Leak Path Factor Calculation of RIPF Hot-cell During an Accident

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1. Introduction

Korea Atomic Energy Research Institute (KAERI) produce various radioisotopes at hot-cell facility in Radioisotope Production Facility (RIPF). The RIPF building has 4 hot-cell banks to produce each radioisotope [1]. Emergency Preparedness Act in Korea demands emergency plan for the licensee who operates the facility producing radioisotope more than 18.5PBq. The RIPF at KAERI produce radioisotope more than 18.5PBq in a year, but the 18.5PBq of radioisotope are distributed in 1 year period at each hot-cell banks during the production. It means that there is no chance having 18.5PBq radioisotope in a same time at RIPF building. RIPF SAR only considers a stack release during an accident. RIPF stack has a 68m height, so the radioactive materials released through the stack will be diffused in air. In case of stack release, there is no needs to respond in a point of view of emergency protective action. U.S. DOE requests to calculate source-term by a building leakage of the facility handling radioactive materials, and suggest methodology to get Leak Path Factor (LPF) by building leakage using MELCOR computer code [2]. The LPF of RIPF hot-cell during an accident was calculated by using MELCOR code and the characteristics was analyzed.

2. Method description

2.1 Major factors to get the source-term

Source-term in a nuclear facility can be calculated by using under equation.

$$ST=MAR \times DR \times ARF \times RF \times LPF$$

Where,
ST = Source-term
MAR = Material at Risk
DR = Damage Ratio
ARF = Airborne Release Fraction
RF = Respirable Fraction
LPF = Leak Path Factor

RIPF can handles and produces about 100 radionuclides in hot-cells based on the license. Each radionuclide is handled in a batch process, and the each batch has maximum amount to treat, so an accident considers the maximum amount of a radionuclide processed at a hot-cell bank. In a point of view of emergency preparedness, only enough amount which can cause a harm of a human outside is interested. RIPF SAR chose 8 nuclides, the maximum batch amount (MAR) of each nuclides, and the accident type possible. So the accident condition in SAR was applied here also. But the RIPF SAR didn't consider DR, ARF and RF, sot these values reviewed through the technical documents from IAEA, U.S.DOE, and determined as Table 1.

Table 1. Major values to calculate the RIPF source-term

Bank No.	Nuclide	Accident Type	MAR (Ci)	DR	ARF	RF
1	Co-60	Fire	50,000	1	0.001	1
	Ir-192		100,000	1	0.001	1
	Yb-169		100	1	0.01	1
	Se-75		1,000	1	0.01	1
3	I-125	Spill	10	1	0.01	1
	I-131		60	1	0.01	1
4	Mo-99 Tc-99m	Spill &Fire	700	1	0.01	1

2.2 MELCOR input design to get LPF

LPF of a building can be calculated by MELCOR simulation. To get the LPF by MELCOR simulation, the building structure should be designed as a numerical data, to accomplish this, the RIPF building structure was investigated and measured on the design drawing. After this procedure, all rooms and doors of RIPF building were designed and defined for the generation of the MELCOR input file. For example, the definition drawing of the first floor of RIPF building as a result is described as Fig. 1.

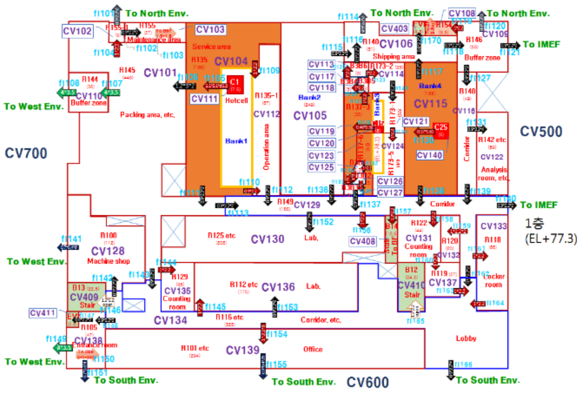

Fig. 1. Definition drawing of RIPF 1st floor for MELCOR input.

2.3 Scenario input for simulation

To simulate the effect of winds outside of the RIPF, 5 m/sec which was the maximum wind speed measured for recent 4 years at 10m height was considered as scenario input file. Normally the heat generated by a fire can reach to 1200℃, so the energy generated by a fire at hot-cell bank was also considered to simulate the effect of 1200℃.

3. Results and discussion

The diffusion of 1 kg radioactive element at each hot-cell bank for 10 sec in a fire condition was simulated as it was 5 m/sec wind from each direction outside RIPF building.

3.1 Effect of fire and wind during release

LPF of Co-60 from hot-cell bank 1 for 10hr at each wind direction and a fire was described as Fig. 2.

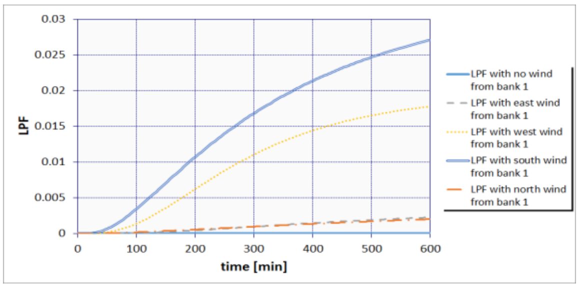

Fig. 2. LPF form hot-cell bank 1.

In the result, the maximum LPF was found when the wind from south and a fire were applied, but the effect of fire was negligible.

At a fire and 5m/sec wind from south, the LPF of each element from bank 1 was described as Fig. 3.

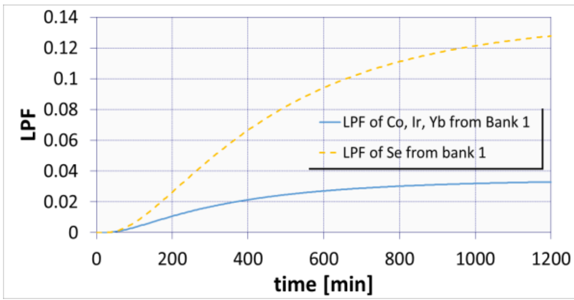

Fig. 3. LPF of each element from bank 1.

All LPF values calculated from each hot-cell bank were described as Table 2.

Table 2. LPF of all nuclide considered at each bank

Bank No.	Nuclide	LPF
1	Co-60, Ir-192, Yb-169	0.033
	Se-75	0.13
3	I-125, I-131	0.28
4	Mo-99/Tc-99m	0.042

As a result, the bank 3 shows the maximum LPF value, but the maximum source-term appears from Ir-192 at bank 1 because of the biggest MAR.

4. Conclusion

The LPF of RIPF hot-cell at KAERI was calculated by using MELCOR code. The maximum source-term was found from bank 1, but the maximum LPF was found from bank 3. These results will be used for dose assessment for the optimization of the emergency preparedness of RIPF hot-cell accident at KAERI.

REFERENCES

[1] "HANARO Safety Analysis Report", Chapter 11, Korea Atomic Energy Research Institute, 2016.

[2] "MELCOR Computer Code Application Guidance for Leak Path Factor in Documented Safety Analysis", Final Report, U.S. Department of Energy, 2004.