Radiation Detection
Selecting The Right Equipment For The Job

RAE SYSTEMS

Radiation Is An Unseen Threat In Many Settings

Exposure to high levels of radiation can be dangerous. Because radiation is odorless and invisible, those who must work with radioactive materials need special equipment to ensure their safety and the safety of those around them. First responders (HazMat, fire, police, EMS), hospital workers, nuclear facilities engineers, and workers at industrial facilities housing radioactive materials operate in different environments, but all share the need for protection from the harmful effects of radiation.

First responders, including HazMat and fire teams, deal with an almost unimaginably wide range of hazardous environments, and technologies have been developed to organize, simplify, and better meet the challenges that face them on a daily basis. Having the right equipment for the job is extremely important to first responders. Using the right equipment can save lives, while using the wrong equipment can endanger them. Knowing the difference can enhance the odds of a quick and successful response to an event and minimize risk to both responders and those in the vicinity of an event.

Terrorism's rise has added a new dimension to the first responder's role, one that introduces greater time pressures in response, identification, isolation and protection. Whereas responses to radiological threats were once primarily directed at identified sources and contained accidents, the first responder must now confront the possibility of widespread civilian-targeted threats using improvised nuclear devices such as "dirty bombs" or dispersed radioactive materials (radioisotopes) in both private and public spaces. Therefore, speed, accuracy and reliability are more important than ever in radiation detection instruments used to assess radioactive threats and to guide life-saving decisions.

Other personnel that work with radioisotopes need different devices. Hospital workers in radiation oncology and radiology departments need instruments to accurately measure the dose of radiation they receive while working near medical equipment containing radioisotopes, and instruments to ensure that the radioactive sources in the equipment are not leaking and giving off hazardous radiation levels. Radiation workers at nuclear facilities share the same needs, but often require more instrumentation as well as equipment that detects and measures alpha, beta and neutron radiation in addition to the standard gamma radiation detectors.

Many industrial facilities either produce or use equipment containing radioactive sources. For example, many facilities with large liquid storage tanks use radioactive level gauges to monitor the level of liquid in the tanks. Many non-destructive industrial imaging systems use radioisotopes as tracers, in the case of pipes or liquid systems, or internally, in the case of x-ray and radiography equipment. Workers that come in contact with any of these systems need to know how much radiation they have been exposed to, and also need equipment to make sure no radioactive sources are leaking, misplaced or stolen.

Security applications are present in all of these realms. It is imperative that no radioactive sources are lost or stolen. If they are, there is the potential for the sources to fall into terrorist hands. Security personnel need fast-responding detectors to immediately track illicit or inadvertently moved materials.

Types of Detection Equipment

There are four main types of radiation detection instruments seen in first responder activities: Personal radiation detectors, dosimeters, identifiers, and survey meters. Each has its inherent strengths and weaknesses that can be magnified depending on how and where they are applied.

Personal Radiation Detectors

A personal radiation detector, sometimes called a PRD, is a small pager-like device that measures radiation. Its main purpose is to alert the wearer to the presence of radiation as quickly as possible. Detectors have very fast response times and display a measurement of the radiation dose rate. They also include features designed for reliable use in unknown environments, such as water and dust resistance, intrinsic safety certifications (which ensure that they will not ignite explosive gases in the environment), backlit displays for use in darkness, rugged cases, and resistance to EMI and RFI (electromagnetic and radio-frequency interference).

Detectors typically sense gamma radiation or gamma and neutron radiation. Gamma radiation is the most abundant and easiest to detect. Neutron radiation can be deadly in smaller doses than other types of radiation, and is an indicator of potential weapons-grade materials, such as plutonium. Most detectors use scintillation crystals, which, when contacted by high-energy particles such as alpha, beta, neutrons, or gamma rays, produce a flash of light that is electronically detected. Typical scintillator crystals are made of cesium iodide (CsI), sodium iodide (NaI), or lithium iodide (LiI) because of their fast response time. Other detectors use semiconductor sensors composed of cadmium-zinc-telluride (CZT) or silicon, but response times for these devices typically are slower than those using scintillators.

Personal radiation detectors typically cost between $600 and $1,200 and last many years.

Dosimeters

The main purpose of a dosimeter is to accurately measure the accumulated radiation dose that the wearer has received while wearing the dosimeter. The radiation sensor in a dosimeter is energy compensated. Energy-compensated sensors have a filter placed over them to ensure a level efficiency over the entire radiation energy range. This translates to a more accurate total dose measurement. Dosimeters can measure gamma, alpha, beta and neutron radiation doses, but most electronic personal dosimeters measure only gamma radiation because it is the most abundant and most likely type of radiation exposure.

Dosimeters come in several forms, from single-use film badges to self-reading electronic pagers. Electronic versions, sometimes called electronic personal dosimeters (EPDs), often have other features that overlap with those of personal radiation detectors, but their response time is often much slower than detectors. EPDs use Geiger-Mueller tubes or silicon sensors to detect radiation.

Film badges use radiosensitive film to measure the total radiation dose. As radiation hits the badge, it interacts with the film. As a result, film badges cannot be read directly, and must be sent to a special facility to determine the dose received. They cannot alarm or warn the wearer when they have received a high radiation dose or when the user is in a high dose rate area.

Electronic personal dosimeters are less expensive than personal radiation detectors and range from $200 to $500 per unit. Most units last several years, but are not built for the rugged environments first responders work in.

Identifiers

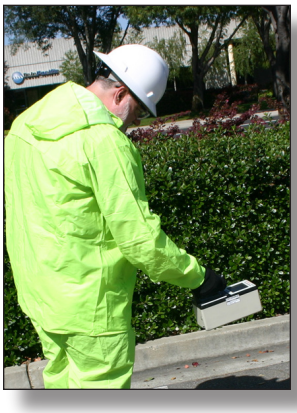
An identifier is an instrument that uses the differences in radiation emission energies to determine which radioisotope is present. Every radioisotope has a unique “signature” of radiation emission types and energies that allows an instrument to identify it. Identifiers are mainly used to identify an unknown radioactive source or contamination. They are larger than both detectors and dosimeters, and historically have been in the form of a brick-shaped box with a handle on top, though new, smaller handheld versions are being developed.

Identifiers use several technologies. Some employ scintillation crystals (such as CsI or NaI), while others use semiconductors such as CZT or germanium (which must be

super-cooled). Units utilizing scintillators tend to be able to identify radioisotopes faster than those using either CZT or germanium. CZT and germanium sensors can be more accurate if multiple sources are present, but require longer sampling times.

Identifiers are expensive, and a single unit can cost more than $10,000.

Survey Meters



Survey meters measure radiation levels using the same radiation sensors employed in detectors and dosimeters. They are the oldest type of device discussed here, and look similar to traditional identifiers, but have a probe that's held in one hand, while the meter box is held in the other.

Each probe is specifically tailored to a particular type of radiation, and can measure gamma, neutron, alpha or beta radiation levels.

The cost of a survey meter is strongly dependent on which probes are purchased with the meter box. At the low end, they can cost $1,000 for a meter box and a single probe, while the highest-priced units can hover around $20,000.

Selecting Appropriate Radiation Equipment

Selecting the right equipment for your needs can be daunting with all of the available devices and options. Most people only need one or two types of devices, which, when used properly, can make their jobs easier and safer. For first responders, speed of response, ease of use, rugged design and portability are often just as important as accuracy.

The following are suggestions for the type and minimum amounts of equipment needed to successfully detect radioisotopes.

First Responders – Law Enforcement

One personal radiation detector per person

Law enforcement officers need fast responding equipment to alert them immediately when radioactive material is near so that they can take proper action to protect themselves and those around them, and therefore should be equipped with radiation detectors. Each officer should have his or her own detector, worn on the belt or torso.

First Responders – Fire

One personal radiation detector per person
One survey meter per team (optional)

Firefighters needs fast responding personal radiation detectors to warn them that they are entering a dangerous radiation or contaminated area. Each firefighter should wear a pager, which should be shock, temperature and water resistant, intrinsically safe, and easy to operate while wearing gloves.

A safe distance from any sources should be determined using a survey meter, and the area should be cordoned off to prevent other responders from inadvertently entering the area. A survey meter should also be used to ensure that the firefighters have not gotten contaminated while performing their duties.

First Responders – HazMat

One personal radiation detector per person
One identifier per team (optional)
One survey meter per team (optional)

First responders in HazMat need the most rugged and fastest responding equipment possible to work in unknown hazardous environments, and should use radiation detectors to accomplish this. Important features for HazMat response include intrinsic safety, water, shock, and EMI resistance, ease of operation while wearing several layers of gloves, and illuminated, easy-to-read displays. Since HazMat responders may be exposed to more significant amounts of radiation, a detector-dosimeter combination instrument is ideal. Each responder should have his or her own detector, worn on the belt or torso. Those responders near higher-risk areas for a terrorism attack, such as major cities or infrastructure facilities, or close to facilities that house fissionable materials, should have at least some team members equipped with detectors for gamma and neutron radiation. This helps to ensure that the team is alerted if potentially deadly neutron radiation is present, which is most likely in the event of a terrorist attack or an accident at a facility containing neutron-emitting materials.

Each response team should also be equipped with an identifier to ascertain any contamination or unknown sources. A survey meter or detector should be used to determine a safe distance from the source, and the area inside that distance should be cordoned off so that others responding to and investigating the incident are not inadvertently contaminated or exposed to high levels of radiation.

First Responders – EMS

One electronic personal dosimeter per person
One identifier per vehicle/team (optional)
One survey meter per department (optional)

Emergency medical services personnel may be exposed to radiation if they are responding to an incident where an area and people in that area have been contaminated with radioactive material. Because life-threatening conditions must be tended to before decontaminating a victim, EMS personnel may be exposed to radiation or contaminated. In this case, the amount of dose that they receive would need to be monitored to ensure they do not receive too high a dose. One dosimeter, worn on the torso, is recommended for each EMS responder. For the best protection, EMS responders should have a dosimeter-detector combination instrument with the fast response and dose rate readings of a detector and the accurate dose accumulation of a dosimeter.

Each EMS team or vehicle should also be equipped with an identifier to determine what type of contamination is present, so that both radioactive and toxic dangers can be identified. A survey meter or detector should be used to ensure that the EMS response vehicle and personnel are not contaminated after an incident.

Security (nuclear, medical, industrial facilities, high-risk buildings)

One personal radiation detector per person

Members of a security team should be outfitted with detectors for the same reasons as law enforcement. Because a first response team should be called in an alarm situation, it is not typically necessary that a security team have additional equipment. However, security personnel at a nuclear facility or other place where radioactive material is transported or stored may be called upon to act as first responders because of their on-site proximity. In such cases, they should be outfitted with the same equipment as a first response team, and should consider detectors that measure both gamma and neutron radiation.

Radiation Workers

One dosimeter per person
Identifiers for health physics (optional)
Survey meters for health physics

Radiation workers are those people who work in facilities where large amounts of radioactive material are stored or used, and who regularly enter radiation fields as a result. Special training is required to become a radiation worker. Each radiation worker should wear a dosimeter when entering a radiation area. Dosimeters are used because it is known that there is radiation in the area, and by law the dose to each worker must be carefully tracked. Identifiers can be used to identify contamination around the facility. Radiation field strengths are mapped by a health physicist using a survey meter, and are updated frequently.

Workers in Hospitals with Imaging and Cancer Treatment Departments

One electronic personal dosimeter per oncologist/technician
One survey meter per department (optional)

Each person who is regularly exposed to radiation from medical equipment should wear a dosimeter to track their dose. A survey meter should be kept on the premises to ensure that no radioactive sources are leaking, and that a safe dose rate is maintained around the equipment.

Workers in Industrial Facilities with Radioactive Materials

Survey meters as needed
Personal radiation detectors for workers entering into areas where radioactive material is stored/used

Many industrial facilities, such as refineries, chemical and manufacturing plants, house radioactive materials in the forms of liquid level gauges, imaging and sterilization equipment. This equipment should not require personnel to be trained as radiation workers (see the Radiation Workers section). Personnel entering areas where the radioactive material is stored should wear a personal radiation detector to alert them of any leaking sources and high dose rate areas, and at least one survey meter should be on the premises to ensure that no sources are leaking, and that a safe dose rate is maintained around

the sources. Workers at refineries and chemical plants have the additional need for intrinsically safe equipment, especially during plant turnarounds, when personnel are working in areas and confined spaces that are not normally occupied.

Role	Detector	Dosimeter	Detector-Dosimeter Combo	Identifier	Survey Meter
Law Enforcement	✓				
Fire	✓				✓
HazMat	✓		✓	✓	✓
EMS		✓	✓	✓	✓
Security	✓				
Radiation Workers		✓		✓	✓
Hospital Workers		✓			✓
Industrial Workers	✓				✓

Response Scenarios Using Radiation Detection

Radiological response scenarios can range from discovery of an innocent source to stopping the theft of radiological materials to prevention of an act of terrorism. For example, at a recent NASCAR race, a police officer patrolling the stadium observed that his personal radiation detector went into alarm, reading well above normal background radiation levels for the area. Responding officers were able to discreetly search the crowd and found that one person had received a barium stress test four days earlier (barium is a radioactive element used in some medical diagnostic procedures).

In another event in March 1998, in Greensboro, North Carolina, 19 small tubes of radioactive cesium used for cancer treatment were stolen from a locked safe at a hospital. Local, state, and federal officials searched the city using radiation detection equipment, but the stolen material was never recovered. Authorities suspect that whoever stole the cesium knew how to safely handle radioactive materials, as unprotected contact with the tubes would have quickly caused serious injury or death. The hospital subsequently improved its security around its radioactive materials.

These two cases illustrate the need for radiation detection equipment in the first responder and security realms. The NASCAR event could have been a "dirty bomb" instead of an innocent source, and the use of radiation detection devices could have prevented the theft in Greensboro. Unfortunately, radioactive sources are frequently lost or stolen, and are available to terrorists. One of the most important things that can be done to prevent these types of incidents is to maintain control of radiological materials, whether at a hospital, industrial facility, or power plant, and to ensure that no illegitimate sources from other countries cross into your own country. The proper use of appropriate radiation detection can help prevent thefts, thwart illicit trafficking of radioactive materials, and protect the public.

Corporate Headquarters
3775 N. First St.
San Jose, CA 95134-1708 USA

Phone: 408-952-8200
Fax: 408-952-8480
Email: sales@raesystems.com

www.raesystems.com