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 objective assessments and validations 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@hq.dhs.gov
Website: https://www.rkb.us/saver

This SAVER TechNote was prepared by the National Urban Security Technology Laboratory for the SAVER Program.

NUSTL

Standoff Radiation Detectors

A radiation detection system that can locate a remote radioactive source and determine if it constitutes a threat is an important tool for law enforcement and emergency response organizations. These systems, known as standoff radiation detectors, generally have large detector area, high detector efficiency[1], the ability to determine the direction of the source, and the ability to discriminate threatening materials from background radiation and naturally occurring radiation. Standoff detection systems are usually mounted in vehicles such as trucks, boats, or helicopters. Their main application is to scan and locate threatening radioactive sources in an area such as a parking lot, housing complex, or marina. Standoff detectors usually contain gamma and neutron detectors, since both types of radiation are emitted from special nuclear materials (SNM) used in nuclear devices.

Performance Considerations

Detection Range

A key performance parameter for a standoff radiation detector is the range at which it can locate and identify a test source that approximates a significant amount of SNM. Although no performance standards have been developed for standoff radiation detectors, they generally have detection ranges varying from about 10 to 100 meters. The detection range is largely determined by the size and efficiency of the detectors. For a given source, the exposure rate[2] varies as the inverse square of the standoff distance. This means that if the standoff distance is doubled, the exposure rate is reduced by a factor of four. As standoff distance increases, larger and costlier detectors are needed to collect enough counts in a reasonable time in order to identify the source. At large enough standoff distances, the exposure rate from the test source will become indistinguishable from background radiation, making it more difficult for even a system with large high-end detectors to distinguish the source as a threat.

Determining Source Location

One of the main characteristics of standoff detectors is their ability to determine the location of a source. One way to achieve this is to have right- and left-side detectors with some shielding between them. More complex systems use detectors with collimators to shield out radiation from certain angles. Collimators reduce the field of view of a detector, but also reduce the contribution of background radiation, which helps to distinguish a radiation signal close to background level. Multiple collimated detectors positioned at different angles can be used to form an effective standoff detection system.

---

[1] Efficiency for a gamma detector is the ratio of the number of counts produced by the detector to the number of gamma rays striking the detector.
[2] Exposure rate, measured in micro-Roentgens per hour (µR/h), is a measure of the intensity of gamma rays (and X-rays if present) at a point in space.

Advanced imaging techniques for locating sources are being used in developmental standoff detection systems. Imaging gives a precise location of the source and also improves the probability of distinguishing a threat from background since a threat is concentrated in one spot while background is spread over a large area (Figure 1). One method of imaging uses a *coded aperture*. This technique involves placing the detector within shielding material that contains one or more apertures. Either the detector or the shield is then rotated, and sensors on the shield capture aperture positions at each point in time. System software correlates variations in the detector signal with aperture positions to determine the angle of the source from the detector. Coded apertures work with gamma and neutron detectors and give a wide field of view compared with other imaging methods.

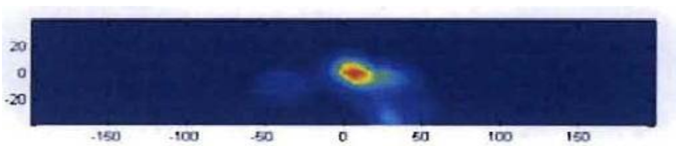

Figure 1 - Source image display from a standoff radiation detector showing location and source intensity.
Photo courtesy of the Domestic Nuclear Detection Office.

Another technique used in developmental systems is *Compton imaging*. This technique makes use of the phenomenon known as Compton scattering, which occurs when a gamma ray transfers part of its energy to a detector and exits at an angle that depends upon the amount of energy deposited. Compton imaging systems deploy layers of flat panels containing scintillating detector arrays so that scattered gamma rays will register on more than one detector panel. When gamma rays in time coincidence register on multiple panels, system software can determine the scattering angles. This data is then used to find the incident angle of the gamma rays and thus the position of the source. Compton imaging is more effective with high-energy gamma rays, while encoded apertures are more effective with low-energy gamma rays. Neutrons can be imaged by measuring the time of flight of the neutrons between two detector panels, a technique similar to Compton imaging.

Threat Discrimination

Standoff detectors use gamma spectroscopy to determine if the source is a threatening material. This technique identifies gamma-emitting isotopes by collecting gamma counts and measuring the energy of each incident gamma ray. The resultant energy spectrum (a plot of the number of gamma rays vs. energy) will contain peaks that isotope-identification software can match to the characteristic gamma ray energies emitted by various isotopes. A threat level is then determined based on whether the detected isotope is naturally occurring, medical, industrial, or SNM.

Many standoff systems contain separate neutron detectors to find neutron-emitting sources. Since fast neutrons emitted by SNM and other materials must be slowed down with moderators before being detected, most neutron detectors only count neutrons without measuring their energy. All neutron alarms are generally considered to be threats that need to be investigated.

Equipment Available

Imaging standoff detectors that seek to achieve a long detection range are currently under development and being tested by the U.S. Department of Homeland Security Domestic Nuclear Detection Office (DNDO). These systems have not yet been commercialized. Source imaging is an emerging technology that may be available in next generation systems.

There are many commercially available standoff detection systems that are or can be mounted in various vehicles (Figure 2). Multiple sodium iodide detectors (typical dimensions are 2 x 4 x 16 inches) are commonly used for gamma detection and spectroscopy. Although sodium iodide provides adequate resolution[3] for isotope identification, detectors with higher resolution (lanthanum bromide and high-purity germanium) are available with tradeoffs in size and cost. Some standoff detection systems use low-cost, high-volume plastic scintillators to obtain gross gamma counts to supplement spectroscopy. Helium-3 gas-filled tubes and lithium-6 glass scintillating fibers are commonly used for neutron detection in commercial standoff systems as they absorb neutrons well, have little sensitivity to gamma rays, and can be manufactured in large volumes.

Figure 2 - Standoff radiation detectors.
Clockwise from top left photos courtesy of Thermo Scientific, Mirion Technologies, Inc., and Nucsafe, Inc.

[3] Resolution is the ability to distinguish closely spaced peaks in a spectrum.