Duncan McClure, Radiation Meteorology Group Leader of the Radiation Protection Division of the UK's Health Protection Agency, describes the real-world challenges of post-incident radiation monitoring

Hall monitor

Compared to many other agents, radiation is a relatively easy pollutant to detect even in real time with hand held portable equipment. The science of radiation detection and measurement is highly evolved, the wide and varied selection of instrumentation available today being the product of a global nuclear industry that has stimulated instrument design and development for over 60 years. In addition, the various detector technologies available ensures that instrument designers can provide us with devices suitable for virtually every conceivable monitoring application. So where are the challenges for the designers in relation to equipment for response to CBRN incidents?

My background is a career of over thirty years in the independent testing, evaluation and development of radiological protection instrumentation (RPI). This also includes much experience of front line monitoring and more recently, even if only in the training environment, the more extreme conditions and circumstances experienced by first responders. As a result I believe that some of the major challenges to the manufacturers of this type of equipment are those associated with the environmental, ergonomic and user interface elements of RPI.

Whilst the nuclear industry has undoubtedly stimulated development and improvements in detector capability, many of the other aspects of instrument design have remained unchanged over an extended period of time, in what has proved to be a relatively conservative market. However, the emergence of a significant new market, in the form of the first responders of the emergency services, has stimulated a new era in development, which is not constrained by what has gone before. As well as having different ergonomic requirements, the incorporation of a range of additional features, which in many circumstances will assist them in their monitoring roles, have been identified as desirable. Remote communication, data logging, GPS positional information, indication of time remaining on task etc. are all good examples of useful additional features. None of this is new of course and many of these features have already been incorporated into RPI, but only in a handful of relatively specialised pieces of equipment designed for skilled users and for limited applications, which have not been produced in any great numbers.

This does however illustrate that it should be relatively straightforward to incorporate many of these features into a monitoring device, but of course the manufacturers are only likely to make the investment in a new design if they perceive there to be a significant market. What is perhaps harder for the manufacturers to address are some of the ergonomic aspects and harder still the problem of interpretation.

Radiation survey monitoring following the detonation of a radioactive dispersal device is likely to fall into two broad areas, principally the monitoring of external, penetrating radiation dose rates and the determination of the level and extent of any resulting contamination of the environment. In the initial stages of an incident, the primary function of this monitoring is to enable the control of the radiation exposure to those members of the emergency services i.e. Fire, Police and Ambulance crews, involved in the immediate response to the incident. In these circumstances it is likely that this radiation monitoring will be performed by the emergency services themselves and each has equipment specifically intended for the various roles they have to perform.

However, within a relatively short space of time, UK National emergency arrangements will result in the additional involvement of a number of expert organisations, in support of these services, but also with their own statutory obligations to fulfil. These expert organisations provided the bulk of the monitoring resources during the national response to the Po incident in late 2006 early 2007. It is interesting to note that the monitoring performed by the various organisations during such an incident, whilst being consistent in terms of equipment, execution and interpretation, is likely to be performed for significantly different purposes. Again, taking the Po incident as an example, much of the monitoring performed by the scientific advisors to the Police was primarily in support of their Forensic investigation,

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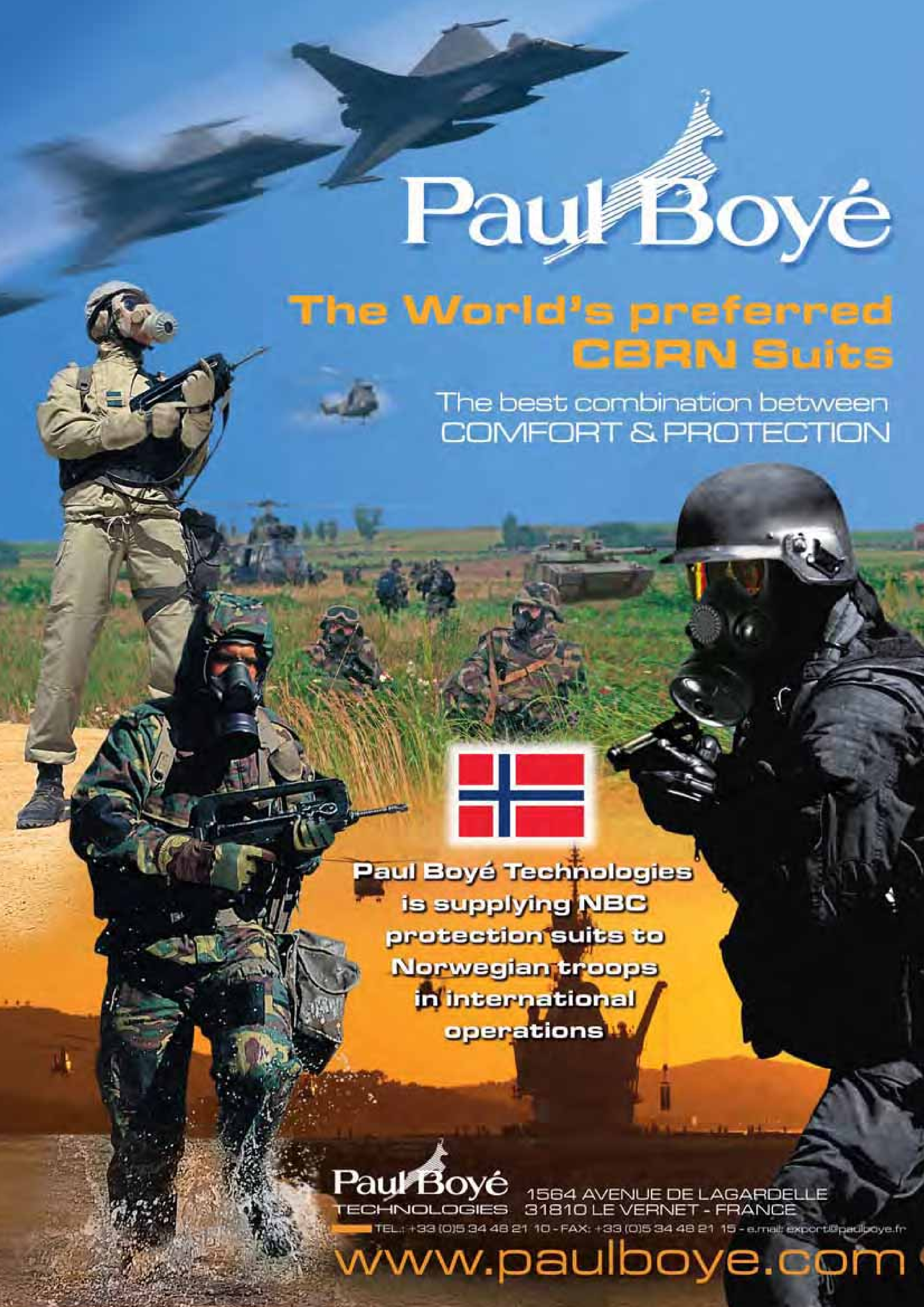

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Hall monitor

whilst that performed by the Health Protection Agency (HPA) was predominantly focussed on protection of the public. The identification of those potentially affected, the assessment of any doses received and the minimisation and control of any future doses, were high amongst HPA objectives.

So what can be learnt, in terms of the performance of the equipment and input into future design, from the experiences of the monitoring performed during such an incident? The Po incident itself is unique, in that 210Po, for all practical monitoring purposes, only emits Alpha radiation. As a result the monitoring programmes implemented by the Police and HPA had to rely solely on contamination monitoring for the identification of affected areas.

One significant advantage of Alpha radiation is that because it is highly ionising it deposits a significant amount of energy within the radiation detector, which in turn makes it easy to discriminate from normal environment gamma background radiation. On the other hand, the major problem associated with monitoring for Alpha radiation is that it has a relatively short range, of only a few centimetres in air. This, combined with the fact that even the very thin window (typically 2-3mgcm-2) of an average Alpha contamination detector will also produce significant attenuation, means that any practical monitoring must be performed at a distance of no greater than 10mm from any potentially contaminated surface. As there was also the potential for the contamination to be highly localised and surveyors had to ensure that the probe itself did not become contaminated by contact with the surface, a diligent approach to the monitoring process was essential. This made the process both demanding and time consuming.

As a result and virtually without exception, the monitoring performed during the incident was carried out by skilled monitoring teams drawn from across the established UK nuclear industry. HPA, MoD, British Energy, Nukem (now Nuvia) and other independent commercial organisations, all provided monitoring effort. This represents an experienced and skilled monitoring force! Not surprisingly there proved to be very little attrition of monitoring equipment even over the protracted period of the incident. Only a handful of probes required the replacement of the thin foil, which provides a light tight barrier over the surface of the detector, which is generically the most common form of failure for this type of equipment. An additional significant contributory factor to the low damage rate was undoubtedly the environments in which the equipment was used. The conditions found within offices, hotels and restaurants is very different from that in the industrial plant for which this equipment was designed.

Although a significant number of monitoring teams, from a wide variety of organisations, were involved in the incident, again not unsurprisingly, there was remarkable consistency in the monitoring equipment employed. It was equipment specifically designed for the detection of Alpha contamination. Generically all the equipment employed used a scintillation based detector with only three specific individual types making up the vast majority of the equipment used. This greatly assisted with the interpretation of the vast amount of all monitoring data that had to be analysed. Interpretation is a key element of any monitoring programme, particularly in respect of contamination monitoring.

So what did we learn – Well for this particular situation and in skilled hands, perhaps not surprisingly the existing equipment worked well. However, it would be foolish, given the potentially wide variety of possible scenarios and environmental conditions, to assume that this would always be the case. For first responders instruments will need to be ergonomically tougher! Admittedly this is a difficult call for contamination monitors, which by definition will have to have a thin fragile window, but it is infinitely possible for most of the other types of monitors. They also need to be simpler to operate, I would challenge many of the manufacturers to successfully use their equipment in full BA and a gas-tight suit! They also need to have large uncomplicated displays with a back-light facility and they need to be capable of operation for extended periods without the need for an exchange of batteries. All just good basic stuff I'm sure you will agree and I believe there are many good parallels manufacturers could look to for examples of good rugged design, which wouldn't necessarily compromise radiological performance.

Of equal if not greater importance is the need of first responders for clear and simple guidance as to what action to take in response to the radiation fields they encounter. Often this is only possible after careful and detailed consideration of the circumstances by radiation experts. The challenge and it is not necessarily one for the manufacturers, is to simplify this process. The problem is the unknown yet almost certainly complex and highly variable nature of the monitoring situation that will be encountered.

For the measurement of external penetrating dose rate fields this should not present too much of a problem. It is relatively straightforward to design an instrument that will intrinsically provide a good measure of such fields, to an accuracy which is more than acceptable for emergency situations. The same is also true for devices designed to measure the dose to an individual. For such devices the interpretation of what the readings mean and what actions might need to be taken by the user are relatively straightforward. However, the same will almost certainly not be true for contamination monitoring, particularly when dealing with weakly penetrating Alpha or Beta emitting radionuclides. The key problems in such circumstances are that it is virtually impossible to design an instrument which has a response that does not change with radiation energy. This results in a response i.e sensitivity per unit deposited activity, that differs from one radioactive substance to another. More significantly, because Alpha and Beta radiations are weakly penetrating, they are easily attenuated by other surface contaminants such as dust and water. Emissions can also be significantly attenuated internally if the material is present in even only moderate amounts, a phenomenon know as self absorption, or if the material has leached into any porous surface. In extreme circumstances this could lead to the material being virtually undetectable by external means. Most or all of these are conditions likely to be encountered in any practical monitoring situation and all serves to corrupt the assessment of deposited activity. Hence the interpretation of contamination monitoring results is a complex process, which cannot currently be readily simplified by changes to the instrumentation alone. This is the challenge for the measurement experts!