

RECYCLING OF RADIOACTIVELY CONTAMINATED MATERIAL

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ABSTRACT

Redundant radioactively contaminated material arises in many industries, both nuclear and non-nuclear. The idea of recycling such of this material that has very low concentrations of radioactivity, instead of condemning it to disposal in waste repositories, has gained considerable support during the last decade.

A major reason for the interest in this approach is the substantial costs of the management of the large volumes of contaminated materials arising from the operation, refurbishment or decommissioning of industrial facilities. Consequently, the minimisation of the volumes that have to be disposed of as radioactive waste is a high priority goal for the industries. The recycling of such material (or its reuse or disposal), without radiological restrictions, is seen as a significant means of achieving this aim. However, the absence of consistent, internationally accepted criteria to regulate the release of recyclable material significantly restricts the utilisation of recycling and reuse as material management practices.

Various international organisations have published proposals or recommendations for the exemption or release of materials from radiological regulations. Hitherto such recommendations have been based exclusively on radiological risks. A task group of the OECD Nuclear Energy Agency's Co-operative Programme on Decommissioning has looked at recycling in a broader context, evaluating both radiological and non-radiological detriments as well as social, economic and environmental aspects. It has compared the risks associated with the recycling of metals with those of disposing them and replacing them with newly produced material.

The paper presents the results of the work of the Task Group against the background of the international recommendations and puts forward the case for a consistent regulatory approach regarding radioactivity in both nuclear and non-nuclear industries.

INTRODUCTION

The OECD Nuclear Energy Agency's Co-operative Programme on Decommissioning was established in 1985 to exchange scientific and technical information between major decommissioning projects. Today the Programme, which is under the direction of the NEA Radioactive Waste Management Committee, has 35 participating projects from 12 countries.

Quite early during the information exchange, it became obvious that the management of the large volumes of contaminated materials arising from the decommissioning of nuclear facilities represents one of the most substantial cost fractions of such projects. Consequently, the minimisation of the volumes that have to be disposed of as radioactive waste is a high priority goal for decommissioners. The recycling of such material (or its reuse or disposal) without radiological restrictions could be a significant means of achieving this aim. So, in 1992, the Programme set up a task group to study the recycling and reuse of redundant material from the decommissioning of nuclear facilities, in particular to provide information and insights into the practicality and usefulness of the criteria being developed for the release of such material from regulatory control, seen from the perspective of organisations currently engaged in actual decommissioning operations.

The OECD/NEA's Task Group on Recycling and Reuse made a survey of the current practices and national regulations in this area, studied the technologies associated with recycling and analysed the proposed international recommendations and proposals for release criteria. A report of the work of the Task Group was published in 1996 [1].

In the last few years, there has been an increasing awareness of naturally occurring radioactive material (NORM) and the enhancement of its concentration in various non-nuclear industrial processes. This technologically enhanced NORM is of the same activity levels as low level waste and is very similar to the candidate material for exemption and clearance in the nuclear industry, but occurs in quantities that are huge in comparison. Both in the United States and in Europe, the radiological regulation of such NORM is under way.

In this paper, the current international recommendations regarding the release of material will be discussed. The results of the work of the Task Group will be presented. The regulatory approaches in Europe and the United States regarding technologically enhanced NORM will be described and the need for a consistent regulatory treatment of all radioactivity will be underlined.

INTERNATIONAL RECOMMENDATIONS, DIRECTIVES AND PROPOSALS REGARDING RELEASE CRITERIA

The international discussions on release of materials for reuse or recycling are taking place mainly at:

- The International Commission on Radiological Protection (ICRP), which has supplied the basic recommendations regarding principles for protection from ionising radiation [2].
- The International Atomic Energy Agency (IAEA) which has tried to translate these general principles into recommendations on nuclide specific release levels [3].
- The European Commission (EC), who have prepared their own recommendations for countries within the European Union [4].
- The OECD/NEA's Task Group on Recycling and Reuse which can be considered as representing the potential users of the recommendations and criteria that are being drawn up by the IAEA and the EC.

In connection with the work and discussions in this area, a number of terms are used to denote specific events and conditions:

Exclusion covers activity sources not amenable to control, such as K-40 in the human body, cosmic radiation, etc.

Exemption had earlier been used to denote all radioactive material placed outside regulatory control because of the low risk they give rise to and because control would be a waste of resources. Later this term has been restricted to cover radioactive sources which *never enter the regulatory regime*, typically small sources such as "tracers used in research, calibration tracers and some consumer products containing small sources or low levels of activity per unit mass" [3].

Clearance has been used, after the restriction of the meaning of "exemption" mentioned above, to denote material that has been *released from regulatory control*. Clearance can either be *unconditional* or *conditional*.

In 1988, the IAEA and the Nuclear Energy Agency (NEA), in co-operation, issued Safety Series No. 89 [5] to recommend a policy for exemptions (i.e. clearance) from the basic safety system of notification, registration and licensing that form the basis of regulatory control. Safety Series No. 89 suggests

- a maximum individual dose/practice of about 10 μ Sv/year,
- a maximum collective dose/practice of 1 manSievert/year

to determine whether the material can be cleared from regulatory control or other options should be examined. A methodology to apply these principles on the recycling or reuse of material from nuclear facilities was subsequently presented. [6]. The results of this document were part of the input in the IAEA process of establishing unconditional release

levels for solid materials [3]. This last mentioned report IAEA TECDOC 855 was issued in January 1996 on an interim basis and will be revised after about three years to react to comments received and to experience gained in its application. This document presents recommended nuclide specific clearance levels for solid materials.

(It should be noted that Safety Series 89 is currently under revision and the revision of TECDOC 855 will be started during this year)

Earlier, a revised *International Basic Safety Standards for Protection against Ionising Radiation and the Safety of Radiation Sources (BSS)* had been published in 1994. It was based on the recommendations of ICRP 60 [2] and jointly sponsored by the Food and Agricultural Organisation (FAO), the IAEA, the International Labour Organisation (ILO), the OECD/NEA, the World Health Organisation (WHO) and the Pan American Health Organisation (PAHO). The International BSS gives a list of nuclide specific exemption values (both quantities and concentrations).

The EC issued, in May 1996, a Council Directive laying down its BSS for radiation protection [7], with nuclide specific exemption values very similar to those in the International BSS. However, the EC BSS makes a difference between "practices" covering processes utilising the radioactive, fissile or fertile properties of natural or artificial radionuclides (i.e. the nuclear industry) and "work activities" where radioactivity is incidental, but can lead to significant exposure of workers or the public.

The EC recommendations - Radiation Protection 89 [4] - have been prepared for the clearance of metals from the dismantling of nuclear installations. The proposals cover steel, aluminium, copper and alloys of these metals. While the IAEA TECDOC 855 treated only unconditional clearance, the EC approach provides two options for releasing material:

- direct release based only on surface contamination,
- melting at a commercial foundry followed by recycle and reuse. Mass specific and surface specific levels are provided.

ANALYSIS OF THE NEA TASK GROUP AND ITS RECEPTION

The main difference in approach between that of the international organisations (IAEA and EC) and that of the NEA Co-operative Programme's Task Group was in the type of risks considered.

Both the IAEA and EC recommendations are for nuclide-specific risk-related clearance levels, the individual risk corresponding to that resulting from exposure to about 10 $\mu\text{Sv}/\text{year}$ (which is about 5×10^{-7} fatalities per year). Both organisations consider only the radiological risks associated with the release of material. The task group of the NEA Co-operative Programme attempted to view recycling in a broader context, evaluating both radiological and non-radiological detriments as well as social, economic

and environmental aspects. This is seen to be fully in harmony with the ICRP concept that the justification of a practice should take into account the total detriment and not only the radiation detriment.

In its assessment of the health risks, the Task Group compared the recycling of 50 000 t of scrap metal, utilised so that the individual radiological exposure was limited to 10 μ Sv/a, to the disposal and replacement of the same amount of material in the USA. The results of this comparison are given in Table I below [1], and show that

- the radiological risks associated with both alternatives are very small in comparison with the non-radiological industrial safety risks,
- these non-radiological risks are much lower for recycling because product manufacture starts from scrap metal. The risks associated with mining and refining of metal are avoided.

Table I
Summary of Health Risks from the Radioactive Scrap Metal Management Alternatives

Impact categories	Recycle/reuse	Dispose and replace
<i>Radiological risk*</i>	• 10^{-7} to 10^{-6} fatal cancer risk to metal workers and public • 10^{-2} to 10^{-1} population risk per year of practice	• Potential elevated cancer risk to miners
<i>Non-radiological risks</i> • Accidents (workplace) • Accidents (transportation) • Chemical exposure from smelting ** • Chemical exposure from coke production	• About 7 fatalities or serious injuries to workers • 10^{-2} fatality risk to workers and public • 10^{-3} fatal cancer risk to workers; 10^{-4} to public • None	• About 14 fatalities or serious injuries to workers • 10^{-2} fatality risk to workers and public • 10^{-3} fatal cancer risk to workers; 10^{-4} to public • 1 fatal cancer risk to workers; 10^{-2} to public

* Risk estimates represent maximum individual lifetime risk associated with a 50 000-t throughput, operated so that individual dose does not exceed 10 μ Sv/a.

**** Maximum individual lifetime risk of cancer fatality resulting from one year of exposure at the maximum permissible concentration in the United States.**

It is encouraging to note that the "total risk" approach of the Task Group seems to be gaining support in the regulatory world. In the foreword to the EC document "Radiation Protection 89" on the recycling of metals [4], it is stated that *"From a larger perspective it is reasonable to assume that metal recycling has a net positive impact on the health of workers and population compared to disposal as radioactive or ordinary waste and compared to the impact of metal ore mining to ensure replacement of spent metals. This net benefit should significantly outweigh the minor radiation detriment associated with the recycling of scrap with very low levels of radioactive contamination"*.

The total health risk approach adopted by the Task Group was a feature of a number of presentations at the First European ALARA Network Workshop. In fact, one of the observations and recommendations of the Workshop [8] was the:

- "Need to take into account a total risk approach with various trade-offs such as radiological and conventional risks...."

The Task group of the NEA Co-operative Programme had, in its report, considered the 10 $\mu\text{Sv/a}$ individual dose criterion as being overly conservative. The excessive influence of this single value on currently proposed exemption and clearance levels was underlined by many speakers and participants at an IAEA meeting in Vienna on "Exclusion, Exemption and Clearance" [9]. It was pointed out that in areas of "measurable, and sometimes elevated, doses" from naturally occurring radioactivity, an additional 10 $\mu\text{Sv/a}$ would be almost impossible to detect.

Also in the European Commission paper at the First European ALARA Network Workshop [10], it was stated that, due to the extremely low probability of multiple exposures, "the rounding downwards of the original criterion of "a few tens" of μSv to 10 μSv in fact seems not to be justified".

At the Vienna meeting, a proposal to "collapse" the values for exemption and clearance into one set, based on the BSS exemption levels, found a lot of support [9]. Some of the reasons advanced for this were:

- The values for clearance and exemption for the various nuclides "are always within a factor of 100 of each other, usually much closer and sometimes the same". For nuclides of most significance to the nuclear industry, such as Co 60, Cs 137 and Ra 226, the factor is 10.
- The IAEA TECDOC 855 groups the nuclides in decades because "uncertainties.....allow.....only categorisation by order of magnitude".
- the BSS exemption levels are to be adopted for transport regulation.
- The rapporteur on the session on "Implementer's perspective" states that "Few people, except experts, understand the difference between exemption and

clearance. Having two sets of values would only confuse the public". Even at this "specialists' meeting", the rapporteur pointed out that it was "apparent from the presentations and subsequent discussions that there remains confusion over the concepts exclusion, exemption and clearance...." [9].

- In the overall summary of the meeting, it is suggested that "another use of such a (single) set of values could be in the context of the Waste Safety Convention where, at some future time, an international definition of radioactive material is likely to be needed".

EMERGENCE OF THE NORM ISSUE

Radiation protection and the management of radioactive material have hitherto been concerned mainly with artificial nuclides arising within the nuclear fuel cycle. In the last few years, there has been an increasing awareness of naturally occurring radioactive material (NORM) and the enhancement of its concentration in various non-nuclear industrial processes. This technologically enhanced NORM can be of the same activity levels as low level waste and is very similar to the candidate material for exemption and clearance in the nuclear industry, but occurs in quantities that are huge in comparison.

Table II illustrates some of the technologically enhanced NORM arising annually in the United States. Ra 226 with a half-life of 1600 years is by far the most important radionuclide. These data are shown only to give an idea of quantities and activity levels. Other industries with significant radioactive waste streams are coal ash, petroleum processing, geothermal plants and paper mills. More or less comparable quantities of NORM arise in Europe, with similar concentrations of radioactivity.

Table II: Some NORM Quantities (Summarised from [11])

Waste Stream	Prod.rate t/a	U+Th+Ra Bq/g
Phosphates	5×10^7	up to 3700
Petroleum Production	2.6×10^5	up to 3700
Water Treatment	3×10^5	up to 1500
Mineral Processing	10^9	up to 1100

The radiological regulation of NORM is still in its infancy and there are understandably great inconsistencies in its regulatory treatment. The radiological impact of NORM and its treatment is the subject of another paper at this WM99 Conference [12]. So only the main issues will be summarised here:

- Both exemption and clearance values in the nuclear industry are derived from the same SS 89 criteria for individual and collective doses. The higher levels for exemption (generally a factor 10 for nuclides typically of interest) are explained by the moderate quantities considered, while studies on clearance has involved much larger quantities of material (typically 10000 t of scrap metal in Europe). When the much larger quantities of NORM are brought under regulation, this principle of relating release levels to quantities obviously cannot be applied (This is yet another reason for "collapsing" the exemption and clearance levels to one list, as mentioned earlier).
- Different exemption levels are applied in different countries. For example, in the oil and gas industry, the exemption levels are
10 Bq/g in Norway,
100 Bq/g in Holland, and
500 Bq/g in Germany.
- Exemption criteria for radiologically similar material vary from 10 μ Sv/year individual dose in the nuclear industry to 1 mSv/year in the oil and gas industries in Holland and Germany.

Against the background of the facts that:

- in spite of its name, the NORM arising in the concerned industries does not occur naturally, but is artificially concentrated,
- according to all radiological regulatory and advisory organisations, there is no plausible rationale for any differences in risks due to ionising radiation arising from naturally occurring and any other radionuclides,

the existing situation is clearly unacceptable.

SUMMING UP

The recycling and reuse of material arising from the decommissioning of radioactive facilities (in both nuclear and non-nuclear industries) can very significantly affect the volume that would have to be disposed of as radioactive waste. Internationally accepted radioactivity clearance levels for such material are a necessary requirement for utilising this alternative advantageously.

Various national and international bodies have issued interim or draft recommendations on exemption and clearance levels. These have been discussed at a number of fora during the last few years. Recent discussions have also covered the management of radioactivity in "non-nuclear" industries, where naturally occurring radioactivity is technologically enhanced to levels, at which aspects of radiological protection to workers and the public would have to be considered.

A study of these discussions indicates that

- there is a well-motivated case put forward by decommissioners for the adoption of a single set of values for both exemption and clearance, e.g. the exemption levels specified in the Basic Safety Standards.
- there should be a perceivable consistency in the regulatory treatment of radioactivity in the nuclear and non-nuclear industries. Any other approach would be difficult to explain and justify from the radiation protection point of view.

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