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Estimation of a boundary to distinguish between radioactive materials and non-radioactive materials around a Main Steam line and a Feed Water line in a Biological Shielding Wall of a BWR for decommissioning

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ABSTRACT

In order to estimate amount of radioactive concrete waste from decommissioning activities of a Boiling Water Reactor (BWR), we performed an estimation of a boundary to distinguish between radioactive materials and non-radioactive (NR) materials, which we call NR boundary in our work. So as to estimate the boundary reliably, we measured radioactivities induced by neutrons with activation foils around a Main Steam (MS) line in a MS tunnel room and also calculated three dimensional (3D) distribution of neutron-flux around both the MS line and a Feed Water (FW) line, which penetrate a Biological Shielding Wall (BSW) of the BWR, by using 3D discrete-ordinate method (Sn) calculation code TORT. We estimated the NR boundary by using TORT and verified a validity with comparing the calculation with the measurements. In the calculation, combinations of various numbers of directional mesh sets and orders of scattering cross section were examined by comparing the calculations with the measurements to survey the best set that simulates neutron transport phenomena in the MS tunnel room. The calculation that we judged reliable showed that the NR boundary around these two lines was located in the BSW concrete and that all materials in the MS tunnel room are non-radioactive.

1. Introduction

According to a report by regulatory body in Japan, materials which are irradiated by neutrons to an effective-dose-rate less than 6.25 μSv/h can be treated as non-radioactive materials (ACNRE, 2007). We call a boundary on which materials are distinguished between radioactive materials and non-radioactive (NR) materials as NR boundary in our work. Reliable estimation of the NR boundary is crucial in preparatory tasks for decommissioning of nuclear power plant (NPP) to determine a decommissioning scenario, a dismantling design, a disposal planning and a decommissioning cost. Especially, the reliability would influence an accuracy of estimation for amount of very-low-level concrete waste because NR boundary would be located inside concrete of a Biological Shielding Wall (BSW) of a Boiling Water Reactor (BWR). Amount of concrete waste is important since it is much larger than that of other materials disposed from decommissioning activity of NPP.

We have already estimated the NR boundary around a Primary Containment Vessel (PCV) of a BWR by referencing to a reliable two dimensional (2D) distribution of neutron-flux in our previous work (Tanaka et al., 2015). The estimation showed that the NR boundary around the PCV was located in the BSW. Although the boundary would be located in the BSW as shown by the previous estimation, an area where both a Main Steam (MS) line and a Feed Water (FW)

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line penetrate the BSW required a separate estimation from the previous one because neutrons which stream through the MS and the FW lines activate concrete around them.

In this work, we estimated the NR boundary around the MS and the FW lines. Neutrons stream through these two lines and diffuse in the MS tunnel room, which is located outside the BSW and connects a reactor building (R/B) and a turbine building (T/B). In order to estimate the effect of neutron-streaming through these lines and the successive diffusion of neutron-flux in the room reliably, we measured radioactivities by using activation foils (foil activation detectors) at ten locations in the MS tunnel room, and also performed three dimensional (3D) distribution calculation of neutron-flux by using a 3D discrete-ordinate method (Sn) code TORT (Oak Ridge National Laboratory, 1998). Since the phenomenon such as neutron-streaming through the lines that occurs locally is hard to be simulated with 2D distribution calculation of neutron-flux, we performed 3D distribution calculation in the corresponding area.

By comparing calculated radioactivities with measured ones, we modified calculation conditions repeatedly to achieve a reliable result (Tanaka et al., 2015). We examined various directional mesh sets so that we would be able to simulate neutron transport phenomena in the MS tunnel room well. By comparing the calculations with the measurements, we verified the reliability of the estimation of the NR boundary.

2. Outline of the facility

2.1. Outline of the MS line, the FW line and the MS tunnel room

Locations of the MS line, the FW line and the MS tunnel room are shown in Fig. 1, which is a cross-section view of the R/B of Tsuruga NPP unit 1 (TS-1) (Tanaka et al., 2015; JAPC,). Steam generated in a reactor flows through the MS line to a turbine located in the next building that is the T/B. The MS line penetrates the BSW at an elevation at center of "Flask" area of the PCV. The FW line, which feeds coolant water to the reactor, also penetrates the BSW near the MS line. They go through the MS tunnel room to the T/B, which is shown in area surrounded with a square of a red dotted line in Fig. 1.

2.2. NR boundary around the PCV

We have already estimated the NR boundary around the PCV by

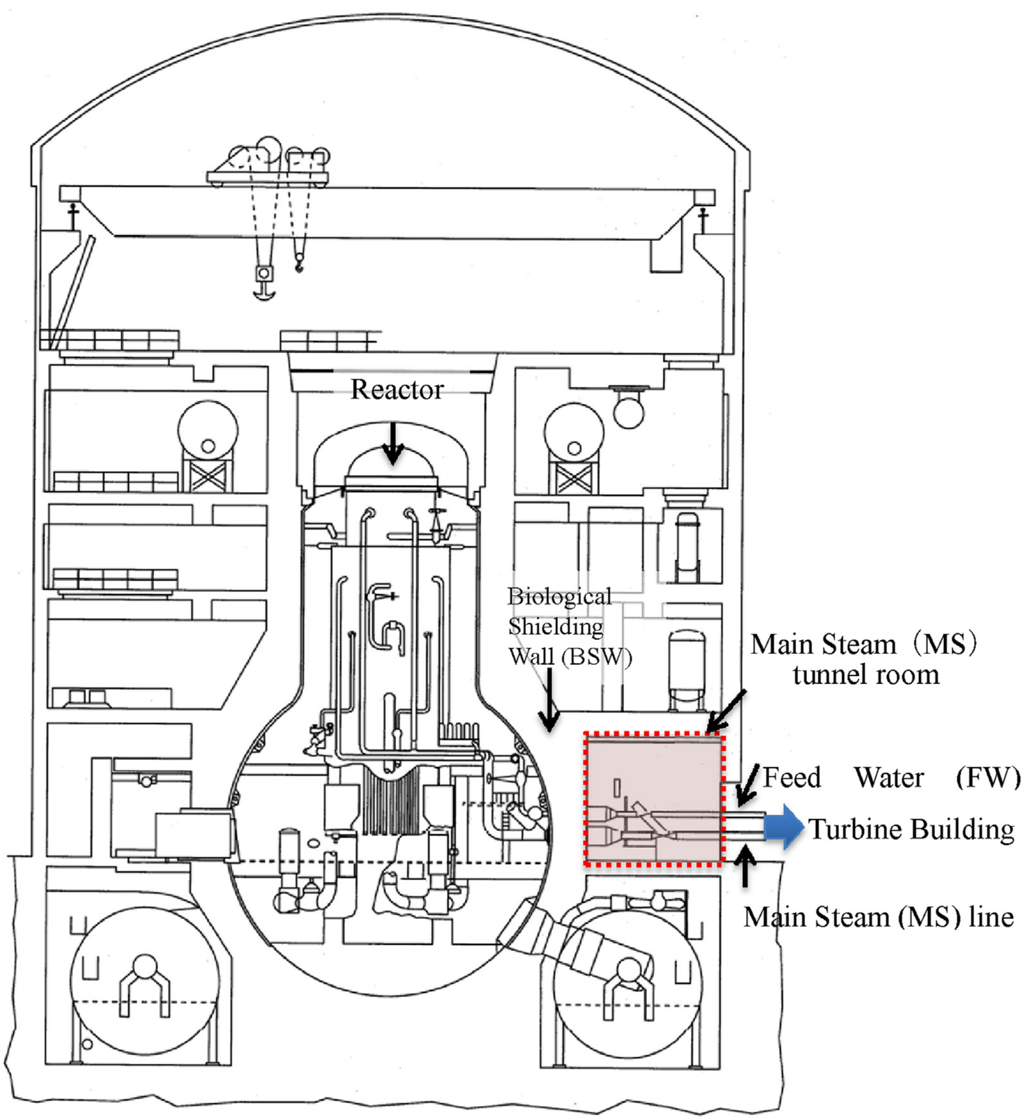

Fig. 1. Cross section view of a Reactor Building of a Boiling Water Reactor.