ARGON™ World leaders in CBRN/ HazMat training systems

A guide to Best Practice in Radiation Safety Training

Introduction

Creating realistic training scenarios that replicate the invisible threat of radiation is a vital and ongoing challenge for CBRNe and HazMat instructors worldwide, whether that training is provided within the context of military training exercises or as a teaching aid for first responders.

While most radiation detection instruments are in themselves fairly straight-forward to use, the skill lies in ensuring that trainees understand the full significance of detector readings that initiate any decisions, changes in units of measurement, shielding, survey, contamination avoidance and decontamination procedures.

The key for those tasked with CBRNe or HazMat instruction is to create applied, hands-on training scenarios that provide participants with the opportunity to experience all the features of a radiation incident in as life-like a context as possible.

High profile international radiological events such as the disasters in Fukushima and Chernobyl, together with the growing concern over North Korea's nuclear weapons programme, have put into even sharper focus the necessity for the military and first response teams to be able to react with confidence and speed to any potential radiological incident.

While exposure to high levels of radiation is not something we expect to encounter in everyday life, in the rare event of a major radioactive event, be it accidental release or a deliberate act of aggression, it is crucial that those charged with first response are trained to recognise, react to and contain the threat.

So what is the best process to ensure that radiological incident instructors can prepare their trainees for the powerful and potentially devastating consequences of radiation? And what training methods currently exist to accurately replicate the conditions of a force that is imperceptible and yet so inherently dangerous?

This eBook explores the challenges that are frequently encountered by instructors, exercise planners, the military and first response teams in their training for radiation incidents. It also highlights the existing options available for radiation training and examines the vital role that electronic detection simulators can play in ensuring radiation safety and preparedness.

What are the desired outcomes of Radiation Safety Training?

The key to successful training for radiation, whether it be for military personnel or first responders, lies in the authenticity of the training scenarios coupled with the opportunity for hands-on learning using true-to-life instrumentation.

With that in mind, there are four specific elements that sit at the heart of effective radiation safety training exercises that can ensure that trainees are confident, and cognisant, of the wide variation and rapidly changing challenges they may face in the field.

Realism

While theoretical understanding and classroom teaching will always have its place, nothing beats the opportunity to experience the conditions of a potential radiation incident in as realistic a setting as possible. The aim of an effective radiation safety training exercise should be to construct a life-like, hands-on search and survey scenario that accurately replicates both the complex physical conditions and the demanding psychological challenges of a live radiation incident.

Hands-On Experience

While there can certainly be value in more traditional “make-believe” training methods (such as when instructors relay a set of pre-designed readings to their trainees) a solely theoretical approach can result in a crucial gap in preparedness.

Having a theoretical understanding of the readings on a radiation detector can only go so far too, if the detectors that trainees are learning with are only registering levels of harmless background radiation.

Radiation training scenarios that focus on applied learning techniques can empower trainees to interpret the readings on their instrumentation, to understand the significance of any changes in the units of measurement and to accurately relay their findings to those further up the chain of command.

Crucially too, repeated access to hands-on training exercises can enable trainees to test their understanding of the importance of personal dose and the significance of shielding, time, distance and inverse square law (1/r2).

Safety

Radiation is an invisible, yet potentially harmful, form of energy, so safety (of the personnel directly involved in the exercise, of the public at large and of the environment) should sit at the heart of any training exercise.

The vast array of legislative, administrative and Health and Safety implications associated with storing, transporting and using live radiological sources or dispersing radioactive contaminants makes the use of live sources a challenging, if not unviable option for radiation safety training.

An obvious solution is to implement safe and environmentally-friendly simulated radiation training systems that enable Beta/Gamma search and survey, radionuclide identification, contamination monitoring, and dose rate assessment.

Ease of Set-Up

The most effective learning comes from repeated exposure and practice. So a radiation safety training scenario should ideally be as simple as possible to set up and with the potential to be carried out in any location, in any weather condition, perform consistently and in the context of an individual or group exercise. The ability to be able to review trainees' performance and then quickly reset an exercise can also be advantageous in enhancing learning outcomes for trainees. Preferably too the instrumentation used in such scenarios should require little or no preventative maintenance or recalibration.

What sorts of radiation scenarios do we need to train for?

The potential threats of radiation exposure are many and varied, from occupational exposure (in the course of civilian radiation operations such as x-ray technicians, radiologists or radioisotope researchers for example) through to illegal disposal, large-scale radiological events such as a major nuclear facility accident, deliberate detonation or dirty bomb.

Radiopharmaceutical / Hospital Irradiator Incidents

Response teams may be called to identify and contain an accidental release of an isotope as the result of damage to equipment containing a sealed radioactive source (e.g. a cell irradiator which may contain a 137Cs source >2000 Ci [74 TBq]) or a laboratory x-ray machine An accidental release of ionizing radiation may also occur due to the incorrect storing, handling, transport or disposal of radioactive material or waste.

Industrial Radiography Incidents

There are a vast array of potential industrial incidents that response teams may need to manage, from a leak of ionizing radiation due to damage to an x-ray generator used for security inspection or Positive Materials Identification (PMI) to the accidental release of radioactive isotopes or sources in the process of non-destructive testing (NDT). Radiation incidents can also occur as a result of road traffic accidents involving vehicles that transport radiological sources.

Civil Nuclear Facility Incidents

Concern over the safety of nuclear power facilities has been a topic of public concern since the very first nuclear reactors were constructed in the early 1950‘s. As of 2014, there had been more than 100 serious nuclear accidents and incidents from the use of nuclear power. To date however there has been only one nuclear emergency in the US - the accident at the Three Mile Island Unit 2 (TMI-2) nuclear power plant near Middletown, Pennsylvania, in 1979 - which remains to this day the most serious incident in U.S. commercial nuclear power plant operating history.

Acts of Aggression

While deliberate acts involving the use of a radiological source are thankfully rare, the potential impact on public safety is devastating, so it is crucial that CBRNe response teams are comprehensively trained to handle such events. Such acts could be in the form of the detonation or dispersal of ionizing radiation (via a Radiological Dispersal Device such as a dirty bomb), a mobile radioactive source that is being carried on a person or in a vehicle, the deliberate placing or dumping of a container of radioactive material in a public place or the theft of a radioactive source with the intent of causing fear or harm.

The unseen power of radiation

Ionizing radiation is an invisible force that is constantly around us - from naturally occurring radiation to man-made radioactive materials such as medical radiotherapy or nuclear fuels.

Any exposure to radioactivity carries with it some risk, dependent on the energy of the radiation emissions, its activity (disintegrations per second), the rate of metabolism (how quickly the radioactivity dissipates in and from the body) and where the radioactivity is concentrated in the body.

The amount of radiation that an individual absorbs is measured as a dose. For ionizing radiation (such as X-rays, gamma-rays, electrons and neutrons) the quantity of absorbed energy is measured in Gray (Gy). The Gy is simply a measure of the energy deposited per unit mass of tissue, it is not a measure of the biological effect of an exposure. Instead biological effect is measured in the unit of sieverts (Sv) [in some countries Rems or Rads]. These are the units typical of most radiation dose rate meters. As a sievert is extremely large, personal dose is typically measured in terms of thousandths of a sievert - or millisievert.

According to the UK based Public Health England (PHE), there is one serious radiation incident which results in death or major radiation injury worldwide every year and modern health and safety laws require all nuclear facilities and other major radiological sites to have regularly updated and exercised emergency plans.
On average, US civilians are exposed to an annual radiation dose of approximately 0.62 rem (or 620 millirem) while in the UK the dose is estimated at approximately 270 millirem per year. Both levels fall well within what are considered safe parameters for individual radiation exposure.

According to the PHE's Radiation Protection Services Unit, the vast majority of civilian radiation exposure in the UK (in the region of 48%) comes from radioactive radon gases from the ground, with 16% from medical radiation, 13% from terrestrial gamma radiation, 12% from cosmic radiation and 11% from intakes of radionuclides. Nuclear weapons fallout accounts for 0.2%, occupational radiation exposure is 0.02% and exposure to radioactive discharges is calculated at 0.01%.

For military personnel or first responders however, whose job it is to react to a range of hazardous radiological incidents, the potential for exposure to dangerous levels of ionizing radiation is much more acute.

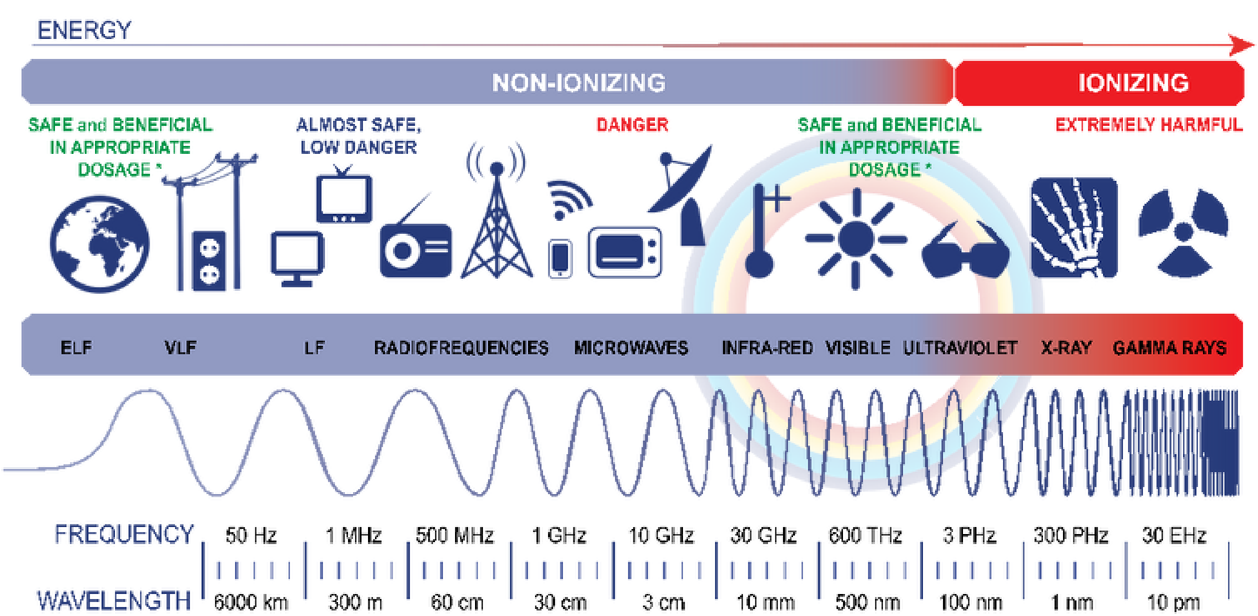
Exposure to radioactivity can be defined as being when part, or all, of the body is irradiated. Such exposures may occur in widely varying situations, for example, very short term exposure to a high dose rate radiation field, or when radioactivity is deposited externally (for example directly onto skin or clothing) or may be internal (as a result of inhalation, ingestion or via a wound.) The effect of radiation on human tissue varies greatly, principally in response to the radiation dose, which is affected by the type of radiation, which part of the body is affected and the exposure situation eg. how much radioactivity is taken into the body.

Individuals who have been exposed to very high levels of radiation can develop Acute Radiation Syndrome (ARS), in some cases within a matter of seconds of coming into contact with the radioactive source. The initial symptoms of ARS can include mild headache, vomiting, altered level of consciousness and increased body temperature.
There are three key factors that will determine an individual's ionizing radiation exposure:

Time: The longer the exposure to radiation, the bigger the dose will be. And any reduction in the time of an exposure will reduce the effective dose proportionally.
Distance: Inverse square law dictates that the greater the distance from a radioactive point source the lesser the dose (ie that a specified physical quantity or intensity is inversely proportional to the square of the distance from the source of that physical quantity.)

Shielding: Solid or liquid materials such as lead, concrete and water can all act as shields to absorb the energy of the radiation. Inserting the proper shield between a person and a radiation source will greatly reduce, or in some cases even eliminate, the dose received.

ELECTROMAGNETIC SPECTRUM (50HZ TO 30EHZ)



What equipment is required for live incident radiation detection?

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Military personnel and first responders rely on two essential pieces of equipment when dealing with live radiation incidents to monitor dose and dose rate:

A Survey Meter

A survey meter (such as the Mirion RDS-200) is a portable, battery-powered radiation detector that is a vital tool in assessing personnel, equipment and facilities for radioactive contamination.

A typical device features an easily readable display as well as providing an audible indication of the ionizing radiation count or dose rate. The devices are programmed to emit an alarm warning when a predetermined rate of radiation counts (or dose) has been exceeded.

A Personal Dosimeter

A Personal Dosimeter (such as the Thermo EPD Mk2) is a hand-held device that measures an individual's cumulative ionizing radiation dose and which is programmed to set off alarms at preset thresholds.

A dosimeter monitors the Hp(10) dose (the depth dose of deep organs) and the Hp(0.07) dose (the estimated skin dose). An audible alarm (or chirp rate) increases with the rate of radiation intensity. Personal dosimeters can be worn to obtain a whole body dose and there are also specialist types that can be worn on the fingers or clipped to headgear, to measure the localised body irradiation for specific activities.

Are there alternatives to actual detectors?

While survey meters and personal dosimeters are both fairly straightforward items of instrumentation, the challenge for CBRNe instructors lies in providing trainees with opportunities to test their knowledge of these devices in realistic training scenarios.

Unlike other HazMat safety training exercises however, where simulants or live sources can be used, there is no alternative to radiation that can replicate a reading on an actual unmodified radiation detector.

So what alternatives are currently available for the creation of realistic training exercises using detectors?
In the next chapter we explore the key role that electronic simulators can play in radiation safety training.

The role of electronic simulators in radiation safety training

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Ionizing radiation is an invisible force that is constantly around us - from naturally occurring radiation to man-made radioactive materials such as medical radiotherapy or nuclear fuels.

An electronic simulator is an intelligent computer/microcomputer-based simulation tool that enables the user to experience every operational feature of an actual detector with life-like accuracy but at zero risk from ionizing radiation.

Electronic simulators are safe and environmentally friendly radiation training systems that can be used in a variety of scenarios, both indoor and outdoor, for beta/gamma search and survey, radionuclide identification, contamination monitoring, dose and dose rate measurement.

They can also offer a significant time-saving advantage for training exercises as they mitigate the costly and time-consuming administrative effort normally associated with the transport, deployment and safe handling of radiological sources.

What are the essential features to look for in a radiation simulator?

An electronic radiation simulator is a vital piece of CBRNe and HazMat training equipment that ensures personnel are thoroughly prepared for real-life radiation incidents.

A well-designed simulator can enhance a trainee's learning experience in the following ways:

- By authentically replicating the appearance, functionality and display of a real d
- Enabling trainees to experience every operational feature (including realistic ala settings, logarithmic analogue bar graph display and numeric display to indicate the dose, dose rate and frequency of pulses)
- By responding to safe electronic sources that simulate ionizing radiation, freein organisations from any regulatory, environmental or Health and Safety concerns
- Requiring no preventative maintenance or recalibration
- Removing the potential for unnecessary and expensive damage to actual detect
- Enabling radiation safety training exercises to be carried out in any location, ind outdoors and including public buildings, in any weather condition and with sufficient reading range and distance from the source
- Offering compatibility with other key instrumentation such as probes required f beta detection
- Working with other hand-held, virtual, tabletop or app-based training systems t greater range of wide area tactical field and nuclear emergency response exercises

The advantages of electronic simulators for radiation safety training

Electronic radiation simulators can offer huge benefits for personnel responsible for radiation safety, providing trainees with first-hand experience of handling detectors that are identical to the ones they will use on a live incident.

Practical Application

The use of replica detectors ensures that trainees learn to trust the values displayed on their instruments, that they develop an understanding of the relationship between the measurements on their survey meter and their own personal dose readings and that they also experience the real-time effects of Time, Distance and Shielding on their instrumentation. Provides equal opportunity for all trainees to participate in training at any time and without any associated Health & Safety restrictions.

Genuine Immersion

Simulator detectors offer the opportunity for genuine immersion training that replicates all the elements of a real-life incident, exposing trainees to the range of emotional responses they may encounter in high-stress settings. The use of simulators also means that training exercises can be repeated as many times as required without the need to decontaminate or to wait for radionuclides used for contamination training to decay.

Better learning outcomes

After action review (AAR) ensures trainees follow clearly set out procedures and that they understand when errors have been made, enabling mistakes to be rectified in future training exercises.

Efficiency

The use of electronic simulators eliminates the high level of administration and paperwork normally involved in moving a highly dangerous source from a secure location into an open field exercise area, freeing the trainer to focus on the training and the trainees.

What are the limitations of radiation simulators?

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As with all forms of simulation used for training, compromises have to be accepted. The key is to strike the right balance between what is achievable, the desired training outcome and overall cost of implementation.

Radiation behaves as it does due to the portion of the electromagnetic spectrum in which it exists coupled with the nature for the source; a single isotropic or directional emitter, particles as with contamination / fallout or liquid. The dynamic ranges associated with radiation readings are also extremely large. All of these issues present specific challenges when we try to implement simulation.

Ultimately you'll want to consider what it is you wish your trainee to experience during the exercise and accept that achieving this has priority over specific physical representations of what occurs in reality.

Instructor Intensiveness

Some current methods are very instructor-intensive ie the instructor will often find him or herself more focused more on creating the "effect" for their student rather than on observing and assessing the student's responses, while other techniques involve the temporary placement of a means to simulate the presence of radioactivity.

Simulating Contamination

For contamination, options include the placement of powder or liquid substances that can represent an actual contaminant. This can have the advantage of simulating cross contamination and is often ideal for teaching the handling of open sources in a laboratory environment, for example.

Alternative methods include the ability to hide a safe item underneath a surface such as clothing or a protective suit to simulate contamination. This provides the instructor with the means to influence the maximum level or reading and to simulate partial or full decontamination based upon observation of the task. It also has the advantage that poor decontamination activity can be accurately represented.

The ability to simulate contamination by virtual means is also possible by determining the physical position and orientation of the simulation probe in relation to a surface, by using a combination of GPS and distance measurement, for example, to effect training in the correct use of an X-Ray probe for ground contamination monitoring.

Simulating Gamma and Beta Emitters

Simulation of Gamma and high energy Beta emitters present their own unique challenges. The use of technology to determine the relative position, and therefore distance, between a simulation source and a simulation radiation meter for the demonstration of time/distance protection is readily achievable, however representing the effects of shielding provided by different materials placed between the simulation source and the simulated detector is quite another matter.

Shielding

The degree of shielding/protection provided by specific material types is a function of the energy concerned and the specific material. The simulation of these effects is perhaps where compromise is relied upon to the greatest extent. The reality is that safe alternatives will not be subjected to the same degree of attenuation as actual radiation.

Technology now enables shielding to be represented to a reasonable degree for the purposes of allowing students to appreciate its importance for protection, however instructors need to clarify the differences as is appropriate for the lesson being delivered, which may vary depending upon the operational responsibilities of the student concerned.

Once again we rely upon the need to demonstrate an effect for the student to experience. For example, while a radio signal used to simulate Gamma will not penetrate a metal shield, there are means by which this can be effectively represented for training purposes.

Scenario Type

There is also the need to consider the specific type of scenario you wish to simulate:

- Contamination, decontamination, people, surfaces
- Fixed source, directional, isotropic
- Single or multiple radionuclides
- Mobile source carried by a person, in a vehicle
- Radioactive fallout due to a plume
- Radiological Dispersion Device (RDD)
- Specialist improvised / non improvised weapon scenarios.

Ultimately what is important is the need to clarify your training objectives to enable the most suitable technology to be applied to achieve the desired training results within the available budgetary constraints.

Conclusion

In this ebook we have explored the challenges that are frequently encountered by the military and first response teams in their training for radiation incidents. We have also highlighted the existing options available for radiation training and we have examined the vital role that electronic detection simulators can play in improving radiation safety and preparedness.

There is no doubt that radiation safety training has a crucial role to play in efficient and effective response to any radiological emergency, whether it be small or large in scale, as a result of accidental release or a deliberate act of terrorism.

For military personnel or first responders, the potential for exposure to dangerous levels of ionizing radiation is a serious and palpable risk.
While exposure to ionizing radiation is thankfully a rare occurrence, it is essential that emergency response crews are comprehensively trained to handle the unique challenges of any radiological incident they may encounter.

As this ebook highlights, the creation of realistic, safe and repeatable training exercises, combined with the opportunity to work with life-like instrumentation, have a vital and life-saving role to play in ensuring effective learning outcomes for radiation safety.

About Argon Electronics

Argon Electronics was established in 1987 and has since become a world leader in the development and manufacture of hazardous material detector simulators, most notably in the fields of military chemical, biological, radiological and nuclear (CBRN) defense. Our simulators have applications from civil response to unconventional terrorism and accidental release, and international treaty verification, with a growing presence in the nuclear energy generation and education markets.

Contact us

Contact Argon Electronics to discuss any of the information contained within this eBook, or to discuss your simulation training requirements.

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Request Argon's online product demonstration

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We will walk you through the details of any simulators you're interested in, including chemical and radiological detectors simulators, as well as exercise training solutions. This will be your opportunity to ask our experts any questions about our simulators.

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