THE OBJECTIVES OF RADIOLOGICAL PROTECTION IN THE LONG-TERM MANAGEMENT OF RADIOACTIVE WASTE

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Introduction

An important element in the selection of radioactive waste management strategies is the consideration of radiological protection objectives and requirements specifically derived from them.

Existing recommendations and national regulations on radiological protection generally apply to situations in which exposure of the public can be influenced by control of the source of radiation or radionuclides, by control of operating procedures, or by control of environmental transfer routes. These possibilities cannot be assumed to exist when considering the disposal of radioactive wastes, for which some radionuclides have decay times much longer than any likely period of institutional control. Beyond this period, a regulatory control of radiation exposures, based on continuing surveillance of the source of radionuclides, is no longer possible. Present decisions can, however, have an influence on predicted radiation exposures of populations in the far future. For this reason, it appears necessary to use an approach to radiation protection in which the authorisation of particular waste disposal practices is conditional on predictive radiological safety assessments based on the assumption that control of the source itself or of environmental transfers no longer exists.

Recognising this need, the NEA Committee on Radiation Protection and Public Health and the Radioactive Waste Management Committee set up jointly, in 1982, a group of experts to study and develop consistent general radiological protection objectives for the long-term aspects of radioactive waste disposal. This paper reflects discussions within this group on the key radiological protection issues. Particular attention has been given to discussion of the extent to which the ICRP system of dose limitation may be applied to the long-term aspects of waste disposal.

The Application of Radiological Protection Principles to Radioactive Waste Disposal

The radiological protection principles recommended by the ICRP represent a well established and widely accepted basis for the regulation of current activities. They provide a consistent mechanism for dealing with radiation exposures to workers and members of the public. There are good reasons for adopting the same principles when dealing with hypothetical exposures to the public in the future from today's waste disposal practices. These are a desire for equity in that future generations should be given the same degree of protection that is given to the present population, and a need for consistency in practical application.

However, while the current radiological protection principles can certainly apply to radioactive waste disposal, there is a need for a different emphasis in their practical implementation. Very long half-lives, the possible persistence of low levels of radiation exposure over long periods of time, and the large numbers of people potentially involved throughout the generations suggest that particular attention should be given to the collective impact of a waste disposal practice, which is a fundamental element for the application of the principle of optimisation of protection. However, any assessment of collective radiological impact in the far future is affected by large intrinsic uncertainties, which make very precarious the possibility of a clear-cut discrimination between different waste disposal options based on an optimisation analysis as suggested by the ICRP. Moreover, several factors other than radiation detriment, such as political, social, economical and technological are likely to be predominant in decision-making concerning waste management.

For these reasons, optimisation of protection in waste management is likely to play a role less important and decisive than envisaged by the ICRP in its recommendations. On the contrary, the protection of individuals may give rise to clear and easily assessed constraints on the choice of disposal practices. Therefore, the limitation of individual risks will be the dominant element in the radiological protection systems for radioactive waste disposal.

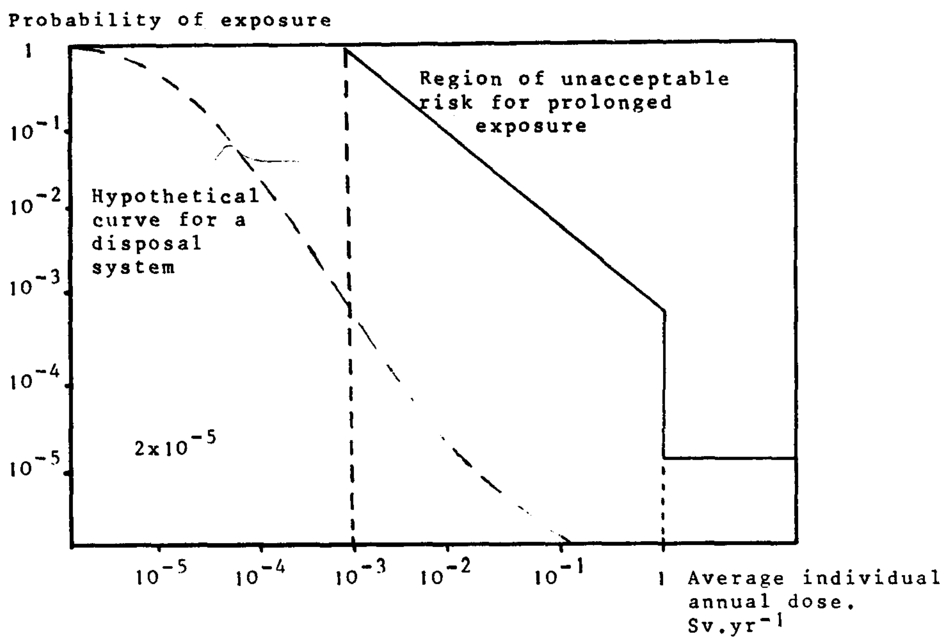
Objectives for Restriction of Individual Detriment

The concept of dose limitation as defined in ICRP recommendations and national regulations requires the implementation of a system of compliance and enforcement. This concept is not directly applicable to the management of long-lived radioactive waste. Present decisions on waste disposal options will have an influence on radiation exposure of populations in the far future, when compliance with any present dose limitation system cannot be enforced or directly demonstrated. For this reason, it appears necessary to use a different concept of a limit, where it is understood simply as a restriction for the planning, design and licensing of waste disposal systems. The authorisation for a particular disposal option should then be conditional on a predictive radiological safety assessment, the results of which are consistent with this limit or objective.

The radiological impact of radioactive waste disposal depends on events and processes which may cause a release of radionuclides into the environment or influence the rate of release or transport through it. Some of these events and processes are certain to occur, others have time-dependent probabilities of occurrence. In order that all events and processes be taken into account on a rational basis, it is suggested that the individual's protection should be based on a limitation of the risk to health, rather than of the level of radiation dose. The risk to health would be defined as the product of the probability of exposure at a particular annual dose and the probability of health effects arising from that annual dose. From the point of view of the protection of the individuals, waste disposal practices should then be judged againt an individual risk limit corresponding to the risk associated with current ICRP dose limits. For future exposures of limited duration, a risk limit objective of 10^{-4} per year corresponds to the individual dose limit of 5 mSv per year. A maximum risk limit of 2×10^{-5} per year corresponds to the objective of 1 mSv per year suggested by the ICRP for scenarios where the exposure is expected to persist over a decade or more in the lifetime of the individuals concerned.

The practical interpretation of a risk limit objective is relatively straightforward in the range of annual doses associated only with stochastic health effects. The relationship between dose and the probability of health effects can be taken as 2×10^{-2} Sv^{-1}, a rounded value consistent with ICRP assumptions. It is extremely unlikely that an individual would receive from a waste disposal practice such a high annual dose that non-stochastic health effects would be of concern, but for completeness and prudence the assumption can be made that annual doses of 1 $Sv.yr^{-1}$ or greater would give rise to non-stochastic health effects. A risk limit would then be interpreted as a limit on the probability of prolonged exposures at 1 $Sv.yr^{-1}$ or above.

An indication of the boundary of unacceptable individual risks can be represented graphically as in the figure below. The boundary in this figure represents the limit on probability of exposures at various annual dose rates, consistent with a maximum risk objective of 2×10^{-5} yr^{-1} for prolonged exposures. The discontinuity in the boundary of unacceptable risk at 1 $Sv.yr^{-1}$ arises simply because the adopted conversion factor from annual dose to health risk changes from 2×10^{-2} Sv^{-1} for stochastic health effects below 1 $Sv.yr^{-1}$, to unity for non-stochastic effects above this value.



The figure also shows a cumulative probability of exposure-versus-individual dose rate relationship that can be generated in a predictive assessment of the radiological impact of a disposal facility. A disposal option would not be acceptable if any part of the calculated cumulative probability-versus-dose curve lay within the area of unacceptable risk.

Optimisation of Radiological Protection

The principle that all exposures should be kept as low as reasonably achievable can also apply to radioactive waste disposal. However, in practice, the techniques of optimisation of radiation protection may not lead to clear preferences between alternative options. Rather, they are likely to represent just one input in a decision-making process using multi-attribute analysis, where social, economical and other factors play a more decisive role.

A major limitation of radiological protection optimisation using cost-benefit analysis in waste disposal is the impossibility of making truly realistic estimates of collective doses in the far future. Apart from the calculation of uncertainties, there are diverging views among experts about the best approach to assess incomplete collective dose commitments on a very long time scale. Some experts suggest an individual dose cut-off to exclude low individual dose components, others favour a truncation in time. It is to be noted that the former approach would be only in line with current ICRP recommendations if the component of collective dose which is excluded is small and quantifiable. A wider agreement exists about the validity of truncating the integration of collective dose in time at a point beyond which calculational and other uncertainties do not allow alternative disposal options to be distinghished.

As far as the valuation of radiation detriment is concerned, there are proposals to apply discounting techniques to the cost of detriments in the far future. Other experts seem to prefer a less formal approach to valuation of far future detriments, whereby the intrisic and substantial uncertainties attached to future collective detriments would justifiy the allocation of less resources to ensure protection against future detriments than might be justified for present detriments.

The debate is still open on all these questions and it may well be that different solutions are eventually adopted by different countries in the detailed application of the general radiological protection objectives briefly described in this paper.