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# Counting Efficiency of $Co^{56}$, $Co^{58}$ and $Co^{60}$ with 2 Counters and 3 Counting Technics. (25355)

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The technic for measuring Vit. $B_{12}Co^{60}$ of low specific activity contained in one liter of solution on a NaI well scintillation counter has been described(1). Hine and Miller(2) reported on efficiency of counting Vit. $B_{12}Co^{60}$ in a large plastic scintillator capable of holding 60-80 ml. Recently the $Co^{58}$ and $Co^{56}$ isotopes have been used in studies with radioactive Vit. $B_{12}$. This paper reports on the counting efficiency of $Co^{56}$, $Co^{58}$, $Co^{60}$ as a function of sample volume in both a modified plastic scintillator and the conventional NaI well and the merit of the counting systems

*Methods.* Vit. $B_{12}Co^{58}$ and Vit. $B_{12}Co^{60}$ were purchased from Merck & Co. and Vit. $B_{12}Co^{56}$ was generously supplied by Dr. E. Lester Smith of Glaxo Labs., Greenford, England. 0.25 $\mu$c aliquots of Vit. $B_{12}Co^{56}$, $Co^{58}$ and $Co^{60}$ were counted in the NaI well using a standard vial up to a maximum capacity of 4 ml and in a beaker containing one liter adapted to fit on and around the NaI well. In addition the 3 isotopes were counted in the plastic well scintillation counter. The counting efficiency of the 3 isotopes as a function of sample volume was compared. The NaI well type scintillation counter for counting up to 4 ml samples as well as the beaker to fit on and around the counter capable of counting 1 liter of solution was previously described(1). The counter* consists of an RCA 5819 phototube, a thallium activated sodium iodide crystal, 1¾″ diameter and 1″ thick with a hole ¾″ in diameter and 1″ deep, and a cathode follower preamplifier. The plastic scintillator† was modified and enlarged on the advice of Dr. G. J. Hine from that previously described and diagram shown in Fig. 1. The plastic well was surrounded by 3 in. of lead shielding except at the tube opening. Test tubes to contain the samples in this well were 38 x 300 mm.

*Results. Small Volumes (1-4 ml.)* If one counts samples in small volumes (1-4 ml), the capacity of most commercially available NaI well crystals, it is apparent from Table I that the plastic well is as efficient as the NaI well for $Co^{56}$ and more efficient than the NaI well for $Co^{58}$ and $Co^{60}$. The NaI crystal used in these studies is slightly less efficient than the more recent commercially available crystals. Since average background rate of the plastic well is about 400 cpm as compared to 120 cpm for the NaI crystal, the ratio of $R_S^2/R_b$ ($R_S$ = total counting rate, $R_b$ = background rate) is greater for the NaI well. It has been shown that the higher the ratio of $R_S^2/R_b$ (merit ratio) the less the counting time necessary for a given accuracy(3).

*Intermediate Volumes (4 ml-250 ml).* The plastic scintillator is highly efficient and the efficiency is almost independent of sample size from 10-100 ml for the 3 isotopes. Larger NaI wells holding more than 4 ml are difficult and very expensive to build. Baskin *et al.*(4) described a NaI well crystal with a capacity of 20 ml and an efficiency for $Co^{60}$ of 22.6%. Thus the plastic well appears to be the most efficient method for counting gamma radiation contained in sample volumes of 10 to 250 ml. Because of relative independence of volume size on efficiency and the larger size of plastic well, whole mice, rats up to about 75 g and

* Model $S_1$—purchased from H. O. Anger, Berkeley, Calif.

† Pilot Scintillator B, Pilot Chemicals. Specific gravity = 1.03 Atomic ratio $\frac{H}{C}$ = 1.10

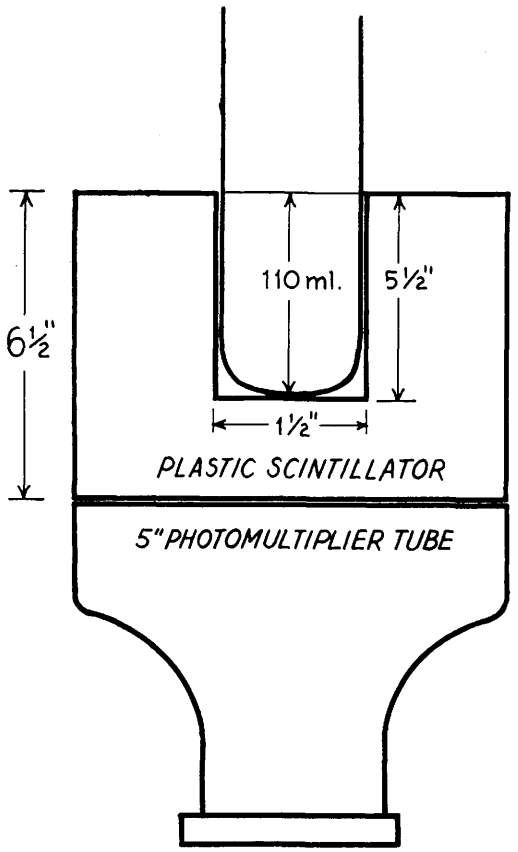


FIG. 1. Plastic scintillator

tissue samples can conveniently be counted in the plastic scintillator without corrections for geometry.

*Large Volumes (Above 250 ml)* Efficiency of about 200 ml in the plastic well is approximately 5 times the efficiency of 1000 ml using beaker and NaI well with the $Co^{58}$ isotope. Thus if 1000 ml samples are available, such as 24 hour urine collections, 200 ml may be counted in the plastic well or 1000 ml in the beaker with the NaI well with equal sensitivity. The choice of instrument to use in this instance would depend upon number of samples to be counted and activity of samples. The higher background rate of the plastic well would require longer counting time, but the relatively more expensive specially designed beaker for the NaI well as compared to the general availability of test tubes for the plastic well would require that the beaker be washed before another sample could be counted. If more than 1000 ml samples are available, the beaker would be the most sensitive technic for counting. For example, if a 2000 ml sample were available, one could count half of this sample in the beaker with the NaI well at 3.5% efficiency for $Co^{58}$ as compared to 1/10 the sample at 16.5% efficiency. If on the other hand, sample volumes of 100 ml to 1000 ml were available, the instrument of greatest sensitivity is the plastic well. With $Co^{56}$, the plastic well with a 200 ml sample is only about 3.5 times the efficiency (28.0% *vs.* 7.8%) of 1000 ml with the beaker and NaI well. In this instance it would be more advantageous to use the beaker with sample volumes of 700 ml or greater. With $Co^{60}$ the efficiency of the plastic well at 200 ml is 6 times the efficiency (22.6% *vs.* 3.8%) of 1000 ml with the beaker and NaI well and it would not be any more advantageous to use the beaker unless the sample size was 1200 ml or greater.

*Comparison of Beaker with NaI well* vs. *NaI well alone.* As pointed out(1) 1000 ml samples of $Co^{60}$ in the beaker over the NaI well results in an efficiency of about 1/6 (3.8% *vs.* 23.2%) that obtained by counting the same amount of radioactivity in a 4 ml volume using a vial placed directly in the well. However, in using a 1000 ml sample, one is counting 250 times more sample material. Multiplying 250 by 1/6 it is apparent that the beaker is more than 40 times more sensitive than the NaI well using just the vial. This is equally true with the $Co^{56}$ and $Co^{58}$ isotopes. The efficiency of $Co^{56}$ and $Co^{58}$ in 4 ml in the vial is 46.8% and 20.5% respectively. The efficiency of $Co^{56}$ and $Co^{58}$ in a 1000 ml sample in the beaker is 7.8% and 3.5% respectively.

*Summary.* A NaI well scintillation counter and a beaker adapted to fit on and around the NaI well as well as a plastic well scintillation counter, were used to compare efficiency of $Co^{56}$, $Co^{58}$, and $Co^{60}$ as a function of volume. The plastic well counter is as efficient for $Co^{56}$ as the NaI well and more efficient for $Co^{58}$ and $Co^{60}$ than the NaI well for small volumes (1-4 ml). For intermediate volumes (4-250 ml) the plastic well is the more efficient and the efficiency is almost independent of sample

TABLE I. Efficiency and Ratio of $R_s^2/R_b$ of $Co^{56}$, $Co^{58}$ and $Co^{60}$ in NaI Well Scintillation Counter and in Large Plastic Scintillation Counter as a Function of Volume.

| | $Co^{56}$ | | $Co^{58}$ | | $Co^{60}$ | |
|---|---|---|---|---|---|---|
| NaI well | Efficiency (%) | $R_s^2/R_b$ | Efficiency (%) | $R_s^2/R_b$ | Efficiency (%) | $R_s^2/R_b$ |
| Vial 1 ml | 59.6 | $14.5 \times 10^9$ | 25.7 | $2.7 \times 10^9$ | 26.3 | $2.8 \times 10^9$ |
| 2 | 56.8 | 13.4 " | 24.0 | 2.4 " | 27.3 | 3.1 " |
| 4 | 46.8 | 8.9 " | 20.5 | 1.7 " | 23.2 | 2.2 " |
| Beaker 100 | 7.2 | $20.8 \times 10^7$ | 3.1 | $3.7 \times 10^7$ | 3.4 | $4.7 \times 10^7$ |
| 200 | 7.3 | 21.8 " | 3.1 | 4.0 " | 3.6 | 5.2 " |
| 400 | 8.2 | 27.6 " | 3.6 | 5.3 " | 4.0 | 6.7 " |
| 600 | 8.7 | 30.4 " | 3.8 | 5.9 " | 4.2 | 7.3 " |
| 800 | 8.5 | 29.1 " | 3.7 | 5.6 " | 4.1 | 7.0 " |
| 1000 | 7.5 | 24.4 " | 3.5 | 4.9 " | 3.8 | 6.0 " |
| Plastic well | | | | | | |
| 1 | 52.6 | $3.4 \times 10^9$ | 31.6 | $1.2 \times 10^9$ | 39.4 | $1.9 \times 10^9$ |
| 2 | 56.6 | 4.0 " | 30.3 | 1.1 " | 39.3 | 1.9 " |
| 4 | 49.6 | 3.1 " | 28.6 | 1.0 " | 37.9 | 1.8 " |
| 10 | 47.6 | 2.8 " | 28.5 | 1.0 " | 39.2 | 1.9 " |
| 20 | 47.4 | 2.7 " | 28.1 | 1.0 " | 38.8 | 1.9 " |
| 40 | 46.2 | 2.6 " | 28.4 | 1.0 " | 38.3 | 1.8 " |
| 60 | 45.8 | 2.6 " | 27.7 | .9 " | 37.2 | 1.7 " |
| 80 | 45.0 | 2.5 " | 27.5 | .9 " | 36.8 | 1.7 " |
| 100 | 43.4 | 2.3 " | 26.0 | .8 " | 35.8 | 1.6 " |
| 125 | 40.0 | 1.9 " | 24.1 | .7 " | 32.8 | 1.3 " |
| 150 | 35.0 | 1.5 " | 21.2 | .6 " | 29.2 | 1.1 " |
| 175 | 31.4 | 1.2 " | 18.8 | .4 " | 25.4 | .8 " |
| 200 | 28.0 | 1.0 " | 16.5 | .3 " | 22.0 | .6 " |
| 250 | 22.6 | .6 " | 11.6 | .2 " | 18.3 | .4 " |

volume from 10-100 ml. Mice or small rats up to about 75 g and tissue samples can be counted in the plastic well without correction for geometry. The efficiency of 250 ml in the plastic scintillation counter is 22.6, 11.6 and 18.3% for $Co^{56}$, $Co^{58}$, and $Co^{60}$ respectively and 7.8, 3.5, and 3.8% respectively for 1000 ml using the beaker on the NaI well. The choice of instrument for counting large volumes is discussed.

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## Mechanism of Hypoglycorrhachia in Experimental Pneumococcal Meningitis.* (25356)

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It is well known that glucose in cerebrospinal fluid decreases in patients with bacterial meningitis, while non-bacterial meningitides are usually not associated with hypoglycorrhachia(1). The reason for this phenomenon is poorly understood particularly since it has been demonstrated that both leukocytes and bacteria are capable of accelerating consumption of cerebrospinal fluid in glucose *in vitro* (2,3). In our experiments pneumococcal meningitis was produced experimentally in dogs made leukopenic by total body irradiation. In these animals the leukocytic response in the CSF was effectively suppressed, and decrease in CSF glucose was also prevented despite heavy bacterial growth.

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