THE DEVELOPMENT OF NRPB ADVICE FOR THE DISPOSAL OF SOLID RADIOACTIVE WASTE

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In the past, problems have been encountered in the practical application of radiological protection principles to solid waste disposal. In order to aid in the interpretation of existing advice and to encourage improvements in the presentation of safety cases for solid waste disposal facilities, NRPB has updated and clarified certain aspects of previous advice. Among other things, it is recommended that, for the purposes of risk assessment, the future should be divided up into time frames, with the emphasis of the assessment changing as the period of prediction increases.

1. INTRODUCTION

As a result of past recommendations by ICRP and others, the basic radiological protection principles for determining the acceptability of disposal facilities for solid radioactive wastes are now well established: namely the optimisation of protection and the limitation of individual risk. Furthermore, it is widely accepted that individuals who might be alive at any time in the future should be accorded a level of protection at least equivalent to that which is accorded to individuals and populations alive now. Nevertheless, there are particular problems in applying such basic principles to solid waste disposals. These problems arise in part because of the long time periods, often hundreds of thousands of years, over which radionuclides could be released into the biosphere from a solid waste disposal site. As a consequence, the rate of release may depend upon events and processes which have probabilities associated with them (eg, faulting in a rock formation) and, furthermore, the exposure of individuals alive in the future will depend upon their habits which are difficult, if not impossible, to predict.

In order to aid in the practical interpretation of existing advice, particularly in the light of ICRP's 1990 recommendations[1], the UK National Radiological Protection Board, a UK Statutory Advisory Body, is updating its advice for the disposal of solid radioactive wastes. The proposed advice applies to land-based disposal in engineered facilities is described in detail in a consultative document[2]. The purpose of this paper is to describe some aspects of this advice.

2. LIMITATION OF INDIVIDUAL RISK

In the case of solid waste disposal it is difficult to apply any standards, which are based solely on dose limitation because it will generally be possible to envisage circumstances, even if they have a low probability of occurrence, which if they were to occur would lead to doses above any selected limit. Therefore, the quantity to be limited is individual risk where risk is defined as

the probability that a dose will be received	*x*	*the probability that the dose will give rise to a deleterious health effect*

A risk limit could be derived directly from the dose limit, however, this would not be strictly appropriate to solid waste disposal. Such a risk limit would pertain to the sum of the risks from all sources to an individual; instead risk limitation is achieved by setting risk constraints for each source. The constraint is an upper bound on the optimisation of protectoin for that source to prevent unacceptable risks to individuals who are exposed to more than one source.

3. ASSESSMENT OF INDIVIDUAL RISK IN THE FUTURE

In order to ensure the protection of future generations it is usually necessary to assess the risks to individuals over long timescales. However, the sophistication of the assessment methods should reflect the confidence which may be attached to the assumptions made in the assessment. This confidence will tend to decrease as the timescale of the assessment increases and therefore it may be appropriate to change the emphasis of the calculations relating to the far future. One way to achieve this is to divide the time period of the assessment into the following series of time frames with the level of calculational detail being changed in each successive time frame:

i) Site operation and up to c 100 years after closure

This period is the 'institutional control period' and it is assumed that the relevant dose limits will apply.

ii) c 100 years to c 10,000 years

This period represents the time between the end of institutional control and the next major environmental 'event' such as glaciation. For this period 'predictive' models can be used to simulate the transfer of radionuclides through the geosphere and biosphere to a hypothetical critical group. This group should be reasonably homogeneous and representative of those individuals likely to be exposed to the greatest risk. The assumptions about human behaviour should be representative of the type of area being studied but not site-specific.

iii) c 10,000 years to c 1,000,000 years

In this time period the uncertainty associated with any detailed calculations related to the biosphere is likely to be so great that an appropriate approach is to define and model an arbitrary 'biosphere' populated by a 'reference community' with reasonably conservative habits such as subsistence farmers. Thus, by requiring a hypothetical reference community to be 'protected', a reasonable degree of assurance will be provided that any real communities which actually exist will not be subject to unacceptable risks. In this time period, the criterion could be expressed as probability weighted releases of radionuclides from the geosphere.

iv) After c 1,000,000 years

This is the approximate lifetime of the human race to date. The scientific basis for risk calculations in this time frame is therefore questionable and NRPB recommends that assessments covering longer time periods should concentrate on qualitative discussions.

4. HIGH CONSEQUENCE EVENTS

The treatment of risk described above only applies to situations where exposures are somewhat less than those which would give rise to deterministic effects (eg, <0.5 Sv). However, in the case of disposal of high level waste and, perhaps, intermediate level waste, situations could be envisaged, albeit improbable ones, where deterministic effects could be experienced. These situations could arise if the waste was brought to the surface by direct human intervention. Requirements to limit the consequences of such improbable events are not desirable; to modify a repository design solely for compliance with such a limit would not be sensible, particularly as such modifications might otherwise detract from the performance of the repository. Therefore, it is suggested that waste disposal sites should be chosen and facilities designed so that the total probability of all events having the potential to lead to doses which would cause deterministic effects should be as low as reasonably achievable.

5. TREATMENT OF UNCERTAINTY

Uncertainty can originate from several sources including, for example, inadequate knowledge of the future behaviour of the disposal site or lack of knowledge of the value for a particular parameter in a model. It is important to present and discuss separately the uncertainties arising from different sources. As an aid to this, it is suggested that uncertainty as to the future evolution of the site could be addressed by selecting a range of scenarios to represent qualitatively different futures. Each of the scenarios should then be assigned a probability, to represent the relative likelihood of that scenario actually occurring. Parameter uncertainty analysis should be undertaken to determine the confidence in the results for each scenario.

6. OPTIMISATION

The main radiological input to optimisation has generally been integrated collective dose. Even with relatively short integration times, collective dose estimates are so dependent on human behaviour that predictions must be treated with caution: with integration times of thousands of years the values are meaningless. Some alternatives have been suggested by ICRP[3] including truncation and discounting, however there are disadvantages to each of them.

To assist in clarifying these issues, NRPB have suggested that a design target, set at a level of individual risk sufficiently low to be of very little concern, may be used as a guide to the extent of optimisation study required. If the estimated risks from a facility are likely to exceed this target, then a full demonstration that the proposed facility is the optimum solution for that particular waste would be required. However, if the estimated risks are below the target, then the optimisation requirement may be confined to the detail of facility design. In the latter situation the release of radionuclides to the biosphere could be used as a surrogate for collective dose in the optimisation.

7. CONCLUSIONS

The ideas described in this paper will form the basis of NRPB's formal advice on the radiological protection aspects of the disposal of solid radioactive wastes in land-based facilities in the UK. It is hoped that the adoption of these ideas will lead to a clearer understanding of the issues and to a more transparent presentation of safety cases.

REFERENCES

1. ICRP. 1990 Recommendations of ICRP. Publication 60. Annals of the ICRP, Vol 21, No 1-3 (1991).

2. NRPB. Consultative Document: Radiological Protection Objectives for the Land-based Disposal of Solid Radioactive Wastes. NRPB-M279, (1991).

3. ICRP. Radiation Protection Principles for the Disposal of Solid Radioactive Waste. Publication 46. Annals of the ICRP, Vol 15, No 4 (1985).