Radiological Consequence Analyses Following a Hypothetical Severe Accident in Japan

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1. Introduction

In order to reflect the lessons learned from the Fukushima Daiichi nuclear power plant accident, a simulator which is named NANAS (Northeast Asia Nuclear Accident Simulator) for overseas nuclear accident has been developed [1,2]. NANAS calculates the radiological consequence to Korea due to the nuclear accident occurred in neighboring countries (i.e. China, Japan and Taiwan). It is composed of three modules: source-term estimation, atmospheric dispersion prediction and dose assessment.

For the source-term estimation module, the representative reactor types were selected as CPR1000, BWR5 and BWR6 for China, Japan and Taiwan, respectively. Considering the design characteristics of each reactor type, the source-term estimation module simulates the transient of design basis accident and severe accident. The output of source-term estimation module is an amount of radioactivity released into the environment. The atmospheric dispersion prediction module analyzes the transport and dispersion of radioactive materials and prints out the air and ground concentration. Using the concentration result, the dose assessment module calculates effective dose and thyroid dose in the Korean Peninsula region.

In this study, a hypothetical severe accident in Japan was simulated to demonstrate the function of NANAS. As a result, the radiological consequence to Korea was estimated from the accident.

2. Source-term Estimation

It was assumed that a severe accident due to earthquake and tsunami occurred at Hamaoka nuclear power plant. Hamaoka nuclear power plant is located on the east coast of Japan similar to Fukushima Daiichi nuclear power plant. The accident was simulated as a single unit accident and Hamaoka Unit 3 was selected as a release point. Hamaoka Unit 3 is a BWR5 reactor model with thermal power of 3,293 MWt.

The initial condition was set to middle of cycle and the earthquake occurred after 300 seconds. Due to the earthquake, reactor was tripped and MSIV (Main Steam Isolation Valve) was closed to control the pressure by SRV (Safety Relief Valve). After one hour, all power supplies including offsite power, EDG (Emergency Diesel Generator) and batteries were lost by tsunami attack. This SBO (Station Blackout) condition was continued to 24 hours. Table 1 shows the accident scenario.

Table 1: Accident Scenario

Time (hh:mm)	Event
00:05	Reactor trip and MSIV closure due to the earthquake
01:00	SBO by tsunami attack
24:00	End of calculation

Figure 1 shows the description of source-term estimation module at the end of calculation and Table 2 is a summary of transient report for the accident scenario. It was shown that the reactor vessel was failed after about 4.5 hours.

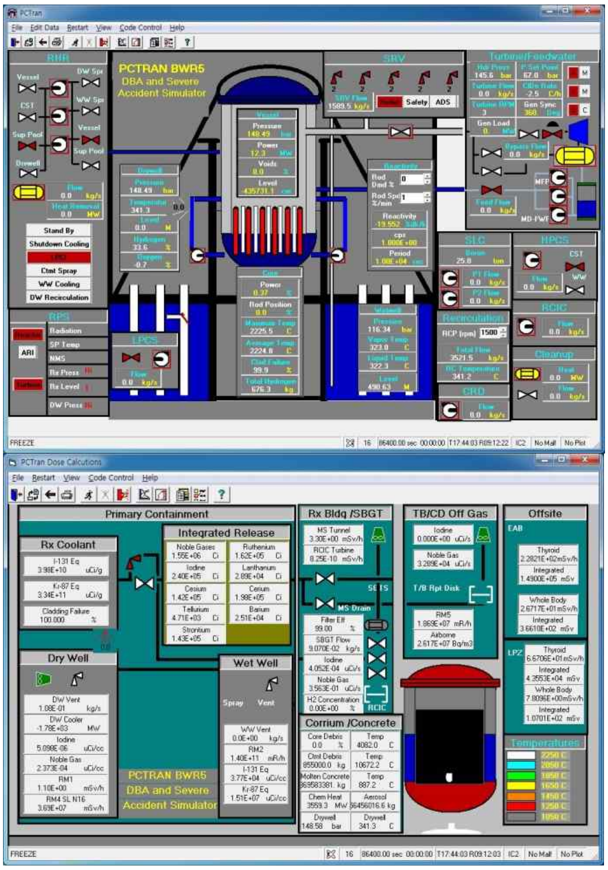

Fig. 1. Result of Transient Analysis

Table 2: Transient Report

Time (sec)	Event
300	- MS Isolation Valve Position Change: 0% - Reactor Trip
304.5	- Reactor Recirculation Pumps Trip - Turbine Trip
3,600	- Station Blackout
4,921	- HPCS Auto Start (failed)
5,985	- LPCS Auto Start (failed)
16,263	- Vessel failed

Figure 2 shows the result of cumulative radioactivity released into the environment for major nuclides (i.e. I-131, Xe-133 and Cs-137). Xe-133 recorded the most amount of 2.88×10^{16} Bq. I-131 and Cs-137 were released 3.38×10^{15} and 3.76×10^{15} Bq, respectively. It can be found that the release rate of each nuclide increased about 4 hours later since the vessel was failed at the moment.

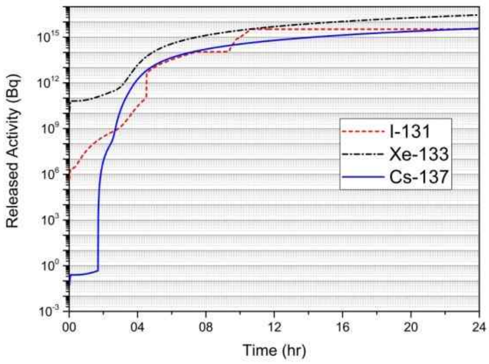

Fig. 2. Result of Released Source-term

3. Atmospheric Dispersion Prediction and Dose Assessment

GDAS (Global Data Assimilation System) 1 degree meteorological data was used for the atmospheric dispersion prediction module. An arbitrary period of meteorological data was selected to demonstrate the radiological consequence in Korea. The period of simulation was 8th May to 14th May of 2016. With the result of source-term release and meteorological data, the atmospheric dispersion prediction module analyzed the transport and dispersion of radionuclides. The domain was limited to the Korean Peninsula region and the grid size was set to 0.1 degree of latitude and longitude.

The dose assessment module calculated effective dose and thyroid dose for the same domain and major monitoring points in Korea. Figure 3 shows the result of dose assessment for the domain. For each time step, the maximum effective dose and thyroid dose were 8.41×10^{-5} and 9.45×10^{-5} mSv, respectively. For the total dose integrated during the period, effective dose and thyroid dose were 6.60×10^{-4} and 6.73×10^{-4} mSv, respectively.

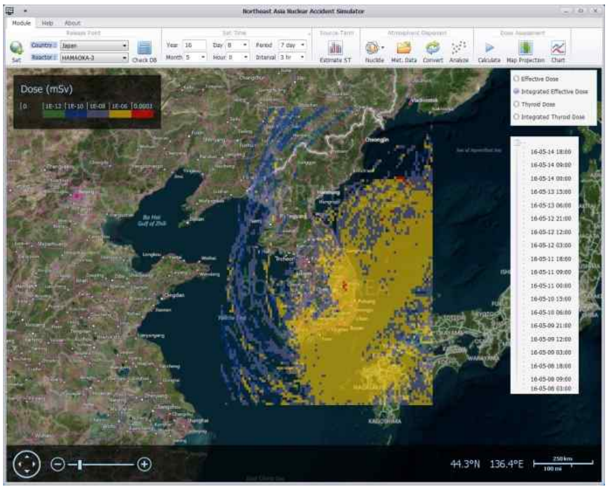

Fig. 3. Result of Dose Assessment

Figure 4 shows the time chart on the thyroid dose result at Ulsan monitoring point. The bottom one is a cumulative result of the top.

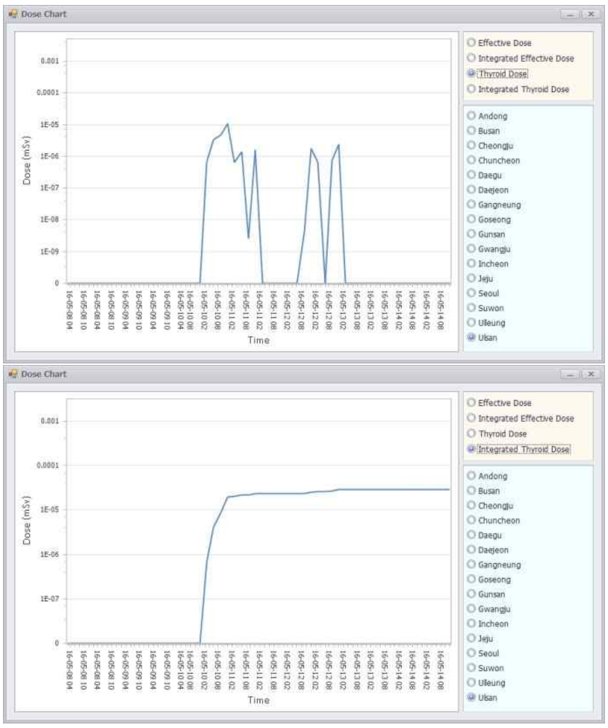

Fig. 4. Result of Time Chart

In this calculation, no point exceeded the regulatory criteria on the emergency public protective action: 10 mSv/2days for sheltering, 50 mSv/7days for evacuation and 100 mGy for distribution of thyroid protection medicine.

4. Conclusions

PC-based nuclear accident simulator, NANAS, has been developed. NANAS contains three modules: source-term estimation, atmospheric dispersion prediction and dose assessment.

The source-term estimation module simulates a nuclear accident for the representative reactor types in China, Japan and Taiwan. Since the maximum calculation speed is 16 times than real time, it is possible to estimate the source-term release swiftly in case of the emergency. Also, database on the source-term for various accident scenarios can be established using this module. The atmospheric dispersion prediction module analyzes the transport and dispersion of radioactive materials in wide range including the Northeast Asia. Final results of the dose assessment module are a map projection and time chart of effective dose and thyroid dose.

A hypothetical accident in Japan was simulated by NANAS. The radioactive materials were released during the first 24 hours and the source-term estimation module calculated the amount of them. The atmospheric dispersion prediction and dose assessment were performed for 7 days. As a result, the radiological consequence to Korea from the accident occurred in Japan was assessed and dose results showed that no point exceeded the regulatory criteria on the emergency public protective action. Although the total period of simulation was 7 days, NANAS performed the simulation in a few hours.

Therefore, NANAS is a swift simulation tool for the radiological emergency occurred in neighboring countries. Especially, it would be utilized as a training tool for the emergency preparedness staff and support the development of strategies on emergency response. Finally, it is expected that NANAS would contribute to improve the capability of emergency preparedness.

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REFERENCES

[1] Juyub Kim, Juyoul Kim, Sukhoon Kim, Seunghee Lee, Taebin Yoon, Li-Chi Cliff Po, Development of Educational and Training Simulator for Emergency Response to Chinese Nuclear Accidents, Transactions of the Korean Nuclear Society Spring Meeting, Jeju, Korea, May 7-8, 2015

[2] Juyub Kim, Juyoul Kim, Sukhoon Kim, Seunghee Lee, Taebin Yoon, Development on Dose Assessment Model of Northeast Asia Nuclear Accident Simulator, Transactions of the Korean Nuclear Society Spring Meeting, Jeju, Korea, May 12-13, 2016