BOX FILL REMINDER

Box fill isn't just the number of wires in the box — it's the total volume of the conductors, devices, and fittings in a box.

You calculate box volume per 314.16(A) and box fill per 314.16(B), but make sure your 314.16(A) box volume is greater than or equal to your 314.16(B) box fill.

BOX VOLUME CALCULATIONS:

You can use Table 314.16(A) only if the box contains no switches, receptacles, luminaire studs, luminaire hickeys, internal cable clamps, or equipment-grounding conductors. **This is rarely the case.**

If Table 314.16(A) is inapplicable for your installation, which it typically will be, it's a matter of adding up individual volumes of assembled parts.

Start with the box itself. If the box is not a standard size, the volume will be marked on the box by the manufacturer.

TABLE 314.16(A) Metal Boxes

Box Trade Size			Minimum Volume		Maximum Number of Conductors* (arranged by AWG size)						
mm	in.		cm^3	$in.^3$	18	16	14	12	10	8	6
100 × 32	(4 × 1¼)	round/octagonal	205	12.5	8	7	6	5	5	5	2
100 × 38	(4 × 1½)	round/octagonal	254	15.5	10	8	7	6	6	5	3
100 × 54	(4 × 2⅛)	round/octagonal	353	21.5	14	12	10	9	8	7	4
100 × 32	(4 × 1¼)	square	295	18.0	12	10	9	8	7	6	3
100 × 38	(4 × 1½)	square	344	21.0	14	12	10	9	8	7	4
100 × 54	(4 × 2⅛)	square	497	30.3	20	17	15	13	12	10	6
120 × 32	(4 11/16 × 1¼)	square	418	25.5	17	14	12	11	10	8	5
120 × 38	(4 11/16 × 1½)	square	484	29.5	19	16	14	13	11	9	5
120 × 54	(4 11/16 × 2⅛)	square	689	42.0	28	24	21	18	16	14	8
75 × 50 × 38	(3 × 2 × 1½)	device	123	7.5	5	4	3	3	3	2	1
75 × 50 × 50	(3 × 2 × 2)	device	164	10.0	6	5	5	4	4	3	2
753 50 × 57	(3 × 2 × 2¼)	device	172	10.5	7	6	5	4	4	3	2
75 × 50 × 65	(3 × 2 × 2½)	device	205	12.5	8	7	6	5	5	4	2
75 × 50 × 70	(3 × 2 × 2¾)	device	230	14.0	9	8	7	6	5	4	2
75 × 50 × 90	(3 × 2 × 3½)	device	295	18.0	12	10	9	8	7	6	3
100 × 54 × 38	(4 × 2⅛ × 1½)	device	169	10.3	6	5	5	4	4	3	2
100 × 54 × 48	(4 × 2⅛ × 1⅞)	device	213	13.0	8	7	6	5	5	4	2
100 × 54 × 54	(4 × 2⅛ × 2⅛)	device	238	14.5	9	8	7	6	5	4	2
95 × 50 × 65	(3¾ × 2 × 2½)	masonry box/gang	230	14.0	9	8	7	6	5	4	2
95 × 50 × 90	(3¾ × 2 × 3½)	masonry box/gang	344	21.0	14	12	10	9	8	7	4
min. 44.5 depth	FS — single cover/gang (1¾)		221	13.5	9	7	6	6	5	4	2
min. 60.3 depth	FD — single cover/gang (2⅜)		295	18.0	12	10	9	8	7	6	3
min. 44.5 depth	FS — multiple cover/gang (1¾)		295	18.0	12	10	9	8	7	6	3
min. 60.3 depth	FD — multiple cover/gang (2⅜)		395	24.0	16	13	12	10	9	8	4

*Where no volume allowances are required by 314.16(B)(2) through (B)(5).

The total volume determines the number and size of conductors and wiring devices that are permitted to be contained in the box. The cubic inch area required for each wire, clamp, support fitting, device and equipment ground is added together. The box must have a cubic-inch capacity that equals or exceeds the total of the contained items.

The minimum cubic inch capacity for each size is given along with the maximum number of conductors of sizes #18 through #6 that are permitted in the box. This number of conductors permitted in various boxes, as shown in the Table, applies only where all conductors are the same size. A calculation must be made of the cubic inch capacity that is required where conductors of different sizes are installed as in section 314.16(b) Box Fill Calculations.

Sometimes more conductors end up in boxes than were originally intended. Where practicable, an extension ring that is the same shape as the box can be installed that will add adequate space so the original box does not have to be replaced.

BOX FILL CALCULATIONS:

TABLE 314.16(B) Volume Allowance Required per Conductor

Size of Conductor (AWG)	Free Space Within Box for Each Conductor	
	cm^3	$in.^3$
18	24.6	1.50
16	28.7	1.75
14	32.8	2.00
12	36.9	2.25
10	41.0	2.50
8	49.2	3.00
6	81.9	5.00

Conductor, Device or Type of Fitting	Counted as Conductors	Based on
Each conductor, originating outside and terminating inside the box	1	Conductor size
Each conductor passing through unbroken	1	Conductor size
Conductor that does not leave the box	0	Not Applicable
Maximum of four fixture wires smaller than #14 plus ground from fixture canopy. Must terminate in box.	0	Not Applicable
Cable clamps, one or more (internal)	1	Largest size conductor present
Support fittings, e.g. fixture studs or hickeys (per type)	1	Largest size conductor present
Device or equipment yoke, e.g. switch, receptacle, pilot light, etc.	2	Largest size connected to device
Equipment grounding conductors, all except isolated ground	1	Largest EGC present
Additional equipment grounding conductors for isolated grounding	1	Largest EGC present
Each loop or coil of unbroken conductor not less than twice the minimum length required for free conductors in 300.14	2	Conductor size

Commentary Table 314.1 Summary of Items Contributing to Box Fill

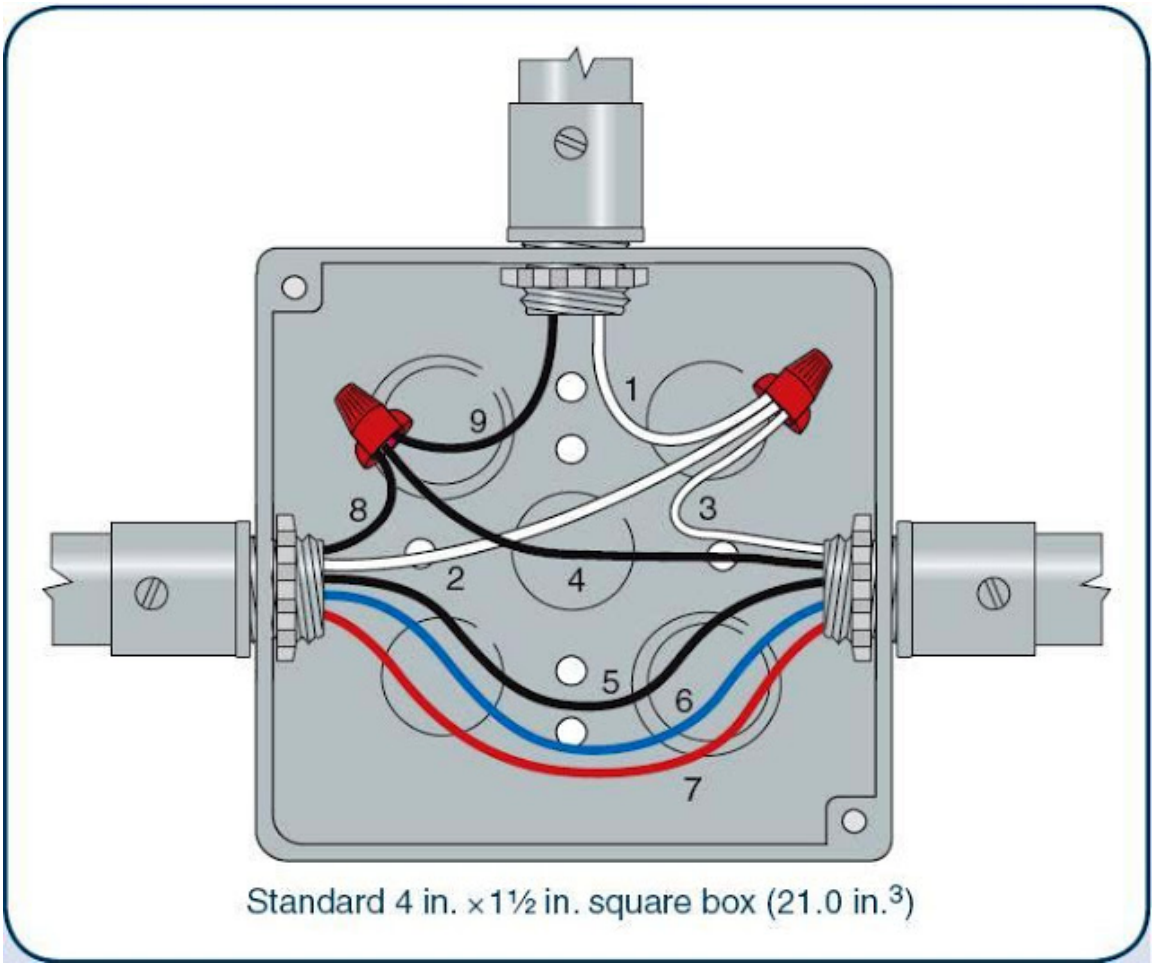
Some other rules:

- No allowance is required for small fittings like locknuts and bushings.
- Where one or more fixture studs or hickeys are present in the box, a single volume allowance is required to be made for each type of fitting in the box. A fixture stud is a fitting that mounts to the top of the box, usually inserts through the knockout of a metal box and is threaded to accommodate the fixture stem. A hickey is a fitting that can be described as a coupling that has threads the same size as the fixture stem and has an oval-shaped hole on one or more sides for the fixture wires to exit inside the box. The hickey is no longer popular and has been replaced with hanger straps that are fastened to the box.
- For each yoke or strap containing one or more devices or equipment, a double volume allowance is required for each yoke or strap. Each device or equipment is considered individually where more than one item is contained in the box. For example, if a switch has #14 wire connected to it, a volume allowance of 2 x 2.0 cubic inches or 4 cubic inches is required. If a receptacle has #12 wire connected to it, a volume allowance of 2 x 2.25 or 4.5 cubic inches must be made.
- Where one or more equipment grounding conductors enters a box, a single volume allowance is required to be made. The allowance is based on the largest equipment grounding conductor. This applies to all equipment grounds except for an isolated equipment ground often installed on computer circuits.

PRACTICE EXAMPLES

Example#1:

A standard-sized box is used where all the conductors are the same size and, as shown in below figure, the box does not contain any cable clamps, support fittings, devices, or equipment grounding conductors. Determine whether the box in below figure is adequately sized or not.



Standard 4 in. × 1½ in. square box (21.0 in.^{3})

Solution:

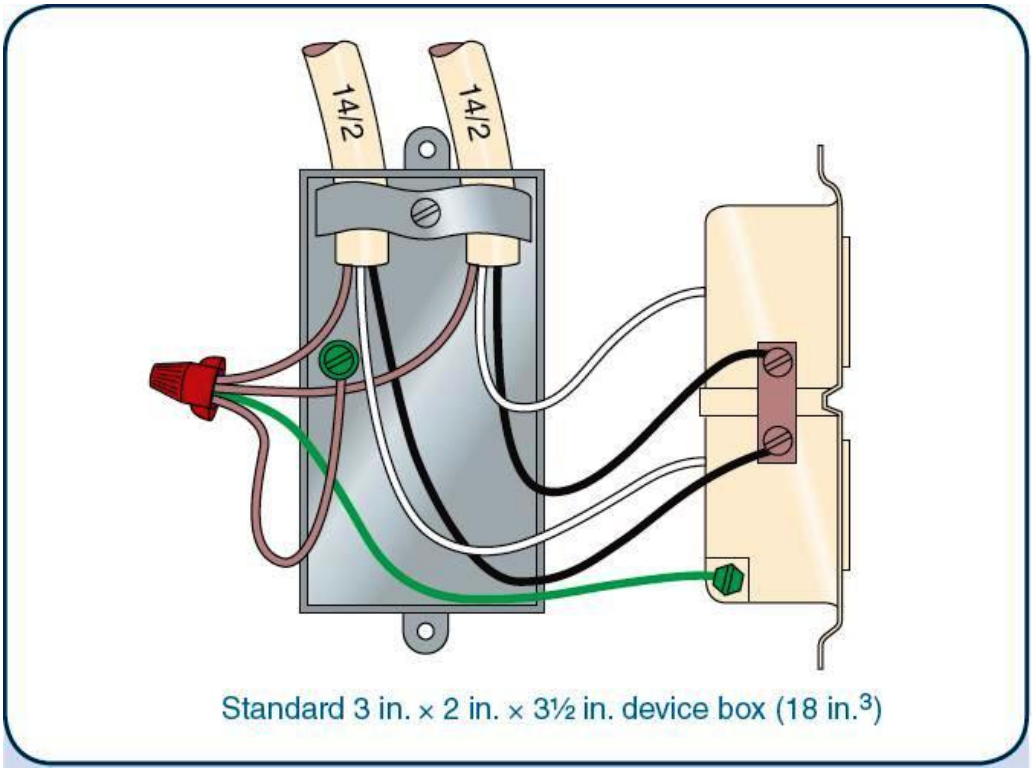
To determine the number of conductors permitted in the box, which is a standard 4 in. x 1.5 in. square box (21.0 in.3), count the conductors in the box and compare the total to the maximum number of conductors permitted by Table 314.16(A).

Each unspliced conductor running through the box is counted as one conductor, and each other conductor is counted as one conductor.

Therefore, the total conductor count for this box is nine conductors. Table 314.16(A) indicates that the maximum fill for this box is nine 12 AWG conductors, so the box is adequately sized.

Example#2:

Determine whether the box in below figure is adequately sized or not.



Solution:

The standard method for determining adequate box size first calculates the total box volume and then subtracts the total box fill to ensure compliance.

For a standard 3 in. x 2 in. x3.5 in. device box, Table 314.16(A) shows the minimum permitted box volume to be 18 in.3 and allows up to a maximum of nine 14 AWG conductors.

Total Box Fill			
Items Contained Within Box	**Volume Allowance**	**Unit Volume Based on Table 314.16(B) (in.3)**	**Total Box Fill (in.3)**
4 conductors	4 volume allowances for 14 AWG conductors	2	8
1 clamp	1 volume allowance (based on 14 AWG conductors)	2	2
1 device	2 volume allowances (based on 14 AWG conductors)	2	4
Equipment grounding conductors (all)	1 volume allowance (based on 14 AWG conductors)	2	2
Total			16

The box fill for this situation as given in Commentary Table 314.2 is 16 in.3. Because the total box fill of 16 in.3 is less than the 18 in.3 total box volume permitted, the box is adequately sized.