

Sizing Raceway—Part 1

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For most contractors, sizing conduit, tubing, and raceway is almost second nature. But depending on the number and type of wires you're pulling, this task becomes more challenging. The NEC rule on sizing wires is simple. Basically, Sec. 300-17 says the number of conductors in a raceway cannot exceed what you can install or withdraw without damaging the conductors or conductor insulation.

You can meet this requirement by limiting the total area of all of the conductors so they do not exceed the percentage of the cross-sectional area of the raceway as listed in Table 1 of Chapter 9 of the NEC (Fig. 1). Remember: Equipment-grounding or bonding conductors also occupy space within a raceway, so you must include them when calculating raceway fill [Note 3 to Table 1, Chapter 9].

The cross-sectional area of a raceway is dependent on the raceway's diameter. You can find conduit dimensions and percent area of conduit and tubing fill area in Table 4 of Chapter 9.

When installing conductors in a raceway, consider the length of the conductors and the number of raceway bends [Table 1, Fine Print Note 1]. Although there is no maximum raceway length, the NEC states a raceway may not contain more than 360° of total bends between raceway terminations (Fig. 2).

Appendix C includes tables that identify the number of conductors permitted in a raceway in accordance with Table 1 of Chapter 9. However, Appendix C is only useful if all of the conductors are the same size and have the same insulation. Let's take a look at a few examples for clarification.

Number of Conductors	Percent Fill
One conductor or cable	53% ¹
Two conductors	31%
Three or more conductors	40%
Raceway 24 in. or less (i.e. nipples)	60% ²

¹ A multi-conductor cable is treated as a single conductor when calculating percentage conduit fill area. For cables that have elliptical cross sections, the cross-sectional area calculation shall be based on using the major diameter of the ellipse as a circle diameter [Table 1, Note 9].

² Raceways having a maximum length not to exceed 24 in. [Table 1, Note 4].

Table. Chapter 9, Table 1.

Conductor Fill - Percent of Raceway Area Permitted
Chapter 9, Table 1

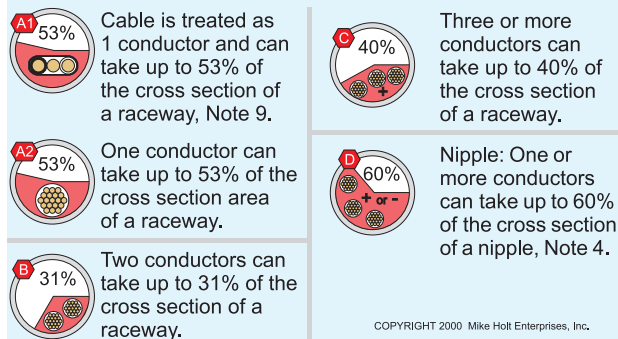


Fig. 1. Conductor fill—percent of raceway area permitted.

Maximum Number (Degrees) of Bends - 360°

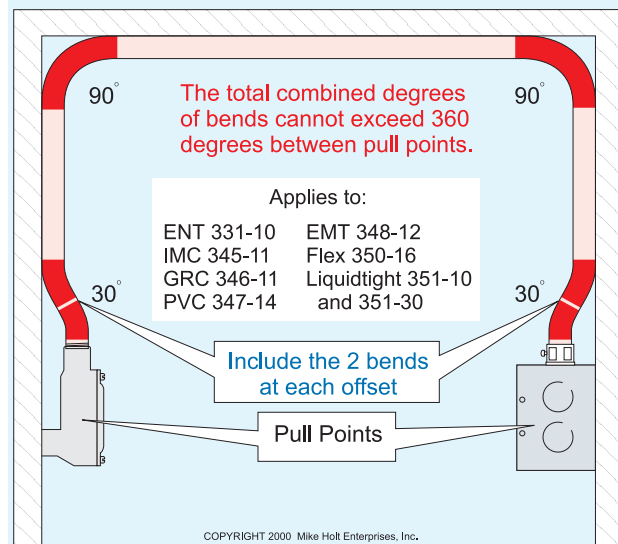


Fig. 2. Total combined degrees of bends.

Example No. 1:

Q. How many No. 12 THHN conductors can you install in 1-in. electrical metallic tubing (EMT)?
(a) 26 (b) 16 (c) 13 (d) 19

A. The answer is (a), 26 conductors. You get this answer directly from Table C1 in Appendix C.

Example No. 2:

Q. How many No. 18 TFFN fixture wires can you install in a 3/4-in. liquidtight flexible metallic conduit?
(a) 40 (b) 26 (c) 30 (d) 39

A. The answer is (d), 39. This answer comes directly from Table C7 in Appendix C.

Determining Raceway Size
Chapter 9, Tables 4 and 5

Schedule 40 PVC Raceway Size ?

Determine the raceway size for these conductors.

Determine the total cross sectional area of the conductors, Chapter 9, Table 5.

1- 500 kcmil THHN = $0.7073 \text{ in.}^2 \times 3 \text{ conductors} = 2.1219 \text{ in.}^2$
 1- 250 kcmil THHN = $0.3970 \text{ in.}^2 \times 1 \text{ conductor} = 0.3970 \text{ in.}^2$
 1- No. 3 THHN = $0.0973 \text{ in.}^2 \times 1 \text{ conductor} = 0.0973 \text{ in.}^2$
 Total area of the conductors = 2.6162 in.^2

Size Raceway at 40% Fill - Chapter 9, Table 4

3 in. raceway required at 2.907 in.²

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Fig. 3. Determining raceway size.

When the conductors you want to install in a raceway are not the same size and/or do not have the same insulation, use these steps to size the raceway:

Step 1: Determine the cross-sectional area for “each conductor.”

- Refer to Table 5, Chapter 9 for insulated conductors.
- Refer to Table 8, Chapter 9 for bare conductors [Note 3, Table 1].

Step 2: Determine the total cross-sectional area for “all conductors” by summing the cross-sectional area for each individual conductor.

Step 3: Size the raceway based on the percent fill as listed in Table 1 of Chapter 9: 40% for three or more conductors; 60% for raceways 24 in. or less in length (i.e. nipples) [Note 4, Table 1].

Let’s look at another example to clarify these steps.

Example No. 3:

Q. If someone installs a 400A feeder in schedule 40 rigid nonmetallic conduit. This raceway contains three 500 kcmil THHN conductors, one 250 kcmil THHN grounded (neutral) conductor, and one No. 3 THHN equipment-grounding conductor. What size raceway do these conductors require (**Fig. 3**)?

- (a) 2 in. (b) 2½ in. (c) 3 in. (d) 3½ in.

A. The answer is (c), 3 in.

Step 1: Determine cross-sectional area of each conductor by referring to Table 5, Chapter 9.

500 kcmil THHN = $.7073 \text{ sq in.}$

250 kcmil THHN = $.3970 \text{ sq in.}$

No. 3 THHN = $.0973 \text{ sq in.}$

Step 2: Determine the total cross-sectional area for all conductors.

500 kcmil THHN = $.7073 \text{ sq in.} \times 3 \text{ wires} = 2.1219 \text{ sq in.}$

Sizing Raceway Nipple
Chapter 9, Tables 4 and 5

Rigid Metal Nipple Size ?

3- No. 3/0 THHN Feeders
1- No. 1 THHN Neutral
1- No. 6 THHN Ground

Determine the nipple size for these conductors.

Determine the total cross sectional area of all the conductors, Chapter 9, Table 5:

1- No. 3/0 THHN = $0.2679 \text{ in.}^2 \times 3 \text{ conductors} = 0.8037 \text{ in.}^2$
 1- No. 1 THHN = $0.1562 \text{ in.}^2 \times 1 \text{ conductor} = 0.1562 \text{ in.}^2$
 1- No. 6 THHN = $0.0507 \text{ in.}^2 \times 1 \text{ conductor} = 0.0507 \text{ in.}^2$
 Total area of the conductors = 1.0106 in.^2

Size Nipple at 60% Fill - Chapter 9, Table 4 [Table 1, Note 4]

1¼ in. nipple = $1.526 \times 0.6 = 0.9156 \text{ in.}^2$, too small
1½ in. nipple = $2.071 \times 0.6 = 1.2426 \text{ in.}^2$, just right
 2 in. nipple = $3.408 \times 0.6 = 2.0448 \text{ in.}^2$, too big

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Fig. 4. Sizing raceway nipple.

250 kcmil THHN = $.3970 \text{ sq in.} \times 1 \text{ wire} = 0.3970 \text{ sq in.}$

No. 3 THHN = $.0973 \text{ sq in.} \times 1 \text{ wire} = 0.0973 \text{ sq in.}$
 2.6162 sq in.

Step 3: Size the raceway at 40% fill per Table 4, Chapter 9.

3 in. Schedule 40 PVC = 2.907 sq in.

Example No. 4:

Q. What size rigid metal nipple do you need for three No. 3/0 THHN conductors, one No. 1 THHN grounded (neutral) conductor, and one No. 6 THHN equipment-grounding conductor (**Fig. 4**)?

- (a) 1 in. (b) 1¼ in. (c) 1½ in. (d) 2 in.

A. The answer is (c), 1½-in. nipple

Step 1: Determine cross-sectional area of each conductor by referring to Table 5, Chapter 9.

No. 3/0 THHN = 0.2679 sq in.

No. 1 THHN = 0.1562 sq in.

No. 6 THHN = 0.0507 sq in.

Step 2: Determine the total cross-sectional area for all conductors.

No. 3/0 THHN = $0.2679 \text{ sq in.} \times 3 \text{ wires} = 0.8037 \text{ sq in.}$

No. 1 THHN = $0.1562 \text{ sq in.} \times 1 \text{ wire} = 0.1562 \text{ sq in.}$

No. 6 THHN = $0.0507 \text{ sq in.} \times 1 \text{ wire} = 0.0507 \text{ sq in.}$

1.0106 sq in.

Step 3: Size the nipple at 60% fill [Note 4, Table 1] per Table 4, Chapter 9.

1¼-in. nipple = $1.526 \times 0.6 = 0.9156 \text{ sq in.}$ (too small)

1½-in. nipple = $2.071 \times 0.6 = 1.2426 \text{ sq in.}$ (just right)

2-in. nipple = $3.408 \times 0.6 = 2.0448 \text{ sq in.}$ (too big)