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 by e-mail or visit the SAVER website.

E-mail: saver@hq.dhs.gov
Website: http://www.firstresponder.gov/saver

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

NUSTL

Dosimeters for Response and Recovery

Dosimeters are radiation safety devices worn to monitor an individual's personal radiation dose received from external sources. Emergency responders could be exposed to radiation from an accidental or intentional radiological release, such as the detonation of a radiological dispersal device (RDD) or an improvised nuclear device (IND). To ensure safety during response and recovery operations, hazardous material (HazMat) teams and other responders would need to know their doses in order to take actions to prevent acute radiation effects and to minimize potential long-term health effects.

Types of Radiation Dosimeters

Several types of dosimeters suitable for various response and recovery applications are available. Devices differ in design, weighing between 1 and 10 ounces, and costing between $25 and $1,000.

Examples of Different Types of Radiation Dosimeters for Response and Recovery. From left to right: electronic, self-reading (pocket ion chamber), self-reading (radiochromic), and personal dosimeter (not to scale).

Electronic Personal Dosimeters

Electronic personal dosimeters (EPDs) provide a digital display of the dose rate and the accumulated dose and will alarm at preset rate and dose thresholds. Most are designed to be worn on the torso and typically weigh between 5 and 10 ounces. EPDs are battery powered and most use gas-filled or semiconductor radiation detectors. Another electronic device, the Personal Emergency Radiation Detector (PERD), differs from an EPD in readout units and in how it is calibrated for low-energy gamma radiation. Both EPDs and PERDs are used for the radiation safety of the wearer and are not to be confused with Personal Radiation Detectors (PRDs), which are used to locate and interdict illicit sources of radiation. PRDs are similar in size to electronic dosimeters, but are not suitable for radiation safety because they alarm at levels well below those of concern to health and do not measure the high dose rates needed for responder safety.

Self-reading Dosimeters

Self-reading dosimeters do not require batteries and measure only the accumulated dose. These include pocket ion chambers and radiochromic cards, which weigh about an ounce. Cylindrically shaped pocket ion chambers are designed to be clipped to a shirt pocket. A battery-powered charger is used to manually zero the reading before use by establishing an initial electrostatic charge on a fiber within the device. The fiber is deflected along a linear scale as radiation ionizes the air around it; the scale is read by looking through a lens at one end toward a source of light. Radiochromic dosimeters have a credit card format containing a radiation-sensitive film that darkens proportionally with radiation exposure. A color-matching scale printed on the card is used to estimate the dose received.

Personal Dosimeter Badges

Another type of personal dosimeter is sometimes called a radiation badge. These do not provide real-time information to the wearer, but instead store the accumulated dose for later readout after processing. Different technologies are in use. Thermoluminescent dosimeters (TLDs) contain crystals that trap electrons released during radiation exposure; a reader heats the crystal and measures the light emitted, which is proportional to the radiation dose. TLDs are available in clip-on badge or card formats and weigh about an ounce. Optically stimulated luminescence (OSL) dosimeters are similar, but use light, rather than heat, to stimulate emission. Both TLD and OSL dosimeters are typically processed by a commercial dosimetry service, but portable readers may also be available for on-site processing. Direct ion storage (DIS) dosimeters come in a clip-on badge format weighing a few ounces. They contain a small battery and can be processed through an Internet connection to a dosimetry service.

Applications

Various types of radiation dosimeters are applicable to the different aspects of response and recovery missions.

Alarming EPDs for HazMat: With their numerical displays and alarms, EPDs offer the most comprehensive measurement and are the most expensive type of dosimeter. In situations where responders could be unexpectedly exposed to high levels of radiation, an alarming device is required to alert them before safe levels are exceeded. EPDs will alert responders to the presence of a radiation hazard. High radiation exposure could occur during the initial response to an incident when the levels are unknown. After radiation levels have been mapped and protection zones established, responders could use alarming EPDs to limit time spent in hot zones for lifesaving operations. Audible and vibratory alarms would allow responders to go about their duties without having to visually monitor the display. EPDs require battery maintenance and training for use. They are well suited for firefighters and HazMat response teams.

Self-reading dosimeters for large-scale preparedness: For radiation safety programs where acute exposures are unlikely, electronic dosimeters may not be warranted or practical, and self-reading dosimeters could provide an alternative. For example, less expensive pocket ion chambers are suitable for stockpiling for large-scale, rapid distribution because they do not require batteries and have a very long shelf life. Single use radiochromic cards are less expensive than pocket ion chambers, but need to be replaced annually. Radiochromic dosimeters could be issued in advance since they may be carried with identification badges or in a wallet. For responders in the field when an event occurs, such as police or emergency medical personnel, the ability to check their dosimeters, if only to show a lack of significant radiation, could be useful. Both types of self- reading dosimeters could also serve as backup systems for electronic dosimeters.

Badges to track exposure and enforce dose limits: While self-reading dosimeters offer the advantage of inexpensive field readability, they lack the precision of radiation badges. Personal dosimeter badges offer the most accurate and precise measurement for a wide range of radiation levels and are used for dosimetry of record by those who routinely work with radiation. Badges could be used by first responders to provide later confirmation of electronic dosimeter readings, or they could be issued to secondary responders, for example, those performing screenings at community reception areas. A personal dosimeter badge system with a portable reader would offer users the ability to read dosimeters as needed. Alternatively, commercial dosimetry services could be contracted for longer term intermediate- and late-phase recovery operations.

Measurement Units and Range

Gamma radiation and X-rays are primarily of interest for responder safety. Products differ in the radiation units displayed, such as roentgen (R), rad, rem, gray (Gy), or sievert (Sv). The units R, rad, and rem are often used interchangeably, but have distinct technical definitions. Dosimeters are available for various dose-response ranges. The key selection criterion is that the overall measurement range should span the dose range appropriate to the local responder department guidelines for tactical decisions in response and recovery missions, such as lifesaving, property protection, and late phase recovery. Recommended dose and exposure rate measurement ranges are found in several standards.

Standards and Testing Programs

The American National Standards Institute (ANSI) publishes several standards that pertain to the various types of radiation dosimeters. They are available at http://ansi.org/. For example, ANSI N42.20 (2003) specifies performance and design criteria for EPDs. For instruments measuring gamma radiation (not neutrons), N42.20 recommends a measurement range from 0.001 rem/h to 100 rem/h. ANSI N42.49A (2011) covers various categories of PERDs and specifies accuracy criteria for exposure rates from 0.005 R/h to 600 R/h. ANSI N13.11 (2009) provides performance tests applicable to personal dosimeters that measure accumulated personal dose equivalent. For the emergency test category, N13.11 covers doses from 5 to 500 rad. The National Voluntary Laboratory Accreditation Program (NVLAP) for processors of dosimeter badges for occupational workers is based on ANSI N13.11 (see http://www.nist.gov/nvlap/dos-lap.cfm). ANSI N322 (2003) applies specifically to pocket ion chambers and includes physical specifications for the optical system and charging device, and accuracy for radiation measurements.