Determining the Number of Innerducts Contained in Outerducts

Outerducts enclosing a given number of innerducts based on volume. --four of many possible compact arrangements of circles within a circle are shown at A, B, C, and D in Fig. 1.

1. **Arrangements of Center of Core Innerducts**: the four most common arrangements of center or core innerducts are shown cross-sectioned in Fig 1. It may seem that the "A" pattern would require the smallest enclosing outerduct for a given number of enclosed innerducts, but this is not always the case since the most compact arrangement will, in part, depend on the number of innerducts to be enclosed.

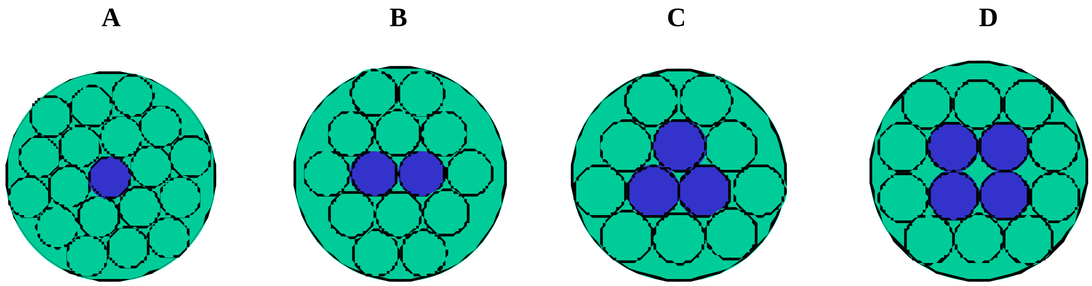

Fig. 1

2. **Diameter of Enclosing Outerduct**: Successive, complete layers of innerducts may be placed around each of the central cores, Fig. 1, of 1, 2, 3, or 4 innerducts as the case may be. The number of innerducts contained in arrangements of complete layers around a central core of innerducts, as well as the diameter of the enclosing outerducts, may be obtained using the data in Table 1.

   Thus, **for example**, the "A" pattern in Fig. 1 shows by actual count, a total of 19 innerducts arranged in two complete "layers" around a central core consisting of one innerduct. This agrees with the data shown in the left half of table 1 for n = 2

   To determine the diameter of the enclosing outerduct, the data in the right half of Table 1 is used. Thus, for $n = 2$ and an "A" pattern, the diameter D is 5 times the diameter d of the enclosed innerducts.

3. **Number of Innerducts, N, Enclosed by an Outerduct**: The diameters of innerduct and outerduct are already known and use the data in the left half of Table 1 is used.

   Thus, **for example**, if D = 16" and d = 1.66", and an "A" pattern, we would divide 16/1.66 (D/d) which gives an answer of 9.64. Truncating the decimal portion gives 9. Therefore, D is 9 times larger than d (D= 9d). Look in the right half of Table 1 and find in the "A" pattern the value "9d." Follow the row across to the "A" pattern in the left half of the table to obtain the No. of innerducts, which is 61.

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Table 1. Number of Circles, n, Contained in Complete Layers of Circles and Diameter of Enclosing Circle

	Arrangement of Innerducts in Center Pattern (see Fig. I)							
n	**"A"**	**"B"**	**"C"**	**"D"**	**"A"**	**"B"**	**"C"**	**"D"**
	No. of Innerducts, N, Enclosed				**Diameter, D, of Enclosing Outerduct***			
0	1	2	3	4	d	2d	2.155d	2.414d
1	7	10	12	14	3d	4d	4.055d	4.386d
2	19	24	27	30	5d	6d	6.033d	6.379d
3	37	44	48	52	7d	8d	8.024d	8.375d
4	61	70	75	80	9d	10d	10.018d	10.373d
5	91	102	108	114	11d	12d	12.015d	12.372d
n	**	**	**	**	**	**	**	**

* Diameter *D* is given in terms of *d*, the diameter of the enclosed circles.
** For n complete layers over core, the number of enclosed circles N for "A" center pattern is 3n^2+3n+1; for "B," 3n^2+5n+2; for "C," 3n^2+6n+3; for "D," 3n^2+7n+4; while the diameter D of the enclosing circle for "A" center pattern is (2n+1)d; for "B," (2n+2)d; for "C," (1+2(n^2+n+1/3)^.5)d; and for "D," (1+(4n^2+5.644n+2)^.5)d.

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Outerducts enclosing a given number of innerducts based on complexity of run.
The volume fill is the amount of volume the innerduct occupies inside the outerduct. To calculate the volume fill of an innerduct use the below equation:
(# of innerducts * cross sectional area of pulled innerducts)/(cross sectional area of outerduct)

- cross sectional area of innerducts is calculated as follows (use OD of innerduct): (3.14*OD^2)/4
- cross sectional area of outerduct is calculated as follows (use ID of outerduct): (3.14*ID^2)/4

The volume fill is called the **"Run Factor."** The more difficult the run, the lower the run factor.

Typical run factors:

- Run factor = .7 maximum value recommended
- Run factor = .5 for shorter and straighter runs
- Run factor = .3 for longer and more complex runs

Adjust value as needed per experience.

To estimate the number of innerducts that can be pulled through an outerduct use the following formula:
No. of innerducts that can be pulled through an outerduct = (Run factor x cross sectional area of outerduct) / (cross sectional area of pulled innerducts).

The Excel Spreadsheet uses the above equation to automatically calculate the number of innerducts that can be pulled through an outerduct.