RADIOLOGICAL PROTECTION CRITERIA FOR THE RECYCLING OF MATERIALS FROM THE DISMANTLING OF NUCLEAR INSTALLATIONS

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A considerable fraction of the materials used in the construction of nuclear installations will, on decommissioning and dismantling, be only lightly active or contaminated. These materials could have high economic value and this provides an incentive for recycling or reuse.

The recycling of materials from the dismantling of nuclear installations, either as scrap or as discrete items, would require them to follow conventional processing and marketing procedures which do not provide for further radiological control. Since numerous installations are reaching the end of their working life, and since large quantities of such scrap and items circulate between the various countries the radiological problems of recycling would have to be resolved on an international scale.

On the initiative of the Commission of the European Communities, the Group of Experts set up under the terms of Article 31 of the EURATOM Treaty to advice the Commission on radiological protection standards, set up a Working Party to look into these problems and propose appropriate criteria. The Working Party prepared a report in which the impact of recycling was assessed, criteria directly applicable to steel scrap and equipment from nuclear power plants were proposed and methods described which can be applied for the development of criteria for other valuable metals, such as copper and aluminium, and other nuclear installations. On the basis of this report, the Group of Experts issued a recommendation to national authorities which includes the criteria set out below.

There have been extensive studies of power reactor decommissioning in the US (1,2,3) and Europe (4), but no practical experience has been gained yet. These studies show that the total quantity of steel in the active areas of a large (1000 MWe) pressurized water reactor or boiling water reactor is approximately 10,000 tonnes, of which about half has a potential for recycling with currently available techniques. An advanced gas cooled reactor of the 600 MW(e) class would also contain in its active areas about 10,000 tonnes of steel with a similar potential for recycling (5), whereas the quantity of steel from active areas resulting from the decommissioning of a typical steel pressure vessel Magnox reactor would be about 13,000 tonnes, of which about a third may be suitable for recycling (6 7).

In the study attention was paid to existing examption criteria and limits (8,9); it was concluded that a suitable basis for establishing criteria for recycling was not available. Two

approaches to the problem were explored, one based on defining acceptable individual and collective dose levels, the other based on setting "clearance" levels for the activity concentration of the materials concerned, such that the potential individual and collective doses resulting from recycling would be insignificant. An analysis of current regulatory practice showed that the stipulation of dose limits for the practice of recycling poses practical, and sometimes intractable, problems for both regulators and operators. The requisite criteria were consequently formulated based on activity concentration levels. These are:

- For β/γ radiation 1 $Bq.g^{-1}$ averaged over a maximum mass of 1000 kg, to avoid the inclusion of highly active items within the average mass there is an additional requirement that no single item may exceed 10 $Bq.g^{-1}$.

- To comply with IAEA regulations (10) for the safe transport of radioactive materials the surface activity for β/γ radiation would have to be limited to 0.4 $Bq.cm^{-2}$ for non-fixed contamination on accessible surfaces, averaged over 300 cm^2 or over the surface area if less than 300 cm^2; for fixed contamination the mass activity concentration clearance level is assumed to apply. The surface activity for α radiation is to be limited to 0.04 $Bq.cm^{-2}$ measured over any area of 300 cm^2 of any part of the surface. For both β/γ and α concentrations, if doubt exists for non-accessible surfaces, the activity must be assumed to be higher than the respective clearance level.

The recommended clearance levels are intended to apply to the total activity concentration of all nuclides, i.e. not only those due to residence in a nuclear installation, but also those present in the raw materials that were used in the manufacture of the steels and equipment involved, and those added during the manufacturing process (such as Co-60 used to indicate the wear of furnace liners).

Examination of the question of the boundary at which the criteria would be applied led to the conclusion that it is not necessarily, in every case, either the boundary of the licensed site or processing plant or of the state concerned. The relevant boundary is that at which all control is in fact relinquished, and as such may vary from case to case.

A generic assessment of radiation exposures resulting from the recycling of materials was performed, in which individual and collective doses to workers and the public were evaluated corresponding to various activity levels, in order to appreciate the relative impact of each radionuclide and to identify the most limiting cases. At the clearance levels recommended, the maximal individual dose to workers or members of the public would be less than 10 $\mu Sv.a^{-1}$. The collective dose from the recycling of 10000 tonnes of steel in a year, arising for example from the dismantling of two large PWRs, would be about 1 man Sv. In exceptional circumstances, associated with very low probabilities of occurrence, the dose to the most exposed individual from the direct reuse of scrap or equipment having an activity concentration equal to the level recommended might be greater than 10 $\mu Sv.a^{-1}$, but the individual risk is not expected to increase (11). Similarly, the

recycling of amounts of materials greater than 10000 tonnes per year will result in a linear increase in the collective dose but will have no effect on the magnitude of individual doses.

For materials with levels of activity concentration above the proposed clearance levels, a case-by-case assessment, of the kind currently performed by the competent authorities in accordance with national regulations, may be required for a particular recycling application.

It will be the responsibility of the national authorities concerned to ensure compliance with the recommended clearance levels. It should be noted, however, that appropriate techniques to ascertain such compliance already exist. To this end, a monitoring programme should be designed and applied, once all significant parameters relevant to the components or metals being released have been identified. This programme should include survey plans for surface contamination measurements, sampling techniques and analyses for activation products, selection of appropriate portable field instruments and fixed and mobile laboratory equipment, and quality assurance methods for the documentation and control of measuring and sampling procedures, instructions, processes and equipment.

It should be noted, however, that practical problems of measurement may well arise in the case of the very low mass activity concentration for alpha emitters derived from the above clearance level for surface contamination. In addition, the experience gained to date with materials having a potential for recycling shows that the alpha activity, if present, is in the form of surface contamination. For these reasons a clearance level for the mass activity concentration of alpha emitters, has not been recommended.

REFERENCES

(1) H.D. OAK, G.M. HOLTER, W.E. KENNEDY and Jr.G. KONZEK
Technology, safety and costs of decommissioning a reference boiling water reactor power station
NUREG/CR - 0672, vol 1 & 2, June 1980

(2) R.I. SMITH and L.M. POLENTZ
Technology, safety and costs of decommissioning a reference pressurized water reactor power station
NUREG/CR-0130, August 1979

(3) Proposed rulemaking exemption from licensing requirements for smelted alloys containing residual technecium-99 and low enriched uranium
NUREG 0518, 158 p., 1980

(4) K.H. SCHALLER and B. HUBER, Eds
Decommissioning of nuclear power plants
Proceedings of a European Conference held in Luxembourg, 22-24 May 1984, EUR 9474

(5) J.D. REGAN, S.J. CRIPPS, B.R. KELLY, B. HAMBLETON and J.R. NICHOLSON
Design features facilitating the decommissioning of advanced gas cooled reactors
CEC Report EUR 92070, Luxembourg, 1984

(6) CEGB Generation Development and Construction Division
Proposals for decommissioning of Magnox nuclear power stations
CEGB Report DCM 1-4, Barnwood, Gloucester, U.K., 1982

(7) P.B. WOOLAM and I.G. PUGH
The radioactive inventory of a decommissioned Magnox power station structure
CEGB Report RD/B/R 4350, Berkeley Nuclear Laboratories, 1978

(8) Council Directive of 15.7.80 amending the Directives laying down the Basic Safety Standards for the health protection of the general public and workers against the dangers of ionizing radiation
(Official Journal of the European Communities, L246 of 17.9.1980) EUR 7330, Luxembourg

(9) International Atomic Energy Agency, IAEA Safety Series No 9 - Basic safety standards for radiation protection, 1982, Vienna

(10) International Atomic Energy Agency
IAEA Safety Series No 6 - Regulations for the Safe Transport of Radioactive material, 1985, Vienna

(11) R. GOERTZ et al.
Statistical evaluation of recycling radioactive metal waste in Untersuchung zur Stillegung kerntechnischer Anlagen - Bundesministerium für Umwelt
Schriftenreihe Reaktorsicherheit und Strahlenschutz (to be published)