ISOCS Mathematical Calibration Software for Germanium Gamma Spectroscopy of Small and Large Objects.

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ISOCS [*In-Situ* Object Counting System] is a portable Ge gamma spectroscopy instrument designed to quantify gamma emitting radionuclides in various sized and shaped objects. The ISOCS instrument consists of a Ge detector, a series of collimators mounted on a transportable cart, the InSpector portable MCA, a laptop PC with GeniePC gamma spectroscopy software, and the ISOCS efficiency calibration software.

With this new portable instrument, the user can now measure the radioactivity content of complete objects, large or small. The successful implementation of this device provides many advantages over the traditional methods of sampling, followed by laboratory analysis.

- Results are available nearly instantaneously;
- Where the object is not homogeneous, the ISOCS results are probably more accurate, since a very large fraction of the sample is measured;
- Detection limits are as low or lower, since a very large sample size is used.

Figure 1 shows the ISOCS used to measure a barrel lying on the ground, simulating a typical accident or D&D application.

Figure 1. ISOCS used to quantify radioactivity in a 200 liter drum

This product is only practical because of the ISOCS mathematical efficiency calibration. Previous techniques that Canberra and others have used [1] [uniform mixtures of radionuclides, large numbers of small sources in inert matrices, and MCNP [2,3] Monte Carlo calibrations] are quite expensive to do, require much time to create, and generate expensive radioactive waste [except for MCNP].

Unlike previous simplified calibration software that treats detectors as points, each ISOCS detector has a unique calibration. This characterization is done by Canberra using MCNP as the reference. The results of that individual detector characterization are included as a part of the ISOCS calibration software. The output of the detector characterization process is a series of equations that define the detector response:

- at any point from the endcap to 50 meter radius,
- at any energy from 50 - 7000 keV, and
- at any angle in all 4π directions.

The ISOCS calibration is a simple process taking only a few minutes. First, a template resembling the generic sample shape is chosen. Nine such templates are available:

- Simple box
- Complex box
- Simple cylinder
- Complex cylinder
- Circular stacked planes
- Rectangular stacked planes
- Pipe
- Marinelli Beaker or Well
- Sphere

Each of these basic shapes has many parameters that can be used where necessary to create many variations. After selecting the template, the various critical parameters

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that define the sample-detector geometry are entered. The collimator combination used is the selected from a list, or alternatively, the parameters are entered manually.

The composition and density of all materials must be defined so that the proper attenuation corrections can be made. The ISOCS materials library contains the full cross-sections of all chemical elements. Also included is a set of common materials [concrete, sand, dirt, wood, water, plastics, etc.]. It is a simple task for the user to create additional materials for addition to the library. The materials editor allows materials to be defined by entry of the chemical formula, by entry of the percentage each element, or by percentage combinations of previously defined materials.

Next, the geometrical relationship between the detector and the sample must be defined. Normally, this is just the distance between the detector and the sample, but several other dimensions are available when the object is not on the axis of the detector, and/or when the detector is not pointing at the center of the object.

Then, the user instructs the ISOCS program to compute the efficiency vs. energy datapoints. During this process, input information is checked, and the efficiency is integrated over the sample volume, corrected for sample self attenuation, container or air attenuation, and collimator attenuation. This process takes from 5-30 seconds [normally] up to 5-10 minutes [large sources, multiple sources, narrow collimators, and/or slow computers].

The output of the ISOCS process is a set of energy/efficiency/error triplets. Upon exiting the ISOCS user interface, this data is converted into the GeniePC energy-efficiency curve format and is displayed for the user to accept/edit and store for future use in sample analysis.

The validation process is nearing completion. A large number [>50 so far] of multi-energy comparisons are being made between the ISOCS efficiency and a reference efficiency. Where possible, we are using traceable sources for comparison. But, most of the difficult validations will be by comparison to MCNP computations for identical objects. MCNP has been shown [3] to be capable of accuracy of 10% or better, when properly applied.

The accuracy of the ISOCS efficiency computation method appears to be approximately <10% for energies >200 keV, <20% for 50-100 keV. Heavily collimated sources will be worse, perhaps a factor of 2. The ISOCS accuracy is expected to be more than adequate for the field measurements where the primary use is expected.

The ISOCS calibration software is quick, efficient, and accurate. For simple laboratory-sized samples containing water-equivalent samples, the use of radioactive sources is still the least expensive and most accurate method. However, when any of the following conditions are present:

- unusual densities
- unusual sample bulk matrix composition
- large samples
- samples at far distances
- heavily attenuated samples

the ISOCS calibration method will be cheaper, quicker, and probably more accurate than traditional source-based calibrations.

REFERENCES

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