RADIATION PROTECTION OBJECTIVES AND PRINCIPLES FOR RADIOACTIVE WASTE

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ABSTRACT

The approach to the special problems of the long term radiation protection principles is described. This includes the concept of probability of an event, the significance of uncertainties in future doses, optimization procedures, etc. All radioactive waste problems should be considered thoroughly with regard to radiological consequences and social and economic factors. The significance of individual and collective doses is discussed. The concepts "cut off" and "de minimis" levels as general terms are not easily applied in practice following the principles of ICRP. However, exemption rules may be defined for various types of low level waste and different routes for disposal.

INTRODUCTION

By 1985 the Swedish nuclear power program which started in 1964 will consist of 12 reactors with a total effect of 9.5 GW_{el}. According to a parliamentary decision the last reactor shall be closed down by the year 2010. The total amount of waste generated during this time will be of the order of 7.000 tonnes spent fuel and 93.000 m^3 low and intermediate level waste. In addition to this, core components and decommissioning waste will be generated. An application for a low and intermediate level waste repository has been approved. Smaller quantities of radioactive waste are also generated in research, medicine and non-nuclear industry.

OBJECTIVES AND PRINCIPLES

General

It is not possible completely to isolate all radioactive waste from man for all time. The necessary degree of containment and isolation of the waste from man depend on a total judgement of the economical, social and political factors. The overall objective for radioactive waste disposal is the protection of man and his environment from the ionizing radiation. The general principles of ICRP, publ. 26, are applicable to radioactive waste. The justification of the waste management should, however, already be included in the justification of the practice causing the waste.

The Solution of Problems; Time Aspects

It is sometimes argued that the solution to a problem would not necessarily need to be good in the long-time perspective but it is left for future generations to solve the long-term problems. That would be their share of the bill for the inherited welfare. There are at least two objections to that. Firstly, there is no guarantee for continued prosperity. Secondly, the application of such a principle to all long term problems would make the future burden of unsolved problems unacceptable, reducing the future margins for expenses and efforts of the future generations to solve their own problems and increase their own prosperity. However, in a short-time perspective it might sometimes be preferable to wait for improved technical solutions, i.e. extend the storage time before the ultimate disposal.

Individual Doses

The limitation of the individual doses caused by waste disposal requires an identification or definition of a critical group and an assessment of the resulting doses to that group. Sensitivity analysis identifies the significance of various parameters and assumptions and the critical pathways. Future doses and effects are estimated as if future man, habits and society are the same as to-day. Due consideration is given to additive contributions from several practices and sources. The design of nuclear power reactors is based on expected doses below 0.1 mSv a^{-1} to the critical group. For waste disposal it has been found reasonable to judge the acceptability of a planned waste disposal system on the basis of the same principles. The individual doses to the critical group caused by the radionuclides from waste disposal would normally be expected to be below 0.1 mSv a^{-1} and often below 0.01 mSv a^{-1}.

Resulting doses are assessed with some conservatism to ensure that limits will be observed with a reasonable margin. The conservatism follows from the limited knowledge of pathways, living habits etc especially as concerns the future. However, a waste disposal system is established on the basis of best knowledge and most probable events or scenarios. Alternative scenarios should be much less probable or, if not, be taken into account such that the sum of probability-weighted dose consequences is less than the set limit. It is therefore necessary to estimate the probability of each alternative event occurring first.

The application of the annual dose limit to the dose commitment by one-year releases of reactor operation prevents an unacceptable build-up of doses in the future. However, for longlived waste these methods of limiting future individual doses from waste disposal sites are not applicable. The repository should be considered as one source which leaks radionuclides in amounts and rates only depending on the quality of the repository and the waste and on the activity and there is no correlation to the rate of accumalation of the waste in the repository.

Collective Dose Commitments

The collective dose commitment (here called collective dose) is estimated for the purpose of judging the detriment and of optimizing the protection (ALARA). It is assessed irrespective of where and when the doses occur and of the size of the individual doses. For optimization, the collective doses are assessed as realistically as possible and conservatism in assumptions is not intentional. Differential cost benefit analysis is usually applied and an α-value of about 10^4 US$ per manSv is used without discounting.

The interpretation and significance of the assessed collective doses vary depending on the purpose and the uncertainties. It is up to the appropriate authorities to give the collective dose due consideration in the final decision-making. A comparison of the collective doses caused by the various parts of the uranium fuel cycle is not decisive but is of general interest and should be known. The distribution in time of the collective dose is also relevant information.

Increasing uncertainties in the collective dose over a very long time decrease its significance in the judgement of future detriment. The major concern in this case is the individual doses. Options for disposal of long-lived low level waste such as tailings may be acceptable even if there are great uncertainties concerning stability and protective barriers after say 10 000 years and the collective dose after that time might be large. This is because the resulting doses to the critical group are moderate and because it will still be possible to make improvements in the protection at that time.

In the case of high level waste the individual doses require long isolation from the biosphere and at the time the radionuclides appear in the biosphere to any significant extent the resulting individual doses must be low because remedial action is practically impossible. The collective dose may nevertheless be high.

For long integration times the increasing uncertainties in the collective dose make its use for justification purposes less meaningful. In the optimization procedure these uncertainties will cancel out if the various options coincide at a future time as concerns the environmental consequences. This is, for instance, the case with very long-lived radionuclides such as ^{129}I which eventually disperse to the ocean irrespective of earlier containments.

Other Bases for Judgement of Methods for Waste Disposal

If the optimization procedure does not give clear answers, preference is given from the point of view of radiation portection to the option that:

- causes the lowest collective doses
- causes the lowest individual doses
- involves the smallest risk for intrusions and accidents
- involves least institutional control
- involves least uncertainties.

Other bases for judgement and factors to consider for the decisions are

- engineering and quality aspects
- confidence in presented solutions
- public relations considerations.

Exemption Rules

It is not practical nor appropriate to define general exemptions and exemptions must be made for individual cases. Exemptions would be justified in the following circumstances:

- the cost of containment is unreasonable as compared with the cost that is normally involved in avoiding a collective dose equal to that caused by exemption of the waste;
- the annual dose equivalent to individuals in the critical group will be below 10^{-2} mSv with a good margin even considering possible summation of doses caused by various wastes;
- satisfactory assurances have been given that the nuclides and activities are those given in the presumptions and conditions.

Special requirements may be needed for the first phase of the distribution of the waste following the exemption (e.g. that only a certain type of disposal or use is permitted).

Institutional Control

Institutional control is necessary for a limited time after the closure of the waste repository. But in the time perspective of several hundred years and more the principle must be that no institutional control should be necessary.

PRACTICAL IMPLICATIONS

Methods for disposal of nuclear waste are:

- exemption of nuclear waste such as slime from purification plants for water coming from areas outside controlled areas (may be used with other slime as fertilizer), slightly contaminated oil from nuclear power plant turbines (to be burnt with other oil in an oil-fired power station), contaminated condenser tubes or other metal items of great economic value (may be treated as scrap-metal with restrictions on the first use).
- shallow land burial of low level waste on the site (some trash waste and decommisioning waste is appropriate for that method; the requirement is that the waste is covered and the leakage rate from the disposed waste to water is much lower than the limit for reactor sites and that the activity is such that institutional control is necessary for 100 years at the most).
- incineration and subsequent encapsulation of low and intermediate level waste from reactor operation in concrete or bitumen. The waste is then stored and eventually disposed in an underground facility in rock (to be effectively isolated from the biosphere for at least 1000 years).
- sea dumping of low and some medium waste (forbidden by Swedish law).
- land disposal of tailings (stabilized and covered by several meters of moraine, to be effective for thousands of years).
- deep geological disposal of spent fuel and high level waste (at about 500 m depth in rock, isolation from the biosphere by several barriers such as the waste matrix itself, glass, metallic capsulation, low-diffusion barriers, rock. The requirement on certainty is greatest for the quality and integrity of the barriers followed by the models for dispersion in rock, water and the biosphere).

THE NEED FOR INTERNATIONAL COOPERATION

International agreement and cooperation should be encouraged concerning:

- a minimum α-value ("cost" of collective dose)
- methods for the calculation of collective doses (factors of concern are the size of individual doses, time and space)
- upperbounds as limits for various sources
- criteria for choice of sites for waste disposal
- criteria for conditioning of waste
- technical solutions for the treatment, storage and disposal of waste
- control measures
- criteria for an overall optimized solution for the disposal of spent fuel and radioactive waste on a regional and global scale.