Conoco

TECHNICAL INFORMATION

The Economics of Pound Volume Comparisons

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The Economics of Pound Volume Comparisons

When comparing the economics of compounds or formulations against competitive materials, the various components (raw materials) and their relative cost per unit are of major importance. The most common cost per unit form encountered is that calculated on a weight basis, such as dollars or cents per pound. However, most PVC end uses actually involve volume cost considerations. While PVC compounds are bought by fabricators by the pound, the end products are usually sold by volume. For instance, PVC shoe soles will require a certain volume of PVC compound to fill the fabricating mold. Hence, costs based on volume become important when comparing the economics of compounds and formulations.

Cost per volume values can be determined by easy conversions of cost per pound values. These types of conversions give rise to what is termed pound volume costs. A pound volume, put simply, is the volume occupied by a pound of material. To calculate the pound volume of a certain material, one needs to know the specific gravity of the material in question. Specific gravity is the ratio of the density of a material to that of water. The density of water, by definition, is equal to one. Hence, a material's specific gravity is a measure of its weight volume relationship relative to water.

Calculation of pound volume costs can be derived from the following equation:

$$\text{Pound volume cost (\$/volume)} = \text{Weight Cost (\$/pound)} \times \text{Specific Gravity}$$

For example, PVC Compound A having a specific gravity of 1.35 and costing 65 cents per pound has a pound volume cost of:

$$0.65\ \$/\text{pound} \times 1.35 = 0.88\ \$/\text{volume}$$

while PVC Compound B having a specific gravity of 1.30 and costing 67 cents per pound has a pound volume cost of:

$$0.67\ \$/\text{pound} \times 1.30 = 0.87\ \$/\text{volume.}$$

One can see that although Compound B costs more per pound, with a lower specific gravity Compound B would produce a finished product, sold by volume, at a lower cost.

When comparing different formulations for pound volume costs, the specific gravity for the formulation can be calculated so that pound volume costs can be compared. The calculation is carried out as follows:

$$\text{Compound specific gravity} = \frac{\text{Total Weight of Ingredients}}{\dfrac{\text{Weight No. 1}}{\text{Specific Gravity No. 1}} + \dfrac{\text{Weight No. 2}}{\text{Specific Gravity No. 2}} + \dfrac{\text{Weight No. 3}}{\text{Specific Gravity No. 3}} + \ldots}$$

An example of this type of calculation along with weight cost and pound volume cost is shown below (please refer to Table 1 on the back page for the specific gravity of the individual ingredients):

Example A

Ingredient	Weight, lb. ×	Cost $/lb.	=	Overall Cost, $	Specific[1] Gravity	Weight / Specific Gravity
PVC Resin	100.0	0.30		30.00	1.40	71.43
DOP Plasticizer	40.0	0.40		16.00	0.99	40.40
Ba/Cd Stabilizer A	3.0	1.00		3.00	1.03	2.91
$CaCO_3$ Filler	20.0	0.10		2.00	2.71	7.38
Stearic Acid	0.5	0.24		0.12	0.94	0.53
	163.5			51.12		122.65

Specific gravity = 163.5/122.65 = 1.33
Compound cost = 51.12/163.5 = 0.3127 $/lb.
Pound volume cost = 0.3127 × 1.33 = 0.4158 $/volume

It is common practice to substitute a more efficient additive for a less efficient one to reduce the per pound cost. The following example illustrates that in many instances a real cost reduction, based on pound volume cost, is not achieved:

Example B

Ingredient	Weight, lb. ×	Cost $/lb.	=	Overall Cost, $	Specific[1] Gravity	Weight / Specific Gravity
PVC Resin	100.0	0.30		30.00	1.40	71.43
DOP Plasticizer	40.0	0.40		16.00	0.99	40.40
Ba/Cd Stabilizer B	2.0	1.20		2.40	1.03	1.94
$CaCO_3$ Filler	20.0	0.10		2.00	2.71	7.38
Stearic Acid	0.5	0.24		0.12	0.94	0.53
	162.5			50.52		121.68

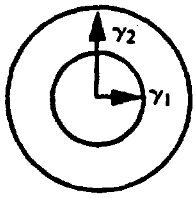
Specific gravity = 162.5/121.68 = 1.34
Compound cost = 50.52/162.5 = 0.3109 $/lb.
Pound volume cost = 0.3109 × 1.34 = 0.4166 $/volume

Comparison of Examples A and B shows that on a cost per pound basis, substitution of a more efficient stabilizer lowers costs. But on a cost per volume basis the costs have actually increased.

The following example illustrates a typical end product volume calculation and cost comparison based on pound volume costs:

Example C
A wire fabricator produces a PVC insulated type T wire[2] using a 14 AWG conductor with an average PVC insulation thickness of 0.76 mm. Calculations of the volume of 1.000 feet of this PVC insulation are as follows:

PVC insulation cross sectional area = (Area of radius 2) - (Area of Radius 1).



For 14 AWG, $\gamma_1 = 0.81$ mm $\therefore \pi\gamma_1^2 = 2.08$ mm^2

$\gamma_2 = \gamma_1 + 0.76$ mm $= 1.57$ mm $\therefore \pi\gamma_2^2 = 7.74$ mm^2.

Cross sectional area of PVC insulation = 7.74 mm^2 – 2.08 mm^2 = 5.66 mm^2

PVC volume of 1.000 feet of wire = 304.800 mm x 5.66 mm^2 = 1.725.168 mm^3 or 1.725.168 cm^3.

$$\text{Compound A} = \frac{\$0.65}{\text{lb.}} \times \frac{1\ \text{lb.}}{454\ \text{g}} \times \frac{1.35\text{g}^{(3)}}{\text{cm}^3} \times \frac{1725.168\ \text{cm}^3}{1.000\ \text{ft.}} = \$3.334/1{,}000\ \text{ft.}$$

$$\text{Compound B} = \frac{\$0.67}{\text{lb.}} \times \frac{1\ \text{lb.}}{454\ \text{g}} \times \frac{1.30\ \text{g}^{(3)}}{\text{cm}^3} \times \frac{1725.168\ \text{cm}^3}{1.000\ \text{ft.}} = \$3.310/1{,}000\ \text{ft.}$$

If these values are extended for three eight-hour shifts per day averaging 2.000 ft/min, 300 days a year, the difference in compound costs between Compound A and Compound B comes to $20.736, even though Compound B costs two cents per pound more.

Sometimes it is necessary to calculate a competitive price based on pound volume consideration. The example below illustrates what Compound A must cost in $/lb to equal the $/volume cost of Compound B:

Example D
Compound A ($/lb) × Specific Gravity = Compound B ($/lb) × Specific Gravity

$$A\ (\$/\text{lb}) \times 1.35 = \$0.67/\text{lb.} \times 1.30$$

$$A\ (\$/\text{lb}) = \frac{(\$0.67/\text{lb.} \times 1.30)}{1.35} = \$0.645/\text{lb.}$$

(1) Table I on the back page lists the specific gravity of the most commonly used raw materials in PVC compounds.
(2) UL 83 Thermoplastic insulated wires and cables.
(3) When density of water equals 1, specific gravity approximates density, with units of g/cm^3.

Table I
Specific Gravities of Various PVC Compound Ingredients

Resins	
General Purpose PVC	1.40
Dispersion Grade PVC	1.40
Plasticizers	
Dihexyl Phthalate (DHP)	1.007
Di-2-ethylhexyl Phthalate (DOP)	0.986
Diisooctyl Phthalate (DIOP)	0.985
Diisononyl Phthalate (DINP)	0.972
Diisodecyl Phthalate (DIDP)	0.968
Ditridecyl Phthalate (DTDP)	0.953
N-$C_6C_8C_{10}$ Phthalate (610P)	0.976
N/i-C_7-C_9-C_{11} Phthalate (711P)	0.972
N-C_8-C_{10} Phthalate (810P)	0.971
N/i-C_{11} Phthalate (DUP)	0.956
Di-2-ethylhexyl Adipate (DOA)	0.927
Diisononyl Adipate (DINA)	0.921
Diisodecyl Adipate (DIDA)	0.918
N-C_6-C_8-C_{10} Adipate (610A)	0.922
N-C_8-C_{10} Adipate (810A)	0.919
Tri-2-ethylhexyl Trimellitate (TOTM)	0.991
Triisooctyl Trimellitate (TIOTM)	0.991
Triisononyl Trimellitate (TINTM)	0.977
N-C_8-C_{10} Trimellitate (NODTM)	0.977
Expoxidized Soybean Oil	0.966
Octyl Epoxytallate	0.922
Typical Polymerics (Polyesters)	1.03-1.15
Chlorinated Paraffin (52 percent Cl)	1.250
Cresyl Diphenyl Phosphate	1.208
Tricresyl Phosphate	1.166
Stabilizers	
Typical BaCdZn (liquid)	0.94-1.02
Typical BaCd (liquid)	0.98-1.02
Typical BaCd (solid)	1.18-1.42
Dibasic Lead Phthalate	4.5
Modified Dibasic Lead Phthalate	3.5
Modified Basic Lead Silicate Sulfate	3.9
Modified Lead Chlorosilicate Complex	3.3
Tribasic Lead Sulfate (Hydrous)	6.4
Modified Tribasic Lead Sulfate	4.6
Fillers, Pigments	
Calcium Carbonate	2.71
Clay	2.68
Antimony Oxide	5.6
Fumed Silica	2.2
Titanium Dioxide (rutile)	4.2
Carbon Black	2.6
Lubricants	
Stearic Acid	0.94
Mineral Oil	0.88

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