



# The Adventures of Conduit Phil

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So you're designing your install and you have a choice: conduit or non-conduit. A lot of cable today is made non-conduit, (i.e. "plenum rated"). This is almost always a better deal. Plenum-rated cable can go anywhere you want it to. Cable in conduit can only go where the conduit goes. There are almost no limitations on how much plenum cable you can put in a drop ceiling. Cable in conduit is limited by the size of the conduit, and big conduit is mighty expensive. It's easier to install plenum cable (not to mention the cost of conduit installation), so your labor costs will be a lot lower. You can add, change or modify an installation of plenum cable easily...just add another cable. With conduit, you might have to add new conduit. Not a simple task.

But let's say you've chosen a cable which is not available in a plenum version. Or let's say your installation is in an area (like Chicago) where everything *must* be in conduit. Well, then you don't have a choice. You're going to be putting in conduit! There are other advantages to conduit beside safety. For one thing, once the cables are installed, conduit will protect them from other installers working in that drop ceiling or raised floor. And conduit gives you unequaled protection against 60 Hz interference, as much as 27 dB, depending on the thickness of the conduit and the workmanship of the joints.

## HOW MUCH SPACE DO YOU HAVE?

But how big a conduit do you need? On the next page is a chart to show you how much space you have. The first column shows the size of the most common conduit. The second column shows the actual amount of space (square inches) in each of those sizes. Then it's a question of how full you want to fill it. The industry standard (NEC) suggest a 40% fill. The other percentages are presented to show how much difference reducing or increasing the standard number would make. Just remember, if you get to higher percentages, your ability to actually pull the cable will becomes harder and harder.

And we haven't taken into account bends in conduit. The maximum number of bends recommended is two 90° bends (or their equivalent, i.e. four 45° bends, or one 90° and two 45° bends, etc.). If you have more than 180° total, put in a pull box part way down the conduit. That way you can pull the cable through that section, out that pull box, and re-feed it back into the box for the rest of the run.

A pull box will also help you if you might want to add conduit at a later date. It gives you a good place to split off. So try to locate the pull boxes where they would be logical split-off points. And, of course, you must plan in now the extra space in the conduit feeding the pull box to add those future cables.

If you plan for expansion, you might want to go with the 30% fill numbers on the following chart.

Conduit Size	Equivalent Square Inches	30% fill	40% fill	50% fill
½	.30	.09	.12	.16
¾	.53	.17	.21	.28
1	.86	.27	.35	.46
1 ¼	1.5	.46	.6	.79
1 ½	2.04	.63	.81	1.08
2	3.36	1.04	1.34	1.78
2 ½	5.86	1.82	2.34	3.11
3	8.85	2.74	3.54	4.69
3 ½	11.55	3.58	4.62	6.12
4	14.75	4.57	5.90	7.82

I once worked in an install where the architect had been told to save money and he did so by making all the 2 1/2" conduits into 2" conduits. Of course, he forgot to tell the Chief Engineer who assumed he would still have all that room. Suddenly, his 40% fill turned into a 56% fill (and to be truthful, it wasn't 40% fill to begin with.) I guarantee you that we exceeded the maximum pulling tension recommended by the cable manufacturer!

### NOT PULLING YOUR LEG!

Basic pulling tension information can be obtained from any cable manufacturer or you can *estimate* it from the chart on the next page. The chart is based on the understanding that, at a certain tension, a copper conductor will begin to elongate. So all you need to do is multiply the conductors you have of a certain size by the tension listed below. If you have different gage sizes, add up all the totals (i.e. add up all 24 AWG wires and multiply by that tension, add up all the 22 AWG wires and multiply by that tension etc.)

For coax cable, it might be easier just to use the center conductor as the only element. For one thing, elongation of that coax center conductor is much more damaging than in, say, an audio cable. To simplify everything, ignore the braids or serve shields in twisted pairs or coaxial cable. (If you want a *real* accurate pull number, the number and gage of a braid or serve shield are usually listed in the manufacturer's catalog.) Don't forget to include the drain wire in foil-shielded twisted pairs. An eight-pair snake has 24 conductors in it. Also be aware that the drain wire with a twisted pair can sometimes be a different gage than the pair itself.

On the other hand, if the pulling tension turns out to be some ridiculously small number, you can contact the manufacturer for the *actual* maximum pulling tension for each cable.

GAGE (AWG)	MAXIMUM TENSION (LBS.)
24	4
22	7
20	12
18	19
16	30
14	48
12	77

The ways you can reduce pulling tension are:

1. Increase the size of the conduit
2. Reduce the fill ratio of the conduit.
3. Use pulling lubricant, available from most good hardware or electrical stores.
4. Decrease the number of bends in the run.
5. Install another pull box at some intermediate location.
6. Put in *larger* gage cables.

## **MIX AND MATCH**

Okay, so you've read the chart and know the square area of the conduit. Or you know the cables you want to put in but you don't know which conduit size to use. Here's what you do:

1. Obtain the diameter (O.D.) in inches of the cable you're going to use.
2. Multiply the O.D. by itself (i.e. square the diameter) and multiply by the factor. 0.7854. That will give you the area (square inches) of each cable.
3. With different types of cables, you must determine the area of each one separately.
4. If you are using cables which are not round, such as Belden's multimedia cable "MediaTwist", you must consult the manufacturer for the area. (MediaTwist® is .0602 sq. in., for instance)
5. If you're trying to determine which size conduit to install, add all the areas of the cables you want to put in the conduit. Then look on the chart on previous page until you see that total number (or a larger number) in the 40% fill column. Then move to the left until you get to the conduit size column. And there you have your conduit size.
6. If you already know the conduit size, then you already know the area, and the 40% area. You can then just add up your cable areas until you get to that 40% area.

## **PROBLEMS WITH THE PIPE?**

If you find yourself choosing huge and expensive conduit, you might consider splitting the install into two or more conduits. Or if you cannot fit everything you need into the existing (or planned) conduit size, you might want to see if you can reduce the size of your cables. Here are some ideas:

1. Remember that, all other parameters being equal, smaller cables almost always have reduced electronic performance than larger cables. But, that being said...
2. If you have snake cable, consider going down in gage size. If you're using 22 AWG, move to 24 AWG. You can even go down to 26 AWG with some manufacturers, but that's pretty small and much less rugged.
3. If you're using snake cable, those designs with individual jackets inside make the O.D. larger. Check out the old style snakes with just foil around each pair. Of course, they're harder to split out at the destination than individual jackets. Your call.
4. Precision video cables now come in a large range of sizes. Some are as small as .150" O.D. Of course, the attenuation of smaller cable is greater than bigger stuff, so you can't go as far.
5. Almost all audio, video and control cables come in smaller sizes. But be sure and check the specs side by side. Often capacitance increases, or attenuation increases, or gage sizes get very

small. It depends on what the manufacturer sacrificed to get down in size. Occasionally, you will find a smaller cable which equals or even out-performs a bigger cable. This means new technology has been used, new materials. This sometimes means the cost will go up for the new smaller cable.

6. You could always split the install into non-plenum (i.e. conduit) and plenum (i.e. non-conduit) cables. Don't waste your precious conduit space with plenum cables.

Just remember, the more you plan ahead, the easier the job will go, the happier everyone will be and the better everything will work. You cannot have too much planning. So have fun with your conduit.