ISOCS, AN *IN SITU* SYSTEM AND PORTABLE GAMMA SPECTROSCOPY LAB THAT CAN BE TAKEN TO THE ACCIDENT SITE

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ABSTRACT

Under most emergency situations, external dose-rates are fairly easy to measure, but determining the specific nuclides and their concentrations, has been much more difficult and time-consuming. Historically, this involved taking samples, transporting them to the lab, analyzing them, and then evaluating the data.

With the advent of modern technologies (Portable Ge detectors, compact electronics, powerful PCs) one person can carry a complete laboratory-quality Ge gamma spectroscopy system to the accident site, as part of the initial emergency response kit.

Efficiency calibrations have been a traditional problem, but the ISOCS mathematical algorithms allow high quality calibrations to be done quickly in the field without any radioactive sources. This allows *in situ* measurements to be done of large samples of food, vegetation, milk, water, soil, much more sensitively and accurately than small samples. People can also be quickly assayed in the field (or hospital) for internal/external contamination. And, traditional samples that must be taken can also be counted.

But, most importantly, high quality results are available immediately, to give to concerned management, politicians, and citizens.

Presented at the
ANS 7th Topical Meeting on Emergency Preparedness and Response
September 14-17, 1999
Santa Fe, NM

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BACKGROUND

This article is written from the author's perspective and previous experience with a variety of emergency situations. These have included TMI (from day two onward), Chernobyl, accidents and exercises at U.S. nuclear power plants, and many crisis' where a very important person (customer, boss, etc.) wanted the answer to a complicated problem right away.

Typical analytical questions that must be answered are:

- Is anything there?
- What is it and how much?
- Is it dangerous?
- Is it above our regulatory limits?
- What can I tell the customer/boss/regulator/ press?

Today's emergency response team typically relies on gross non-quantitative portable instrumentation to make these educated guesses in the field, and then substantiates them by sampling and laboratory analysis. That has served the industry well in the past, as plenty of qualified and experienced health physicists were available to respond to emergencies. And, generally, adequate time was available to evaluate and present the results. But today's HPs have much less experience with "uncontrolled" situations, and today's management/regulator/press wants results instantaneously, and they had better be right.

The ISOCS (*In Situ* Object Counting System) instrument to be discussed here is another tool for the emergency response team to use. This tool will give quantitative nuclide-specific results for a wide range of measurement conditions. Because it uses a Germanium detector, it is very easy for the operator, and the software, to determine exactly what radionuclides are being detected. For simple cases under controlled temperature conditions, and with experienced operators, NaI spectroscopy might suffice, but real emergencies can't be planned this way.

Conventional mobile laboratories use Ge spectroscopy, and can be driven to the accident location rather quickly. But, they are large in size, and still require the sample to be found, extracted, packaged, prepared for counting, and then analyzed. Portable Ge systems, like ISOCS can be used in this way, as a very portable sample counting lab. And, the same instrument can be used as an *in situ* system, to bypass the time, expense, and sensitivity limitations of sampling, packaging, and sample preparation. It is the capability of performing efficiency calibrations in the field *without radioactive sources* that gives the ISOCS instrument such important value for emergency applications. Emergency situations are not predictable. Therefore, it is to be expected that unexpected measurement conditions will happen. In this day of "procedures for everything" it is important to retain flexibility to handle a wide range of situations, especially those that are not planned.

THE ISOCS INSTRUMENT

ISOCS is a portable Ge gamma spectroscopy instrument designed to both identify and quantify gamma emitting radionuclides in various sized and shaped objects. The ISOCS instrument consists of the following components:

- Ge detector of appropriate type, size, and shape for the application;
- Detector mounted in all-attitude cryostat so that it can point in all directions; typical cryostat holds five days of LN;
- Series of 25 mm and 50 mm thick shields each with various angle collimators to define the field of view of the Ge detector, and to reduce interference from other objects; these collimators can be configured for sample counting, or for *in situ* counting;
- Sturdy and portable cart to allow detectors and shields to be transported to the measurement site and to aim the detector at the objects to be measured, or to count samples taken from the objects;
- InSpector, a portable battery-operated electronics package that includes HVPS, amplifier, ADC, and MCA, all controlled by the computer;
- Laptop computer, also battery operated, for data analysis and storage of the spectrum;
- Genie-2000 Gamma Spectroscopy software to convert the spectrum into identified nuclides and their activity and/or concentration;
- ISOCS mathematical efficiency calibration software to allow quantitative analysis of a wide variety of *in situ* and *ex situ* samples.

Figure 1 shows the basic detector, shield set, and carrying cart. Mounted on the detector is the 50 mm thick shield set, with the 25 mm thick set on the floor. Not shown is the tray which carries the unused shields.

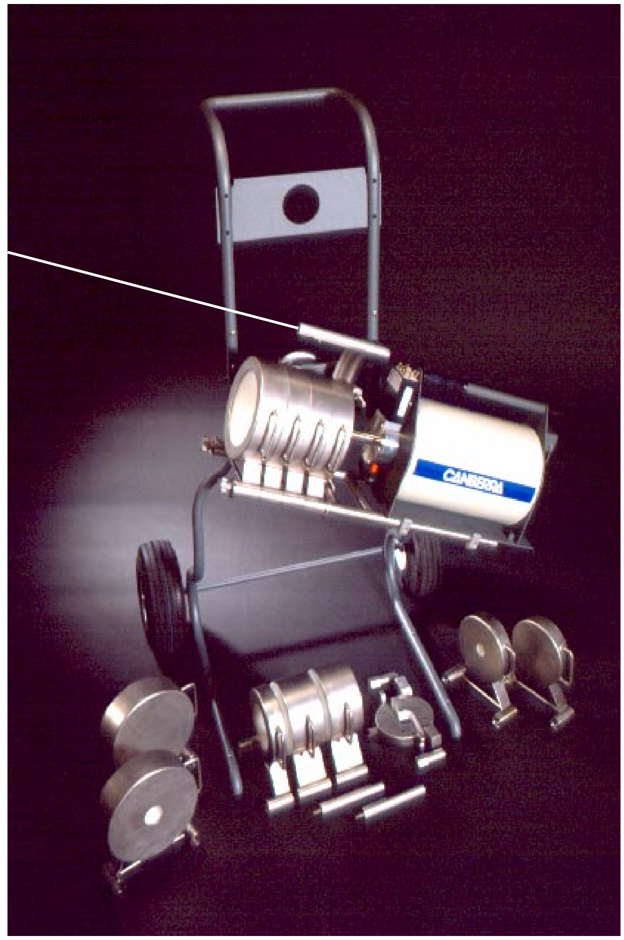

Figure 1.
ISOCS detector and shield set

With this new portable instrument, the user can now measure the radioactivity content of complete objects, large or small, or samples from these objects. For *in situ* applications, the detector is aimed at the item to be assayed. Figure 2 shows the ISOCS used to measure a barrel lying on the ground, simulating a typical accident or D&D application.

Figure 2.
ISOCS used to measure drum

In situ Ge gamma spectroscopy measurements provide many advantages over the traditional methods of sampling, followed by laboratory analysis.

- Results are available nearly instantaneously. Then, reliable decision can be made about what to do next.
- Where the object is not homogeneous, the ISOCS results are probably more accurate, since a very large fraction of the object is measured;
- Detection limits are as low or lower, since a very large sample size is used.
- Costs are typically lower;
- Risks/doses are typically lower, as less work with potentially contaminated material is done.

This is an ideal instrument for decontamination surveys, environmental measurements, emergency response teams, operational radiation protection surveys before maintenance operations, occasional use waste assay measurements, and regulatory inspection teams.

There are some cases where taking samples is the appropriate thing. This includes areas where access is difficult for the detector, items that are heavily shielded, or where samples must be taken for other types of analyses. Examples include air particulate samples, removable contamination assessment samples, subsurface soils, etc. For these cases, quantitative field assay using the ISOCS instrument still provides the benefits of quick turn-around, reliable analysis results, and the capability of handling many different sample types. Figure 3 shows the ISOCS instrument in a shield configuration for counting large Marinelli beakers of sample. Here the back shield and a part of the side shield are used. The beaker with a large sample provides the rest of the shielding. Also shown, is the detector with both shield sets installed. This provides a fully shielded 10 cm dia. x 15 cm long sample cavity.

Figure 3.
ISOCS used to assay Marinelli beakers and small sample containers

Since accidents cannot be predicted in advance, pre-defined counting geometries also cannot be predefined for all scenarios. The ability to react in the field to whatever situation is found is quite important to the emergency team. Field calibrations of counting instrumentation is historically quite difficult, as they involve transporting radioactive sources, and preparing them into field geometries, generally in unfavorable conditions. This is where the advantages of the ISCOS sourceless calibrations make field gamma spectroscopy very practical today.

The patented ISOCS method involves the use of MCNP for a detailed factory characterization of the response functions for each individual detector. Then, the user adds the final correction for modifying factors, such as sample size and density, container size and material and density, other absorbers, air temperature and pressure and relative humidity, any collimation, and distance and angle between the source and the detector. The efficiency is then computed at the user-specified energies. The source can be basically any size, from points up to hundreds of cubic meters. The source can be at zero distance from the detector, to as far away as 500 meters. The source can be at any location around the detector, from the front, to the back. Collimators are supported, both rectangular and cylindrical.

Independent validation comparisons have been performed with approximately 10 different detectors and approximately 150 different geometries, each with approximately 10 different energies. These show accuracy in the 4-8% sd range.

EXAMPLES OF ACCIDENT / INCIDENT SCENARIOS WHERE *IN SITU* GAMMA SPECTROSCOPY IS IMPORTANT

A. Suspected airborne release from NPP

Here the traditional method is to take gross measurements in the field, take many samples, and report the results to the public several weeks later when the analyses are done. But, with ISOCS, the response team can count the ground surface directly and show quantitatively what is (or is not) there. Instead of taking small milk samples, count the entire milk truck. Instead of taking small samples of edible crops, count large bags or pallets of them in place. Count the air gas/particulate/iodine samples in the field, and report only the nuclides of interest, not radon daughters, not xenon on iodine samples.

B. Transportation accident

Here, a truck is in an accident and is overturned, spilling the contents on the highway. There are several boxes with radioactive materials labels on them. The outside of these boxes are wet. The ground is wet. Is this a radioactive materials contamination problem? *In situ* analysis of the soil and the truck will help provide the answer. Field sample assay of the shipping boxes can also be performed. This, combined with traditional gross beta/gamma survey instruments can quickly arrive at the correct answer for most of the situations.

C. Alarm on truck monitor at scrap steel yard or landfill site

What has caused the alarm to go off? The truck monitor is a gross instrument, and responds to many things. Is this alarm just some soil with more thorium than normal, or is this a real public health concern? This is an excellent application for ISOCS. Just aim the detector at several locations along the side of the truck, as shown in Figure 4. Calibrations are quite simple and then not only will the nuclides be known, but also an estimate of the concentration.

This same counting geometry could be used by a prudent D&D contractor to prove that their “clean” construction debris really is, or for the local/federal regulatory authorities who are providing independent monitoring to assure that the public is protected.

Figure 4.
ISOCS used to monitor truck or trash container

D. Accident at which worker is injured and contaminated

Most large NPP and DOE facilities have good WBC systems to assess internal contamination, but many other facilities do not. But, for all cases where the worker is injured, the first priority is to take care of the injury, not to get a whole-body count. The ISOCS instrument is well suited for this application, as it is small enough to take to the hospital. It is flexible enough to be used to count thyroid, lungs, total body, and wounds. The mathematical calibrations can also be used for these unusual geometries. The counter can also be used for hospital and attendant personnel to assure that they are not contaminated. The same instrument can be used to provide *in vivo* assessments of members of the public or hospital staff where suspected contamination from patient treatment or an accident has occurred.

E. Evaluation of suspected past releases from radioactive materials sites

Examination of past records often shows that large quantities of materials have been released from sites, but does not provide adequate documentation showing that these were not contaminated. *In situ* gamma spectroscopy with ISOCS is quite valuable to search for large areas of property to find it, or to prove that it is not present. When small amounts are found, the use of the gamma spectrum to place the amount found into perspective by comparison with the natural Radium, Thorium and ^{40}K has also proven quite useful.

CONCLUSION

The use of *in situ* Ge gamma spectroscopy is a valuable tool to add to the arsenal of the emergency response team. It is small, and easy to transport. It is easy to use, and provides reliable nuclide-specific results. It provides these results quickly to the radiation protection professional in the field, so that he and others can quickly make the proper assessments and report them to all the other interested parties.