Radiation Protection challenges into the 21st Century;
Action Planning

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Abstract

Building on the work undertaken by the UK Health and Safety Executive in liaison with the wider health and safety community to examine emerging technological trends and their implications for occupational health and safety, a paper was produced for the Southport ’99 International Symposium which looked at the likely impact on radiation protection.

This paper reports on the next phase of the work which is designed to set the agenda for regulators, duty holders, qualified experts and other key stakeholders and intermediaries. Broad trends and themes determined by phase 1 of the work are translated into action plans aimed at anticipating the key challenges and exploiting the opportunities offered by technological developments for radiation protection purposes. These might equally be to achieve improved risk assessment and exposure characterisations of uncertain or novel practices (or interventions), to promote improved design of equipment and systems of work and adoption of inherently safer processes or procedures, to raise standards of competence in key workers and managers, or to encourage greater collaboration and joined up working between different groups of stakeholders and across national boundaries.

The principle purpose of sharing this vision of the future is to encourage radiation protection professionals and others with an interest in radiation and nuclear technologies, to register an interest. It will only be by engagement that the priorities and activities proposed in the action plan can be refined and only by a team effort that the implementation plan can be fully realised. And then there is the next action plan to build and tackle....

Trends in Technology - The background

The UK Health and Safety Executive (HSE) as the principle regulator for occupational health and safety, has long recognised the need to anticipate the impact of emerging developments in science and technology. Central to this is the effective gathering and analysis of knowledge from a wide range of discipline and specialist interests. HSE employs its own specialists and through them has access to extensive networks of external experts and practitioners. Since specialists are also trained as regulatory inspectors, they are ideally placed to interpret technological trends in the context of occupational health and safety, ie. to foresee both the challenges and also opportunities associated with emerging industrial processes and activities. Importantly, they also operate within the broader socio-economic and political environment and identify crosscutting trends and strategic themes. They also liaise closely with other regulators and government departments on matters that have broader implications eg. environmental or transport.

Conditioned by the rapid growth in information systems and technology, HSE decided in 1998 that the time was right to bring an added discipline and structure to knowledge collection and analysis. A methodology was developed and used within HSE to produce a “snapshot” vision of the near future for all aspects of occupational health and safety. This was published in May 1998 in an open discussion document (1). Underpinning the forward look methodology were four key elements;

- means of capturing implicit as well as explicit knowledge representative of a broad range of interests and opinion;
- open access to this knowledge pool and a culture of sharing, acceptance of constructive challenge and peer review and tolerance of new and radical ideas;
- capability to identify cross links between individual trends to produce broad crosscutting trends and strategic themes;
- capacity to analyse the broader trends and themes for their implications in the wider socio-political and economic context.
The approach has been demonstrated to give some real benefits over looking at individual, isolated items of information. It forces a review of what is currently known and understood, encourages interdisciplinary working and lateral thinking. The output can simply act as an aide memoire to the individual specialist or be a ready reference source for strategic planning, prioritisation and to identify resources and competencies needed for tomorrow’s world. It is also an important means of storing, quality assuring and retaining corporate knowledge independent of individuals entering and exiting the organisation. Work is continuing to improve and refine the Trends in Technology database and methodology. An upgraded, HSE Intranet version, is due to go on line in 2000 and a corresponding Internet version is under consideration for 2001/02.

Trends in Technology - Radiation Protection Implications

Adopting the above approach, Radiation Specialist Inspectors in HSE with operational and policy colleagues, produced a forward look specifically in relation to trends in science and technology with radiation safety, and radiation protection implications (both ionising and non-ionising radiations). A paper presented at the Southport ’99 International Symposium (2), shared this vision of the key radiation protection challenges for the first decade of the 21st Century. Subsequently, the Trends have been analysed by systematically reviewing the nature and scale of risk, available controls and standards, gaps in information and control measures, existence of partners and intermediaries for collaboration. Key priority areas have been derived, each associated with a set of related issues, gaps in knowledge and pointers for action as follows;

**Ionising Radiations**

**Key Priority Area 1 - Accounting, Control and Storage of Sources (including surveillance and security devices incorporating sources)**

Existing arrangements for regulating sources from “cradle to grave” are being increasingly challenged by;

i) technological developments in ‘smart’ devices incorporating hidden sources as either power supplies or active components;

ii) closed, sealed or encapsulated sources in use beyond their design life. The continued integrity of the containment becomes uncertain with implications for use, maintenance, transportation and emergency contingency planning;

iii) unregulated, cross-boundary movement of unaccounted for sources or contaminated articles as scrap materials, as “orphaned” sources or as a result of illicit trading (according to IAEA this is one of the biggest challenges facing the RP community);

iv) the expectation of joined up working between governments and agencies;

v) absence of clear policies on waste disposal, justification and exemption levels;

**Key Priority Area 2 - Industrial Radiography**

i) analysis of worker dose records, accidents/incidents and field experience indicate that industrial radiography, and particularly site radiography, continue to give rise to some of the highest doses to radiation workers. The technology and techniques used in industrial radiography which have not altered radically over the last twenty years, now show signs of emerging, significant change through the introduction of equipment capable of radiography in smaller controlled areas. This new approach, in addition to being inherently safer, should allow for improved management of the practice thereby reducing risk;

ii) other developments in safety by design, imaging and alternative non-destructive technology (NDT), offer opportunities for significant risk reduction. Specialised radiography using linear accelerators, neutrons etc., may also be poised to expand, and to pose additional and/or novel problems;

iii) contractor and individual radiographer attitudes continue to be a barrier to effective self-
regulation and continue to challenge the provision of effective supervision, training and motivation;

**Key Priority Area 3** - Naturally occurring radioactive materials (NORMs) and sources including Radon in Schools and other above-ground workplaces  

i) relative public unconcern about exposure to radon (workplace and residential) continues;  

ii) the absence of good risk assessments and evaluated control measures for exposure to NORM (excepting radon), limits effective regulation and risk minimisation;

**Key Priority Area 4** - Medical Exposures  

i) medical exposure continues to give the highest proportion of collective doses in the UK with the largest scope for increased optimisation (worker, carer and patient). Medical applications of IR increasingly rely on use of sophisticated equipment and procedures with significant automation and computerisation. Robust quality assurance arrangements (hardware and systems) are yet to be universally implemented and maintained;  

ii) health care is at the forefront of technological innovation and exploitation with the potential for unnecessary or excessive doses due to poorly controlled novel/pilot procedures and therapies. But also adoption and adaptation to assist in dose/risk reduction in other non-health care sector applications of these technologies;  

iii) clinical judgement versus good RP practice always creates a tension which needs to be resolved for optimisation purposes;

**Key Priority Area 5** - Decommissioning, Decontamination and Remediation  

i) unquantified, residual risks arising from discontinued radioactive or nuclear processes. No comprehensive inventory exists of abandoned or “mothballed sites” or plant which foreseeably might be contaminated or otherwise retain hazardous quantities of radioactive materials;  

ii) lack of competence in identification, management and undertaking of decommissioning, decontamination and remediation (outside the nuclear industry?) New or amended technologies may be untried. Potential shortfalls in expertise and the training to provide this need to be countered;

**Key Priority Area 6** - Transportation of Sources  

i) sources are “lost” or temporarily outside proper controls, posing potential and practical risk to workers and the public;  

ii) lack of awareness and acceptance of roles and responsibilities along the transportation chain;  

iii) general (international) requirements for transport of hazardous goods require to be reconciled with those specifically for radioactive materials;

Non-ionising Radiations  

**Key Priority Area 1** - Responding effectively to political and public concerns about NIR (includes risk communications; internal and external)  

i) public and political concern about electromagnetic fields (EMFs) has increased over the last ten years. Initially focussed on the effects from living near power lines and substations, also briefly microwave ovens and magnetic resonance imaging (MRI), most recently it has been broadcasting and telecoms masts and mobile telephony that have dominated. Complicated by lack of differentiation between NIR and IR (all radiations are to be feared) and by loss of amenity value of properties sited near existing or planned installations. It is difficult to assess the true public and political concern about
EMFs alone. Mobile phone use continues to expand exponentially. Nevertheless, pressure groups do exist and there have been concerted media campaigns. Individual enquiries are growing in number and knowledge of the topic. The demands for action are persistent, and are time consuming and resource intensive for the regulator;

ii) optical NIR has a much lower profile. Solar and artificial UV tanning are not viewed as high risk, despite the well publicised, enhanced danger of skin cancers. Lasers are being introduced into research, industry, communications, health care, alternative and cosmetic medicine and leisure with seemingly few incidents/injury and little risk aversion. The laser pointers episode was brief and more linked to antisocial behaviour and spurious compensation claims than technophobia;

iii) a low (remote?) risk remains that EMFs, and some optical radiations will be found to be a substantial cause of human or environmental harm. A much higher political risk exists that a powerful lobby or popular public antipathy to new technology will challenge government’s regulation of EMFs in particular. There is growing pressure from some European Member States to more strictly regulate EMFs;

iv) most NIR is related to new and emerging technology and the ground rules have yet to be fully worked out and agreed with all concerned parties. There is generally consensus on the exposure guidelines/basic restrictions and investigation levels to be applied, but they are complex and difficult to explain to non-specialists. Governments need to liaise closely on NIR for co-ordination, particularly on external risk communication. The RP community needs to raise general awareness of NIR and to facilitate proper open debate of the risks, and proportionate and “fit for purpose” action;

Key Priority Area 2 - Security, Surveillance and Leisure Applications of NIR

i) in response to institutional and individual concerns about property security and personal safety, devices employing infra-red, ultrasonic, light emitting diode (LED), pulsed EMF (and ionising radiation) sources are rapidly being developed and marketed. They are becoming widespread in commercial and public locations and for home/DIY use. The trend is towards higher powers. In many cases, the risk is considered to be low but is unassessed;

ii) lasers and LED’s, are finding increasing use in leisure and surveillance applications, for example laser displays, theatre, films, traffic tracking and information systems, toys and equipment displays. LED’s are often employed in clusters (arrays) and are steadily increasing in power and coherence, (they are becoming more laser like and higher hazard). These arrays may be set to replace conventional filament bulbs for general lighting in the next 10-20 years. The ability to vary the output wavelength (colour) and power, will be a key selling feature. Little evidence of eye damage to date but potential considered to exist;

iii) halogen and other non-filament high power spot lights and sources for concentrated illumination have been suspect from a total white light, blue light and UVR risk to the eyes (and skin; UVR), although to date provided that adequate filtering is incorporated in the product, there is no evidence of practical risk;

iv) cosmetic lasers and artificial UV tanning equipment continue to be popular. The former are often LED based rather than lasers, but the associated risks and efficacy are often unassessed or questionable. The latest in commercial UV tanning, is unstaffed, ‘coin in the slot’ booths. All tanning is considered to carry a risk of elevated skin (and eye?) cancer risk and possibly also other adverse health effects eg immunosuppression. Trends in using longer wavelength UVA as opposed to UVB (which can cause rapid skin reddening and burning) may be increasing the risk of malignant melanoma. As also the use of some skin care products. Some UVR exposure may be necessary to counter growing Vitamin D deficiency in some sections of the general population;

v) the lack of risk assessments and deployment of these devices and technologies in largely non-industrial, less regulated environments. Hazardous sources may be being built into a wide range of products unknowingly and subsequently be used and serviced by individuals unaware of any risks. There is also significant scope for abuse of the devices. Regulation is likely to be complicated by the
absence of serious, immediate injury, the voluntary nature of many exposures and overlapping or unclear regulatory and duty holder responsibilities;

**Key Priority Area 3 - Highest risk industrial, research and medical applications of NIR**

i) excepting communications and broadcasting, some of the highest electromagnetic field strengths (and therefore potential for exposure) are associated with radio frequency RF dielectric heating and (plastics) welding, low frequency/high frequency LF/HF induction heating and arc furnaces, arc welding, electrochemical processes and railways (and tramways?). A number of these activities could involve complex exposure patterns to primary frequency EMFs and harmonics. All of these processes could give exposures exceeding published investigation levels (but not necessarily exceeding the basic restrictions);

ii) physiotherapy using RF and HF and magnetic resonance imaging (MRI) represent potential for higher exposures. MRI in particular is going for higher fields to gain greater image resolution;

iii) industrial, materials processing lasers (hundreds of watts to kilowatts) are mainly of concern in relation to ‘in situ’ and ‘ad hoc’ alignment, maintenance and servicing when non-specialist engineers and local factory staff could be at risk from eye and skin injury. Misdirected or ‘escaped’ laser beams from delivery systems or nozzles, could cause injury or initiate fires or explosions. Associated risks from high voltages and fume and shielding gases, are not negligible;

iv) medical, dental and veterinary application of lasers often involve powers which equate to industrial use and pose many of the same problems. Associated risks as above;

v) emerging uses of UVR at high powers include sterilisation, most notably water purification, and developments in high power, halogen lighting;

vi) for EMFs, there is still a lack of risk assessments and source characterisations coupled with limited practical guidance on the published guidelines for exposure restriction. Laser and other high power optical systems are often deficient in design features which build in safety for industrial and commercial application eg on-line beam diagnostics and adjustment, beam quality monitoring, stray beam detection, automatic reduced power alignment and testing etc. Poor familiarisation with optical hazards, Standards and controls and the need for specialist training are widespread. High power lasers in research have caused serious incidents and eye injuries in particular. The near infra-red wavelengths at high repetition rate pulsed outputs, are most often involved. Excimer (UV lasers) and high power UV lamps pose significant risk to the skin and eye, for the same reasons;

**Key Priority Area 4 - “Wireless” communications and Broadcasting (including optical fibre systems).**

i) broadcasting is mainly associated with high powers (across a range of frequencies) but these are generally inaccessible other than to mast riggers, maintenance staff and engineers. Exposures can be complex, mixed in frequency and power levels, and complicated by individuals climbing through the fields. Significant potential for exceeding investigation levels for EMFs (but not necessarily the basic restrictions);

ii) communications at microwave frequencies, particularly use of mobile telephones, are rapidly expanding. The trend is towards higher frequencies, smaller cells and hence an increased number of local base stations. Public buildings and street furniture are typical mounting points for these transender units. Accessibility to inadvertent or wilful interference will increase and power close to the base stations may not be insignificant. The relatively low “dispersed” powers in use have not persuaded detractors that the technology is without risk. Telecoms, cable TV and distributed sensing and information transfer systems can make use of optical fibres carrying optical radiations (often in the near infra-red wavelengths). Optical powers are currently not very high but the trend is towards higher powers, and risks are greatest to engineers and maintenance staff, and potentially to inadvertent or deliberate interference. Optical computers are likely in the near future;

iii) lack of risk assessments and source characterisations coupled with limited practical guidance on Standards and exposure restriction guidelines. Some aspects of safety by design may yet need to be
encouraged/developed eg. for distributed optical fibre systems. Absence of clear, unambiguous land use planning guidance is unhelpful in relation to broadcasting and communications masts and base stations, in meeting local public and political concerns.

Next Steps in Action Planning

Accepting that the above key priority areas are complete, reasonable and realistic, it will be necessary to determine what should be done, on what time scales, and by whom. A primary consideration here is the proportionate allocation of resources on a risk related basis not just within radiations but arguable in the wider context of total occupational, public and environmental health and safety risk optimisation. Some of the common themes emerging from ongoing work by HSE and others to develop action plans and programmes are the need to:

- gather and analyse intelligence on security, surveillance, and self-powered “smart” devices and sensors, communications and broadcasting equipment, incorporating radiation sources or generators;
- develop risk assessments for the above equipment devices and sensors and influence design for safety to encompass manufacture, supply and installation, in-service adjustment and maintenance and disposal and dismantling. Also the provision of effective information at each stage;
- ensure effective communications, accounting and tracking of sources and co-operation between regulatory authorities, agencies, suppliers, transporters and users;
- participate in the development of common policies for waste disposal, justification criteria, exemption and clearance levels, land planning use etc.;
- compile and maintain good records of contaminated sites and industrial plant with effective systems to identify in advance and to regulate any intervention or decontamination/decommissioning activities;
- improve awareness, training and competence in RP of all involved in NDT and related work. Encourage greater client involvement and responsibility, and look to building partnership between clients, contractors, insurance companies and NDT equipment designers and suppliers. Promote lower risk NDT techniques including reduced controlled area radiography;
- develop meaningful risk assessment methodologies and effective control measures for NORMs;
- engage local government, business and residents’ groups in promoting adoption of practical control measures for reducing risk of exposure to radon;
- promote optimisation in relation to medical exposures to radiations and look to improve equipment and procedures quality assurance, to raise and maintain standards and eliminate unnecessary overexposures and harmful underexposures;
- gather intelligence and make risk assessments of emerging new techniques in medical imaging, therapy and automated control and image analysis. Seek to exploit benefits that greater sensitivity and discrimination can offer for exposure and dose reductions;
- investigate the technological and competencies requirements for “safe” decontamination, decommissioning and remediation. Encourage the growing availability of resources and training to meet these needs;
- improve openness and accountability particularly in relation to the public and special interests groups. Develop effective communication and education strategies and ensure that standards and risk estimation and protection schemes, and guidelines are in a form which lend themselves to lay understanding and debate.

Conclusions

The intention of this paper is to challenge the RP community with a view of the near future and to initiate a process of review and forward thinking. The goal would be to gain consensus on a common agenda of actions and priorities to be pursued which would form the basis for effective, anticipatory regulation of emerging radiation risks. This agenda would be proportionate, “fit for purpose” and not unnecessarily restrictive to technological advance. It would be well communicated and provide comfort and reassurance to politicians, special interest groups and public alike. Realistically, if the RP community can agree on the main priorities and tackle them in a reasonably co-ordinated fashion, much will have been achieved. I look to IRPA to pick up this initiative, in partnership with the national societies and other key players in radiation protection and to encourage and facilitate active participation in future action planning for RP.
References

