UNIT

5

RACEWAY AND BOX CALCULATIONS

Introduction to Unit 5—Raceway and Box Calculations

Anyone who's ever pulled wire into a raceway probably understands the reason to have limits on the wire fill for raceways. Trying to pull too many conductors into a raceway can damage conductor insulation due to the friction and abrasion doing so causes. We've all heard the joke about tying a wire-pulling rope onto the hitch of the service truck and putting it in four-wheel drive.

Chapter 9, Table 1 in the *NEC* provides limits for wire fill in terms of the maximum percentage(s) of a raceway's interior cross-sectional area. This unit explains those limits and provides instruction regarding the use of the associated tables in Chapter 9 to calculate conductor fill. How to use the tables in Annex C when the conductors in the raceway are the same size (total cross-sectional area including insulation) is also covered.

Conductor intolerance results from disregarding the limits on the radius of bends required for making transitions to and from a wireway, and the number of conductors and splices allowed.

The *Code* also provides a limit to the number of conductors allowed in outlet boxes, based on Table 314.16(A). This limit is often joked about as being the "maximum number of conductors that can be installed in the outlet box while using the persuasion of your hammer handle." In this unit, you'll learn how to properly calculate the maximum number of conductors and "conductor equivalents" to be installed in an outlet box.

Be sure to read and study this material thoroughly and frequently so your understanding of what the *NEC* means by "conductor equivalents" and "conductor fill" becomes second nature.

An explanation of the sizing requirements of 314.28(A)(1) and (2) for larger pull boxes, and junction boxes which enclose conductors 4 AWG and larger, rounds out the information provided here in Unit 5.

5.7 Sizing Raceways Using Annex C

When all conductors in a conduit or tubing are the same size (total cross-sectional area including insulation), the number of conductors permitted in a raceway can be determined by simply looking at the tables located in Annex C—Raceway Fill Tables for Conductors and Fixture Wires of the Same Size.

- Tables C.1 through C.13(A) are based on maximum percent fill as listed in Chapter 9, Table 1.
- Table C.1—Conductors and fixture wires in electrical metallic tubing (EMT)
- Table C.1(A)—Compact conductors in electrical metallic tubing (EMT)
- Table C.2—Conductors and fixture wires in electrical nonmetallic tubing (ENT)
- Table C.2(A)—Compact conductors in electrical nonmetallic tubing (ENT)
- Table C.3—Conductors and fixture wires in flexible metal conduit (FMC)
- Table C.3(A)—Compact conductors in flexible metal conduit (FMC)
- Table C.4—Conductors and fixture wires in intermediate metal conduit (IMC)
- Table C.4(A)—Compact conductors in intermediate metal conduit (IMC)
- Table C.5—Conductors and fixture wires in liquidtight flexible nonmetallic conduit (orange type) (LFNC-A)

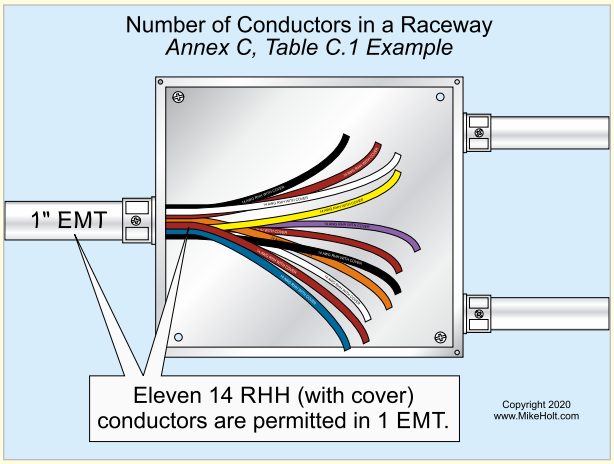
- Table C.5(A)—Compact conductors in liquidtight flexible nonmetallic conduit (orange type) (LFNC-A)
- Table C.6—Conductors and fixture wires in liquidtight flexible nonmetallic conduit (gray type) (LFNC-B)
- Table C.6(A)—Compact conductors in liquidtight flexible nonmetallic conduit (gray type) (LFNC-B)
- Table C.7—Conductors and fixture wires in liquidtight flexible nonmetallic conduit (LFNC-C)
- Table C.7(A)—Compact conductors in liquidtight flexible nonmetallic conduit (LFNC-C)
- Table C.8—Conductors and fixture wires in liquidtight flexible metal conduit (LFMC)
- Table C.8(A)—Compact conductors in liquidtight flexible metal conduit (LFMC)
- Table C.9—Conductors and fixture wires in rigid metal conduit (RMC)
- Table C.9(A)—Compact conductors in rigid metal conduit (RMC)
- Table C.10—Conductors and fixture wires in rigid PVC conduit, Schedule 80
- Table C.10(A)—Compact conductors in rigid PVC conduit, Schedule 80
- Table C.11—Conductors and fixture wires in rigid PVC conduit, Schedule 40 and HDPE conduit
- Table C.11(A)—Compact conductors in rigid PVC conduit, Schedule 40 and HDPE conduit
- Table C.12—Conductors and fixture wires in Type A, rigid PVC conduit
- Table C.12(A)—Compact conductors in Type A, rigid PVC conduit
- Table C.13—Conductors and fixture wires in Type EB, PVC conduit
- Table C.13(A)—Compact conductors in Type EB, PVC conduit

The Annex C.1 through C.13(A) tables can't be used to determine raceway sizing when conductors of different sizes are installed in the same raceway. For situations where conductors of different sizes are mixed together in a raceway, Chapter 9 contains the information necessary to calculate the required raceway size. Because different conductor types (THW, TW, THHN, and so forth) have different insulation thicknesses, the number and size of conductors permitted in a given raceway often depend on the conductor type used.

▶ Annex C, Table C.1—Conductors in EMT Example 1

Question: *How many 14 RHH conductors (with cover) can be installed in trade size 1 EMT?* ▸Figure 5–28

(a) 13 conductors *(b) 11 conductors*
(c) 19 conductors *(d) 25 conductors*



▸Figure 5–28

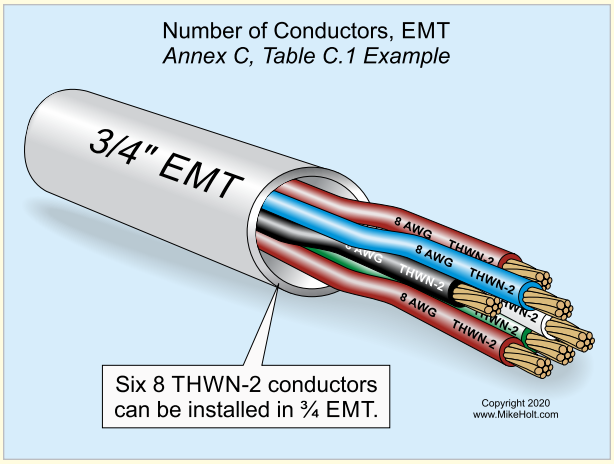
Answer: *(b) 11 conductors [Annex C, Table C.1]*

The asterisk (*) note at the end of Annex C, Table C.1 indicates that conductor insulation types "RHH*," "RHW*," and "RHW-2*" means that these types of conductors don't have an outer covering. Insulation types "RHH," "RHW," and "RHW-2" (without the asterisk) do have an outer cover. This is a cover (which may be a fibrous material) that increases the dimensions of the conductor more than the thin nylon cover encountered with conductors such as THHN.

▶ Annex C, Table C.1—Conductors in EMT Example 2

Question: *How many 8 THHN conductors can be installed in trade size ¾ EMT?* ▶Figure 5–29

(a) 3 conductors *(b) 5 conductors*
(c) 6 conductors *(d) 8 conductors*



▶Figure 5–29

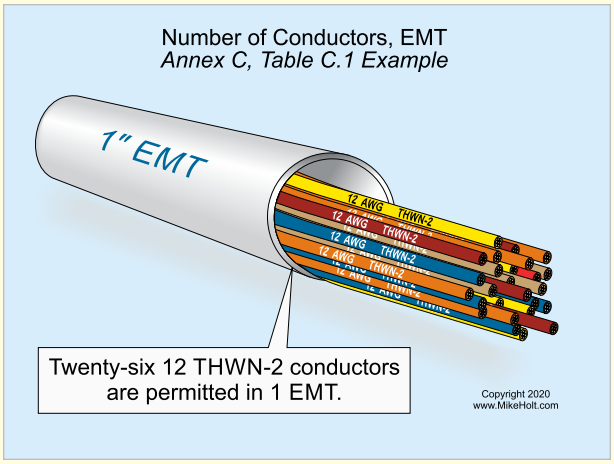
Answer: *(c) 6 conductors [Annex C, Table C.1]*

▶ Annex C, Table C.1—Conductors in EMT Example 3

Question: *How many 12 THHN conductors can be installed in trade size 1 EMT?* ▶Figure 5–30

(a) 13 conductors *(b) 15 conductors*
(c) 18 conductors *(d) 26 conductors*

Answer: *(d) 26 conductors [Annex C, Table C.1]*

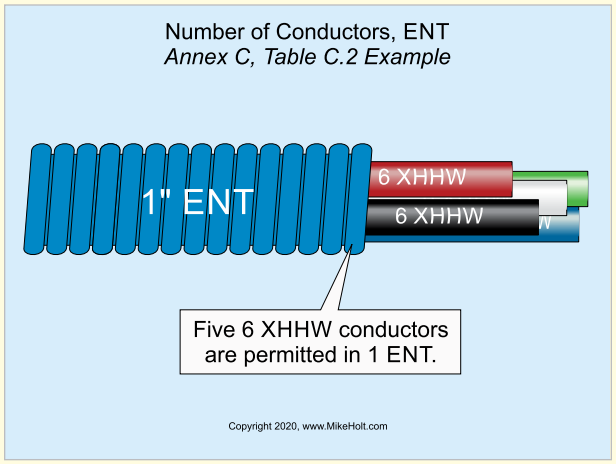


▶Figure 5–30

▶ Annex C, Table C.2—Conductors in ENT Example

Question: *How many 6 XHHW conductors can be installed in trade size 1 ENT?* ▶Figure 5–31

(a) 4 conductors *(b) 5 conductors*
(c) 6 conductors *(d) 7 conductors*



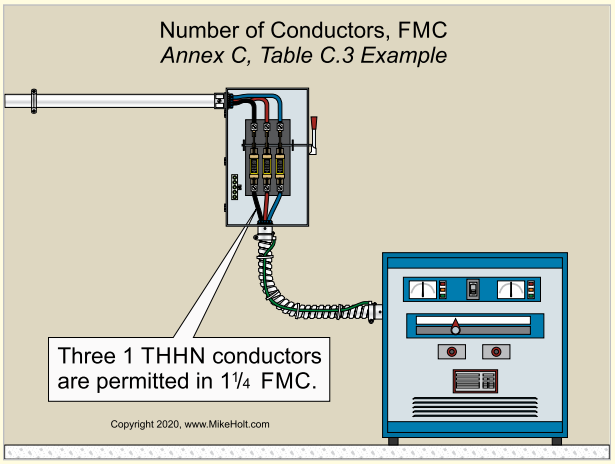
▶Figure 5–31

Answer: *(b) 5 conductors [Annex C, Table C.2]*

▶ Annex C, Table C.3—Conductors in FMC Example

Question: *If a trade size 1¼ FMC raceway has three THHN conductors (not compact), what's the largest conductor permitted to be installed?* ▶Figure 5–32

(a) 1 THHN (b) 1/0 THHN (c) 2/0 THHN (d) 3/0 THHN



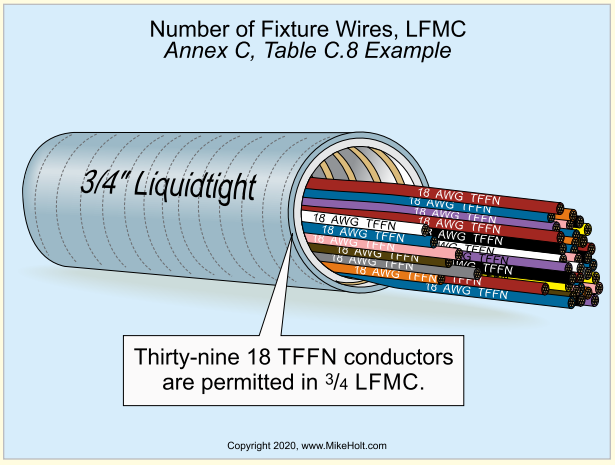
▶Figure 5–32

Answer: *(a) 1 THHN [Annex C, Table C.3]*

▶ Annex C, Table C.8—Fixture Wire in LFMC Example

Question: *How many 18 TFFN conductors can be installed in trade size ¾ LFMC?* ▶Figure 5–33

(a) 14 conductors (b) 26 conductors
(c) 30 conductors (d) 39 conductors



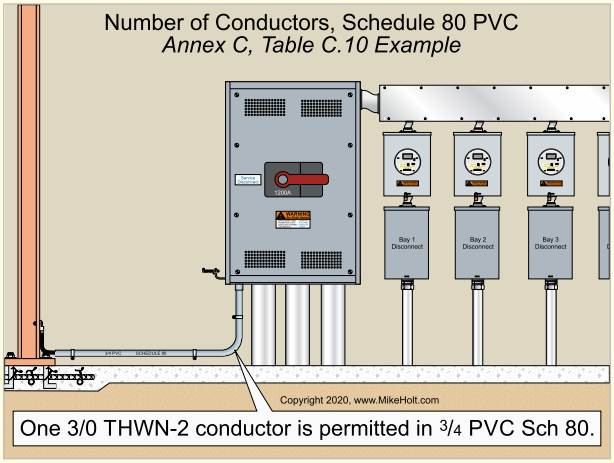
▶Figure 5–33

Answer: *(d) 39 conductors [Annex C, Table C.8]*

▶ Annex C, Table C.10—Conductors in PVC Schedule 80 Example

Question: *What's the smallest trade size PVC Schedule 80 raceway that can be used for the installation of a single 3/0 THHN as a grounding electrode conductor?* ▶Figure 5–34

(a) Trade size ½ (b) Trade size ¾
(c) Trade size 1 (d) Trade size 1¼



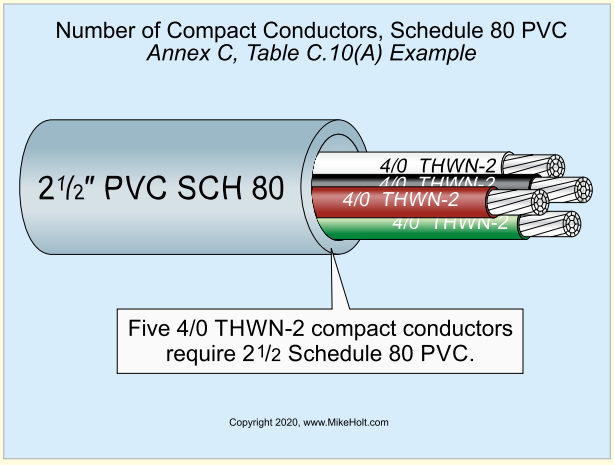
▶Figure 5–34

Answer: *(b) Trade size ¾ [Annex C, Table C.10]*

▶ Annex C, Table C.10(A)—Compact Conductors in PVC Schedule 80 Example

Question: *What minimum trade size Schedule 80 PVC raceway is suitable for four 4/0 THHW compact conductors?* ▶Figure 5–35

(a) Trade size 1 (b) Trade size 1½
(c) Trade size 2 (d) Trade size 2½



▶Figure 5–35

Answer: *(d) Trade size 2½ [Annex C, Table C.10(A)]*

Annex C, Table C.11—Conductors in PVC Schedule 40 Example

Question: *What's the smallest trade size PVC Schedule 40 raceway that can be used for five 6 THWN-2 conductors?* Figure 5–36

(a) Trade size ½ *(b) Trade size ¾*
(c) Trade size 1 *(d) Trade size 1¼*

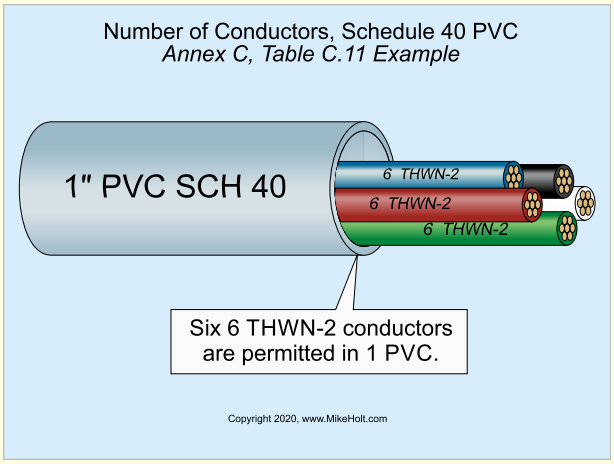


Figure 5–36

Answer: *(c) Trade size 1 [Annex C, Table C.11]*

Annex C, Table C.11(A)—Compact Conductors in PVC Schedule 40 Example

Question: *If a trade size 2 PVC Schedule 40 raceway has four THWN compact conductors, what's the largest compact conductor permitted to be installed?* Figure 5–37

(a) 1/0 THWN *(b) 4/0 THWN*
(c) 350 kcmil THWN *(d) 750 kcmil THWN*

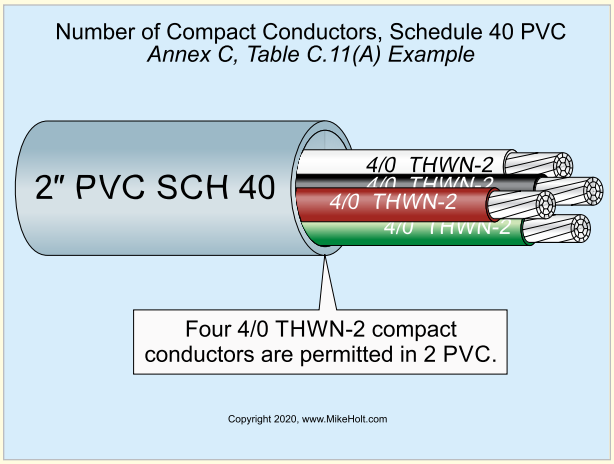


Figure 5–37

Answer: *(b) 4/0 THWN [Annex C, Table C.11(A)]*

Author's Comment:

- Compact stranding is the result of a manufacturing process where the conductor strands are shaped and compressed to the extent that the voids between the strands are virtually eliminated [Annex C, Table C.11(A) Definition]. Unless the question specifically states compact conductors, assume the conductors aren't the compact type.