Box Fill

We have learned how to fill … or NOT overfill …a conduit.

We must also determine how to fill **boxes** and **conduit bodies**.

Box Fill

This falls into four categories:

1. Small box fill (NEC 314.16)
2. Small Conduit Body fill (NEC 314.16)
3. Large box fill (NEC 314.28)
4. Large conduit body fill (314.28)

Box Fill

This means we will heavily rely on two sections of Article 314.

You need to commit this two sections to memory.

314.16

- Small Box Fill
- Small Conduit Body Fill

314.28

- Large Box Fill
- Large Conduit Body Fill

Box Fill

Whether you are doing large or small fill is determined by the size of the conductors in the box or conduit body.

See 314.16.

314.16 for #6 AWG and smaller

- Small Box Fill
- Small Conduit Body Fill

314.28 for #4 AWG and larger

- Large Box Fill
- Large Conduit Body Fill

Box Fill

Once you understand the difference between …

Small (#6 AWG or smaller)

Large (#4 AWG and larger)

…then you need to understand all the types of boxes and conduit bodies and where they are referenced in 314.

Box Fill

Once you understand the difference between …

Small (#6 AWG or smaller)

Large (#4 AWG and larger)

…then you need to understand all the types of boxes and conduit bodies and where they are referenced in 314.

Box Fill

Small Boxes:

- Most standard metal boxes are NOT stamped with their maximum volume so refer to Table 314.16(A) Metal Boxes
- Plastic boxes are stamped with maximum volume.
  See 314.16(A)(2)
- Bell boxes are metal but not included in Table 314.16(A) – Metal Boxes
  Like plastic boxes, Bell boxes are stamped with their max volumes.

Box Fill

Small Boxes:

- The available volume for a box is from Table 314.16(A) Metal Boxes or the box is stamped with the maximum volume.

- To determine the volume of the wire and devices going into the box you must apply the FIVE RULES in 314.16(B)(1)-(5) and the volume allowances in Table 314.16(B) – Volume Allowance Required per Conductor.

Box Fill

Small Boxes:

- For example, suppose you have two duplex receptacles with two separate circuits of #12 THHN (hot/neut/grd, hot/neut/grd) and you want to put them in a 4-square metal box 1-1/4” deep. Will these devices and wire fit?

Box Fill

Small Boxes:

For example, suppose you have two duplex receptacles with <u>two separate circuits</u> of #12 THHN (hot/neut/grd, hot/neut/grd) and you want to put them in a 4-square metal box 1-1/4” deep. Will these devices and wire fit?

The maximum box volume for a 4x4x1-1/4 box is found in 314.16(A) and is 18 cu in.

Now to determine the volume of what I need to put in the box I must apply the FIVE RULES in 314.16(B)(1)-(5) and the volume allowance table – Table 314.16(B).

Conductors (non-ground) covered in 314.16(B)(1).
Hot/Neut plus another Hot/Neut = 4-#12 AWG conductors x 2.25 in. cu. = 4.5 in. cu.

Ground conductors covered by 314.16(B)(5): 1-#12 AWG conductor x 2.25 in cu = 2.25 in. cu.

The two receptacles are covered by 314.16(B)(4). 2 recepts x double volume allowance = 2 x 2 x 2.25” = 9 cu. in.

4.5 cu. in. + 2.25 cu. in + 9 cu. in = 15.75 cu. in. This will fit in the box with 18 cu. in.

Box Fill

Small Boxes:

For example, suppose you have two duplex receptacles with <u>two separate circuits</u> of #12 THHN (hot/neut/grd, hot/neut/grd) and you want to put them in a 4-square metal box 1-1/4” deep. Will these devices and wire fit?

KEEP IN MIND – IF BOTH OF THESE RECEPTACLES WERE THE SAME CIRCUIT AND YOU JUST JUMPED A HOT WIRE AND NEUTRAL WIRE FROM ONE RECEPTACLE TO THE OTHER, YOU WOULD NOT COUNT THE JUMPERS AS CONDUCTORS WITH VOLUME. YOU CAN EXCLUDE THE JUMPERS FROM THE CALCULATIONS.

Box Fill

Small Boxes:

Another Example:

The total volume occupied by two internal clamps, six 12 AWG conductors and one grounding conductor, and a single-pole switch is _____ cu in.

Box Fill

Small Boxes:

Another Example:

The total volume occupied by two internal clamps, six 12 AWG conductors and one grounding conductor, and a single-pole switch is _____ cu in.

Clamps: 1 x 2.25 = 2.25 cu. in.

Grounding conductor = 1 x 2.25 = 2.25 cu. in.

Conductors (non-ground): 6 x 2.25 = 13.5 cu. in.

Single pole switch: 2 x 2.25 = 4.5 cu. in.

2.25 + 2.25 + 13.5 + 4.5 = 22.5 cu. in. **Next slide shows a step-by-step with NEC referernces.**

-**two internal clamps:**

Section 314.16(B)(2) & TABLE 314.16(B) =

= 1 volume allowance x 2.25 cu. in. = 2.25 cu in

EGC:

Section 314.16(B)(5) & TABLE 314.16(B) =

= 1 volume allowance x 2.25 cu. in. = 2.25 cu in

-six 12 AWG conductors:

Section 314.16(B)(1) & TABLE 314.16(B) =

= 6 conductors x 2.25 cu. in. = 13.5 cu in

-single-pole switch:

Section 314.16(B)(4) & TABLE 314.16(B) =

= 2 (a double volume allowance x 2.25 = 4.5 cu in

Now add each part together:

2.25 + 2.25 + 13.5 + 4.5 = **22.5 cu. in.**

SMALL Box Fill – Know the FIVE RULES!

314.16(B) (1)-(5)

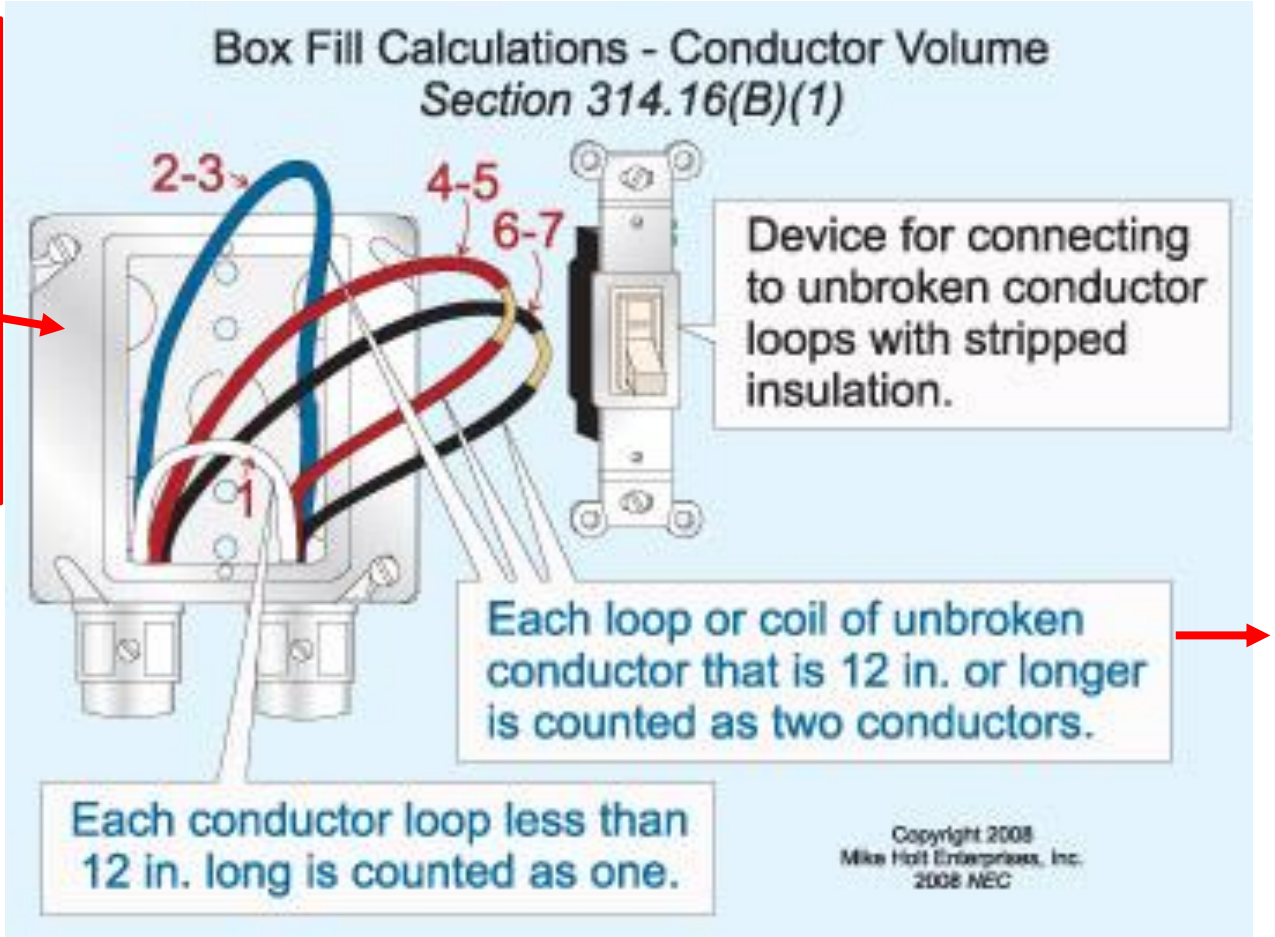
(for conductors < #4 AWG)

1. Conductor Fill
2. Clamp Fill
3. Support Fittings Fill
4. Device or Equipment Fill
5. Equipment Grounding Conductor Fill

Box Fill Graphic 1

The mud ring will have a volume stamped on it. You can add this volume to the volume of the box for the max fill.

The same is true for extension rings.

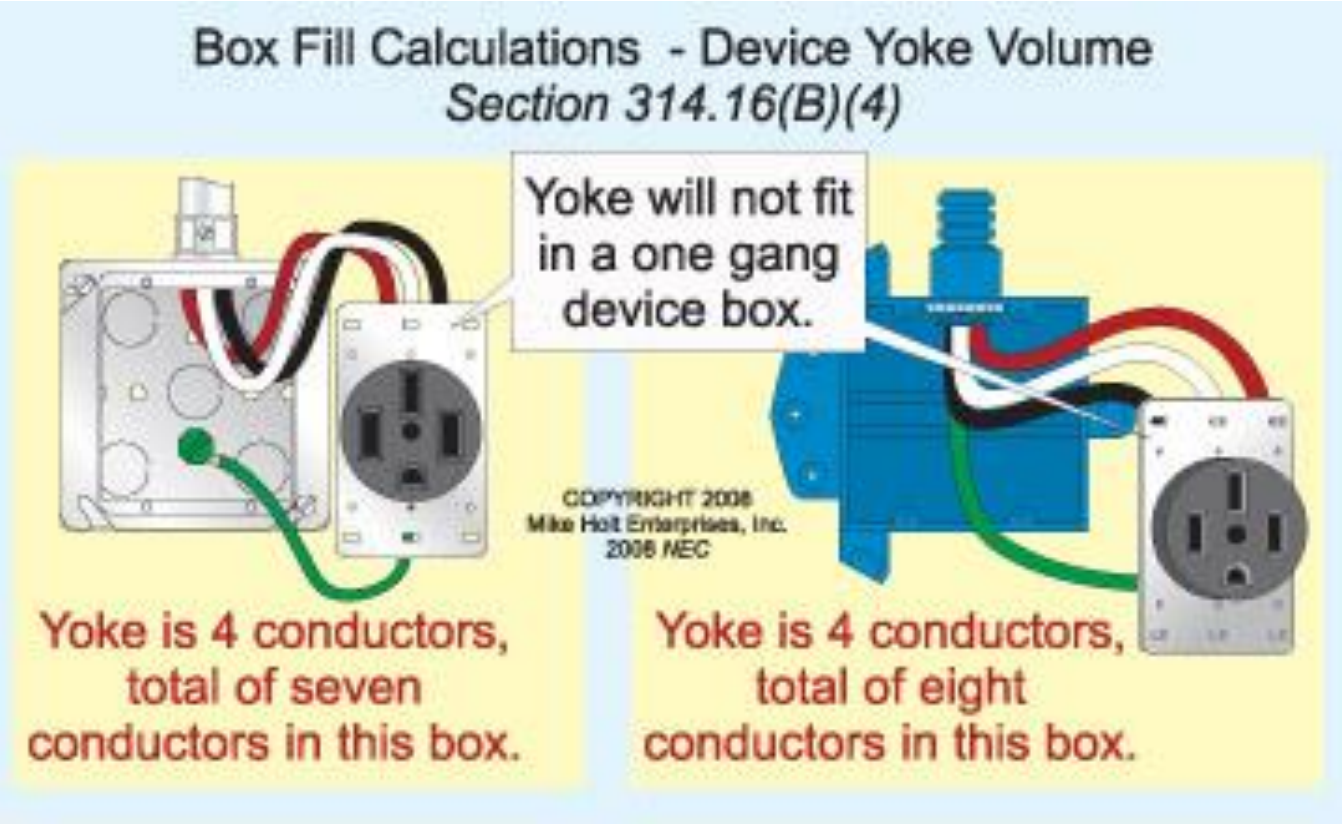


Most of the time you do NOT have loops this long, but when you do, count this long loop as two conductors.

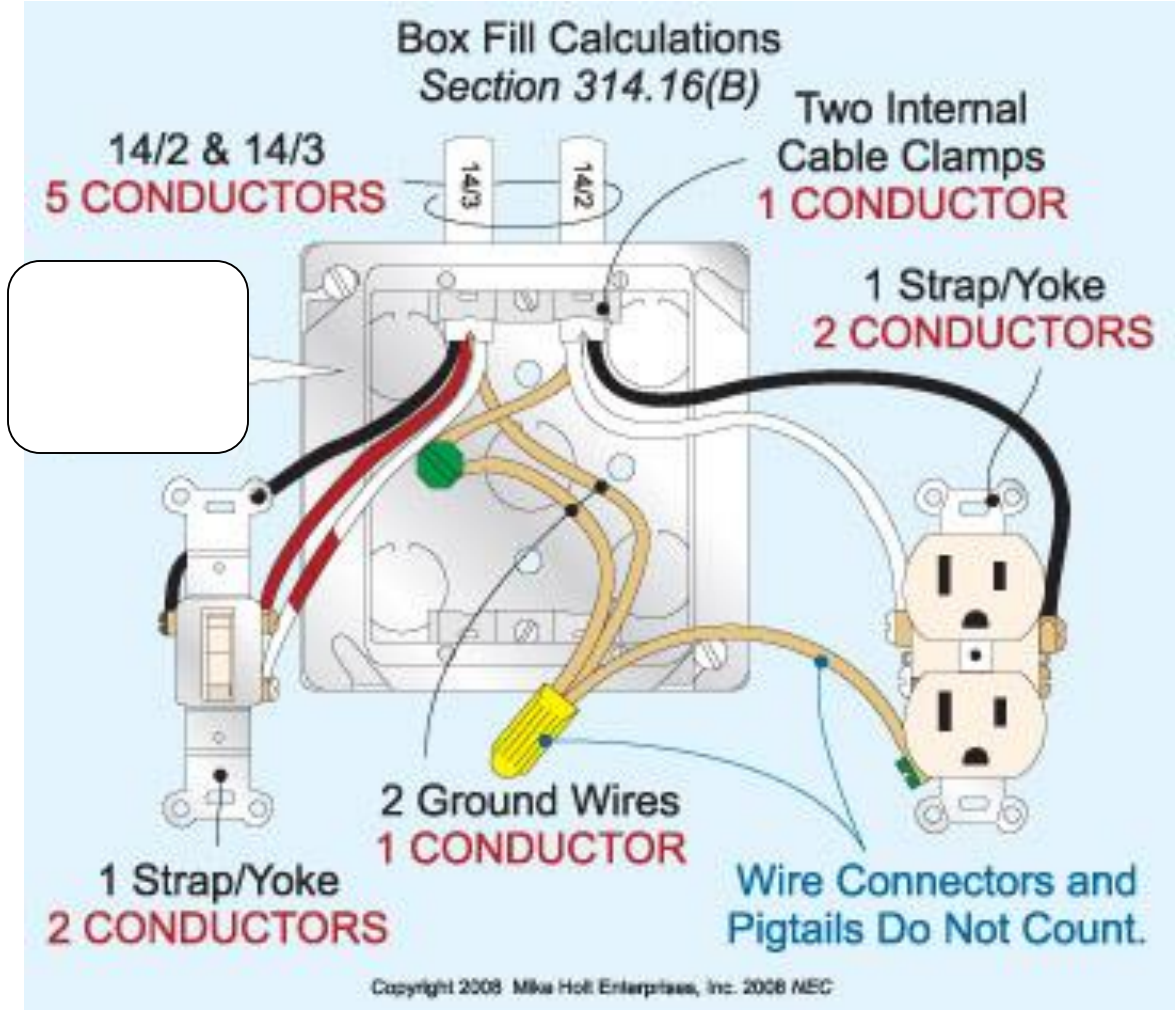
The mud ring will have a volume stamped on it. You can add this volume to the volume of the box for the max fill. See 7.5 CU.IN.

The same is true for extension rings.

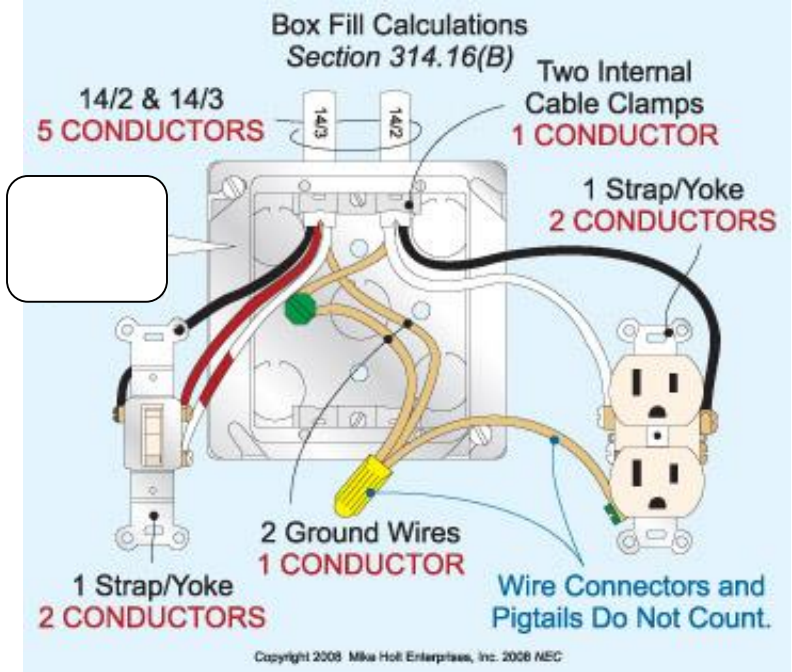
Box Fill Graphic 2



Box Fill Graphic 3



Box Fill Graphic 3



Switch and conductors: five – 14 AWG
5 x 2.00 in^3 = 10 in^3

Receptacles and conductors: four – 14 AWG
4 x 2.00 in^3 = 8 in^3

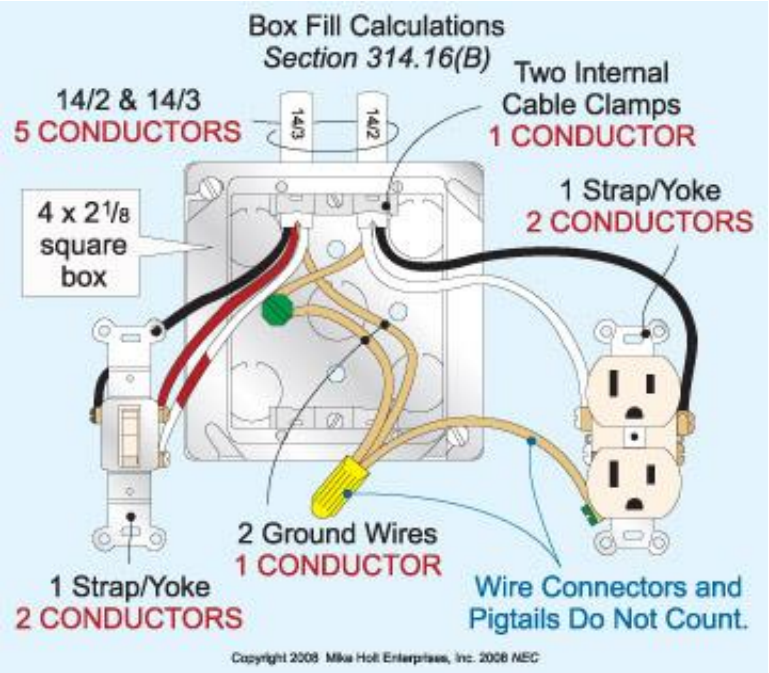
Equipt grounding conductor: one – 14 AWG
1 x 2.00 in^3 = 2 in^3

Cable Clamps: one – 14 AWG
1 x 2.00 in^3 = 2 in^3

TOTAL = 10+8+2+2 = 22 in^3

What is the minimum size box 4-square box from Table 314.16(A) for this fill?

Box Fill Graphic 3



Switch and conductors: five – 14 AWG
5 x 2.00 in^3 = 10 in^3

Receptacles and conductors: four – 14 AWG
4 x 2.00 in^3 = 8 in^3

Equipt grounding conductor: one – 14 AWG
1 x 2.00 in^3 = 2 in^3

Cable Clamps: one – 14 AWG
1 x 2.00 in^3 = 2 in^3

TOTAL = 10+8+2+2 = 22 in^3

What is the minimum size box 4-square box from Table 314.16(A) for this fill?

4 x 2-1/8

Box Fill
… another example

Determine the size (cu. in.) that you will need if you have a box that contains the following:

3—#12 / 2 Romex cables
2—#12 / 3 Romex cables
1—Single Pole Switch
1—3-way Switch
5—Romex connectors (internal clamps)
5 —Grounding conductors, one for each NM cable

Box Fill
… another example

Determine the size (cu. in.) that you will need if you have a box that contains the following:

3—#12 / 2 Romex cables
3 cables x 2 vol. allowances x 2.25 in^3 = 13.5 in^3
2—#12 / 3 Romex cables
2 cables x 3 vol. allowances x 2.25 in^3 = 13.5 in^3
1—Single Pole Switch
1 switch x 2 vol. allowances x 2.25 in^3 = 4.5 in^3
1—3-way Switch
1 switch x 2 vol. allowances x 2.25 in^3 = 4.5 in^3
5—Romex connectors (internal clamps)
1 vol. allowances x 2.25 in^3 = 2.25 in^3
Plus one equipt grounding conductor: 1 x 2.25 in^3 = 2.25 in^3
13.5 + 13.5 + 4.5 + 4.5 +2.25 + 2.25 = 40.5

Familiarize yourself with all the typical small box types so you understand what you are filling and how or where to find the maximum volume.

Remember standard metal box volumes are covered in Table 314.16(A) – Metal Boxes. They are NOT stamped in the box with their maximum volume.

Bell boxes are metal but not covered in Table 314.16(A) so their volume is stamped in the box.

Plastic boxes are stamped with their max volume.

STANDARD BOXES (follow these box types right down Table 314.16(A).

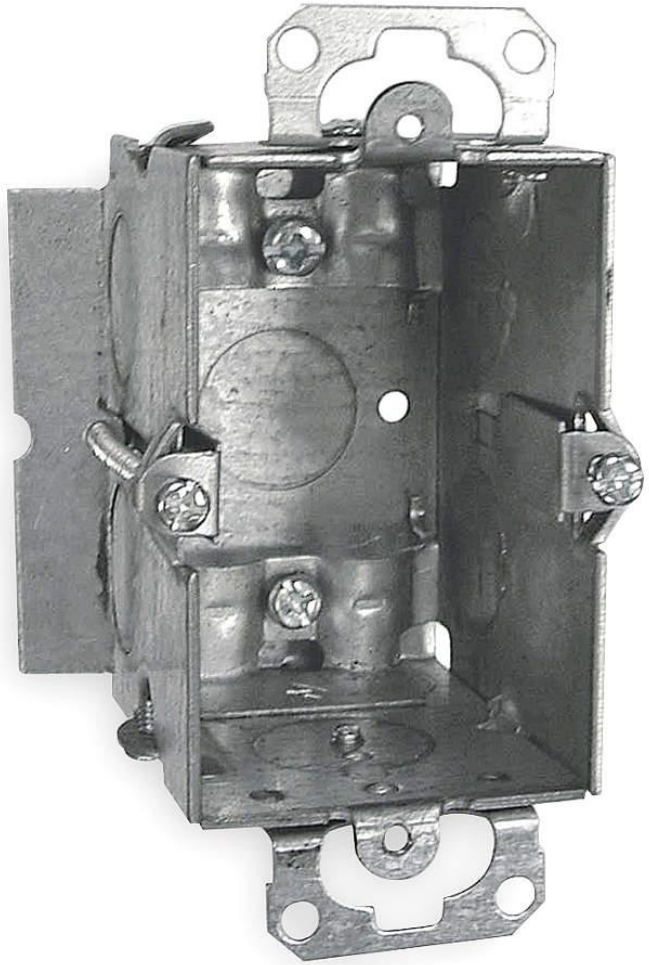
Round/Octagonal Boxes

STANDARD BOXES - 4S Boxes and 4-11 Boxes - **Square Boxes**

4” x 4” x depth

4-11/16” x 4-11/16” x depth

STANDARD BOXES - 3 x 2 Device Boxes and 4 x 2 **Device Boxes** (aka Handy Boxes)



3x2x2 with Internal Clamps.
How much volume do we need to subtract for clamps?

STANDARD BOXES - **Masonry** Boxes (aka mud boxes)

FSC`

Gangable Masonry
With a 10-32 ground
provision

STANDARD BOXES - **FS** and **FD** Boxes

Shallow
Depth

FSC

Deep
Depth

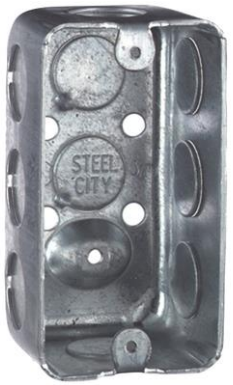
FDC

FS and FC Boxes

Cycle Back through and look at the STANDARD BOXES again.

STANDARD BOXES

1



2

3

4

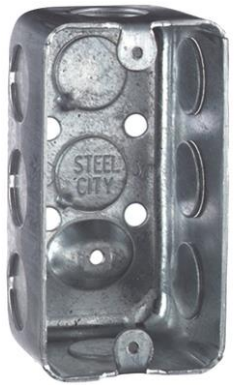
5

6

7

STANDARD BOXES

1



2

3

4

5

6

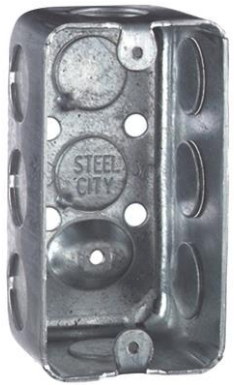
7

Octagon/Round 4 Square and 4-11 3x2 (Handy) or 4 x 2 (Handy) Masonry FS - FD

STANDARD BOXES

WHAT MATERIAL DO ALL OF THESE BOXES HAVE IN COMMON?

1



2

3

4

5

6

7

Octagon/Round 4 Square and 4-11 3x2 (Handy) or 4 x 2 (Handy) Masonry FS - FD

WHAT MATERIAL DO ALL OF THESE BOXES HAVE IN COMMON?

What do we do with Plastic boxes?

How do we determine their volume?

WHAT MATERIAL DO ALL OF THESE BOXES HAVE IN COMMON?

What do we do with Plastic boxes?

How do we determine their volume?

314.16(A)(2) OTHER BOXES

Pass a plastic box around the class.

Box Fill

Small Conduit Bodies:

Now small conduit bodies instead of small boxes.

- The same FIVE RULES apply, 314.16(B)(1)-(5) and the volume allowance table 314.16(B) …

…but governed by 314.16(C)(1)-(3)

First let's make sure we have a basic understanding of the types of conduit bodies

CONDUIT BODIES

CONDUIT BODIES = Condulets. These two terms mean the same thing.
Condulets is a trademarked term from Cooper/Couse-Hinds.

CONDUIT BODIES

Can I splice in a conduit body?

CONDUIT BODIES

Can I splice in a conduit body? YES provided conditions are met 314.16(C)

CONDUIT BODIES. In-Class Quiz

What is this conduit body called?

1.

CONDUIT BODIES

What is this conduit body called?

2.

CONDUIT BODIES

What is this conduit body called?

3.

CONDUIT BODIES

What is this conduit body called?

4.

CONDUIT BODIES

What is this conduit body called?

5.

CONDUIT BODIES

What is this conduit body called?

CONDUIT BODIES

What is this conduit body called?

CONDUIT BODIES

What is this conduit body called?

8.

CONDUIT BODIES

What is this conduit body called?

END Quiz

Conduit Bodies – Extra Material

CONDUIT BODIES – FORM 7

Wedgenuts
(aka “wings” “tabs”.

Don’t mix Form types - covers probably will NOT fit if you mix Form types.
Don’t mix manufacturers – covers will NOT fit.

Conduit Bodies - Extra

WHAT IS THIS CALLED?

Conduit Bodies - Extra

WHAT IS THIS CALLED?

Conduit Body – TYPE E

Conduit Bodies - Extra

What part do I need to make the C into a E ?

That is , how to make the C conduit body into a termination for the conduit run.

Conduit Bodies - Extra

What part do I need to make the C into an E?

A threaded plug – recessed head or non-recessed head.

Conduit Bodies - Extra

A Tee with EMT set screw connections.
Do not need separate EMT connectors.

Box Fill

Small Conduit Bodies:

Now small conduit bodies instead of small boxes.

- The same FIVE RULES apply, 314.16(B)(1)-(5) and the volume allowance table 314.16(B) …

…but governed by 314.16(C)(1)-(3)

First let's make sure we have a basic understanding of the types of conduit bodies

Conduit Bodies - Fill

FIT / NOT FIT?
(Assume RMC. Assume THHN.)

1” conduit with a 1” LB.
12.20 Cu In.
Max. 3 #4 AWG

Wire size = (3) #6 and a (1) #6 ground.

Conduit Bodies - Fill

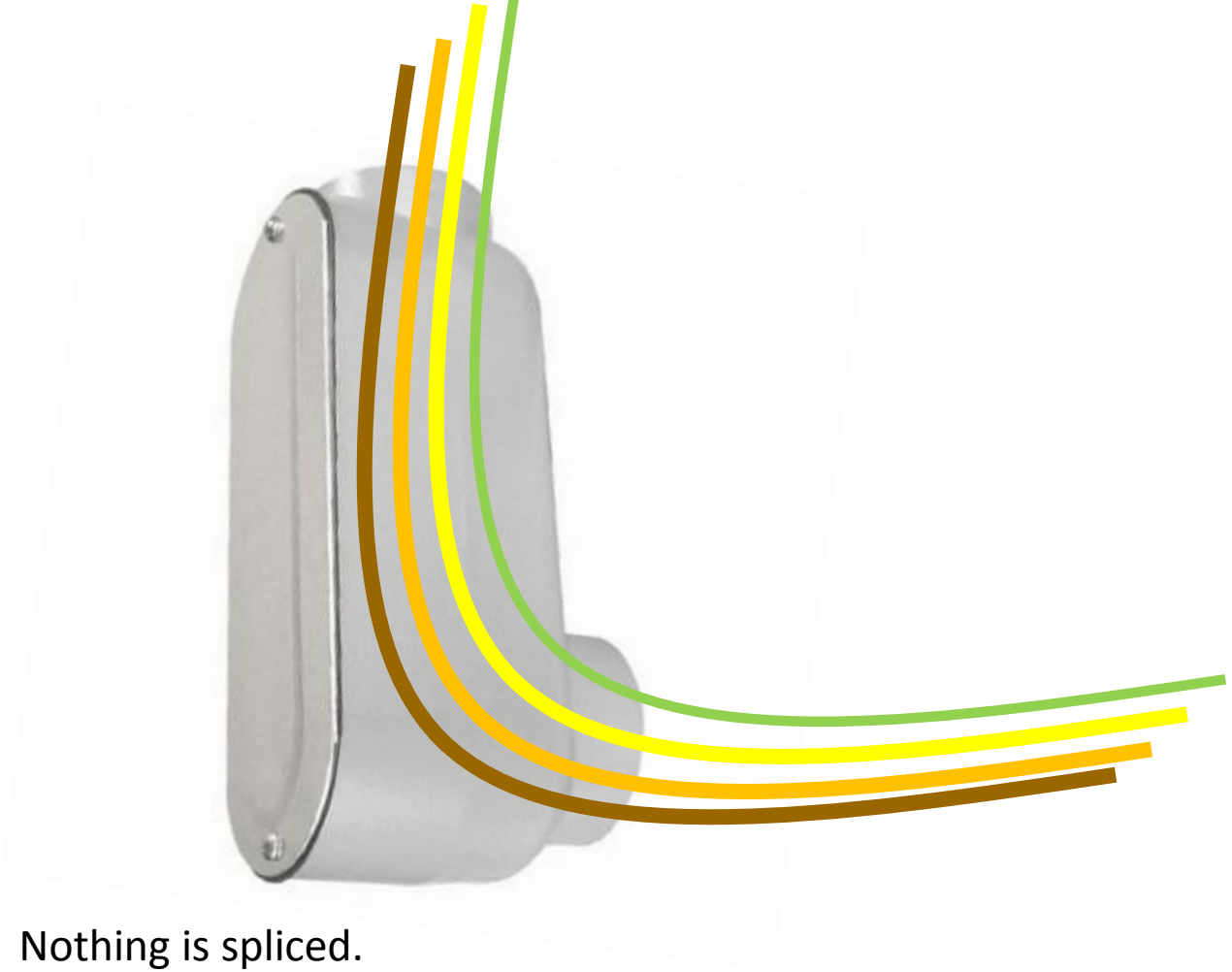
FIT / NOT FIT?
(Assume RMC. Assume THHN.)

Nothing is spliced.
See 314.16(C)(1)… last sentence.

1” conduit with a 1” LB.
12.20 Cu In.
Max. 3 #4 AWG

Wire size = (3) #6 and a (1) #6 ground.

Conduit Bodies - Fill



Nothing is spliced.
See 314.16(C)(1)… last sentence.

Can fill to 40% of a 1” conduit.
1” conduit at 40% = 0355 in^2
4 x 0.0507 in^2 = 0.2028 in^2

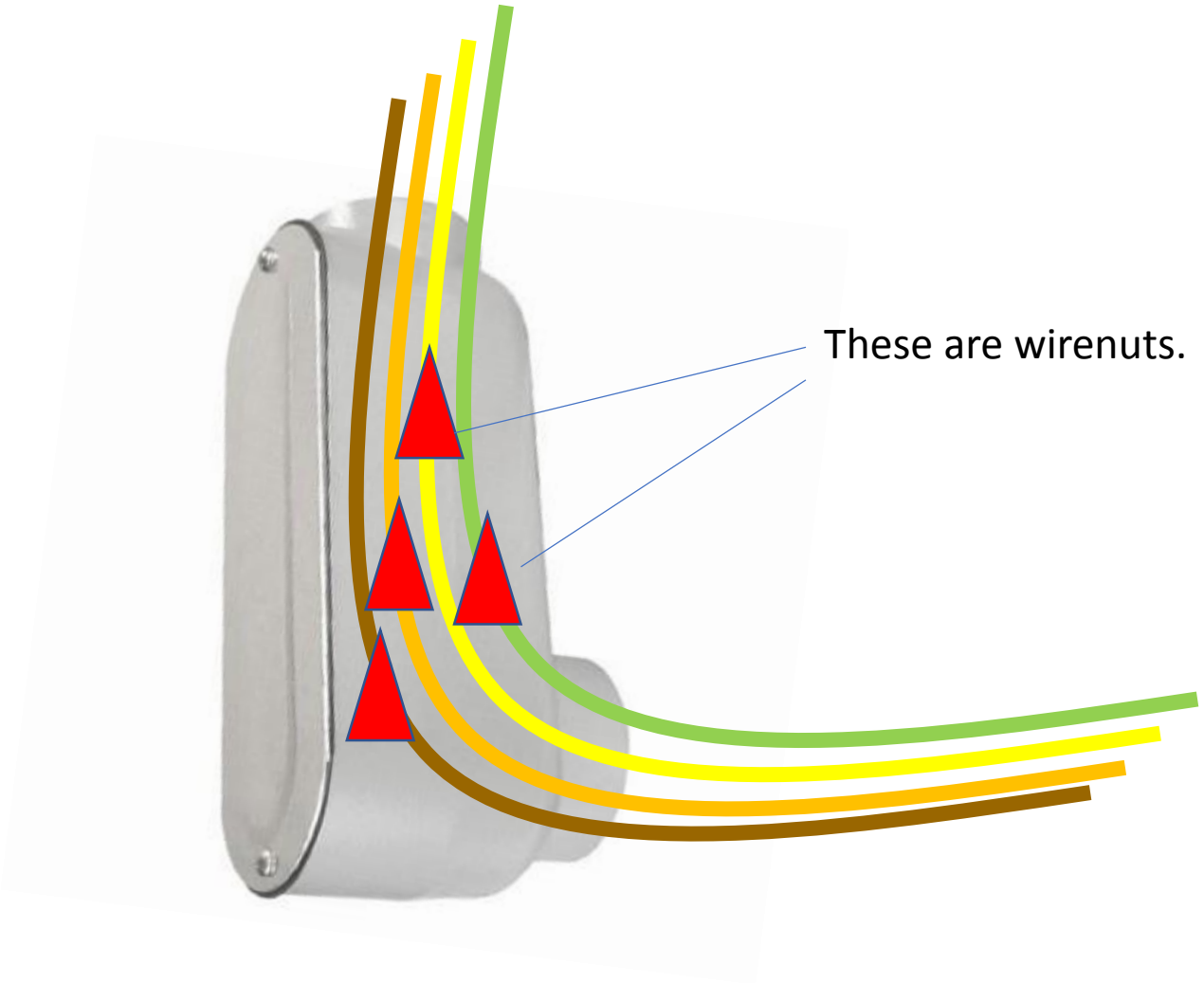
0.0355 > 0.2028 so wire WILL FIT.

FIT / NOT FIT?
(Assume RMC. Assume THHN.)

1” conduit with a 1” LB.
12.20 Cu In.
Max. 3 #4 AWG

Wire size = (3) #6 and a (1) #6 ground.

Conduit Bodies - Fill

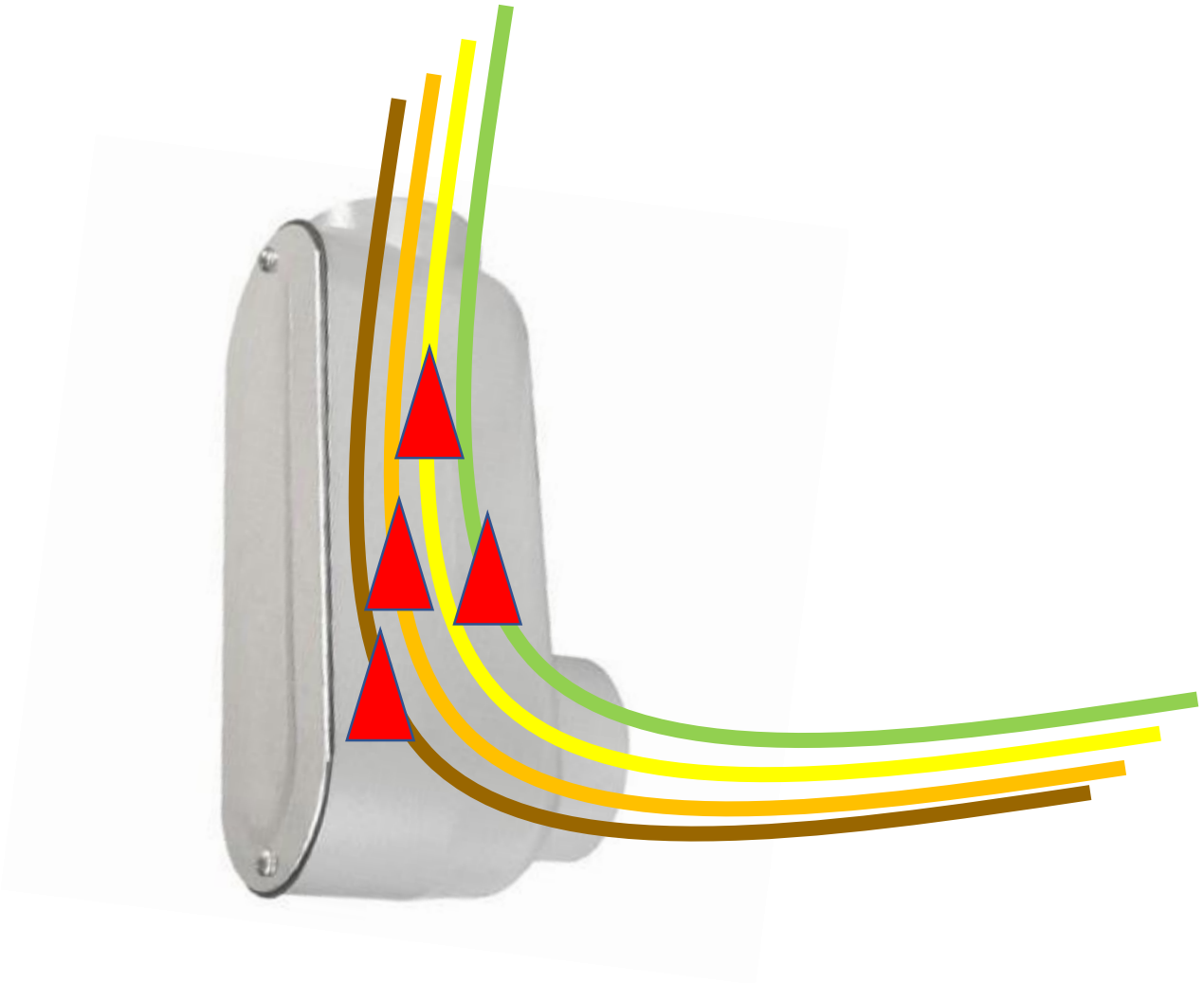


FIT / NOT FIT?
(Assume RMC. Assume THHN.)

1” conduit with a 1” LB.
12.20 Cu In.
Max. 3 #4 AWG

Wire size = (3) #12 and a (1) #12 ground.

Conduit Bodies - Fill



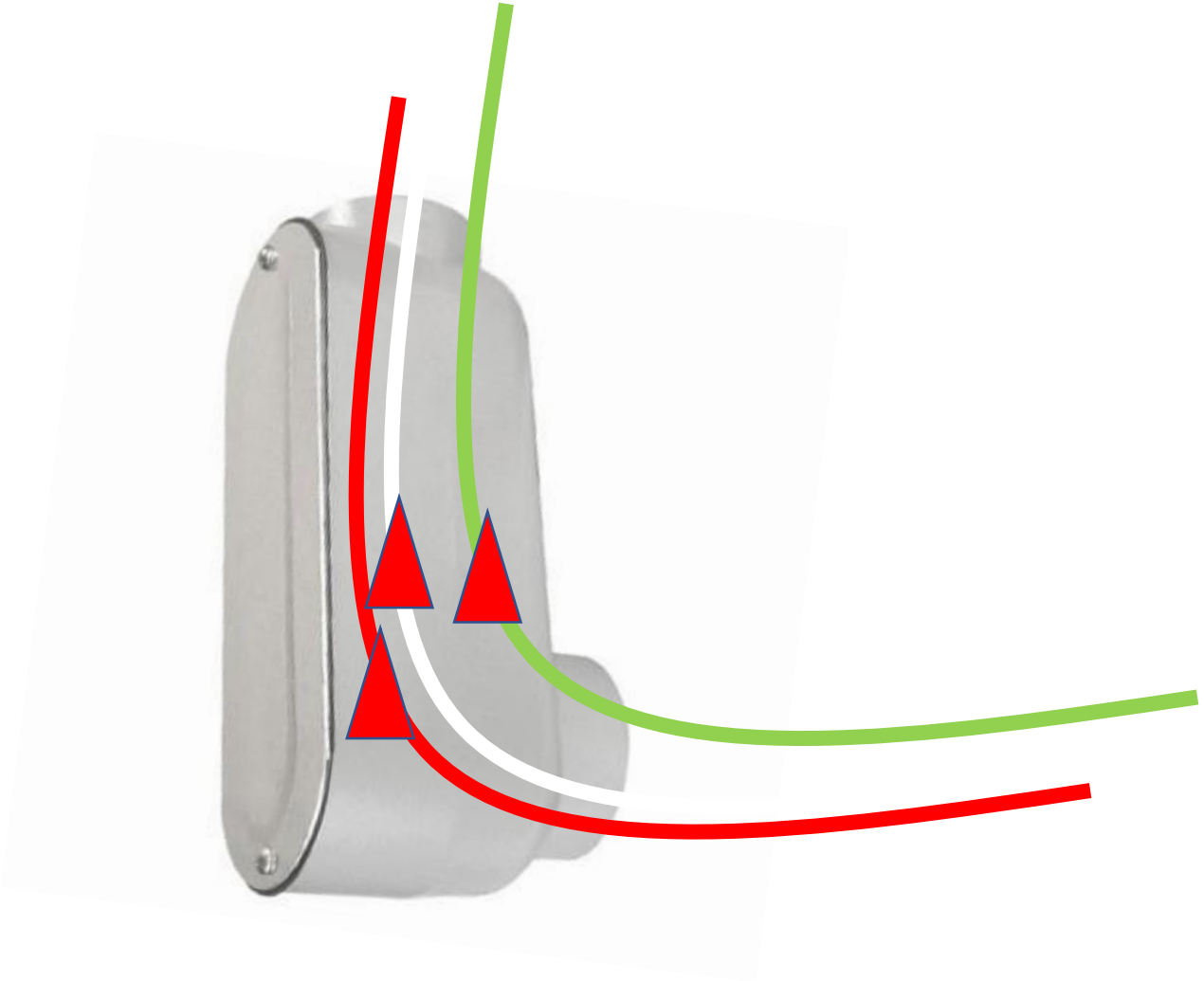
FIT / NOT FIT?
(Assume RMC. Assume THHN.)

Everything is spliced. See 314.16(C)(2).
314.16(B)(1) … 6 wires x 2.25 in^3 = 13.5 in^3
314.16(B)(5) …1 EGC = 2.25 in^3
CANNOT SPLICE THIS IN A 1” LB.

1” conduit with a 1” LB.
12.20 Cu In.
Max. 3 #4 AWG

Wire size = (3) #12 and a (1) #12 ground.

Conduit Bodies - Fill

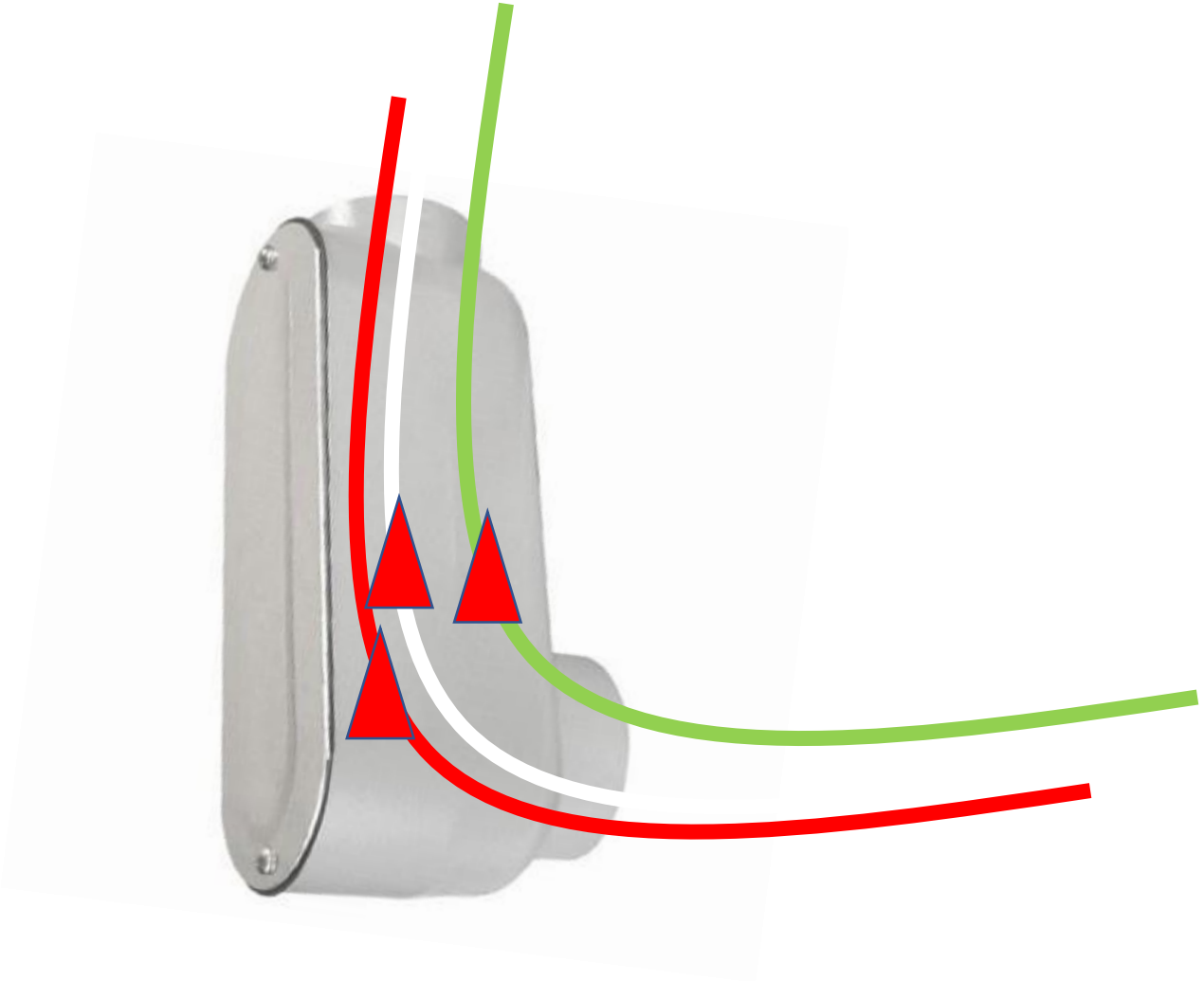


FIT / NOT FIT?
(Assume RMC. Assume THHN.)

1” conduit with a 1” LB.
12.20 Cu In.
Max. 3 #4 AWG

Wire size = (2) #12 and a (1) #12 ground.

Conduit Bodies - Fill



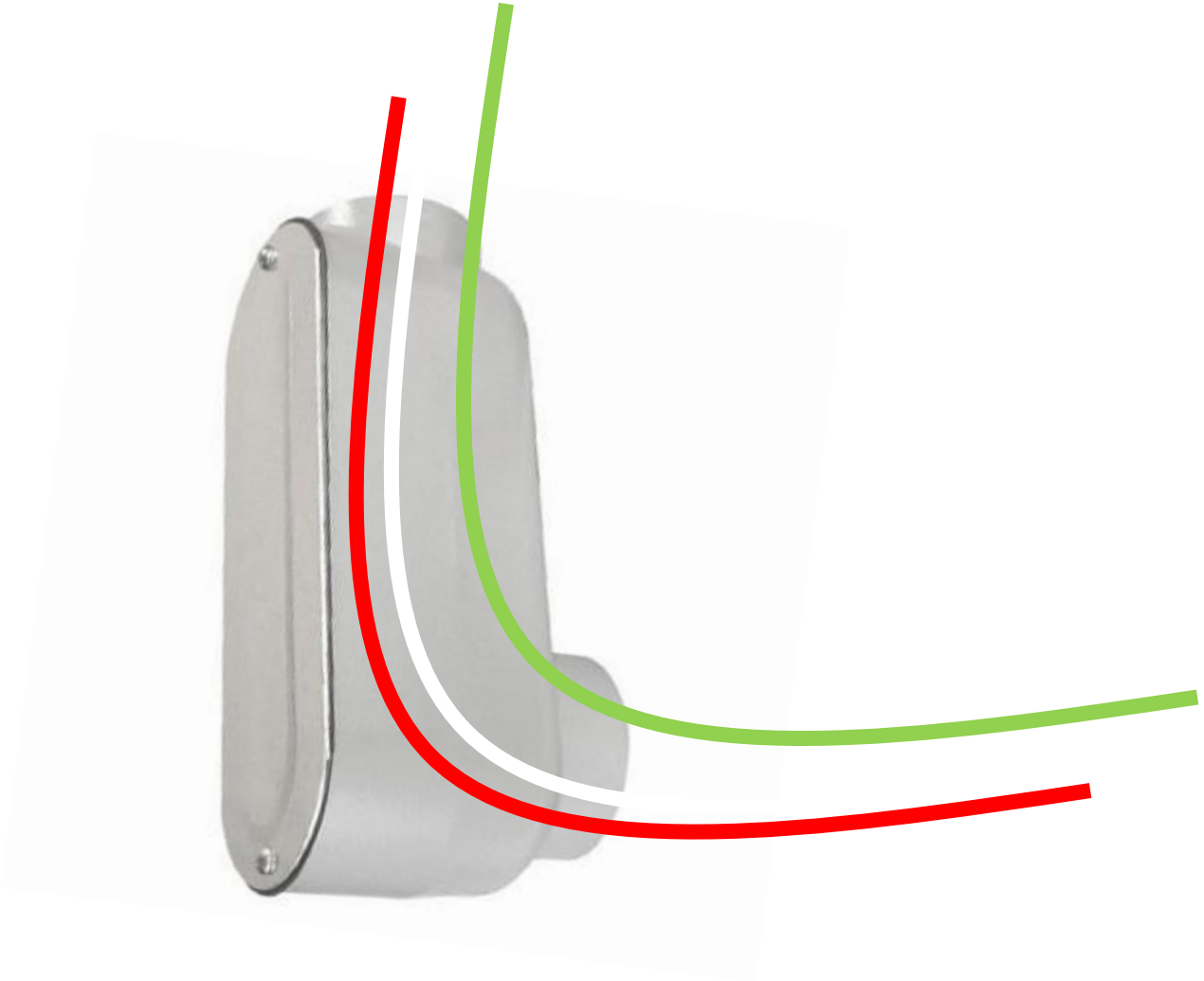
FIT / NOT FIT?
(Assume RMC. Assume THHN.)

Splices.
4 wires x 2.25 in^3 = 9 in^3
1 wire x 2.25 in^3 = 2.25 in^3
9 + 2.25 = 11.25 in^3 < 12.20
THIS WILL FIT.

1” conduit with a 1” LB.
12.20 Cu In.
Max. 3 #4 AWG

Wire size = (2) #12 and a (1) #12 ground.

Conduit Bodies - Fill

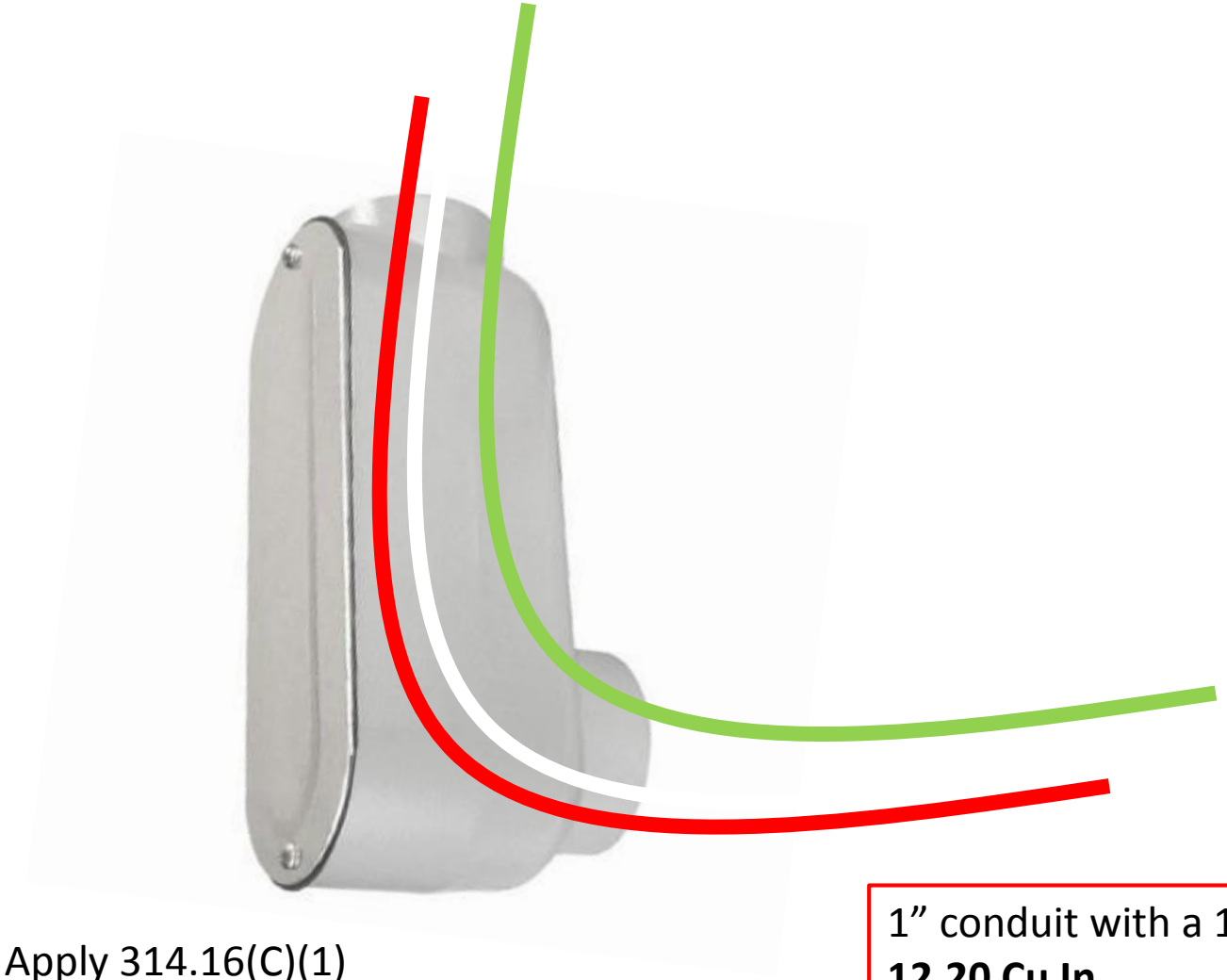


FIT / NOT FIT?
(Assume RMC. Assume THHN.)

1” conduit with a 1” LB.
12.20 Cu In.
Max. 3 #4 AWG

Wire size = (21) #12 AWG

Conduit Bodies - Fill



1” conduit with a 1” LB.
12.20 Cu In.
Max. 3 #4 AWG

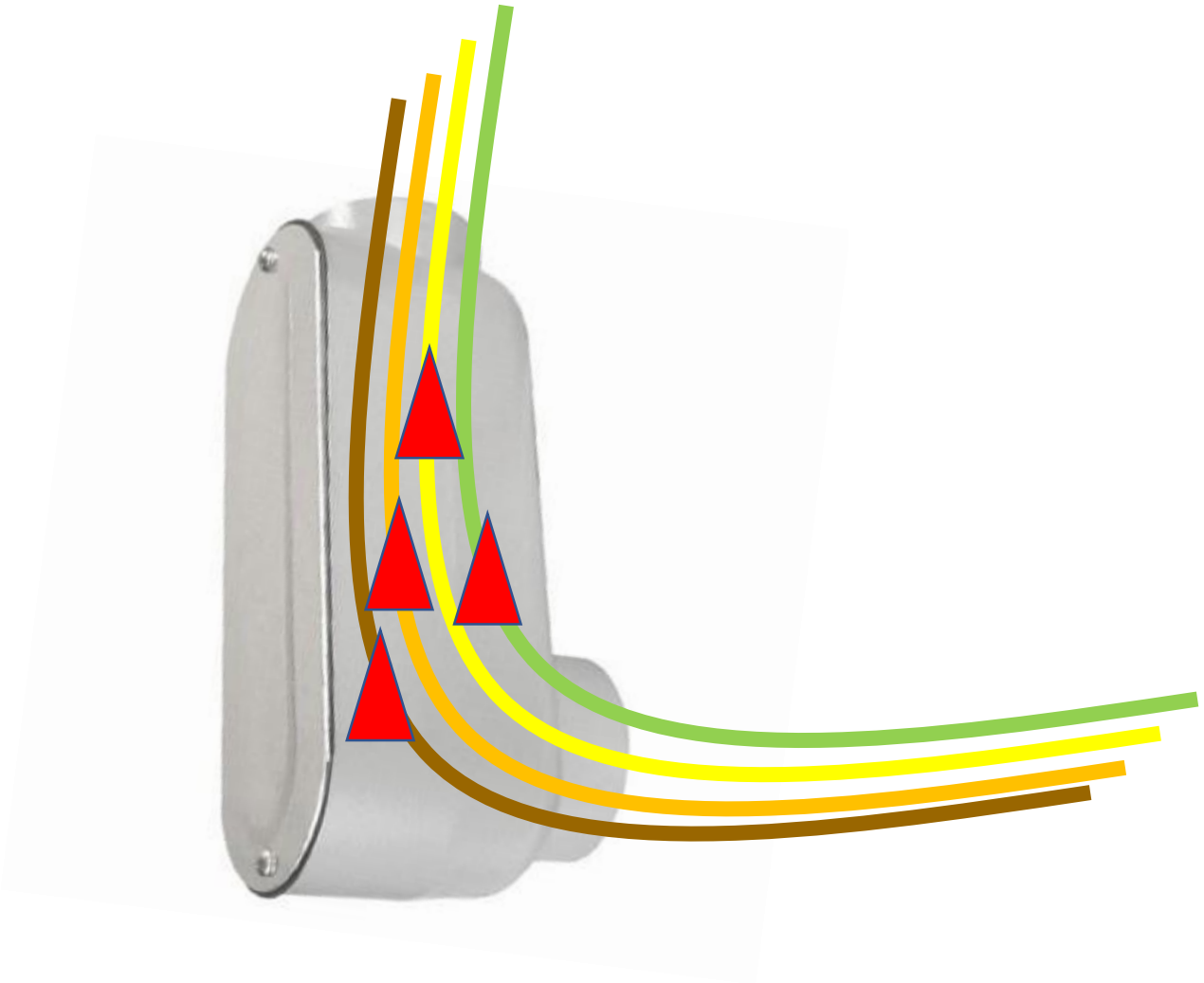
Wire size = (21) #12 AWG

Apply 314.16(C)(1)
21 x 0.0133 in^2 = 0.2793 in^2.

CSA for 1” RMC at 40% is from
Chap 9, Table 4 and equals 0.355in^2.
THIS FITS. We could have used Annex C also since all wires are same size.

FIT / NOT FIT?
(Assume RMC. Assume THHN.)

Conduit Bodies - Fill

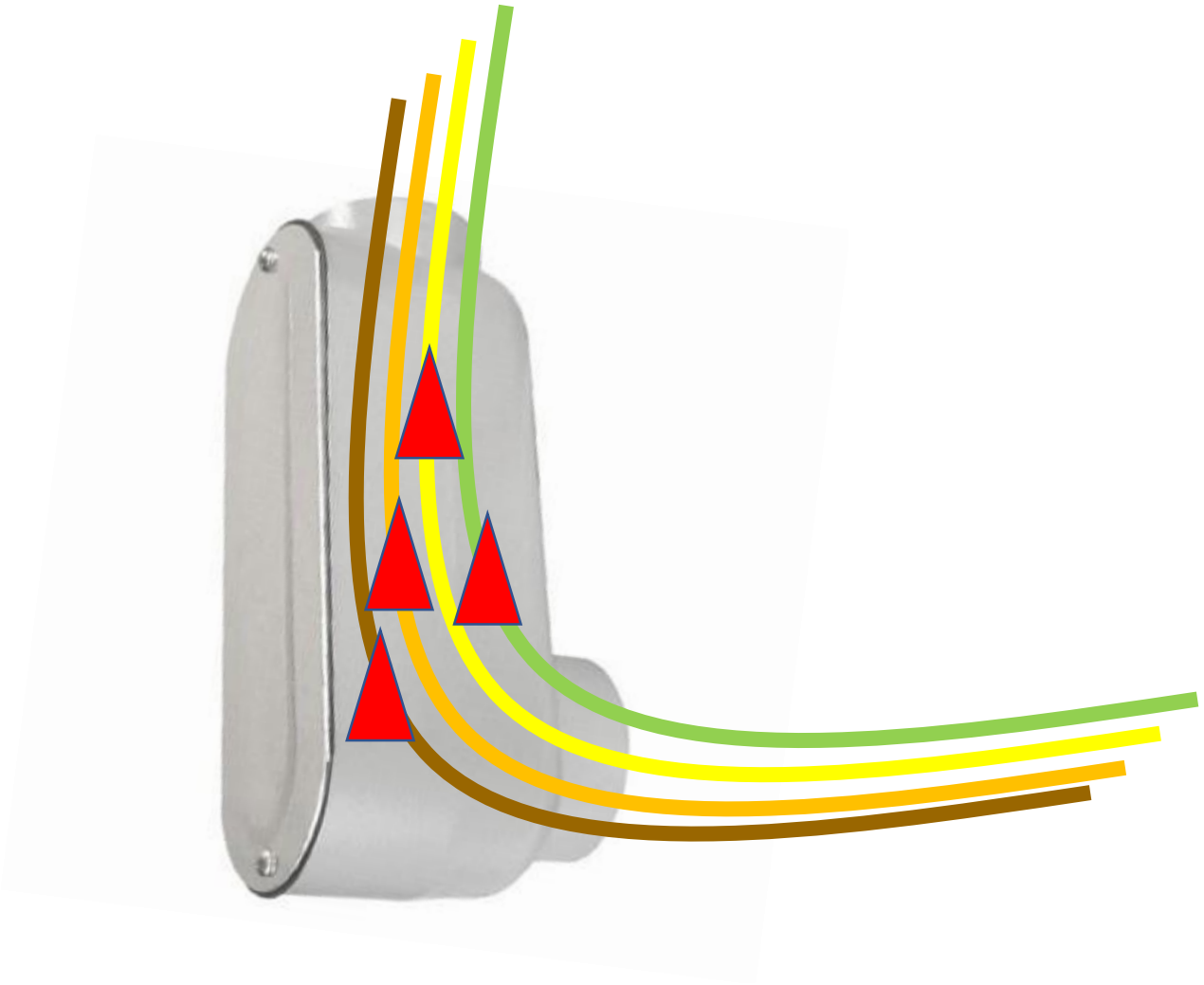


FIT / NOT FIT?
(Assume RMC. Assume THHN.)

1” conduit with a **1-1/4” LB.**
33.10 Cu In.
Max. 3 #2 AWG

Wire size = (3) #12 and a (1) #12 ground.

Conduit Bodies - Fill



FIT / NOT FIT?
(Assume RMC. Assume THHN.)

6 wires x 2.25 in2 = 13.5 in^3
1 x 2.25 in2 = 2.25 in^3

13.5 in^3 + 2.25 in^3 = 15.75 in^3
This will FIT.

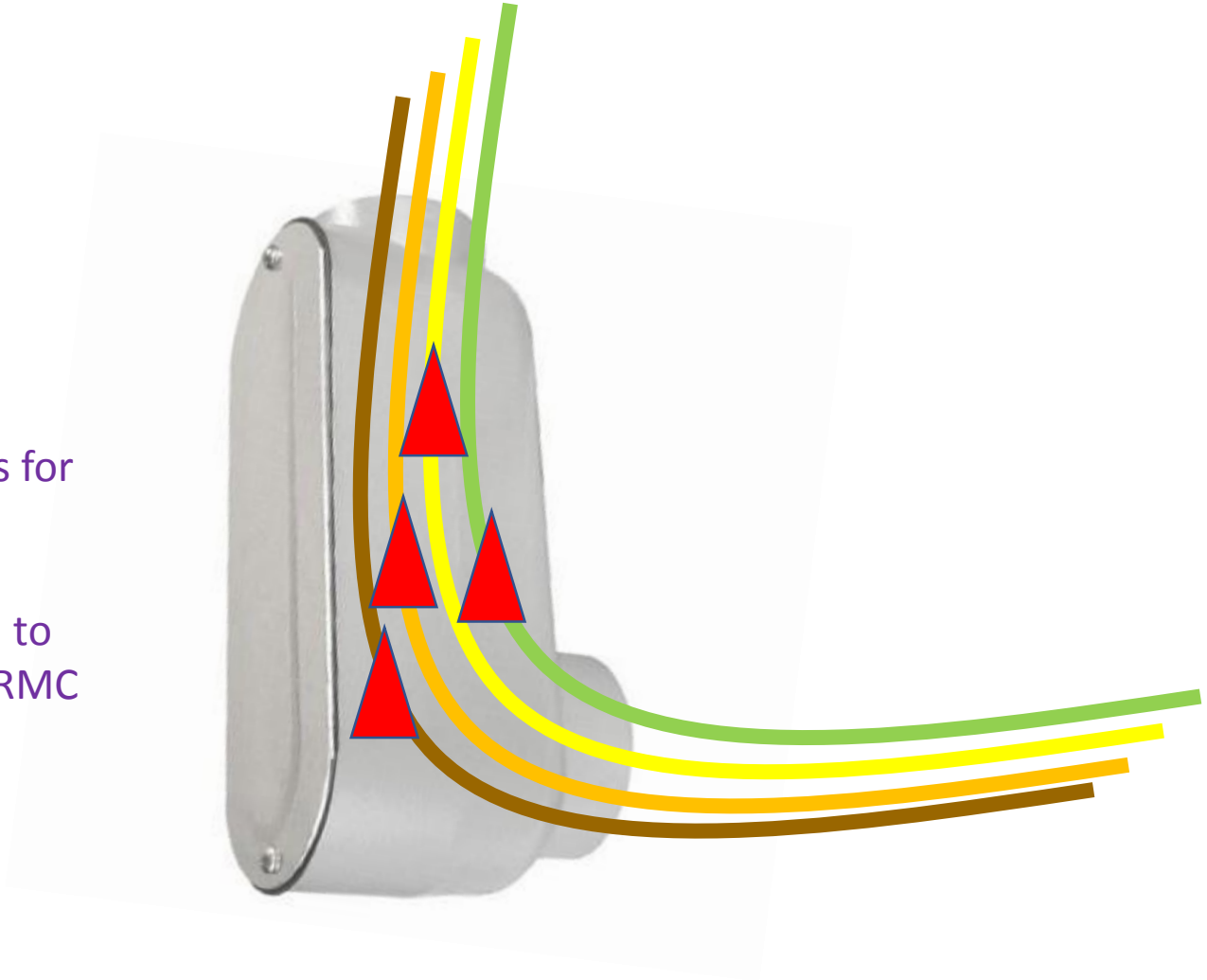
1” conduit with a **1-1/4” LB.**
33.10 Cu In.
Max. 3 #2 AWG

Wire size = (3) #12 and a (1) #12 ground.

Conduit Bodies - Fill

But what does upsizing the conduit body, but not the conduit, do to requirements for supporting a conduit body?

What part did I need to add to the 1-1/4” LB to get the 1” RMC to thread into the LB?



FIT / NOT FIT?
(Assume RMC. Assume THHN.)

1” conduit with a **1-1/4” LB.**
33.10 Cu In.
Max. 3 #2 AWG

Wire size = (3) #12 and a (1) #12 ground.

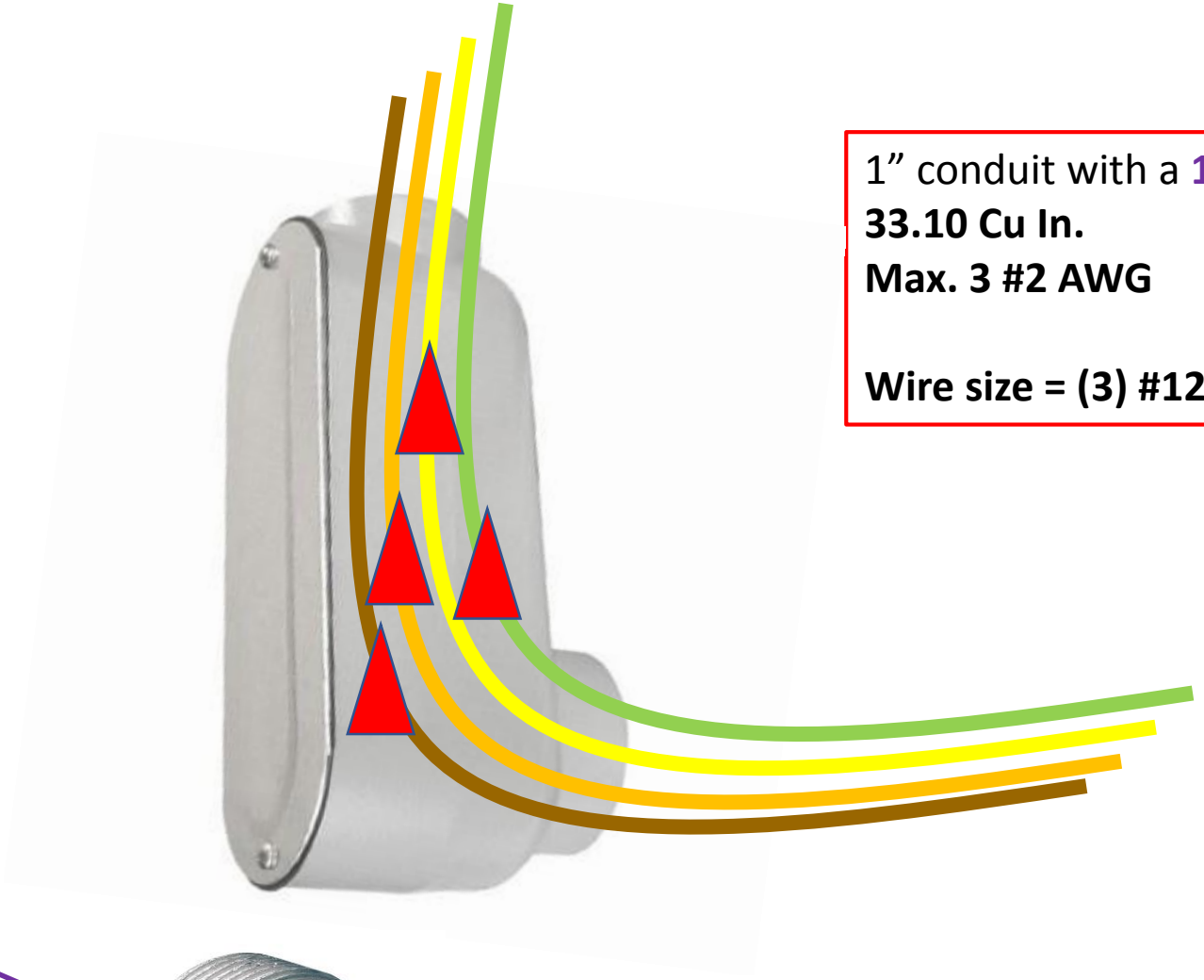
Conduit Bodies - Fill

But what does upsizing the conduit body, but not the conduit, do to requirements for supporting a conduit body?

314.23(E) Have to support within 3’ of body now.

Before the conduit body was just part of the conduit system and the conduit and body only need to be supported at the specific raceway requirement, typically every 10’

What part did I need to add to the 1-1/4” LB to get the 1” RMC to thread into the LB?



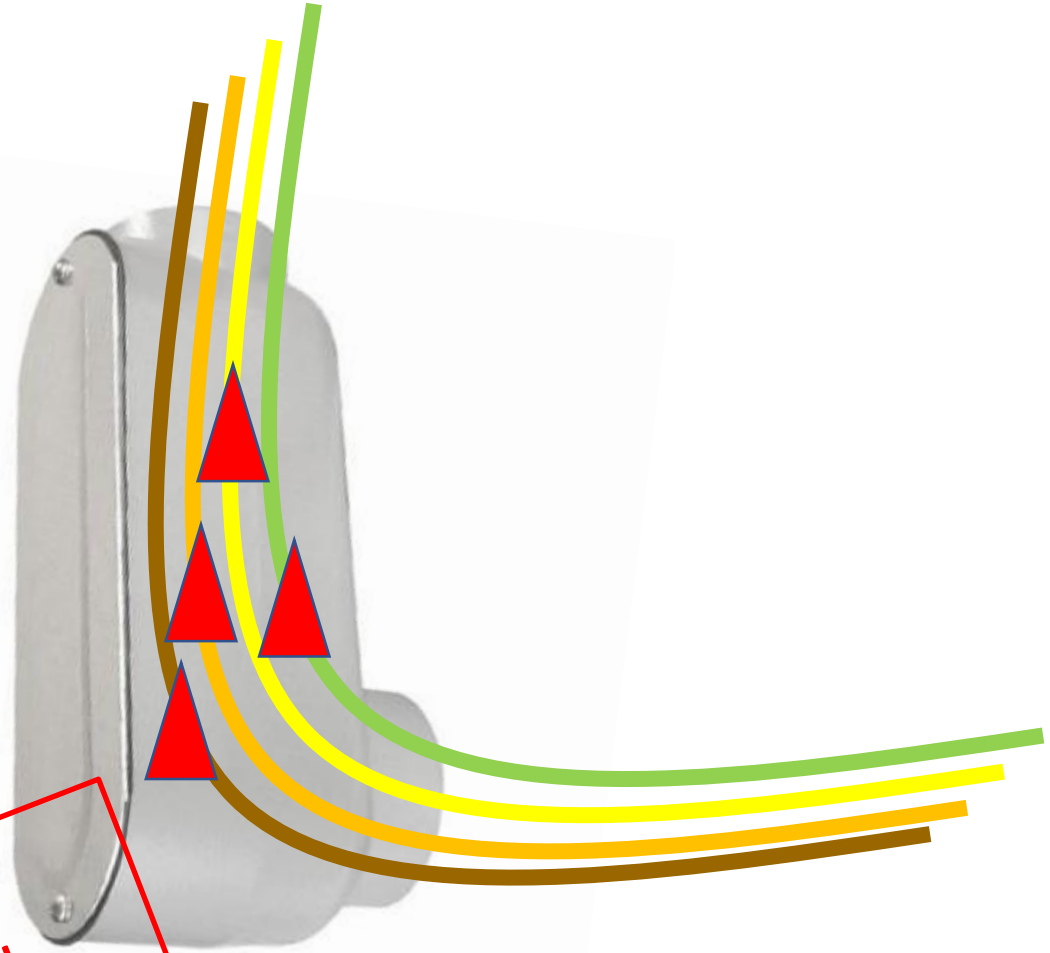
1” conduit with a **1-1/4” LB.**
33.10 Cu In.
Max. 3 #2 AWG

Wire size = (3) #12 and a (1) #12 ground.

RE or Reducing Bushing.

FIT / NOT FIT?
(Assume RMC. Assume THHN.)

Conduit Bodies - Fill



REMEMBER
ALL THESE BOX FILL
RULES APPLY TO #6
AND SMALLER

Box Fill ...
for conductors #4 AWG or larger

See 314.28(A)(1) and (2)

Straight Pulls:
8 x largest raceway

Angle or U Pulls, or Splices:
6 x largest raceway plus sum of diameters of each other raceway in same row.

For large conduit bodies:
314.28(A)(3).

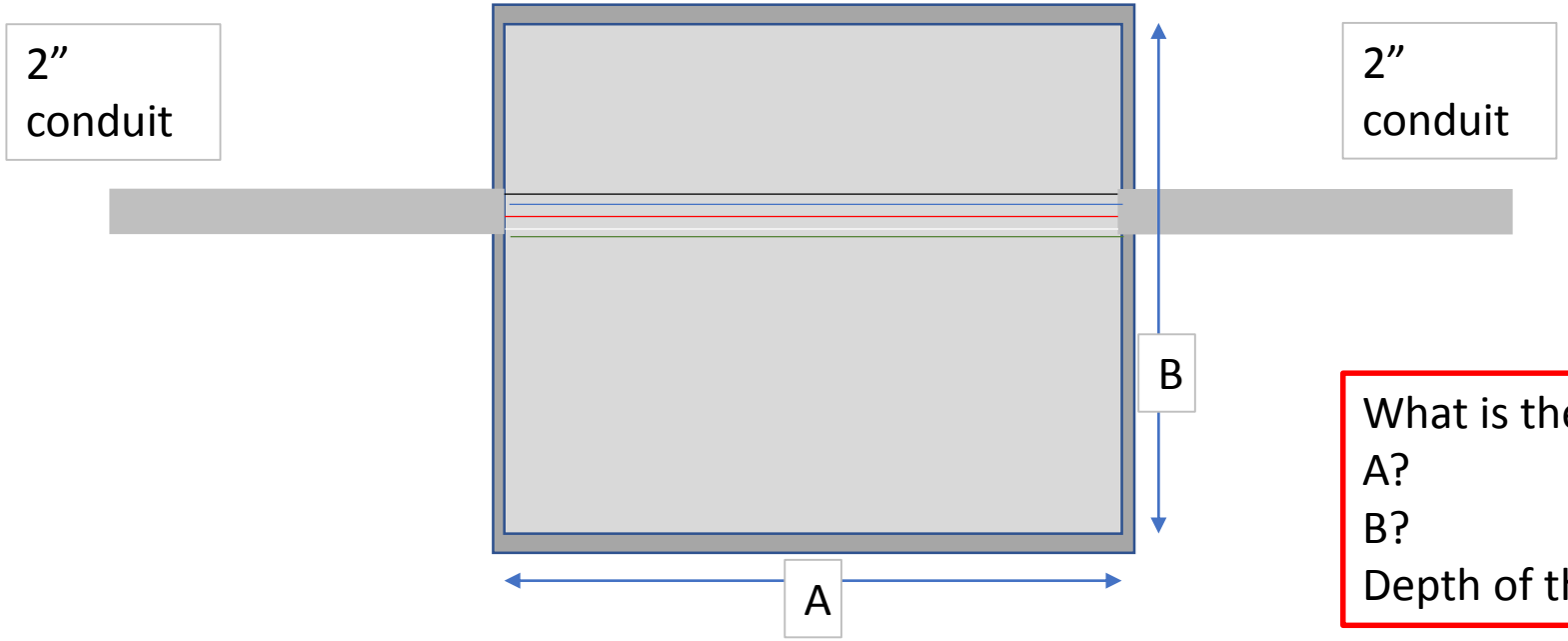
WHEN CONDUCTORS ARE #6 AND SMALLER
– STAY IN 314.16

WHEN CONDUCTORS ARE #4 AND LARGER
– GO TO 314.28

See 314.28(A)(1)

Straight Pulls:

8 x largest raceway



What is the minimum dim for:

A?

B?

Depth of the box?

See 314.28(A)(1)

Straight Pulls:

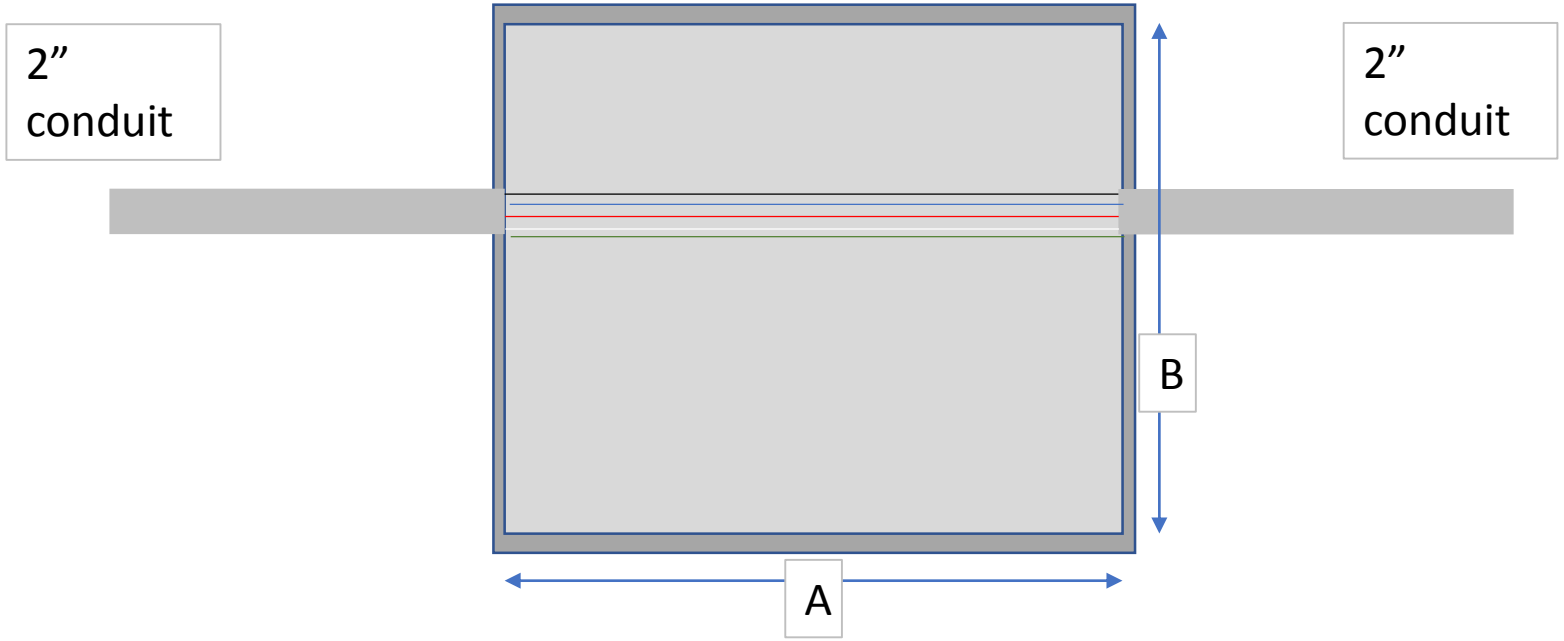
8 x largest raceway

What is the minimum dim for:

A? 2” x 8 = 16”

B? enough space to get locknuts on

Depth of the box? Enough space for locknuts

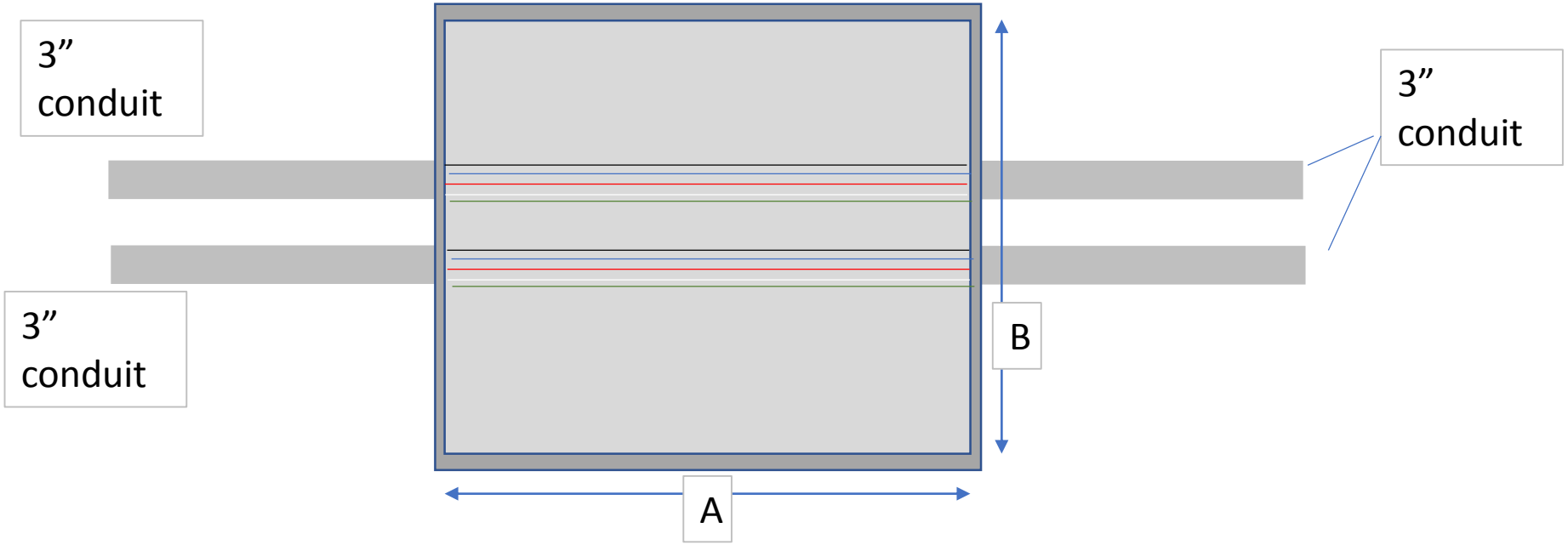


See 314.28(A)(1)

Straight Pulls:

8 x largest raceway

What is the minimum dim for:
A?
B?
Depth of the box?



See 314.28(A)(1)

Straight Pulls:

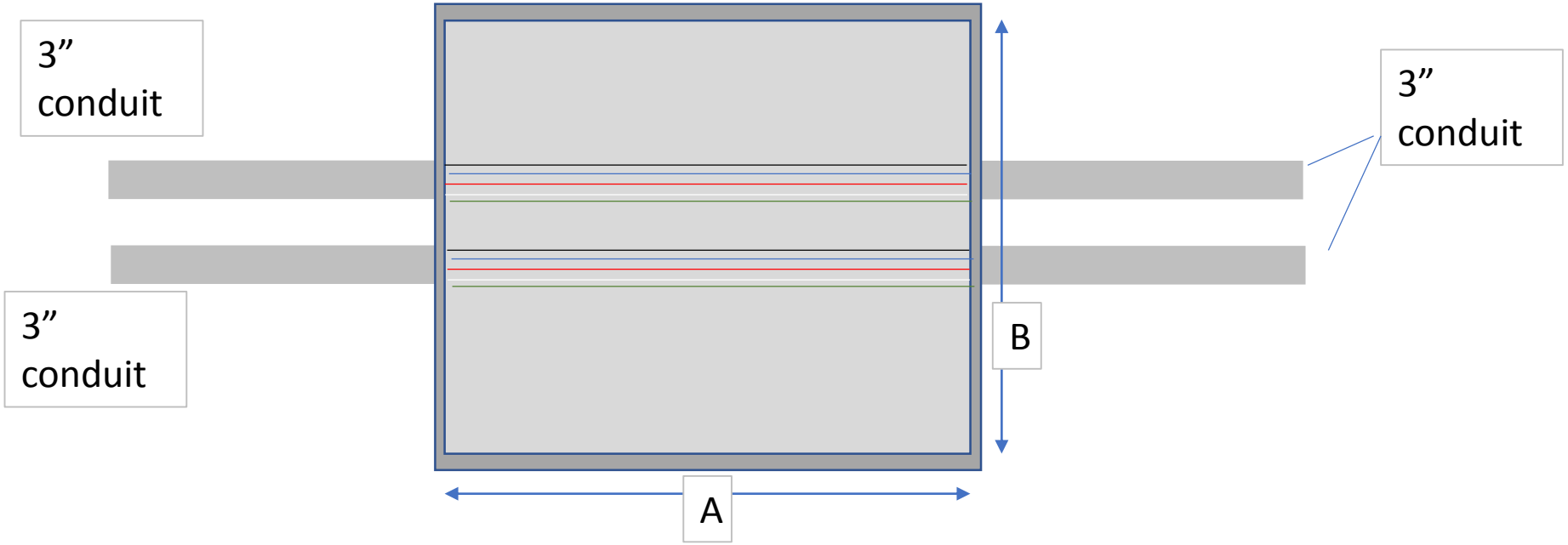
8 x largest raceway

What is the minimum dim for:

A? 3” x 8 = 24”

B? enough for both conduits and locknuts

Depth of the box? enough for locknuts

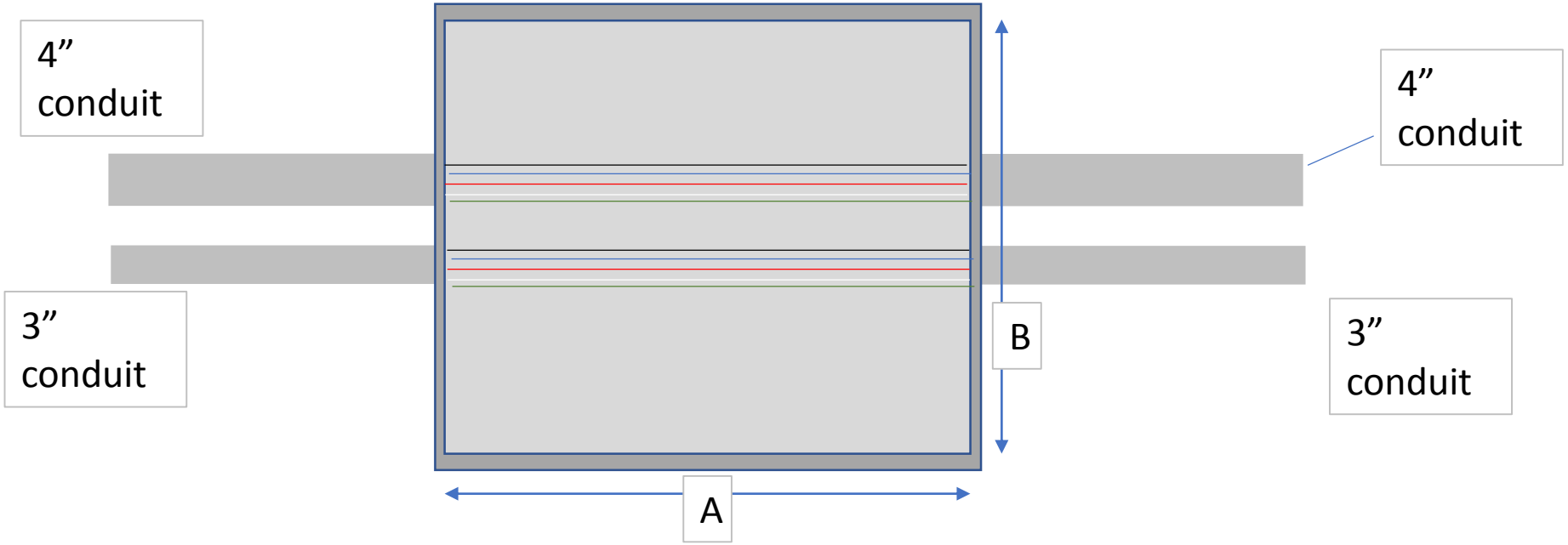


See 314.28(A)(1)

Straight Pulls:

8 x largest raceway

What is the minimum dim for:
A?
B?
Depth of the box?



See 314.28(A)(1)

Straight Pulls:

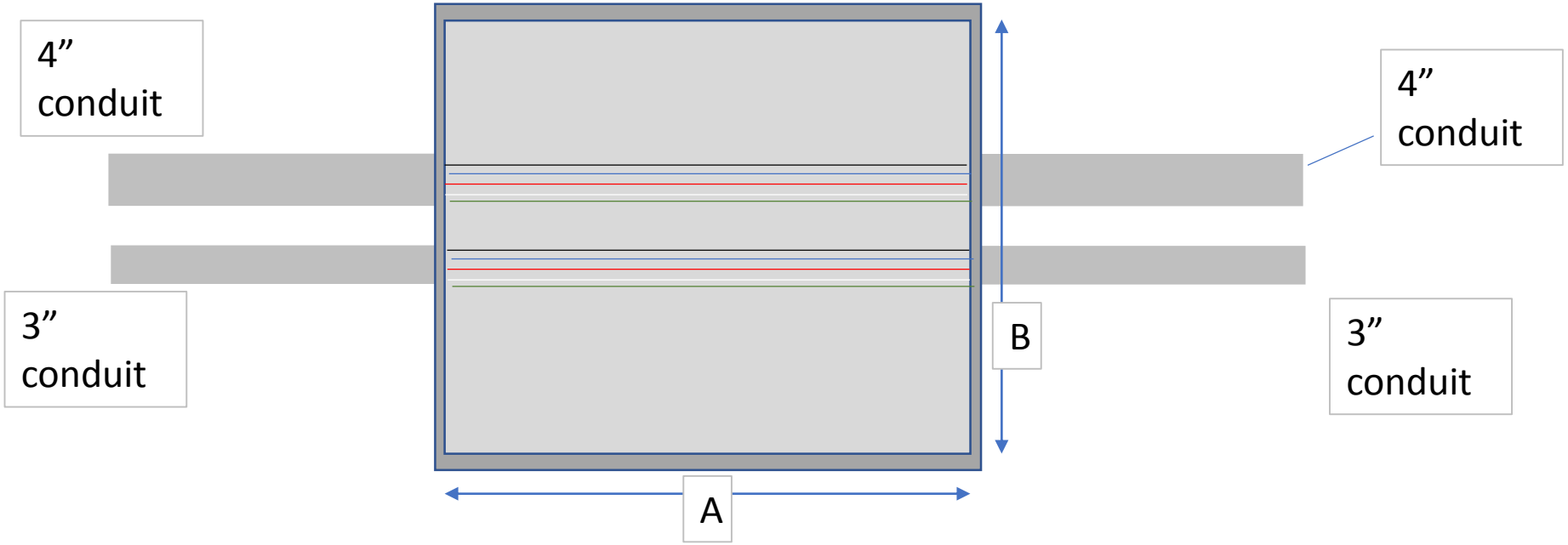
8 x largest raceway

What is the minimum dim for:

A? 4” x 8 = 32”

B? enough for both conduits and locknuts

Depth of the box? enough for locknuts

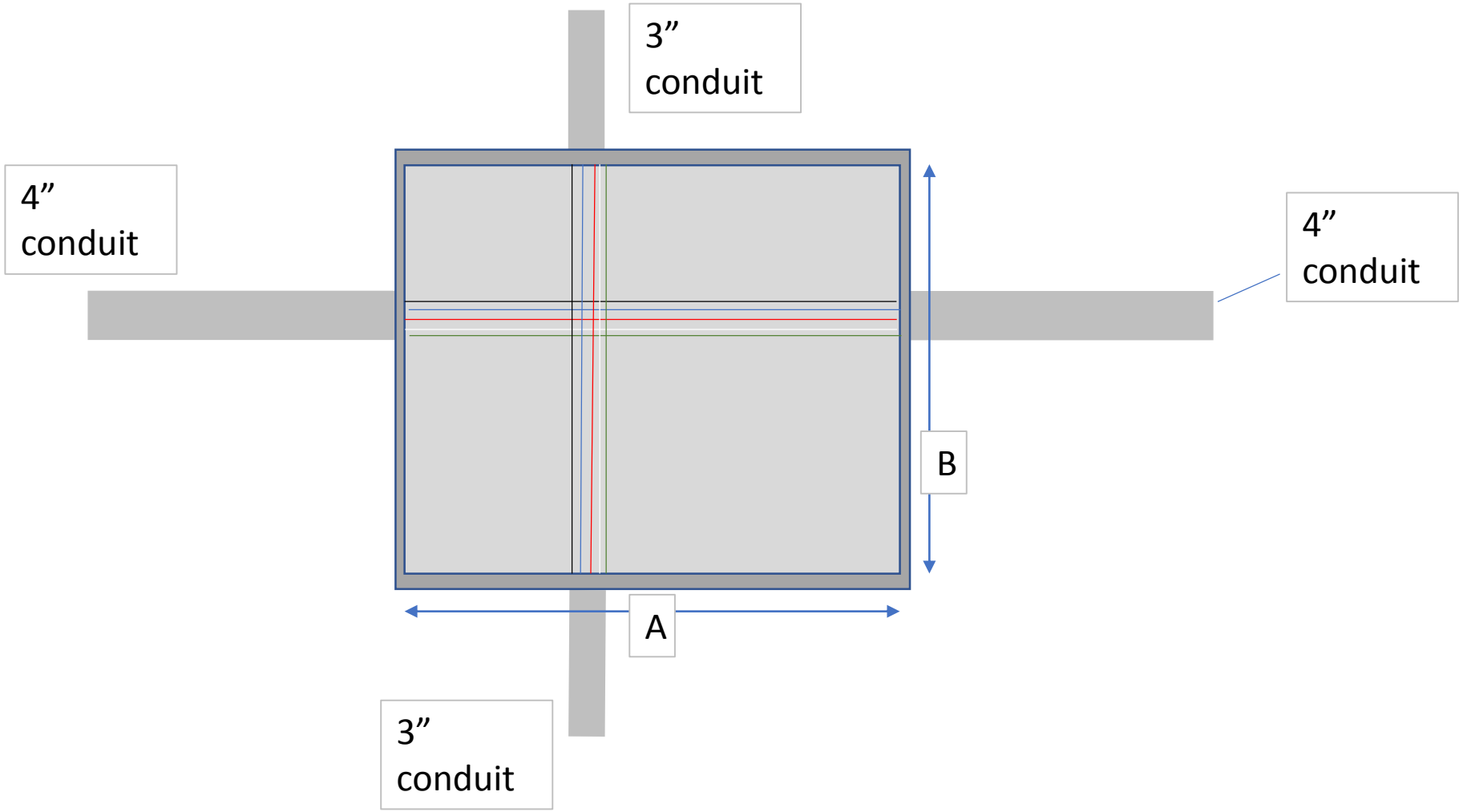


See 314.28(A)(1)

Straight Pulls:

8 x largest raceway

What is the minimum dim for:
A?
B?
Depth of the box?



See 314.28(A)(1)

Straight Pulls:

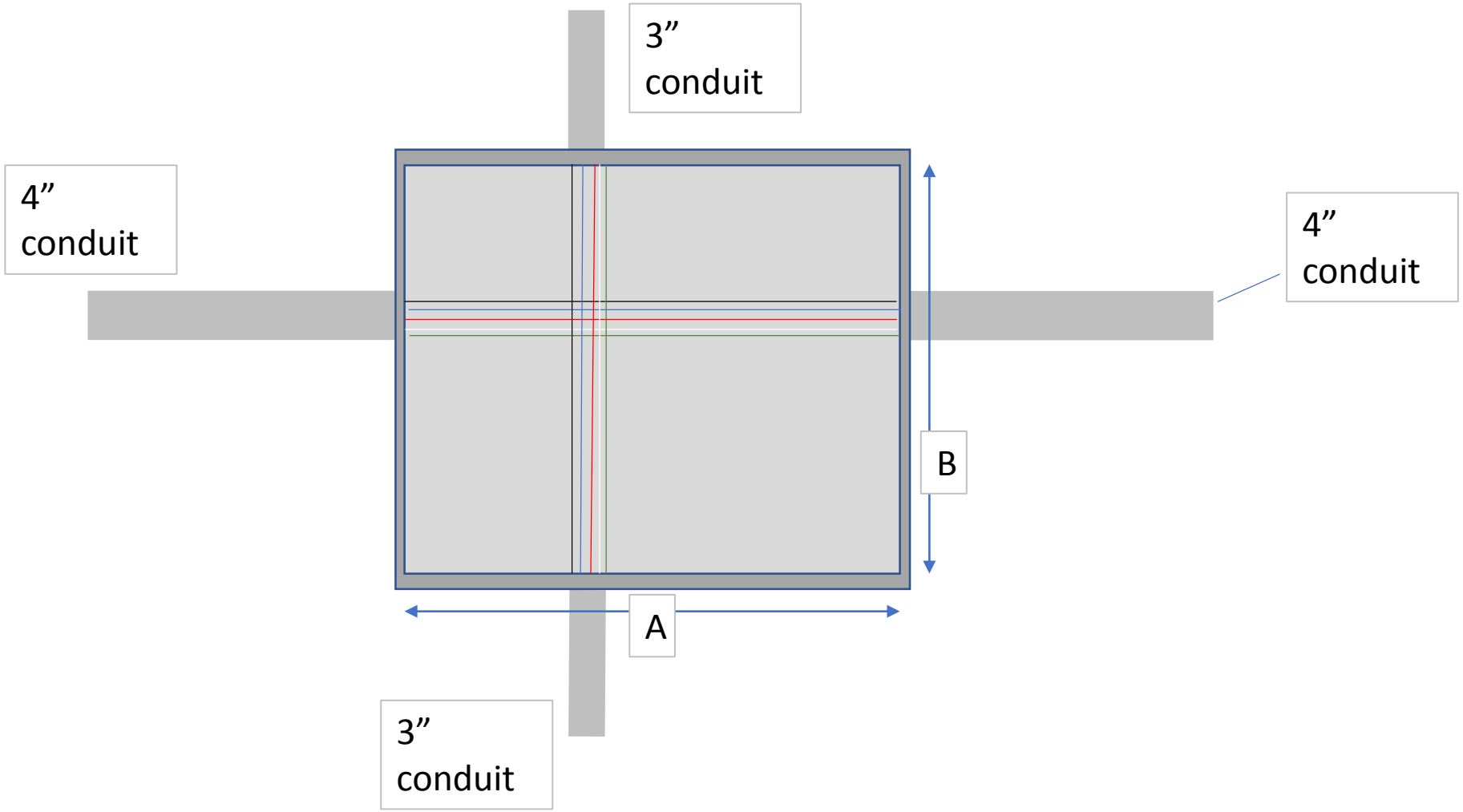
8 x largest raceway

What is the minimum dim for:

A? 4” x 8 = 32”

B? 3” x 8 = 24”

Depth of the box? Enough for locknuts



Box Fill ...
for conductors #4 AWG or larger

See 314.28(A)(1) and (2)

Straight Pulls:
8 x largest raceway

Angle or U Pulls, or Splices:
6 x largest raceway plus sum of diameters of each other raceway <u>in same row.</u>

314.28(A)(2) Angle or U Pulls or Splices.

(REMEMBER for #4 and Larger.)

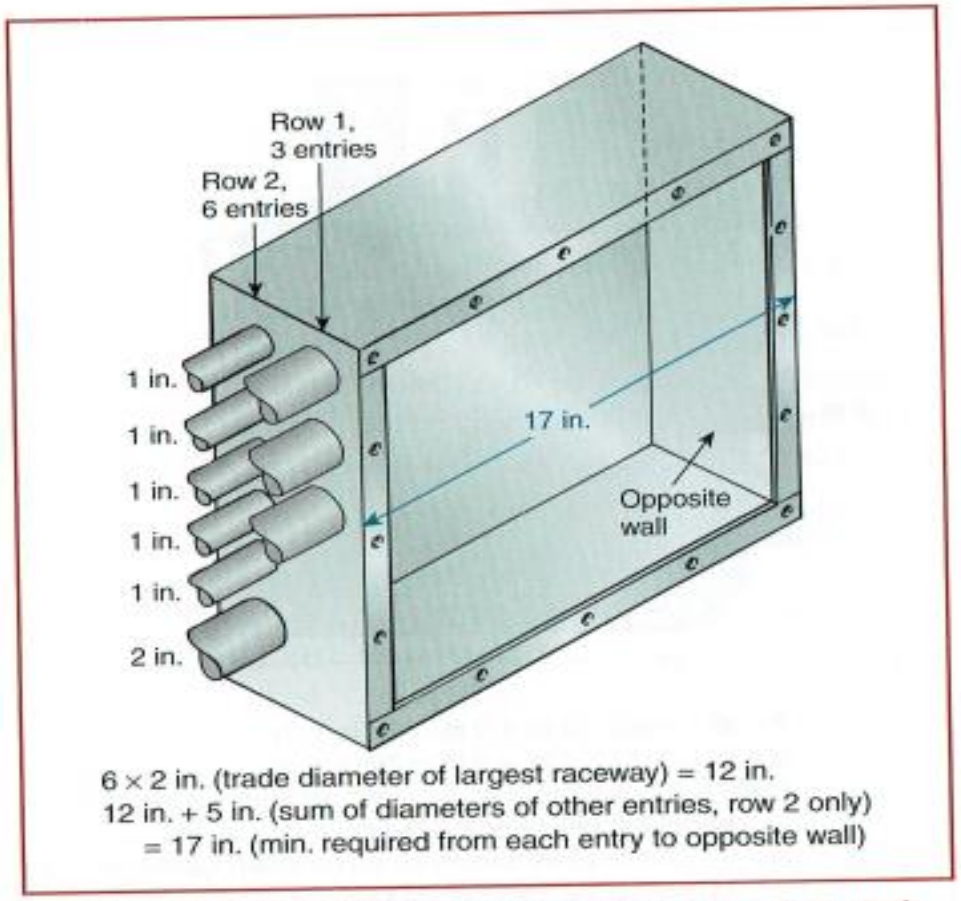
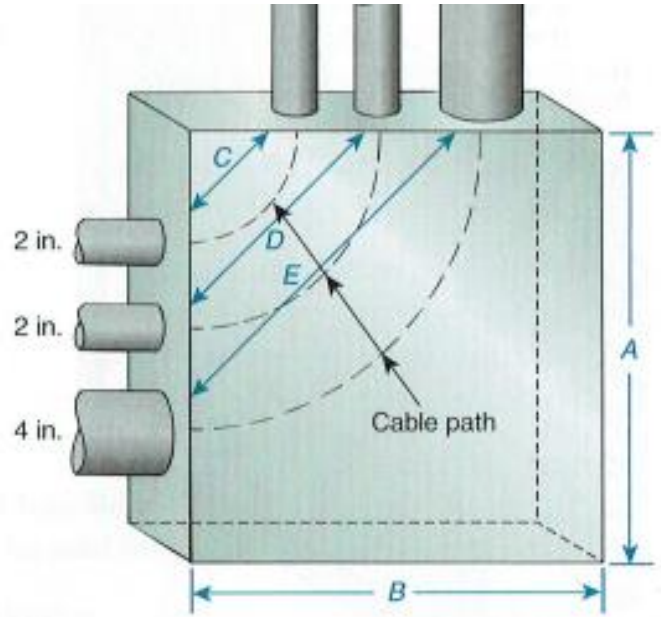


EXHIBIT 314.10 *An example showing calculations for splices, angle pulls, or U pulls.*

314.28(A)(2) Angle or U Pulls or Splices.

(REMEMBER for #4 and Larger.)



$A = (6 \times 4 \text{ in.}) + 2 \text{ in.} + 2 \text{ in.} = 28 \text{ in. min.}$

$B = (6 \times 4 \text{ in.}) + 2 \text{ in.} + 2 \text{ in.} = 28 \text{ in. min.}$

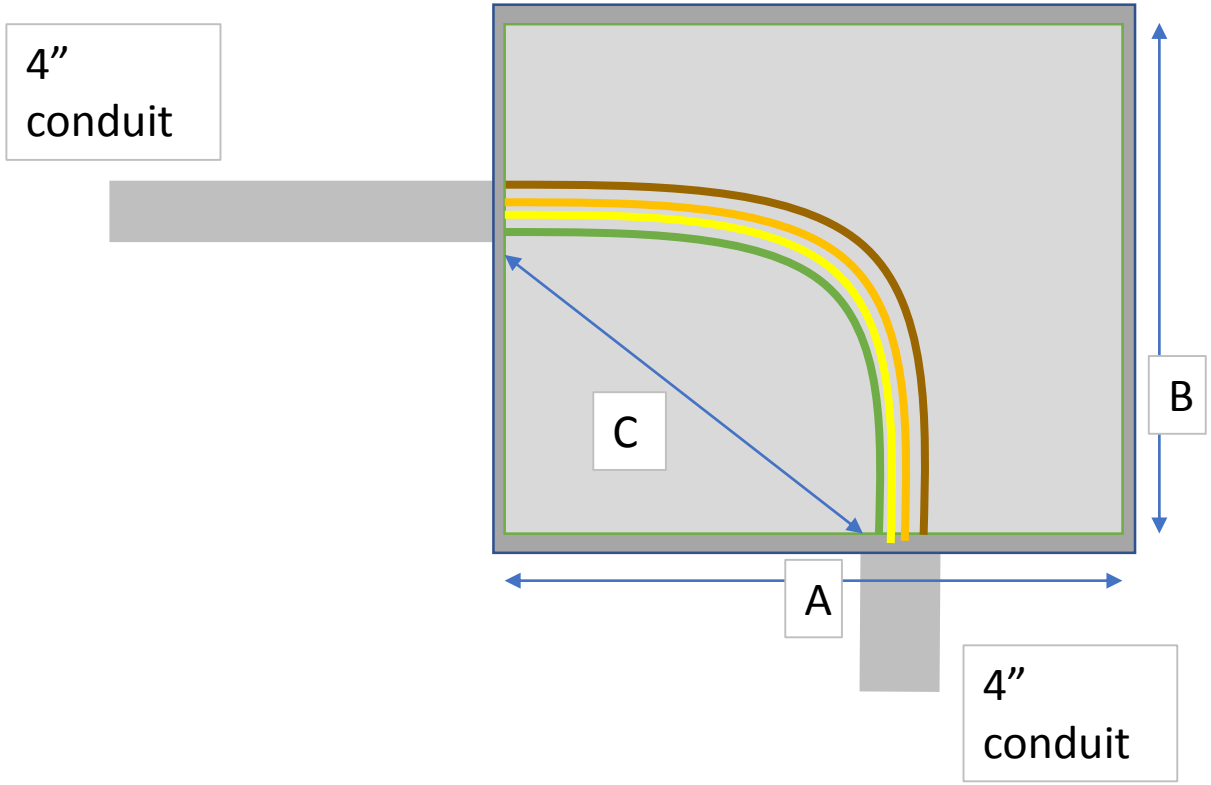
$C = 6 \times 2 \text{ in.} = 12 \text{ in. min.}$ required between raceways enclosing the same conductor

$D = 6 \times 2 \text{ in.} = 12 \text{ in. min.}$ required between raceways enclosing the same conductor

$E = 6 \times 4 \text{ in.} = 24 \text{ in. min.}$ required between raceways enclosing the same conductor

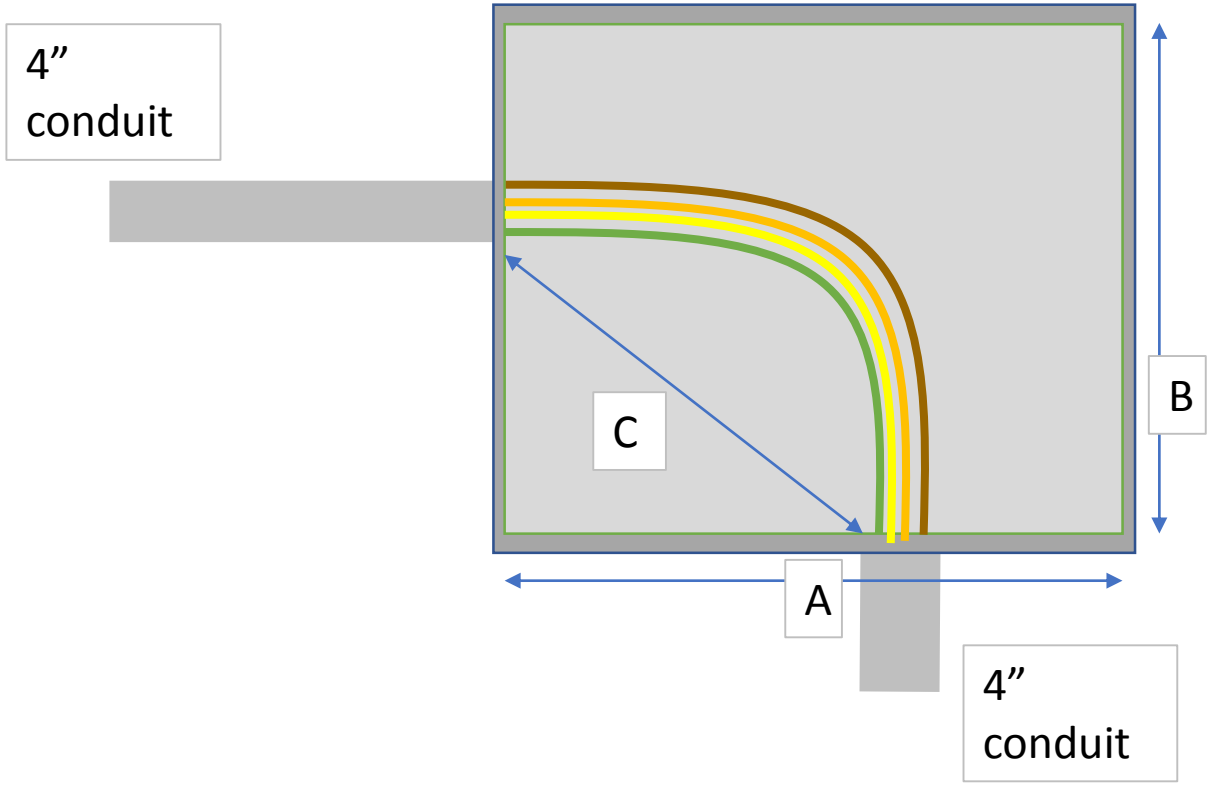
Angle or U Pulls, or Splices:
6 x largest raceway plus sum of diameters of each other raceway in same row.

What is the minimum dim for:
A?
B?
C?



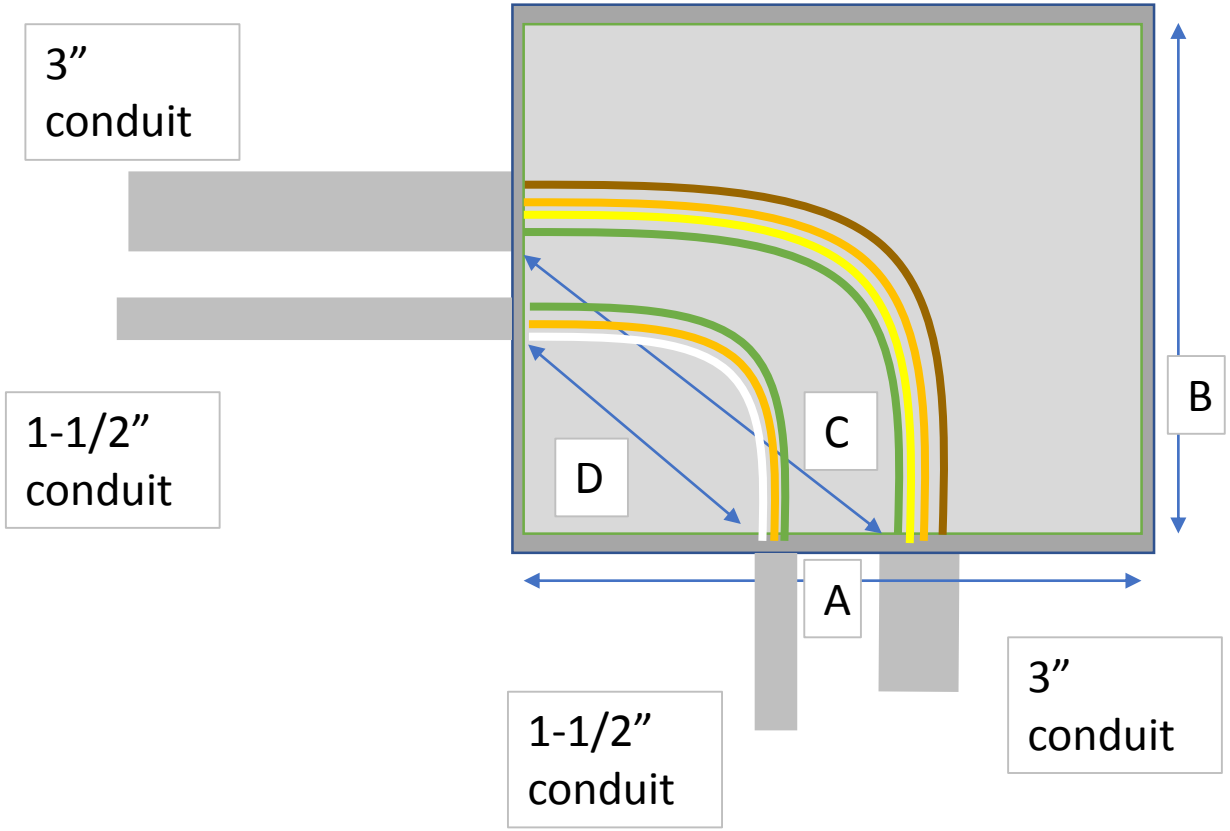
Angle or U Pulls, or Splices:
6 x largest raceway plus sum of diameters of each other raceway in same row.

What is the minimum dim for:
A? 4” x 6 = 24”
B? 4” x 6 = 24”
C? 4” x 6 = 24”



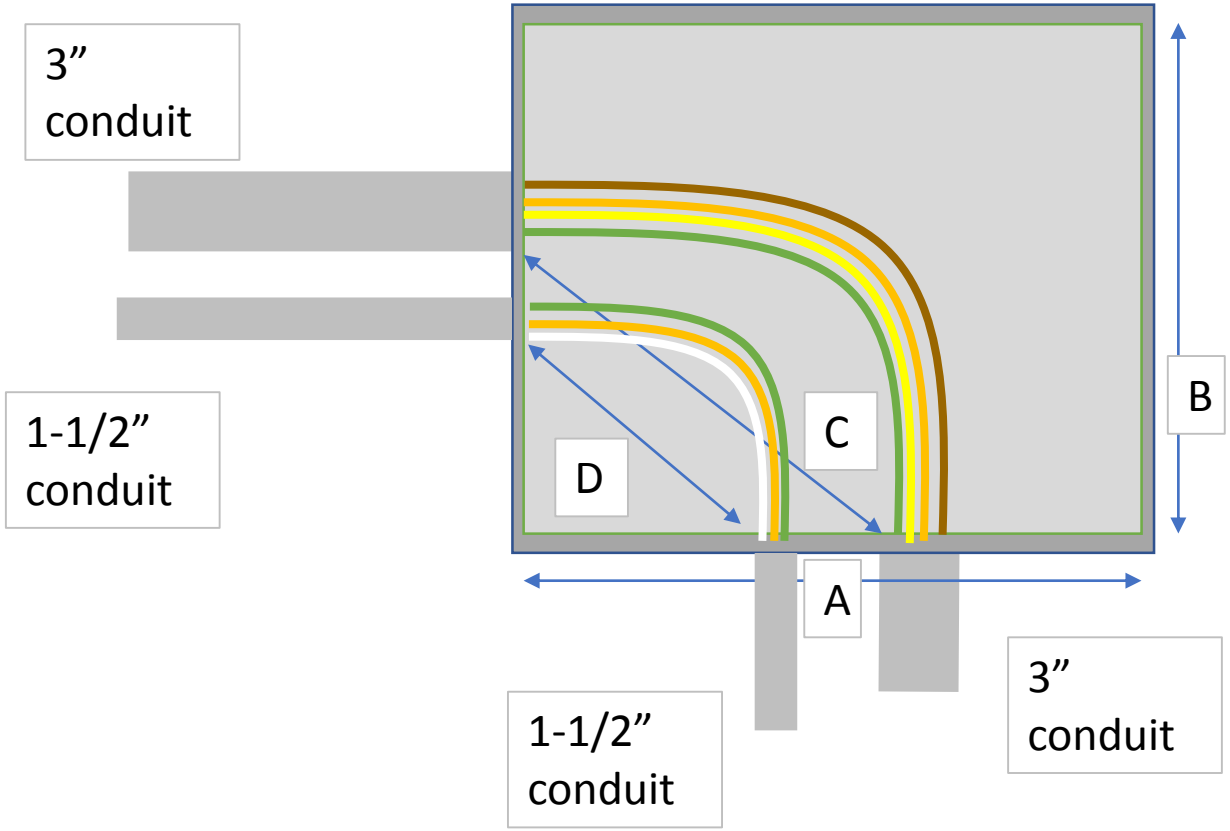
Angle or U Pulls, or Splices:
6 x largest raceway plus sum of diameters of each other raceway in same row.

What is the minimum dim for:
A?
B?
C?
D?



Angle or U Pulls, or Splices:
6 x largest raceway plus sum of diameters of each other raceway in same row.

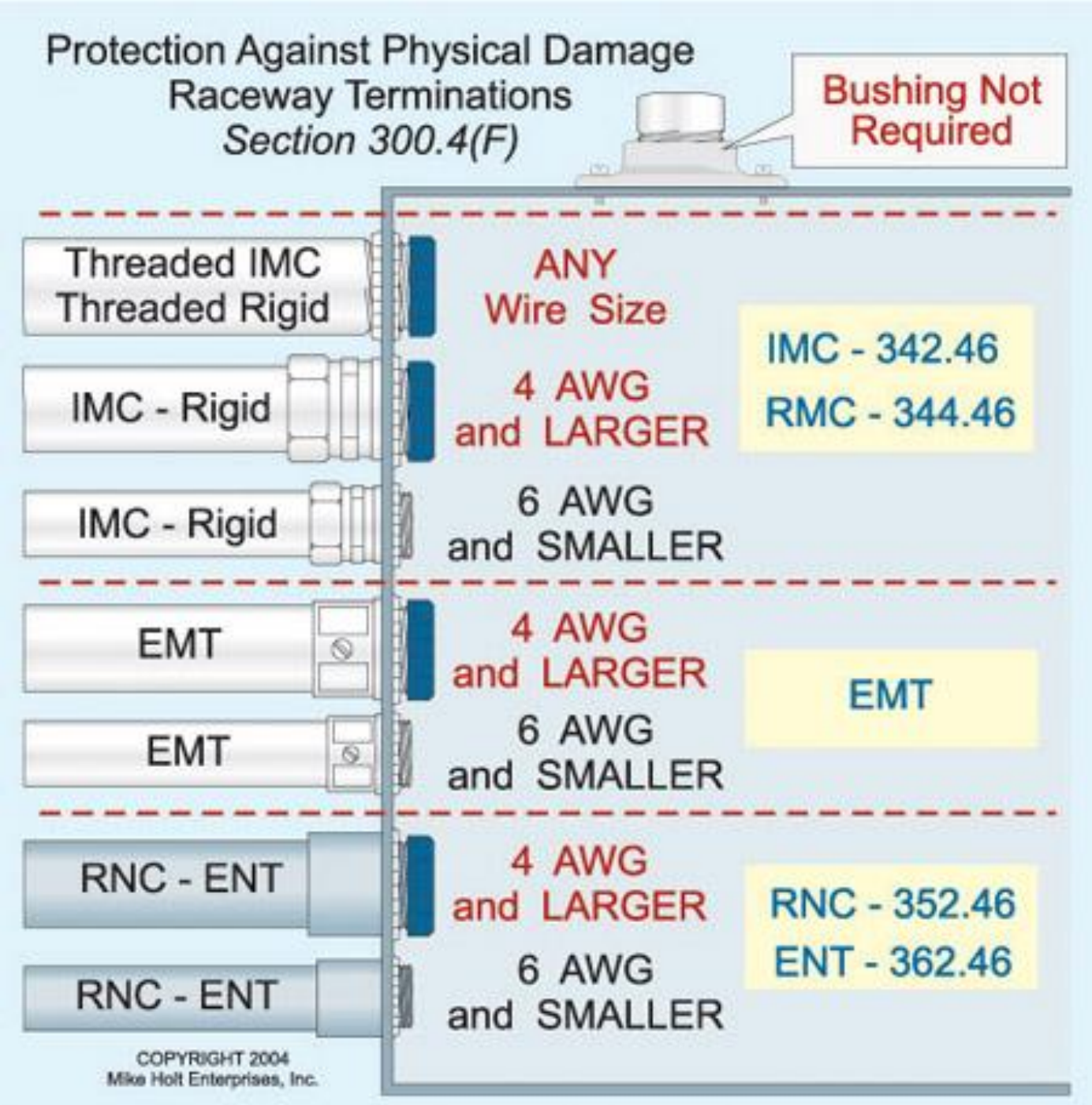
What is the minimum dim for:
A? 3” x 6 = 18” plus 1-1/2” = 19-1/2”
B? 3” x 6 = 18” plus 1-1/2” = 19-1/2”
C? 3” x 6 = 18”
D? 1-1/2” x 6 = 9”



What does 314.17(D) say?

Why is this often relevant to installation?

What does 300.4(G) say?


Protection Against Physical Damage
Raceway Terminations
Section 300.4(F)
Bushing Not Required
Threaded IMC
Threaded Rigid
ANY
Wire Size
IMC - Rigid
4 AWG
and LARGER
IMC - 342.46
RMC - 344.46
IMC - Rigid
6 AWG
and SMALLER
EMT
4 AWG
and LARGER
EMT
EMT
6 AWG
and SMALLER
RNC - ENT
4 AWG
and LARGER
RNC - 352.46
ENT - 362.46
RNC - ENT
6 AWG
and SMALLER
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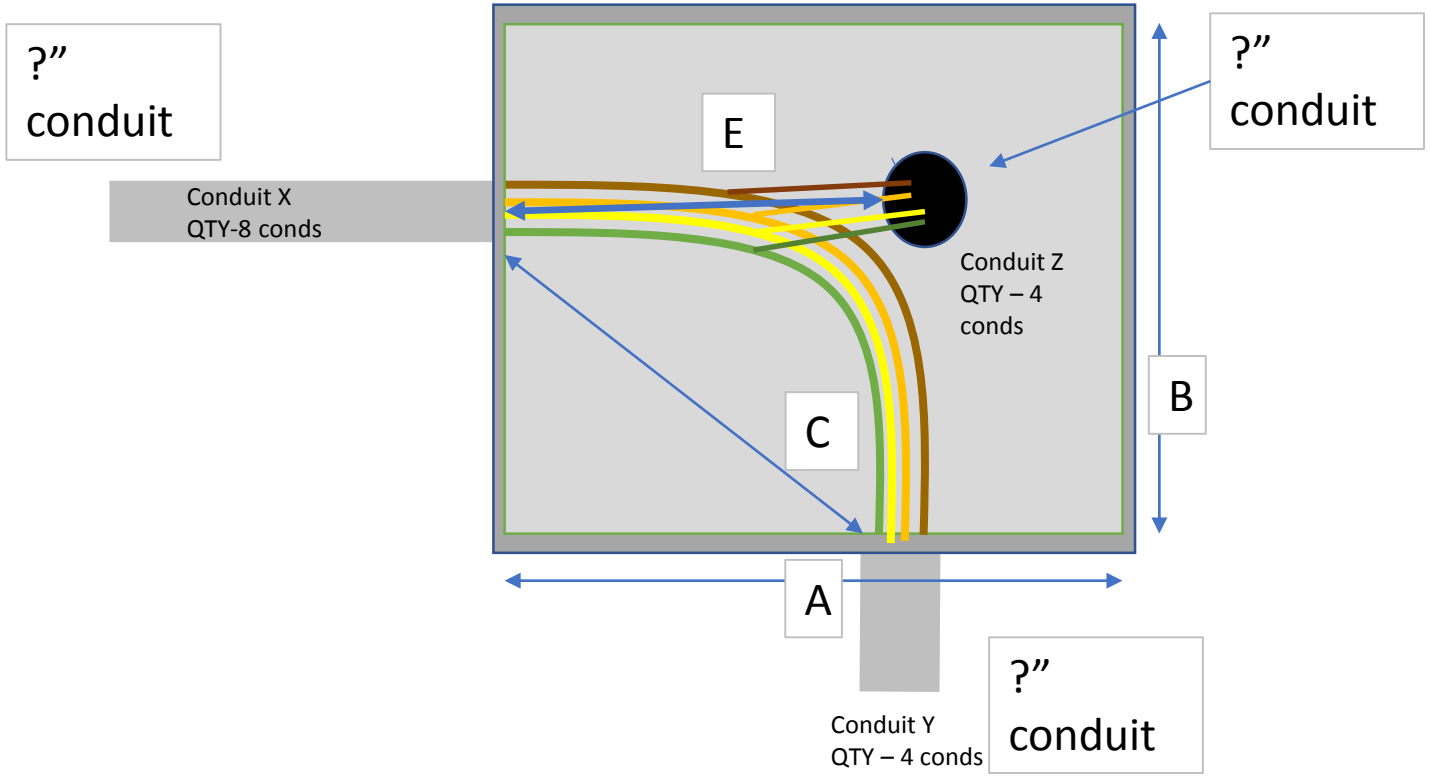
Angle or U Pulls, or Splices:
6 x largest raceway plus sum of diameters of each other raceway in same row.

First: What is the minimum size EMT conduits for Conduits X, Y, Z?
Assume 300 kcmil THHN for ungrounded conductors and #4 AWG THHN for EGCs.

Minimum Size Conduit:
X:
Y:
Z:



D

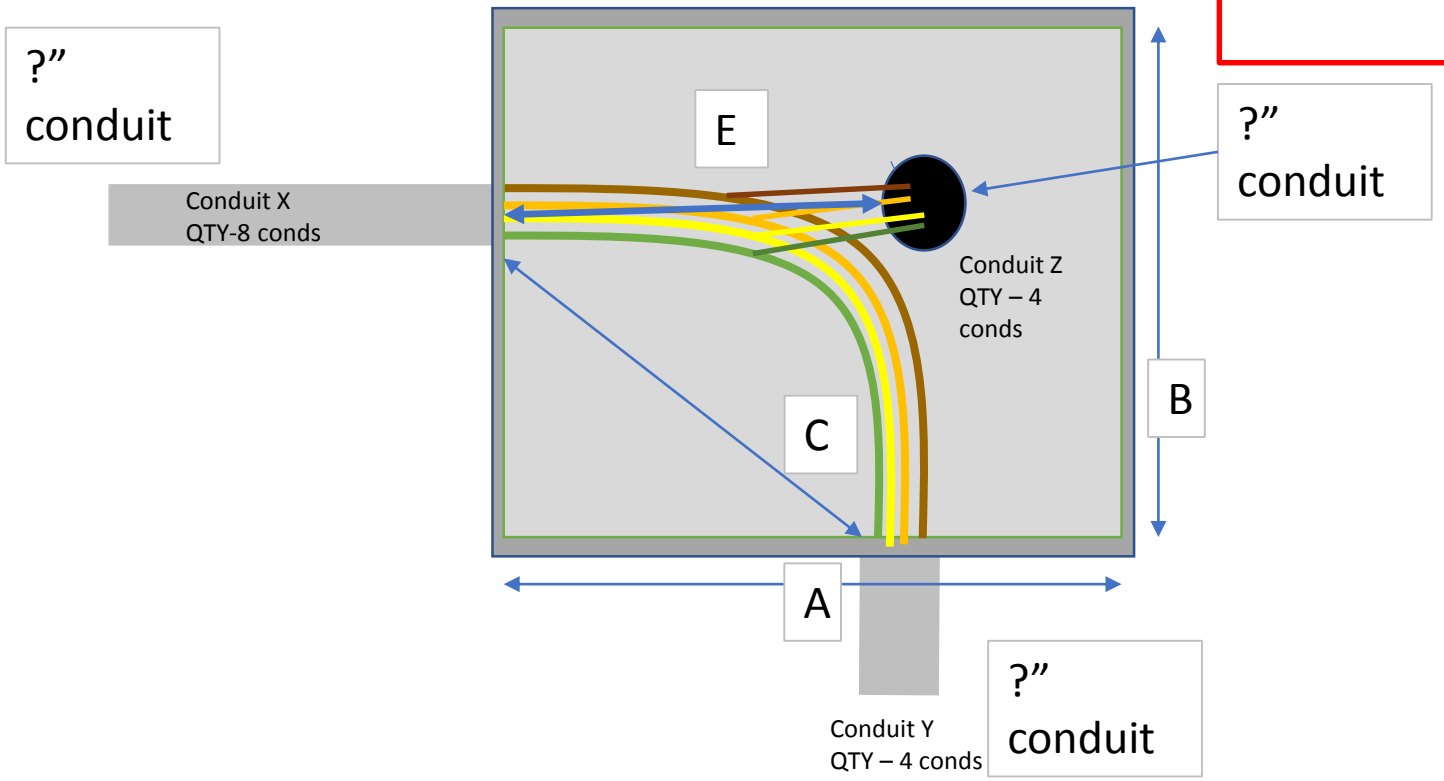
What is the minimum Depth required?

Angle or U Pulls, or Splices:
6 x largest raceway plus sum of diameters of each other raceway in same row.

First: What is the minimum size EMT conduits for Conduits X, Y, Z?

Assume 300 kcmil THHN for all grounded and ungrounded conductors and #4 AWG for EGCs

Minimum Size Conduit:
X: (6 x 0.4608 in^2) + (2 x 0.0824 in^2) = 2.9296 in^2
This CSA will fit into a 3" EMT at 40% = 3.538 in^2.

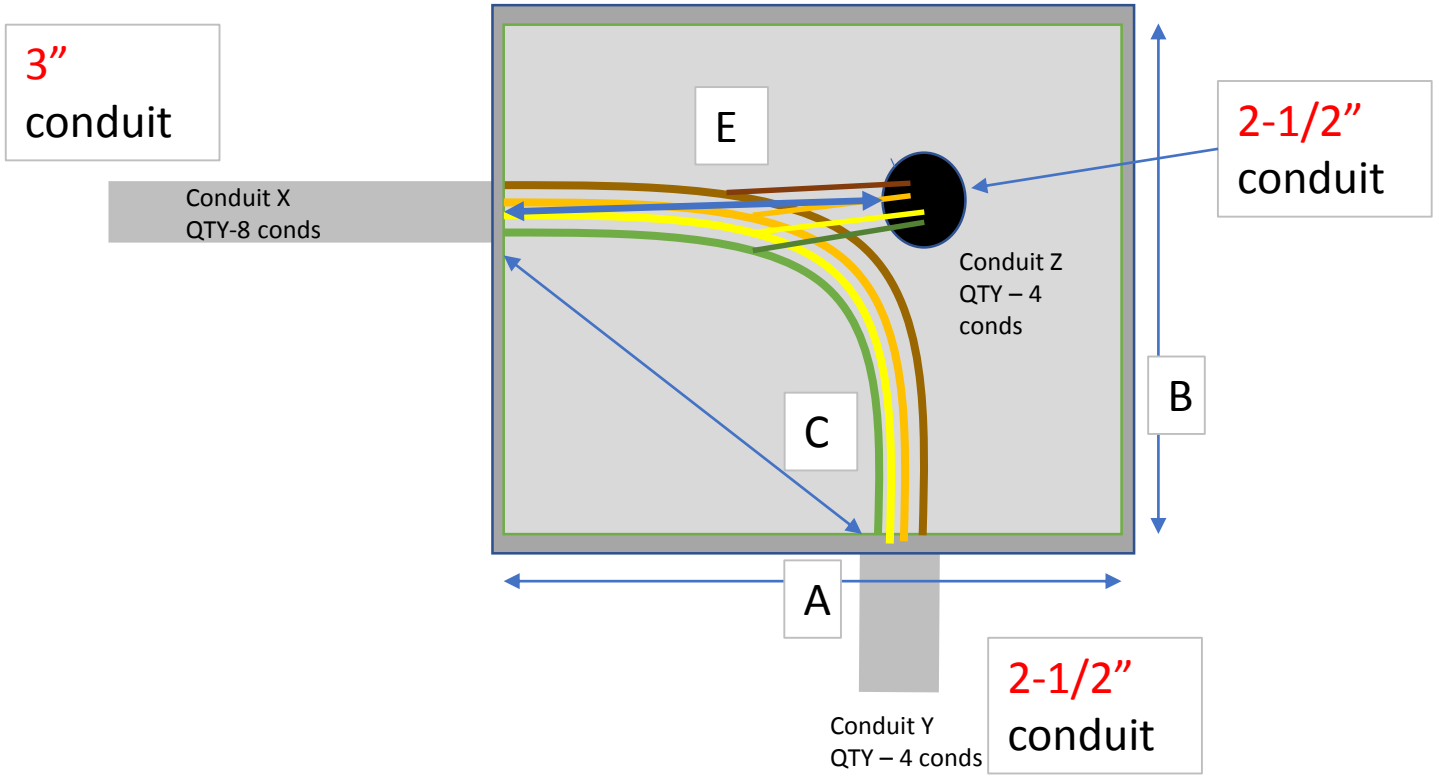


D

What is the minimum Depth required?

Angle or U Pulls, or Splices:
6 x largest raceway plus sum of diameters of each other raceway in same row.

Second: What is the minimum dims?
A: ?
B: ?
C: ?
E: ?

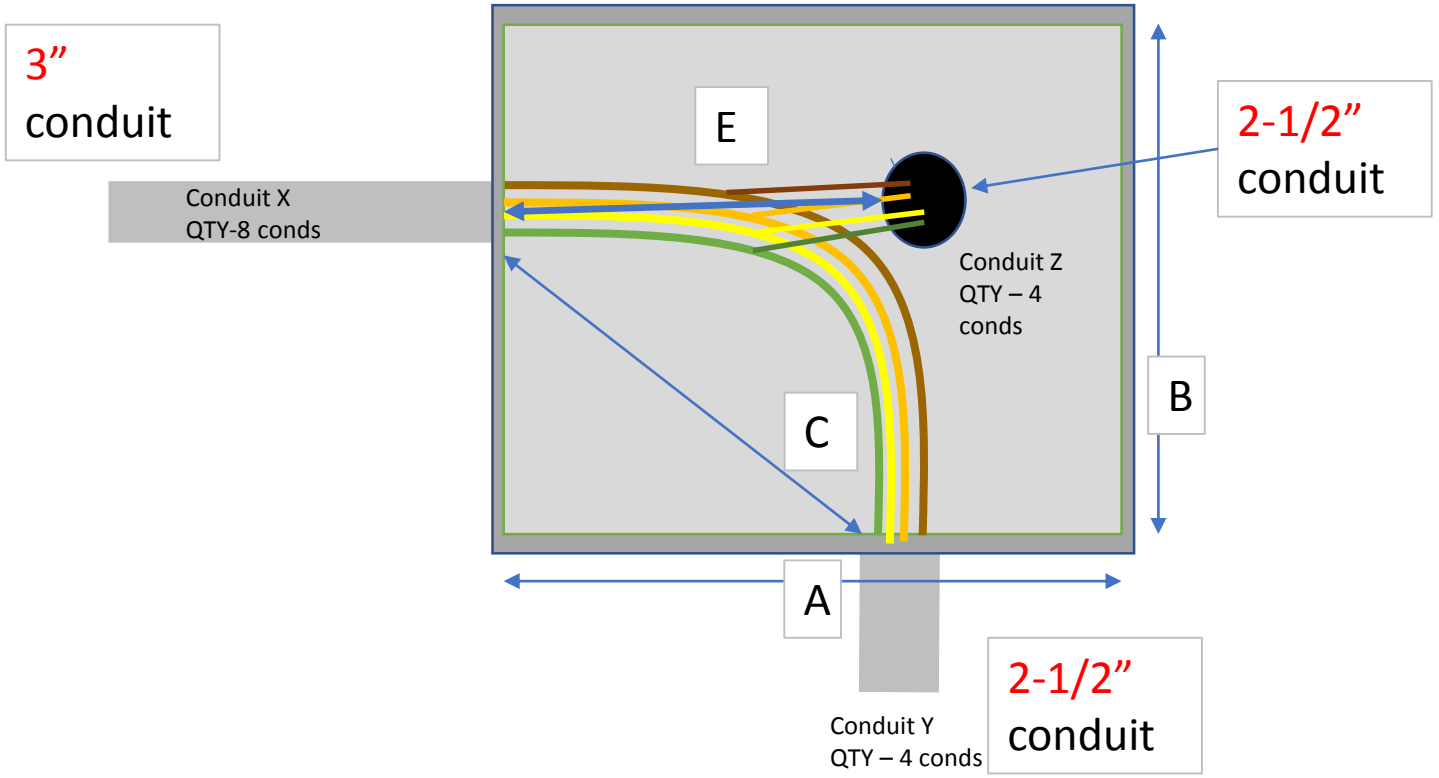


D

What is the minimum Depth required?

Angle or U Pulls, or Splices:
6 x largest raceway plus sum of diameters of each other raceway in same row.

Second: What is the minimum dims?
A: 3” x 6 = 18”
B: 2-1/2” x 6 = 15”
C: 3” x 6 = 18”
E: 3” x 6 = 18”

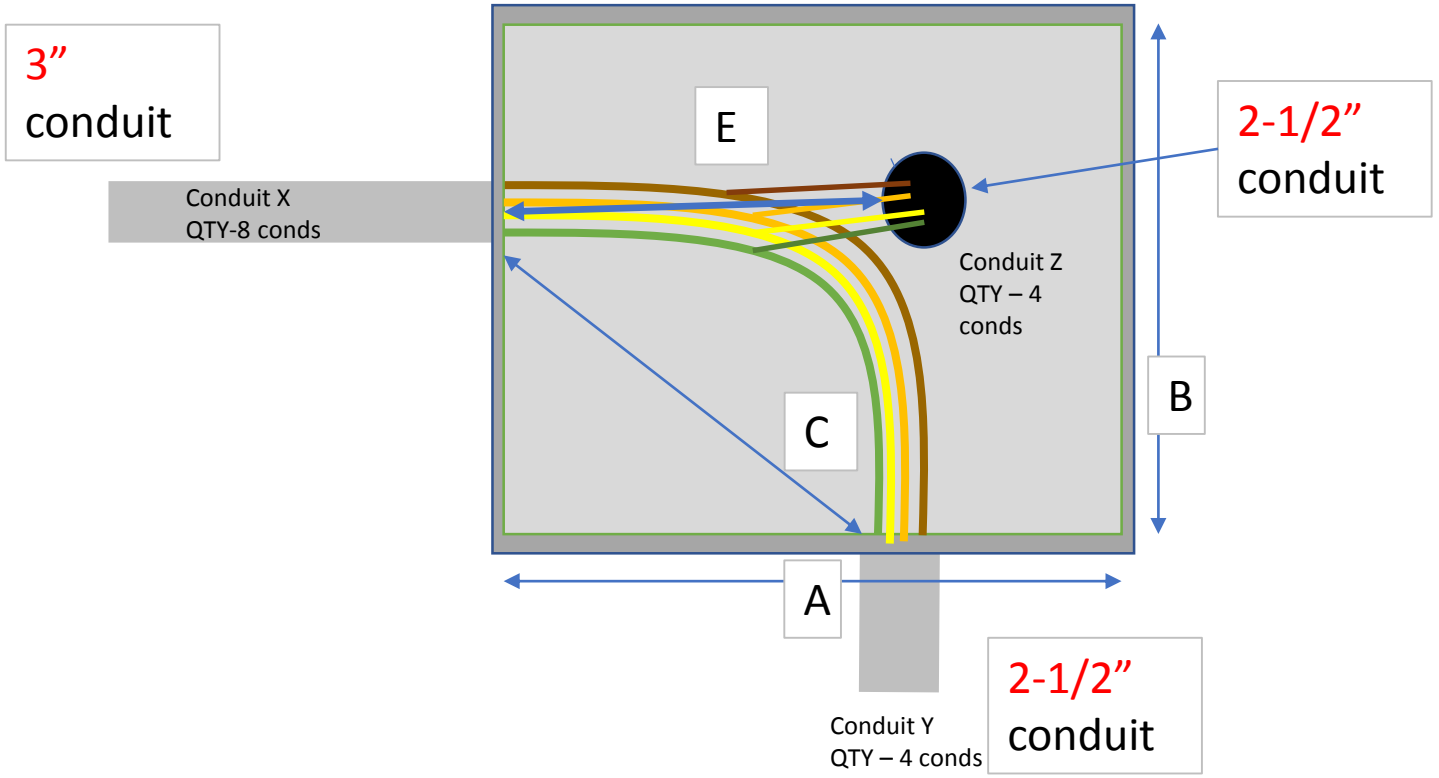


D

What is the minimum Depth required?

Angle or U Pulls, or Splices:
6 x largest raceway plus sum of diameters of each other raceway in same row.

Second: What is the minimum dims?
A: 3” x 6 = 18”
B: 2.5” x 6 = 15”
C: 3” x 6 = 18”
E: 3” x 6 = 18”
Third: Now what is D – Depth:

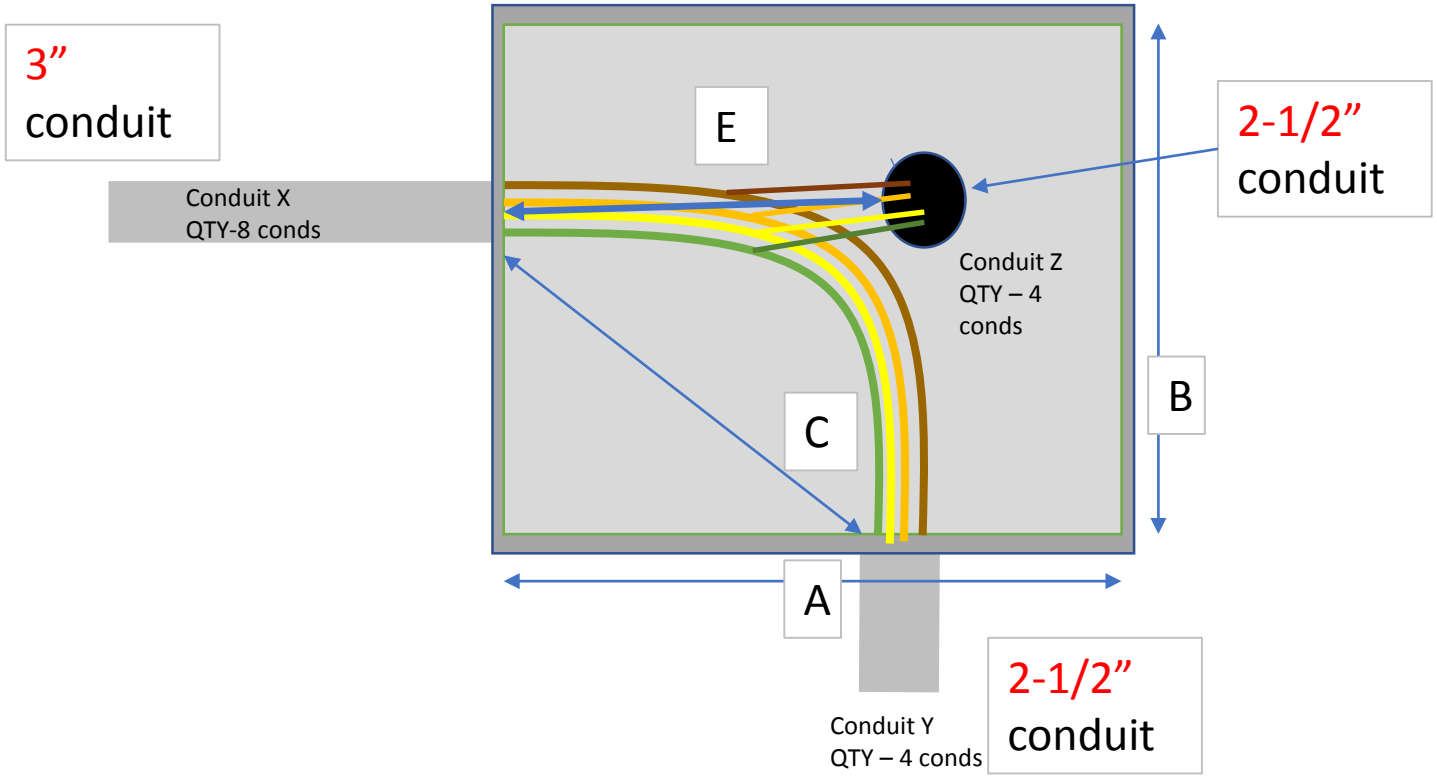


D

What is the minimum Depth required?

Angle or U Pulls, or Splices:
6 x largest raceway plus sum of diameters of each other raceway in same row.

What is the minimum dims?
A: 3” x 6 = 18”
B: 2.5” x 6 = 15”
C: 3” x 6 = 18”
E: 3” x 6 = 18”
Now what is D – Depth: from 312.6(A) = 5”

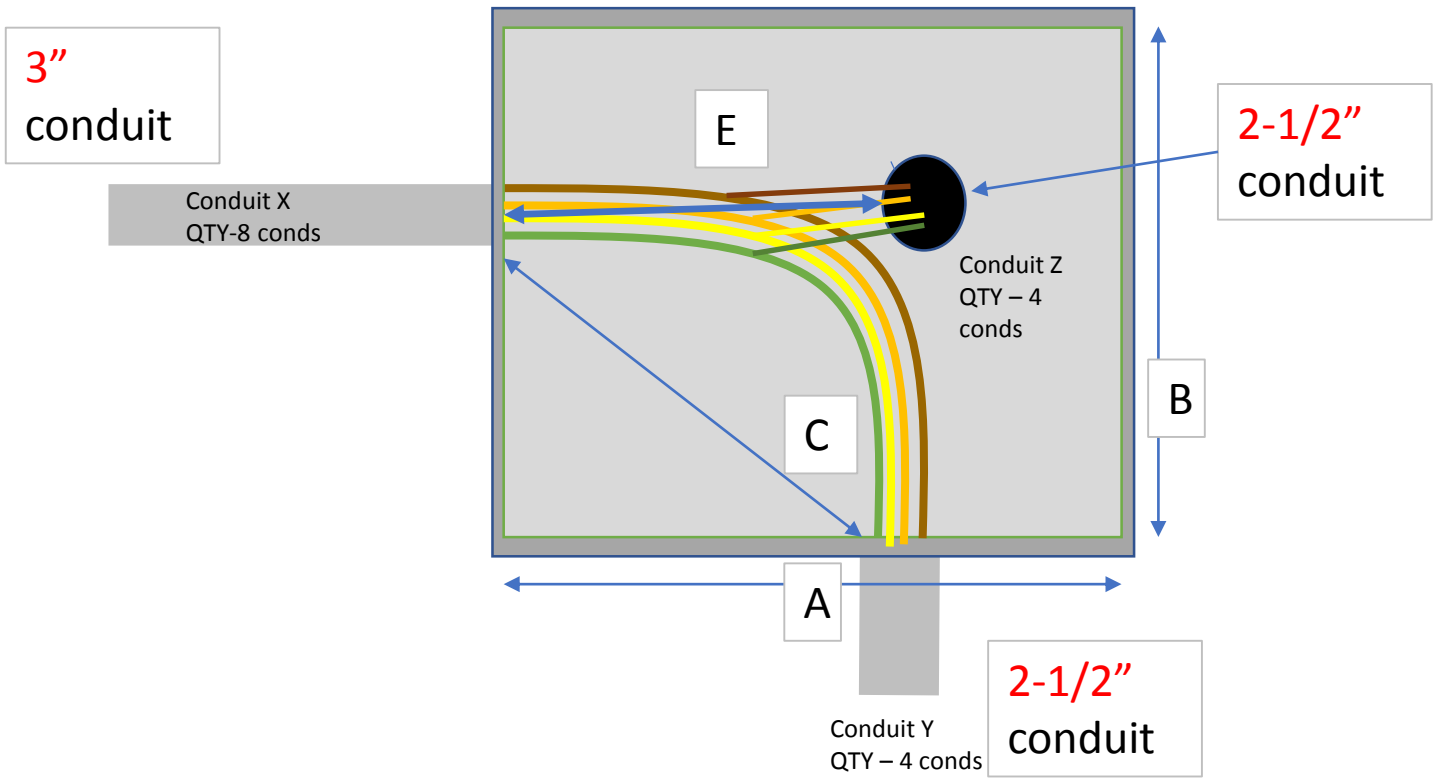


D

What is the minimum Depth required?

Angle or U Pulls, or Splices:
6 x largest raceway plus sum of diameters of each other raceway in same row.

What is the minimum dims?
A: 3” x 6 = 18”
B: 3” x 6 = 18”
C: 3” x 6 = 18”
E: 3” x 6 = 18”
Now what is D – Depth: from 312.6(A) = 5”

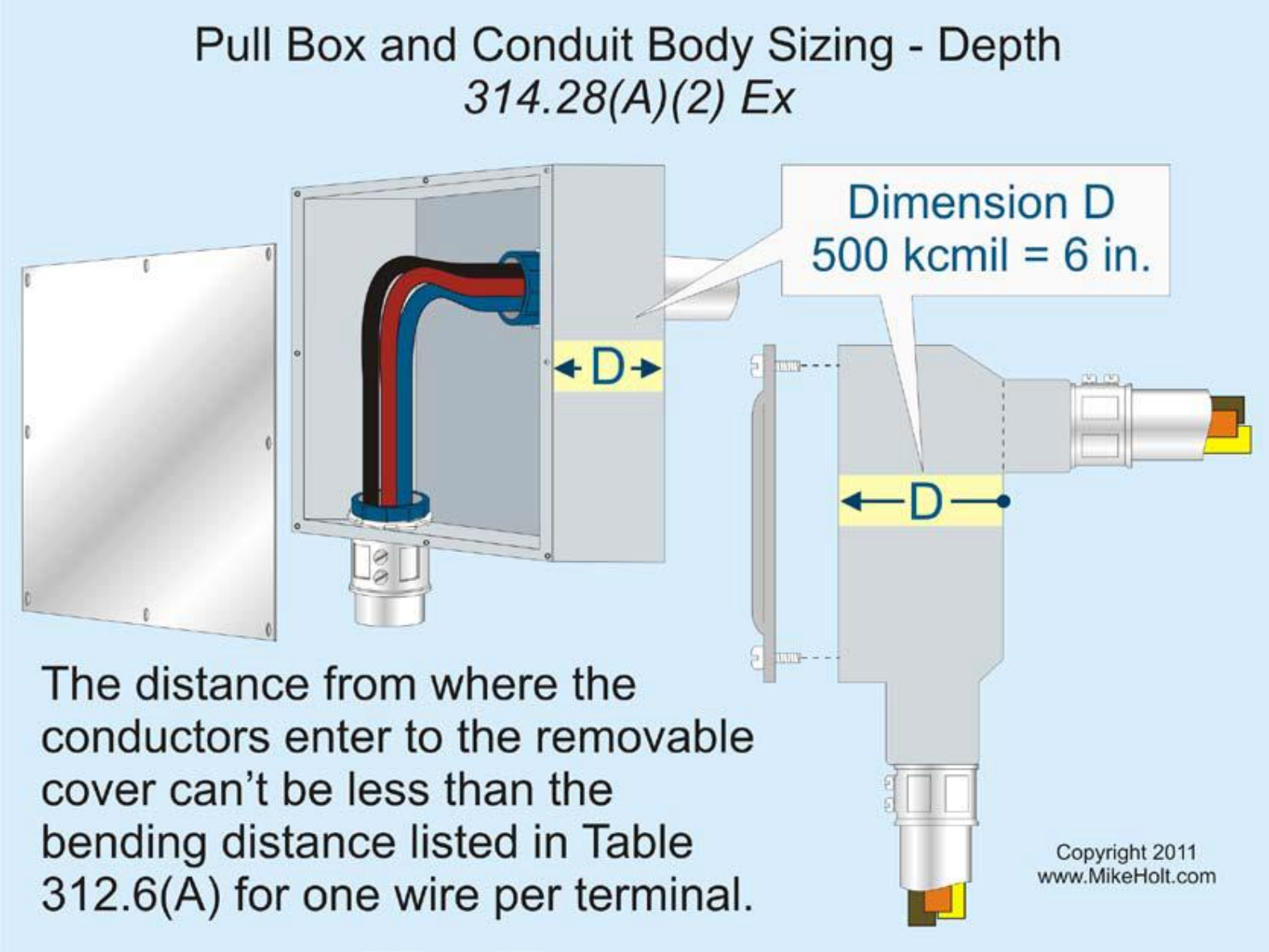


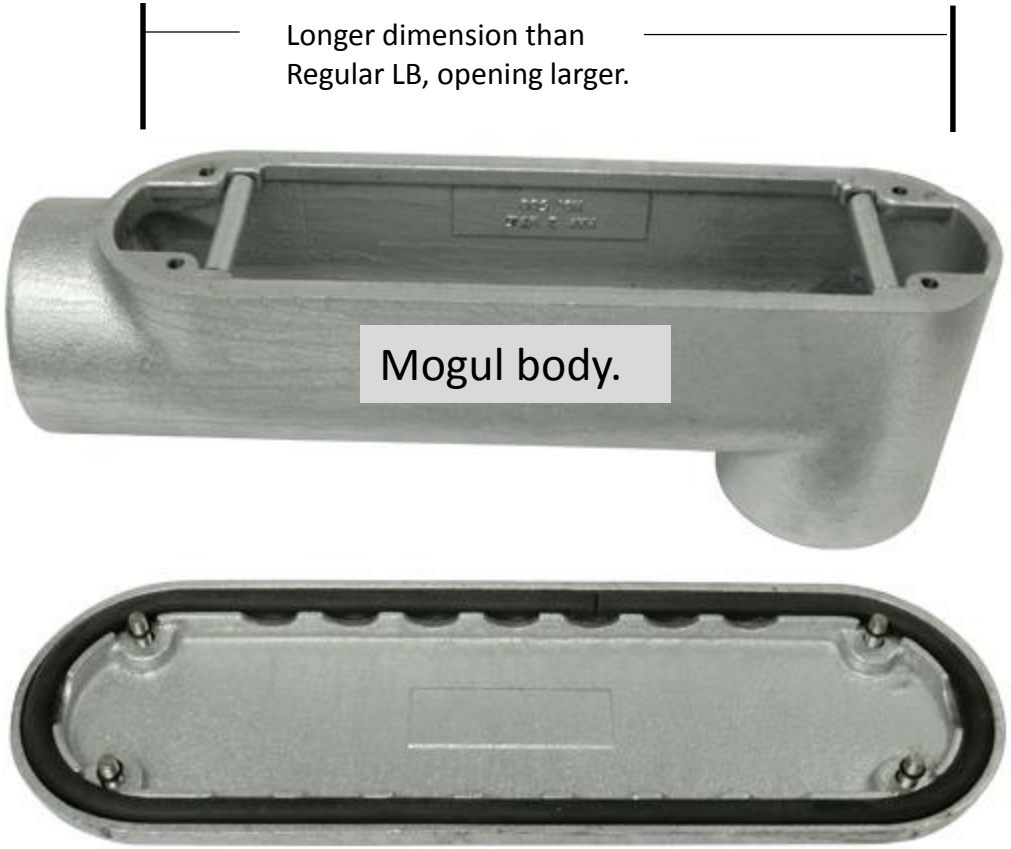
What size box will you need to purchase?
18 x 18 x 10
20 x 20 x 10
24 x 24 x 10
Also go to Hoffman Enclosure or Wiegmann.

D = 5”

What is the minimum Depth required?

The depth rule – opposite a removeable cover – also applies to conduit bodies.





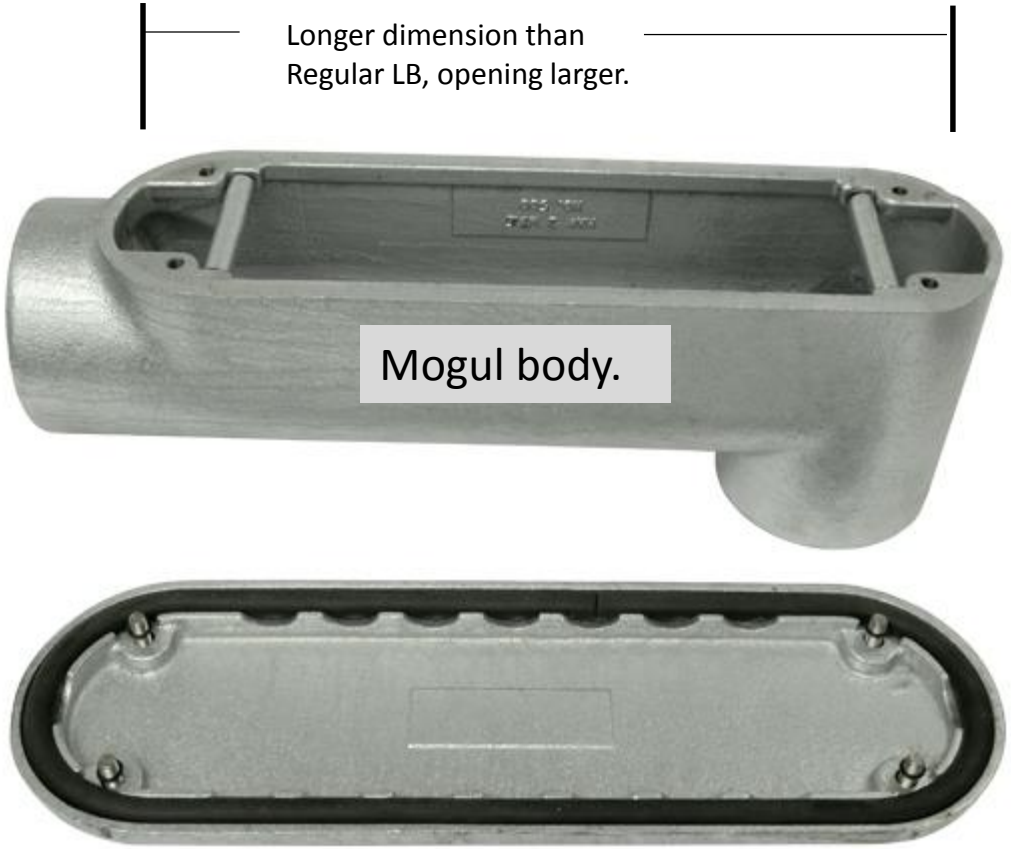
We have covered fill for:

1: Small Standard Boxes and Other Boxes

2. Small Conduit Bodies

3. Large Junction Boxes

NOW LARGE CONDUIT BODIES



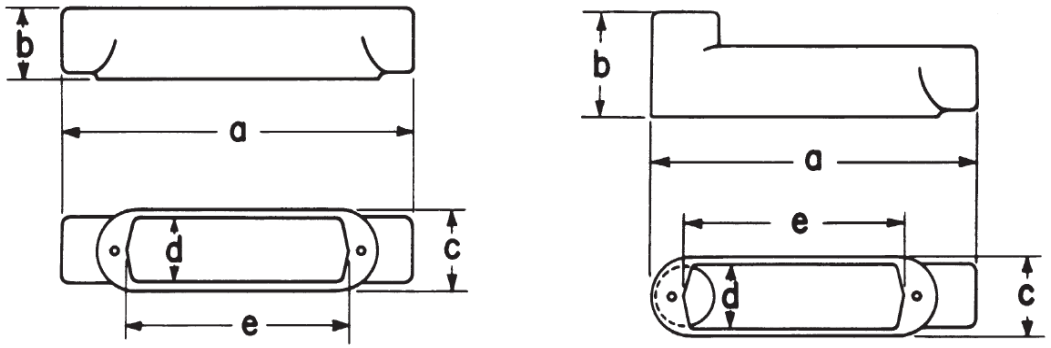
Let's parse all three sub-sections that apply to LARGE CONDUIT BODIES 314.28(A)(1), (2), (3).

If we try to firsts apply rules (A)(1) and (A)(2) which is what we are suppose to do, we will find even a larger mogul body will NOT satisfy the requirements of 314.28(A)(1) and (2).

So even a conduit body which is elongated (mogul) is still not big enough for the requirement of the first two sub-sections. Let's use the next couple of slides to prove this.

Dimensions

In Inches:



Mogul Series BC

Size	1	1¼	1½	2	2½	3	3½	4
a	9 9/16	9 9/16	13¾	13¾	18⅜	18⅜	23¾	23¾
b	1⅞	2 5/16	2 9/16	3⅛	3⅝	4⅜	4⅞	5⅜
c	2 3/16	2 3/16	3	3	4¼	4¼	5¼	5¼
d	1⅞	1⅞	2⅝	2⅝	3 13/16	3 13/16	4¾	4¾
e	6	6	10	10	15	15	20	20

Mogul Series BLB

Size	1	1¼	1½	2	2½	3	3½	4
a	8 19/32	8 19/32	12 11/16	12 11/16	16 29/32	16 29/32	22⅛	22⅛
b	2 27/32	3 9/32	3⅝	4 3/16	5 3/32	5 27/32	6½	7
c	2 3/16	2 3/16	3	3	4¼	4¼	5¼	5¼
d	1⅞	1⅞	2⅝	2⅝	3 13/16	3 13/16	4¾	4¾
e	6	6	10	10	15	15	20	20

Dimensions for Mogul body Cs and LBs (Cooper Crouse-Hinds cut sheet)

Consider a 4” conduit installed into a 4” C-style body.

This is a “straight pull”. So look at applying 314.28(A)(1)

This mogul body, which is already oversized – that’s what mogul means – is still not big enough.

4”x 8 = 32” However, the C-style for 4” has a total length of 23-3/4”. This is obviously shorter than 32”. Notice the actual opening is even smaller – at 20”

Consider 4” conduit into a 4” LB-style body.

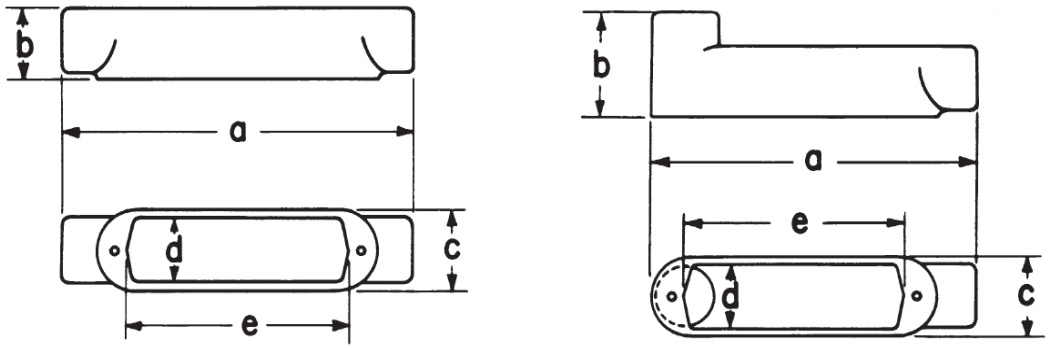
This is an “angle pull”. So look at applying 314.28(A)(2)

This mogul body, which is already oversized (at least in the “a” dimension).

4”x 6 = 24” But LB dim is 22-1/8””. Too short.
Of course the “b” dimension is even shorter and 314.28(A)(2) requires 4”x6 = 24” versus 7” on “b” dim.

Dimensions

In Inches:



BC BLB

Mogul Series BC

Size	1	1¼	1½	2	2½	3	3½	4
a	9 9/16	9 9/16	13¾	13¾	18⅜	18⅜	23¾	23¾
b	1⅞	2 5/16	2 9/16	3⅛	3⅝	4⅜	4⅞	5⅜
c	2 3/16	2 3/16	3	3	4¼	4¼	5¼	5¼
d	1⅞	1⅞	2⅝	2⅝	3 13/16	3 13/16	4¾	4¾
e	6	6	10	10	15	15	20	20

Mogul Series BLB

Size	1	1¼	1½	2	2½	3	3½	4
a	8 19/32	8 19/32	12 11/16	12 11/16	16 29/32	16 29/32	22⅛	22⅛
b	2 27/32	3 9/32	3⅝	4 3/16	5 3/32	5 27/32	6½	7
c	2 3/16	2 3/16	3	3	4¼	4¼	5¼	5¼
d	1⅞	1⅞	2⅝	2⅝	3 13/16	3 13/16	4¾	4¾
e	6	6	10	10	15	15	20	20

So even <u>mogul</u> body fittings will not meet the size requirements in 314.28(A)(1) and (2)!

Dimensions for Mogul body Cs and LBs (Cooper Crouse-Hinds cut sheet)

Consider a 4” conduit installed into a 4” C-style body.

This is a “straight pull”. So look at applying 314.28(A)(1)

This mogul body, which is already oversized – that’s what mogul means – is still not big enough.

4”x 8 = 32” However, the C-style for 4” has a total length of 23-3/4”. This is obviously shorter than 32”. Notice the actual opening is even smaller – at 20”

Consider 4” conduit into a 4” LB-style body.

This is an “angle pull”. So look at applying 314.28(A)(2)

This mogul body, which is already oversized (at least in the “a” dimension).

4”x 6 = 24” But LB dim is 22-1/8””. Too short.
Of course the “b” dimension is even shorter and 314.28(A)(2) requires 4”x6 = 24” versus 7” on “b” dim.

So even <u>mogul</u> body fittings will not meet the size requirements in 314.28(A)(1) and (2)!

This means, for large conduit bodies …

LARGE CONDUIT BODIES = holding #4 and larger conductors

… we must refer to ***314.28(A)(3) Smaller Dimensions.***

GET IT? This is because we are using conduit bodies with SMALLER DIMENSIONS than required in (A)(1) and (A)(2) and we are using these because manufacturers do not make massive conduit bodies which will satisfy (A)(1) and (A)(2)

So now
Let's look closely at the sub-section
314.28(A)(3) Smaller Dimensions.

There are three paragraphs … let's break them down.

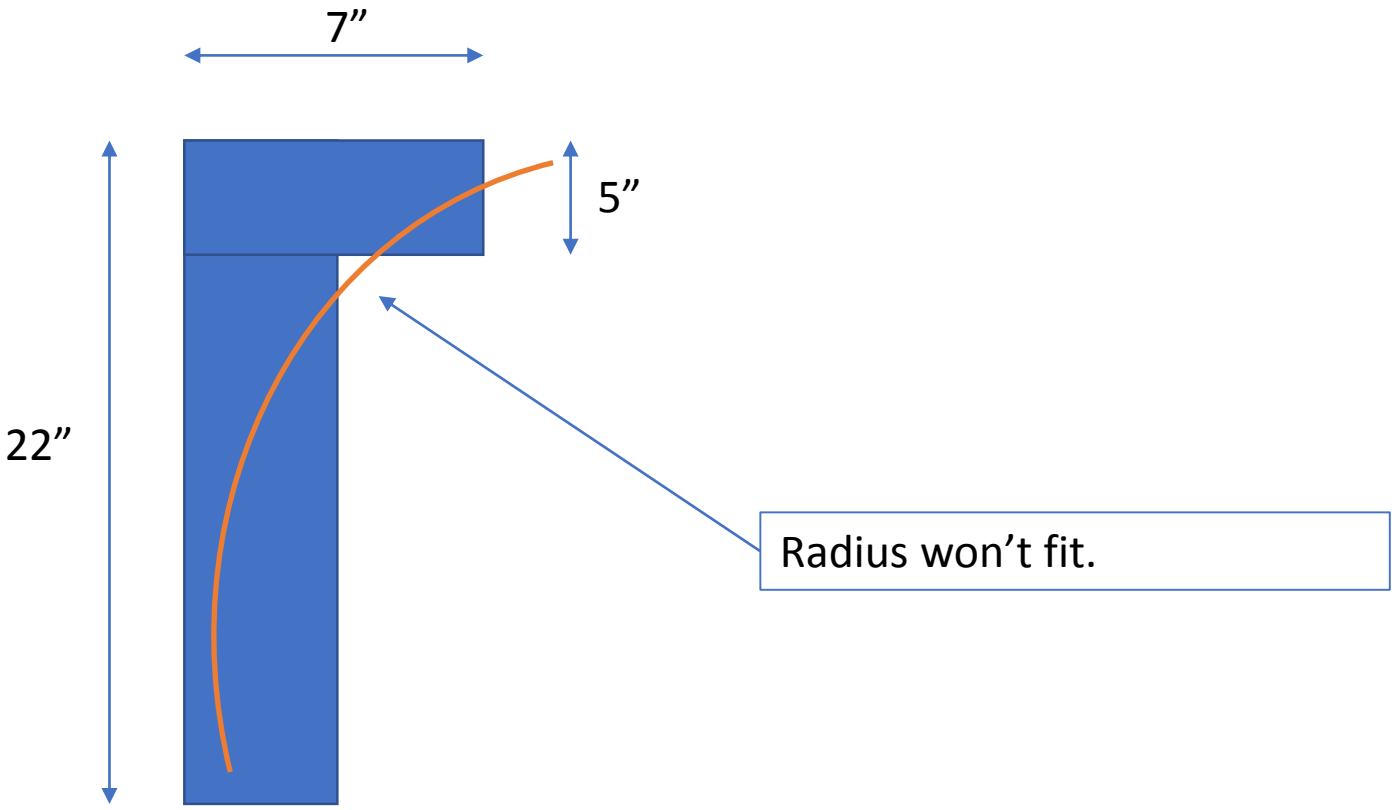
Paragraph 1: This simply says, if you are going to use a conduit body that has smaller dimensions than required in (A)(1) and (A)(2), then the conductors cannot exceed the conduit fill from Chapter 9, Table 1 for the conduit being used with the conduit body. **This is sort of stating the obvious.**

So now
Let's look closely at
314.28(A)(3) Smaller Dimensions.

There are three paragraphs … let's break them down.

Paragraph 2: This refers to a special conduit body that meets the radius requirements listed in Chapter 9, Table 2. For example, for a 4" conduit, the smallest radius would be 16". This means the wire, as it travels through the conduit body, cannot be turned sharper than a 16" radius AND if the conduit body meets the requirements of Chapter 9, Table 2, then it must be marked to show it meets this requirement. This is a RARE animal.

Exercise: Use the dims from the Cooper C-H cut sheet in previous slide to draw two rectangles. Rectangle One: 22" x 5". Then overlay another Rectangle Two that is 7" x 5". These two rectangles will closely simulate the 4" LB mogul body. Then draw a 16" radius. Will this radius sweep through this fitting simulated by the rectangle?
(See next slide for more detail).


7”
5”
22”
Radius won’t fit.

So now
Let's look closely at
314.28(A)(3) Smaller Dimensions.

There are three paragraphs … let's break them down.

Paragraph 2: This refers to a special conduit body that meets the radius requirements listed in Chapter 9, Table 2. For example, for a 4" conduit, the smallest radius would be 16". This means the wire, as it travels through the conduit body, it cannot be turned sharper than a 16" radius. AND, if the conduit body meets the requirements of Chapter 9, Table 2, then it must be marked to show it meets this requirement. RARE.

So Paragraph 2 is rare and almost never applicable in real-life.

So now
Let's look closely at
314.28(A)(3) Smaller Dimensions.

There are three paragraphs … let's break them down.

Paragraph 3: This is the paragraph that matters for real-life installations.

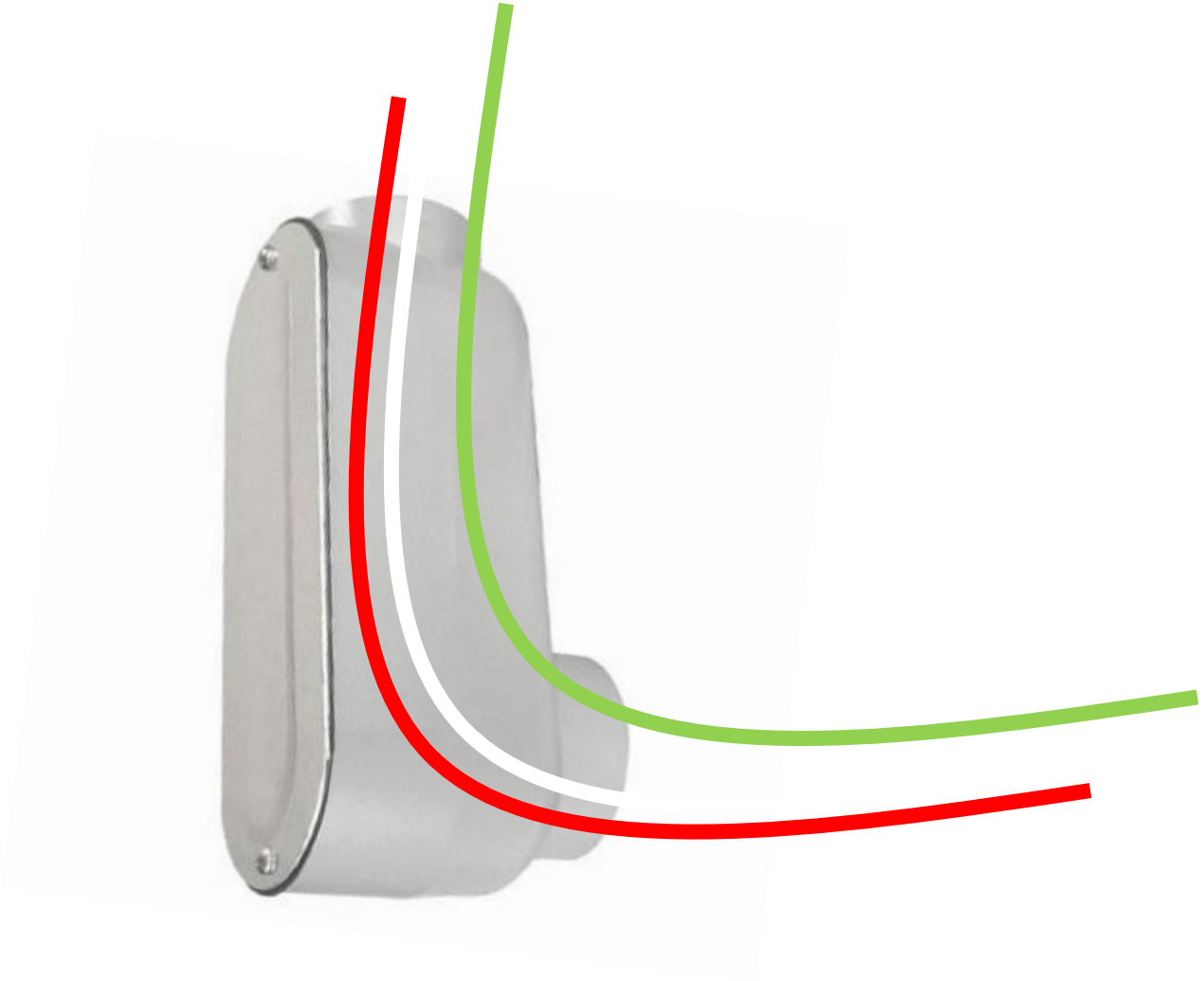
This paragraph says where the conduit body is marked with a max volume indicating the size and number of conductors which will be less than the max fill required in Chapter 9, Table 1 (31%-two wires, 40%-two or more wires, 53%-one wire) then use the max conductor marking as the capacity.

A 4" LB may have the following mark: 3 #400 MCM MAX

This means I must know what type of conductor was used to determine that three #400 MCMs maxed out the fitting. Manufacturers use XHHW conductors, per UL 514C, to test for maximum fill. To determine maximum fill use Chapter 9, Table 5 for #400 kcmil. The total CSA for three #400 kcmil conductors is equal to the max fill for this fitting. The CSA for a single 400 MCM XHHW conductor is 0.5782 in^2.
Whatever you want to put into this body must be equal or less than 3 x 0.5782 in^2.

MCM = kcmil … see next slide for details
CSA = cross sectional area.

Conduit Bodies - Fill



FIT / NOT FIT?
(Assume RMC. Assume THHN.)

1” conduit with a 1” LB.
12.20 Cu In.
Max. 3 #4 AWG

Wire size = (3) #4 AWG

Conduit Bodies - Fill

FIT / NOT FIT?
(Assume RMC. Assume THHN.)

1” conduit with a 1” LB.
12.20 Cu In.
Max. 3 #4

Wire size = (3) #4 AWG and a (1) #4 ground.

Conduit Bodies - Fill

FIT / NOT FIT?
(Assume RMC. Assume THHN.)

NO. The (1) #4 ground puts the fill over the capacity for the LB.

1” conduit with a 1” LB.
12.20 Cu In.
Max. 3 #4

Wire size = (3) #4 AWG and a (1) #4 ground.

So now
Let’s look closely at
314.28(A)(3) Smaller Dimensions.

The max volume fill for some conduit bodies is stamped with wire size as say, Max 3 #250 MCM.

MCM stands for:
M = 1000 (based on Roman numeral for 1000)
C= circular
M = mils

So MCM = kcmil. These both mean 1000 circular mils.

MCM is the “old way” to say kcmils.

The prefix “k” in kcmils also means 1000 (from the Greek word “kilo” meaning 1000).

Recall a circular mil is a circle with a diameter of 0.001”.

LB Conduit Body

One of the most common mistakes I see in the field: L<u>arge conduit bodies exceeding capacity.</u>

LB Conduit Body

314.28 (A)(3) … last paragraph
Relevant UL Standard: UL 514C (max conductor marking is based on XHHW conductors).

Take a 4” LB marked for a MAXIMUM 3 #400 MCM. Can you put 3 #350MCM and 1 #1/0 in this LB? Assume the wire you are installing is typical dual rated THHN/THWN-2.

LB Conduit Body

314.28 (A)(3) … last paragraph
UL 514C (max conductor marking is based on XHHW)

So let's say a 4" LB is marked for a MAXIMUM 3 #400 MCM. Can you put 3 #350MCM and 1 #1/0 in this LB? Assume the wire you are installing is typical dual rated THHN/THWN-2.

First find total area of 3 #400 MCM XHHW: 3 x 0.5782 in^2 = 1.7346 in^2
(we used XHHW because that is what manufacturer used to determine max)

Now find CSA for THHN/THWN-2: 3 x 0.5242 in^2 + 0.1855 in^2 = 1.7581 in^2 … WILL NOT FIT.
(we used THHN/THWN-2 because this is what we typically – 99.5% of time – install in the field.)

LB Conduit Body

314.28 (A)(3) … last paragraph
UL 514C (max conductor marking is based on XHHW)

So let's say a 3" LB is marked for a MAXIMUM 3 #300 MCM. Can you put 3 #250MCM and 1 #2 AWG in this LB? Assume your wire is typical dual rated THHN/THWN-2.

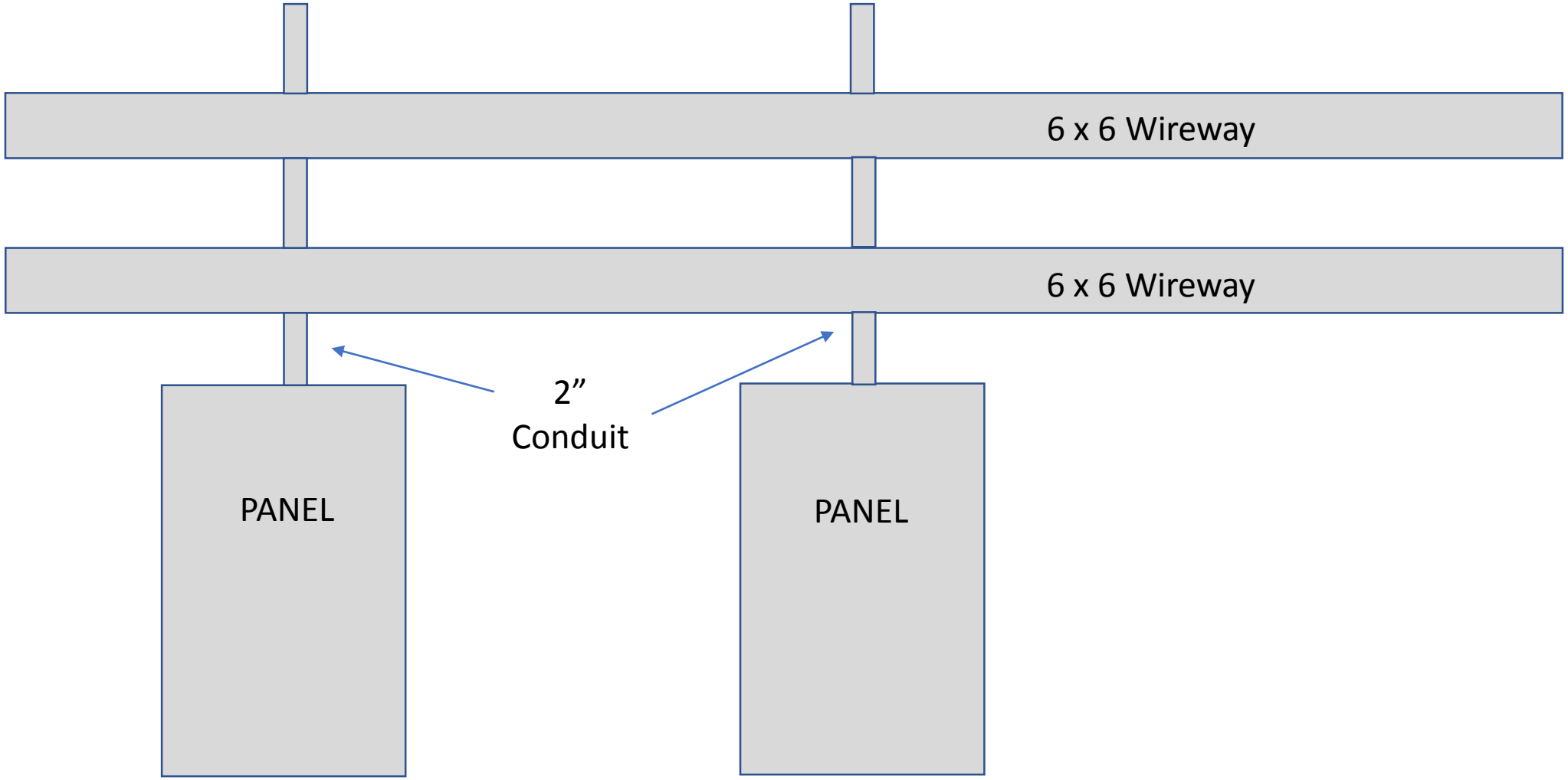
LB Conduit Body

314.28 (A)(3) … last paragraph
UL 514C (max conductor marking is based on XHHW)

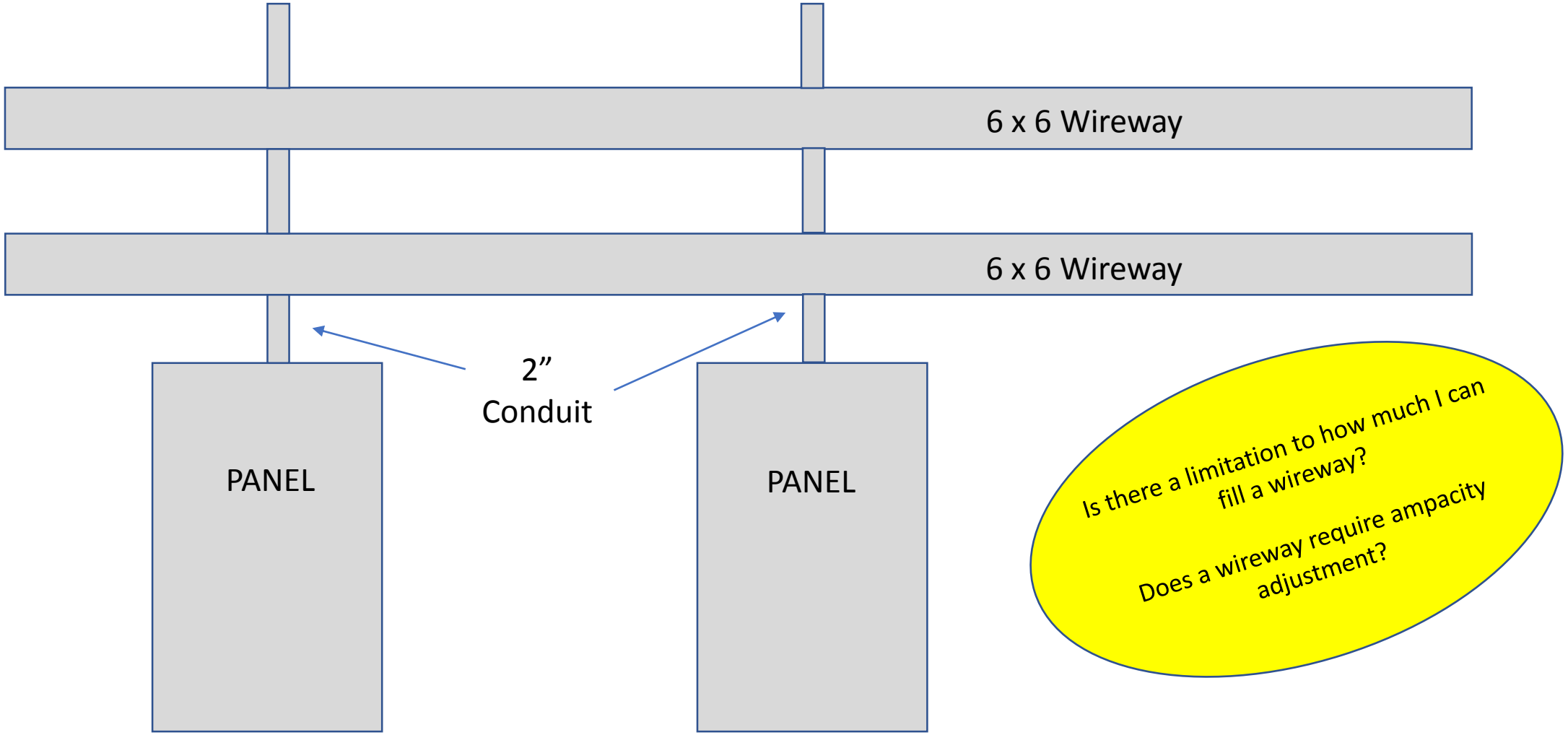
So let's say a 3" LB is marked for a MAXIMUM 3 #300 MCM. Can you put 3 #250MCM and 1 #2 AWG in this LB? Assume your wire is typical dual rated THHN/THWN-2.

First find total area of 3 #300 MCM XHHW: 3 x 0.4536 in^2 = 1.3608 in^2
(we used XHHW because that is what manufacturer used to determine max)

Now find CSA for THHN/THWN-2: 3 x 0.3970 in^2 + 0.1158 in^2 = 1.3068 in^2 … WILL FIT.
(we used THHN/THWN-2 because this is what we typically – 99.5% of time – install in the field.)

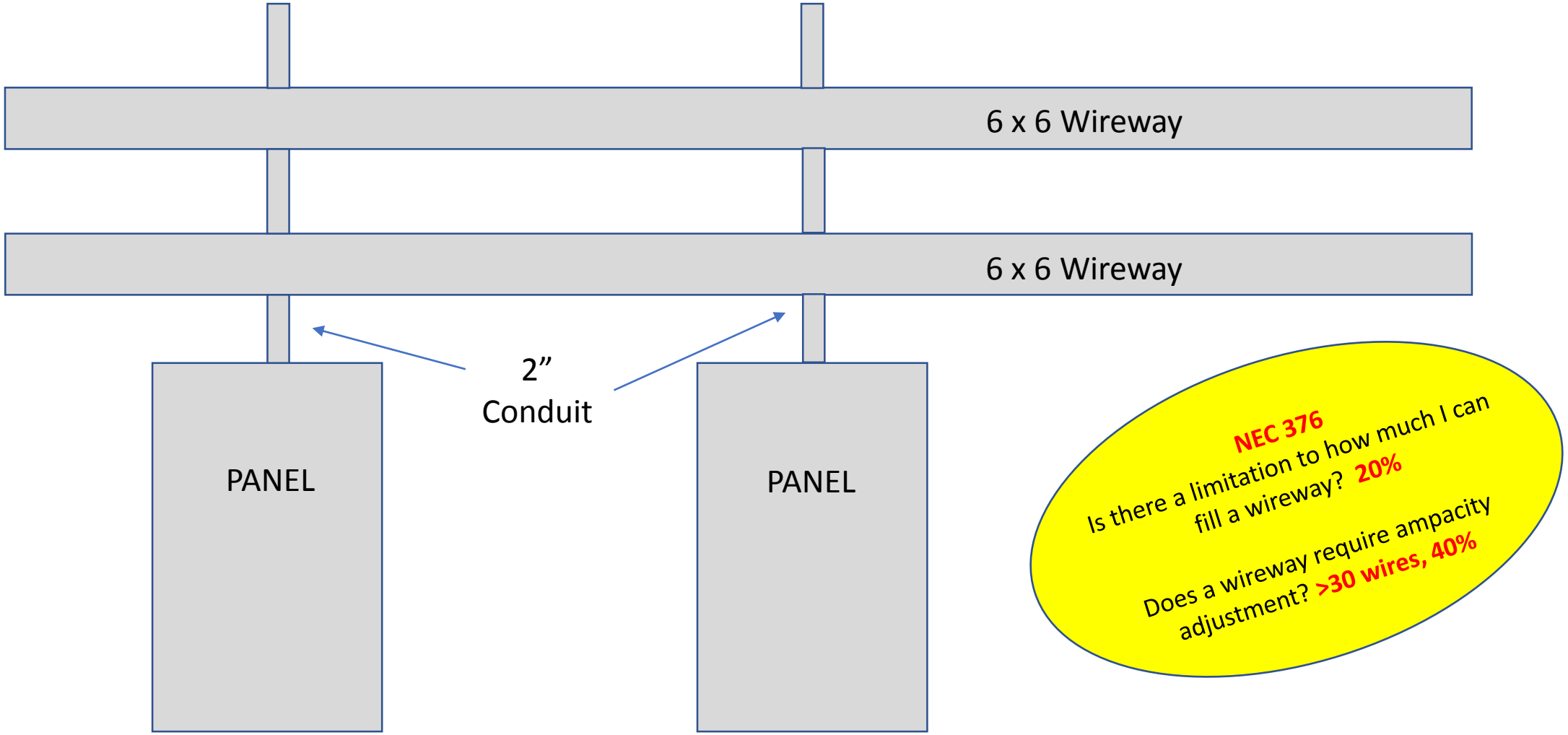


For example, in a Kroger electric room…
Why are we permitted to stack 6x6 troughs (wireways) with 2” conduit and not violate 314.28?
The feeders for the panels will be larger than #4 AWG and 2” x 8 = 16” … much more than a 6” trough.



Why are we permitted to stack 6x6 troughs (wireways) with 2” conduit and not violate 314.28?

You must ask the AHJ first. He will typically let you do this provided you pull straight through the troughs – do NOT use them as a pulling point for the feeders.



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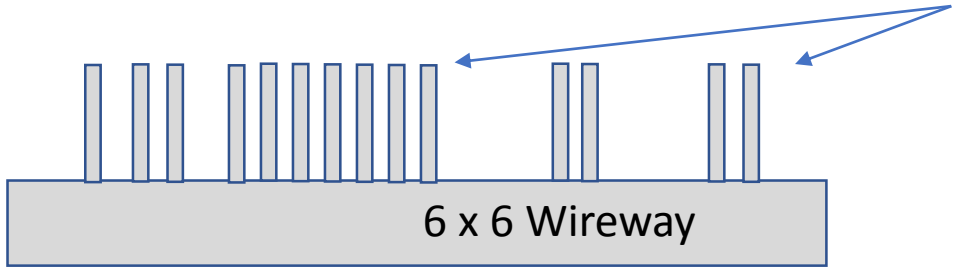


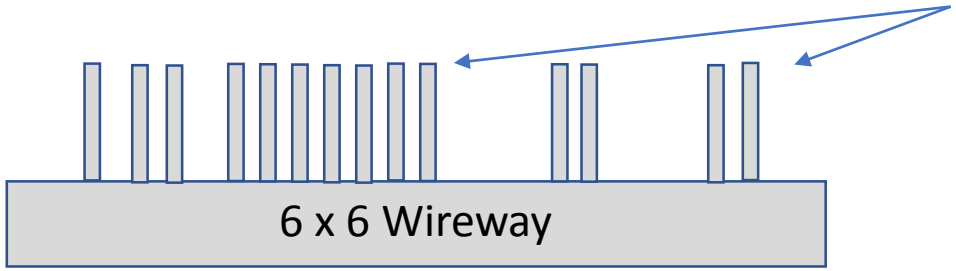
(14) 1” conduits all in the same row.

NEC 376

Is there a limitation to how much I can fill a wireway? **20%**

Does a wireway require ampacity adjustment? **>30 wires, 40%**

For example, trough (wireway) over sales floor in a Kroger,
Why are we permitted to run (14) 1” conduits, all in the same row, into a 6x6 wireway?
Doesn’t this violate 314.28?



(14) 1” conduits all in the same row.

NEC 376

Is there a limitation to how much I can fill a wireway? **20%**

Does a wireway require ampacity adjustment? **>30 wires, 40%**

Why are we permitted to run (14) 1” conduits, all in the same row, into a 6x6 wireway?
Doesn’t this violate 314.28?

NO – the wire in these 1” conduits will be #6 and smaller.
But I still have to adhere to NEC 376 for wireway fill and ampacity adjustment.

WHEN CONDUCTORS ARE <u>#6 AND SMALLER</u>
– STAY IN 314.16

WHEN CONDUCTORS ARE <u>#4 AND LARGER</u>
– GO TO 314.28