Ensuring a Safe Installation With a Simple Calculation

How many conductors can fit inside a conduit body?

This is an important question any electrician installing conduit bodies should be asking. And the first reason why has to do with safety.

Energized conductors generate heat. Each additional conductor in a conduit body increases the amount of heat generated in the confined space, while also decreasing the ability to dissipate that heat. The National Electrical Code (NEC) limits the fill ratio of conductors in conduit and fittings to keep heat levels within safe limits, without the need for derating.

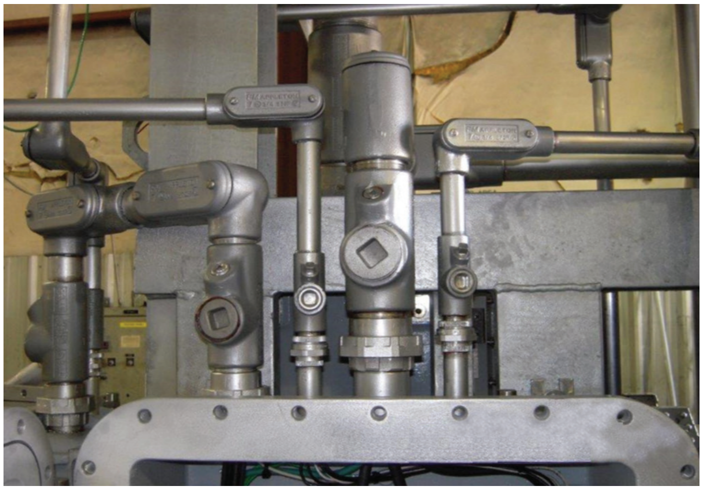
Moreover, the NEC specifies the minimum bending radius allowed for specific types and gauges of conductors. Over-bending a conductor can damage it, increasing its resistance and the amount of heat generated, or even leading to arcing. Limiting the gauge and number of connectors that can be installed in a given size of conduit body ensures that installers have enough room to make proper bends without forcing wires to fit.

A secondary reason for not exceeding the maximum allowed conductor fill is to avoid failing inspection. Since the mission of the authority having jurisdiction (AHJ) is to ensure electrical safety of facilities, this secondary reason is actually another way of stating the first reason. This includes the additional motive that no electrical contractor wants to expend the time and expense needed to redo an installation that has been judged to be non-compliant.

Calculating Maximum Conductor Fill

An easy to learn how to calculate the maximum conductor fill for a conduit body is by way of example. Let's work through the answer to a typical question by using this example:

What is the maximum wire fill in an Appleton Form 35 or O-Z/Gedney Spec 5 conduit body, 1-inch trade size, LB style? Can I fit ten #10 AWG THHN conductors in this conduit body?



This example has two parts that need to be addressed in order:

1. Determine the maximum wire fill for a particular form, style and size of conduit body (in this example, Form 35/ Spec 5, 1-inch, LB style).

We have made this determination easy, with a convenient chart (Maximum Wire Fill Comparison | Appleton™ and O-Z/Gedney™ Conduit Bodies) that lists available conduit bodies by trade size and style and shows the maximum XHHW wire size that can be used in a three-conductor fill of wire.

In our example, the 1" LB or UB row in the Form 35/Spec 5 column shows that the conduit body can accommodate three conductors with a maximum wire size of #4 AWG XHHW.

An installer may question whether a larger wire size can be used when pulling fewer than three conductors. For example, can two #2 AWG conductors be used instead of three #4 AWG conductors? The answer is no, since maximum conductor size is partially based on minimum bending radius. Since #2 AWG conductors have a larger minimum bending radius than #4 AWG, they cannot be installed even if the total cross-section of two #2 AWG conductors is less than the total cross-section of three #4 AWG conductors. The conductor sizes shown in the chart are the maximum sizes allowed, without regard to the number of conductors used.

What about using more conductors than three? Is that allowed if the conductors are smaller than the listed maximum size? Here, the answer is yes, as long as the total cross-sectional area of all conductors does not exceed that of the conductors shown in the chart. This brings us to the second part of our two-part example:

2. Determine the maximum number of smaller conductors that can fit in a conduit body, based on the maximum conductor size shown in the chart. (In this example, can ten #10 AWG THHN conductors be used in a Form 35/ Spec 5, 1-inch, LB style conduit body?)

Smaller conductors have a smaller minimum bending radius, so bending radius is not a factor. However, the installer will need to ensure that the conductors being installed do not exceed the total cross-sectional area of the conductors listed in the chart. To do this, the installer can reference NEC Chapter 9, Table 5 and apply some simple math.

According to NEC Chapter 9, Table 5, #4 AWG XHHW conductors have a diameter of 0.322”. Divide that figure by 2 to calculate the conductor radius: 0.161”. Now apply the formula for determining the area of a circle (Pi x R2 = Area) and multiply by 3 (the total number of conductors):

3.1416 x 0.1612 = 0.0814
(area of circle)

0.0814 x 3 conductors = 0.2442 square inches
(total cross-sectional area of conductors)

Next, perform the same calculation for the smaller conductors you want to install. NEC Chapter 9, Table 5 lists a diameter of 0.164” for #10 AWG THHN, so the radius is 0.082”. With ten conductors, the formula for the total cross-sectional area is as follows:

3.1416 x 0.0822 = 0.0211
(area of circle)

0.0211 x 10 conductors = 0.211 square inches
(total cross-sectional area)

Because the cross-sectional area of ten #10 AWG conductors is less than the area of three #4 AWG conductors, the installer is allowed to pull ten #10 AWG conductors in a 1” LB conduit body.

Reminder

Keep our maximum fill chart handy (found on the following page), along with NEC Chapter 9, Table 5 and the Pi x R2 formula for calculating the area of a circle, and you can easily determine the maximum wire fill allowed for any type and size of conductor. Just remember to never use a larger conductor than the maximum size shown in the chart, since this would violate the minimum allowable bending radius.

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Trade Size	Body Style	Appleton Form 35	Appleton Form 85	Appleton FM7	Appleton FM8	Appleton FM9	Appleton Mogul
		O-Z/Gedney Spec 5	O-Z/Gedney Aluminum	O-Z/Gedney Form 7	—	—	O-Z/Gedney Mogul
1/2"	All	All 1/2" Max Wire Fill Calculations per the NEC - Annex C - Table C8					—
3/4"	C	(3) # 6	(3) # 6	(3) # 6	(3) # 6	(3) # 6	—
	LB	(3) # 6	(3) # 6	(3) # 6	(3) # 6	(3) # 6	—
	LL	(3) # 6	(3) # 6	(3) # 6	(3) # 6	(3) # 6	—
	LR	(3) # 6	(3) # 6	(3) # 6	(3) # 6	(3) # 6	—
	T	(3) # 6	(3) # 6	(3) # 6	(3) # 6	(3) # 6	—
	E	(3) # 6	(3) # 6	(3) # 6	—	—	—
	L or LRL	(3) # 6	—	(3) # 6	—	—	—
	TA	(3) # 6	—	(3) # 6	—	—	—
	TB	(3) # 6	(3) # 6	(3) # 6	(3) # 6	(3) # 6	—
	X	(3) # 6	(3) # 6	(3) # 6	(3) # 6	(3) # 6	—
1"	C	(3) # 4	(3) # 4	(3) # 4	(3) # 4	(3) # 4	(3) # 2
	LB or UB	(3) # 4	(3) # 4	(3) # 4	(3) # 4	(3) # 4	(3) # 2
	LL	(3) # 4	(3) # 4	(3) # 4	(3) # 4	(3) # 4	(3) # 4
	LR	(3) # 4	(3) # 4	(3) # 4	(3) # 4	(3) # 4	(3) # 4
	T	(3) # 4	(3) # 4	(3) # 4	(3) # 4	(3) # 4	(3) # 4
	E	(3) # 4	(3) #6	(3) # 4	—	—	—
	L or LRL	(3) # 4	—	(3) # 4	—	—	—
	TA	(3) # 4	—	(3) # 4	—	—	—
	TB	(3) # 6	(3) # 6	(3) # 4	(3) # 4	(3) # 4	—
	X	(3) # 4	(3) # 4	(3) # 4	(3) # 4	(3) # 4	—
1-1/4"	C	(3) # 2	(3) # 2	(3) # 3	(3) # 2	(3) # 2	(3) # 1/0
	LB or UB	(3) # 2	(3) # 2	(3) # 3	(3) # 2	(3) # 2	(3) # 1/0
	LL	(3) # 2	(3) # 2	(3) # 2	(3) # 2	(3) # 2	(3) # 2
	LR	(3) # 2	(3) # 2	(3) # 2	(3) # 2	(3) # 2	(3) # 2
	T	(3) # 2	(3) # 2	(3) # 3	(3) # 2	(3) # 2	(3) # 2
	E	(3) #2	—	—	—	—	—
	L or LRL	(3) # 2	—	(3) # 2	—	—	—
	TA	—	—	(3) # 3	—	—	—
	TB	(3) # 6	(3) # 6	(3) # 3	(3) # 2	(3) # 2	—
	X	(3) # 4	—	(3) # 3	(3) # 2	—	—
1-1/2"	C	(3) # 1/0	(3) # 1/0	(3) # 3	(3) # 1/0	(3) # 1/0	(3) # 3/0
	LB or UB	(3) # 1/0	(3) # 1/0	(3) # 3	(3) # 1/0	(3) # 1/0	(3) # 3/0
	LL	(3) # 1/0	(3) # 1	(3) # 2	(3) # 1/0	(3) # 1/0	(3) # 1/0
	LR	(3) # 1/0	(3) # 1	(3) # 2	(3) # 1/0	(3) # 1/0	(3) #1/0
	T	(3) # 1	(3) # 1	(3) # 3	(3) # 1/0; side (3) # 1	(3) # 1/0; side (3) # 2	(3) #1/0
	E	(3) # 1/0	—	—	—	—	—
	L or LRL	(3) # 1/0	—	(3) # 2	—	—	—
	TA	—	—	(3) # 2	—	—	—
	TB	(3) # 4	(3) # 4	(3) # 2	(3) # 1/0; back (3) # 1	(3) # 1/0; back (3) # 2	—
	X	(3) # 1/0	—	(3) # 2	(3) # 1/0; side (3) # 1	—	—
2"	C	(3) # 4/0	(3) # 3/0	(3) # 1/0	(3) # 4/0	(3) # 2/0	(3) 300
	LB or UB	(3) # 4/0	(3) # 4/0	(3) # 1/0	(3) # 4/0	(3) # 3/0	(3) 300
	LL	(3) # 4/0	(3) # 2/0	(3) # 3/0	(3) # 4/0	(3) # 4/0	(3) # 4/0
	LR	(3) # 4/0	(3) # 2/0	(3) # 3/0	(3) # 4/0	(3) # 4/0	(3) # 4/0
	T	(3) # 2/0	(3) # 2/0	(3) # 2	(3) # 4/0; side (3) # 3/0	(3) # 2/0; side (3) # 1	(3) # 4/0
	L or LRL	(3) # 4/0	—	(3) # 2	—	—	—
	TA	—	—	(3) # 2	—	—	—
	TB	(3) # 1/0	(3) # 1/0	(3) # 2	(3) # 4/0; back (3) # 3/0	(3) # 2/0; back (3) # 1	—
	X	(3) # 2/0	—	(3) # 2	(3) # 4/0; side (3) # 3/0	—	—
2-1/2"	C	(3) 300	(3) 300	(3) 2/0	(3) 300	(3) 300	(3) 400
	LB or UB	(3) 300	(3) 300	(3) 3/0	(3) 300	(3) 300	(3) 400
	LL	(3) 300	(3) 300	(3) 250	(3) 300	(3) 300	—
	LR	(3) 300	(3) 300	(3) 250	(3) 300	(3) 300	—
	T	(3) 300	(3) 300	(3) 1/0	(3) 250	(3) 250	(3) 300
3"	C	(3) 300	(3) 300	(3) 2/0	(3) 350	(3) 350	(3) 700
	LB or UB	(3) 400	(3) 400	(3) 3/0	(3) 350	(3) 300	(3) 700
	LL	(3) 350	(3) 350	(3) 250	(3) 350	(3) 350	—
	LR	(3) 350	(3) 350	(3) 250	(3) 350	(3) 350	—
	T	(3) 300	(3) 300	(3) 1/0	(3) 250	(3) 250	(3) 350
3-1/2"	C	(3) 350	(3) 350	—	—	(3) 350	(3) 900
	LB or UB	(3) 500	(3) 500	(3) 300	(3) 500	(3) 500	(3) 900
	LL	(3) 350	(3) 350	(3) 350	—	(3) 350	—
	LR	(3) 350	(3) 350	(3) 350	—	(3) 350	—
	T	(3) 350	(3) 350	(3) 3/0	—	(3) 350	(3) 350
4"	C	(3) 350	(3) 350	—	—	(3) 350	(3) 1000
	LB or UB	(3) 500	(3) 500	(3) 300	(3) 500	(3) 500	(3) 1000
	LL	(3) 350	(3) 350	(3) 350	—	(3) 350	—
	LR	(3) 350	(3) 350	(3) 350	—	(3) 350	—
	T	(3) 350	(3) 350	(3) 3/0	—	(3) 350	(3) 350
5	LB	(3) 600	—	—	—	—	—
6	LB	(3) 700	—	—	—	—	—

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