Homeland Security

TechNote

SAVER

The U.S. Department of Homeland Security, Preparedness Directorate, Office of Grants and Training (G&T) established the System Assessment and Validation for Emergency Responders (SAVER) Program to assist emergency responders in performing their duties. The mission of the SAVER Program is to

- Provide impartial, practitioner relevant, and operationally oriented assessments and validations of emergency responder equipment.
- Provide information that enables decision-makers and responders to better select, procure, use, and maintain emergency responder equipment.
- Assess and validate the performance of products within a system, as well as systems within systems.
- Provide information and feedback to the user community through a well-maintained, Web-based database.

The SAVER Program established and is supported by a network of technical agents who perform the actual 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?"

To contact the SAVER Program Support Office
Phone: 877-347-3371
E-mail: FEMA-ASKTS@fema.gov
Visit the SAVER Web site: https://saver.fema.gov

Identifiers

Background

When radiation presence is detected and a radiation alarm is triggered by a radiation pager, survey meter, or portal monitor, the next critical step is to identify the radioactive material as

- legitimate commercial radioactive source (e.g., medical, industrial).
- naturally-occurring radioactive material (NORM)—present in shipments of kitty litter, ceramic tiles, fertilizer.
- potential terrorist weapons (i.e., radiological dispersion device [RDD] or improvised nuclear device [IND])—both containing radioactive materials.

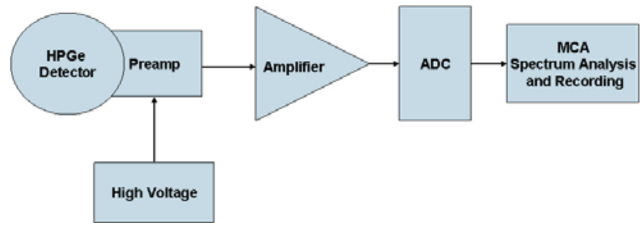
To make this distinction between different radioactive isotopes, it is necessary to perform a spectroscopic analysis using portable gamma spectroscopy systems known as identifiers. Spectroscopic analysis relies on measuring energy of characteristic gamma ray energies emitted by radioactive elements. Collected spectra provide a unique "signature" for identifying the original isotopes. Proper identification of an isotope is important for determining the appropriate response actions.

Fundamentals

Radioactive isotopes, during their decay, emit gamma rays of specific energies (some examples are listed in the table on the right).

Isotope	Main Gamma Energy (keV)
Americium-241 (Am-241)	60
Cesium-137 (Cs-137)	661
Cobalt-60 (Co-60)	1173, 1332

Several types of gamma radiation detectors — scintillators like Sodium Iodide (NaI), semiconductors like Cadmium-Zinc-Telluride (CdZnTe) or High Purity Germanium (HPGe) crystals — are capable of recording energies of incoming gamma rays. In such detectors, the incoming gamma radiation produces pulses of light or electric charges proportional to the kinetic energy of the incoming radiation. The associated nuclear electronic components — preamplifiers, amplifiers, analog to digital converters (ADCs), and multi-channel analyzers (MCAs) — shape and amplify the signal from a detector, perform analog to digital conversion, and segregate the generated pulses according to their amplitude (height) that is proportional to incoming photon energy. As seen in figure 1, the segregated pulses are recorded in a histogram with the X axis representing energy and the Y axis representing count rate (i.e., intensity of incoming radiation). The obtained distribution of the incoming photons as pulses (counts) versus their energies is a gamma spectrum. The spectrum is a signature of the original isotope, and as such can be compared to reference spectra stored in the isotope library. In the spectrum shown in figure 2, the peaks represent the full energy of the incoming photons (i.e., a fingerprint of the original isotope). The sharper the peaks, the higher the resolution of the detection system; therefore, the ability to distinguish between two isotopes emitting photons of similar energies is enhanced. The resolution of the gamma spectroscopy systems is the function of the detector type. HPGe detectors have the highest resolution and scintillation detectors have the lowest. However, to reduce electronic noise HPGe detectors must be cooled with liquid nitrogen, making them more difficult to use in portable field instruments. The scintillation detectors operate at room temperature, but with a resolution about 30 times less than HPGe detectors. Recently developed CdZnTe detectors offer a compromise solution; CdZnTe detectors are semiconductor detectors that operate at room temperature. Their resolution is significantly less than HPGe detectors, but much better than scintillation detectors. Only small detection crystals are available for CdZnTe detectors, therefore, the sensitivities are rather low. The latest in portable high-resolution detector technology for field gamma spectrometry are mechanically-cooled HPGe systems that do not require liquid nitrogen for cooling, instead the battery-operated mechanical cooling systems (heat pump) are incorporated into the detector units.



Components of typical HPGe gamma spectroscopy system.

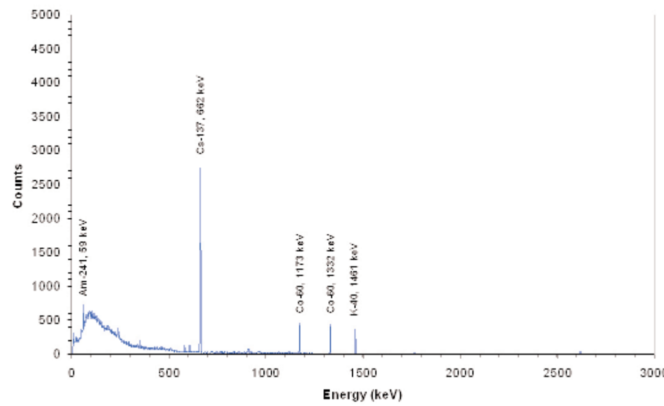


Figure 1. High resolution gamma spectrum of mixed Am-241, Cx-137 and Co-60 source.

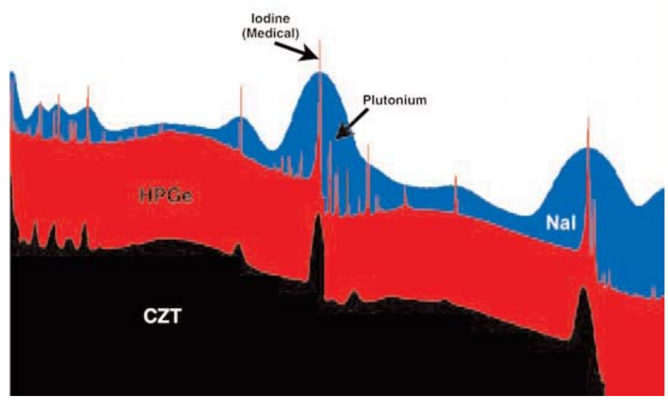


Figure 2. Radioactive material "fingerprints." Gamma spectra taken with different technology detectors.

Performance Factors

Performance criteria of portable identifiers are defined by the American National Standards Institute (ANSI) Standard 42.34-2003, "American National Standard Performance Criteria for Hand-Held Instruments for the Detection and Identification of Radionuclides." The ANSI standard requires hand-held portable identifiers to be battery operated, self-contained units without external laptop computers for spectral analysis. According to the

ANSI standard, the instrument shall include a display that is easily readable, controls that are user friendly for routine operation, a menu structure that is simple and easy to follow intuitively, and a user-definable isotope library. The identifiers should identify radionuclides that are most likely to be encountered by emergency responders and those belonging to four different categories:

- Special nuclear materials: Uranium (used to indicate U-233, U-235), Np-237, Pu.
- Medical radionuclides: Ga-67, Cr-51, Se-75, Tc-99m, Pd-103, In-111, Iodine (I-123, I-125, I-131), Tl-201, Xe-133.
- NORM: K-40, Ra-226, Th-232 and daughters, U-238 and daughters.
- Industrial radionuclides: Co-57, Co-60, Ba-133, Cs-137, Ir-192, Tl-204, Ra-226, and Am-241.

Note: This is an informative list and should not be considered as all-inclusive.

Applications

Portable identifiers, despite being much more complicated and expensive in comparison to radiation pagers and survey meters, are critical components in a layered approach advocated by the U.S. Department of Homeland Security (DHS) to reduce the threat from RDDs and INDs. The identifiers allow for quickly determining if the radiation alarm was caused by a legitimate source or by the radiation component of an RDD or IND. Identifiers that can segregate radioactive materials into easy to understand categories, such as "Medical" or "Natural," can reduce time for cargo inspections, persons' screening before events, or vehicle screening at checkpoints. Therefore, identifiers may be suitable for law enforcement personnel investigating suspicious activities, for explosive ordnance disposal, or for hazmat teams.

For additional applications, see the Environmental Protection Agency's (EPA) Radiation Protection Basics or the Health Physics Society's (HPS) Radiation Basics.

Limitations

The primary limitation of portable identifiers is the dependence on the built-in or user-defined isotope library, and the quality of the built-in radionuclide identification algorithms. The identifiers are expensive ranging from $10,000 up to $70,000. They also require more extensive user training or scientific support to use properly.

Resources

IEEE ANSI N42.34-2003, "American National Standard Performance Criteria for Hand-Held Instruments for the Detection and Identification of Radionuclides."

Radiation Basics
(http://hps.org/publicinformation/ate/faqs/radiation.html).

Radiation Protection Basics (http://www.epa.gov/radiation/understand/protection_basics.htm).

SAVER is sponsored by the U.S. Department of Homeland Security, Preparedness Directorate, Office of Grants and Training.