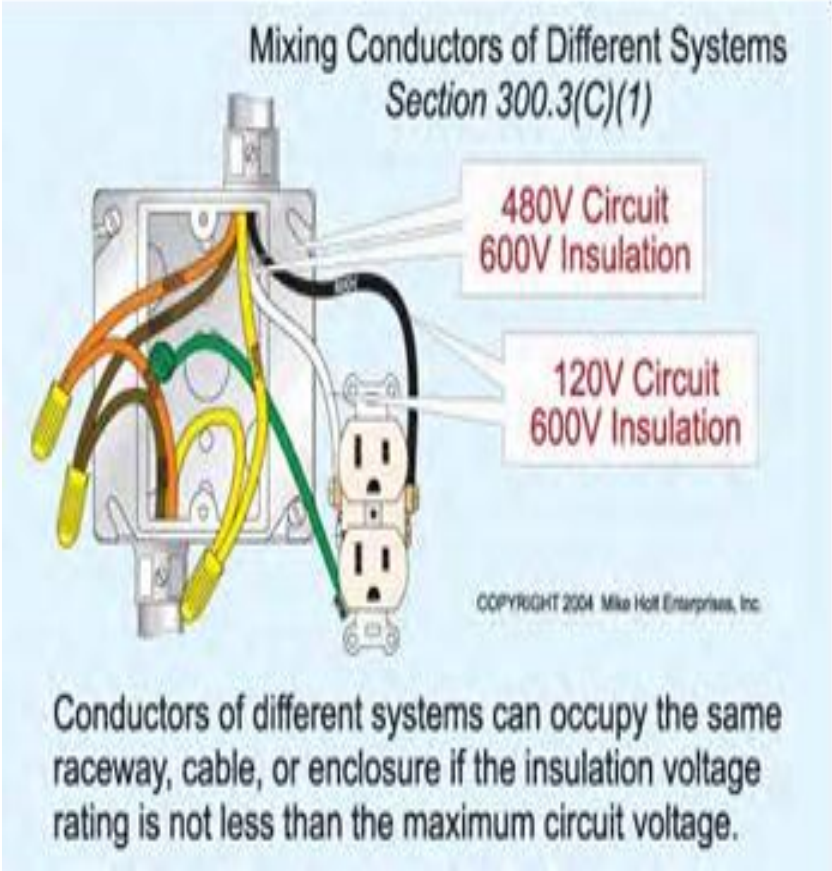


Wiring Methods

IIEE – Cebu Chapter

(1) Mixing.

Power conductors of different systems can occupy the same raceway, cable, or enclosure *if all conductors have an insulation voltage rating* not less than the maximum circuit voltage.

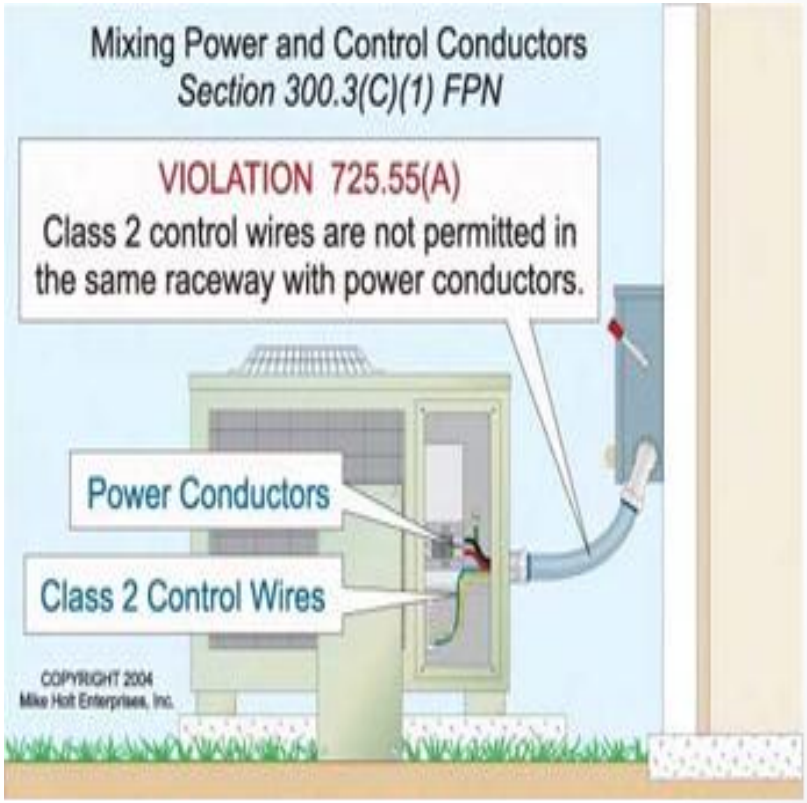


Wiring Methods

IIEE – Cebu Chapter

Control, signal, and communications wiring must be separated from power and lighting circuits so the higher-voltage conductors do not accidentally energize them. The following *Code* sections prohibit the mixing of signaling and communications conductors with power conductors:

- CATV Coaxial Cable,
- Class 1, Class 2, and Class 3 Control Circuits.



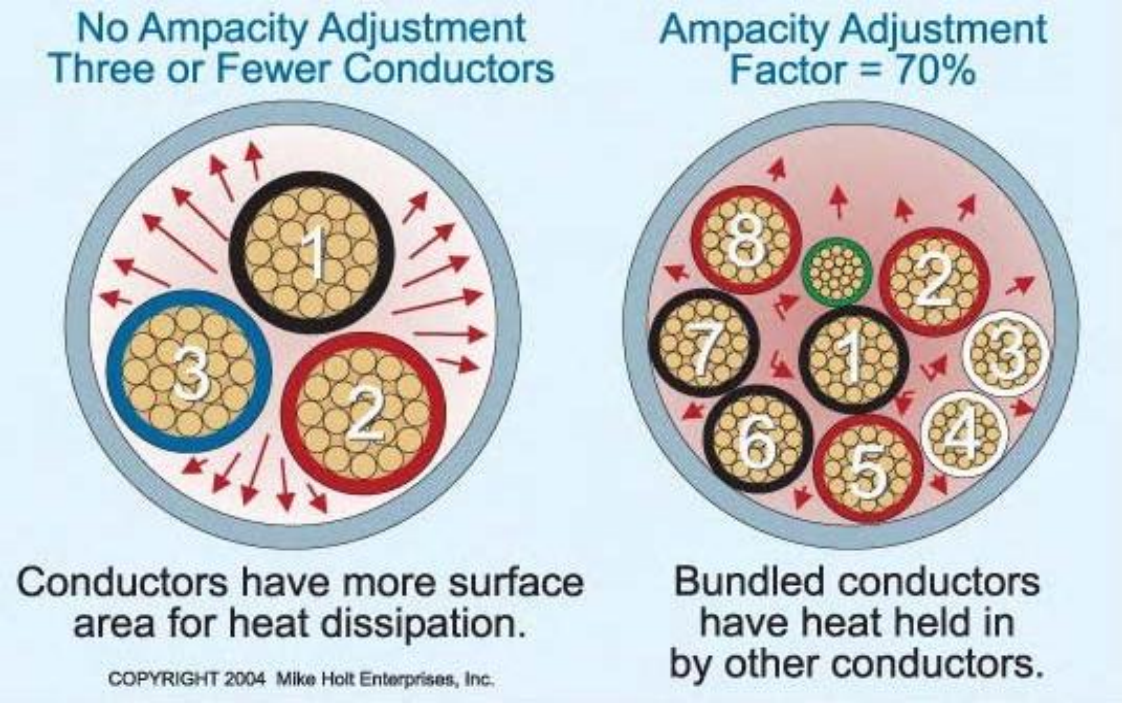
4.) Derating of wires/cables in a conduit fill

- When circuits are bundled or combined in a single conduit such that more than three current-carrying conductors are involved, the derating factors to ampacity tables shall apply, often resulting in reduced ampacities.
- The overall ampacity of the insulated conductors in a bundle of more than three (3) must be derated, whether in a raceway or cable.

Wiring Methods

IIEE – Cebu Chapter

Table 3.10.1.15(b)(2)a Adjustment Factor for More Than Three Current-Carrying Conductors in a Raceway or Cable



Wiring Methods

IIEE – Cebu Chapter

Table 3.10.1.15(b)(2)(a) Adjustment Factors for More Than Three Current-Carrying Conductors in a Raceway or Cable

Number of Current-Carrying Conductors	Percent of Values in Tables 3.10.1.16 through 3.10.1.19 as Adjusted for Ambient Temperature if Necessary
4–6	80
7–9	70
10–20	50
21–30	45
31–40	40
41 and above	35

Wiring Methods

IIEE – Cebu Chapter

Case #1: What is the adjusted ampacity value of 250mm² THW copper cable if the raceway contains four current-carrying conductors?

(a) 300A (b) 296A (c) 229A (d) 240A

Answer: ***(a) 300A***

250mm² Cu. THW = 375A (PEC Table 3.10.1.16)
Adjustment factor = 0.80 (PEC Table 3.10.15(b)(2)(a))
Adjusted Ampacity = 375A x 0.80 = ***300A***

Wiring Methods

IIEE – Cebu Chapter

Case #2: What is the adjusted ampacity value of 250mm² THW copper cable if the raceway contains four current-carrying conductors? and is installed in an ambient temperature of 37°C?

(a) 300A (b) 264A (c) 229A (d) 240A

Answer: ***(b) 264A***

250mm² Cu. THW = 375A
(@75°C column from PEC Table 3.10.1.16)
Conduit fill adjustment factor = 0.80
(PEC Table 3.10.15(b)(2)(a))
Temperature Correction factor = 0.88
(@ 75°C coulumn from PEC Table 3.10.1.16)
Adjusted Ampacity = 375A x 0.80 x 0.88 = ***264A***

Common Wiring Methods

IIEE – Cebu Chapter

Table 3.10.1.16 Allowable Ampacities of Insulated Conductors Rated 0 Through 2000 Volts, 60°C Through 90°C (140°F Through 194°F), Not More Than Three Current-Carrying Conductors in Raceway, Cable, or Earth (Directly Buried), Based on Ambient Temperature of 30°C (86°F)

Size mm²(mm dia.)	Temperature Rating of Conductor (See Table 3.10.1.13.)						Size mm²(mm dia.)
	60°C (140°F)	75°C (167°F)	90°C (194°F)	60°C (140°F)	75°C (167°F)	90°C (194°F)	
	Types TW, UF	Types RHW, THHW, THW, THWN, XHHW, USE, ZW	Types TBS, SA, SIS, FEP, FEPB, MI, RHH, RHW-2, THHN, THHW, THW-2, THWN-2, USE-2, XHH, XHHW, XHHW-2, ZW-2	Types TW, UF	Types RHW, THHW, THW, THWN, XHHW, USE, ZW	Types TBS, SA, SIS, FEP, FEPB, MI, RHH, RHW-2, THHN, THHW, THW-2, THWN-2, USE-2, XHH, XHHW, XHHW-2, ZW-2	
	COPPER			ALUMINUM OR COPPER-CLAD ALUMINUM			
2.0(1.6)*	20	20	25	—	—	—	2.0(1.6)*
3.5(2.0)*	25	25	30	20	20	25	3.5(2.0)*
5.5(2.6)*	30	35	40	25	30	35	5.5(2.6)*
8.0(3.2)	40	50	55	30	40	45	8.0(3.2)
14	55	65	70	40	50	60	14
22	70	85	90	55	65	80	22
30	90	110	115	65	80	90	30
38	100	125	130	75	90	105	38
50	120	145	150	95	110	125	50
60	135	160	170	100	120	135	60
80	160	195	205	120	145	165	80
100	185	220	225	140	170	190	100
125	210	255	265	165	200	225	125
150	240	280	295	185	225	250	150
175	260	305	345	205	245	275	175
200	280	330	355	220	265	300	200
250	315	375	400	255	305	345	250

5.) Sizing of Conduit

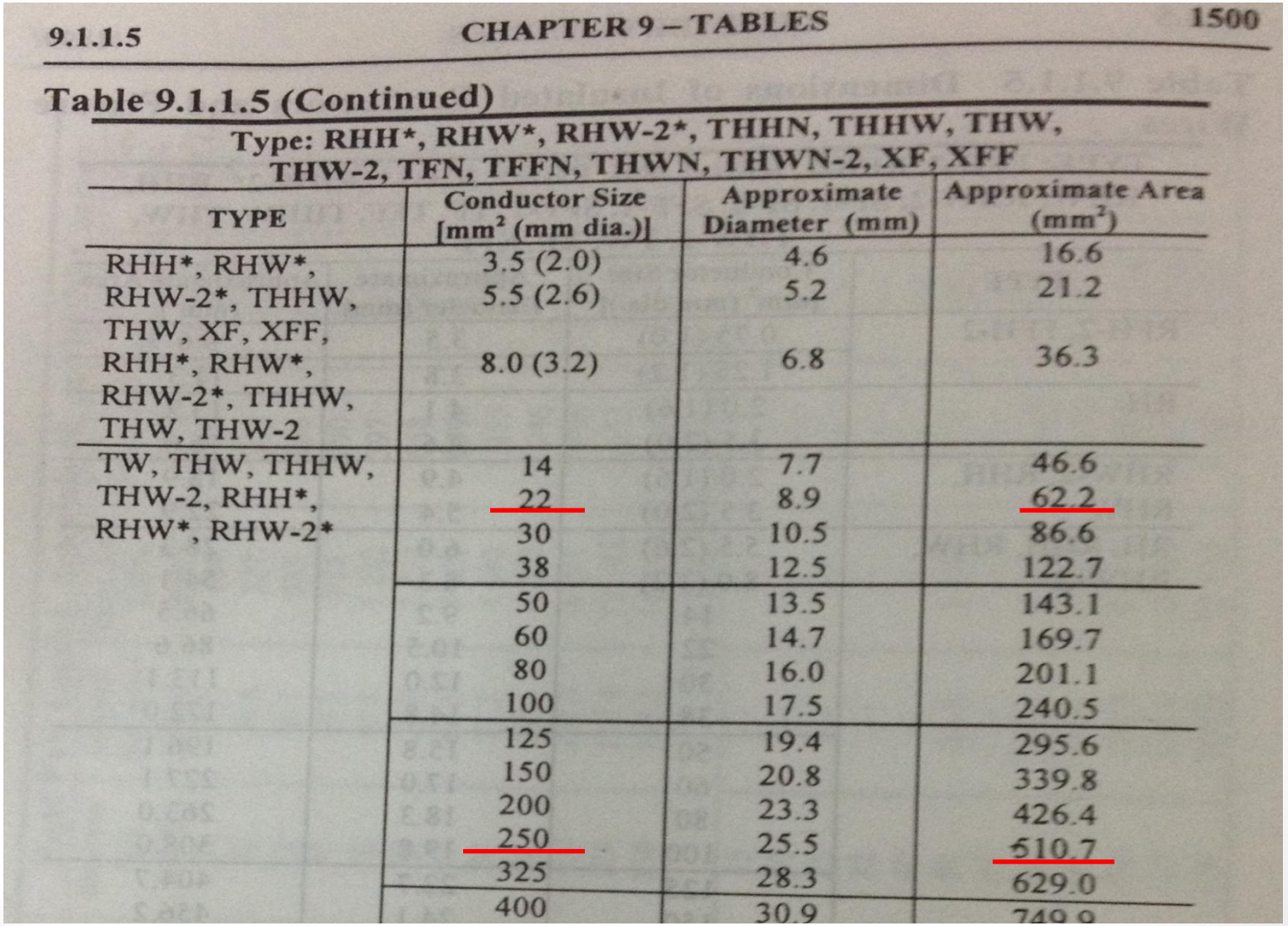
Question: What size of RMC conduit is recommended to accommodate 4 x 250mm² Cu. THW Cable + 1 x 22mm² Cu. THW Wire as Equipment Grounding.

(a) 80mmØ (b) 90mmØ (c) 100mmØ (d) 110mmØ

Answer: ***(b) 90mmØ***

Common Wiring Methods

IIEE – Cebu Chapter



9.1.1.5 CHAPTER 9 – TABLES 1500

Table 9.1.1.5 (Continued)

Type: RHH*, RHW*, RHW-2*, THHN, THHW, THW, THW-2, TFN, TFFN, THWN, THWN-2, XF, XFF

TYPE	Conductor Size [mm² (mm dia.)]	Approximate Diameter (mm)	Approximate Area (mm²)
RHH*, RHW*, RHW-2*, THHW, THW, XF, XFF, RHH*, RHW*, RHW-2*, THHW, THW, THW-2	3.5 (2.0)	4.6	16.6
	5.5 (2.6)	5.2	21.2
	8.0 (3.2)	6.8	36.3
TW, THW, THHW, THW-2, RHH*, RHW*, RHW-2*	14	7.7	46.6
	22	8.9	62.2
	30	10.5	86.6
	38	12.5	122.7
	50	13.5	143.1
	60	14.7	169.7
	80	16.0	201.1
	100	17.5	240.5
	125	19.4	295.6
	150	20.8	339.8
	200	23.3	426.4
	250	25.5	510.7
	325	28.3	629.0
	400	30.9	749.9

Common Wiring Methods

IIEE – Cebu Chapter

From PEC 2009, Table 9.1.1.5 @page 1500

250mm² THW (4 x 510.7 mm²)	=	*2,042.80 mm²*
22mm² THW (1 x 62.20 mm²)	=	*62.20 mm²*
Total Area		*2,105.00 mm²*

From PEC 2009, Table 9.1.1.4 @page 1496
Rigid Metal Conduit, Schedule 40
Over 2 wires, 40% (mm²) column
Maximum Conduit Fill Area = 2,584.00 mm²
Minimum Use: ***90 mm Ø, Schedule 40, RMC***

Common Wiring Methods

IIEE – Cebu Chapter

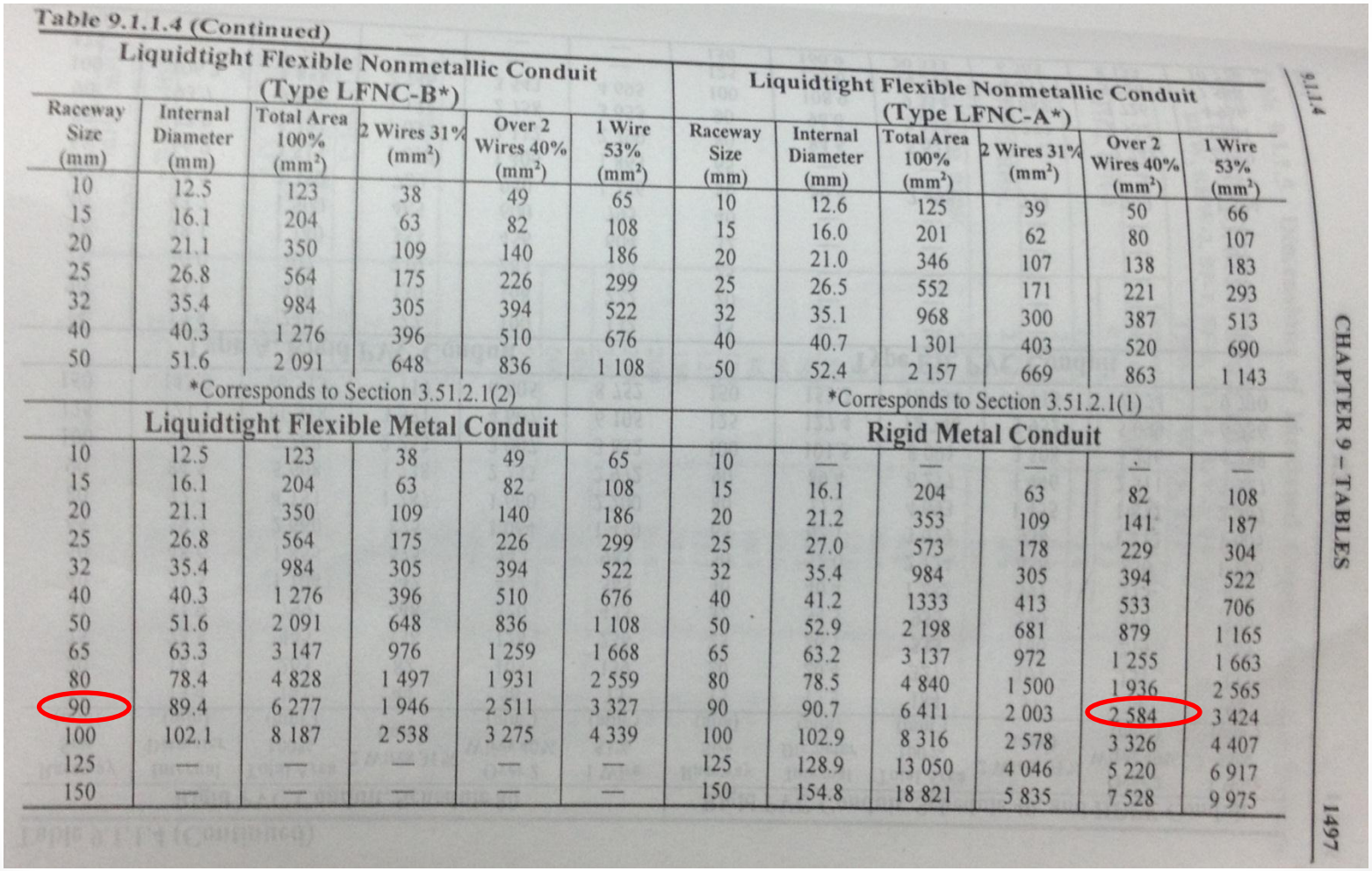


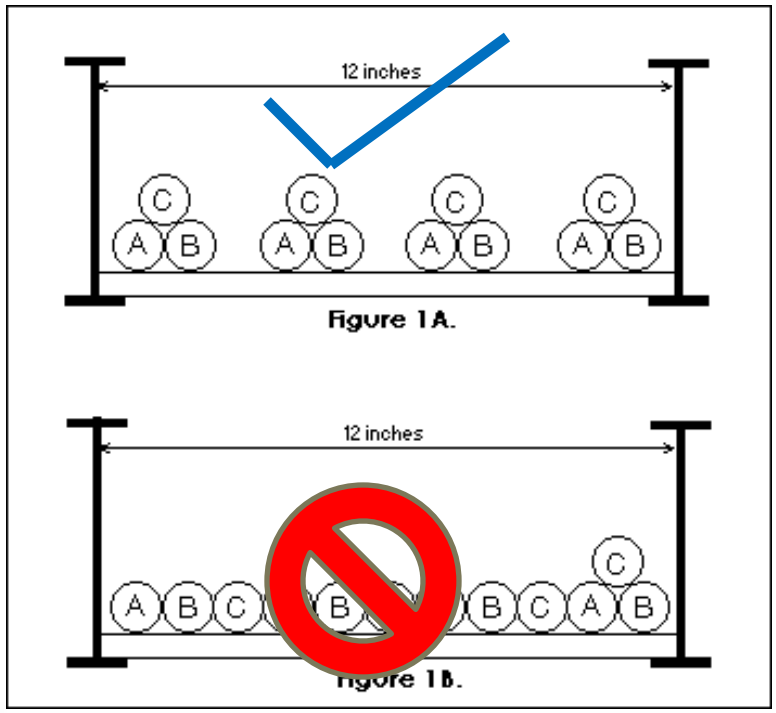
Table 9.1.1.4 (Continued)

Liquidtight Flexible Nonmetallic Conduit (Type LFNC-B*)						Liquidtight Flexible Nonmetallic Conduit (Type LFNC-A*)					
Raceway Size (mm)	Internal Diameter (mm)	Total Area 100% (mm^2)	2 Wires 31% (mm^2)	Over 2 Wires 40% (mm^2)	1 Wire 53% (mm^2)	Raceway Size (mm)	Internal Diameter (mm)	Total Area 100% (mm^2)	2 Wires 31% (mm^2)	Over 2 Wires 40% (mm^2)	1 Wire 53% (mm^2)
10	12.5	123	38	49	65	10	12.6	125	39	50	66
15	16.1	204	63	82	108	15	16.0	201	62	80	107
20	21.1	350	109	140	186	20	21.0	346	107	138	183
25	26.8	564	175	226	299	25	26.5	552	171	221	293
32	35.4	984	305	394	522	32	35.1	968	300	387	513
40	40.3	1 276	396	510	676	40	40.7	1 301	403	520	690
50	51.6	2 091	648	836	1 108	50	52.4	2 157	669	863	1 143
*Corresponds to Section 3.51.2.1(2)						*Corresponds to Section 3.51.2.1(1)					
Liquidtight Flexible Metal Conduit						Rigid Metal Conduit					
10	12.5	123	38	49	65	10	—	—	—	—	—
15	16.1	204	63	82	108	15	16.1	204	63	82	108
20	21.1	350	109	140	186	20	21.2	353	109	141	187
25	26.8	564	175	226	299	25	27.0	573	178	229	304
32	35.4	984	305	394	522	32	35.4	984	305	394	522
40	40.3	1 276	396	510	676	40	41.2	1333	413	533	706
50	51.6	2 091	648	836	1 108	50	52.9	2 198	681	879	1 165
65	63.3	3 147	976	1 259	1 668	65	63.2	3 137	972	1 255	1 663
80	78.4	4 828	1 497	1 931	2 559	80	78.5	4 840	1 500	1 936	2 565
90	89.4	6 277	1 946	2 511	3 327	90	90.7	6 411	2 003	2 584	3 424
100	102.1	8 187	2 538	3 275	4 339	100	102.9	8 316	2 578	3 326	4 407
125	—	—	—	—	—	125	128.9	13 050	4 046	5 220	6 917
150	—	—	—	—	—	150	154.8	18 821	5 835	7 528	9 975

Common Wiring Methods

IIEE – Cebu Chapter

6.) Wiring Method using Cable Trays (PEC Article 3.92)



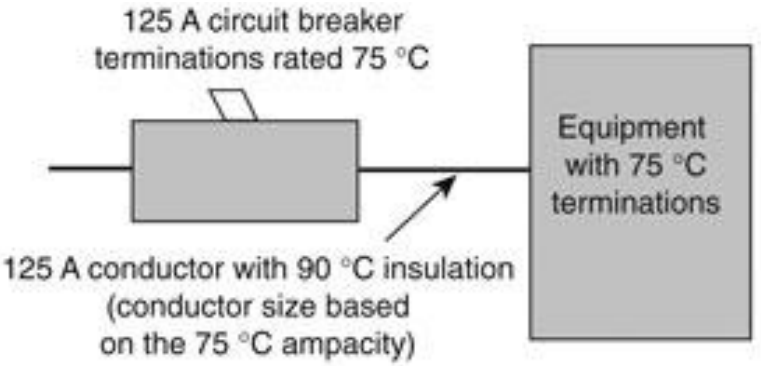
PEC Section 3.92.1.8(d) ***Cable Installation*** @page 531

- Conductors of the same circuit including the neutral and equipment grounding *shall be installed in a group to prevent current imbalance in the paralleled conductors due to inductive reactance.*

8.) *Electrical Connections* (PEC Article 1.10.1.14)

PEC Section 1.10.1.14(c)
Temperature Limitations
@page 40

Temperature rating associated with ampacity of conductor shall be selected and coordinated so as not to exceed the lowest temperature rating of any connected termination, conductor, or device.



Common Wiring Methods

IIEE – Cebu Chapter

(1) Equipment Provisions.
Unless the equipment is listed and marked otherwise, conductor sizing for equipment termination must be based on Table 310.1.16 in accordance with (a) or (b):

(a) Equipment Rated 100A and Less.

(a) Conductor sizing for equipment rated 100A or less, or marked for 2.0mm² through 38mm² conductors must be sized using the 60°C temperature column of Table 3.10.16. Figure 110–27

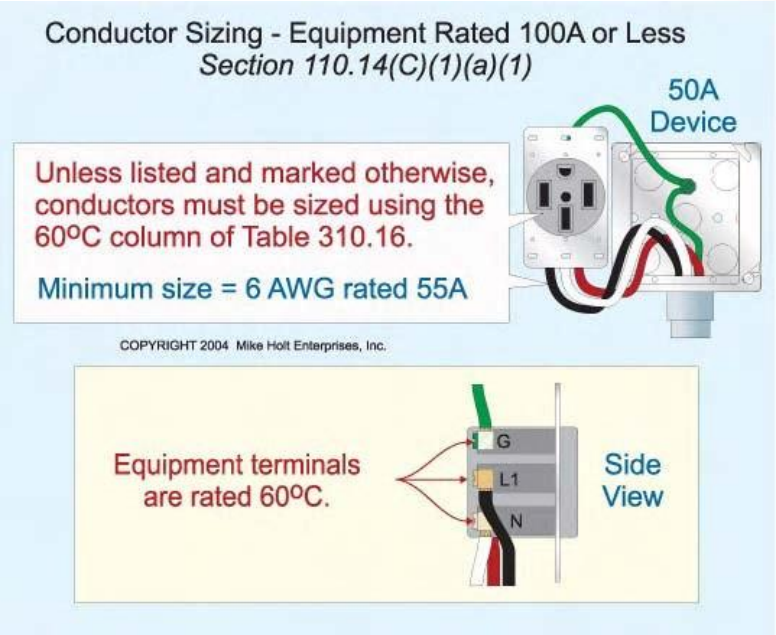
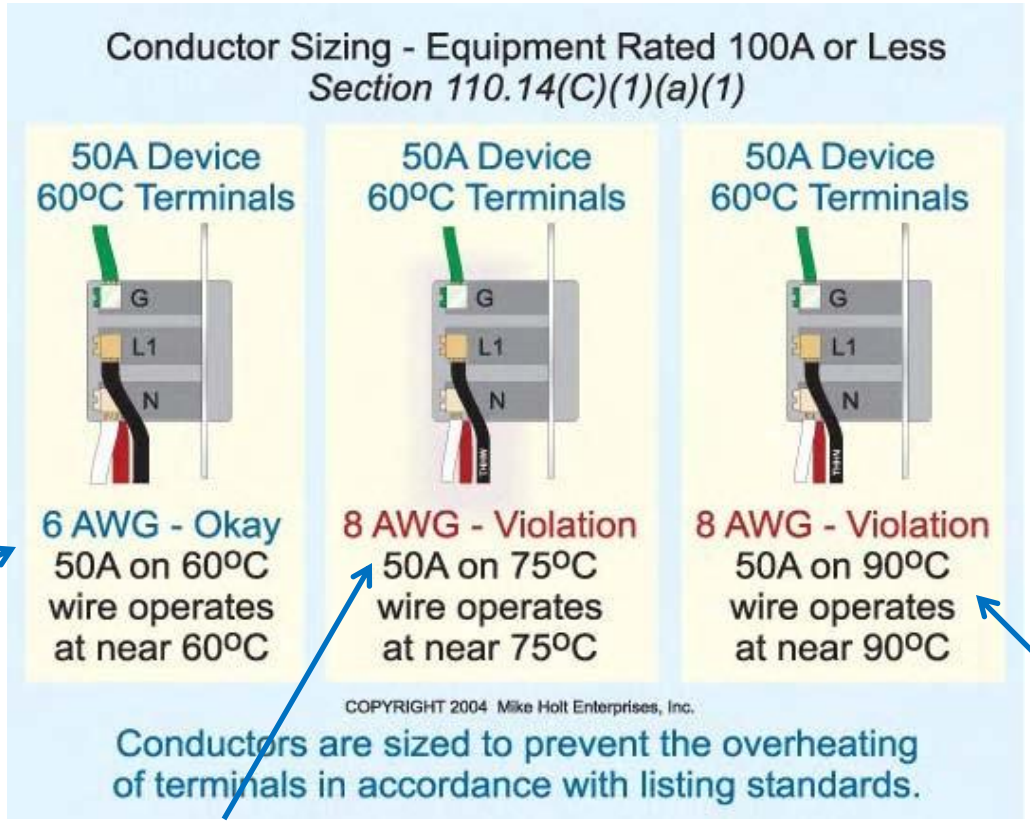


Figure 110–27

Common Wiring Methods

IIEE – Cebu Chapter



14mm² (55 A) @60°C column

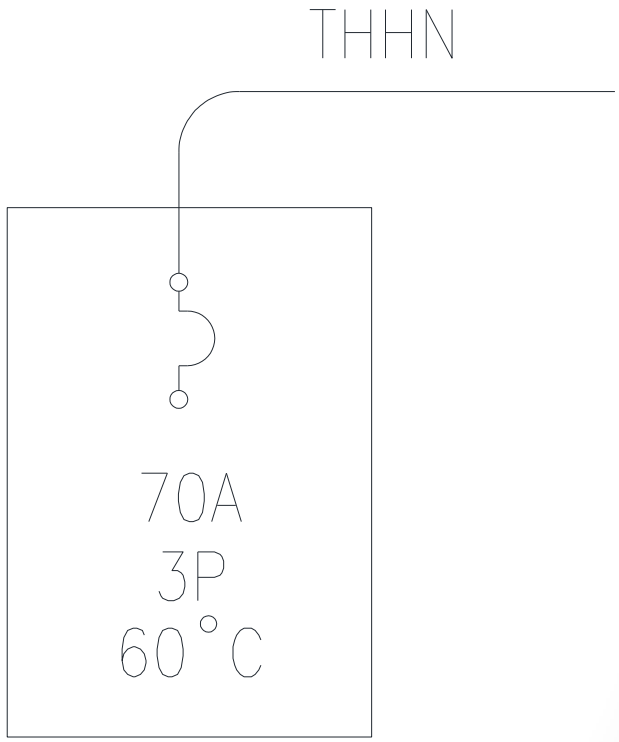
8mm² (50 A) @75°C column

8mm² (55 A) @90°C column

Common Wiring Methods

IIEE – Cebu Chapter

Question: What size of incoming feeder is recommended to be used with a THHN specification?



Answer:

22mm² THHN Wire based at 60°C column

(from PEC Table 3.10.1.16 @page 350)

Common Wiring Methods

IIEE – Cebu Chapter

Table 3.10.1.16 Allowable Ampacities of Insulated Conductors Rated 0 Through 2000 Volts, 60°C Through 90°C (140°F Through 194°F), Not More Than Three Current-Carrying Conductors in Raceway, Cable, or Earth (Directly Buried), Based on Ambient Temperature of 30°C (86°F)

	Temperature Rating of Conductor (See Table 3.10.1.13.)						
	60°C (140°F)	75°C (167°F)	90°C (194°F)	60°C (140°F)	75°C (167°F)	90°C (194°F)	
Size mm²(mm dia.)	Types TW, UF	Types RHW, THHW, THW, THWN, XHHW, USE, ZW	Types TBS, SA, SIS, FEP, FEPB, MI, RHH, RHW-2, THHN, THHW, THW-2, THWN-2, USE-2, XHH, XHHW, XHHW-2, ZW-2	Types TW, UF	Types RHW, THHW, THW, THWN, XHHW, USE, ZW	Types TBS, SA, SIS, FEP, FEPB, MI, RHH, RHW-2, THHN, THHW, THW-2, THWN-2, USE-2, XHH, XHHW, XHHW-2, ZW-2	Size mm²(mm dia.)
	COPPER			ALUMINUM OR COPPER-CLAD ALUMINUM			
2.0(1.6)*	20	20	25	—	—	—	2.0(1.6)*
3.5(2.0)*	25	25	30	20	20	25	3.5(2.0)*
5.5(2.6)*	30	35	40	25	30	35	5.5(2.6)*
8.0(3.2)	40	50	55	30	40	45	8.0(3.2)
14	55	65	70	40	50	60	14
22	70	85	90	55	65	80	22
30	90	110	115	65	80	90	30
38	100	125	130	75	90	105	38
50	120	145	150	95	110	125	50
60	135	160	170	100	120	135	60
80	160	195	205	120	145	165	80
100	185	220	225	140	170	190	100
125	210	255	265	165	200	225	125
150	240	280	295	185	225	250	150
175	260	305	345	205	245	275	175
200	280	330	355	220	265	300	200
250	315	375	400	255	305	345	250

Common Wiring Methods

IIEE – Cebu Chapter

- Partial Ending of Presentation -