MASSEMETRIC EFFICIENCY CALIBRATIONS OF GE DETECTORS FOR LABORATORY APPLICATIONS

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It is traditional in laboratory applications to calibrate gamma spectroscopy detectors in terms of absolute efficiency, i.e. counts in the photopeak per gamma of that energy emitted by the sample. Then, the sample is weighed and placed into the counting container and counted. The result is converted to concentration [e.g. Bq/g] of the nuclide of interest by the following formula:

Bq/g = [net peak counts] / [seconds][efficiency in c/γ][grams of sample][gamma yield]

This formulation has a few well defined characteristics.

- As the sample diameter increases, the efficiency decreases.
- As the sample thickness increases, the efficiency decreases.
- As the density increases, the efficiency decreases.

Consequently, the laboratory must prepare a different calibration for each unique combination of sample diameter, sample height, and sample density.

Following are a series of graphs. They show data computed with the ISOCS mathematical efficiency computation software. The detector used was a nominal 42% relative efficiency coaxial p-type detector.

Figure 1 shows the effect of the changing of sample diameter on the counting efficiency for several energies. The sample was water at a fixed thickness of 10cm.

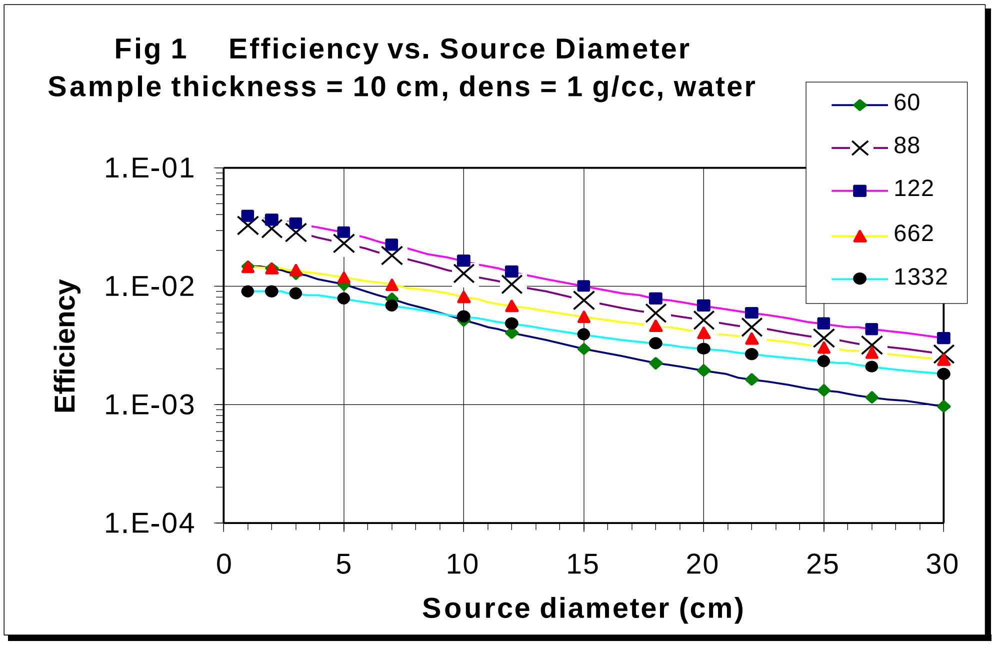


Figure 2 shows the effect of the changing of sample thickness on the counting efficiency for several energies. The sample was water at a fixed diameter of 15cm.

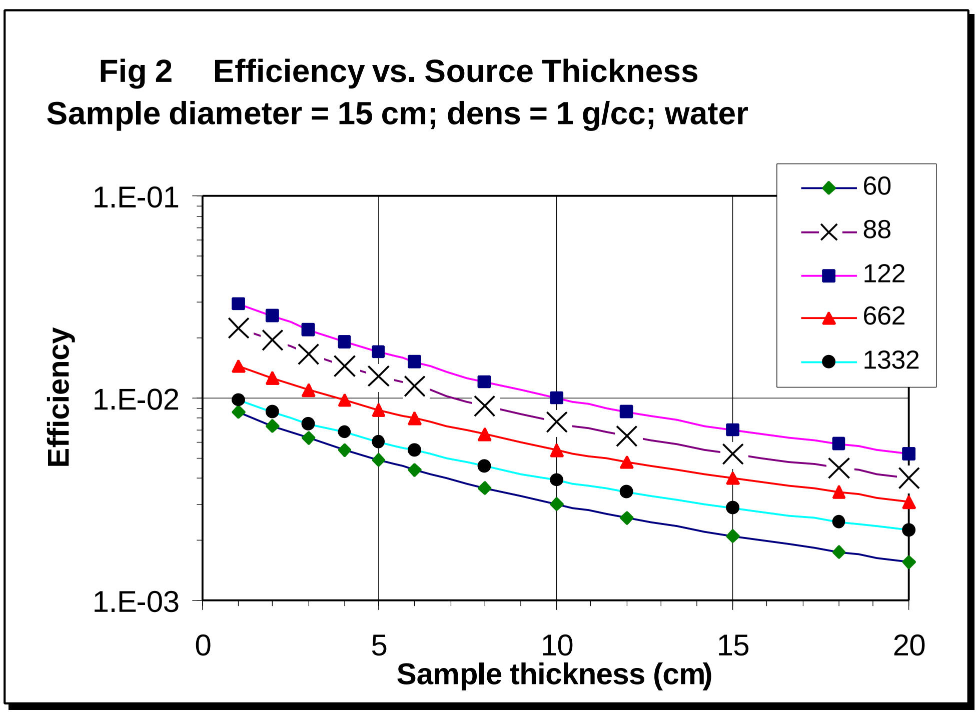
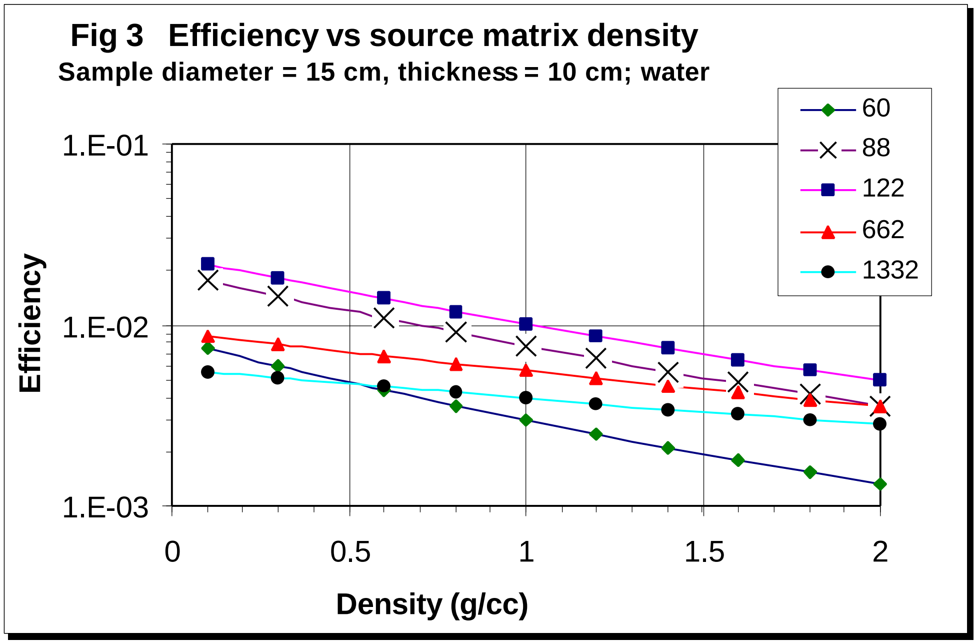


Figure 3 shows the effect of the changing of sample density on the counting efficiency for several energies. The sample was water at a fixed diameter of 15cm and a fixed thickness of 10cm.



Now, consider the consequences of using massemetric efficiency calibrations. Massemetric efficiency units are in terms of net peak counts/sec per gamma/sec per gram of sample. These types of calibrations have long been used for *in-situ* soil measurement applications. The counting result is converted to concentration [e.g. Bq/g] of the nuclide of interest by the following formula:

Bq/g = [net peak counts] / [seconds][efficiency in cps/γps/g][gamma yield]

Now, note the changes that this method of calibration creates:

- As the sample diameter increases, the efficiency <u>increases</u> until it reaches a constant value.
- As the sample thickness increases, the efficiency <u>increases</u> until it reaches a constant value.
- As the density increases, the efficiency <u>increases</u> until it reaches a near-constant value.

Figure 4 shows the effect of the changing of sample diameter on the massemetric counting efficiency for several energies. The sample was water at a fixed thickness of 10cm. The water was at zero source-detector distance. Note here, that as the source diameter gets in the 20-30cm region, further increases in diameter have very little effect. That sample size is called the infinite diameter. This means that if you use massemetric efficiency calibrations for an infinite diameter geometry, that calibration is valid for any diameter greater than 20-25 cm. While that may not be too practical in the counting lab, it is of great importance for *in-situ* spectroscopy of large objects.

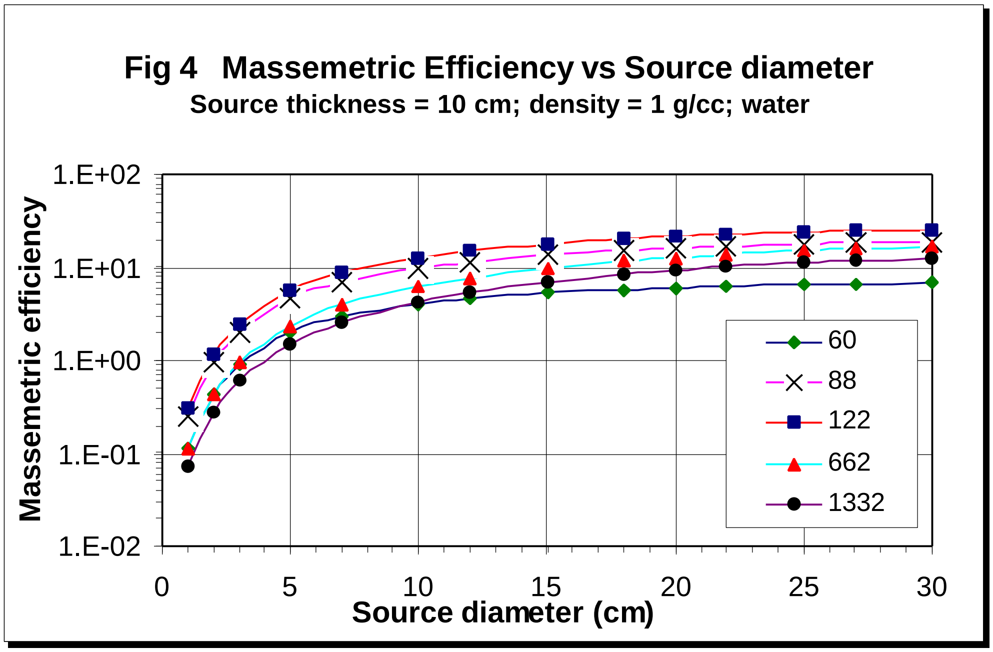


Figure 5 shows the effect of the changing of sample thickness on the massemetric counting efficiency for several energies. The sample was water at a fixed diameter of 15cm. The water was at zero source-detector distance. Note here, that as the source thickness gets in the 8-10cm range, further increases in thickness have very little effect. That sample size is called infinite thickness. This means that if you use massemetric efficiency calibrations for an infinite thickness geometry, that calibration is valid for any thickness of water greater than 10-15 cm.

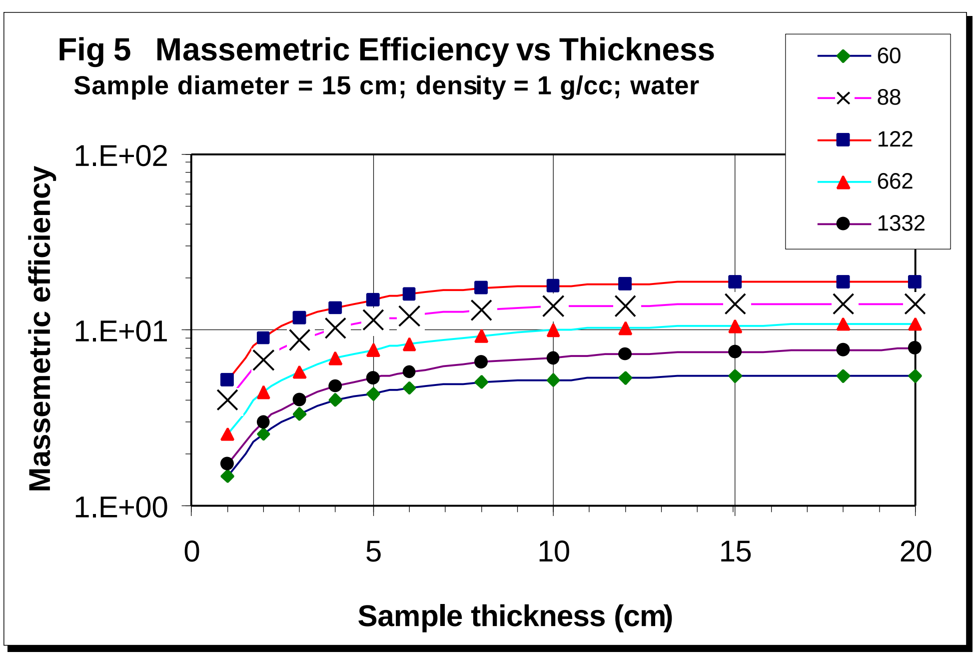
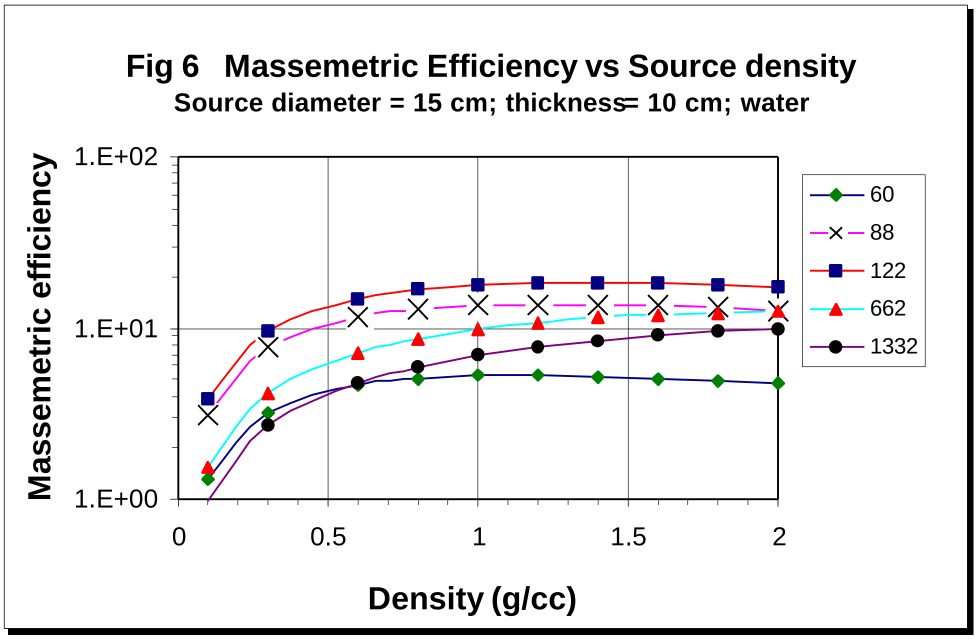
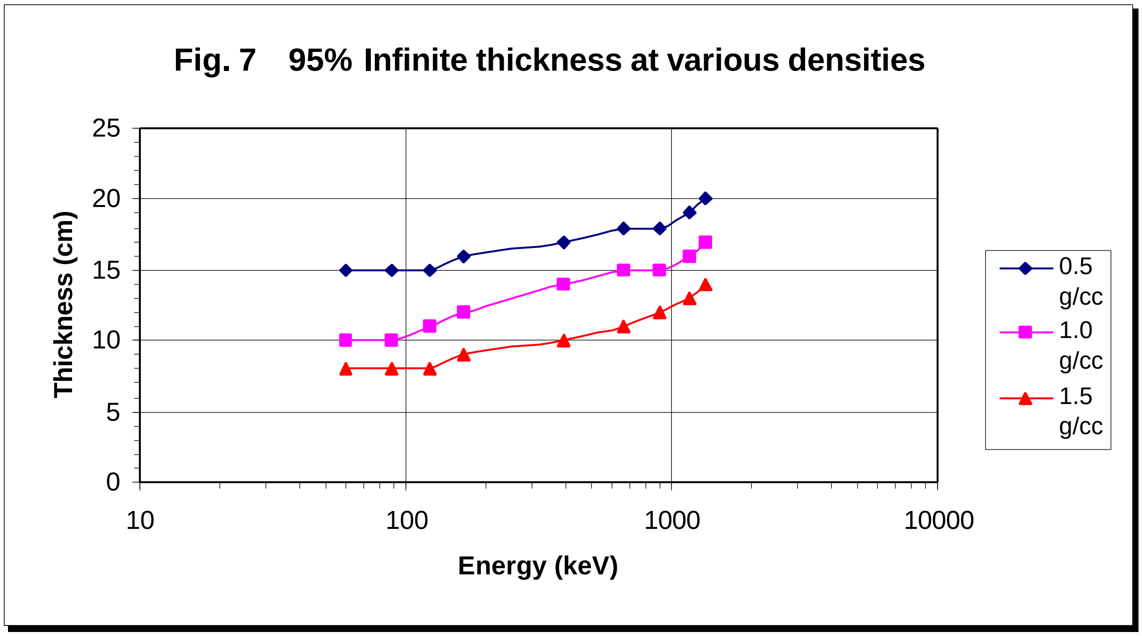


Figure 6 shows the effect of the changing of sample density on the massemetric counting efficiency for several energies. The sample was water at a fixed diameter of 15 cm and a fixed thickness of 10 cm. Now, note that the efficiency does not perfectly approach an asymptotic value. There is a maximum, after which there is a decrease. For geometries where the detector is far from the sample, as in normal *in-situ* measurements, a plateau is indeed reached. At far distances, the efficiency does not dramatically change over the depth of infinite samples, but it does for laboratory geometries.



The advantage of massemetric efficiency calibrations here, is that when minor unexpected changes in sample density happen, there is less of an impact on the counting efficiency, than when traditional efficiency calibrations are used.

The infinite thickness value [and also the infinite diameter value] is a function of the sample density. The higher the density the smaller the infinite thickness [diameter]. Figure 7 shows the 95% infinite thickness dimension for various sample densities.



Using massemetric efficiencies and near-infinite thickness counting geometries can have both economic and accuracy benefits to an assay laboratory. Samples do not need to be weighed, saving time and recordkeeping is reduced. Sample containers do not need to be filled precisely to the same level. Just make sure that the volume is above the 90% infinite thickness level and the calibration will be within 5% accuracy, no matter what the sample height. If density varies by as much as +/- 20%, the calibration accuracy will only vary by less than 5%, as long as the sample is at the 95% infinite thickness value.