Insights from the Probabilistic Safety Assessment Application to Subsurface Operations at the Preclosure Facilities

Meejeong Hwang, Jong Tae Jung
Korea Atomic Energy Research Institute, 1045, Daekduk-daero, Yusung-Gu, Daejon, Korea
mjhwang@kaeri.re.kr

1. Introduction

In this paper, we present the insights obtained through the PSA (Probabilistic Safety Assessment) application to subsurface operation at the preclosure facilities of the repository.

At present, medium-low level waste repository has been constructed in Korea, and studies for disposal of high level wastes are under way. Also, safety analysis for repository operation has been performed. Thus, we performed a probabilistic safety analysis for surface operation at the preclosure facilities with PSA methodology for a nuclear power plant.

Since we don't have a code to analyzethe waste repository safety analysis, we used the codes, AIMS (Advanced Information Management System for PSA) and FTREX (Fault Tree Reliability Evaluation eXpert) which are developed for a nuclear power plant's PSA to develop ET (Event Tree) & FT (Fault Tree), and to quantify for an example analysis.

2. Example: Surface Operation Analysis

In this analysis, we assumed the accident sequences which are initiated by an assembly drop during transportation of assemblies with a bridge crane in the transfer cell. The systems for mitigation of the accident are cladding, HVAC (Heating, Ventilation and Air Conditioning) system and HEPA (High Efficiency Particulate Air) filters. In this example analysis, the following accident sequences are considered.

- Accident sequence 1: There is no breach after the drop of assembly and the end state of the accident sequence becomes 'OK'
- Accident sequence 2: Breach occurs and the primary HVAC system and primary HEPA filter are successful. Noble gas is released to the public and outside workers.
- Accident sequence 3: Breach occurs and the primary HVAC system is successful but the primary HEPA filter fails. Noble gas and particulates are released to the public and the outside workers.
- Accident sequence 4: Breach occurs and the primary HVAC system fails. Noble gas and particulates are released to inside workers.

Developed ET is shown in Figure 1, and system failure analysis is performed by FT analysis as shown in Figure 2 and 3.

Initiating event frequency is estimated with the following data.

- Bridge Crane Drop Rate: 5.6e-5 drops/lift (Assumed based on NUREG-1774)
- Number of Assemblies Transferred: 12,000/yr (Assumed)
- Failure of Bridge Crane frequency: 5.65 drops/lift * 12,000 lift/year = 0.672 drops/year
- Assembly cladding failure and breach probability: 1 (Assumed)

In the result of system FT analysis, the failure probabilities are estimated as follows for the HVAC system and HEPA filter, respectively:

- Failure probability of HVAC system: 8.063e-5
- Failure probability of HEPA Filter: 1.201e-5

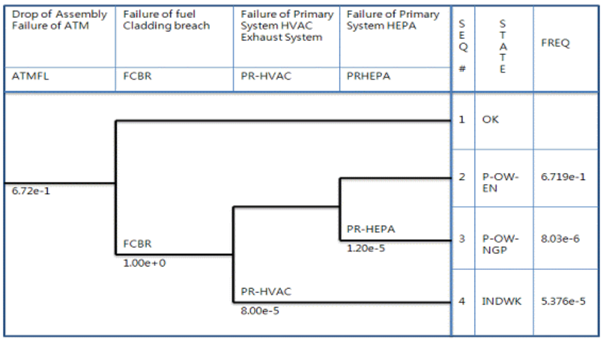

Figure 1. Event Tree Model

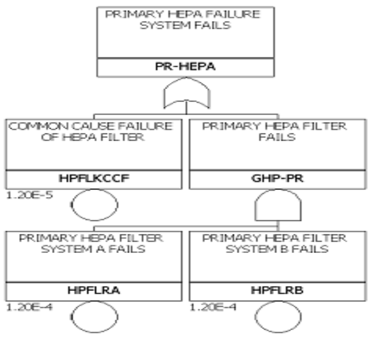

Figure 2. FT for the Primary Area HEPA Filter System

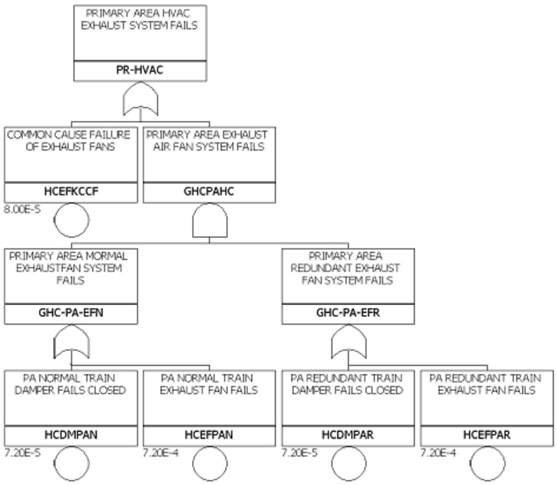

Figure 3. FT for the Primary Area HVAC System

Figure 3 shows the quantification results for the example ET through AIMS and FTREX. The end state is grouped only one at a nuclear power plant's PSA. Therefore, AIMS has no function to categorize for each end state.

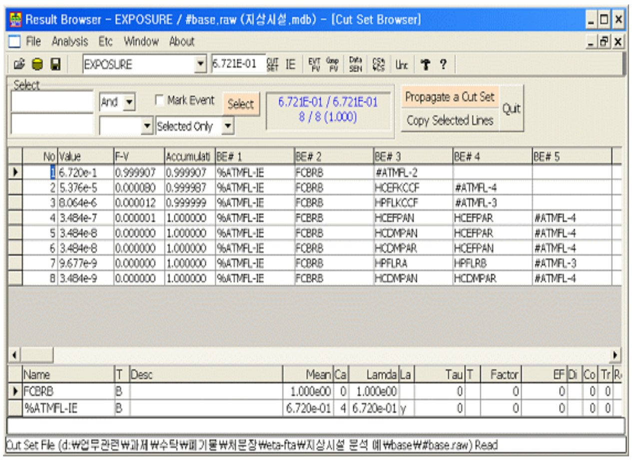

Figure 4. Quantification Result (FTREX is used)

3. Insights from the Example Analysis

Through the example analysis, we obtained some insights to imply the PSA codes developed for a nuclear power plant.

In the repository PSA, the accident's end states are categorized as several kinds unlike those of nuclear power plant's cases. For example, the following end states can be considered for the subsurface operation at the preclosure facilities:

- "OK"
- Direct Exposure (Degraded Shielding, Loss of Shielding)
- Radionuclide Release (Filtered, Unfiltered)
- Radionuclide Release, Filtered, Also Important to Criticality
- Radionuclide Release, Unfiltered, Also Important to Criticality
- Important to Criticality

Therefore, the function to estimate the quantification result is necessary according to each end state.

Even though the initiating event groups with the same accident sequences, the success criteria for each mitigating system can be different. Therefore, at the quantification process, it should be dealt with as the same as the initiating group. Also, even though the failure probability of a mitigating system is 1, the absorption rule of Boolean algebra is not applied during the quantification process. That is, we should obtain not the minimal cutsets but the cutsets. Since the end states are categorized as several kinds at the repository PSA, an accident sequence ends with another end states even though a mitigating system failed.

4. Conclusions

We identified that it is possible to apply the PSA codes for a nuclear power plant's PSA to the repository PSA. However, it is necessary to revise the codes for the consideration of repository characterization.

Acknowledgments

This research was supported by "The Mid-&-Long Term Nuclear R&D Program" of MEST (Ministry of Education, Science and Technology), Korea.

REFERENCES

1. 000-PSA-MGR0-00500-00000A, Subsurface Operations Reliability and Event Sequence Categorization, Bechtel SAIC Company, 2008
2. 000-PSA-MGR0-00400-000-00A, Subsurface Operations Event Sequence Development Analysis, Bechtel SAIC Company, ACC: ENG.20080214.0004
3. W.S. Jung, S.H. Han, J.J. Ha, "An Overview of the Fault Tree Solver FTREX," 13th International Conference on Nuclear Engineering, Beijing, China, 2005.
4. NUREG-1864, "A Pilot Probabilistic Risk Assessment of a Dry Cask Storage System at a Nuclear Power Plant", USNRC, 2007.
5. DOE/RW-0573, Yucca Mountain Repository License Application, Safety Analysis Report, 2008