

**Study on Evaluation of Project Management Data for
Decommissioning of Uranium Refining and Conversion Plant - 12234**

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ABSTRACT

Some of nuclear facilities that would no longer be required have been decommissioned in JAEA (Japan Atomic Energy Agency). A lot of nuclear facilities have to be decommissioned in JAEA in near future. To implement decommissioning of nuclear facilities, it was important to make a rational decommissioning plan. Therefore, project management data evaluation system for dismantling activities (PRODIA code) has been developed, and will be useful for making a detailed decommissioning plan for an object facility.

Dismantling of dry conversion facility in the uranium refining and conversion plant (URCP) at Ningyo-toke began in 2008. During dismantling activities, project management data such as manpower and amount of waste generation have been collected. Such collected project management data has been evaluated and used to establish a calculation formula to calculate manpower for dismantling equipment of chemical process and calculate manpower for using a green house (GH) which was a temporary structure for preventing the spread of contaminants during dismantling.

In the calculation formula to calculate project management data related to dismantling of equipment, the relation of dismantling manpower to each piece of equipment was evaluated. Furthermore, the relation of dismantling manpower to each chemical process was evaluated. The results showed promise for evaluating dismantling manpower with respect to each chemical process. In the calculation formula to calculate project management data related to use of the GH, relations of GH installation manpower and removal manpower to GH footprint were evaluated. Furthermore, the calculation formula for secondary waste generation was established.

In this study, project management data related to dismantling of equipment and use of the GH were evaluated and analyzed.

INTRODUCTION

JAEA was established by integrating JAERI (Japan Atomic Energy Research Institute) and JNC (Japan Nuclear Cycle Development Institute) in 2005. JAEA had more than 230 various types of nuclear facilities after the establishment.

JAEA has been carried out integration and focused functions of nuclear facilities that have similar or redundant functions, and efficiently and systematically decommissioned nuclear facilities that would no longer be required.

As of now, some nuclear facilities have been decommissioned in JAEA as follows.

FUGEN nuclear power plant (FUGEN NPP) was operated from March 1978 to March 2003. Actual dismantling activities in FUGEN NPP were started from May 2008 [1].

The uranium refining and conversion plant (URCP) was operated from 1981 to 1999. Equipment of the wet conversion facility in the URCP was dismantled from FY2000 to FY2001. Dismantling activities of the dry conversion facility in the URCP began in 2008 [2].

Thus, in the future, a lot of nuclear facilities will be decommissioned in JAEA.

To implement decommissioning of these nuclear facilities, it is important to make a rational decommissioning plan from a long term point of view.

Therefore, project management data evaluation system for dismantling activities (PRODIA code) has been developed, and will be useful for making a detailed decommissioning plan for an object facility [3].

In planning a decommissioning project, project management data (such as manpower needs, costs, schedule, occupational dose, and waste generation) need to be evaluated.

To create an effective decommissioning plan for each nuclear facility, an evaluation model should be developed according to the type of nuclear facility based on actual dismantling data.

For this purpose, actual dismantling data has been collected during dismantling activities in various nuclear facilities of JAEA.

Ningyo-toge Environmental Engineering Center is currently being dismantled, and dismantling data is being collected.

In the URCP, dismantling procedure consists of separation, transfer, cutting, and storage, where “separation” means to separate equipment from its original position, “transfer” means to transfer separated equipment, “cutting” means to cut separated equipment into smaller pieces, and “storage” means to store cut pieces in the drum.

In this study, project management data such as manpower and amount of secondary waste were collected during dismantling activity in the URCP and evaluation model were analyzed.

OUTLINE OF PRODIA CODE

PRODIA is used to evaluate project management data (such as manpower needs, occupational dose etc.) based on the work breakdown structure, and to be useful for making a detailed decommissioning plan for an object plant.

The dismantling scenario and physical data such as weight, and contaminated levels are prepared as an input data. PRODIA code calculates manpower and amount of waste based on the evaluation models. Then, the output data such as manpower, secondary waste production, and occupational dose can be obtained.

The conventional models are classified into two types; the preparation / clean-up process and the dismantling process.

In preparation / clean-up process, the manpower is calculated using constant calculation formula involving 3 levels of working area: L1, L2 and L3. L1 is under 30 m², L2 is between 30 to 50 m², and L3 is over 50 m².

In the dismantling process, the manpower can be calculated by the multiplying the unit productivity factor and the weight of equipment using conventional evaluation model. The unit productivity factor is classified by the kinds of the equipment.

The conventional calculation formulas of PRODIA were derived with actual data related to the decommissioning of the JPDR, and therefore, the applicability of the conventional calculation formulas must be verified for decommissioning nuclear facilities of other types.

DECOMMISSIONING OF THE URCP

Outline of the URCP

The URCP is located in the Ningyo-toge Environmental Engineering Center of JAEA. The URCP was constructed in 1981 to demonstrate uranium refining and conversion technology, and then to develop methods on the purification and conversion technology of reprocessed uranium hexafluoride. The URCP is the 3-story building of reinforced concrete structure, and the radiation controlled area is 7,300m². The URCP is composed of two main facilities: a wet conversion facility for natural uranium, and a dry conversion facility for reprocessed uranium. The wet conversion facility was operated from March 1982 to March 1991. Equipment of the wet conversion facility was dismantled until FY2001 [4].

On the other hand, the dry conversion facility was operated from November 1982 to July 1999.

Capacity of conversion in the URCP was 200tU/y. Capacity of operating commercial conversion facility to UF₆ in the world is about 60 – 20,000tU/y [5]. Therefore, the URCP was equivalent to a commercial scale conversion facility.

Equipment of the dry conversion facility consists of utility process and chemical process. The dry conversion facility consisted of 6 chemical processes, that is, hydration pretreatment process (HP process), dehydration and reduction process (DR process), first and second HF fluorination processes (HF process I, II), and first and second F₂ fluorination processes (F₂ process I, II). Figure 1 shows the chemical process scheme of the dry conversion facility. In this facility, the HP process hydrated reprocessed uranium, UO₃. The DR process dehydrated hydrated UO₃ and reduced UO₃ to UO₂. Dehydration of hydrated UO₃ under high temperature condition increases the reactivity of UO₃. The HF processes I and II fluorinated UO₂ to UF₄. The F₂ processes I and II fluorinated UF₄ to UF₆. Each chemical process consists of feed hopper, receiver and reactor. The feed hopper, the reactor and receiver were set up from 3rd floor to 1st floor to transfer uranium compound by gravity.

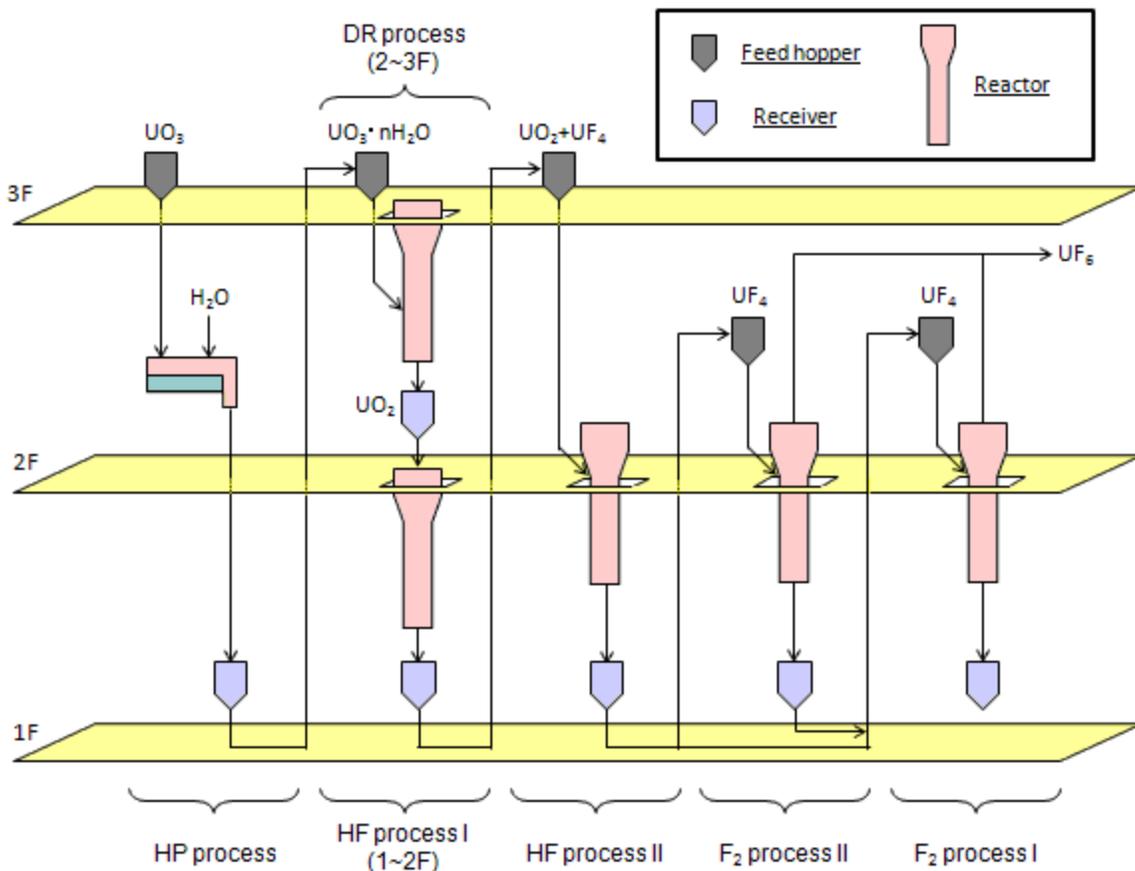


Fig 1. Chemical processes in the dry conversion facility.

Outline of Decommissioning of the URCP

Equipment from the wet conversion facility was dismantled from FY2000 to FY2001. The

decommissioning of the dry conversion facility of the URCP is expected to generate large amount of radioactive wastes, to take a long period of decommissioning, and to cost a huge amount. Therefore, in order to reduce costs, the basic strategy of decommissioning of the URCP is the optimization of the labor costs and the minimization of the radioactive wastes.

JAEA has no waste disposal site. Therefore, dismantled waste has to be temporary stored in the URCP.

Decommissioning the dry conversion facility will be carried out in two stages to ensure waste storage spaces.

1st stage (FY2008 - FY2011) : Dismantlement of equipment of the main chemical processes of the dry conversion facility.

2nd stage (FY2012 - FY2014) : Dismantlement of fluidization media storage underground tank, neutralization and precipitation system, and ventilation system.

Further plans have not been decided yet because of the uncertainty of the waste disposal scheme.

The first stage of the dismantling activity was started in FY2008 and finished in September 2011. About 470 tons of equipment was dismantled in the dry conversion facility from 2008 to 2011. The required manpower to accomplish this was about 12,000man-day.

ANALYSIS OF PROJECT MANAGEMENT DATA

Project management data has been collected during dismantling activities of the dry conversion facility. Then collected data was analyzed to make a calculation formula for the dismantling process and project management data concerning green house (GH).

Calculation Formula for Dismantling Process

The number of equipment items installed in the dry conversion facility was 3,722, and these equipment items were classified into several dozen kinds such as reactor, feed hopper, receiver, scrubber, rotary kiln, cold trap, chemical trap, cradle, concrete base and so on.

Manpower for dismantling several kinds of equipment was analyzed based on the actual dismantling data. The dismantling procedures of chemical process considered here were, separation from the cradle, transfer it to GH dedicated for cutting, cutting for storage, and storage of cut pieces. Figure 2(1) shows the relation between weight of equipment and dismantling manpower for each piece of equipment. There was correlation between weight of equipment and manpower for dismantling for each piece of equipment from Figure 2(1).

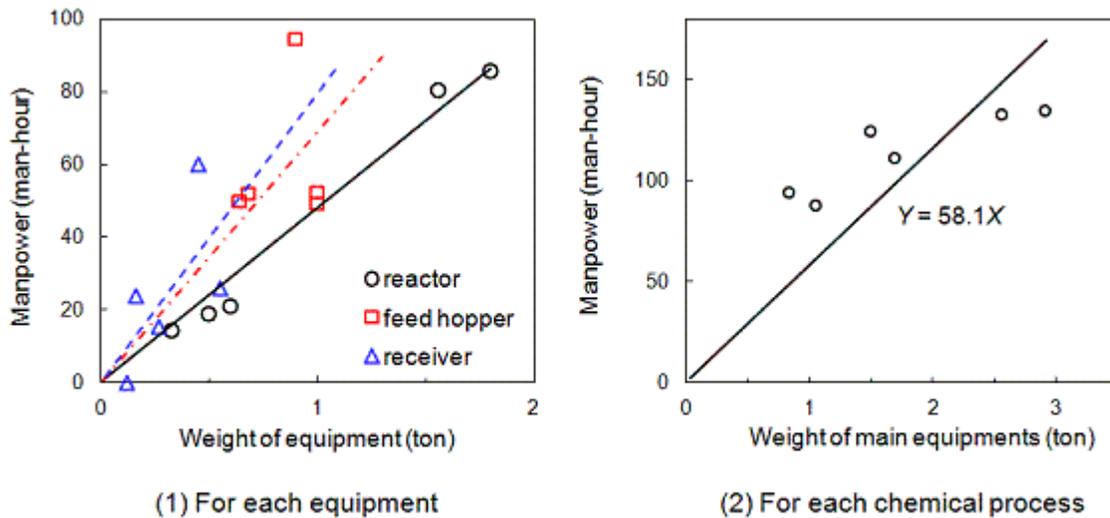


Fig 2. Relation between weight of equipment and manpower for dismantling.

The degree of dispersion of the data varied depending on the kind of the equipment.

Consequently, establishment of the calculation formula for dismantling of each kind of equipment makes it possible to evaluate manpower for dismantling the whole facility. However, it is not easy to prepare calculation formula for all kinds of equipment that exist in the facility. Therefore, a simpler evaluation method was considered to calculate manpower based on facility characteristics.

The main equipment of each chemical process consists of a feed hopper, reactor, and receiver. The feed hopper, the reactor, and the receiver were set up from top to bottom in this order, and uranium compound was transferred by gravity.

The dry conversion facility consisted of six processes; HP process, DR process, HF processes I, II, and F₂ processes I, II. The main equipment was the feed hopper, the reactor, and the receiver.

Each piece of main equipment in the dry conversion facility was separated and transferred to GH dedicated for cutting in the following order: (1) receiver, (2) reactor, and (3) feed hopper.

There was no significant difference in the dismantling procedures of dismantling feed hopper, reactor, and receiver between the six processes. Hence, actual dismantling data of each process were analyzed. As shown in Figure 2(2), it was shown that there was correlation between weight of equipment and manpower for dismantling.

It was found that weight of reactor was correlated with manpower for dismantling reactor.

These results showed promise for evaluating manpower with respect to each chemical

process. Therefore manpower for dismantling equipment of each process could be described as follows.

$$Y = 58.1 X \quad (\text{Eq. 1})$$

Where, X (ton) is weight of main equipments and Y (man-hour) is manpower for dismantling.

Calculation Formula for Project Management Data Concerning GH

For dismantling of contaminated equipment, a GH has been used for protection of the spread of contamination. The GH is installed by attaching plastic sheet to pipe frame by using adhesive tape. Each single lumen pipe constituting the pipe frame is also covered with plastic sheet to avoid contamination deposition. The use of a GH increases manpower for installation and removal of GH etc. Moreover, structural materials of the GH such as plastic sheets, adhesive tape become a burnable secondary waste.

In the URCP, the dismantling method had been improved as follows. In FY2008, the GH was installed for each piece of contaminated equipment, and dismantling activity for each piece of equipment was conducted on-site in each GH. By this dismantling method, the amount of secondary waste increased, and total manpower also increased. For example, when isolation house (weight: 550kg) was dismantled in the UF_4 supply room, the manpower for installation and removal of the GH (62.8m^2) was 248man-hour and 333kg of secondary waste was generated.

On the other hand, from FY2009, a GH dedicated for cutting equipment (9.7m^2) was installed in the fluoride precipitation room in 1st floor of the URCP. For this GH, an existing small room was reused as dismantling room (discussed later).

Each piece of contaminated equipment was removed from its original position and transferred to a GH dedicated for cutting. By these changes, the amount of secondary waste in 2009 decreased 30% compared to amount of secondary waste in FY2008.

To create an effective dismantling plan, it is necessary to carefully consider use of a GH preliminarily. Thus, an evaluation method of project management data such as manpower and secondary waste generation was considered.

At first, characteristics of a GH used in dismantling of the dry conversion facility were organized, and the structure of the GH was classified into standard type, small type, and additional type.

Figure 3 show the structural drawing of a standard type GH. The standard type GH consisted of 5 rooms, that was, a dismantling room (DI room), a protective clothing changing room (PC room), a radiation survey room (RS room), a drum entrance room (DE room), and a drum radiation survey room (DS room). DI room was exhausted through the HEPA filter and kept under

negative pressure. Dismantling workers entered the DI room through the RS room and the PC room, and cut contaminated equipment into smaller pieces in the DI room. Then, cut pieces were transferred from the DI room to the DE room, and put into the drum in the DE room. The drum was transferred from the DE room to the DS room after decontaminating the surface of drum. The drum was surveyed in the DS room. Dismantling workers put on and take off protective clothing such as tyvek suits and full face masks in the PC room. The surface of the dismantling worker's body was surveyed in the RS room.

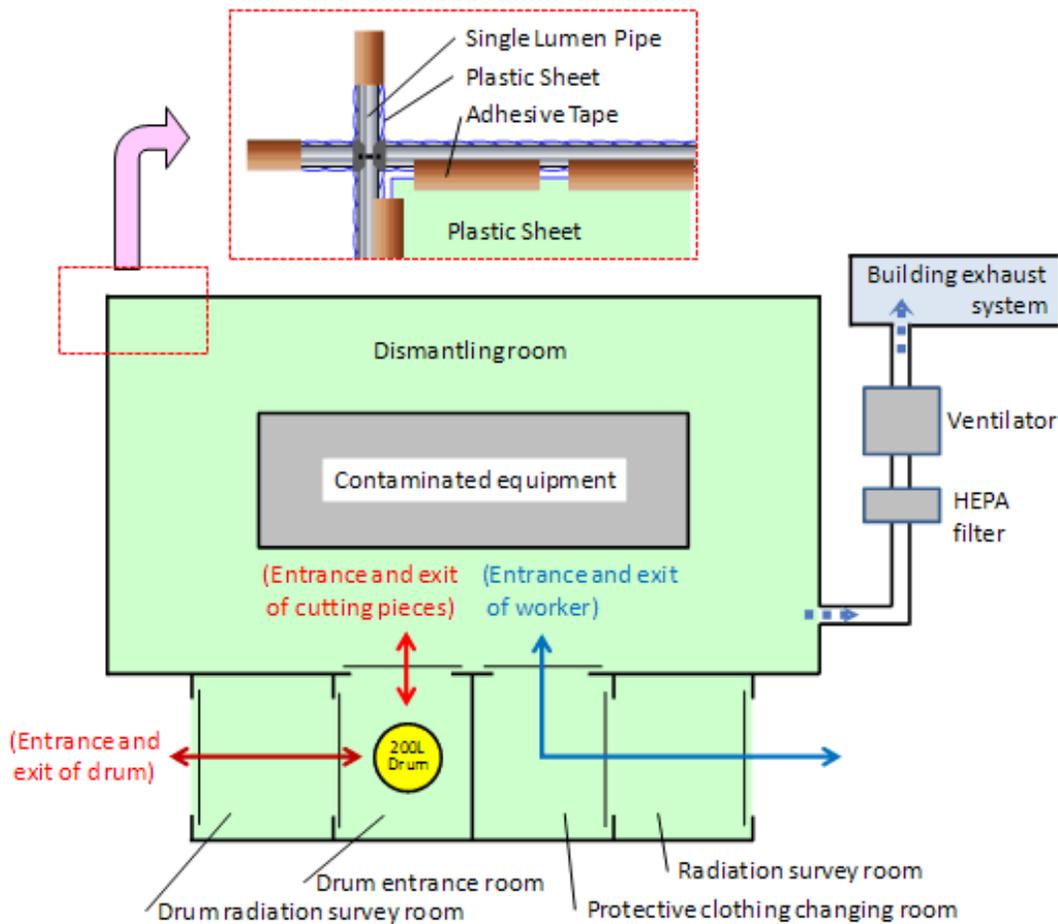


Figure 3. Structure of standard type GH (Top view).

The small type GH consisted of less than 5 rooms because of the situation of the installation of equipment to be dismantled. For example, some were designed without DE room, DS room and so on.

The additional types of GH were exceptional GH used for special purpose, and excluded from

the evaluation. The additional types of GH were designed to reuse an existing small room such as a DI room. For example, a robot hood made by plastic panels was used as DI room in fluoride precipitation room. Eight of the standard type GH, six of the small type GH, and one of the additional type GH were installed for dismantling equipment from the dry conversion facility.

During dismantling activities in the dry conversion facility, manpower required was collected for installation and removal of GH. Figure 4 shows the relation between the GH footprint and manpower for installation and removal of the GH. It was found that the GH footprint was related to manpower of installation and removal of the GH. The evaluation method of manpower about GH was considered based on the actual data gained from dismantling of dry conversion facility. For the standard type and the small type GH, calculation formula for installation and removal manpower was established using the GH footprint as parameter.

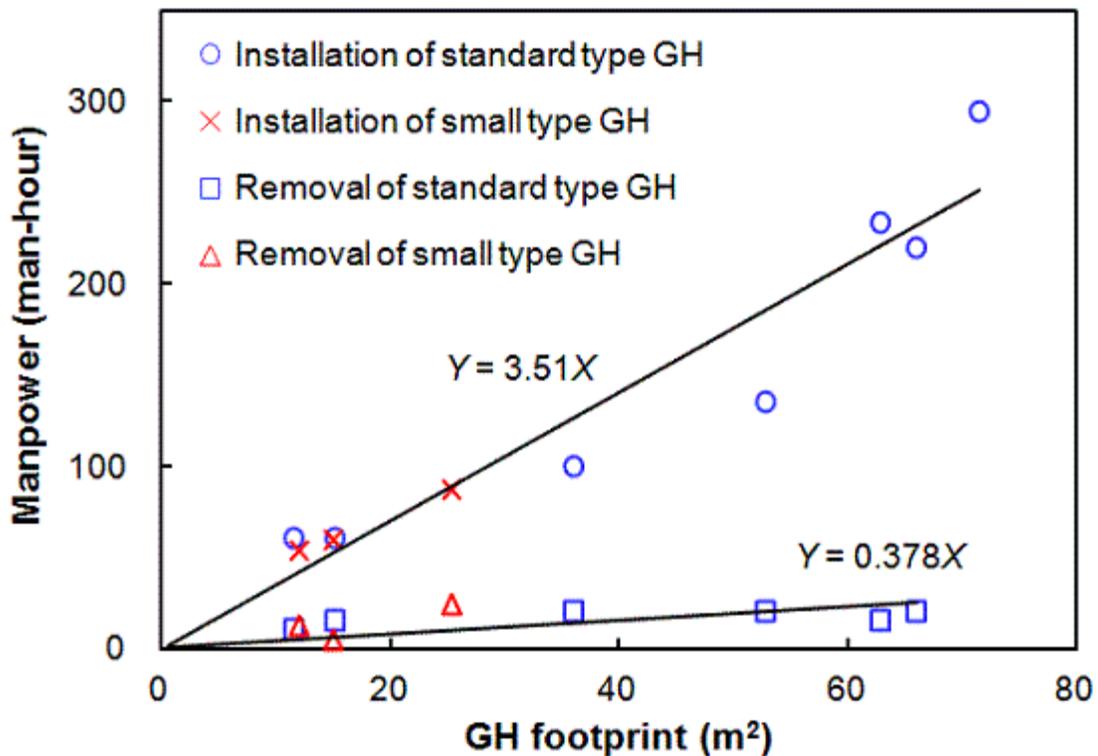


Figure 4. Relation between GH footprint and manpower of GH installation and removal.

Table I shows the calculation formula for installation and removal manpower, where X means GH footprint (m²), and Y means manpower (man-hour) according to GH type.

Table I. Calculation formula for manpower of installation and removal of GH.

GH type	Installation of GH		Removal of GH	
	Individual formula	Common formula	Individual formula	Common formula
Standard type GH	$Y = 3.50 X$	$Y = 3.51 X$	$Y = 0.34 X$	$Y = 0.38 X$
Small type GH	$Y = 3.69 X$		$Y = 0.81 X$	

There were not any significant differences between calculation formula for the standard type and the small type GH. Therefore, a common formula $Y = 3.51 X$ was established for installation of the GH, and $Y = 0.38 X$ was established for removal of the GH. Where, error is given by twice the standard error.

Evaluation of Secondary Waste Generation Concerning Use of GH

Meanwhile, a calculation method of secondary waste generation from use of the GH (standard type) was considered. Secondary waste arising from use of the GH was divided into three areas: structural material of the GH (plastic sheet, adhesive tape), decontamination material of floor in the GH (damp paper towel) and protective clothing of workers (tyvek suite, rubber gloves, and cotton gloves) during dismantling activities in DI room.

Secondary waste generation of structural material of the GH could be calculated as follows. The amount of plastic sheet generation could be calculated by weight per unit area (101.2g/m^2), inner surface area of the GH (S_{GH} (m^2)), and surface area of single lumen pipe ($0.05 \pi L_{GH}$ (m^2)). The last term describes the plastic sheet covering the surface of single lumen pipe to avoid contamination deposition. L_{GH} (m) is total length of single lumen pipes used as frame of the GH. Plastic sheets of the GH were fixed to single lumen pipes with adhesive tape. Amount of adhesive tape generation could be calculated by weight per unit length (18.4g/m) and L_{GH} . The calculation formula for secondary waste generation of structural material of the GH could be expressed as follows.

$$Y = 101.2 S_{GH} + 34.3 L_{GH} \quad (\text{Eq. 2})$$

Where, Y (g) is amount of secondary waste. Secondary waste generation of decontamination of floor of the GH could be calculated as follows. Decontamination of floor of the GH was carried out after dismantling activities in the GH with damp paper towels. Amounts of damp paper towel generation was calculated by coefficient 1.2×10^4 (g/m^2), derived from weight of actual damp paper towel generation and the GH footprint F_{GH} (m^2). The calculation formula for secondary waste generation of decontamination material could be expressed as follows.

$$Y = 1.2 \times 10^4 F_{GH} \quad (\text{Eq. 3})$$

The amount of protective clothing generation was calculated by coefficient 8.08, 98.4 (g/man-hour) which were derived from gross weight of protective clothes used for the GH installation and removal, and dismantling in the GH, respectively.

Calculation formula for secondary waste generation of protective clothes for dismantling in the GH could be expressed as follows.

$$Y = 98.4 M_{PG} \quad (\text{Eq.4})$$

Where, M_{PG} (man-hour) is manpower for dismantling in the GH.

From the above coefficient (8.08 (g/man-hour)) and F_{GH} , and calculation formula for manpower of the GH installation and removal (Table I), calculation formula for secondary waste generation of protective clothes for the GH installation and removal was established as follows.

$$Y = 3.1 \times 10^1 F_{GH} \quad (\text{Eq. 5})$$

A calculation formula for secondary waste generation was established using the GH footprint, length of single lumen pipe, inner surface area of the GH, and manpower for dismantling in the GH as parameters as follows.

$$Y = 101.2 S_{GH} + 34.3 L_{GH} + 1.2 \times 10^4 F_{GH} + 98.4 M_{PG} \quad (\text{Eq. 6})$$

Verification of reproducibility of established calculation formula of secondary waste generation

Reproducibility of established calculation formula of secondary waste generation was tested with actual data of hydration conversion room II. Actual data of hydration conversion room II could not be decomposed into amount of structural material of the GH and amount of decontamination material. For this reason, amount of structural material of GH and amount of decontamination material were grouped together for comparison. Table II shows the result of comparison.

Table II. Comparison of calculated data and actual data (hydration conversion room II).

	Calculated value (kg)	Actual value (kg)	Reproducibility (%)
Protective clothing	2.7	4.3	63.0
Structural material of GH and decontamination material	196.1	52.1	376.4
Total	198.8	56.4	352.5

In the result, calculated value of structural material of the GH and decontamination material was about four times larger than that of actual value. This is because there was great difference in the amount of decontamination material between calculated value and actual value. Therefore, the coefficient of decontamination material generation (1.2×10^4 (g/m²)) should be improved in the future.

CONCLUSION

Dismantling of dry conversion facility in the uranium refining and conversion plant (URCP) at Ningyo-toke began in 2008. During dismantling activities, project management data such as manpower and amount of waste generation have been collected.

The project management data, manpower for dismantling of equipment, manpower for installation and removal of GH, and secondary waste generation from GH were considered.

Establishment of the calculation formula for dismantling of each kind of equipment makes it possible to evaluate manpower for dismantling the whole facility. However, it is not easy to prepare calculation formula for all kinds of equipment that exist in the facility. Therefore, a simpler evaluation method was considered to calculate manpower based on facility characteristics.

The results showed promise for evaluating dismantling manpower with respect to each chemical process.

For dismantling of contaminated equipment, a GH has been used for protection of the spread of contamination. The use of a GH increases manpower for installation and removal of GH etc. Moreover, structural materials of the GH such as plastic sheets, adhesive tape become a burnable secondary waste.

To create an effective dismantling plan, it is necessary to carefully consider use of a GH preliminarily. Thus, an evaluation method of project management data such as manpower and secondary waste generation was considered.

The results showed promise for evaluating project management data of GH by using established calculation formula.

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