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A PRACTITIONER'S VIEW OF RADIATION AND THE LAW

Roger Coates
President, International Radiation Protection Association

Abstract

The paper describes the role of the International Radiation Protection Association (IRPA) and the fundamentals of the internationally accepted system for radiation protection. Some key current challenges within the system of protection are discussed, with emphasis on the need to ensure a balanced practical outcome for the protection of society. The need for cooperation between all parties, including international organisations, regulators and practitioners is highlighted.

The International Radiation Protection Association (IRPA)

IRPA is an independent non-profit association of radiation protection professionals, joining through national and regional radiation protection societies (the Associate Societies). The organisation is run via voluntary effort, having no staff.

The defined **Mission Statement** is as follows: *IRPA is the international professional association for radiation protection. Through national and regional Associate Societies and radiation protection professionals, IRPA promotes excellence in radiation protection by providing benchmarks of good practice and enhancing professional competence and networking. IRPA encourages the application of the highest standards of professional conduct, skills and knowledge for the benefit of individuals and society.*

IRPA has the pre-eminent role in the generic field of radiation protection 'practice'. Our strength is the involvement of professionals/practitioners across all fields of radiation protection, covering scientific research, teaching, regulation, medical practice, nuclear and non-nuclear industry, national/international policy and all other fields. Through our 18,000 members in 52 Associate Societies covering 67 countries, we encompass the full spectrum of national experiences, from large developed countries through to practitioners working in small developing nations.

IRPA has defined the following **Vision Statement**: *IRPA is the international voice of the radiation protection profession.* In living this vision we have made significant progress on our aspiration to be recognised by all our stakeholders as *the* international organisation representing the views of the radiation protection profession in the enhancement of radiation protection culture and practice worldwide. IRPA's views are increasingly sought by the principal radiation protection international organisations, including ICRP, IAEA, NEA and WHO.

The System of Radiological Protection

The conceptual framework for addressing radiation protection has been developed over many years, largely under the auspices of the ICRP, with several other international organisations such as IAEA and WHO developing related standards and guidance.

Protection is based on the best current scientific understanding of the effects of radiation. At high levels of exposure there are effects that are known to occur above certain thresholds, called deterministic effects, such as organ failure or skin burns. The objective is therefore to completely avoid these effects by keeping doses below the thresholds. However, there are some effects such as cancer which have a 'probabalistic' impact, called stochastic effects. There is good scientific evidence of the incidence of these effects at relatively high doses, but it is scientifically challenging to determine or clearly demonstrate these effects at lower doses. For the purposes of protection it is therefore prudently assumed that there is a linear relationship between the probability of an effect and the dose – known as the Linear No Threshold (LNT) model. This means that even at very low exposures there is still an *assumption* of residual risk. Some implications of this assumption are discussed below.

The primary aim of the system of protection is: '*to contribute to an appropriate level of protection for people and the environment against the detrimental effects of radiation exposure without unduly limiting the desirable human actions that may be associated with such exposure'.*

This approach leads to three fundamental principles of protection related to:

- *Justification* - doing more good than harm,
- *Optimisation* - keeping doses as low as reasonably achievable, and
- *Limitation* - ensuring no person receives an unacceptably high dose.

The current recommendations address several different situations of exposure as follows:

- *Planned Exposure situation*: where radiological protection can be planned in advance, and exposures can be reasonably predicted.
- *Existing Exposure situation*: Situations that already exist when a decision on control has to be taken.
- *Emergency Exposure situation*: Unexpected situations that may require urgent protective actions.

For these situations, exposures are considered in three categories: *occupational exposure, public exposure* and *medical exposure*.

These categories of exposure and exposure situations are used to consider how best to approach radiological protection in different circumstances. The resulting system of protection is therefore quite complex, with subtly different rules and expectations relating to differing real life contexts.

This paper principally discusses occupational and public exposures in planned exposure situations, i.e for controlled and regulated sources, although parallels can be drawn with other circumstances.

Dose Limits

As an example of the complexity within the system of protection, it is illustrative to consider dose limits. Occupational and public dose limits are usually given central prominence in regulation and in general overviews of radiation protection. In reality they play a very limited role – for example the dose limits do not apply to existing or emergency exposure situations. They only have relevance to planned exposure situations, and even here the limits do not apply to medical exposure: for example in the case of CT scans and radiotherapy, doses necessary to achieve the justified medical benefit will be much higher than any dose limit.

This serves to create confusion and, to some extent, undermine a lay person's confidence in the system. How can it be acceptable to have a public dose limit of 1 mSv/y, which is lower than the natural background exposure (existing exposure) experienced by everyone? Does this mean that man-made radiation is much more dangerous than natural radiation? When an emergency arises, why is it suddenly acceptable to allow exposures up to twenty times higher? These are obvious questions, for which the answers are not intuitive. Of course there are explanations written into the 'fine print' of radiation protection philosophy, but these are not easily accessible, nor indeed widely understood.

Natural Background Exposure

Radiation is all around us, and always has been, as a completely natural phenomenon. This 'natural background' radiation is by far the dominant contribution to our overall radiation exposure. In fact this radiation used to be higher as biological life evolved on our planet, and there is no such thing as a radiation-free environment, and there never has been.

The largest contribution to our natural exposure comes from the rocks around us that contain radioactive elements such as uranium and thorium, which give off gamma rays. The rocks also produce a radioactive gas called radon that seeps out of the ground and enters our homes and workplaces. The doses we get from these sources are highly variable and reflect the geology of where we live. Most countries have regions where the doses, particularly from radon, are significantly higher than the average.

Another component of our natural exposure comes via cosmic rays from outer space. To some extent these are shielded by the atmosphere, but this means that the exposure we receive increases with altitude. This also means that when we fly in an aeroplane we get an enhanced dose – small but measureable.

Taken together, the radiation dose that we receive from natural background is highly variable. Very few people in the world get less than 2 mSv/year[1], but a small number in high radon areas could get up to many tens of mSv/year. The majority of people get between 2 and 4 mSv/year. And how we live our lives will impact on our exposure. A two week holiday in a high radon area (the rock structures often make attractive scenery!) could give an enhanced dose of around 0.3 mSv or more, and a return inter-continental air flight could give at least an extra 0.1 mSv.

The Context of Natural Background and Planned Exposures

Doses to the public from planned (regulated) sources are subject to a dose limit of 1mSv/year. In practice the exposures are always much lower - authorities apply lower restrictions ('constraints') and require optimisation assessments. Public exposures from a source therefore rarely exceed 0.1 mSv/year, and are usually much lower. These exposures are additional to the natural background doses received by every individual, and hence when viewed from a total dose perspective, such planned exposures do not make a material difference to individual exposure – there is no change from the '2 to 4 mSv/year' typical range described above. Indeed, the additional increment from the planned exposure lies within the natural background variability due to 'lifestyle' decisions of an

[1] The milliSievert (mSv) is the basic unit of radiation exposure, which takes account of the biological effectiveness of different types of radiation and its impact on various body organs.

individual, such as whether to move house or location, where to spend a vacation or whether to travel by aeroplane.

Doses from occupational exposure only present a slightly different picture. Whilst the dose limit for occupational exposure in most countries is 20mSv/year, the overwhelming majority of exposures are less than 3 mSv/year, with very few exceeding 6 mSv/year. Hence most exposures do not make a significant extension to the range of total dose received by an individual.

At these levels of exposure (around 'a few' mSv/year), what do we know about the risks from radiation? No scientific study of health effects has been able to identify enhanced cancer incidence or any other effect. In fact, a combination of the 'expected' low risk based on the LNT model, together with the variability of normal cancer rates makes it virtually impossible to demonstrate an effect. However, the absence of evidence is not the same as evidence of absence. There is some evidence from radiation biology studies that would lead to supporting the risk expectation from LNT, but also there is some other evidence that (at least in some situations) there could be a threshold below which risks are significantly lower, or even zero. The only thing we know for certain is that, if there is a risk of harm from these levels of exposure, it is what would normally be regarded as very low.

Implications

Despite much scientific research on radiation effects, increasingly focussed on the low dose region, it is clear that there is scientific uncertainty on the level of risk from radiation at low doses and particularly at low dose-rates. This is particularly so at levels around a few mSv/year which are important for almost all practical exposure situations. There seems little prospect of any definitive scientific clarification of low dose risk in the foreseeable future. Whilst some practitioners argue for a change from the LNT approach to one based on a dose threshold, which would imply zero risk at these low dose levels, there is a wider acceptance of the need for using the LNT approach as a basis for protection, with the important caveat that this is recognised as a prudent basis for protection and not as a scientific fact. But it can be argued that focussing on the shape of the dose response model is addressing the wrong question at this time. Perhaps the emphasis should move a little from 'What is the risk at these very low doses' towards 'What is the best pragmatic framework for making decisions, including how we apply LNT, at these very low doses'? Are there other considerations which should enter the decision framework at these low levels?

It is clear that in many situations society is spending very significant money and resources in order to achieve extremely low levels of exposure. There is a growing concern amongst radiation protection practitioners that society is getting very poor 'value for money' from the current approach to protection in these situations. Every million dollars spent on saving a few fractions of a mSv has an opportunity cost, in that this resource cannot be used elsewhere for society where a much better 'risk return' or benefit is possible.

Consider the following illustration. One concept in the system of protection is that of 'clearance', whereby material can be released from regulatory control if it meets defined low levels of radioactivity concentration. The concept is based on ensuring that resulting doses will not exceed doses around 0.01 mSv/y to the most exposed person. A recent study (1) has demonstrated that due to many unnecessary conservatisms in the assessments, the approach actually results in doses which are at least 100 times lower – around 0.0001 mSv/year. The cost to operators of having to achieve these levels is typically measured in millions of dollars.

Hence our approach to low dose exposure can result in operators and authorities spending vast resources to achieve compliance with requirements which are based on a very small number of persons receiving no more than extremely small fractions of a mSv. On the other hand, using a UK example, tens of thousands of people each year make decisions to go on vacation to Cornwall, a high radon area, each receiving an additional dose of at least several tenths of a mSv – i.e. involving a far higher level of exposure.

Does this make sense? Indeed, does it align with normal notions of 'common sense'? It could be argued that one type of exposure is imposed on society, whilst the other is free personal choice. But the latter decision is actually made without any knowledge or understanding of radiation risk – and so it should be, for the risks (if they exist) are indeed very small. Is there really such a fundamental difference between these exposure situations that requires such a divergence of approach in the allocation of resources?

How to Move Forward

There is a range of issues where those of us engaged in the radiation protection profession can seek to make a more rational progress.

Reasonableness

Optimisation means keeping exposures As Low As Reasonably Achievable (ALARA). It is universally accepted that the optimisation principle, including ALARA, is the central pillar for the practical implementation of radiation protection and is the dominant factor controlling exposures in any well-developed system of protection. For example it can be clearly shown that the remarkable decreases in occupational exposure over many years in the nuclear industry have been achieved through very effective ALARA programmes. However, there is a significant concern within the profession that an overly-simplistic approach, perhaps plus natural regulatory caution, is leading to continuing expectations of ever lower doses. Put another way, there is more emphasis on 'As Low As' and much less on 'Reasonable'. There is therefore a need to develop a wider consensus on what may be understood to be 'reasonable' in various situations. This could mean a focus of ALARA efforts on the higher levels of exposure above the 'few mSv/year' range, with optimisation at lower levels being less formal and based on the effective application of a radiation protection culture approach. It could also involve a review of approaches to discharges from facilities and other forms of public exposure, where perhaps the emphasis to date has been on minimisation rather than true optimisation.

Conservatism

There is a growing awareness of the impact of our traditional professional mindset of prudence and conservatism. Whilst in general this is an admirable quality, it is important to match the degree of prudence and conservatism to the level of associated risk, rather than apply a 'one size fits all' approach. Most of our assessments, which ultimately determine the level of exposure, contain several parameters, each of which is often established on a somewhat conservative basis. The conservatisms multiply together within the assessment, with the resulting outcome often being needlessly over-conservative (and usually with the conservatism well hidden), as shown in the example of clearance above.

The Graded Approach

Graded approach is a well-established regulatory principle, aiming to apply increasing levels of regulatory stringency as the level of risk increases – i.e the extent of regulation should be proportionate to the risk. Its application in practice is highly variable and patchy, often resulting in regulatory requirements which are unnecessarily strict for the circumstances. It requires a mature level of understanding and judgement by both regulators and operators for its successful application. There are many benefits to be obtained from a more active and consistent application of this approach.

Conclusions

National laws and regulations, based on the international system of protection, provide the basic foundation for radiation protection. However, practical application has evolved to provide in general a higher level of protection than is required by the basic legal requirements. There are many areas of uncertainty and judgement involved in the practical application of protection requirements, and there is a growing recognition that a more conscious and overt consideration of underpinning expectations is needed in some key areas of practice.

In particular there are many challenges in the effective application of the system of radiological protection to exposures at or below the radiation levels typical of natural background – i.e a few mSv/year or less. This is however an important exposure range, because it encompasses the majority of exposures and the related decisions which must be made by practitioners.

Several of the important issues arising can be addressed within the radiation protection profession. However, for some of the issues raised there are additional considerations related to public understanding and perception which have not been addressed in this paper, but which would need to be taken into account.

From the perspective of a radiation protection practitioner, the control of radiation exposures raises several fundamental aspects regarding how the law and related regulation should address some key issues. These include uncertainty in risk estimates, how to ensure value for money for society, and the need to remain aligned with what many would consider to be common sense.

To address these issues effectively it is important that all relevant parties engage constructively together, including those organisations developing the underpinning philosophy and those engaged in developing associated standards and legal requirements. It is also essential that the practitioners in the field, who understand the impact of such decisions, are closely involved. This is why there are clear advantages for national authorities to work closely with local radiation protection societies, and for the International Radiation Protection Association to represent the experiences of the practitioners at international discussions on the development of the system of protection.

Reference

(1). Prudence and conservatism in radiation protection: a case study. R Coates. Radiat Prot Dosimetry (2017) 173 (1-3): 100-103.