Preliminary Safety Assessment on Predisposal Management of Metal Waste Generated from Decommissioning of Nuclear Power Plants

Ji Su Kang [a], Jae Hak Cheong [a*]
[a]*Nuclear Engr., Kyunghee Univ.,1732, Deogyeong-daero, Giheung-gu, Yongin-si, Gyeonggi-do, Republic of Korea*
**Corresponding author: jhcheong@khu.ac.kr*

1. Introduction

While the radioactive waste management framework at nuclear power plants(NPPs) in operation has been well established in Korea, the regulatory guide considering the characteristics of decommissioning waste has not been developed yet. Therefore, the operator of the NPP may take various options for predisposal management of decommissioning waste generated during the dismantling and decontamination processes.

Each decommissioning waste would be subject to various predisposal management steps such as pretreatment including proper sorting and collection, treatment, conditioning, storage, and transport. In order to systematically identify these management steps, it is essential to develop regulatory technologies that can evaluate and verify the safety of decommissioning waste in various predisposal management phases. The development of authorizations and of limits, conditions and controls for the predisposal management of radioactive waste benefits from close communication and cooperation between the operators, regulatory bodies and other interested parties [1].

The International Atomic Energy Agency (IAEA) has provided safety assessment principles and basic approaches in predisposal management of radioactive waste as well as an example of the safety review of the regulatory body in the Safety Guide for the Safety Case and Safety Assessment for Predisposal Management of Radioactive Waste [2]. The IAEA commenced joint research on Safety Assessment Driving Radioactive Waste Management Solutions (SADRWMS) on the safety of predisposal management and Safety Assessment Framework (SAFRAN) computer code was developed. In this regard, research using the SAFRAN computer code for predisposal management of decommissioning waste has been conducted in the Third World, such as Iraq and Brazil, but has not been found in other countries [3-4].

In the previous case, domestic application studies were approached and review for predisposal management methodology to radioactive waste generated during decommissioning were reported in May 2019 [5]. The authors identify representative decommissioning wastes generated during decommissioning through the Decommissioning Experience Report in other countries and expected amount of Kori Unit 1 permanently shut down [6].

2. Methods and Results

In 2004, the IAEA commenced SADRWMS methodology on the safety of radioactive waste management prior to disposal. The SADRWMS was carried out for the purpose of establishing the safety assessment methodology for the predisposal and storage facilities of radioactive waste, and the SAFRAN computer code was developed in 2005. The SAFRAN computer code can be used to perform the predisposal management safety assessment of each decommissioning waste through the algorithm.

2.1 Predisposal management modeling of radioactive waste generated from decommissioning of NPPs

The types of radioactive waste generated during the decommissioning of NPPs can be classified into metal, concrete, soil, spent filter, resin, and DAW. Consideration should be given to facilities for radioactive waste predisposal management and the various treatment processes of decommissioning waste. Korea Hydro & Nuclear Power Co., Ltd. is planning to process decommissioning wastes generated from domestic NPPs at any waste disposal facilities. Fig. 1 below shows some examples of predisposal management processes for different types of waste that was presented at the Waste Treatment and Disposal Working Group Technical Exchange Workshop [7].

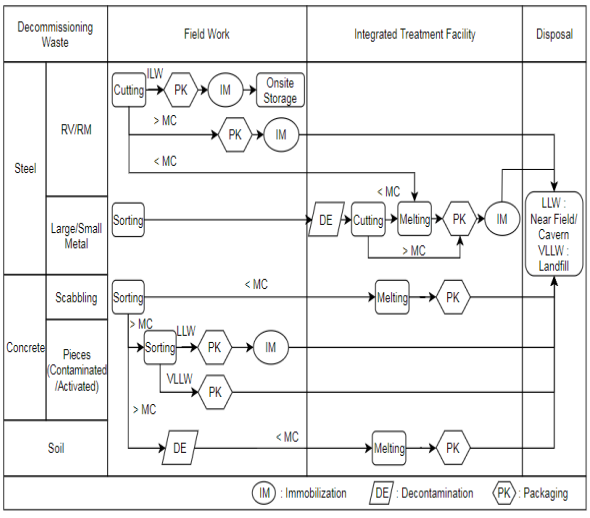

Fig. 1. Example of predisposal management of decommissioning waste from NPPs.

2.2 Radioactive Metal Predisposal Management Modeling

The waste stream was implemented by SAFRAN computer code in the predisposal management step by selecting radioactive metal from the types of radioactive waste shown in Fig. 1. The predisposal management process for radioactive metals is simplified and shown in Table 1. Each process of predisposal management of metal waste is divided into four stages of cutting, melting, packaging and storage, and ingot, slag and dust are generated when melting. In this study, ingot generated during melting was modeled by designating process 1, slag as process 2 and dust as process 3.

Table 1. Simplication for Predisposal Management Processing of Metal Waste Generated from Decommissioning.

Process	Predisposal management processing
1	Cutting-Melting-Ingot-Packaging-Storage
2	Cutting-Melting-Slag-Packaging-Storage
3	Cutting-Melting-Dust-Baghouse filter-Storage

The safety assessment of predisposal management in the integrated processing facility uses SAFRAN computer codes and requires various input factors. Table 2 shows the input parameters of the SAFRAN computer code.

Table 2. The SAFRAN Computer Code Input Factor for Predisposal Management Safety Assessment.

Factor	Input Data	Unit
Integrated Processing Facility	Air Release rate	Bq/y
	Liquid Discharge rate	Bq/y
	Filtration Efficiency	-
	Concentration in air	Bq/m^3
	Capacity of Equipment	m^3
	External Dose Rate	Sv/h
Waste Components	Duration of the waste processing	y
	Annual volume of waste	m^3/y
	Annual mass of waste	kg/y
	Type of container or package	m^3
	Volumetric concentration	Bq/m^3
Worker	Working time for each process	h/y

2.3 Preliminary safety assessment for each step of predisposal management of radioactive metal waste

The preliminary safety assessment of predisposal management of radioactive waste using the SADRWMS methodology assesses the radiation exposure doses of workers and hazard for each process step in normal operation. The criteria for safety assessment should be based on national regulations and/or IAEA regulations or a user can define its own definitions of general regulatory requirements and specify the types of outcomes and criteria used in different safety assessment [8].

The International Commission on Radiological Protection (ICRP) derive the limit of an average of 20 mSv per year over five years for the occupational dose limit and 1 mSv per year for the public dose limit [9]. In the case of worker exposure, the total worker exposure was 4.13 mSv/y, with cutting at 1.04 mSv/y, melting at 3.48E-01 mSv/y, packaging at 8.70E-02 mSv/y, and storage at 8.70E-02 mSv/y. These results met the criteria of the ICRP 60 recommendations for workers. In the case of hazard, 1.74E+03 was derived for each process. This is a very high level of hazard for each process, and the safety assessment will be verified later.

3. Conclusions

Since the actual decommissioning system differs from the operation, the safety assessment for various stages in predisposal management is required. Through the standard methodology, SADRWMS, its applicability to the predisposal management stage of domestic decommissioning waste was identified. As a result of the preliminary safety assessment of radioactive metal waste generated during decommissioning, the radiation exposure doses of workers did not exceed the annual worker exposure dose recommended by ICRP 60.

However, the hazard of each process was very high at 1.74E+03, the level of hazard for each process needs to be additionally verified. A study will be conducted on the safety assessment of predisposal management of concrete waste with a high proportion of radioactive waste. The SAFRAN code enables the calculation of the radiation exposure doses of worker at the predisposal management facility in the event of an accident such as drop of the drum, fire, lightning, flooding or extreme temperatures. Assuming accidents, safety assessments can be conducted to verify worker exposure doses against regulatory guidelines. An important accident scenario for metal waste management would be the drop of the drum stored at the predisposal step. If information on the processing system to be adopted at the actual decommissioning site is available, more detailed practical studies are to be needed.

In this study, through the predisposal management of various wastes generated by the decommissioning of NPPs, it is possible to operate radioactive waste repository economically and efficiently by processing them before they are transferred to disposal facilities. Furthermore, if an integrated processing facility for decommissioning waste is established on the site, it will be possible to minimize worker and public exposure affected by safe management of radioactive decommissioning waste.

4. Acknowledgement

This work was supported by the Nuclear Safety Research Program through the Korea Foundation Of Nuclear Safety (KOFONS), granted financial resource from the Nuclear Safety and Security Commission (NSSC), Republic of Korea (No. 1605008).

REFERENCES

[1] International Atomic Energy Agency (IAEA), "Predisposal Management of Radioactive Waste", Safety Standards Series No. GSR part 5, 2009.
[2] International Atomic Energy Agency (IAEA), "Safety Guide for the Safety Case and Safety Assessment for Predisposal Management of Radioactive Waste", Safety Standards Series No. GSG-3, 2013.
[3] Kinker M., et al., "Safety assessment driving radioactive waste management solutions (sadrwms methodology) implemented in a software tool (safran)", Brazilian Journal of Radiation Sciences, 2014.
[4] Arkan T., et al., "Safety Assessment Analysis for Legacy Radioactive Waste", International Journal of High Energy Physics, 2017.
[5] Ji Su Kang, Na Yoon Choi and Jae Hak Cheong, "Review and Preliminary Application of SADRWMS Methodology to Decommissioning Waste from NPPs", Proc. of the KRS 2019 Spring Conference, May 8-10, Busan.
[6] Electric Power Research Institute (EPRI), "Review of Waste Management Best Practices during Nuclear Plant Decommissioning", 2015.
[7] Korea Hydro and Nuclear Power Corporation (KHNP), "Decommissioning Waste Management System Using RFID", Workshop of Radioactive Waste Treatment and Disposal, June 26, 2018, Daejeon.
[8] Pakistan Nuclear Regulatory Authority (PNRK), "A Case for Safety Assessment of Pre-Disposal Waste Management Using SAFRAN Tool", 2012.
[9] International Commission on Radiological Protection (ICRP), ICRP Publication 60, 1991.