RADIOLOGICAL PROTECTION

RECOMMENDATIONS ON RADIOACTIVE WASTE MANAGEMENT FROM THE INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION

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Just over a decade ago, the International Commission on Radiological Protection (ICRP) elaborated, in *Publication 60,* a radiological protection policy whose primary aim is to provide an appropriate standard of protection for people without unduly limiting the beneficial practices giving rise to radiation exposure.

Beneficial practices may give rise to radioactive waste; the Commission's policy for the disposal of all types of radioactive waste is given in *Publication 77, Radiological Protection Policy for the Disposal of Radioactive Waste*. In the context of the Commission's recommendations, waste is any material that will be or has been discarded as being of no further use. *Waste* includes liquid and gaseous effluents as well as solid materials such as process residues. Waste storage is the temporary retention of waste. *Waste disposal* is the discarding of waste with no intention of retrieval. The term disposal covers the discharge of effluents and solid waste disposal. *Waste management* means the whole sequence of operations starting with the generation of waste and ending with disposal.

Waste disposal strategies can be divided into two conceptual approaches: "dilute and disperse" or "concentrate and retain". Early or deferred releases of radionuclides to the environment would inevitably result from either of these strategies and therefore an objective of no release in not feasible. Both strategies are in common use and are not mutually exclusive. The possibility of elevated exposures from disruptive events is an inescapable consequence of the decision to concentrate waste in a disposal facility rather than diluting or dispersing it.

The Commission's system of protection is directly applicable to the "dilute and disperse" strategy. Exposures are estimated in order to place adequate control on the source of exposure. The characteristics and habits of exposed individuals and populations are taken into account. Furthermore, in these situations it can be verified to a great extent that protection is being achieved by measuring releases to the environment and by taking action in the case of unexpected releases.

In the case of disposal of long-lived solid radioactive waste using the concentrate and retain strategy, the main protection issue concerns exposure that may or may not occur in the far future, i.e., a situation of potential exposure. An effective waste disposal system will retain the wastes during the period of greatest hazard with only residual radionuclides entering the environment in the far future. Any corresponding estimates of doses to individuals and populations will have growing associated uncertainties as a function of time due to incomplete knowledge of the future disposal system behaviour, of geologic and biosphere conditions and of human habits and characteristics. Nevertheless, the Commission's system of protection can be applied to the disposal of long-lived radioactive waste.

Publication 81, Radiation Protection Recommendations as Applied to the Disposal of Long-lived Solid Radioactive Waste, deals with the radiological protection of members of the public following the disposal of long-lived solid radioactive waste using the concentrate and retain strategy. It covers options including shallow land burial and deep geological dis-

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posal. The recommendations apply to new disposal facilities where there is the opportunity for their implementation during the site selection, design, construction and operational phases; they should also be taken into account in justification decisions involving practices generating waste. The Commission is also issuing in *Publication 82, Principles for the Protection of the Public in Situations of Prolonged Exposure,* recommendations for dealing with long lived radioactive residues already in the environment arising from, for example, past practices that were not regulated.

Radiological Assessment. The radiological assessment of a disposal system for solid radioactive waste needs to consider the various possibilities for human exposure. Processes, which could lead to human exposures, have to be identified on a site-specific basis. Some natural processes may result in a gradual release of radionuclides to the environment. A typical example is the gradual degradation of the waste package due to corrosion and the consequent release of radionuclides. Subsequent natural processes, which could lead to human exposure, may include transport of radionuclides by groundwater with the associated processes of sorption, diffusion and dispersion. Other, less likely, natural processes may disrupt or otherwise affect the performance of the disposal system, e.g., seismic events and glaciation.

Human actions in the future may also disrupt a waste disposal system. A human action affecting repository integrity and potentially having radiological consequences is known as human intrusion. The consequences for a deliberate intruder are primarily considered the intruder's responsibility. There is also the possibility of inadvertent human intrusion after knowledge of the disposal system has been lost, i.e., actions taken unknowingly by someone that disrupt the waste disposal system. These actions include inadvertent drilling into a deep repository and inadvertent construction on a shallow repository. Such inadvertent actions are the main issue for human intrusion in the long term; here, the term human intrusion refers to inadvertent intrusion.

The dosimetric quantities used by the Commission are defined in *Publication 60*. (In this article the term dose means effective dose.) The quantity that reflects both the dose and the number of people is the collective dose, given by the product of the mean dose to an exposed group and the number of individuals in the group. However, in paragraph 58 of *Publication 77*, the Commission recognized the problems of estimating collective dose over long periods into the future. *"Both the individual doses and the size of the exposed population become increasingly uncertain as time increases. Furthermore, the current judgements about the relationship between dose and detriment may not be valid for future populations … forecasts of collective dose over periods longer than several thousand years and forecasts of health detriment over periods longer than several hundred years should be examined critically*".

Justification of a Practice. Waste management and disposal operations are an integral part of the practice generating the waste. It is wrong to regard them as an independent practice, needing its own justification. The waste management and disposal operations should therefore be included in the assessment of the justification of the practice generating the waste. If the national waste disposal policy has changed and the practice is continuing, it may be necessary to reassess the justification of the practice. If the practice has ceased, it is intervention rather than the practice that has to be considered for justification.

Optimization of Protection. The main input to optimization of protection has generally been taken to mean the total (integrated) collective effective dose. However for solid waste disposal, the use of collective dose is far from ideal. The optimization of protection has become too closely associated with collective dose and the use of cost-benefit analysis and other quantitative procedures. Misunderstandings in the use of collective dose, unrestricted in space and time, lead to the misapplication of resources. At long distances and periods, the estimates of individual and collective doses are unreliable, partly because of uncertainties in modelling techniques. For effluent assessments, collective doses should be used with great caution and presented to decision-makers in disaggregated blocks of individual doses and the time when they will be received.

The optimization of protection has the broad interpretation of doing all that is reasonable to reduce doses. Much of the Commission's emphasis is now on the qualitative specification of the optimization of protection. The basic role of the concept of optimization of protection is to engender a state of thinking in everyone responsible for control of radiation exposures such that they are continually asking themselves the question: "Have I done all that I reasonably can to reduce these radiation doses?" Thus, the Commission's policy on optimization is judgmental and in essence is summarized in paragraph 117 of *Publication 60* -- If the next step of reducing detriment can be achieved only with a deployment of resources that is seriously out of line with the consequent reduction, it is not in society's interests to take that step.

Protection of Future Generations. The objective of protecting future generations to at least the same level as current generations implies the use as indicators of the current quantitative dose and risk constraints derived from considering the associated health detriment. *Publication 77* states that doses and risks, as measures of health detriment, cannot be forecast with any certainty for periods beyond around a few hundreds of years into the future. Instead, estimates of doses or risks for longer time periods can be made and compared with appropriate criteria in a test to give an indication of whether the repository is acceptable given current understanding of the disposal system. *Such estimates must not be regarded as predictions of future health detriment.*

It cannot be assumed that future generations will have knowledge of disposals undertaken by the current generation. Therefore, the protection of future generations from the disposal of radioactive waste should be achieved primarily by passive measures at the repository development stage, and should not rely unduly on active measures taken in the future. However, the Commission recognizes that institutional controls maintained over a disposal facility after closure may enhance confidence in the safety of the disposal facility particularly by reducing the likelihood of intrusion. The Commission feels that there is no reason why these controls may not continue for extended periods of time and, therefore, may make a significant contribution to the overall radiological safety of shallow disposal facilities in particular. Furthermore, for surface or near surface disposal of uranium mill tailings, these controls may be relied on for long periods of time in situations where, if the controls fail, consequences will be generally lower than those associated with other long-lived radioactive wastes.

Natural Processes & Human Intrusion. Two broad categories of exposure situations should be considered: natural processes and human intrusion. The latter only refers to intrusion that is inadvertent. The radiological implications of deliberate intrusion into a repository are the responsibility of the intruder. Assessed doses or risks arising from natural processes should be compared with the ICRP recommended maximum constraint of 0.3 mSv per year or its risk equivalent of around 10^{-5} per year. With regard to human intrusion, the consequences from one or more plausible stylized scenarios should be considered in order to evaluate the resilience of the repository to such events.

The Commission considers that in circumstances where human intrusion could lead to doses sufficiently high that intervention on current criteria would almost always be justified, reasonable efforts should be made at the repository development stage to reduce the likelihood of human intrusion or to limit its consequences. In this respect, the Commission has previously advised that an existing annual dose of around 10 mSv may be used as a generic reference level below which intervention is not always likely to be justifiable. Conversely, an existing annual dose of around 100 mSv per year may be used as a generic reference level above which intervention should be considered almost always justifiable. Similar considerations apply in situations where the thresholds for deterministic effects in relevant organs are exceeded.

In the Commission's view, provided reasonable measures have been taken both to satisfy the constraint for natural processes and to reduce the likelihood or the consequences of inadvertent human intrusion, and technical and managerial principles have been followed, then radiological protection requirements can be considered to have been met. ❒