APPLICATION OF EXEMPTION CONCEPTS OVERVIEW OF PRACTICES IN SOME COUNTRIES

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ABSTRACT

This paper discusses the release of redundant materials from nuclear sites as practiced in a few countries within the OECD. The information background has been produced as part of a study being conducted by a Task Group on the recycling and reuse of material.

Starting with a general survey of material that has been released, the paper goes on to describe the concept of melting for the recycling of metals and some specific case histories of material released from nuclear sites in Sweden and Belgium.

INTRODUCTION

The OECD Nuclear Energy Agency's Co-operative Program on Decommissioning was set up in 1985 to facilitate the exchange of information internationally from major nuclear decommissioning projects. The Co-operative Program today includes 27 projects from 11 countries and thus in total represents the largest producers of nuclear "recycleable" waste (i.e. excluding fuel and operational waste).

In order to perform in depth analyses of specific topics of common interest the Program works through "Task Groups". Early in 1992, a special Task group was established to study and report on recycling and reuse of redundant material.

As part of its work, the Task Group has conducted a survey on current international policies and experiences in this field based on decommissioning projects within the Co-operative Program or associated with it. This paper briefly reports on the preliminary results of the survey.

A large part of the waste produced at nuclear facilities is metallic. Melting has been identified as a major technology for making possible the recycling of contaminated metals. In the last few years, several melting plants have started commercial operations for recycling metallic scrap. This paper will describe how these plants, operating in controlled areas, can basically affect the calculation models and scenarios used currently for arriving at release limits for various nuclides.

The paper will finally describe three case histories of components and materials that have been (or will be) released without radiological restrictions.

SURVEY OVER MATERIAL RELEASED

The survey was based on the answers to a questionnaire sent to the projects in the Co-operative Program. Replies were received covering 22 projects. In addition data was also obtained regarding proposed national regulations or recommendations regarding 6 countries.

Countries/Projects Covered

In the following Table I is shown the regulatory situation in the various countries and the projects about which data was received.

The projects covered a wide range of nuclear installations, as is shown in Table II.

Apart from the technical diversity seen in Table II, the projects and the individual circumstances for release of material differed very widely in many respects. They were owned or managed by private companies, state companies, research institutes or governmental organizations. The releases were authorized by approved radiation protection agencies, the Ministries of Health or the appropriate ministries of federal states. In most cases, the releases were on a case by case basis. In some countries (like Sweden) where there are general regulations for unrestricted release, there has also been such release on a case-by-case basis at higher values of activity than in the general regulations.

Types of Release

Various types of release practices have been applied in the individual projects:

- *Unrestricted reuse of materials and/or systems* has been applied in Belgium (metal and concrete), France (buildings and gravel), Germany, Great Britain, Italy, Sweden, Slovakia and the United States (steel scrap).
- *Disposal of material without any radiological restriction* on e.g. a public dumping ground has been performed in most of the countries, as in Belgium (concrete), France, Germany, Great Britain, Italy, Sweden and the United States.
- *Restricted reuse in the non-nuclear world:* Some material has been released for specific reuse after melting in a specific melter as in Germany and Sweden.
- *Release for restricted reuse in the nuclear world* has been applied in France, Germany (after melting in a specific melter) and the United States (lead and concrete blocks).
- *Disposal with radiological restrictions:* A great deal of material has been disposed of with radiological restrictions on different destinations depending on the specific contamination limits as in France (soil and gravels), Germany (metal and concrete) and Great Britain (contaminated asbestos or chemicals).

Criteria for Release

The criteria applied for release vary widely over the projects (sometimes even in the same country) and over the different countries. Some typical criteria for unrestricted release are cited below:

- *Surface contamination limits* for beta-gamma emitters:

0.37	Bq/cm^2,	in *Germany* over 100 cm^2 anyway for fixed and removable contamination and for each single item;
0.4	Bq/cm^2,	in *Finland*, for removable surface contamination over 0.1 m^2 for accessible surfaces;
0.4	Bq/cm^2,	in *Belgium*, mean value for removable surface contamination over 300 cm^2, for beta-gamma emitters and alpha emitters with low radiotoxicity;
0.83	Bq/cm^2,	in the *United States*, surface contamination above back-ground over not more than 1 m^2, with a maximum of 2.5 Bq/cm^2 above background if the contaminated area does not exceed 100 cm^2;
4	Bq/cm^2,	in *Sweden*, mean value for removable surface contamination over 100 cm^2, with a maximum of 40 Bq/cm^2 if the contaminated area does not exceed 10 cm^2.

The limits for alpha emitters are generally one-tenth of the above values.

Specific activity limits regardless of kind of emission:

0.1	Bq/gram,	in *Germany*;
0.1	Bq/gram,	in *Sweden*, over and above the content of natural activity which occurs in corresponding goods outside the nuclear installation, mainly for limiting the activity in materials which, after melting down, can be reused in new products;
0.4	Bq/gram,	in *Great Britain*, total activity for solids, other than sealed sources, which are substantially insoluble in water;
0.4	Bq/ml,	in *Great Britain*, total activity for organic liquids radio- active solely because of the presence of C14 and H3 or both;
1	Bq/gram,	in *Germany*, for reuse of metal in a general melting facility.

In addition there are specified separate limits for alpha and beta-gamma emitters in Finland and Belgium as well as nuclide specific limits in the United States and Great Britain.

In several countries, there are regulations in force indicating scope and number of measurements to be taken for satisfying the criteria. In addition, there are quality assurance requirements in some countries such as:

- documentation of sampling and measurement techniques
- list of material released
- calibration of measurement equipment
- disposal site, radionuclides and their activity, total quantity disposed of, etc.

TABLE I
Regulatory Status and Projects in Various Countries

	Regulation	Project/Site
Belgium	Proposal	6A/B Pilot Project Eurochemic
Finland	General Regulation	
France		Attila Le Bouchet Reactor EL3 Le Forez Gueugnon Reactor Triton
Germany	General Regulation	KKN MZFR
Great Britain	General Regulation	Capenhurst SGHWR
Italy	Garigliano	
Sweden	General Regulation	Barsebck Oskarshamn Ringhals Forsmark Studsvik
Slovakia	Bohunice	
United States	General Regulation	EBWR Shippingport Weldon Spring

Quantity Released

The materials released by the projects under survey represent more than 358.000 tons. Briefly they can be subdivided into:

- Materials released for unrestricted reuse:
  - about 6.750 tons of carbon steel (plus a non-identified amount from one project),
  - about 900 tons of stainless steel,
  - about 420 tons of various metals without any decontamination (plus a non-identified amount of lead from two projects),
  - about 130 tons of various metals after decontamination,
  - about 2.800 tons of gravel,
  - about 155.600 tons of other material.
- Materials released for *disposal* without any radiological restriction:
  - about 34.300 tons of concrete (plus a non-identified amount from one project),
  - about 36.600 tons of soil and gravel,
  - about 308 tons of other material.
- Materials released for restricted reuse in the nuclear world:
  - about 33 tons of various metals without any decontamination,

TABLE II
Types of Projects

Pressurized Water Reactor	Boiling Water Reactor	Heavy Water Reactor	Research Reactor	Fuel Facility	Uranium Milling Plant
Shippingport	Barsebäck Oskarshamn Ringhals Forsmark EBWR EBWR Garigliano	KKN MZFR SGHWR Bohunice	EL3 Triton Studsvik	6A/B Pilot Pr Eurochemic Attila Capenhurst Weldon Spring	Le Bouchet Le Forez Gueugnon

- about 349 tons of concrete,
- about 814 tons of other material.

- Materials released for disposal with radiological restrictions:
  - about 4.090 tons of carbon steel,
  - about 3.490 tons of stainless steel,
  - about 44.100 tons of concrete
  - about 57.900 tons of soil and gravel,
  - about 7.220 tons of other material.
- Materials released for restricted release to a specific melter:
  - about 220 tons of various metals without any decontamination,
  - about 2.025 tons of various metals after decontamination.

The dominating nuclides were Co60, Cs137, Fe55 and Ni63. Both in regard to surface contamination and specific activity, the values were conservatively below the limits of the release criteria in each case. The total activity released was about 1.100 MBq beta-gamma and about 700 MBq alpha activity.

MELTING FOR RECYCLING

Low level contaminated metallic waste constitutes a large part of the waste arising from the change-out of equipment and the final decommissioning of a nuclear power plant. Much of this waste consists of bulky equipment like heat exchangers, moisture separators or steam generators, which would utilize considerable final repository volume. Moreover, much of this equipment contains valuable materials like pressure vessel and stainless steels as well as Inconel.

The concept of melting low level contaminated scrap aims at achieving recycling of metals as well as saving expensive space at final disposal facilities. In the short period of the last five years, this concept has developed as a new industry, where established techniques are being utilized for minimizing the quantity of active metallic waste (2). Four plants are currently melting contaminated metals on an industrial scale:

- Carla plant, Siempelkamp, Germany (Start 1989)
- Studsvik melting facility, Sweden (Start 1987)
- INFANTE plant, Marcoule, France (Start 1992)
- SEG plant, Oak Ridge, USA (Start 1992)

By October 1993, these plants had achieved the following:

	Melted	Recycled/released
Carla	7.000 t	6.800 t recycled in nuclear industry, 50 t free release
Studsvik	1.500 t	230 t free release, rest stored for decay
INFANTE	3.600 t	
SEG	2.000 t	Recycling in nuclear industry

All the above plants are in "controlled" areas, with filtered ventilation, health physics supervision, etc. The slag and the dust collected in the filters are treated as radioactive waste.

At Studsvik, where the aim is to achieve free release, the ingots are stored for decay (if necessary) till they can be released, after certification by the radiation protection authorities, for remelting at commercial foundries. When the ingots are thus remelted, after a first melt of contaminated scrap in a controlled area, there are a number of differences in the radiological conditions compared with those assumed in current calculation models and scenarios used for arriving at release limits for various nuclides. Examples of such differences are:

- Volatile nuclides like Cs137 have been removed in the first melt. So the inhalation of dust is no longer a radiological problem.
- There is no loose surface contamination. So segmenting has no radiation protection significance.
- The slag has been removed as radioactive waste. In some current scenarios, the slag is assumed to be used for road surfacing.

Since the start of the Studsvik plant, some 1.600 t of contaminated metals have been melted. Of this 230 t has been released (without radiological restrictions) in the form of ingots for remelting at commercial foundries. The material has been released in batches at intervals. The distribution of activity in the ingots released in 1993 is shown in *Fig. 1 below*. The total weight of the released material was 65 t. The maximum activity concentration was 0.8 Bq/g Co60, while the average concentration was just over 0.5 Bq/g.

CASE HISTORIES OF MATERIAL RELEASE

Recycling of Metals in Sweden

As was mentioned earlier (in Chapter 3), Studsvik RadWaste in Sweden has one of the four plants currently recycling contaminated metal scrap on an industrial scale.

Studsvik's basic approach to recycling is to achieve the free release of metals from components at a suitably low level of contamination. If the ingots resulting from melting are not at a radioactivity level low enough for release without

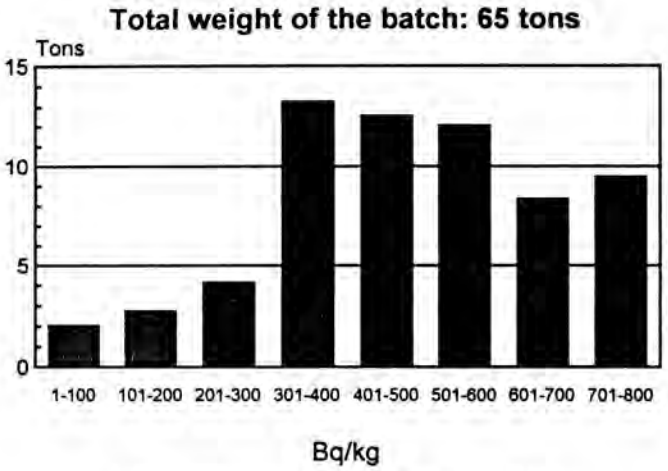

Fig. 1. Activity of ingots released in 1993.

restriction, they are stored until the activity has decayed to such a level. There are two variations in this basic approach, depending on the degree of contamination:

- For components with a very low level of contamination, e.g. large steam-side components of direct cycle BWR plants, the practice is to melt them directly, after segmenting to sizes acceptable to the furnace.
- For components with higher degrees of contamination, e.g. steam generators in the primary circuit of a PWR, the primary side is decontaminated before the component is segmented and melted.

As examples, the case histories are given of two components, each representing one type of treatment described above.

High Pressure Preheater from the Ringhals 1 Plant

Ringhals 1 is an 800 MWe direct cycle BWR plant. The two high pressure preheaters were replaced after about 10 years of operation. The melting of the preheaters was proposed to achieve free release of the material instead of sending the components to the SFR final repository for reactor waste. The proposal was accepted by the owners as well as the authorities in 1988.

The preheaters were large components with the following dimensions:

Diameter	2.5 m
Length	14.2 m
Weight about	72.5 t each.

The preheaters were basically horizontal heat exchangers with stainless steel U-tubes and a carbon steel shell. Steam was flowing on the shell side of the preheaters, feed water in the tubes. So activity was concentrated on the inside of the shell and the outside of the tubes. The total nuclide inventory was estimated to be 1 to 2.10^8 Bq per preheater.

In Studsvik the preheaters were segmented with oxyacetylene cutters, mechanical sawing and diamond wire sawing. Afterwards they were melted in 50 melts, most of which resulted in 4 ingots, each weighing about 740 kg. 28 melts were of stainless steel, the others being of carbon steel.

The total quantity of radioactivity in the ingots proved to be $6.3.10^8$ Bq. Secondary waste produced amounted to about 4.25 ton. The collective dose for the 4 staff involved was about 1 millimanSv.

If the 0.8 Bq/g Co60 criterion (used hitherto) is applied, 32% of the carbon steel ingots could be released immediately, 55% by the year 2000 and the remaining 13% by 2004. On the same basis, 36% of the stainless steel ingots could be released by the year 2004, 61% by 2009 and the remaining 3% by 2011.

It was estimated that each preheater would occupy 113 m^3 of storage volume in the SFR repository. The 4.25 t of secondary waste would, in its conditioned state, occupy between 3 and 4 m^3 of storage volume.

Pilot Project on Recycling of Retired Steam Generators

As a second example, a pilot project has been carried out to demonstrate the feasibility of recycling the material in a steam generator by decontaminating the primary side to very low activity levels and then melting the decontaminated generator after segmenting (4).

The objective of the project was the free release (immediate or within a reasonable period of time) after decontamination and subsequent melting, of the tube bundles of two steam generators from the 80 MWe Ågesta plant, that operated outside Stockholm, Sweden, between 1964 and 1974. It contained a pressurized water reactor with heavy water as moderator and coolant, and four main cooling circuits, each with its own steam generator and recirculation pump.

The whole pilot project included:

- cutting out of the two steam generators from the primary system at the Ågesta site and transporting them to Studsvik;
- decontaminating the primary side surfaces using the SODP (Strong Ozone contamination Process) method, a single step process at room temperature, developed for the decontamination of (pressurized water reactors) scrap for free release of the material, where the chemistry is based on the use of ozone and cerium in nitric acid;
- segmenting and melting of the decontaminated steam generators, the stainless steel tubes, the stainless steel tube plate and the carbon steel in separate melts;
- conditioning of secondary waste from decontamination and melting.

The nuclide specific characterization of the oxide layers of the steam generators (1982) showed the activity to be 6.4 kBq/cm^2 due to Co60, 0.75 Bq/cm^2 to Pu239 and Pu240, 0.75 Bq/cm^2 to Pu238 and 0.80 Bq/cm^2 to Sr90.

The H3 content in the tube walls of the steam generators had been estimated to be about 0.8 MBq/g resulting in a total H3 content of 1.9 TBq for one steam generator and 2.4 TBq for the other.

The collective dose for the dismantling of the two steam generators was 3.3. millimanSv (shared by 14 persons) and that for decontamination was 14 millimanSv (shared by 12 persons).

After melting, nuclide specific measurements have indicated residual radioactivity levels of respectively 1 Bq/g and 4 Bq/g in the ingots of the tube bundles of the two steam generators. Total secondary waste produced amounted to 22 drums (200 litre) of conditioned waste.

With such activity levels of Co60, it is expected that the ingots from the decontaminated primary side tube bundles can be released in ten to twelve years from 1993.

Release of Concrete Demolition Waste in Belgium

The Eurochemic reprocessing facility, at the Mol-Dessel site in Belgium, was operated during 1966 to 1974. It was kept in a standby condition between 1975 and 1987, when it was decided to remodel the site for being used as a central waste processing and interim storage site. For this many of the existing buildings are being dismantled. Belgoprocess is responsible for the decommissioning project.

In order to check techniques and cost estimates for this major decommissioning project, the buildings 6A and 6B on the site were emptied and decontaminated as a pilot project. The buildings had been used for the storage of uranyl nitrate and spent solvents. For demonstrating the feasibility of the general decommissioning strategy, the demolition of the buildings and the removal of the demolition waste from the site were included as project objectives.

All process equipment was removed from the buildings and the concrete surfaces of the floors, walls and ceilings were decontaminated down to background level. This meant decontamination to a level of 0.04 Bq/cm for alpha emitters and of 0.4 Bq/cm for beta-gamma emitters. The monitoring of 100% of the surfaces was carried out twice by the Belgoprocess Health Physics Department to confirm that the contamination was below the above mentioned levels. Random spot measurements were then made by an independent officially approved inspection organization. The results of this inspection agreed with the earlier in-house results. In addition core samples were taken at the areas that had the highest contaminations before decontamination. The specific activities of these samples proved to be well below 1 Bq/g. There were only naturally occurring radioisotopes present. On the basis of these results, the buildings 6A and 6B were released from the "controlled" area.

After withdrawal from the controlled area, the final steps in the pilot decommissioning project were the demolition of the two buildings, the removal of the demolition waste to an industrial dumping ground of wastes, and the restoration of "green field" conditions. These final steps were complicated by the lack of regulations in Belgium for unrestricted reuse or uncontrolled dumping of material from radioactive sites. So evidence had to be supplied based on other decommissioning projects and on the recent recommendations within the European Community such as:

- removable alpha surface contamination < 0.04 Bq/cm^2,
- removable beta-gamma surface contamination < 0.4 Bq/cm^2,
- total specific beta-gamma activity < 1 Bq/g (mean value over an arbitrary mass of 1000 kg with an individual maximum of 10 Bq/g).

The results of the multiple 100% surface measurements in the two buildings and the additional controls (gamma spectrometry and total alpha and beta measurements) on selective core samples taken showed that the requirements of the first two criteria were met and that the third criterion limited to the core samples was also complied with.

It should be noted that many conservative factors had been used in the core sampling process:

- the operational history had been taken into account,
- the core samples had not been chosen on a random basis but had been taken from areas that had shown the highest degrees of contamination,
- the upper parts of the core samples (closest to the surface) had been used for the analysis of alpha and beta activity.

These measurements were subjected to statistical analysis for evaluating the probable mean value with a 99% confidence. These values were found to be conservatively below the requirements. So the building structures could finally be demolished and the demolition waste, about 2325 t of concrete, could be removed to an industrial dumping site.

CONCLUSIONS

From the material presented above, the following conclusions can be drawn:

- Considerable quantities of material are being released today from various projects at nuclear facilities. This is being done on a case by case basis.
- Such release can lead to problems, e.g. in connection with the trans-boundary movement of released material.
- The quantities of material eligible for release can be much higher in the future due to:
  - the replacement of components at aging nuclear plants,
  - the decommissioning and dismantling of nuclear facilities.
- Sentencing such material to burial as nuclear waste will result in:
  - high (avoidable) costs for expensive space at final disposal facilities,
  - the waste of valuable materials instead of reusing them.
- It is therefore vitally important to arrive at internationally accepted criteria for the release and reuse of redundant material from nuclear sites. These criteria should reflect an optimization of all aspects of recycling material and saving natural resources of the world for the future.

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