# RAINMAN - A METHODOLOGY FOR THE EVALUATION OF DECOMMISSIONING WASTE

**B. Bitetti[b], L. Brusa[c], M. Dionisi[a], A. Farina[a], G. Grossi[d], G. Mantero[b], S. Orlandi[b], G. Ruggeri[c], G. Scarsi[b]**

[a] ANPA
Rome, Italy

[b] ANSALDO
Genoa, Italy

[c] SOGIN
Rome, Italy

[d] ANPA
Rome, Italy
(now retired)

XA0202896

**Abstract.** The main objective of this study, promoted by ANPA, the Italian Nuclear Regulatory Body, carried out with ANSALDO and in close co-operation with SOGIN, was to define a methodology for the evaluation of the inventory of the amount of radioactive waste produced during the NPPs decommissioning activities, in terms of both volume and radioactivity content, and estimate the solid materials suitable for release from the regulatory control. The simulation code RainMan, developed within this project, allows, according to a selected scenario, for the evaluation of the solid materials that could be cleared and the volumes of the L-MLW that should be sent to a disposal facility.

## INTRODUCTION

The evaluation and classification of solid materials produced in the dismantling of a Nuclear Power Plant depends on different parameters.

With the aim to develop a standardised methodology for such evaluations, ANPA, the Italian Nuclear Regulatory Body, promoted a co-operation study with ANSALDO. The collaboration of SOGIN, responsible for the decommissioning of the 4 Italian NPPs was of great importance.

The main objective of the study was to define a methodology for the evaluation, with an acceptable accuracy and reliability, of the inventory of the amount of radioactive waste produced during the NPPs decommissioning activities, in terms of both volume and radioactivity content. Another objective was the estimation of the solid materials that could be released from the regulatory control.

## INPUT DATA

The study concerned the 4 NPPs that operated in Italy, namely:

| NPP | Type | Installed gross EP [MWe] | Date of Start Up | | Shut Down |
|---|---|---|---|---|---|
| | | | First criticality | Commercial Operation | |
| Caorso | BWR | 882 | 31/12/1977 | 28/11/1981 | 24/10/1986 |
| Garigliano | BWR | 160 | 05/06/1963 | 01/01/1964 | 08/08/1978 |
| Latina | GCR | 160 | 27/12/1962 | 01/01/1964 | 26/11/1986 |
| Trino | PWR | 257 | 21/06/1964 | 01/01/1965 | 21/03/1987 |

A data base was developed, containing the available inventory of systems, components and materials present in the controlled area[1] for each of these NPPs. The components and materials have been subdivided in different groups with its associated radioactivity contents (activation and/or contamination).

## IDENTIFICATION OF THE MOST SUITABLE TREATMENT AND CONDITIONING PROCESSES

The study has been developed considering mature and well referenced experiences in treatment and conditioning processes as well as the most advanced technologies in the decontamination field, with the intent of evaluating both the volume of final waste to be stored in a final repository and the volume of materials which can be cleared. The following processes have been considered.

### Decontamination

It is used to decrease the material residual contamination for twofold beneficial aspects, the reduction of the personnel exposure during the decommissioning activities (on-line decontamination) and the increase of the amount of materials whose residual activity will be lower than the release limit (decontamination of materials resulting from the dismantling activities in the frame of the decommissioning). Within the second type of decontamination it is useful to mention the decontamination of concrete structures by means of washing and even by mechanical removal of surface layers where most of the contamination resides.

[1] The inventory is being updated as far as the contamination of plant systems, components and structures is concerned.

### Incineration

It is a thermal process, applicable to the waste belonging to the category of combustible waste, which typically guarantees a rather high volume reduction factor. Sometimes, the incinerator feed may contain non combustible waste (e. g. contaminated liquid, slurry waste, small metallic objects, etc.) that, if present in limited amount, will not affect the result of the process.

The incineration process produces a waste residue in different forms: it may be ash (to be further conditioned in a stable matrix like cement), glass beads, glass matrix depending on the type of incinerator used.

### Supercompaction

Typically, the supercompaction is used to treat dry active waste (DAW) consisting of easily compactable material like gloves, suits, plastic, overshoes, etc.. Moreover, metallic scrap with low bulk density (e.g. cable trays, heat exchanger tubes, etc.), which is not profitable to be decontaminated, may be treated, as well.

The supercompactor feed is waste packaged in drums that are volume reduced by means of a press capable of very high compression strength, the product is a puck. A number of pucks are loaded into an overpack in order to produce a package suitable for the final storage.

### Smelting with induction furnace

It is a thermal process used for the volume reduction of non-combustible waste like metallic scraps, mainly obtained by the decommissioning activities, characterised by superficial contamination.

This process is capable of removing the contamination due to Cs-137, which is volatile at the operating temperature of the furnace, whilst Co-60 is homogeneously distributed within the melting bath and then it is fixed after solidification of the metal.

Depending on the initial scrap contamination, the resulting ingots may have a residual contamination below the limit of clearance.

### Liquid Waste Treatment

It includes a number of specific processes addressed to concentrate the radiochemical contamination in a reduced volume of slurry, sludges or concentrates subject to be immobilised in a hard matrix (e. g. cement) for storage and leaving a water phase with extremely low residual contamination suitable to be released to the environment.

Typical liquid waste treatment processes are the following:

- filtration
- evaporation / drying
- neutralisation
- solidification
- treatment with ion exchange resins
- precipitation.

### Embedding in cement

In some circumstances for solid waste, it may happen that a specific treatment is deemed not profitable or the treatment proved to give an unsatisfactory result in terms of residual activity of the material.

In this case clean cement mixture is poured on solid waste (packaged in a suitable container) to block the contamination in view of the final storage.

### No treatment

Radioactive waste with very low radioactivity content is allowed to be packaged in suitable container and shipped to the (final) storage without further treatment.

## EVALUATION METHODOLOGY

In order to obtain a complete evaluation tool, a simulation code has been developed by integrating the Data Base with a section where all the relevant characteristics for the identified treatment/dismantling/decontamination/conditioning processes are described. The parameters, having direct correlation with the final waste volumes to be sent to the repository, are specified in terms of: decontamination factor, volume reduction factor, secondary waste production, release limits.

The accuracy of such estimations is differently affected and the results are inherently impacted by the following evaluation process:

- knowledge of the complete inventory of systems, components and materials in terms of both geometrical dimension and radioactivity content;
- identification of all the processes suitable for the treatment of radioactive materials including the decontamination techniques;
- the clearance levels.

According to a specific scenario and by fixing a specific clearance level (e.g. 1 Bq/g) for the release of materials, the simulation code, named RainMan, allows for the evaluation of the solid materials that could be cleared and the volumes (activities) of the L-MLW that should be sent to a disposal facility.

Furthermore, the code allows for a choice of a particular treatment strategy associated to a particular group of material or component, that is function of the different volume reduction and decontamination factors characterising the process applied to the considered waste materials.

Due to the fact that the type and geometrical characteristics of the containers, suitable for the final repository, have not been consolidated yet, the waste volumes evaluated by means of this methodology (that are net volumes) have to be increased by a factor in the range of 1.5÷2 to take into account the volume increase of the packaging.

## RAINMAN TESTS

According to the methodology described in par. 4, different evaluations have been done of the volumes of waste to be stored in the final repository.

Table 1 shows an evaluation of the materials produced during the decommissioning of Caorso NPP before the treatment/conditioning processes.

As an application of the RainMan methodology, three different tests were carried out according to different waste management strategies:

- **LOW**

Where treatment processes with the maximum volume reduction and high decontamination factors are used.

- **HIGH**

Where treatment processes with lower volume reduction and lower decontamination factors are considered.

- **MEDIUM**

Where decontamination processes with low decontamination factor combined with treatment processes with high volume reduction factor are considered.

The results are summarized in the Table 2 and represented in Figure 1.

The assessment performed by SOGIN, based on the assumptions made in the preliminary design of Caorso NPP dismantling, is reported in Table 5.2 and shows a good agreement with the results obtained by the RainMan methodology.

## CONCLUSIONS

The activity was completed in 2001 and the RainMan code effectively demonstrated to be a powerful tool for investigation on how the different parameters involved in the decommissioning activities could affect either the dismantling strategy and the volumes of produced radioactive waste.

## APPENDIX I

Table 1 – Evaluation of materials produced from decommissioning Caorso NPP, before treatment/conditioning processes

| Non-radioactive materials ($m^3$) | Radioactive materials below clearance levels ($m^3$) | Radioactive materials above clearance levels ($m^3$) |
|---|---|---|
| 101126 | 47563 | 16531 |

Table 2 – Evaluation of Caorso NPP waste volumes resulting after the treatment/conditioning processes

| Waste management strategy | Volume of materials with activity below the clearance level ($m^3$) | Volume (*) of waste to the final repository ($m^3$) |
|---|---|---|
| LOW | 58926 | 2281 |
| HIGH | 56501 | 4147 |
| MEDIUM | 56501 | 3274 |
| SOGIN assessment | 62200 | 3400 |

*(*) not including the volume increase due to the packaging*

*Figure 1- Caorso NPP Waste volumes resulting after the treatment/conditioning processes*