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Evaluation on the Source-term Release to Environment of a Nuclear Accident in Neighboring Countries for Development of Emergency Response Training System

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1. Introduction

In the Northeast Asia region where the Korean Peninsula is located, more than 100 nuclear reactors are in operation or under construction in China, Japan and Taiwan [1]. As nuclear power plants are concentrated and keep increasing, the emergency response system for radiological disaster in neighboring country should be strengthened.

When the Fukushima Accident occurred, there was no direct radiological effect on the Korea since there was no direct inflow of radioactive material. However, there were social confusions due to the lack of information. In order to respond quickly and efficiently in the case of radiological disaster in neighboring country, conducting research to improve the emergency response system at the national level is required.

As a part of efforts to strengthen the emergency response system for radiological disasters in neighboring country, we developed specific training scenarios by evaluating the source-term release Hongyanhe in China and Hamaoka in Japan [2, 3]. In this study, we focused on constructing database of source-term release by applying several accident scenarios for each country.

2. Accident Scenarios

We selected the representative reactor type by considering the number of reactor and potential consequence on Korea for China, Japan and Taiwan as CPR-1000, BWR-5 and BWR-6, respectively [4]. Two scenarios for each representative reactor type were considered: 1) LBLOCA (Large Break Loss-of-Coolant Accident) scenario as DBA (Design Basis Accident), 2) SBLOCA (Small Break Loss-of-Coolant Accident) + SBO (Station Blackout) scenario going to SA (Severe Accident). These scenarios are referred from previous study [4]. The source-term estimation was performed by NANAS (Northeast Asia Nuclear Accident Simulator) code [4]. Due to the generic limitation of the simulator, we performed simulations for about 12 hours.

2.1 CPR-1000

First, a size of 2,300 cm^2 cold leg rupture occurred and all systems operated normally in LBLOCA scenario for CPR-1000. SBLOCA (Small Break Loss-of-Coolant Accident) and SBO were considered together in SA scenario for CPR-1000. In SA scenario, a size of 45.6 cm^2 cold leg rupture occurred and all systems were shut down due to on-site and off-site station blackout simultaneously. Turbine driven auxiliary feed water pump was operated for 4 hours immediately after the accident and stopped due to depletion of battery.

2.2 BWR-5

LBLOCA scenario for BWR-5 type assumed that a recirculation line break of 2,900 cm^2 occurred and that all systems operated normally. SA scenario for BWR-5 assumed that all systems were shut down due to SBO.

2.3 BWR-6

LBLOCA scenario for BWR-6 type assumed that a recirculation line break of 5,000 cm^2 occurred and that all systems operated normally. SA scenario assumed that all systems were shut down due to SBO.

3. Results

3.1 CPR-1000

Figures 1 thorough 3 show the results of evaluating source-term release following the expected accident scenarios for major nuclides: I-131, Xe-133 and Cs-137. Tables 1 through 3 show the transient report for each case. First, the result of CPR-1000 LBLOCA scenario is shown in Table 1.(a) and Fig.1.(a). It shows that HPSI (High Pressure Safety Injection) system operated 2 seconds after accident. And the core was uncovered after 13.5 seconds, but it was not melted. The result of CPR-1000 SBLOCA+SBO scenario is shown in Table 1.(b) and Fig.1.(b). The core was uncovered after 7.7 minutes, and collapsed after 1 hour. After 1.2 hours vessel was failed and turbine driven auxiliary feed water pump stopped after 4 hours due to depletion of battery. After about 8 hours, radionuclides in containment increased.

Table 1: Transient report in CPR-1000: (a) LBLOCA scenario, and (b) SBLOCA+SBO scenario

(a)

Time (sec)	Event
2.0	- HPSI Start
3.0	- Reactor Trip
13.5	- Core Uncovered
230.0	- Core Recovery

(b)

Time (sec)	Event
3.0	- Reactor Trip
52.5	- HPSI Start
459.5	- Core Uncovered
3623.5	- Core Collapsed
4357.5	- Vessel Failed

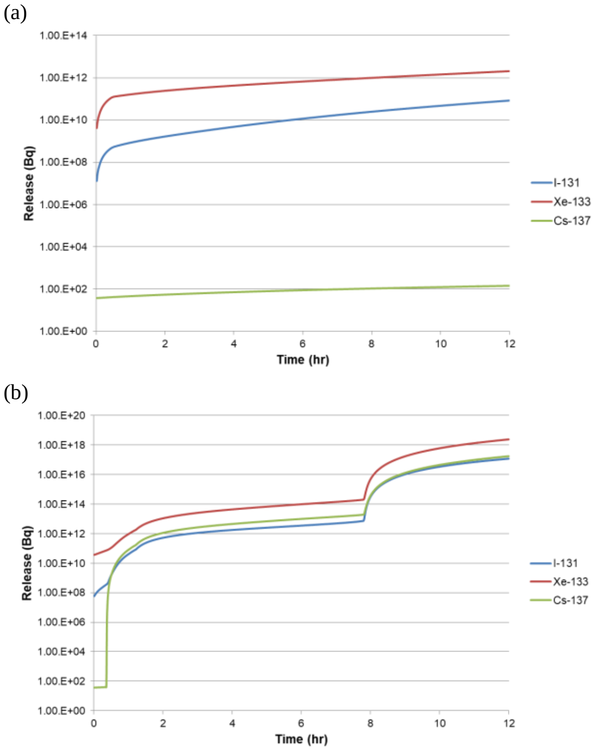

Fig.1. Results of source-term release in CPR-1000: (a) LBLOCA scenario, and (b) SBLOCA+SBO scenario.

3.2 BWR-5

The result of BWR-5 LBLOCA scenario is shown in Table 2.(a) and Fig.2.(a). It shows that HPCS (High Pressure Core Spray) System, RCIC (Reactor Core Isolation Cooling) System, and LPCI (Low Pressure Coolant Injection) System operated 3 seconds after accident. The result of BWR-5 SBO scenario is shown in Table 2.(b) and Fig.2.(b). The core was collapsed after about 4 hours and after 4.2 hours vessel was failed. After about 9 hours, pressure and radionuclides increased in dry well and wet well.

Table 2: Transient report in BWR-5: (a) LBLOCA scenario, and (b) SBLOCA+SBO scenario

(a)

Time (sec)	Event
1.5	- Reactor Trip
3.0	- HPCS, LPCI, RCIC Auto Start
5.5	- Turbine Trip

(b)

Time (sec)	Event
5.0	- Reactor Trip
9.0	- Turbine Trip
58.5	- HPCS Auto Start
100.5	- LPCI Auto Start
5898.0	- Core Collapsed
7012.5	- Vessel Failed

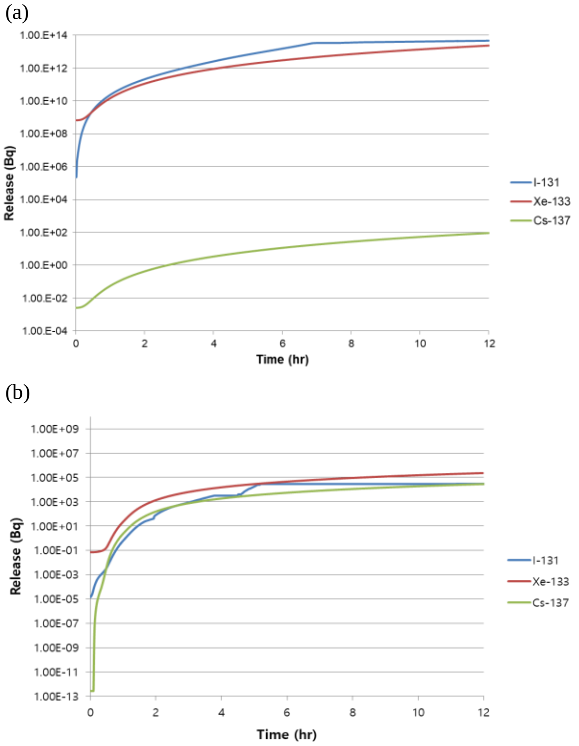

Fig.2. Results of source-term release in BWR-5: (a) LBLOCA scenario, and (b) SBLOCA+SBO scenario.

3.3 BWR-6

The result of BWR-6 LBLOCA scenario is shown in Table 3.(a) and Fig.3.(a). It shows that HPCS (High Pressure Core Spray) System, RCIC (Reactor Core Isolation Cooling) System, and LPCI (Low Pressure Coolant Injection) System operated 2 seconds after accident. The result of BWR-6 SBO scenario is shown in Table 3.(b) and Fig.3.(b). The core was collapsed after about 2.3 hours and after 2.5 hours vessel was failed. After about 8 hours, pressure and radionuclides increased in dry well and wet well.

Table 3: Transient report in BWR-6: (a) LBLOCA scenario, and (b) SBLOCA+SBO scenario

(a)

Time (sec)	Event
1.5	- Reactor Trip
2.0	- HPCS, LPCI, RCIC Auto Start
5.5	- Turbine Trip

(b)

Time (sec)	Event
6.5	- Reactor Trip
10.5	- Turbine Trip
15.5	- HPCS Auto Start
89.5	- LPCI Auto Start
5668.5	- Core Collapsed
7081.5	- Vessel Failed

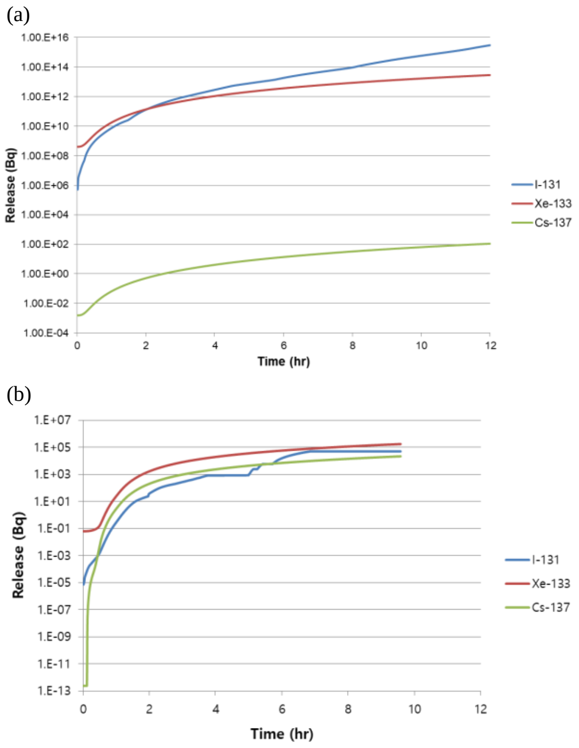

Fig.3. Results of source-term release in BWR-6: (a) LBLOCA scenario, and (b) SBLOCA+SBO scenario.

Table 4 shows the total release of source-term for each scenario and each reactor type. There are much amounts of release in SA scenarios than those in DBA scenarios.

Table 4: Evaluated results for total release of source-term by reactor types and accident scenarios

Country (Reactor Type)	Accident Scenario	Total Release (Bq)		
		Xe-133	I-131	Cs-137
China (CPR1000)	LBLOCA	2.07.E+12	8.39.E+10	1.42.E+02
	SBLOCA+ SBO	2.44.E+18	1.20.E+17	1.76.E+17
Japan (BWR5)	LBLOCA	2.38.E+13	4.74.E+13	9.19.E+01
	SBLOCA+ SBO	1.08E+15	8.48E+15	1.06E+15
Taiwan (BWR6)	LBLOCA	2.89.E+13	3.02.E+15	1.12.E+02
	SBLOCA+ SBO	1.86E+15	6.47E+15	8.01E+14

4. Conclusions

In this study, we evaluated the source-term release based on DBA and SA scenarios for each representative reactor type of China, Japan and Taiwan. By understanding the tendency of the source-term release by reactor types or several accident scenarios, it would be helpful to develop training scenarios of emergency response training system for radiological disasters in neighboring countries.

We can apply the results of this study as an input to the exposure dose assessment with meteorological data in case of radiological accident in neighboring countries. Various case studies on the consequence analysis including the source-term estimation should bring an insight in development of training scenario. Therefore, the result of source-term release would contribute to improve the emergency response system. In addition, if limitation of the simulator would be improved, we could attain more precise results.

It is also expected to provide a basis for meeting the demand on information of public for radiological disaster in neighboring country. Furthermore, the result of this study will strengthen the capability of international emergency response through the linkage of disaster prevention training of Northeast Asian countries.

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