Overview of ICRP Approach to Waste Management

Christepher McKenney[1] & Francois Besnus[2]

[1]U.S. Nuclear Regulatory Commission (NRC), USA

[2]Institute for Radiological Protection and Nuclear Safety (IRSN), France

Overview

- The Three Fundamental Radiological Protection Principles
  - The Principle of Justification
  - The Principle of Optimisation of Protection
  - The Principle of Application of Dose Limits
- The Three Exposure Situations
  - Planned exposure situations
  - Emergency exposure situations
  - Existing exposure situations
- Application to near surface disposal

The Principle of Justification

- “Any decision that alters the exposure situation should do more good than harm.” (ICRP 103)
- Radioactive waste management and disposal operations are an integral part of the practice that generated the waste.
- They are not a free-standing practice that needs its own justification.
- The justification should be reviewed periodically as new information arises.

Principle of Optimisation of Protection

- “The likelihood of incurring exposure, the number of people exposed, and the magnitude of their individual doses should be all kept as low as reasonably achievable, taking into account economic and societal factors.” (ICRP 103)
- A key principle guiding the application of the ICRP system of protection of the ICRP system of protection to the disposal of radioactive waste.
- Practical considerations include the use the source-specific dose constraints, and to define and implement a process to enhance the isolation and containment capabilities through siting, design, construction, and operational considerations.
- At a national policy level, decisions should consider optimisation in its broadest sense when decisions are taken on the number and type of disposal facilities to develop.

Principle of Application of Dose Limits

- “The total dose to any individual from regulated sources in planned exposure situations other than medical exposure of patients should not exceed the appropriate limits specified by the Commission.” (ICRP 103)
- The Commission recommends a dose constraint of 0.3 mSv per year for normal exposure situations, or a risk constraint of 10^{-5} per year for potential exposure situations for members of the public.
- In evaluating doses to the public, the Commission recommends the use of the representative person. (ICRP 101 and ICRP 103) When dealing with radiological protection post-closure in the distant future, the representative person is hypothetical and should use present day data.

Protection of the Environment

- Protection of the environment is the aim of ‘preventing or reducing the frequency of deleterious effects on fauna and flora to a level where they would have negligible impact on the maintenance of biological diversity, the conservation of species, or the health status of natural habitats, communities and ecosystems’. (ICRP 103)
- Recommend using the Reference Animals and Plants approach to evaluate the ecosystem resilience.
- Provides additional lines of reasoning on the impacts of releases from the disposal site over time.
- For waste disposal and long-term frames, evolution of the biosphere is likely, thus future possible scenarios may need to be created with stakeholders to evaluate sensitivity and uncertainty.

Planned Exposure Situations

- Situations involving the deliberate introduction and operation of sources of exposure
- Although the situation is planned -> exposures are not necessarily anticipated or planned to occur!
- If exposures are anticipated, they are called normal exposures. They are virtually certain to occur and have a magnitude which is predictable, albeit with some uncertainty.
- If exposures could occur but are not anticipated to occur, they are called potential exposures. These are situations that are the result of an unexpected evolution or an accident in the system.

Emergency Exposure & Existing Situations

- Emergency Exposure Situations result from a loss of control of a planned source (e.g., an accident), or from any unexpected situation (e.g., a malevolent event), which require urgent action to avoid or reduce undesirable exposures.
- Existing Exposure Situations result from sources that already exist when a decision to control them is taken (e.g., sources of natural radiation, past activities, or after emergencies).

Application to Waste Disposal

- The process of siting, designing, constructing, operating, and closing a near-surface disposal facility is a planned exposure situation.
- There is an obligation to ensure an optimized level of protection during both the operational and post-closure phases. Decisions on siting, design, waste inventory and operations all influence the optimization of the system.
- While a planned exposure situation, exposures from the disposal facility to the public are not planned to occur as such. One design goal is to prevent and avoid exposures to the extent possible, both in the operational phase and in the post-closure phase.

Application to Waste Disposal (cont'd– post-closure)

- The facility relies largely on passive systems for its isolation and containment, especially in the long term.
- As time passes, radioactive decay will be decreasing the hazard of the waste, while the level of isolation and containment may decrease due to deterioration or because of disturbing events or intrusion events.
- There is no certainty that such exposure will occur and there is a range of possible doses that could occur. Thus, these are potential exposures.

Application to Waste Disposal (cont'd– post-closure constraints)

- For evaluating the post-closure period, it is generally useful to dis-aggregate the probability and dose for those scenarios and events with probabilities less than 10^{-3} and use the 0.3 mSv per year dose constraint.
- For lower probability scenarios and events in the post-closure period, aggregate the probability and dose to use the 10^{-5} risk constraint.
- Very low probability scenarios have likely been excluded by the use of siting and design criteria.
- Human intrusion evaluation are assessed to comply with a 20 mSv per year dose constraint.
- All of these constraints are subject to further optimization!

Application to Waste Disposal (cont'd– operations)

- During the operational phase of a disposal facility, both normal exposures and potential exposures should be considered.
- The range of scenarios should be relevant to the range of activities at the site, which could lead to potentially emergency exposure situations for certain events (e.g., if waste processing for high-activity sources was co-located with the disposal facility).
- The exposures during operations consider both workers and public.

Application to Waste Disposal (cont'd- existing situation?)

- Near surface disposal facilities are at various phases of development and operation in numerous countries.
- These are planned exposure situations as they are being sited, under design, under construction, in operation or closed and under some degree of regulatory control.
- One type of an existing situation would be sites developed outside of the regulatory control, such as legacy mining waste sites.
- Another type would be where a major unexpected deviation from the planned functioning of control by the regulatory authority occurs, such as a breakdown of civil society due to war, political upheaval or widespread natural disaster.
- The regulatory authority would utilize optimization for the decisions to be taken to bring the facility under regulatory control.

Summary (1)

- Waste disposal facilities are planned exposure situations.
- Justification of waste disposal is a required part in justifying the practice generating the waste.
- The combination of siting, design, and operations optimize the post-closure performance.
- Exposures in the post-closure period are potential exposures and are not planned to occur.
- Exposures should be constrained below 0.3 mSv per year for dose or 10^{-5} per year for risk constraints. Where probability of situations cannot be reliably assessed, a disaggregated approach (separate evaluation of probability and dose) is applied.

Summary(2)

	Indicative probability of occurrence of conditions, events and processes causing exposure	Circumstances	Requirement
Design basis	1	Circumstances that are expected to occur during the development, operation and after closure	Assessed to comply with dose constraints 0.3 mSv. Considered in optimisation.
Design basis	10^{-1} to 10^{-3}	Incidents, accidents and events that are likely to arise from time to time during the period of development, operation and after closure	Assessed to comply with dose constraints 0.3 mSv. Considered in optimisation.
Design basis	10^{-3} to 10^{-6}	Accidents / incidents / disturbing events that could occur but are not expected to occur during the period of development and operation and for a period of a few hundred years after closure	Assessed to comply with risk constraints 10^{-5} . Considered in optimisation. Or emergency reference levels
Design basis	Assumed 1 after licence termination and zero before	Human intrusion	Assessed to comply with intrusion criteria 20 mSv. Considered in optimisation.
Outside design basis	< 10^{-6}	Extreme but unlikely events	Demonstrated to be outside scope of assessment. Not considered in optimisation.

Summary (3)

- Dose assessments in the long term are necessarily associated with large uncertainties and thus should be considered as indicators of the radiological impact.
- The comparison of calculated dose and risk with constraints or reference values is a way to check if the system can reasonably meet the protection targets and criteria but numerical compliance with dose criteria alone should not compel acceptance or rejection of a disposal facility.
- Optimisation of protection is a judgmental process on the quality of design and management principle.
- Optimisation is central to the demonstration that radiation protection principles are met and has to be understood in the broadest sense as an iterative, systematic, and transparent evaluation of options for enhancing the protective capabilities of the disposal facility and for reducing impacts (radiological and others).
- Optimisation also should be considered within the context of the broader national waste management policy and strategy when deciding the type and location of disposal facilities considering both radiological impact and non-radiological aspects.