A Study on Pressurizer Cutting Scenario during Decommissioning of Pressurized Water Reactor

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ABSTRUCT

The operations of design lifecycle in a nuclear power plant targeted to be decommissioned leads to neutron activation. The decommissioning process comprises many operations, such as cutting, decontamination, disposal and processing. Among these, since cutting is done in close proximity to the target material, for the cutting workers are overexposed to radiation. As there are not enough studies on pressurizers, more are necessary to assess the radiation exposure dose. This study obtained specifications of the AP1000 pressurizer of Westinghouse and distribution of radionuclide inventory of a pressurizer in a pressurized water reactor, which is operating for 40 years, for evaluation based on literature studies. Additionally, VISIPLAN S/W was chosen as a tool to estimate the exposure dose. A cutting scenario was created to develop an optimal method so that the cut pieces fully fill a radioactive solid waste drum of dimension 0.571 x 0.834 m. The estimated exposure dose ranged from DF-0 to DF-100, indicating that DF-90 and DF-100 met the ICRP recommendation on exposure dose 0.0057 mSv/hr. Finally, although flame cutting was considered as the most efficient method in terms of cutting speed, laser cutting was the most reasonable one given the financial aspects and secondary waste.

METHOD

I. Introduction

At a nuclear power plant targeted to be decommissioned, its operations during the design lifecycle leads to neutron activation. The decommissioning process consists of many operations, such as cutting and decontamination, but among these, cutting is likely to make workers overexposed to radiation, as it is one of the operations done in close proximity to the targeted structure. Large structures targeted to be decommissioned include a reactor, steam generator, RCS, and pressurizer, but there are relatively insufficient studies being done on pressurizers.

Against this backdrop, this study chose pressurizers out of the large structures to be dismantled and assessed the exposure dose of workers by establishing a cutting scenario. VISIPLAN S/W was chosen as a tool to estimate the exposure dose, and a cutting scenario was created as a way to produce an optimal method of making a radioactive solid waste drum with the dimensions of 0.571 m * 0.834 m fully filled with the cut pieces.

II. VISIPLAN S/W

The application of ALARA plan to operations and all operations carried out at a nuclear power facility are generally complicated, which makes assessment planning and operation analysis difficult. VISIPLAN 3D ALARA planning was developed by SCK·CEN in 1995 as a new calculation method used for facility operation planning based on a three-dimensional structure and material composition and radiological information.

II-1. Point Kernel Integration

Density of uncollided flux, caused by a line source, area source, or volume source in large size, refers to a calculation method of dividing the source into smaller parts and adding all of them by considering the divided source as a point source.

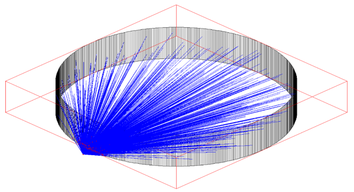

Fig. 1. Point Kernel Integration.

Table I: Specification of pressurizer

Parameter		Value
Body	Height	14.4 m
	Outer radius	1.41 m
	Inner radius	1.27 m
Material (Carbons steel)		7.87 g/cm^2

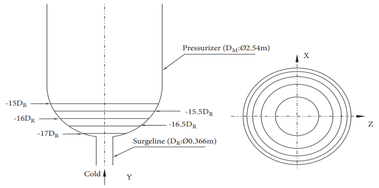

Fig. 2. Specification of pressurizer head.

II-2. Modelling and Source Entry

To model a pressurizer with the VISIPLAN S/W, the information on the materials and overall specifications of the pressurizer are required. The pressurizer referenced for this study was Westinghouse's pressurized water reactor AP1000. The applied specifications are shown in Table 1 and Figure 2.

The major source of contamination of pressurizers is the reactor coolant that flows through the pipes of the primary system. The entire reactor coolant system becomes contaminated by radioactive substances that are accumulated for a long time as the activated coolant flows in the closed cycle.

This study adopted the distribution of nuclides of a pressurized water reactor that had been run for 40 years to reflect its degree of contamination. Furthermore, the lower head with a relatively high level of radiation was differentiated by being applied with the quantity of radiation emitted from the heater.

Table I: Specification of pressurizer

	Body (Bq/cm^2)	Heater (Bq/cm^2)
^{58}Co	3.00E+00	9.00E+00
^{60}Co	1.29E+03	9.05E+03
^{94}Nb	4.15E+00	1.01E+01
^{110m}Ag	1.0E+00	5.01E+01
^{137}Cs	4.0E+00	10.0E+00
^{54}Mn	5.05E+01	2.75E+03

II-3. Cutting Scenario

This study assumed that the 11.58-meter-long cylindrical body was cut into 13 pieces in ring type, which in turn were cut into 16 pieces in y-axis in consideration of the standard size of a radioactive solid waste drum. Furthermore, the operation scenario where the head at the top and the bottom was cut into 16 pieces in y-axis and then into two pieces in x-axis was established.

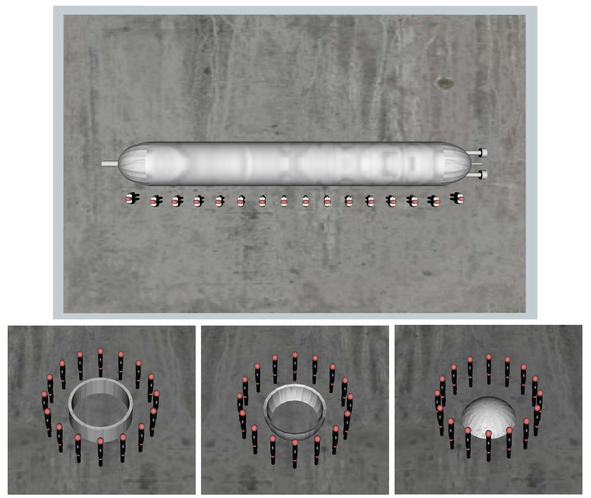

Fig. 3. Cutting scenario.

As for the adopted cutting techniques, the following two methods were compared with another for further evaluation: plasma-arc (16.51 cm/min) and laser (12.7 cm/min) cutting.

CONCLUSIONS

This study assessed each cutting technique per decontamination factor based on the established cutting scenario. The results showed that plasma and laser cutting were recorded at 0.21 mSv and 0.26 mSv respectively at DF-100, 0.39 mSv and 0.52 mSv respectively at DF-50, and 20.10 mSv and 25.79 mSv respectively at DF-0.

The results of this study indicated that all of the results fell within the limit on annual effective dose, except for those before the decontamination. However, as the decommissioning of a nuclear power plant involves the dismantling of not only a pressurizer but other large structures, it is deemed necessary to execute proactive exposure control based on a proper decontamination factor for effective protection of workers involved in such an operation.