How to Calculate Conduit Fill

When sizing a conduit, there are three factors that must be taken into account. The number of cables being placed in the conduit, the cross-sectional area of the cable or cables being placed in the conduit, and the number of conduit bends.

Conduit			Maximum Occupancy Recommended			Minimum Radius of Bends	
Trade Size inches	Internal Diameter in (mm)	Cross-Sectional Area in² (mm²)	1 Cable = 53% Fill in² (mm²)	2 Cables = 31% Fill in² (mm²)	3+ Cables = 40% Fill in² (mm²)	Layers of Steel within Sheath in (mm)	Other Sheath in (mm)
¾	0.82 (20.9)	0.53 (345)	0.28 (183)	0.16 (107)	0.21 (138)	8 (210)	5 (130)
1	1.05 (26.6)	0.87 (559)	0.46 (296)	0.27 (173)	0.35 (224)	11 (270)	6 (160)
1¼	1.38 (35.1)	1.51 (973)	0.80 (516)	0.47 (302)	0.60 (389)	14 (350)	8 (210)
1½	1.61 (40.9)	2.05 (1,322)	1.09 (701)	0.64 (410)	0.82 (529)	16 (410)	10 (250)
2	2.07 (52.5)	3.39 (2,177)	1.80 (1,154)	1.05 (675)	1.36 (871)	21 (530)	12 (320)
2½	2.47 (62.7)	4.82 (3,106)	2.56 (1,646)	1.49 (963)	1.93 (1,242)	25 (630)	25 (630)
3	3.07 (77.9)	7.45 (4,794)	3.95 (2,541)	2.31 (1,486)	2.98 (1,918)	31 (780)	31 (780)
3½	3.55 (90.1)	9.96 (6,413)	5.28 (3,399)	3.09 (1,988)	3.98 (2,565)	36 (900)	36 (900)
4	4.03 (102.3)	12.83 (8,268)	6.80 (4,382)	3.98 (2,563)	5.13 (3,307)	40 (1,020)	40 (1,020)
5	5.05 (128.2)	20.15 (12,984)	10.68 (6,882)	6.25 (4,025)	8.06 (5,194)	50 (1,280)	50 (1,280)
6	6.07 (154.1)	29.11 (18,760)	15.43 (9,943)	9.02 (5,816)	11.64 (7,504)	60 (1,540)	60 (1,540)

Sizing a Conduit

Step 1

The first step in sizing a conduit is to determine the number of cables to be placed in the conduit. This will determine the maximum fill allowance (see table below).

Number of Cables in Conduit	Maximum Fill
1	53%
2	31%
3 or more	40%

Step 2

Next, determine the cross sectional area (A) of cable(s) being placed in the conduit via the following equation:

$A = \frac{\pi D^2}{4}$ or $A = 0.79D^2$

If there is more than one cable being placed in the conduit, simply add up the results of the calculations as follows:

$A_T = 0.79D^2$ (Cable 1) + $0.79D^2$ (Cable 2) + $0.79D^2$ (Cable 3) + $0.79D^2$ (Cable 4) +…

Step 3

Finally, determine the number of bends to be placed in the conduit. For each 90° conduit bend, subtract 15% from the total cross-sectional area (see examples below). It is recommended that no more than two 90° bends be placed in a single section of conduit.

Example 1

Suppose two RG-6 Quad Shield (QS) coaxial cables and two 4-pair Unshielded Twisted Pair (UTP) cables are to be placed in a conduit with no bends. The outside diameter (OD) of each RG-6 QS coax is 0.31 inch and the OD of each UTP is 0.25 inch.

To find the cross-sectional area of any cable use the following equation:

$A = 0.79D^2$ where D = outside diameter (OD) of the cable

So, for this example, the calculation for each cable type would be as follows:

Coax: $0.79D^2 = 0.79 \times 0.31^2 = 0.076$ in²
UTP: $0.79D^2 = 0.79 \times 0.25^2 = 0.049$ in²

Simply add the results for all 4 cables as follows:

Coax + Coax + UTP + UTP = total cross-sectional area
0.076 + 0.076 + 0.049 + 0.049 = 0.25 in²

Because 3 or more cables are being placed in the conduit, the maximum fill is 40% based on the Conduit Fill Requirements. In the table, go to the column marked “3+ Cables = 40% Fill”. This column states the maximum allowed occupancy for each trade size conduit. For ¾“ conduit, the maximum occupancy is 0.21 in², which is less than the 0.25 in² required, and is therefore unsuitable for the application. For a 1” conduit, the maximum occupancy is 0.35 in², which of course is greater than 0.25 in², and therefore appropriate for this application.

Example 2

Now suppose that the same two RG-6 QS coax and two 4-pair UTP cables are placed in a conduit that includes two 90° bends.

Calculations

The total cross-sectional area of the cables is still 0.25 in². However, since there are two, 90° bends, the acceptable fill must be reduced by 15% for each bend (a total of 30%) to find the proper maximum fill. This is done via the following calculations:

100%	
-30%	(two, 90° bends)
70%	
x 40%	(proper fill for 3 or more cables)
28%	(new fill requirement)

Now the new maximum fill is 28%. Since there is no column for 28%, calculate the available space in the conduit manually. Finding the proper trade size, in an example such as this, is a matter of trial and error. From the table, 1" conduit has an area of 0.87 in² and 1¼" conduit has an area of 1.51 in².

To calculate the maximum occupancy for these conduits, use the following equation:

Area x 28% = maximum occupancy
For 1": 0.87 x 28% = 0.24 in²
For 1¼": 1.51 x 28% = 0.42 in²

The maximum occupancy for a 1" conduit is 0.24 in², which is less than the 0.25 in² required, and is therefore unsuitable for the application. The maximum occupancy for a 1¼" conduit is 0.42 in², which of course is greater than 0.25 in², and therefore appropriate for this application.

Summary

This document should be used as a guideline for cable fill requirements. Please keep in mind that these requirements are minimum values and do not take into account additional factors that may affect conduit fill, or future cabling requirements.