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Uncertainties of Source Term Estimation in Fukushima Accident

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1. Introduction

Many reports published which describe on the Fukushima accident such as NERHQ, TEPCO, IAEA, etc. They estimated source terms based on the field measurement. Source term estimation is a starting point to estimate the impact of nuclear radiological accident to the public or environment. In the Fukushima accident, the cores of three units are damaged and a certain per cent of volatile fission products are released to the atmosphere. Based on the simulation of three units with MELCOR code, atmospheric release amount of Cs-137 is estimated. During this simulations a lot of information are used. But there still exists many unclear phenomena.

2. Accident sequences

Accident progressions are estimated by MELCOR code for units 1, 2, and 3. Depending on the initial and boundary conditions on plant conditions make uncertainty on the results. Accident sequence follows on the event chronology described in the reports such as NERHQ, TEPCO, etc. Initial radioisotope inventory is estimated by ORIGEN code based on the refueling histories on each unit. Finally release of radionuclide from the core to environment is estimated by MELCOR code. Water injection, venting, and hydrogen explosion, and pressure reduction in plant log is major uncertain phenomena which impact on the release amount of radionuclide to environment. Leakage or break paths through unknown paths is one of the difficulties in modeling by MELCOR. Measurement data on RPV and PCV pressure is a reference data tried to follow when MELCOR simulation. The RPV pressure drop to PCV pressure occurs at 5, 72 and 36 h for Unit 1, 2, and 3, respectively. Water leakage to the basement of turbine building is another evidence of radioisotope leakage water side other than atmospheric release.

Source terms are estimated for Fukushima Units 1, 2, and 3 for 500 hours (about 20 days) from March 11 to April 1, 2011. Early injection of water into containment will reduce environmental source term due to the elimination of the molten corium and concrete interaction (MCCI) and revaporization process in RPV or in containment. However, it is assumed that no water is injected to the core during 500 hours in unit 1. RPV and PCV pressure behaviors are shown in Fig. 1.

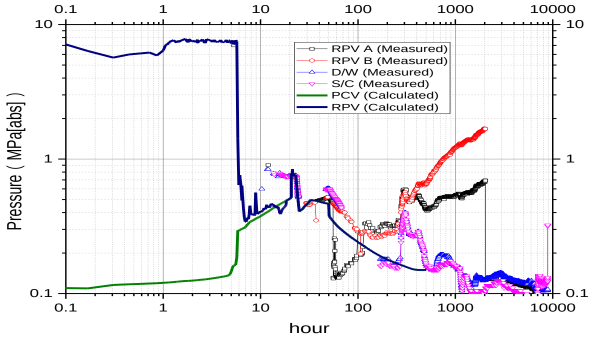

Fig. 1. RPV and PCV pressures simulated and measurements

Unit 2 PCV pressure behavior is shown in Fig. 2. Unit 2 RPV pressure is maintained by the operation of RCIC successfully up to 72 h.

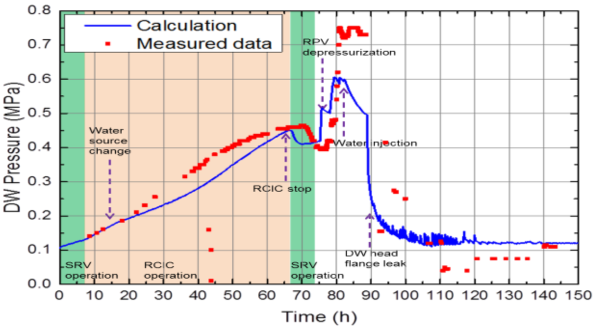

Fig. 2 Unit 2 PCV Pressure Behavior (S.I.Kim, KAERI provided)

Unit 3 RPV and PCV pressure scenarios are shown in Fig 3. Unit 3 RPV pressure is maintained by the operation of RCIC/HPCI successfully up to about 40 h.

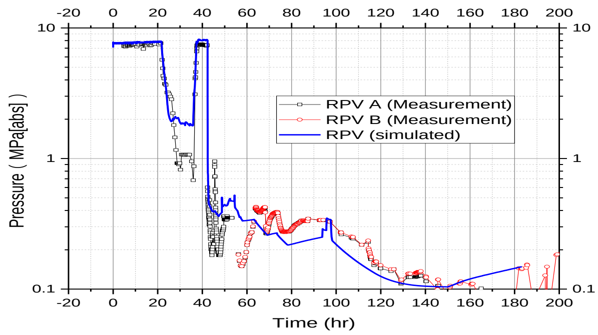

Fig.3 RPV pressure scenario of Unit 3

3. Cs137 Release to Environment

Approximately 20, 5, and 10 PBq of Cs137 are estimated to be released to the environment from Unit 1, 2, and 3, respectively based on MELCOR code simulations. Total 35 PBq is released to the environment during 500 hours. (Fig. 4).

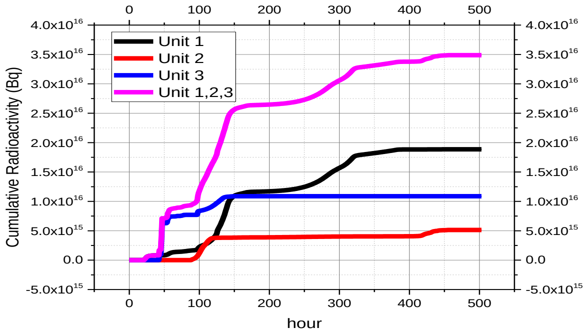

Fig. 4. Cumulative Released Activity (PBq) of CS137 from Units 1, 2 and 3

Activity release rate (Bq/h) is shown in Fig. 5 for unit-wise and in Fig. 6 for summation of units 1, 2 and 3. Estimated result can be compared with measurement data shown in Fig. 7.

Table I summarized release amount of Cs137 from core to atmosphere and stagnant water in buildings. The release fraction to stagnant water of buildings are estimated in paper of Nishihara et al. AESJ, 2012. Approximately 6, 34 and 17% of initial core inventory of Cs137 are leaded to stagnant water in buildings.

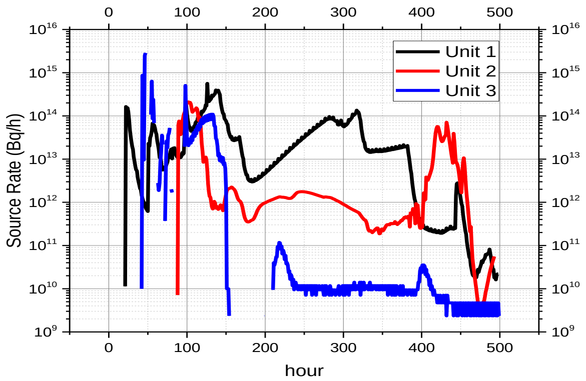

Fig. 5 Activity release rate (Bq/h) from units 1, 2 and 3

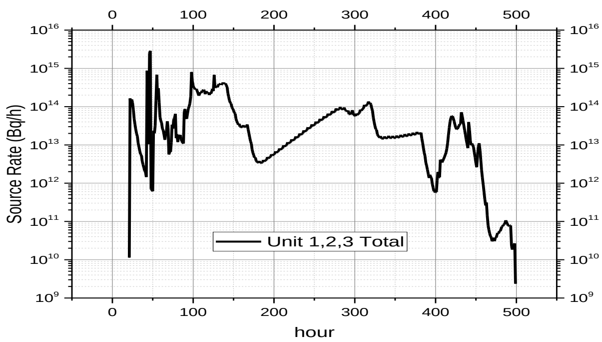

Fig. 6 Total activity release rate (Bq/h) from Units 1, 2 and 3

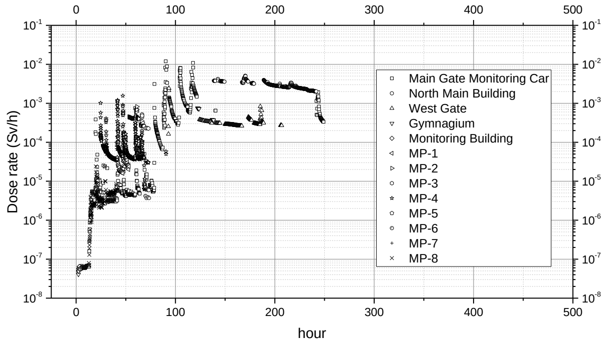

Fig. 7 Dose rate measurement at Fukushima Daiichi site

Table I Summary of release amount of Cs137 from core to atmosphere and stagnant water in buildings

	Unit 1	Unit 2	Unit 3	Total
Initial Inventory at core	200	260	240	700
Atmospheric Release	20	5	10	35
%	10%	2%	4%	5%
release amount to stagnant water	12	88	41	140
%	6%	34%	17%	20%
total release to environment	32	93	51	175
%	16%	36%	21%	25%

4. Conclusions

Total release amount of Cs137 from Fukushima units 1, 2 and 3 are estimated to 35 PBq from the MELCOR code simulation. It seems to be 2 or 3 times higher than other results. However, the temporal release trend is very similar to monitoring post measurement data as shown in Fig. 8 above. Main uncertainty sources are in environmental consequence assessment are for example, the initial core inventory of radionuclide in ORIGEN code, the accident scenario, initial and boundary conditions in MELCOR code, and finally the meteological data and concentration measurement data, in environmental transport code predictions.

REFERENCES

[1] OECD/NEA BSAF Project, Phase II Report, Draft, 2019
[2] UNSCEAR 2013 report
[3] MELCOR code description, SNL, NRC, 2005
[4] Nishihara et al. AESJ, 2012.