METHODOLOGY FOR EVALUATING RADIOLOGICAL CONSEQUENCES OF THE MANAGEMENT OF VERY LOW-LEVEL SOLID WASTE

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Summary

A radiological assessment has been made of the management options for waste materials containing very low levels of radioactivity arising in the decommissioning of a pressurised water reactor (PWR). Estimates have been made of the masses of materials activated and contaminated to within three limits of specific activity, 0.37, 3.7 and 37 Bq g⁻¹, at three times after reactor shutdown, 5a, 25a and 100a. The disposal options considered are shallow land burial, at a municipal landfill site or at the reactor site, and disposal on the seabed in coastal waters or the deep ocean. It is assumed that there is no special treatment to reduce or eliminate the potential radiological hazard. Consideration has also been given to the recycle of contaminated steel.

The radiological impacts of all the management options for the wastes considered were found to be small. It may therefore be acceptable to allow such very low-level wastes to be disposed of without special restrictions provided that the level and type of activity of the wastes can be verified.

1. INTRODUCTION

The aim of the study is to develop a methodology for evaluation of individual doses and collective dose commitments arising as a result of various management modes for very low-level solid radioactive waste arising from the dismantling of nuclear power plants.

The management modes studied include disposal at a normal municipal refuse tip, burial at the reactor site, disposal on the seabed, and recycling of materials. In each case it has been assumed that no special measures have been taken relating to the potential radiological hazard. Assessments have been made of disposal of wastes of less than 0.37, 3.7 and 37 Bq g⁻¹ specific activity. The three specific activity limits for unrestricted release have been chosen to investigate their suitability, or otherwise, for the kinds of waste under consideration. For comparison, the level of 0.37 Bq g⁻¹ is the current limit implied by legislation (1) for unrestricted disposal for many types of solid wastes in the United Kingdom.

Within the study responsibility for the definition of the wastes, in terms of materials and radionuclide inventory, rests with the Commissariat a l'Energie Atomique (CEA), as does assessment of the recycle management mode. Assessment of the other management modes is the responsibility of the National Radiological Protection Board (NRPB). Full details of the
study will be given in a Final Report, which is to be published by the Commission of the European Communities.

2. WASTE COMPOSITION

The quantities and activities of steel and concrete activated and contaminated at levels near to the limits given above have been estimated. Information has been used from several reactors including for example PALUEL, a 1300 MW(e) pressurised water reactor (PWR) (2), and BUGEY, a 540 MW(e) graphite moderated reactor (3). Inventories have been estimated at three times after reactor shutdown, 5a, 25a and 100a. Results presented here are representative of those for a PWR.

2.1 Contamination

The investigation of various radioactive wastes and their classification indicates that the mass of contaminated wastes decreases by a factor of two when their specific activity increases by a factor of ten. This relationship has been assumed for wastes arising from dismantling of nuclear power plants. Contamination arises on surfaces rather than throughout the body of a waste. Therefore, to relate levels of contamination to specific activity, assumptions must be made about the surface area associated with a given mass. For the purpose of the study it is supposed that the concrete is cut into blocks having a contaminated surface area of 1 m$^2$ per tonne. For the purpose of the study it is supposed that the concrete is cut into blocks having a contaminated surface area of 1 m$^2$ per tonne. Primary circuit steel is expected to be too contaminated for consideration here and would remain as radioactive waste requiring special disposal. Steel near the limits for unrestricted release would come from auxiliary circuits, effluent circuits, pools, treatment and storage tanks, runways, gratings and stairs. A contaminated surface of 10 m$^2$ per tonne of steel has been assumed.

Estimates of masses and activities of contaminated concrete and steel for a PWR falling within the assumed limits are given in Table I. Considering surface contamination in relation to a specific activity limit of, eg 37 Bq g$^{-1}$, the level of contamination averaged over 400t gives rise to an average specific activity somewhat below the limit, ie. 10 Bq g$^{-1}$. Similarly, for the other limits, the level of contamination averaged over a large mass is about $\frac{1}{4}$ of the limit. The radionuclides in the waste have been determined from studies of contaminants in primary coolant, and liquid and gaseous effluents, and are given in Table II.

2.2 Activation

Estimates have been made of the level of thermal and epithermal neutron activation of the reinforced concrete of a PWR biological shield. Neutron fluxes within layers of the shield are given in Table III. Reinforcement is assumed to include 50 kg of iron per m$^3$ of concrete and the elemental compositions of concrete and iron have been derived from references (4-7) and (8-9) respectively. Waste masses and activities falling within the assumed limits are given in Table IV. The radionuclides in activation products are taken to be the same as those given in Table V for the specific activity in the fourth layer of concrete. The level of activity in each successive outer layer is about an order of magnitude lower than that of the layer inside it.

Some steels within the reactor could be activated near to the levels under consideration but the masses and corresponding neutron fluxes are very difficult to analyse. No estimates of levels of activation of steel are presented here.