QUICK METHOD FOR CALCULATING SPECIFIC GRAVITIES OF LIQUIDS.

(With Special Applications to Alcohol Determinations.)

BY L. S. CROSBY.

In many control laboratories where a Westphal balance will not give sufficiently accurate results, and where dependence must be placed on the use of a pycnometer for the determination of specific gravity, a considerable amount of time is consumed in the calculations. Any expedient which will facilitate these calculations and save time is therefore welcome.

With this idea in mind the following quick method for calculating specific gravities of liquids was developed. It is applicable to determinations on liquids where the limits of specific gravity do not vary too widely, but for purposes of illustration the method will be outlined for alcohol determinations only.

To determine the specific gravity of any liquid at 15.56° C., it is only necessary to multiply the weight of the liquid (necessary to fill the pycnometer) at that temperature by a factor, F, which varies with the individual pycnometer and is calculated as follows:

Let W = Weight of liquid at any definite temperature (15.56° C. in the case of alcohol).

W′ = Weight of water at the same temperature.

$$\text{Then Sp. Gr.} = WW' = \frac{1}{W'} \times W = F \times W,$$

where $F = 1/W'$.

Example: Weight of alcoholic distillate at 15.56° C. necessary to fill pycnometer = 21.4567 Gm. = W.

Weight of water at same temperature = 21.8847 = W′.

$F = 1/W' = 1/21.8847 = 0.045694$.

Sp. Gr. = $21.4567 \times 0.045694 = 0.98044$.

It has been found that the above method, in which only a multiplication is involved, is somewhat shorter than the usual method where a long-hand division process is necessary.

In order to further facilitate the calculations the following short multiplication method has also been used.

A table of multiples (Table 1) of the factor is calculated in order to avoid the time-consuming multiplication at every determination. Even with the use of these multiples, however, there is considerable unnecessary calculation, as will be observed when the multiplication is actually carried out as illustrated in Column 1 below:

Column 1.

	045694	
	abcdef	
	214567	
f	31	9858
e	274	164
d	2284	70
c	18277	6
b	45694	
a	91388	
	0.980442	4498
	123456	

Column 2.

	123456
a	91388
b	45694
c	18278
d	2285
e	274
f	32
	0.980443

Since for general use only five decimal places are significant, it will be seen that all figures to the right of vertical line may be disregarded entirely, the sixth decimal place being retained. It is obvious that the same result will be obtained by setting down the figures as in Column 2. The figures in the first column to the left of the vertical line have been rounded off in the standard fashion. Any error which this may introduce is so slight that it may be disregarded for ordinary work.

Furthermore, since it is standard practice to take such a volume of liquid for alcohol determination that the percentage of alcohol in the distillate falls below 25%, the weight of the distillate will fall within the limit of less than 1 Gm., *i. e.*, in the illustration given above between 21.000 Gm. (equivalent to 35% alcohol) and 21.8847 Gm., the weight of distilled water necessary to fill the pycnometer.

Consequently the calculation may be further simplified by combining *a* and *b* as follows:

	123456
a	91388
b	45694
	0.959574
c	18278
d	2285
e	274
f	32
	0.980443

Carrying this procedure one step further a table (No. 2) is computed, giving multiples of the factor F from 21.0 Gm. to 21.8 Gm.:

TABLE 1.

1	45694
2	91388
3	137082
4	182776
5	228470
6	274164
7	319858
8	365552
9	411246

TABLE 2.

21.0	959574
21.1	964143
21.2	968713
21.3	973282
21.4	977852
21.5	982421
21.6	986990
21.7	991560
21.8	996129

In computing this table, as in using the method, care should be taken in setting down the first left-hand figure in its correct position, bearing in mind that, as shown in Table 1, there are five digits in the second multiple of F and six in all further multiples.

Example:

21.0 × F = 0.959574	21.0 × F = 0.959574
0.2 × F = 9139	0.3 × F = 13708
21.2 × F = 0.968713	21.3 × F = 0.973282

The following directions and examples should make the method clear.

	Position —	123456	
1. Set down the weight of distillate in question	*Example 1* —	214567	= W
2. Look up multiple in Table 2 and set down directly below:	*abc* 21.4 =	0.977852	
3. Consult Table 1 for further multiples, setting down figures in proper position which, until accustomed to the method, is determined as follows:	*d* 5 =	2285	
	e 6 =	274	
	f 7 =	32	
		0.980443	= Sp. Gr.

Example.

If second decimal (*d*) in wt. is 1 or 2 place 1st left-hand figure in position 4 4
If second decimal (*d*) in wt. is 3 or 9 place 1st left-hand figure in position 3 1–3
If third decimal (*e*) in wt. is 1 or 2 place 1st left-hand figure in position 5 2–3
If third decimal (*e*) in wt. is 3–9 place 1st left-hand figure in position 4 1–4
If fourth decimal (*f*) in wt. is 1 or 2 place 1st left-hand figure in position 6 1
If fourth decimal (*f*) in wt. is 3–9 place 1st left-hand figure in position 5 2–3–4
If a zero occurs in weight simply disregard it and follow directions for next figure.

Example 2:

1: Wt. distillate	=	21.1732	2: Wt. distillate	=	21.7019
		96 4143			99 1560
		3199			46
		137			41
		9			
			Sp. Gr.	=	0.991647
Sp. Gr.	=	96 7488		=	0.99165
	=	96 749			
3: Wt. distillate	=	21.0915	4: Wt. distillate	=	0.21.5146
		0.95 9574			0.982421
		4112			457
		46			183
		23			27
Sp. Gr.	=	0.96 3755	Sp. Gr.	=	0.983086 = 0.98309
	=	0.96376			

That the method checks the regular method for determining specific gravities well within the limits of experimental error, can readily be shown by a few trials. It is, of course, quite possible to compute a table for each individual pycnometer whereby the percent of alcohol might be read off from the weight of distillate necessary to fill pycnometer. Unfortunately, pycnometers do not remain constant, and any change in their content would render such a table valueless. For this reason, it was not considered worth while to carry the method further than indicated above.

CONCLUSION.

With the use of the tables the calculation resolves into a simple addition. Any slight initial difficulty in properly placing the multiples will be easily overcome by a little practice, and after becoming familiar with the figures involved, the entire calculation can be readily completed in less than one minute.

ANALYTICAL AND RESEARCH DEPT.,
UNITED DRUG COMPANY,
BOSTON, MASS.