CONTROLLABLE DOSE:

A discussion on the control of individual doses from single sources

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OVERVIEW

Contaminated land is an issue of considerable interest in many countries. It arises as a result of accidental releases, as from Chernobyl, and from manmade activities including atmospheric testing of nuclear weapons. Contamination is also an historic liability from, for example, luminising plants using radium, or from excessive effluent discharges.

A particular issue at present is the decommissioning of nuclear facilities, old reactors and weapons fabrication facilities. These liabilities require the expenditure of considerable amounts of money and some people think that too much money is being, and will be, spent to achieve low levels of residual contamination. If contaminated land is not cleaned up there is public concern and in some countries there will be litigation, charging that the environmental risk is too great. These concerns have led to an increased pressure from some individuals to propose a threshold in the dose-response relationship in order to reduce the expenditure.

It is true that, increasingly, our science is judged in the courts rather than by national academies of science. Judge and jury will decide on the issue of the threshold and it is they who must be convinced as to whether there are no risks at low doses of radiation. The issue is primarily in relation to public not occupational exposure, and because of the continuing lack of definitive scientific evidence, a new approach to protection could be considered.

THE PROBLEM

ICRP has made clear that the present system of protection distinguishes between practices, which add doses and risks, and interventions, which reduce doses and risks. The dose limits apply to the sum of doses from a restricted set of sources or circumstances and, additionally, are often misunderstood, since a limit is sometimes taken to mean the boundary between safe and unsafe. For public exposure in particular, there is confusion about the application of the 1 mSv annual dose limit when the Action Level for radon in homes is to bet set between 3 and 10 mSv in a year. Then, in the event of an accident, perhaps when people especially expect to be protected, the dose limit does not apply and intervention is not taken until doses are liable to be in the range of 5 to 50 mSv.

ICRP recommendations, in the context of the use of radionuclides, have been for the control of protection from single sources by optimization within the individual maximum dose constraint of 0.3 mSv per year. In the case of accidents, intervention levels have been suggested

for taking action to reduce exposures, but there is no international guidance on the withdrawal of intervention actions. At what level of dose can normal living be resumed? More than 1 mSv per year surely, and if a new population moves from outside into the area, is it a practice to which the 1 mSv dose limit applies? Thus, at what point after an accident do the principles of protection for practices apply, if at all? Along these lines, is building a house in an area of high natural background radiation to which people might move from areas of lower background, a practice to which the 1 mSv limit is applied? Strict application of the definition of a practice given in ICRP Publication 60 might suggest that this is so.

These are situations that do not easily fall into the current definitions of practice or intervention; radiological protection philosophy might usefully be re-examined in order to develop an alternative logically consistent framework for protection to that used at present. The following thoughts are for discussion and are a first attempt to do this by bringing the three categories of exposure, occupational, medical and public, within an overall framework that encompasses the present system of protection for practices and interventions. These represent a scheme that may be complementary to, rather than a fundamental change in, the Commission's system of protection and may be of use in its application.

A POSSIBLE WAY FORWARD

In protecting individuals from the harmful effects of ionizing radiation, it is the control of radiation doses that is important, no matter what the source. Thus, a start may be made with a definition:

> **A Controllable Dose is the dose or the sum of the doses to an individual from a particular source that can reasonably be controlled by whatever means.**

Such doses could be received at work, in medical practice and in the environment from the use of artificial sources of radionuclides, or could arise from elevated levels of natural radiation and radionuclides, including radon. The term covers doses that are being received e.g., from radon, and doses that are to be received in the future, e.g., from the introduction of new sources or following an actual or potential accident. It does not apply to exposures that not amenable to control, such as cosmic radiation at ground level, but would apply to high terrestrial levels of natural exposure.

The significance of a level of controllable dose depends on its magnitude, the benefit to that individual and the ease of reducing or preventing the dose. There will, of course, be some level of dose where control will be mandatory. This will clearly be for the avoidance of deterministic effects in accident situations or for the protection of healthy tissues in high dose medical procedures. Doses of some hundreds of millisieverts up to several sieverts will cause deterministic effects of various types depending upon whether the exposure is acute or chronic. Apart from in radiotherapy, such doses may be encountered in interventional radiology, where there is a life-threatening situation. In other circumstances, such exposures will be entirely unacceptable to the individual, unless taken for life-saving rescue in an emergency. **These situations are considered to be outside the scope of the proposed scheme of controllable doses set out here.**

THE PRINCIPLE

The protection philosophy for controllable dose is based on the individual. If the individual is sufficiently protected from a single source, then that is a sufficient criterion for the control of the source. In the past ICRP has used societal criteria, using collective dose summed over all populations and all times in cost-benefit analysis to determine the optimum spend on the control of a source. This new approach is a totally individual source-related criterion. The principle is

> **If the risk of harm to the health of the most exposed individual is trivial, then the total risk is trivial – irrespective of how many people are exposed**

The principle of individual source-related protection was recognised by ICRP in Publication 60 with the introduction of the concept of a **constraint** on the optimisation process.

CONTROLLABLE DOSE

For those exposures that are to be controlled, the philosophy is essentially set out in the attached figure with a regime of controllable doses showing their different significance in terms of individual fatal cancer risk. In addition, the current criteria for controlling doses in normal, accident or medical situations are presented.

Thus, the highest dose that will normally be tolerated before control is definitely instituted is in the range of a few tens of millisieverts although this may be tolerated in successive years. This covers:

- The permanent relocation of people following an accident is recommended to avert a dose of 1 Sv in a lifetime, which corresponds to some 10s of mSv in the first year,
- The occupational dose limit of 20 mSv in a year,
- The upper (justified) action level for radon in homes (10 mSv per year),
- A CT scan (~few 10s of mSv), and
- The lower level of averted dose above which evacuation is recommended after an accident (50 mSv).

While these levels of dose to the individual can hardly be called unacceptable, they are levels at which questions should be asked as to whether the dose and associated fatal risk which will be of the order of 10^{-3}, or 1 in1000, can be avoided by some sort of action. That action may be disruptive, or, as in the case of a CT scan, be simply to question whether the required information can be obtained by another means involving lower dose.

Controllable doses should not generally exceed this level and actual or potential doses approaching this level would only be allowed if the individual receives a benefit or the doses cannot be reduced or prevented without significant disruption to lifestyle.

At levels of controllable dose of the order of a few millisieverts per year, the exposures should not be of great concern from the point of view of an individual’s health. Natural

background radiation is about 2-3 mSv in a year, and even if radon exposures are excluded, the figure is 1-2 mSv. The exposures covered would be:

- the lower level of optimized range for radon intervention (3 mSv),
- the lower level for simple countermeasures (sheltering, KI) in an accident (5 mSv),
- the existing dose limit for members of the pubic (1 mSv), and
- simple diagnostic x-ray examinations (1 mSv)

Steps may be taken to reduce these exposures, or to prevent them, particularly if the individual receives no benefit. Thus from a controllable dose of a few millisieverts upwards it becomes increasingly desirable to reduce or prevent the dose depending both on the practicability of doing so and whether the individual is deriving any tangible benefit from the exposure, e.g.. Annual occupational exposures or medical examination doses. The associated levels of fatal risk would be 10^{-4}, 1 in 10,000.

Does that are below the millisievert level are also relevant in the control of exposures. In connection with manmade uses of radiation, the Commission has set the maximum dose from a single new source to a member of the public at 0.3 mSv a year. The associated level of fatal cancer risk is about 10^{-5} per year. This level of dose is about 10% of total natural background dose and is also of the same order as to variation in background radiation (excluding the radon contribution) over much of the world.

A level of risk of death of 10^{-6} per year is commonly regarded as trivial and the corresponding annual dose of about 10-20 μSv has been used to set exemption criteria for the Basic Safety Standards. At this level of dose there should be no need to consider protection of the individual.

A POSSIBLE SOLUTION

A suggested way forward may be to work toward a single “limit” on controllable dose. The value would be around 20-30 mSv in a year. Doses significantly above this level would only occur in uncontrolled accident situations or in life-saving medical procedures. It may be that rather than referring to this value as a limit, the term **Action Level** should be used. In fact, that is what it would be - if controllable doses (actual or projected) are above this level action should be taken. This may have an advantage that Action Levels are understood, whereas a “limit”, as has been said, can be and often is misunderstood.

The management of controllable doses below the Action Level would be by individual-related source-specific **Investigation Levels**. They would apply to different actions taken to reduce exposures at the source, in the environment or by moving people. They would cover, for example, occupational exposures, simple medical procedure doses, exposures from domestic radon or from other elevated levels of natural radionuclides, and those after an accident**.** The need for distinguishing between practices and interventions may no longer be required. This Investigation Level of around few millisieverts per year would prompt an investigation to see if anything simple could be done to reduce the exposure.

Within this scheme, exposures of the public from the use of sources of radionuclides

would still need to be justified. **A fraction of a millisievert would be the most that would ever be allowed from a single source, irrespective of the number of sources** - effluents from a hospital, from a power plant, a diagnostic x-ray, a smoke detector, etc. These sources would be treated independently because the chance of one individual being exposed to all sources is very small and actual exposures from several sources would be unlikely to amount to more than a fraction of a millisievert. The term **Constraint** could still be retained and the principle of optimisation applies for each source.

THE CONSEQUENCES

The proposals presented here focus on the protection of the individual. The Commission's principles of justification and optimisation would still apply although further guidance on their application would be required to clarify: -

(a) what quantity is to be used to assure that the source provides an overall net benefit from its introduction, and

(b) how is "as low as reasonably achievable" to be judged when individual dose is the determining criterion.

However, there would be considerable scope for a simplification of the system of protection and remove confusion by not distinguishing between Practices and Interventions. Additionally, it may be that there is no longer a need to differentiate between Occupational, Public and Medical exposures. The same guidance is equally applicable for protection of each category. Any particular concerns about the protection of the unborn child would also be covered, by the constraint of 0.3 mSv and investigation level of 3 mSv. There would be no need for the existing 1 mSv dose limit for the public. In addition there would be no use made of collective dose, since the proposed principle of protection is that if the most exposed individual is sufficiently protected, then everyone else is also sufficiently protected from that source.

If at some time in the future it became possible that some individuals might be liable to receive, in due course and over a prolonged period of time, a significant accumulation of doses from many sources, local, regional and global, then a further restriction on sources may be necessary. There would, however, be likely to be a considerable time period available to effect change.

This more straightforward system of protection may be explained to individuals in terms of acceptable risk, or perhaps more understandably as multiples or fractions of the natural background. In which case, perhaps there is no need to destroy the credibility of the profession in arguments for or against a threshold.

CONTROLLABLE DOSE

Fatal Risk	Dose µSv	Proposed System	Current Criteria
10^{-3}	30000	Dose should not exceed this level - approach only if there is benefit to individual or dose is difficult to reduce or prevent	• Occupational dose limit • Upper Rn Action Level • Relocation IL • CT Scan
10^{-4}	3000	There may be a need to reduce or prevent doses, particularly if no benefit to individual	• Lower IL for shelter, KI • Lower Rn Action Level • Average Background • Diagnostic Levels
10^{-5}	300	Maximum dose to individual who receives no direct benefit from one source of radiation	• Maximum constraint from a single source • Background variation - excluding Rn
10^{-6}	30	Trivial risk to the individual	• Exemption Levels • Clearance Levels