Radiological Emergencies; Tools, Training, and National Assistance for First Responders.

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Abstract

Firefighters, police, and other first responders have a variety of tools, training, and national radiological emergency assistance available to them. These assets can be used by first responders to perform an initial assessment of the event and take appropriate steps to protect themselves and the public. The primary factors for determining the appropriate radiological emergency assessment and response tools are: (1) The type of event (explosive dispersal, fire, reactor incident, orphan source, or general contamination), (2) the nature of the radiological material (activity, chemical form, and decay mode), and (3) the phase of the emergency.

There are several national programs that support first responders, either remotely or with the rapid deployment of local or national assistance teams comprised of radiological safety experts. The effective use of these resources is built on planning and communication. For this reason, many assistance resources have an active outreach program comprised of training, drills and exercises. Free or low cost radiological emergency response training is available from several local and national venues. This training provides the basic information necessary to properly respond to a radiological emergency and utilize the tools available.

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First Responders

Firefighters embody the image of "First Responders." When an event occurs that places individuals or the community in jeopardy, firefighters respond, usually within minutes, to perform rescue and mitigate the hazard. When considering radiological events and issues however, a more complete list of first responders might be;

- Fire Fighters / Paramedics (Responding to fires, explosions, hazmat spills, and medical calls)
- Law Enforcement (investigating suspicious activity, serving warrants, etc...)
- US Coast Guard (inspecting vessels, responding to waterborne emergencies)
- Hospital Emergency Department Staff (large event and walk in emergencies)

Since you can not see, hear, smell, or taste radiation, the initial determination of radiological event is a technological problem. Whether an accident (e.g., transportation fire) or a malevolent act (e.g., radiation dispersal devise), the actions and equipment carried by these individuals can help quickly identify the radiological nature of an event and may significantly reduce its overall impact.

Radiological Emergencies

Radiological emergencies involving the public could involve exposure to high intensity radioactive sources (e.g., industrial or medical therapy sources) or the dispersal of radioactive material (e.g., transportation accidents, releases from nuclear facilities, and malevolent acts). The

actual hazard depends, among other factors, on the quantity of radioactivity, the type of radiation emitted, the chemical form, and the distribution of the radioactive material.

Recognition of a radiological event

If the incident occurs at a fixed facility known to handle radioactive material, then the identification of the hazard and the response should be outlined in that facility's licensing agreement. If it occurs on a legitimate radioactive material transport, then the vehicle's placarding, manifest, or originator should be able to help identify its radiological nature and provide emergency response guidance. More information can be found at: http://hazmat.dot.gov/.

Since specialized equipment is required to detect radioactive material, an unknown dispersal may not be identified for some period of time. Local responders should be trained to investigate the possibility of radiological (or other) contamination on suspicious explosions or fires. Ideally, first responders should have equipment that alerts them to the radiological nature of an event without having to relying on their performing any action.

To determine the presence of radiological issues at an incident site, initial responders need instruments to measure both radiation fields (beta and gamma radiation) and surface contamination (alpha, beta and gamma radiation). Radiation detectors measure the deep penetrating gamma radiation and often read out in units of dose. Contamination monitors have thin windows to allow short range radiation (like alpha particles) to penetrate to the active

volume. Some training is necessary to properly operate and interpret the results of these instruments, especially the contamination monitors which must be used in a specific manner to be effective.

The wide distribution of inexpensive radiation monitoring equipment to initial responders can help quickly determine if radioactive material is involved in an incident. A positive indication of the presence of radioactive material can then indicate the need for follow-on characterization efforts.

Radiological characterization

Once the radiological nature of an event has been identified, then specially trained local, state, or federal radiological emergency responders can be called upon to provide more specific information about the nature and extent of the radiological contamination.

Tools for First Responders

With the increased emphasis on homeland security, many government agencies and initial responders are looking into procuring radiation detection and identification equipment. Unfortunately the type of instrumentation procured is not always suited for the user or application. Often prospective users are misled by scientific jargon and manufacturer's exaggerated claims.

To be a good first responder tool, the instrument should have the following properties:

1) Alarm at the presence of radiation without user interaction, but without a large number of alarms from naturally occurring radioactive material
2) Should be able to detect low energy beta & alpha contamination.
3) Work continuously without user intervention to operate.
4) Records dose
5) Alarms in hazardous situations.
6) Simple and intuitive, requiring little training to operate.
7) Small size, something easily worn (not carried).
8) Inexpensive to purchase and maintain.

Unfortunately, the ideal instrument with all of the properties above does not exist, though several of the instrument types described below have many of the desirable properties noted above. This is not a complete listing of all radiological monitoring equipment, but it does provide an overview of the general categories of radiological instrumentation. Inclusion in the tables below DOES NOT constitute an endorsement of any manufacturer or product line.

Table 1: Electronic Dosimeters

About the size of a pager, these electronic devices track the total radiation dose received by the wearer. They often use low power (and low sensitivity) silicon chips or small Geiger-Müller (GM) tubes to measure dose. Most have the ability to alarm at certain dose rates or total dose. Although these devices are not necessarily sensitive enough to necessarily find fugitive radioactive material, they can quickly detect significant events and **protect the wearer from**

overexposure.

Pros	Cons
• Tracks wearer's dose, can alert them to some hazardous situations. • Sensitive enough to identify a significant radiological event with dose rates greater than 1 µSv hr^{-1} (0.1 mrem hr^{-1}). • Long battery life (often several months of continuous operation) • Small size (pager or wrist watch sized) • Simple operation (requires no user action, simply wear the unit) • Often very rugged	• Not necessarily sensitive enough to detect low levels of radiation. • Won't detect alpha or low energy beta radiation

Issues

Will only detect events involving alpha emitting isotopes if there is sufficient accompanying penetrating radiation.

Units with 2 or more alarm levels preferred, one alarm can be used for radiation proximity "alert" (1 µSv hr^{-1}) and one used to indicate hazardous "turn back" levels (0.1 Sv hr^{-1} or 0.1 Sv).

Training must be provided to ensure that the user continues to perform rescue and first aid efforts even with "alert" alarms. Additional victim casualties could result from ill trained responders who leave the scene at alert levels.

Typical costs are several hundred dollars per unit, but models that detect beta or neutron radiation, or these with external probes, can be more expensive.

Application:

Well suited for emergency responders who may need to quickly enter a scene, these devices can help ensure responder safety by alerting them to potentially hazardous radiation levels without any user activation or operation. The units can also alert the wearer when unusual radiation levels are present, though they may not be sensitive enough to find fugitive or contraband radioactive material.

Examples of Electronic Dosimeter Products (no endorsement implied).

Canberra Industries**:** http://ww2.canberra.com/PCatalog.nsf/all/RPI_PDF/$file/ANUDR13.pdf**,**
http://ww2.canberra.com/PCatalog.nsf/all/RPI_PDF/$file/Dosicard.pdf
Far West Technology, Inc: http://www.fwt.com/hpi/hpi_4083ds.htm
MGP Instruments: http://www.mgpi.com/html/en/produits/masque.cfm?le_num_prod=87
POLIMASTER, Ltd.: http://www.polimaster.com/en/products/dosimeters.htm
Science Applications International Corporation (SAIC): http://www.saic.com/products/security/pd3i/pd3i.html
Siemens Environmental Systems - UK: http://www.siemens.co.uk/env-sys/uk/electronic_dosimetry/epd.shtml
Thermo Electron Corp: http://www.thermormp.co.uk/rmp/index.html

Table 2: Personal Radiation Proximity Alert Systems

Often called "Radiation Pagers," and similar in appearance to the electronic dosimeters, these units have the very different function of finding low levels of radiation using very sensitive crystal or plastic scintillators. Although good for finding contraband radioactive material, these units do not have the range necessary for personnel protection (i.e., high dose rates).

Pros	**Cons**
• Very sensitive. Alerts the user of any statistically significant changes to natural background radiation levels. • Useful for finding contraband radioactive material. • Good battery life (often several weeks of continuous operation) • Small Size (pager or notebook sized) • Simple operation (requires no user action, simply wear the unit)	• Will alarm in the presence many legitimate commercial, medical, or naturally occurring sources of radiation. • Does not accurately measure high dose rates which would be of concern to emergency responders performing rescue operations. • Won't detect alpha or low energy beta contamination. • Expensive ($800 – $2,000)

Issues

Although most units have been ruggedized, the technology is inherently shock sensitive.

Training must be provided to ensure that the user realizes that the alarms do not necessarily indicate a hazardous situation. Additional victim casualties could result from ill trained responders who leave the scene because of the proximity alarms. Training must also be provided on how to resolve the many alarms that will occur from legitimate radioactive material uses.

Typical costs are $800 to $1000 dollars per unit, but models that detect neutron radiation or with external probes can be more expensive.

Application:

Well suited for law enforcement or inspectors, these devices can alert the wearer to any unusual radiation in their proximity. These devices are best used when there is an opportunity for a measured response, as most alerts will occur from legitimate commercial, medical, or natural radioactive material. Training and protocols need to be provided on alarm resolution.

Examples of Personal *Radiation Proximity Alert Systems*.
POLIMASTER, Ltd: http://www.polimaster.com/en/products/ratemeters.htm
Sensor Technology Engineering, Inc http://www.nttc.edu/ertProgram/radpagers.asp
T_ATECHNICAL ASSOCIATES: http://www.tech-associates.com/dept/sales/product-info/dsi-2.html

Table 3: Isotope Identification Equipment (Gamma Spectroscopy)

These highly sophisticated pieces of equipment use the different gamma ray signatures given off by the radioactive material to identify the originating isotope(s). Proper identification of the isotope is important for determining the appropriate response actions. Although the analysis

performed is extremely complicated, these units offer a simple interface to help non technical users make a measurement. Many of the units have modes of operations similar to the proximity alerts and electronic dosimeters. Although fairly good at identifying common isotopes with simple spectra, these units can not identify all possible isotopes of concern and can mis-identify isotopes.

Pros	**Cons**
• Very sensitive. Alerts the user of any statistically significant changes to the natural background radiation level. • Useful for finding contraband radioactive material. • Often tracks dose rates and total dose of user while on. • Can identify many common isotopes	• Will alarm in the presence many legitimate commercial, medical, or naturally occurring sources of radiation (though the analysis can often resolve this) • Expensive ($8,000 - $12,000) • Won't detect alpha or low energy beta contamination. • Requires extensive training or support to use properly

Issues

Although most units have been ruggedized, the technology is inherently shock sensitive.

The automated analysis is not 100% effective, accurate assessment requires an experienced spectroscopist to assess data. Fortunately, many of the units have the ability to download the spectrum for remote analysis by an expert. Due to limited resolution, accurate analysis may not be possible and higher resolution, liquid nitrogen cooled detectors would need to be used ($30,000+)

Application:

Best suited for experienced users or well trained and practiced responders, these units will provide the most accurate assessment of radiation and contamination levels. Good for follow-on hazmat or radiological emergency response teams.

Examples of Personal *Isotope Identification Equipment (Gamma Spectroscopy)*.
Berkeley Nucleonics Corp http://www.berkeleynucleonics.com/radiation/rindex.htm
Bicron/Thermo Electron: http://www.thermormp.co.uk/us/rmp/
Exploranium Radiation Detection Systems: http://www.exploranium.com/gr135pg1.htm
Perkin Elmer (Ortec): http://www.ortec-online.com/safeguards.htm
Quantrad Sensor: http://www.quantradsensor.com/
Radiation Alert: http://www.seintl.com/ursa.htm
XRF Corporation: http://www.xrfcorp.com/products/ics.html

Table 4: Simplified Contamination Survey Instruments

Often the size of a small notebook, these electronic devices use Geiger-Müller (GM) detectors to measure surface contamination and dose rates. Whether by internal or external detector, a thin window that allows them to measure alpha and low energy beta contamination. Most have the ability to alarm at certain count rates. Although often ***more sensitive than the electronic dosimeter***, these devices are not necessarily as sensitive as the radiation proximity alert systems.

Although they have a ***higher range than the personal radiation proximity alert systems***, many models will still not function well in the emergency response dose rate ranges (0.1 Sv hr^{-1}). Their simplified operation is designed for the occasional user.

Pros	**Cons**
• Good Sensitivity. Alerts the user of any significant (low level) radiation levels. • Many models have an "open window" design that can be used to check for alpha and beta contamination. • Small size (notebook sized) • Simple operation (user action required, but usually only one or two switches) • Many models have variable alarm set points. • Rugged, simple technology.	• Will occasionally alarm in the presence many legitimate commercial, medical, or naturally occurring sources of radiation. • May not accurately measure high dose rates which would be of concern to emergency responders performing rescue operations.

Issues

Some models have internal detectors and the unit must be held very near the surface being measured to make a contamination assessment.

There is a large variety of capabilities in this class of instrument. Training must be provided to ensure that the user understands how to interpret readings. Using the instrument to detect contamination will also require special training.

Typical costs are $300 - $600 dollars per unit. For the occasional user, the more expensive digital models require less interpretation of the readout.

Application:

Well suited for emergency responders and hospital staff who may need to determine quickly if radioactive material contamination is present. The units can also alert the wearer when unusual radiation levels are present. Training must be provided on their use as successful contamination monitoring requires specific techniques.

Examples of *Simplified Contamination Survey Instruments*.
Berkeley Nucleonics Corp: http://www.berkeleynucleonics.com/PalmRAD/
Canberra Industries**:** http://ww2.canberra.com/PCatalog.nsf/all/RPI_PDF/$file/radiagem4.pdf
Health Physics Instruments: http://www.fwt.com/hpi/hpi_4020ds.htm
Radiation Alert Instruments: http://www.seintl.com/mon5.htm, http://www.seintl.com/dig50.htm, http://www.seintl.com/inspect.htm, http://www.seintl.com/insp_exp.htm
T_ATECHNICAL ASSOCIATES http://www.tech-associates.com/dept/sales/product-info/tbm-3.html

Table 5: Industry Standard Radiation Instruments

Industry Standard Radiation / Contamination Survey instruments are those commonly used by health physicists and radiation control technicians at nuclear power plants, hospitals, and

research laboratories. These instruments use a variety of detector technologies (GM, Ion chamber, scintillator, proportional counter, etc...) to measure dose rates and contamination. Although well suited for the experienced user, they may not be appropriate for the occasional user like an emergency responder.

Pros	**Cons**
• Various depending on detector type, but generally good accuracy	• Various depending on detector type, but generally requires a knowledgeable user.

Issues

Although appropriate for the knowledgeable, frequent user, most industry standard radiation and contamination detection equipment is not easy for the first responder to use with confidence. Examples of difficulties often encountered are:

- Several units and scales on the same instrument
- Proper use and interpretation of scaling switches (x0.1, x1, x10, x100, x1000)

No alarm or interpretation of instrument reading

Application:

Best suited for experiences users or well trained and practiced responders, these units will provide the most accurate assessment of radiation and contamination levels. Good for follow-on hazmat or radiological emergency response teams.

These are common companies that produce industry standard equipment.
Bicron/Thermo Electron: http://www.thermormp.co.uk/us/rmp/
Canberra Industries**:** http://ww2.canberra.com/PCatalog.nsf/ProductCatalog
Eberline/Thermo Electrón: http://www.eberline.com/frmain.htm
Health Physics Instruments: http://www.fwt.com/hpi/prod_hpi.htm
T_ATECHNICAL ASSOCIATES: http://www.tech-associates.com/dept/catalog.html
Victoreen (Syncor / Inovision): http://www.inovision.com/IRM/products.htm

Training

High quality, low cost, radiological emergency response training materials exists for first responders. The Nunn-Lugar-Domenici legislation directed the Federal Government to improve the capabilities of state and local agencies to respond to incidents involving WMD. Many of these efforts by various departments of our government can be found in *Compendium of Weapons of Mass Destruction Training"* produced by the federal government.

http://hld.sbccom.army.mil:80/downloads/dp/compendium_wmd_aug_2000.pdf

Outside of the WMD Arena, there are several excellent programs on radiological emergency response. An example of this is the Department of Energy's Transportation Emergency Preparedness Program which provides free, multimedia rich training materials to trainers as part of a comprehensive emergency management system for DOE radioactive materials shipments or use. http://www.em.doe.gov/otem/program.html

Given the extensive number of responders who need to be trained, many of these programs use the "Train the Trainer" format in which a representative from each local response organization is trained and given materials so that they can provide the training at their home organization. Another approach is Computer Based Training (CBT) and Web Based Training (WBT) formats in which the student has individual, self-paced interactive training via a computer. Although both are cost efficient methods for providing training to large populations, they do not necessarily provide a knowledgeable instructor to address concerns about radiological emergency response often expressed by first responders.

An example of excellent CBT program can be found in the Department of Energy (DOE), Emergency Operations Training Academy's *Weapons of Mass Destruction CDs*. These **8 CDs** are available for loan and were distributed to each state's FEMA representative who can be found at www.fema.gov/fema/statedr.shtm. For more information or examples of WBT products, contact DOE's Emergency Operation Training Academy at www.eota.doe.gov or call (505) 845-5170 ext.172

Often what first responders find most valuable is “hands on” training with a knowledgeable instructor who can address their concerns about radiation safety and demonstrate the different properties of radiation using the instruments that might be required to use at an actual response. For this reason, the Health Physics Society’s support of programs like the Homeland Defense Equipment Reuse (HDER) is invaluable.

Radiological Assistance Resources

When a first responder seeks radiological assistance, there are many resources available to them. First, many counties have HAZMAT responders trained and equipped with rudimentary radiological assessment capability. Often radiation safety officers or health physicists are also available in the county or state department of health, radiological health branch (or equivalent). Another state asset can be found in the National Guard Civil Support Teams, who’s chemical, biological, and radiological equipment and training make them an excellent resource.

Federal assistance also available from;

- DOE’s Radiological Assistance Program
- Federal Bureau of Investigation (FBI) WMD/HAZMAT teams
- Other National Assistance (FEMA)
- Training and equipment resources available through the Department of Justice, Office for Domestic Preparedness Homeland Defense Equipment Reuse (HDER) Program. {Calibration and Training Support Provided by HPS}

The DOE's Radiological Assistance Program (RAP) utilizes health physicists (HP) and HP technicians from DOE nuclear & radiological facilities scattered across the country to provide free radiological emergency response assistance to local responders. These volunteer HPs and HP technicians receive special training to help them manage off site emergency response and integrate with first responders. Through this program, the local responders can tap into the skills, experience, and equipment of people who are actively working in radiological environments at DOE sites located cross the country.

Responses can be as trivial as getting phone advice to a full blown event that requires all of the DOE assets about to be discussed. Most common response is a low-key site visit involving a few, non-uniformed, RAP experts. But when the need arises for a large radiological emergency response, RAP provides access to all DOE assets.

- **Radiation Emergency Assistance Center/Training Site (REAC/TS)**

  Provides medical advice, specialized training, and the unique capability of on-site assistance for the treatment of all types of radiation exposure accidents.

- **National Atmospheric Release Advisory Center (NARAC)**

  Provides atmospheric dispersion modeling to generate potential population exposures and PAG affected areas.

- **Aerial Measurement System (AMS)**

  Sensitive detectors mounted on airframes to accurately measure contamination.

- **Accident Response Group (ARG)**

  Provides safe recovery and transport for accidents involving nuclear weapons.

- **Federal Radiological Monitoring and Assessment Center (FRMAC)**

  Helps coordinate monitoring and assessment data with other federal agencies.

For more information on DOE radiological emergency response assets, see http://www.doeal.gov/opa/Freedom.htm

For suspected terrorist acts, the FBI should be contacted as soon as possible. Specially trained and equipped agents can help evaluate the situation.

Summary:

There are many different ***detection tools*** for first responders, always consider; (1) the task and (2) the user. Carefully consider how the tool will be used and the abilities of the user. Regardless of which tool is selected, some ***training*** must be provided to give the responder the confidence to respond properly. Even simple detection tools can lead to inappropriate responses without training. Finally, first responders need to ***forge links*** with their regional radiological responders. Many local response agencies may not be aware of the resources available to them.