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Sensitivity analysis for exposure dose fraction by radioactive elements for the Severe Accidents in the OPR1000

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1. Introduction

The main cause of the Fukushima accident in 2011 was that the power was not supplied for a long time due to natural disasters, thus eventually the design safety function could not be operated. As a result, large amounts of radioactive materials released to the outside of nuclear power plants, causing massive damage to the environment. After the accident in 2011, the public has been learned about radionuclides such as cesium or iodine, and concerned about the influences of nuclear severe accidents.

At the viewpoints of this, it was evaluated that the exposure dose fraction by radioactive elements at the exclusive area boundaries, assuming the postulated severe accident in the OPR1000 nuclear power plant. In this paper, sensitivity analysis for exposure dose fraction by radioactive elements was conducted. As a result, it could be obtained additional insights for exposure dose fraction by radioactive elements through comparison with the base results.

2. Methods

Modular Accident analysis Program (MAAP) 5.03 code was used to calculate the amounts of radioactive materials for the severe accident scenario [1]. And the RADionuclide Transport, Removal, And Dose (RADTRAD) 3.03 code was used to evaluate the exposure dose fraction by each radioactive element using the output of MAAP calculations. [2].

2.1 Accident Scenario and selection of sensitivity factors

From the viewpoint of the deterministic analysis, selected initial event is large loss of coolant accident (LLOCA) and assumptions are as follows.

- The break point is cold leg.(because cold leg break accident is more severe than hot leg break)
- The design safety function is unavailable except by passive safety injection.
- The mitigation strategies of severe accidents are available; hydrogen control equipment, mobile pumps, and so on.

And selected sensitivity factors are as follows, which can be affect the results.

- The availability of the containment spray system
- The analysis period of exposure dose estimation

2.2 Selection of Representative Elements

Reflecting the radionuclide group according to RG-1.183, the following 9 representative elements were selected [3].

2.3 Inventory of fission products in core

Inventory of fission products was calculated based on conservative assumptions.

2.4 To estimate the amount of radioactive materials released to the environment

Using MAAP 5.03 Code, it was performed to calculate existence fraction of representative elements by time steps in reactor containment building.

2.5 Atmospheric dispersion factor

It was based on the latest meteorological data measured by plant site. To evaluate atmospheric dispersion factor (χ/Q), RG-1.145 methodology was applied [4].

2.6 Exposure Path and Dose Conversion Factor

It was assumed the following exposure pathways and dose conversion factors (DCF).

- External exposure from the plume: FGR-13 [5]
- External exposure from surface contamination: FGR-13
- Internal exposure by inhalation of contaminated air: ICRP-72 [6]

2.7 Methodology for dose assessment

NUREG/CR-6604 methodology was applied to evaluate exposure dose [7].

3. Results

The effective dose in the case of operating the containment spray system is much less than base case, and the effective dose in long period analysis is greater than base case.

Fig 1 through Fig 4 show that the portion of radioactive materials released to the environment and the exposure dose fraction by radioactive elements through comparison with the base results [8]; reactor containment spray was not available and analysis period was 3 days.

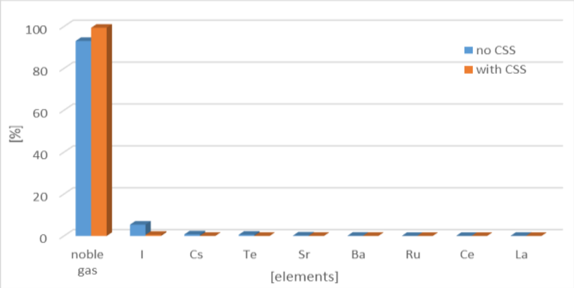

Fig 1. The portion of radioactive materials released to the environment by comparison of results related to the availability of the containment spray system

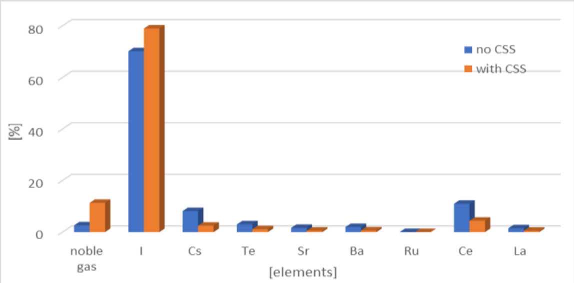

Fig 2. The exposure dose fraction by radioactive elements by comparison of results related to the availability of the containment spray system

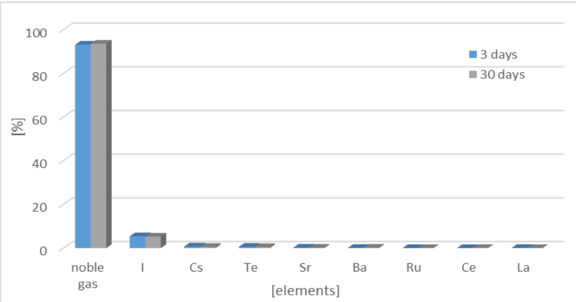

Fig 3. The portion of radioactive materials released to the environment by comparison of results related to the analysis period

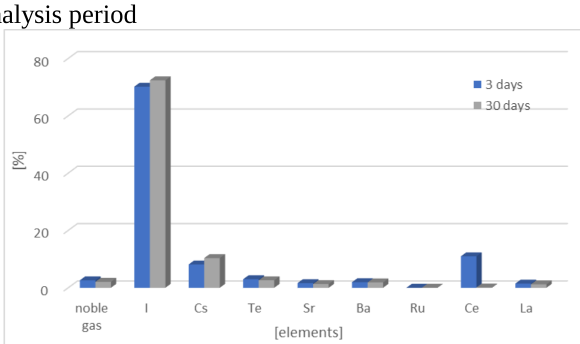

Fig 4. The exposure dose fraction by radioactive elements by comparison of results related to the analysis period

4. Conclusions

Following insights could be confirmed in this study.

- (Fig 1 and Fig 2) If the containment spray system was operated, the radioactive materials released to the environment occupied by aerosol type elements was decreased than when the containment spray system had not been operated. And this tendency is similar to the viewpoint of exposure dose fraction.
- (Fig 1 and Fig 2) On the other hand, the exposure dose fraction occupied by noble gas and iodine increased than when the containment spray system had not been operated.
- (Fig 1 and Fig 2) In the case of iodine, the exposure dose fraction was increased because of elemental iodine, although the release fraction to environment was decreased.
- (Fig 3 and Fig 4) Even if the analysis period of exposure dose estimation was longer than base case, there was little change in the release fraction to environment.
- (Fig 3 and Fig 4) But the exposure dose fraction occupied by cesium with half-life longer than other elements increased than base case.

As a results, it can be confirmed that iodine is the most significant element in exposure dose for LLOCA in OPR1000 through the base and sensitivity analysis. Also sensitivity analysis showed that the exposure dose fraction of aerosol type elements was decreased in condition of operating containment spray system and the exposure dose fraction was increased by the long half - life radionuclide when the evaluation period was extended.

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