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

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1. 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.

2. Methods and Results

2.1 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.

2.1.1. 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.

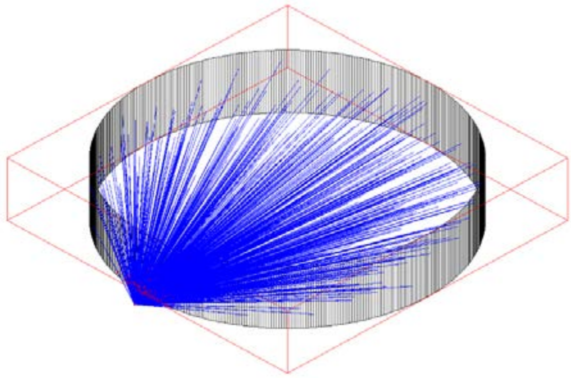

Fig. 1. Point Kernel Integration.

2.2. Modeling 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.

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

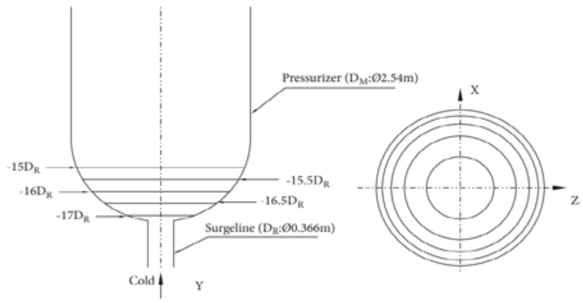

Fig. 2. Specification of pressurizer head.

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 II: Distribution of Nuclides in Pressurizer

	Pressurizer body (Bq/cm^2)	Pressurizer 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

2.3. 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.

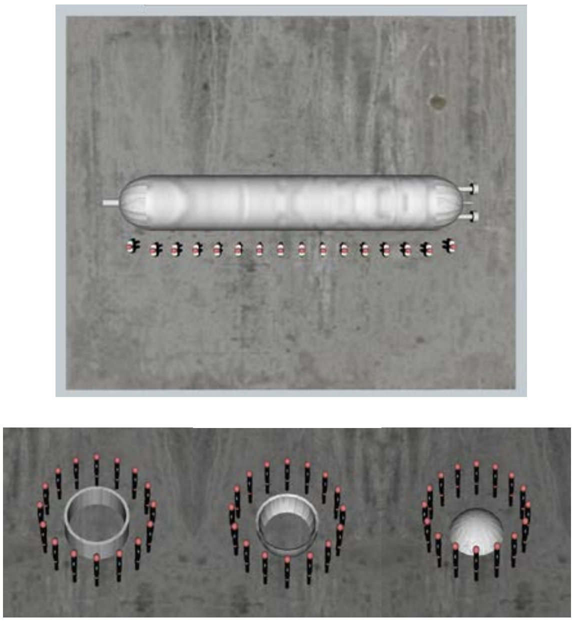

Fig. 3. Cutting scenario.

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.

3. Conclusions

Table III: Distribution of Dose per Decontamination Factor

Value (mSv)	Plasma-arc	Laser
DF-100	0.21	0.26
DF-90	0.22	0.29
DF-80	0.24	0.33
DF-70	0.29	0.37
DF-60	0.34	0.43
DF-50	0.39	0.52
DF-40	0.50	0.66
DF-30	0.67	0.89
DF-20	1.01	1.29
DF-10	2.04	2.60
DF-0	20.10	25.79

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.

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