Radiation Survey and Waste Inventory Estimation for Decommissioning of Taiwan NPP

Chun-Cheng Lin[1*], Wei-Sin Chen[1], Jyi-Lan Wuu[1], Shu-Jun Chang[1]

[1] *Health Physics Division, Institute of Nuclear Energy Research, No. 1000, Wenhua Rd., Jiaan Village, Longtan District, Taoyuan City 32546, Taiwan (ROC)*

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Abstract

Both radiation survey and waste inventory estimation are parts of the NPP (nuclear power plant) decommissioning program issues. This paper describes the radiation survey and site investigation methods based on MARSSIM. Waste inventory estimation for decommissioning is also essential in the whole decommissioning study; it affects D&D methods, decommissioning cost estimation, packing containers selection and repository design for decommissioning waste etc. This paper presents the preliminary outcomes of radiation survey and waste inventory estimation for decommissioning of Chinshan NPP.

1. Introduction

The purpose of the site survey and site investigation is to define the extent and magnitude of residual radioactive and hazardous materials within the radiological site. Accurate accounting of all contaminated materials and structures of the site is a prerequisite for the performance of reasonable cost and schedule estimation for the whole site dismantling and demolition. Both radiation survey and site investigation for radiological sites and facilities provide the radiation information for decommissioning strategy and waste inventory estimation.

This study presents the whole radiation survey and site investigation method based on the MARSSIM [1] (Multi-Agency Radiation Survey and Site Investigation Manual) and MARSAME [2] (Multi-Agency Radiation Survey and Assessment of Materials and Equipment Manual). The survey and investigation results can also be used to plan the further decommissioning strategy, including decontamination techniques, schedules, costs, waste volume, and health and safety considerations.

In the other hand, the waste inventory estimation is also an important issue during NPP decommissioning program, since D&D methods, decommissioning cost estimation, packing container selection, repository design for decommissioning waste etc. would be affected, hence the waste estimation methodology have to be determined.[3][4][5][6][7][8]

2. Methods and Results

2.1 Radiation Survey

In this section, the site survey and site investigation flowchart, survey investigation instruments and survey investigation techniques will be introduced.

2.1.1 Site Survey and Site Investigation Flowchart

The flowchart for site investigation and survey package classification is shown in Fig 1. The first step of site investigation is the historical site assessment (HSA). The purpose of HSA is to collect and evaluate information about the structures and systems to support a categorization decision and potential disposition of the material and elements (e.g., release or interdiction). The HSA results allow for the classification of site areas as affected or unaffected by the operational history, which can be corresponding to contaminated and non-contaminated. Based on the classification results and material properties, they can further divided into various survey packages, including A-, B-, C-, D- and R-survey packages.

A- and B-survey packages respectively represent the contaminated and non-contaminated structures, which include the building interiors and exteriors with associated structures, and the exterior surfaces of plant systems and components. An example for A-survey package survey position map is shown in Fig.2. It indicates the layout of the fifth floor in the sub-main building in the facility. There are 2 survey units and 59 survey points included in this survey package.

C- and D-survey packages respectively represent the contaminated and non-contaminated operating systems, which include interior surfaces of process piping, components, ventilation ductwork, and installed drains and sumps.

R-survey packages represent the land area and environment, which include the facility grounds within and outside the restricted area, the liquid effluent pathway, bay, groundwater wells and remote locations within the site boundaries.

Each survey package for its survey area shall contain the following elements: preparing a walk down worksheet, developing specific survey instructions for that area, and assembling the survey package.

After all the survey package designs are developed, the further processes will be executed as following: on-site measurement, activation analysis, sampling and laboratory analysis. Fig. 3 shows the R-survey package map for the radiological site. The potential contamination areas include the main building (R00600), sub-main building (R00700), the laboratory building (R00300) and storage building (R00800); survey packages will increase in those areas.

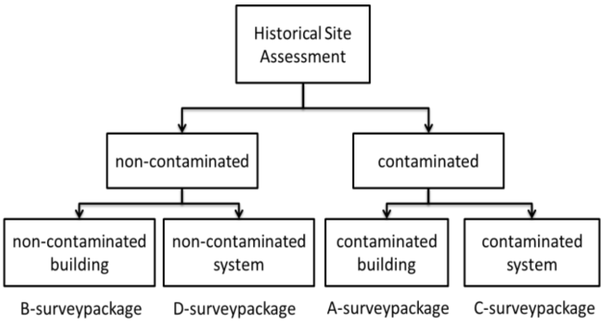

Fig. 1. The flowchart for survey designs and the classifications for survey packages.

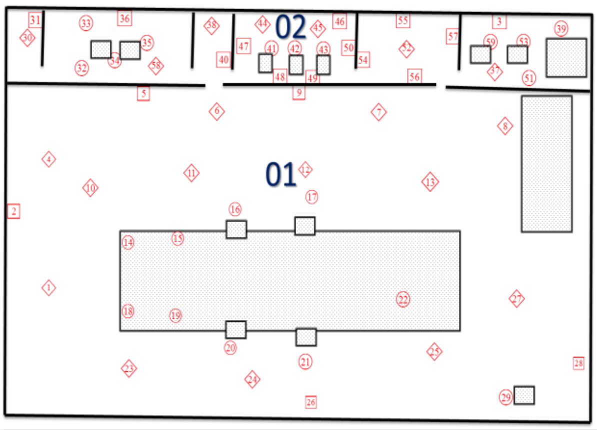

Fig.2. An example for the A-survey package maps. The symbols are represent to various detection types (e.g., □ for wall, ◇ for floor, and ○ for equipment)

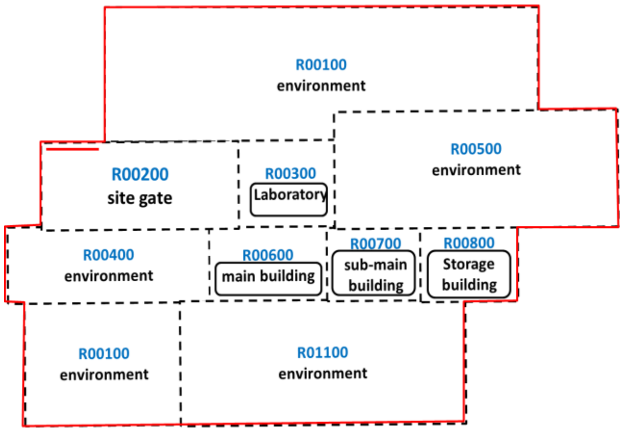

Fig. 3. The R-survey package map for the buildings and environment area at the site.

2.1.2 Survey Investigation Instruments

The detection types used in this study included on-site measurement detections and laboratory radionuclide analysis; the detailed information of used devices and instruments are listed in Table 1. All the detectors and instruments must be calibrated before use.

Table 1: Survey Investigation Instruments Lists

Detection Type	**Instrument Type**	**Instrument model**
On-site measurement (contaminated area)	Geiger	Automess 6112/ 6112B, THERMO FH40 F2/F4
	GM tube	Rados RDS-30
On-site measurement (non-contaminated area, environment)	NaI	RADEYE PRD, RADEYE PRD-ER
Laboratory Analysis	HPGe Detector, Gas-filled Proportional Counter, Liquid Scintillation Counting Counter, etc.	

2.2 Waste Inventory Estimation

2.2.1 Decommissioning Strategies and Information

In general, the decommissioning strategies include immediate dismantling, deferred dismantling and entombment. The option of entombment is only valid for emergencies and is not considered a proper decommissioning strategy.

A waste estimation, that is site-specific, is based on site radiological and hazardous material characterization information and further defined engineering data, including site and plot plans, general arrangement and architectural drawings, piping and instrument diagrams, one-line electrical diagrams, equipment specifications, reference manuals, etc., to provide a basis for the facilities, systems and structures requiring decontamination and dismantling.

Data collection also includes the site-specific inventory of systems and structures, local labor requirements for skilled labor and management and local consumables and materials.

2.2.2 Classifications of Radioactive Waste

The first step before waste estimation is to define the classifications by radioactivity, such as HLW (high level waste), SNF (spent nuclear fuel), TRU (transuranic waste), ILW (intermediate level waste), LLW (low level waste), FRW (free released waste), EW (exempt waste) and VLLW (very low level waste).

It has to be noticed that the LLW includes four subcategories (i.e. A, B, C and GTCC) only by NRC's requirement.

SNF is regard as operational waste in common, thus is not considered in the decommissioning waste estimation.

And the second step is to confirm the origins of radioactive waste that was from surface contamination, activation of materials or water processing streams.

2.2.3 Classification of Low-level Waste (LLW)

Determination of the classification of radioactive waste involves two considerations. One is the long-lived radionuclides; the other is shorter-lived radionuclides (and their shorter-lived precursors).

Taiwan refers the waste classification regulation to the NRC 10CFR61.55 for developing the classification of LLW.

Table 2 and 3 are to classify the LLW. If the concentration does not exceed 0.1 times the value in Table 2, the waste is Class A. If the concentration exceeds 0.1 times the value in Table 2 but does not exceed the value in Table 2, the waste is Class C.

If the concentration does not exceed the value in Column 1 of Table 3, the waste is Class A. If the concentration exceeds the value in Column 1 of Table 3, but does not exceed the value in Column 2 of Table 3, the waste is Class B. If the concentration exceeds the value in Column 2 of Table 3, but does not exceed the value in Column 3 of Table 3, the waste is Class C.

If the concentration exceeds the value in Table 2 or the concentration exceeds the value in Column 3 of Table 3, the waste is Class GTCC (Greater Than Class-C)

Table 2：Classification determined by long-lived radionuclides

Radionuclide	**Activity Concentration**
^{14}C	0.30 TBq/m^3
^{14}C in activated metal	3.0 TBq/m^3
^{59}Ni in activated metal	8.1 TBq/m^3
^{94}Nb in activated metal	0.0074 TBq/m^3
^{99}Tc	0.11 TBq/m^3
^{129}I	0.0030 TBq/m^3
TRU (Alpha emitting transuranic nuclides with half-life greater than 5 years)	3.7 kBq/g
^{241}Pu	130 kBq/g
^{242}Cm	740 kBq/g

Table 3：Classification determined by short-lived radionuclides

Radionuclide	**Activity Concentration (TBq/m^3)**		
	Column 1	Column 2	Column 3
Total of all nuclides with less than 5 year half-life	26	*Note**	*Note**
^{3}H	1.5	*Note**	*Note**
^{60}Co	26	*Note**	*Note**
^{63}Ni	0.13	2.6	26
^{63}Ni in activated metal	1.3	26	260
^{90}Sr	0.0015	5.6	260
^{137}Cs	0.037	1.6	170

Note*：There are no limits established for these radionuclides in Class B or C wastes. Practical considerations such as the effects of external radiation and internal heat generation on transportation, handling, and disposal will limit the concentrations for these wastes. These wastes shall be Class B unless the concentrations of other nuclides in Table 3 determine the waste to the Class C independent of these nuclides.

2.2.4 Low-level Waste (LLW) Inventory Estimation

It can be summarized the above information of decommissioning waste in two templates, material and radiological inventories, respectively. The accurate estimation of the waste quantities and activities to be generated during the dismantling operations and of the associated radiological burden requires a thorough and comprehensive inventory of all the plant system components and structures which are subject to potential radioactive contamination. There are the LLW inventory estimation of Chinshan NPP shown in Fig.5, Fig.6 and Fig.7.

Category	Weight %	Activity %
Metal RW		
Activated	12 %	95.6 %
Contaminated	88 %	4.4 %
Concrete RW		
Activated	42.5 %	~ 0 %
Contaminated	57.5 %	~ 100 %
Other RW		
Dry Active Waste	33.4 %	~ 0 %
Wet Solid Waste	62.4 %	~ 100 %
Insulation	4.2 %	~ 0 %

Category	Weight %	Activity %
Metal RW		
Class A	86.4 %	0.54 %
Class B	8.2 %	0.62 %
Class C	4.7 %	10.62 %
GTCC	0.7 %	88.22 %
Concrete RW		
Class A	100 %	100 %
Class B	0 %	0 %
Class C	0 %	0 %
GTCC	0 %	0 %
Other RW		
Class A	81.9 %	4.78 %
Class B	18.1 %	95.22 %
Class C	0 %	0 %
GTCC	0 %	0 %

Fig. 5. LLW Inventory Estimation of Chinshan NPP - Category (Activated, Contaminated, Metal, Concrete & Other).

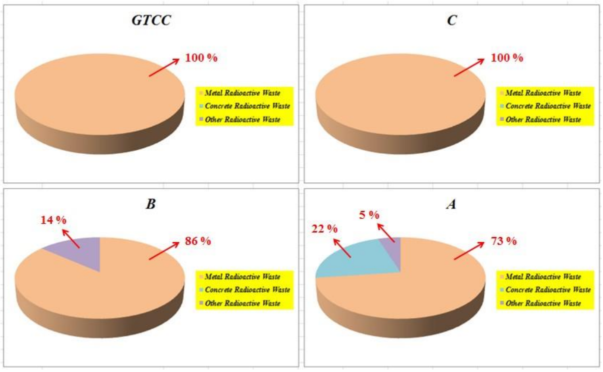

Fig. 6. LLW Inventory Estimation of Chinshan NPP - Classification (A, B, C & GTCC).

Category	Weight %	Activity %
GTCC	0.5 %	88 %
C	3.5 %	11 %
B	7 %	1 %
A	89 %	1 %
Total	100 %	100 %

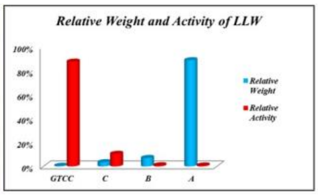

Fig. 7. LLW Inventory Estimation of Chinshan NPP - the weight and activity percentage of waste classification.

3. Conclusions

This study presents the whole radiation survey and site investigation methods based on the MARSSIM. On-site measurement and laboratory analysis are practiced with the survey methods and designs.

Radiation survey and site investigation can provide the radiation information for decommissioning planning and waste inventory estimation. These studies introduce the methodology of waste inventory estimation, including material and radioactivity, and demonstrate the preliminary outcomes of Chinshan NPP.

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