Simulators for radiation training

Electronic radiation simulators can offer significant benefits in radiation safety training, providing the opportunity for first-hand experience in handling detectors in live-incident scenarios, without any risk of exposure, as **Steven Pike** explains

Foreword by Dr Chris Murdock, Peak RPA

The Ionising Radiations Regulations 2017 (IRR17) came into force on 1 January 2018 in Great Britain replacing IRR99. The regulations transpose into law EU directive 2013/59/EURATOM laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation.

One significant aspect of the directive relates to the preparedness for the planning of response to and the management of emergency exposure situations that are deemed to warrant measures to protect the health of members of the public or workers. Radiation experts must be able to provide "preparedness and response in emergency exposure situations".

Regarding site based occupational exposures in Britain (that are below the scope of onsite/offsite REPPIR emergencies), this has been interpreted in the strengthening of the requirement to rehearse contingency plans for radiation incidents (Regulation 13(2) IRR17). Where a risk assessment identifies that there is potential for significant radiation doses to be received from a foreseeable incident a suitable contingency plan must be in place that, so far as practicable, mitigates the incident's radiological impact.

The expectation in British law is that, where appropriate, such a plan should be rehearsed. When assessing the need to rehearse a plan the operator should consider: the potential severity of the accident; likely doses that could be received by employees or others; complexity of the plan; number of people likely to be involved in its implementation; involvement of the emergency services.

A selection of "reasonably foreseeable incidents" such as personal and/or environmental contamination, loss or damage of a sealed source and subsequent retrieval, a radiography source failing to retract, fire, flooding, failure of engineered controls etc. are explored within this article and also how training simulators may assist in rehearsing contingency plans to support compliance. ■

Steven Pike

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MOST RADIATION DETECTION INSTRUMENTS ARE fairly straightforward to use, allowing trainees to understand the full significance of detector readings that initiate any decisions. But changes in units of measurement, shielding, survey, contamination avoidance and decontamination procedures can challenge users.

Exposure to high levels of radiation is not something we expect to encounter in everyday life. But in the event of an 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 situation, in practical exercise scenarios.

Equally important is the need to ensure those responsible for response management and stakeholder liaison are well rehearsed in their decision making and communication processes.

While theoretical understanding and classroom teaching will always have its place, nothing beats the learning experience of a lifelike, hands-on search and survey scenario that accurately replicates the complex physical conditions and demanding psychological challenges of a live radiation incident.

The regulatory, administrative, and health and safety implications of storing, transporting and using live radiological sources or dispersing radioactive contaminants makes it almost impossible to use live sources for radiation safety training. Simulation can overcome this problem.

Scenarios that focus on applied learning techniques can help trainees interpret instrument readings, understand the significance of any changes and accurately relay their findings to those further up the chain of command. They can also test understanding of the importance of personal dose and the significance of shielding, time, distance and the inverse square law ($1/r^2$).

Training scenarios should be as simple as possible to set up in any location, perform consistently and make it possible to review trainees' performance in the context of an individual or group exercise to enhance learning.

Potential accident scenarios

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 Cs-137 source >2000 Ci [74 TBq]) or a laboratory x-ray machine. Accidental releases may also occur due to the incorrect storing, handling, transport or disposal of radioactive material.

Typical industrial incidents to be managed by response teams include an ionising radiation leak due to damage to an x-ray generator, or the accidental release of radioactive isotopes or sources in the process of non-destructive testing (NDT). Radiation incidents can also occur if vehicles transporting radiological sources are in an accident.

The safety of nuclear power facilities has been a topic of public concern since the first reactors were constructed in the early 1950s. 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 USA – at Three Mile Island 2 near Middletown, Pennsylvania, in 1979.

The Chernobyl incident in Ukraine, attributed to a combination of human error and violation of procedures has been well documented and underpins the need for thorough training and testing of all procedures and drills.

In March 2011, a tsunami that followed the Tohuku earthquake disabled the generators that would have powered the cooling system pumps at the Fukushima Daiichi nuclear power plant, resulting in catastrophic failure and subsequent release. This unfortunate sequence of events was found in July 2012 by the Fukushima Nuclear Accident Independent Investigation Commission (NAIIC) to have been "foreseeable".

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 response teams are comprehensively trained to handle such events. Such acts could arise from using an explosion or similar means to deliberately distribute radionuclides, a mobile radioactive source carried on a person or in a vehicle, deliberate placing or dumping of a container of radioactive material in a public place, or the theft of a radioactive source.

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. Modern health and safety laws require all nuclear facilities and other major radiological sites to have regularly updated and exercised emergency plans.

Practical application

An intelligent microcomputer-based simulation tool enables the user to experience every operational feature of a detector with zero risk from ionising radiation. Radiation training systems can be used in a variety of scenarios, indoor and outdoor, for beta/gamma search and survey, radionuclide identification, contamination monitoring, and dose and dose-rate measurement.

They offer a significant time-saving in training exercises as they mitigate the costly and time-consuming administrative effort associated with the transport, deployment and safe handling of radionuclides. By eliminating the paperwork involved in moving a highly dangerous source from a secure location into an open-field exercise area, the trainer is free to focus on the training exercise and the trainees.

Different types of radiation behave differently, depending on the region of the electromagnetic spectrum in which they exist, and the nature of the source. So the simulation has to represent a single isotropic or directional emitter, particles (from contamination) or liquids; each presents specific challenges. This places limits on the simulation and the user will want to consider what the trainee has to experience during the exercise, and accept that achieving this has priority over specific physical representations of what occurs in reality.

Replica detectors ensure 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 experience the real-time effects of time, distance and shielding without the associated health and safety restrictions.

Typical non-emergency exercise scenarios would include preventative maintenance training; repairing/replacing pumps and valves, generating methods to carry out these tasks while keeping dose to a minimum.

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

Other options include the ability to simulate contamination underneath a surface such as clothing or a protective suit. The instructor can change the maximum reading and simulate partial or full decontamination based on observations made during the task. This also has the advantage that poor decontamination activity can be accurately represented.

Simulation of gamma and high-energy beta emitters present their own challenges. The use of technology to determine the relative position, and therefore distance, between a simulation source and a simulation radiation meter to demonstrate time or 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.

The simulation enables shielding to be represented to a reasonable degree so students can appreciate its importance for protection, but instructors need to clarify how it differs from reality as appropriate for the lesson being delivered. This may vary depending upon the operational responsibilities of the student concerned.

Immersive training, which replicates all the elements of a real-life incident, exposes trainees to the range of emotional responses they may encounter in high-stress settings or real accident scenarios.

An 'after action review' ensures trainees follow clearly set-out procedures and understand when errors have been made. This means that mistakes can be rectified in future training exercises.

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 budget. There is no doubt that radiation safety training has a crucial role to play in efficient and effective response to any radiological emergency. ■

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