



Code Check[®] Electrical 9th Edition

Based on the 2020 NEC[®]

BY DOUGLAS HANSEN, REDWOOD KARDON & SKIP WALKER

Illustrations & Layout: Paddy Morrissey

© 2021 by the authors ISBN xxx-x-xxxx-xxx-x

Code Check[®] is a registered trademark of The Taunton Press, Inc., registered in the U.S. Patent & Trademark Office.

Code Check Electrical 9th Edition is a field guide to common code issues in residential electrical installations. It is based on the **2020 National Electrical Code (NEC)**[®]. Significant changes are highlighted throughout the text. If an item is not shown as a change, then the code line is also valid for the 2017 NEC. Therefore this book can be used in areas using either the 2017 NEC or the 2020 NEC. Before beginning any electrical project, check with your local building department to determine the code edition used in your area. In addition to a model code, energy codes and utility regulations also apply to electrical installations. This book also references the smoke and carbon monoxide alarm location requirements of the **2021 International Residential Code**.

KEY TO USING CODE CHECK ELECTRIC

Each line that begins with a checkbox is a rule in the 2020 NEC. The code section is at the right end of the line. The following examples show how to use the key.

- Trees may not support overhead conductors _____

This line summarizes the code rule found in section 225.26 which prohibits trees from supporting overhead spans of conductors between buildings.

When a code rule has exceptions, the line ends with EXC and the exceptions are listed in a bulleted item or list of items below that line. In the following example, the exceptions are noted to the rule limiting the number of circuits between buildings.

- Max 1 feeder or branch circuit between each building EXC _____ 225.30
 - EV chargers L&L for more than single branch circuit or feeder _____ 225.30A7
 - ≤ 6 feeders from common supply to grouped disconnects _____ 225.30B⁵

The first exception is that a second circuit is allowed for EV charging stations. The second exception demonstrates how code changes are shown. Up to 6 feeders can supply a building if each feeder ends in a disconnecting means, and those disconnects are grouped together. This rule is new, so the code citation is shown in a different color and has a superscript number after it, indicating that the rule is a change from the previous code edition. The change is further explained in the corresponding note at the bottom of that page:

- 5.** Allows multiple feeders from a pedestal service if disconnects grouped at destination.

The explanation for this change is also giving an example of a situation where it might be used, when a pedestal service is located remotely from a building and has more than one feeder supplying the building. This situation would now be permitted by the code as long as the disconnects at the source building are grouped together.

The following example from **p.5** shows how tables and figures are referenced.

- Cover from top of cable or conduit to finish grade per **T1, F4** _____ 300.5A

*This line is showing how burial depth of cables and conduits is measured, and references Table 1 and Figure 4. Throughout the book these are abbreviated as **T1** and **F4**.*

A code rule may sometimes have more than one citation. The following example is also from **p.5**.

- Seal underground raceway entries at either or both ends _____ 230.8 & 300.5G

This line shows that the rule is found in those two distinct sections of the code.

Multiple citations for a single line may also be combined in the manner of this example from **p.25**.

- Dry locations only, not OK in wet or damp locations _____ 320.10 & 12

This line is saying that the rule is found in sections 320.10 and in 320.12.

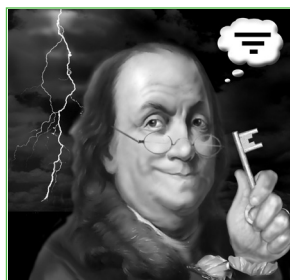
The information in this book is believed to be accurate; however, it is provided for informational purposes only and is not intended as a substitute for the full text of the referenced codes. Publication by the Taunton Press, ICC, and the authors should not be considered by the user to be a substitute for the interpretation of the local Authority Having Jurisdiction. Contact the building department in your area to learn what codes apply as well as any local amendments and procedures.

ABBREVIATIONS

| | |
|---|--|
| 1FD = Single Family Dwelling | lb. = pound(s) |
| 1&2FD = 1- & 2-Family Dwellings | LFMC = liquidtight flexible metal conduit |
| A = amp(s), amperage, amps | LFNC = liquidtight flexible nonmetallic conduit |
| AC = air conditioning | max = maximum |
| AC = alternating current | MC = metal-clad cable |
| AC = armored cable, a.k.a. "BX" | MFED = multifamily dwelling |
| AFCI = arc-fault circuit interrupter | er(s) |
| | branch circuit |
| | Electrical Code |
| | Electrical Manufacturers |
| | heated cable |
| | Branch Circuit AFCI |
| | protection device |
| | ring, requirement |
| EMT = electrical metallic tubing | req'd, req's = required, requires |
| ENT = electrical nonmetallic tubing | RMFC = rigid metal conduit |
| ESS = energy storage system | RNC = rigid nonmetallic conduit (PVC) |
| EV = electric vehicle | RS = rapid shutdown (photovoltaics) |
| EVSE = electric vehicle supply equipment | RTRC = reinforced thermosetting resin conduit |
| EXC = exception(s) | SCCR = short circuit current rating |
| FMC = flexible metal conduit | SER = service entrance cable (round) |
| ft. = foot, feet | SEU = service entrance cable (flat) |
| GEC = grounding electrode conductor | SPD = surge protective device |
| GES = grounding electrode system | sq. = square, as in sq. in. |
| GFCI = ground-fault circuit interrupter | temp = temperature |
| hp = horsepower | TR = tamper-resistant |
| IBT = Intersystem Bonding Termination | UF = underground feeder cable |
| IFC = 2021 International Fire Code [®] | USE = underground service entrance cable |
| IMC = intermediate metal conduit | V = volt(s), such as a 120V circuit |
| IRC = 2021 International Residential Code [®] | VA = volt-ampere(s), units of apparent power |
| in. = inch(es) | VD = voltage drop |
| kcmil = 1,000 circular mil units (wire size) | w/ = with |
| kVA = kilovolt-amperes (1,000's of VAs) | w/o = without |
| kW = kilowatts (1,000s of Watts) | W = watt(s), units of true (useful) power |
| L&L = listed & labeled, listing & labeling | WR = weather-resistant |
| LED = light-emitting diode | |

The first page has explanatory material on the codes, conventions, and abbreviations used in the book.

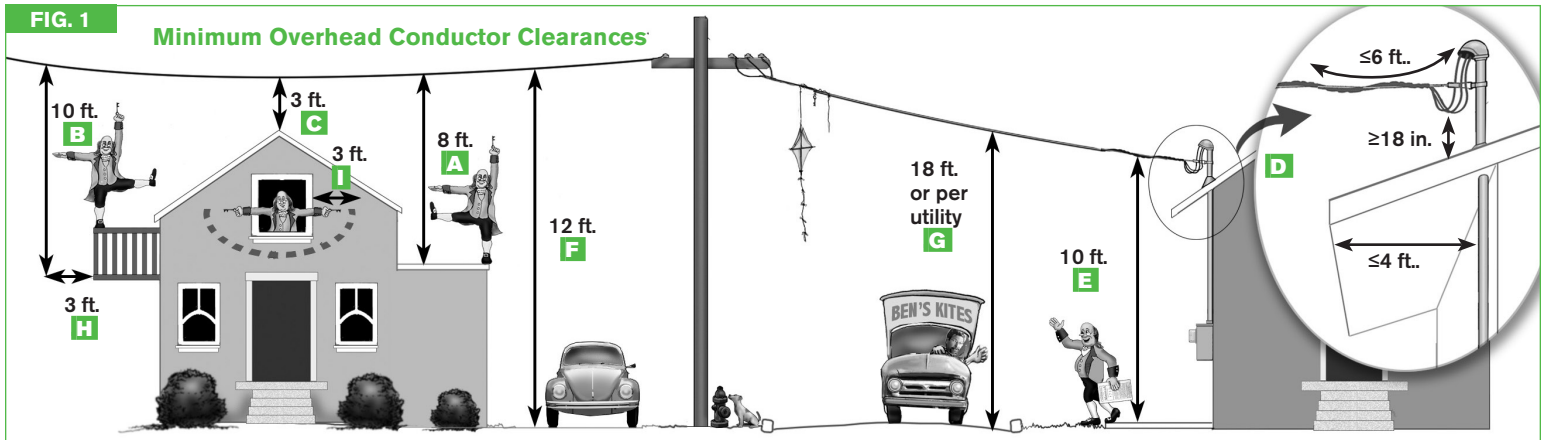
For further information, articles, videos and all things Code Check visit: www.codecheck.com



After proving lightning and electricity are the same thing, Ben invented the lightning rod, which he believed was his most important invention.

Benjamin Franklin was chosen as the main character in our Code Check illustrations for a number of reasons. The "First American's" insatiable curiosity, scientific genius, and civic-mindedness drove him to promote fire safety, safe exiting, public sanitation, improved heating methods to reduce air pollution, and of course, electricity. Franklin contributed to each of the four main disciplines of building inspection: Building, Plumbing, Mechanical, and Electrical.

To find out more, visit: codecheck.com/why-ben/



OVERHEAD SERVICE DROP CLEARANCES

The splice between the utility service drop and permanent building wiring is the service point – the handoff from the utility to the customer. In an underground system, the service point may be at the service panel or some other agreed-upon location. The utility may share jurisdiction with the building department for conductors up to the meter. The utility typically determines the service point.

- Vertical Clearances above Roofs**
- Min 8 ft. if slope < 4:12 EXC **A** _____ 230.24AX1
 - Min 10 ft. vertical above walkable roof deck **B** _____ 230.24AX1
 - Min 3 ft. if slope ≥ 4:12 EXC **C** _____ 230.24AX2
 - 18 in. above roof OK ≤ 4 ft. overhanging eave **D** _____ 230.24AX3
 - Maintain req'd clearance for 3 ft. past roof edge EXC _____ 230.24A
 - Clearance above roof not req'd if attached to side of building _____ 230.24AX4
 - 3 ft. clearance OK for guarded/isolated roof areas _____ 230.24AX5
 - Metal support structures for conductors passing over roofs req bonding to neutral of service drop _____ 230.29

The book has 66 illustrations

Vertical Clearances from Grade F1 20 NEC

- Service conductors (including drip loop) 10 ft. min above areas accessible only to pedestrians **E** _____ 230.24.B1
- 12 ft. above residential property & driveways **F** _____ 230.24.B2
- 18 ft. above public streets & tractor trailer parking **G** _____ 230.24.B4

- 10 ft. **B** _____ 230.9B
- 3 ft. past edge **B, H** _____ 230.9A&B
- 3 ft. to sides of doors/windows & below openable windows **I** EXC _____ 230.9A
 - Not req'd for raceway or cable w/ overall outer jacket _____ 230.9A
- Distance above window per utility or local AHJ _____ 230.9AX

Clearance for Communications Wires & Cables

- If from same pole, locate below power conductors where practical 800.44A1
- Min 1 ft. separation from parallel insulated ungrounded power wires 800.44A4
- Above-roof clearances same as for power conductors _____ 800.44B
- May terminate on separate mast – not power mast _____ 230.28 & 800.44C

SERVICES

Service Risers

20 NEC

- Raceway size, material, & bracing also per utility _____ 90.2C
- Riser req'd to have adequate strength & bracing _____ 230.28A
- Conduit hubs to be identified for use w/ service equipment _____ 230.28A
- Only service conductors on riser (no CATV or phone) _____ 230.28
- No couplings between structural support & weatherhead _____ 230.28B

Code changes are highlighted in the text, and summarized at the bottom of the page

Service Entrance Conductors

- Arrange conductors of different potential through separately bushed holes in weatherhead, length per utility specs _____ 230.54E
- Arrange conductors to prevent water entry into riser _____ 230.54G
- Arrange conductors w/ drip loop below weatherhead **F1** _____ 230.54F
- Identify (white marking or tape) insulated neutral at each end _____ 200.6B
- Exposed wire either listed or L&L sunlight-resistant or covered w/ tape or sleeving that is listed or L&L as sunlight-resistant _____ 310.10D
- No other conductors in same raceway w/ service conductors EXC _____ 230.7
 - GECs or supply-side bonding jumpers OK in service raceways _____ 230.7X1
- Not OK to pass through interior of another building _____ 230.3
- Size service conductors to meet load of **T2,3** EXC _____ 230.42
 - 83% of **T13,16** allowed for SFD & individual dwelling units **T17** _____ 310.12A

SE Cables **F53** used as Service Entrance Conductors

- Secure SE cable max interval 30 in. & within 12 in. of termination _____ 230.51A
- Where subject to damage, protect SE cables w/ RMC, IMC, PVC-80, EMT, RTRC, or other approved means _____ 230.50B
- Overhead cable req's service head listed for wet locations EXC _____ 230.54A&B
 - SE cable OK w/ gooseneck & taped connections _____ 230.54BX
- Use waterproof gland or equivalent to prevent water entry to box _____ 230.54G

Meters & Service Equipment (also see p.12)

20 NEC

- Verify meter height, location, fees w/ utility _____ 90.2C
- Service panel listed & marked as suitable for service **F16** _____ 230.66A
- Meter socket alone not considered service equipment _____ 230.66B
- 1&2FD req disconnecting means on exterior & marked as EMERGENCY DISCONNECT _____ **230.85¹**
- Service disconnect readily accessible & nearest to the point of entrance of service conductors _____ 230.70A1
 - 1 disconnecting means per service EXC _____ **230.71²**
 - 6 disconnects if each in separate enclosure w/ single main or in boards or meter centers w/ separate disconnects in each section _____ **230.71B²**
 - 2 to 6 disconnects allowed, must be grouped in one location _____ 230.72A
 - of mains allowed by **230.71B** may exceed service conductor ampacity _____ **230.90AX3**
 - service conductors adequate for calculated load **T2,3** _____ 230.90AX3
- Each service disconnect durably marked to indicate load served _____ 230.72A
- Barriers req'd over supply terminals & buses in services **F16** _____ **230.62C³**
- Neutral bar bonded in service equipment **F16** _____ 250.24B

Surge Protection

- All services supplying dwelling units req SPD _____ **230.67A⁴**
- SPD integral w/ or immediately adjacent to service EXC _____ **230.67B⁴**
 - OK to install Type 2 at each next level distribution equipment _____ **230.67BX⁴**
- Applicable to replacement service equipment (service upgrades) _____ **230.67D⁴**

2-Family & Multifamily Dwellings (MFDs)

- Only 1 service per building _____ 230.2
- Adjoining units considered separate buildings if separated by firewalls _____ 100
- Each occupant of multi-family to have access to their disconnect EXC _____ 230.72C
 - where under continuous building management supervision _____ 230.72CX
- 2FD & MFDs common areas not to be supplied by individual unit _____ 210.25B
- Service conductors may not pass through another building _____ 230.3

1. Purpose of exterior emergency disconnect is for first responders.
2. Each service enclosure allowed only 1 disconnecting means (formerly ≤ 6)
3. Moved from article 408 & deleted exception for services w/ > 1 main; if the main is open, no uninsulated component within its enclosure can have voltage.
4. SPD req'd at service must be Type 1 or 2. Additional SPDs are allowed.

UNDERGROUND WIRING

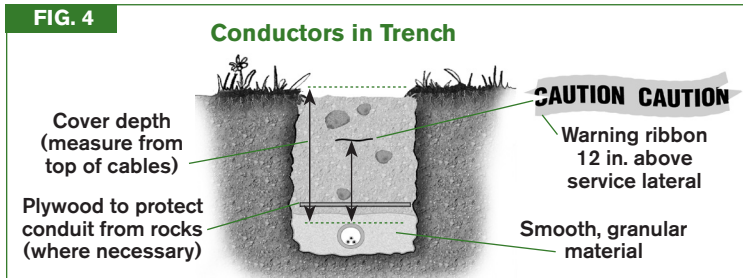
When underground conduits end on lower elevations than their source, a drain box may be needed at the lower elevation to prevent water rising into the service conduit. Joint trenches typically include communication cables, and separation of these from power conductors is typically per agreement of the parties (utilities).

General 20 NEC

- Cover from top of cable or conduit to finish grade per **T1, F4** _____ 300.5A
- Backfill w/ smooth granular material—no sharp rocks **F4** _____ 300.5F
- Provide running boards or sleeves if subject to damage from backfill _____ 300.5F
- OK to splice or tap direct-buried conductors w/out boxes if splicing means is listed for the purpose (e.g. – resin kits) _____ 300.5E
- All conductors of circuit in same trench or raceway EXC _____ 300.5I
 - Parallel raceways each containing all conductors & EGC of circuit _ 300.5IX1
- Provide for earth movement (settlement or frost) using “S” loops, flexible connections _____
- Cables & raceways installed approved for the purpose (sp _____)
- Interior of underground raceway _____
- Conductors installed underg _____
- Seal underground raceway e _____
- Sealants identified for use w/ cable insulation _____ 230.8 & 300.5G
- Spare or unused raceways to also be sealed _____ 230.8 & 300.5G

Service Laterals

- Size, depth, material, & testing (mandrel) per utility _____ utility
- Sewer not in joint trench _____ utility
- Warning ribbon ≥ 12 in. above direct-buried service conductors & cables that are ≥ 18 in. below grade & not encased in concrete **F4** _____ 300.5D3



Tables and illustrations help to explain the referenced code sections

| TABLE 1 | MIN. COVER REQUIREMENTS ♦ 300.5 | | | | |
|---------------------------|---------------------------------|----------------|----------------|------------------------|------------------------|
| Cover | UF Cable | RMC or IMC | PVC | GFCI ≤ 20A Circuit | ≤ 30V ^A |
| Other than below | 24 in. | 6 in. | 18 in. | 12 in. | 6 in. |
| ≥ 2 in. concrete | 18 in. | 6 in. | 12 in. | 6 in. | 6 in. |
| Under building | 0 ^B | 0 ^B | 0 ^B | 0 ^B | 0 ^B |
| ≥ 4 in. slab, no vehicles | 18 in. | 4 in. | 4 in. | 6 in. 4 in. raceway | 6 in. 4 in. raceway |
| Street | 24 in. | 24 in. | 24 in. | 24 in. | 24 in. |
| 1&2 FD Driveway | 18 in. | 18 in. | 18 in. | 12 in. | 18 in. |

A. Applies to central irrigation or landscape lighting in UF cable or a raceway. Listed low-voltage lighting OK per installation instructions at lesser depths. Listed pool, spa, or fountain lighting ≤30V OK in _____ for direct burial or concrete encasement.

20 NEC

- Allowed only during period of construction – remove at completion _____ 590.3A&D
- Service height, grounding, clearance, etc., same as permanent **F1** _____ 590.4A
- NM & SE OK in any building & SE OK in underground raceway _____ 590.4B&C
- No receptacles on branch circuits supplying temporary lighting _____ 590.4D1
- NM cable or MC cable OK without splice box if EGC continuity maintained (including listed metal cable fittings) _____ 590.4GX1
- Permanent branch circuit w/ GFCI protection in framed construction site walls OK to omit box cover if splice inside box w/ plaster ring _____ 590.4GX⁶
- Protect cords & cables from accidental damage _____ 590.4H
- Cords & cables not OK on floor or ground exc extension cords _____ 590.4J
- Lampholders req guards _____ 590.4F
- Cords & cables not supported on vegetation _____ 590.4J
- GFCI req'd on all 125V 15, 20 & 30A temporary receptacles _____ 590.6A1
- Listed GFCI cord-sets OK only to supplement GFCI on temporary receptacles or as first device on permanently wired receptacle _____ 590.6A1&2
- Other receptacles GFCI or assured EGC program _____ 590.6B⁷

6. Temporary splices OK from permanent wiring where protected as noted.
7. Assured EGC program documentation must now be available to the AHJ.

Conductor Length in Boxes

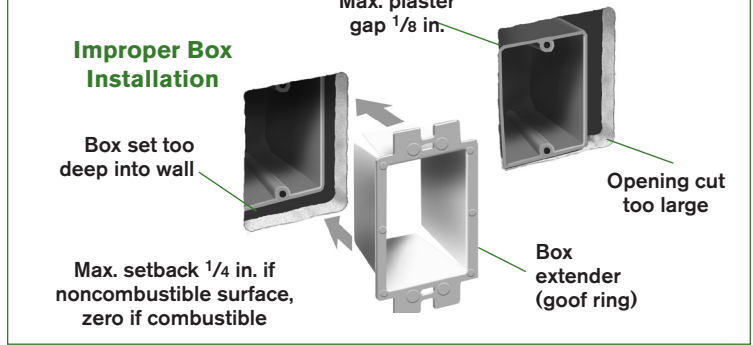
20 NEC

- Min 6 in. conductor brought into box **F48** _____ 300.14
- Min 3 in. free conductor past face of box **F48** _____ 300.14

Box Fill

- Size must be sufficient to provide free space for conductors _____ 314.16
- Standard metal boxes per **T9** _____ 314.16A1
- Include volume of marked mud rings & extensions _____ 314.16A
- Spaces within boxes w/ barriers counted separately _____ 314.16B
- Barrier volume as marked or 1/2 cu. in. metal boxes, 1 in. plastic _____ 314.16A
- Plastic boxes are marked w/ their volume _____ 314.16A2
- 4 in. (6 cu. in.) pancake OK only end of 14/2 run **F36** _____ 314.16B
- 18 cu. in. box too small for 3 12/2 Romex **T10, F33** _____ 314.16B

FIG. 35



Box Fill Factors T9,10

20 NEC

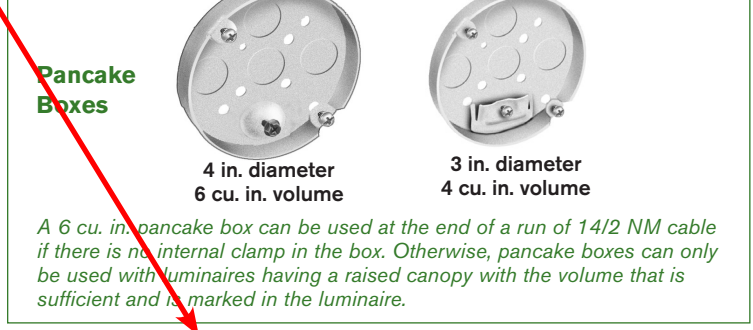
- Count each conductor exiting box EXC _____ 314.16B1
 - EGCs from luminaires or up to 4 conductors < #14 _____ 314.16B1X
- ies _____ 314.16B1X
- rough box count _____ 314.16B1
- 12 in. count as 2 _____ 314.16B1
- s to devices _____ 314.16B1
- ed on largest conductor in box _____ 314.16B2
-) count as 1 conductor for _____ 314.16B3
- t conductor in box _____ 314.16B3
- based on connected wire size _____ 314.16B4
- sed on largest _____ 314.16B5
- Add 1/4 of largest conductor for each additional EGC after 4 _____ 314.16B5⁴²

**There are 23 tables in the book.
"Fill-in" tables (worksheets) are included for
box fill and load calculations**

| TABLE 9 | | METAL BOX VOLUMES ♦ T314.16A | | | | | | |
|--|---------------------|------------------------------|-------------------------------------|----|----|----|----|--|
| Box Trade Size | Shape or Type | Cu. in. volume | Size (AWG) and Number of Conductors | | | | | |
| 4 × 1¼ | Round/octagon | | | | | | | |
| 4 × 1½ | Round/octagon | | | | | | | |
| 4 × 2⅞ | Round/octagon | | | | | | | |
| 4 × 1¼ | Square | | | | | | | |
| 4 × 1½ | Square | | | | | | | |
| 4 × 2⅞ | Square | | | | | | | |
| 4 ¹¹ / ₁₆ × 1¼ | Square | 25.5 | 5 | 8 | 10 | 11 | 12 | |
| 4 ¹¹ / ₁₆ × 1½ | Square | 29.5 | 5 | 9 | 11 | 13 | 14 | |
| 4 ¹¹ / ₁₆ × 2⅞ | Square | 42.0 | 8 | 14 | 16 | 18 | 21 | |
| 3 × 2 × 1½ | Device ¹ | 7.5 | 1 | 2 | 3 | 3 | 3 | |
| 3 × 2 × 2 | Device ¹ | 10.0 | 2 | 3 | 4 | 4 | 5 | |
| 3 × 2 × 2¼ | Device ¹ | 10.5 | 2 | 3 | 4 | 4 | 5 | |
| 3 × 2 × 2½ | Device ¹ | 12.5 | 2 | 4 | 5 | 5 | 6 | |
| 3 × 2 × 2¾ | Device ¹ | 14.0 | 2 | 4 | 5 | 6 | 7 | |
| 3 × 2 × 3½ | Device ¹ | 18.0 | 3 | 6 | 7 | 8 | 9 | |
| 4 × 2⅞ × 1½ | Device ¹ | 10.3 | 2 | 3 | 4 | 4 | 5 | |
| 4 × 2⅞ × 1 ⁷ / ₈ | Device ¹ | 13.0 | 2 | 4 | 5 | 5 | 6 | |
| 4 × 2⅞ × 2⅞ | Device ¹ | 14.5 | 2 | 4 | 5 | 6 | 7 | |
| 3¾ × 2 × 2½ | masonry box/gang | 14.0 | 2 | 4 | 5 | 6 | 7 | |
| 3¾ × 2 × 3½ | masonry box/gang | 21.0 | 4 | 7 | 8 | 9 | 10 | |
| FS | single cover/gang | 13.5 | 2 | 4 | 5 | 6 | 6 | |
| FD | single cover/gang | 18.0 | 3 | 6 | 7 | 8 | 9 | |
| FS | multiple cover/gang | 18.0 | 3 | 6 | 7 | 8 | 9 | |
| FD | multiple cover/gang | 24.0 | 4 | 8 | 9 | 10 | 12 | |

1. Device boxes accept #6 screws.

FIG. 36



| TABLE 10 | | BOX FILL WORKSHEET ♦ 314.16 | | |
|--|------|-----------------------------|-------|--|
| Item | Size | # | Total | |
| #14 conductors exiting box | 2.00 | | | |
| #12 conductors exiting box | 2.25 | | | |
| #10 conductors exiting box | 2.50 | | | |
| #8 conductors exiting box | 3.00 | | | |
| #6 conductors exiting box | 5.00 | | | |
| Up to 4 EGCs—count only largest one | | 1 | | |
| Additional EGCs - count 1/4 of largest in box for each | | | | |
| Devices: 2x connected conductor size | | | | |
| Internal clamps—one based on largest wire present | | 1 | | |
| Fixture fittings—one for each type based on largest wire | | | | |
| TOTAL | | | | |

⁴². New req to add volume allowance for > 4 EGCs