The Mathematics of Metalworking Fluids

The two most commonly asked questions about metalworking fluids that require some math to answer are:

1. How big is that sump, tank, or whatever? Meaning how may gallons or liters of fluid does it hold.
2. How much fluid should I add to that sump to achieve the desired concentration?

One cubic foot (ft^3) of water contains 7.48 gallons or 28.35 liters.
One cubic inch (in^3) of water contains 0.00433 gallons or 0.0164 liters.
One cubic meter (m^3) of water contains 1000 liters or 283.85 gallons.
One cubic centimeter (cm^3) of water contains 1 liter or 0.2642 gallons.
One cubic millimeter (mm^3 or ml) of water contains 0.01 liters or 0.00264 gallons.

Thus, a sump that is 2 feet wide and 62 1/2 inches long on the inside, and filled to a depth of 19 inches, has a volume of 28,500 in^3 (24x62.5x19) or 123 gallons (28,500/231 = 123.376 or 28,500 x 0.00433 = 123.405). Using the calculated value of 123 gallons or even rounding it off to 120 or 125 gallons will give more than sufficient accuracy for working tank side with metalworking fluids. If at all possible, it is best to do these calculations when the fluid is at rest (turned off) so that all the fluid in the system is in the tank and measured. When working with central systems, even when the trenches are dry, there can be a lot of fluid held in the clean fluid delivery pumps, tanks and plumbing. Don't forget these volumes when you are doing your calculations.

In the field, dealing with metalworking fluids, we are nearly always dealing with volume percent. In other words, what percent of the total volume of the system is made up of the item to be measured. Chemists in the laboratory nearly always deal with weight percent, or how much of the total weight is represented by the material to be measured. When in doubt, ask!

Yet, it is understood that it is bad mathematics and poor science not to consider the fact that when something is added to a working solution, you no longer have the volume you started out with. If we look again at our hypothetical 123 gallon sump and want to raise the concentration 1%; then, if I add 1.23 gallons I will not have 123 gallons any more but rather 124.23 and so my 1% add is just a little light. To do this job properly, we should differentiate the volumes, meaning that my add should have been about 1.24 gallons. However on a practical basis, as we can only measure concentration tank side within about 1/4%, the percentage of the calculated value works just fine.

Traditionally, concentration of metalworking fluids has been expressed both as a ratio (10:1) and a volume percent (10%). We at Master Fluid Solutions much prefer volume % as it is less ambiguous than is a ratio. These fluid ratios come in two forms, the ratio of water to coolant concentrate necessary to make a given concentration 9:1 (9 parts of water to 1 part of concentrate = 10%) or the ratio of concentrate to the total working solution (1 part of concentrate in 10 parts of working solution = 10%).

Thus, if I want to make a 1% add to my hypothetical 123 gallon sump, I can arrive at the 1.23 gallon add by either dividing the 123 gallons by 100 (as in 1 part of concentrate in 100 parts of working solution) or by multiplying the 123 by the 1% (123 x 0.01 = 1.23). With either method, we wind up with a usable number for the amount of product to add.

The Relationship of Various Metalworking Fluid Concentration Conventions

Volume percent or percent by volume is the percent of the total volume that the material to be measured represents in the total volume of material.

Sump ratio is the ratio between the material to be measured and total volume of material.

Mix ratio is the ratio between the amount of material to be mixed and the amount of material that needs to be added in order to achieve the desired concentration.

Volume %	Sump Ratio X:1	Mixing Ratio X:1
1	100	99
1.5	66.7	65.7
2	50	49

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3	33.3	32.3
4	25	24
5	20	19
6	16.7	15.7
6.7	14.9	13.9
7	14.3	13.3
7.5	13.3	12.3
8	12.5	11.5
8.3	12.5	11.5
9	11.1	10.1
10	10	9
11	9.1	8.1
11.1	9	8
12	8.3	7.3
12.5	8	7
13	7.7	6.7
14	7.1	6.1
14.3	7	6
15	6.7	5.7
16	6.3	5.3
17	5.9	4.9
18	5.6	4.6
19	5.3	4.3
20	5	4

Other Useful Conversion Factors:

1. 1 Imperial gallon equals 1.2009 U.S. gallons or 4.5459 liters.
2. 1 U.S. gallon equals 3.7853 liters or 231 in^3
3. 1 liter equals 0.264178 U.S. gallons or 61.026 in^3
4. 1 ppm (parts per million) equals 0.0001%
5. 1% equals 10,000 ppm

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