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Containment EQ Dose Analysis of LOCA Condition Using NAME_LSC Code

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1. INTRODUCTION

The estimation of equipment environment qualification is to find out the safety related system performance in duration of design basis accidents. The purpose of this paper is to apply the newly developed accident impact assessment code to environmental verification.
For this reason, the NAME_LSC code was applied to this study. The NAME_LSC code is a multi-compartment analysis program that simulates the behavior and release of nuclides.
In this analysis, the conservatism of the existing analysis method is also confirmed through comparative analysis with the results of the existing methods.
The existing method is based on NUREG-0588 Category I and Regulatory Guide 1.89 Rev1. In this study, the environmental analysis of LOCA conditions is introduced.

2. METHODOLOGY

2.1. Environmental Analysis during Normal Operation

Under normal operating conditions, the cumulative dose for each compartment is determined using data periodically measured for recent years.

TID-n = D x T

Where, TID-n : accumulate dose in normal operating
D : designed dose rate for each compartment
T : Power Plant design life

2.2. Environmental Analysis under Accident Conditions

For environmental analysis at the time of the accident, LOCA, which is a representative discharge accident was selected.

In LOCA, the spray decontamination effect and the deposition effect on the walls of compartments etc. are major factors.

Existing methods simply estimate the cumulative dose at the center point of the containment building, the center point of the recirculation strainer, the center point of the upper dome and the average point of the containment wall.

2.3. Detailed Modeling by NAME_LSC code

Fig. 1 shows the simple modeling with roughly compartmentalized parts. Here, the central point in the simply divided compartment is the main evaluation point.

Fig. 2 shows the modeling of the compartment inside the containment building using the NAME-LSC code.

As shown in Fig. 2, compartment modeling was performed by subdividing using 99 compartments and 98 pathways.

The Fig.2's detailed modeling is to calculate in detail the accumulated dose for each region inside the containment building

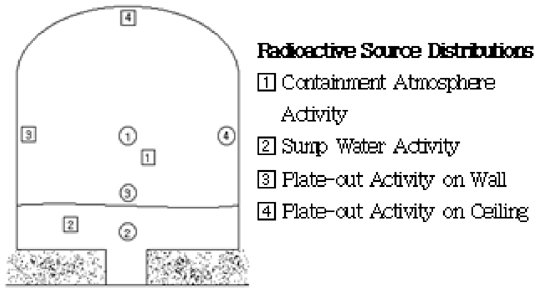

Fig. 1 Evaluation concept frame for the current methodology

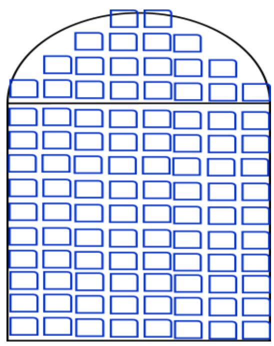

Fig. 2 Detailed modeling concept for the environmental evaluation method using NAME-LSC code.

Fig.3 shows a part of the output modeled in detail using 99 compartments using the NAME-LSC code. As like RADTRAD, the NAME_LSC code has a function for off-site dose evaluation, so the EAB part is basically output in modeling. However, since EAB modeling is not required for EQ analysis, the EAB part was ignored and not modeled.
The source term and the decontamination calculation were modeled to be calculated by using the existing methodology.

```
Compartment number 97
Name: 98
Compartment volume =   2.0000E+01 (Cubic feet)
Compartment type is Normal
Pathways into and out of compartment 97

Compartment number 98
Name: 99
Compartment volume =   2.0000E+01 (Cubic feet)
Compartment type is Normal
Pathways into and out of compartment 98

Compartment number 99
Name: 100
Compartment volume =   2.0000E+01 (Cubic feet)
Compartment type is Normal
Pathways into and out of compartment 99

Total number of pathways =  98


########################################################################
   NAMELSC BySCLEE 1.00 (Spring 2017) run on  8/16/2023  at 15:43:44
########################################################################

########################################################################
                    Scenario Description
########################################################################


Pathway number 97: 99 to 100

     Piping:  Removal Data

        Time (hr)      Flow Rate                        DF
                         (cfm)        Aerosol      Elemental     Organic
       0.0000E+00     0.0000E+00   1.0000E+00   1.0000E+00   1.0000E+00

Pathway number 98: 100 to 101

     Piping:  Removal Data

        Time (hr)      Flow Rate                        DF
                         (cfm)        Aerosol      Elemental     Organic
       0.0000E+00     0.0000E+00   1.0000E+00   1.0000E+00   1.0000E+00

LOCATION DATA
     Location EAB     is in compartment   3

     Location X/Q Data
      Time (hr)          X/Q (s * m^-3)
       0.0000E+00           0.0000E+00

     Location Breathing Rate Data
      Time (hr)          Breathing Rate (m^3 * sec^-1)
       0.0000E+00                  3.5000E-04
       8.0000E+00                  1.8000E-04
       2.4000E+01                  2.3000E-04
       7.2000E+02                  0.0000E+00
```

Fig. 3 Detailed modeling output of NAME-LSC code.

2.4. Analysis for Internal Environment of the Containment Building

For containment spray operation time, the RG 1.195 guideline were applied. The effective time of spray decontamination was considered when the decontamination factor reached 100.

The correlation equation loaded in the NAME-LSC code is as follows.

$$\frac{A_0}{DF_{100}} = A_0 \exp(-\lambda_{eff} T^{100})$$

Here, A_0 : initial activity in containment
DF_{100}: spray decontamination coefficient
$1\lambda_{eff}$: effective decontamination rate
T^{100}: DF time reached to 100

In this study, 100% noble gas and 50% Iodine were released from the core under LOCA conditions.

The dose analysis in the main areas inside the containment building was simulated as being introduced for diffused into 99 compartments uniformly and sequentially. In addition, for realistic evaluation, the source of the containment atmosphere, sump strainer, containment wall, and dome upper region was subdivided and modeled.

The subdivided modeling compartment was designed to calculate the dose considering the geometrical location.

3. RESULTS AND DISCUSSIONS

The detailed evaluation by NAME-LSC code and the results by current method were compared. Each evaluation result is shown Table 1 and Table 2.

Table 1. TID for 1 year after LOCA at each dose point by current method

Dose Point	Dose for 1 year (rads - carbon)		
	Gamma	Beta	Total
Containment Atmosphere Center	1.48E+7	3.25E+7	4.74E+7
Sump Water Center	2.49E+7	1.33E+7	3.83E+7
Sump Water Surface	1.97E+7	3.26E+7	5.23E+7
Containment Wall Surface	2.19E+7	3.26E+7	5.45E+7

Table 2. TID for 1 year after LOCA by NAME-LSC

Dose Point	Dose for 1 year (rads - carbon)		
	Gamma	Beta	Total
Containment Atmosphere Center	1.11E+7	2.93E+7	4.04E+7
Sump Water Center	1.97E+7	1.01E+7	2.98E+7
Sump Water Surface	1.63E+7	3.11E+7	4.74E+7
Containment Wall Surface	1.99E+7	3.02E+7	5.01E+7

From the results of Table1 and Table2, NAME-LSC code shows a slightly smaller value. Table1 is a result of conservative, rough, and simple modeling.

In addition, the result shows high values using the assumption that nuclides are uniformly released into the containment building at the same time as an accident occurs. On the other hand, in Table2, due to the detailed modeling of NAME-LSC code, using modeling in which nuclides released at the same time as an accident occur are realistically diffused in 99 compartments, it takes a certain amount of time to reach a uniform concentration before they are evenly distribution inside the containment building. Because of that, it is judged that NAME-LSC shows a smaller value than the existing conservative method.

By considering both the exposure during the period of non-uniform concentration and the actual decontamination effect based on the realistic analysis, the dose effect is smaller than current method's value until uniform concentration is achieved.

In the end, it was concluded that the detailed method of NAME-LSC code, which simulates a series of process in which the concentration inside the containment become uniform, includes a non-uniform concentration period in which a relatively small dose is calculated.

4. CONCLUSIONS

Comparison of Evaluation Results of the Current Method and the Detailed Modeling Method is carried out by NAME-LSC code

In the detailed modeling, multi-subdivided compartments were arranged and calculations were made in the form of sharing the nuclides concentration through short-distance diffusion between the compartments.

These calculations are confirmed to realistically simulate the behavior of nuclides in the containment building.

Therefore, the radioactive effect is relatively small until a uniform radioactivity concentration is formed in the early stage of the accident, and it is judged that this difference is the difference between the existing calculation method and this study's calculation result.

From this study, it was confirmed that NAME-LSC as a design basis accident impact assessment code can also be used for containment environment analysis. In addition, for the multi-compartment modeling function of NAME-LSC code, it was confirmed that EQ dose calculations can be made using a number of subdivided compartments.

REFERENCES

[1] NUREG-0855, "Interim Staff Position on Environmental Qualification of Safety-Related Electrical Equipment", July(1981).

[2] USNRC, "Qualification of Class 1E Equipment for Nuclear Power Plants", Regulatory Guide 1.89, November (1974).