

AN IMPLEMENTOR'S VIEWS ON CLEARANCE LEVELS FOR RADIOACTIVITY CONTAMINATED MATERIAL

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ABSTRACT

Currently, a great deal is happening in the regulatory field regarding the release of radiologically contaminated material:

- The IAEA is working on the revision of Safety Series 89 (governing the principles of exemption and clearance) and of the TECDOC 855 on clearance levels.
- The European Commission Directive on basic safety standards for protection against ionising radiation in both nuclear and non-nuclear industries, will become effective in May 2000.
- The US NRC has issued its draft on clearance of material from nuclear facilities (NUREG 1640), as well as an "issues" paper on the release of solid materials.
- The US State Department has launched an International Radioactive Source Management Initiative, one of the objectives being to "develop international standards and guidelines and 'harmonize' US and IAEA radioactive clearance levels".

Of great significance to the implementor of clearance regulations in the nuclear industry is the emergence of the NORM issue during the last decade. Both the EC and the IAEA seem to be proposing much more stringent standards for the clearance of relatively small quantities of material from the nuclear industry, while allowing the public to be exposed to up to 100 times higher individual doses from the technologically enhanced NORM arisings from the non-nuclear industries. For public acceptance and for transparency, it is important to have consistent approaches to clearance of radioactively contaminated material, irrespective of the industry of origin.

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 38 participating projects from 13 countries, thus making it the major forum and spokesman for the implementors of decommissioning.

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. It was also noted that much of this redundant material was valuable, eg stainless and other high quality steels. The recycling of such material (or its reuse or disposal) without radiological restrictions could be a significant means of achieving the aim of waste minimisation. 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.

A great deal is happening today in the area of release of all types of radiologically contaminated material, both internationally and in certain countries. This paper will start with a brief overview of the recommendations and proposals made by the various regulatory agencies and then proceed to discuss them from the viewpoint of nuclear decommissioners.

OVERVIEW OF RECOMMENDATIONS AND PROPOSALS REGARDING RELEASE CRITERIA

Organisations involved

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 implementors of the recommendations and criteria that are being drawn up by the IAEA and the EC.

In addition, work is going on in some countries on national regulations in the area. For instance, in the USA:

- The US Nuclear Regulatory Commission has been active in the areas of the release without radiological restriction of nuclear sites and of material from such sites.
- The US State Department has launched an International Radioactive Source Management Initiative, one of the objectives being to "develop international standards and guidelines and 'harmonize' US and IAEA radioactive clearance levels.

Terms used

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*.

Overview of published documents

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 $\mu\text{Sv}/\text{year}$,
- a maximum collective dose/practice of 1 manSv/year

to determine whether the material can be cleared from regulatory control or other options should be examined. Safety Series No 89 is currently being revised.

A methodology to apply the principles of Safety Series No 89 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 is being revised after about three years to react to comments received and to experience gained in its application. This document presented recommended nuclide specific clearance levels for solid materials.

EC recommendations - Radiation Protection 89 [4] - were published in 1998 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.

The nuclide specific clearance levels in Radiation Protection 89 are also based on the Safety Series No. 89 criteria.

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 USNRC regulation on radiological criteria for the release of a nuclear site for unrestricted use was published in July 1997 [14]. The individual dose criterion to be used according to this NRC regulation is a maximum of 250 $\mu\text{Sv}/\text{year}$ to be compared to Safety Series No 89:s 10 $\mu\text{Sv}/\text{year}$. The USNRC also published draft criteria for the clearance of equipment and material from nuclear facilities in January 1999 [15]. These, however, were based on 10 $\mu\text{Sv}/\text{year}$ maximum allowable individual dose.

Parallel to the draft criteria, the USNRC has also published an "issues" paper in June 1999 [16]. The paper summarised the background and topics for comments and discussion at a series of public meetings, to be held during the later half of 1999. This would encourage early public input into the decision process regarding the release of solid materials from radiologically licensed sites.

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 I illustrates some of the technologically enhanced NORM arising annually in the United States [11]. 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 petroleum processing, geothermal plants and paper mills. More or less comparable quantities of NORM arise in Europe, with similar concentrations of radioactivity [12].

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

Waste Stream	Prod.rate t/year	U+Th+Ra Bq/g
Phosphates	5×10^7	up to 3700
Coal ash	6.1×10^7	up to 2
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 quantities shown above should be viewed in comparison to candidate material for recycling from the nuclear industry. The European studies for recycling of steel from nuclear facilities have used a basis of 10 000 t/year [4]. The OECD/NEA Task Group on Recycling and Reuse used a quantity of 50 000 t/year in the United States in their study [1].

DISCUSSION

Types of Risks Considered

Both the IAEA and the EC recommendations as well as the draft USNRC clearance proposals consider only the radiological risks associated with the release of material, the individual risk corresponding to that resulting from exposure to a maximum of 10 μ Sv/year. The NEA Task Group assessed the total health risks, comparing the radiological risks associated with the recycling of material with disposing the material instead as radioactive waste and replacing it with new material. The results of this comparison 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.

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"*.

It should be noted however that the contents of the document do not in anyway reflect these views.

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...."

Individual Dose Criterion of 10 μ Sv/year/practice

The Task Group of the NEA Co-operative Programme had, in its report, considered the 10 μ Sv/year 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, doserates" from naturally occurring radioactivity, an additional 10 μ Sv/year 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 μ Sv to 10 μ Sv in fact seems not to be justified".

Regulation of NORM and its Implications for the Nuclear Industry

The regulatory structure for exempting or releasing material from radiological regulation is based on the principle of triviality of individual, doses to members of the public. The ICRP criterion of "some tens of microsieverts" became "ten microsievert or less" in the IAEA Safety Series No 89, which was created at a time when NORM was unknown or, at any rate, not considered. The **one** and the **same** criterion was later used for two regulatory concepts:

- exemption (from entering regulation)
- clearance (for release from regulation)

with generally a factor ten higher activity concentration values for exemption as for clearance. The difference in activity levels was explained by "quantities", exemption being applied to **small** ("moderate") quantities and clearance to **large** quantities. Quantitatively: "small" meant say 1-10 t. In European studies on (clearance for) recycling, the figure of 10000 t has been used to exemplify "large" quantities.

Later NORM was discovered. Its **huge** quantities (2-3 orders of magnitude larger than those used in the European studies on nuclear recycling), its activity levels and the large number of industries involved have been (are being) mapped. It has become obvious that the triviality approach can no longer be used.

The European Commission, in their BSS [7], propose to solve this problem by dividing occurrences of radioactivity into

- *Practices*, which utilise the radioactive properties of materials, i.e. the nuclear industry,
- *work activities*, where radioactivity is incidental (NORM industries).

For the nuclear industry, the EC-BSS prescribes an individual dose constraint of 10 μ Sv/year/practice. It is not clear in the BSS what is proposed for the NORM industries. However, both in Germany [17] and in Holland [18] the level of 1 mSv/year individual dose is being used.

The complications of such dual standards in the real world of recycling are demonstrated in the following example [17]:

The German company, Siempelkamp, has melted 350 t of scrap from the natural gas industry resulting in

18 t of slag:	average specific activity:	93 Bq/g
1 t of filter dust:	” ” ”	535 Bq/g
3.6 t of floor sweepings	” ” ”	255 Bq/g.

Four of the waste drums exceeded the exemption level of 500 Bq/g. The Federal Collection Depot for radioactive waste offered to store 3 of the drums for the price of 475 000 DEM. The fourth drum was refused because the activity level of Ra 226 was too high.

”Practicable and economic” waste management alternatives were sought. The radiological impact of five such alternatives were studied:

- Road construction,
- Shallow land burial,
- Sidewalk,
- Playground,
- Parking lot.

The allowed individual dose criterion was **1 mSv/year**. Using the slag for road construction was the chosen method of waste management.

At the same company, radiologically similar slag arises from the melting of

- material used in ex-vessel core melt experiments (metals with depleted UO₂ powder added to simulate fuel)
- scrap from fuel element fabrication.

Slag from these melting operations, being from the nuclear industry, is proposed to be regulated under the **10 μ Sv/year** individual dose criterion.

The EC-BSS gives a nuclide specific table of exemption levels for *practices*. A typical value for nuclides of interest (Co 60, Cs 137, Ra 226) is 10 Bq/g. The BSS does not give a corresponding table for *work activities*. However, it was noted at the NORM II meeting in Krefeld, Germany [19], that much higher levels were being used in certain European countries.

Germany 500 Bq/g for NORM total activity
65 Bq/g for Ra 226 (in the above case history)
Holland 100 Bq/g for NORM.

Norway uses the “nuclear” level of 10 Bq/g also for Ra 226, Ra 228 and Pb 210 from the oil and gas industry.

The IAEA seems to be proposing the 10 $\mu\text{Sv}/\text{year}$ individual dose criterion for the nuclear industry and “optimisation” in each individual case of NORM regulation. In effect, this will mean the release of huge quantities of material from the non-nuclear NORM industry at much higher levels of individual dose as criterion.

The process of optimisation seems vague and undefined. In the IAEA TECDOC 855, there is reference to the optimisation of radiation protection using “cost-benefit analysis, intuitive or formal, or other methods”. Another IAEA document TECDOC 987 has an Appendix II on the justification and optimisation of clean-up. The paper refers to “multiattribute utility analysis”, and gives an example of an equation, where the net benefit is a function of a number of parameters like

- avertable collective dose,
- monetary costs of clean-up,
- anxiety regarding the contamination,
- reassurance by the clean-up, etc.

It can be stated about such an “optimisation” that

- it is arbitrary. The dollar values of the parameters, specially the last two, can be chosen to give any predetermined result,
- such “optimisation” will lead to different results in calculations by different authorities in different states. Consistency, harmonisation of regulations as well as trans-boundary transport will be impaired,
- such calculations will be difficult to explain in communication with the public and difficult to defend in public debate.

The USNRC “issues” paper [16] regarding the release of solid materials from licensed sites makes an interesting connection with NORM. It notes that coal ash from thermal power plants, with technologically concentrated levels of NORM, has been exempted from regulation by the US Environment Protection Agency (USEPA). Under this exemption, coal ash can be used in building materials. The resulting individual dose to members of the public can be about **100 $\mu\text{Sv}/\text{year}$** and “could be viewed as a precedent or benchmark for possible NRC release levels” [16].

About 61 million tons of coal ash were generated by thermal power production in 1990 [11]. At present, such ash is either disposed or utilized for various industrial uses (more than half for the production of concrete/cement). The current distribution between these two alternatives is about 80% disposal to 20% utilization. The American Coal Ash Association hopes to ultimately reverse this distribution to 20% disposal and 80% utilization. It is pointed out that such a high utilization rate is technically achievable, as rates upto 70% utilization are not uncommon in Europe. The USEPA has however concluded that a utilization rate of about 30% is more realistic. Its exemption of coal ash from regulation and the radiological consequences should be viewed against this background [11].

Finally, it can be noted that the US National Academy of Sciences has very clearly rejected any possible radiation protection reasons for treating radioactive material from the nuclear industry and that arising from the non-nuclear NORM industries on different risk evaluation standards. In its "Evaluation of EPA Guidelines for Exposure to NORM [13]", it states:

"The committee is not aware of any evidence that the properties of NORM differ from the properties of any other radionuclides in ways that would necessitate the development of different approaches to risk assessment. In regard to radiological properties, if one accepts the view currently held by all regulatory and advisory organisations involved in radiation protection that estimates of absorbed dose in tissue are the fundamental physical quantities that determine radiation risks for any exposure situation, there is no plausible rationale for any differences in risks due to ionizing radiation arising from naturally occurring and any other radionuclides, because absorbed dose in tissue depends only on the radiation type and its energy, not on the source of the radiation".

SUMMARY AND CONCLUSIONS

The regulatory structure for exempting or releasing material from radiological regulation is based on the principle of triviality of individual doses to members of the public. The ICRP criterion of "some tens of microSieverts" became "ten microSievert or less" in Safety Series 89, which was created at a time when NORM was unknown. The **one** and the **same** criterion was later used for two regulatory concepts:

- exemption (from entering regulation),
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with generally a factor ten higher activity concentration values for exemption as for clearance. The difference in activity levels was explained by "quantities", exemption being applied to **small** quantities and clearance to **large** quantities.

Later NORM was discovered. Its **huge** quantities, its activity levels and the large number of industries involved have been (are being) mapped. It has become obvious that the triviality approach can no longer be used.

The EC solution to this problem seems to be to relax the **10 μ Sv/year individual dose** to a level of **1 mSv/year for the non-nuclear industries**. The IAEA seems to be proposing the 10 μ Sv/a individual dose criterion for the nuclear industry and "optimisation" in each individual case of NORM regulation, which can only increase difficulties for achieving consistency, harmonisation, ease of trans-boundary movement of material, etc. Thus, both the EC and IAEA treat radioactivity from the nuclear sphere and the non-nuclear industries on different scales of judgement, having extremely stringent release conditions for the material from the nuclear industries, while allowing up to 100 times higher exposures from the much larger quantities of arisings from non-nuclear industries.

In its "issues" paper regarding the release of solid materials, the USNRC suggests that the exposure level due to the use of coal ash in building materials (about 100 μ Sv/year individual dose) could be a possible benchmark level for NRC release levels. This seems to reflect the views of the US National Academy of Sciences that there is no plausible difference in the judgement of risks due to exposure to natural or artificial radioactivity.

In the long term, a consistency in the regulatory treatment of radioactivity, irrespective of the industry it arises in, can be very important for all the industries concerned, for international transport of material and for public acceptance.

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