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Study of LOCA Shine Dose Evaluation Methodology by NAME_LSC Code

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1. Introduction

The purpose of this paper is to evaluate external dose in LOCA. For this study, APR1400 type NPP is selected. Generally, LOCA is largely divided into three categories: containment building leakage model, engineering safety facility leakage model, and recirculation sump leakage model. Often, it is possible to set the external dose that can be received in other areas, and in the case of LOCA, the dose due to radionuclides present in the containment building and airborne radioactivity in the external environment can be additionally considered. Although the impact is minimal, it is a model that can be considered additionally.

This research paper focuses on that and creates a new evaluation method. Here, a methodology will be established using the NAME_LSC code, an accident impact assessment code that was developed in 2017 and has been verified since 2017. And, the ISOPC code will be used as an additional code. This research paper will introduce additional evaluation methodologies that can be considered that have not been attempted so far.

In this study, the main control room is the evaluation target point that will be considered in LOCA. In the case of the main control room habitability by the operator must be secured, and if the influence of external sources is additionally considered, a more precise evaluation of MCR habitability will be achieved. The ARCON96 code will be used for the atmospheric diffusion factor, and the evaluation of the external dose that can be received in the main control room will consider the concrete thickness of the containment building, the thickness of the main control room wall, and the straight line distance from the external source.

Dose analysis method is refer to regulatory guide 1.195 [1-4].

2. Methodology

2.1. Selection and Overview of Computer Code for External Dose Analysis

Several computer codes were adopted for this study. Three representative codes were used. NAME_LSC code, ISOPC, and ARCON96 codes were used [5-7].

The NAME_LSC code is a general-purpose code for performing accident impact assessment. This code has a variety of functions such as release time control, break flow input, modeling for each compartment, and modeling according to the release path of radionuclides, and can perform dose evaluation for all accidents.

In addition, overall compartment modeling for external dose evaluation can be performed perfectly.

The NAME_LSC code is a code developed through personal research by KHNP-CRI. The initial version was developed in 2017 and verified through design basis accident, and the development results were announced in a research paper at the KNS conference in 2021 [5].

ISOPC is a code that evaluates external exposure from the location of geometric source part. External dose evaluation can be performed by considering geometric distance and material attenuation coefficient [6].

The ARCON96 code is a code that simulates the diffusion or behavior of radioactive materials inside the site. In general, it is a unique code that evaluates the atmospheric diffusion factor within a cow. This code was developed by NRC [7].

In this study, a new methodology for external dose evaluation was developed using these three codes.

2.2. Modeling Strategy for LOCA External Dose

The iodine activities in the source term were adjusted The external source port in LOCA can take into account the presence of nuclides inside the containment building, nuclides released into the environment due to containment building leaks, nuclides leaked from engineering safety facilities, and nuclides leaked from the recirculation sump. Nuclides present inside the containment building can be modeled in a cylinder shape. All nuclides present in the air are modeled as being shielded by the walls of the main control room.

2.3. Source Term Generation Strategy of External Dose

To evaluate external dose, source term calculations are necessary. In this study, the calculation of the source term is evaluated using the NAME_LSC code. The NAME_LSC code can model containment building leakage models, engineering safety facility leakage models, and recirculation sump leakage models. For each of these models, the nuclide inventory remaining in the containment building will be used as a source port inside the containment building. And the nuclear mass released into the environment will be used as a source port in the external environment.

2.4. New Methodology Concept of LOCA Shine External Dose

Fig. 1 shows the concept of evaluation modeling established by this research for LOCA Shine Dose. "CTMT Source Term" and "ENV External Source Term" will be calculated by NAME_LSC code. And in the modeling shown in Fig. 1, external dose evaluation at the "External Dose Point" will be performed using ISO PC code.

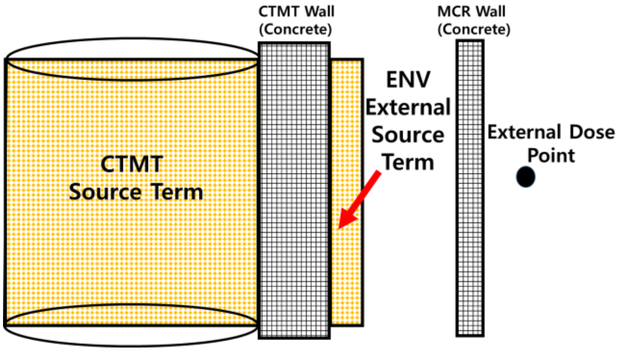

Fig. 1 LOCA Shine Dose Modeling of NAME_LSC Code.

In the Fig.2, new methodology of radiological estimation is introduced.
The useful work frame is shown in Fig.2. In this methodology, library files are easily changed to simulate the radiological event. The NAME_LSC code can freely create and replace a working library file for calculation. This method is similar to the principle of easily assembling pre-made modules for calculation. In this evaluation, we intend to establish modeling using such a method.

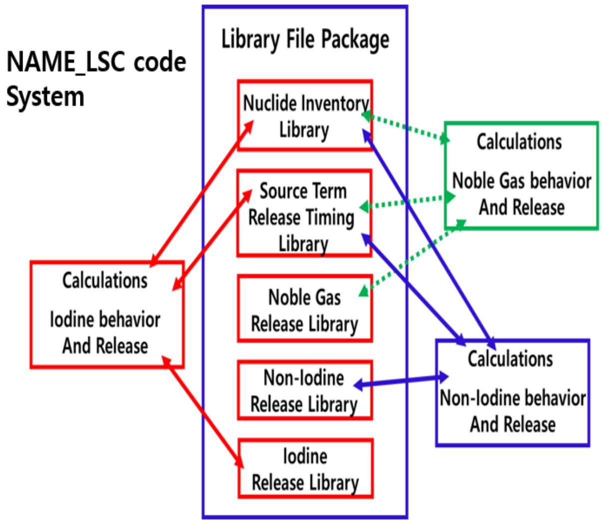

Fig. 2 The Library File Package of NAME_LSC code for the new methodology of LOCA Shine Dose

3. RESULTS AND DISCUSSIONS

3.1. ISO PC input parameters for External Dose

Table 1 is the result of generating input data by organizing the geometric factors in Fig. 1 for ISO PC calculation. Using these geometric factors, the external dose received from the containment building and the external dose received into the air will be calculated separately.

Table1. Input parameters from Containment external source term.

Item	Input parameters
Containment inner radius	- 2286cm
Containment Wall thickness	- 121.92cm
Air thickness between Containment wall and MCR wall	- 1500cm
MCR Wall thickness	- 76.20cm
Ratio of containment volume to cylinder cross-sectional area	- 5394.96cm

Table2. Input parameters from Environment external source term.

Item	Input parameters
MCR Wall thickness	- 76.20cm
Distance between MCR Wall and Dose point	- 30.48cm
Ratio of Environment volume to MCR cross section area	- 4458.58cm

Table 2 is the input data used to calculate the external dose received when inside the MCR from nuclides released into the environment. Assuming that the volume of the external environment relative to the cross-sectional area of the MCR wall was a cube, the ratio of the cross-sectional area and volume was calculated and converted into a linear distance.

3.2. MCR External Dose Results from LOCA Shine Dose Model

Table 3 shows the final results of evaluating the external radiation dose and evaluating the dose for radioactive materials flowing into the MCR. As a result of the evaluation, the external dose value shows a very small value compared to the skin beta and thyroid dose. This is confirmed by the phenomena in which most of the external dose is ionized and attenuated on the walls of the containment building, the walls of the MCR, and in the outside air. Therefore, the contribution of external dose is ranged 1.91% ~ 12.08% compared to other doses.

Table 3 shows that the contribution of external dose is 12.08% for skin beta and about 1.91% for thyroid dose.

Table3. MCR Dose analysis results from LOCA Shine Dose Modeling

Items	Dose Results (mSv)
LOCA Shine Dose of External source terms(A)	- From Containment : 5.00E-01 - From Environment:: 2.47E+00 - In-leakage to MCR : 1.07E+00 - Total Sum : 4.05E+00
Beta Skin of Internal source term(B)	- In-leakage to MCR: 3.35E+01
Thyroid of Internal source term(C)	- In-leakage to MCR: 2.12E+02
Relative contribution of Item (A) to Item (B)	- 0.1208
Relative contribution of Item (A) to Item (C)	- 0.0191

4. CONCLUSIONS

Through this study, a method to evaluate external dose was implemented in addition to the existing LOCA evaluation. The LOCA Shine Dose method in this study served as an opportunity to confirm the contribution of external dose that could be additionally considered. And also, a methodology to evaluate external dose was established. Through this evaluation, several conclusions were obtained:

a. A method of creating an external dose source term from containment building using the NAME_LSC code was established. In addition, a method for creating external dose source terms from the environmental atmosphere was established using the NAME_LSC code.
b. Analysis of external dose showed a relative contribution of 12.08% to skin beta and 1.91% to thyroid.
c. The source term was derived using the NAME_LSC code, and a linkage method between NAME_LSC and ISO PC codes was established to calculate external dose.

From these results, it is believed that a method to evaluate external dose along with the production of external source ports has been established. In the future, we will work to create a more precise model by using the code used here.

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