Homeland Security
Science and Technology

TechNote

U.S. Department of Homeland Security

SAVER

System Assessment and Validation for Emergency Responders

The U.S. Department of Homeland Security (DHS) established the System Assessment and Validation for Emergency Responders (SAVER) Program to assist emergency responders making procurement decisions.

Located within the Science and Technology Directorate (S&T) of DHS, the SAVER Program conducts unbiased operational tests on commercial equipment and systems and provides those results along with other relevant equipment information to the emergency response community in an operationally useful form. SAVER provides information on equipment that falls within the categories listed in the DHS Authorized Equipment List (AEL).

The SAVER Program is supported by a network of technical agents who perform assessment and validation activities. Further, SAVER focuses primarily on two main questions for the emergency responder community: "What equipment is available?" and "How does it perform?"

For more information on this and other technologies, contact the SAVER Program Support Office.

RKB/SAVER Telephone: 877-336-2752
E-mail: SAVER@dhs.gov Website: https://www.rkb.us/saver

This SAVER TechNote was prepared by the Environmental Measurements Laboratory,

EML

Science and Technology Directorate,
U.S. Department of Homeland Security,
New York, N.Y. 10014

Radioisotope Identification Devices (RIIDs)

Radioisotope Identification Devices (RIIDs) are instruments that are designed to determine the identity of radioactive materials by measuring the energy of the emitted gamma rays. Law enforcement, customs, and other personnel are being equipped with RIIDs as part of a national strategy to interdict illicit movement of radioactive material. When radiation sources are detected by screening devices such as radiation portal monitors or radiation pagers, RIIDs are used to determine whether the source of radioactivity constitutes a high level threat. Radiological emergency personnel, firefighters and other response personnel also use RIIDs for situational assessment during radiological emergencies.

How They Work

Most radioisotopes emit gamma rays with characteristic energies. Gamma rays emitted by a radioactive source strike a detector within the RIID and are converted into a signal that indicates the energy of the incident gamma ray. The number of gamma rays at each energy are counted and plotted versus energy in an energy spectrum which reveals characteristic energy peaks (Figure 1). Identification is based on matching the peaks in the spectrum to the known peaks and peak ratios of gamma emitters. This matching process is done using proprietary isotope identification software which is a critical component of these instruments. Two key RIID features are energy resolution and sensitivity.

- Resolution is a measure of how close two energy peaks can be and still be differentiated; the lower the percent resolution, the better the detectors' ability to distinguish two or more closely spaced peaks.
- Sensitivity is a measure of how efficiently incoming gamma rays are detected; this determines the counting time needed to obtain a spectrum.

These features are a function of the size and the type of RIID detector material.

RIID Detectors

Two different types of detectors are used in commercially available RIIDs.

1. **Scintillator detectors** are transparent materials (crystals) that, when struck by gamma rays, produce light pulses with intensities that are proportional to the gamma ray energies. These light pulses are converted to electrical pulses by a photomultiplier tube (PMT) and then processed by a multi-channel spectrometer to produce characteristic gamma ray spectra. RIIDs using scintillation detectors are lighter and less expensive than other technologies, but have poorer resolution.

The most common scintillator material used in RIIDs is thallium doped sodium iodide (NaI(Tl)) crystals. A relatively new scintillator material, cerium doped lanthanum bromide (LaBr3:Ce) has twice the resolution of NaI(Tl), and also has a higher light output, but RIIDs using this material could cost about twice as much.

2. **Semiconductor detectors** are made from specially processed crystalline material. Gamma rays striking the detector create free positive and negative charges that are detected as a current; the higher the energy of the gamma ray, the higher the current that is generated. The most common semiconductor material used in RIIDs is high purity germanium (HPGe) crystals (2 inches dia. x 1.2 inches high), these must be cooled to liquid nitrogen temperatures (-321°F) with a built-in refrigeration system in order to operate. HPGe RIIDS are much larger

and heavier, and cost about five times as much as NaI(Tl) RIIDS. While scintillator RIIDs are ready to operate in a few minutes, an HPGe based RIID that is at room temperature is inoperable until it is fully cooled, which takes approximately two hours.

Another type of semiconductor device that is becoming available uses cadmium zinc telluride (CZT). It does not require refrigeration and its energy resolution is about twice as good as that of NaI(Tl), but the small crystal size in many CZT RIIDs gives them lower sensitivities than other RIID types, especially for high energy gamma rays.

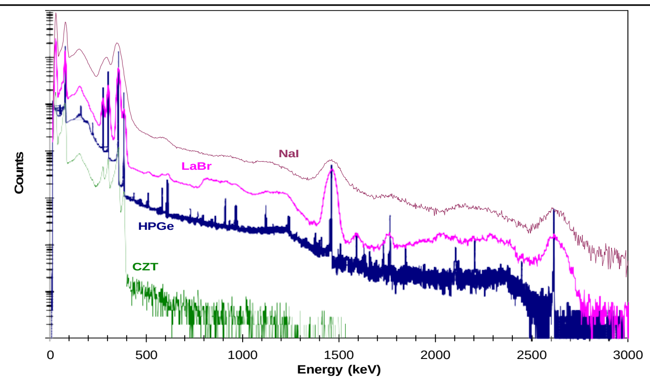

Figure 1. Comparison of Ba-133 calibration source gamma-ray spectra for CZT, HPGe, $LaBr_3$(Ce) and NaI(Tl) crystal detectors. Note that the best resolution is obtained with HPGe, followed by $LaBr_3$(Ce) and NaI(Tl). Note also that CZT has low sensitivity for gamma ray energies above 400 keV.

Figure 2. Typical handheld RIID detection systems; left to right: $LaBr_3$(Ce), NaI(Tl), and HPGe.

Features

Handheld RIIDs (Figure 2) are battery powered, have built-in software for spectral analysis and are capable of identifying the radioisotopes most commonly encountered by emergency responders. Radioactive isotopes are divided into four groups:

- special nuclear material (SNM), plutonium, highly enriched uranium (HEU) and neptunium, that could be used in a nuclear weapon;
- medical isotopes (used in radiotherapy and medical imaging);
- industrial isotopes (used in weld inspection devices, civil engineering equipment, food irradiators), and
- naturally occurring radioactive material (NORM), commercial products such as ceramics and fertilizers containing radioactive elements such as potassium, uranium, thorium and radium.

Some RIIDs also contain neutron detectors, which may enhance their ability to detect neutron emitting SNM isotopes. RIIDs should be designed in conformance with ANSI Standard N42.34 (2006) and/or ASTM Standard ASTM C1237-99 which define minimum acceptable sensitivity to neutrons and gamma radiation.

Many RIIDs are equipped with radiation dose rate meters, which can be set to alarm to warn users that they are approaching significant radiation sources.

Attributes such as size, weight, battery lifetime, cost, and ease of use, including the ease of electronically uploading spectra from the RIID for further analysis, should be thoroughly evaluated by potential users.

Limitations

Radioactive sources can be shielded so that gamma or neutron radiation is below the RIID detection limits or the spectrum is greatly distorted. It is particularly easy to shield SNM isotopes that emit only low energy gamma rays. For example, about 1 inch of lead will reduce the emission from plutonium by about a factor of 1000, and 0.25 inch of lead will reduce the emission from HEU by the same factor. The energy calibration of some RIIDs can be affected by temperature changes such as moving between indoors and outdoors, which may result in misidentifications. Some devices contain a built in check source for recalibration.

Isotope identification software currently used in RIIDs can misidentify radioactive sources even when the data was collected with a properly calibrated RIID. For this reason, the DHS Domestic Nuclear Detection Office established the Joint Analysis Center (JAC) Regional Reachback Program. Highly trained gamma spectrometry specialists are available on a 24/7 basis through this program to provide analysis of RIID data to first responders.

Resources

ANSI Standard 42.34-2006 "American National Standard Performance Criteria for Hand Held Instruments for the Detection and Identification of Radionuclides"

ASTM C1237-99 (Re-approved 2005): Standard Guide to In-Plant Performance Evaluation of Hand Held SNM Monitors (www.astm.org).

Evaluation of Handheld Radionuclide Identifiers, L. Pibida et. al, Journal of Research of the National Institute of Standards and technology, Volume 109, Number 4, July-August 2004. http://nvl.nist.gov/pub/nistpubs/jres/109/4/j94pib.pdf

DHS-DNDO Joint Analysis Center Regional Reachback Program: http://www.dhs.gov/xabout/structure/gc_1192453282596.shtm

Responder Knowledge Base information on RIIDs products: https://www.rkb.us/search.cfm?action=filter&typeid=2&subtypeid=142

SAVER RIID Assessment Report and Focus Group Report (June 2008)