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Development of a Base Model for the New Fire PSA Training

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1. Introduction

US NRC/EPRI issued a new fire PSA method represented by NUREG/CR 6850[1], and have been training many operators and inspectors to widely spread the new method. However, there is a limitation in time and efficiency for many foreigners, who generally have communication problem, to participate in the EPRI/NRC training to learn the new method. Since it is about time to introduce the new fire PSA method as a regulatory requirement for the fire protection in Korea, a simple and easy-understandable base model for the fire PSA training is required, and KAERI-KINS is jointly preparing the base model for the new fire PSA training. This paper describes how the base model is developed.

2. Educational Base Model for the New Fire PSA

In this section, the base model to be used for the new fire PSA training is described.

2.1 Internal PSA model for a simple NPP

For the educational purpose, a simple nuclear power plant (NPP) should be used, and the simple NPP which is used in the NRC fire PRA training [2] is used. As shown in Fig. 1, the simple NPP consists of one S/G, one RCP, one pressurizer, CVCS/HPSI, RHRS, MSS & MFWS, AFWS, CCW, IA, AC/DC power, which locate in containment, auxiliary bldg, T/B bldg, DG bldg, and switch yard. An internal PSA model for the simple NPP was developed.

2.2 The base model for Fire PSA Model

As the first step, the components that are to be credited for plant shutdown following a fire should be selected. Components selected would generally include many components credited in the 10 CFR 50 Appendix R post-fire safe shutdown analysis, and the components credited in the plant's internal events PSA. Also, the components related to the multiple spurious operation (MSO) and operators error should be selected.

The next step is to set up a mapping table shows the affected components and their failure modes, etc., when a fire occurred in each room. With this mapping table, we can calculate CDF of the fire PSA with two methods. One method is to use CCDP (Conditional Code Damage Probability), and the other one is to modify the fault trees (FTs) of internal PSA model.

Also, there are two methods in the FT modification. That is, we can manually build a fire PSA model by modifying the FTs of the internal PSA, or automatically generate a fire PSA model with IPRO-Zone [3] since IPRO-ZONE automatically modifies the FTs of the internal PSA by reading the mapping table.

2.3 FT modification with IPRO-ZONE

The mapping table should be a little bit massaged to be read by IPRO-ZONE, and which is stored as 4 tables in an ACCESS DB as shown in Fig. 2. In Fig. 3, IPRO-ZONE reads the ACCESS DB, and generates SIMA files to be used in the AIMS of PSA software. In Fig. 4, AIMS reads the SIMA file(e.g., test0305.sima.txt), and generates fire PSA model, and CDF.

2.4 Results

The CDF and minimal cutsets generated by the modified FT with IPRO-ZONE and the results generated by the CCDP are compared with in Fig. 5. The results are the same.

3. Conclusions

Using an imaginary simple NPP, a base model of fire PSA following the new fire PSA method was developed in two ways from the internal PSA model. Since we have the base model and know the process of making the fire PSA model, the training for the new fire PSA method can be in detail performed in Korea.

REFERENCES

[1] EPRI/NRC-RES, "Fire PRA Methodology for Nuclear Power Facilities," NUREG/CR-6850, Nuclear Regulatory Commission, Washington, DC, (2005).

[2] EPRI / NRC-RES Fire PRA Course, May 22, 2012

[3] DaeIl Kang, SangHoon Han, "Development of the IPRO-ZONE to construct one top fire event PSA model", Trans. of the KNS, Autumn Meeting, Gyeongju, Korea, Oct 27-28, 2011

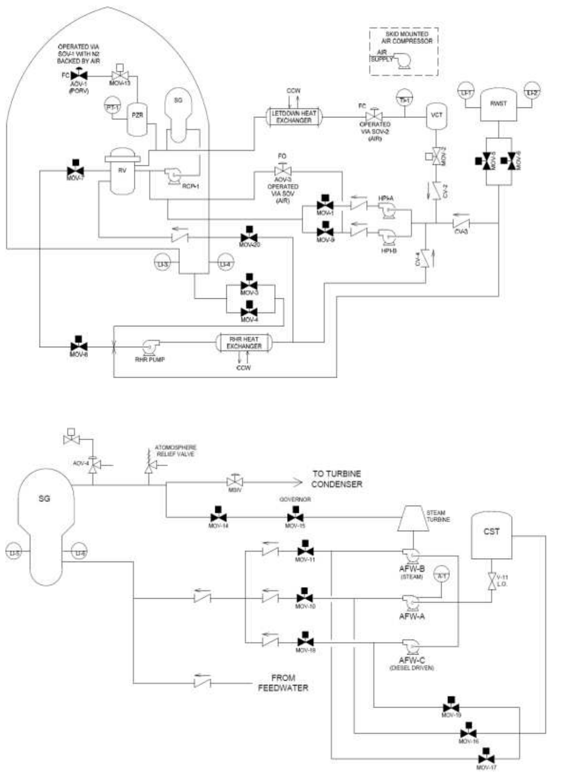

Fig. 1 A simplified P&ID of the simple NPP

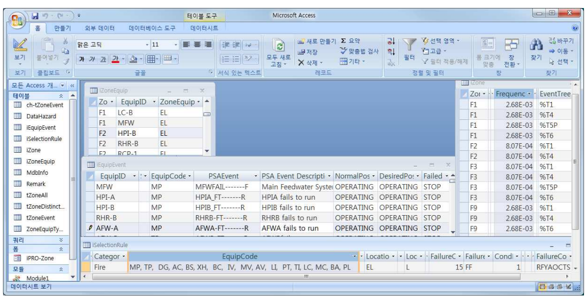

Fig. 2. Mapping Tables in ACCESS DB for IPRO-ZONE input

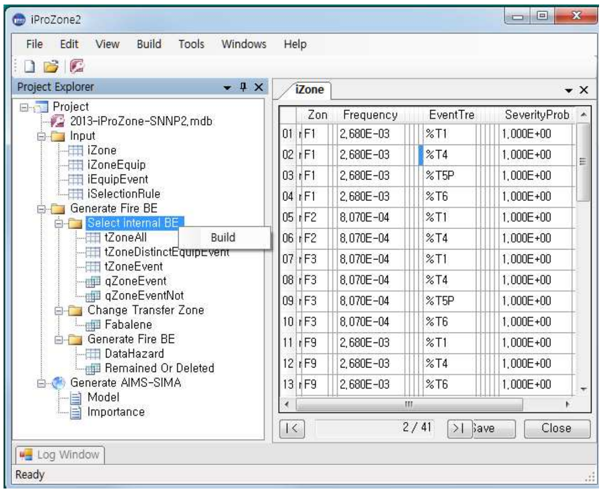

Fig. 3. IPRO-ZONE generates SIMA file using ACCESS DB

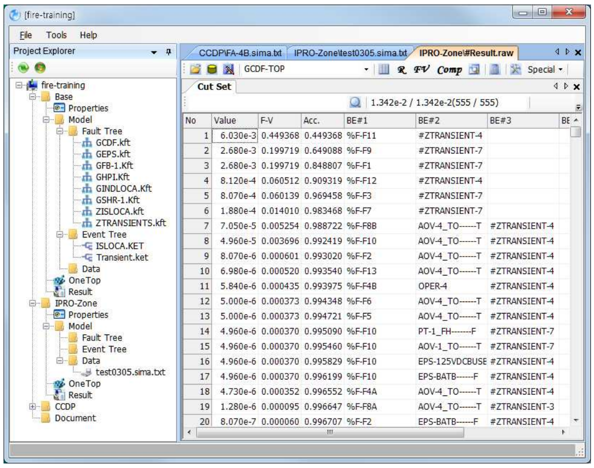

Fig. 4. Fire PSA quantification by AIMS using the SIMA file

Scenario	Ignition Frequency	CCDP	CDF	IPro-Zone CCDP	IPro-Zone CDF
FA-1	2.68E-03	1.0E+00	2.68E-03	1.00E+00	2.68E-03
FA-10	4.96E-03	1.4E-02	6.95E-05	1.41E-02	6.98E-05
FA-11	6.03E-03	1.0E+00	6.03E-03	1.00E+00	6.03E-03
FA-12	8.12E-04	1.0E+00	8.12E-04	1.00E+00	8.12E-04
FA-13	6.98E-04	1.99E-02	1.39E-05	2.00E-02	1.40E-05
FA-15	6.66E-04	4.85E-04	3.23E-07	4.88E-04	3.25E-07
FA-2	8.07E-04	1.3E-02	1.05E-05	1.31E-02	1.06E-05
FA-3	8.07E-04	1.0E+00	8.07E-04	1.00E+00	8.07E-04
FA-4A	4.73E-04	1.01E-02	4.76E-06	1.01E-02	4.75E-06
FA-4B	7.3E-04	4.41E-02	3.22E-05	4.41E-02	3.22E-05
FA-5	5.0E-04	1.4E-02	7.01E-06	1.41E-02	7.03E-06
FA-6	5.0E-04	2.0E-02	1.0E-05	2.02E-02	1.01E-05
FA-7	1.88E-04	1.0E+00	1.88E-04	1.00E+00	1.88E-04
FA-8A	1.28E-04	1.4E-02	1.79E-06	1.41E-02	1.80E-06
FA-8B	7.05E-03	1.01E-02	7.13E-05	1.01E-02	7.13E-05
FA-9	2.68E-03	1.0E+00	2.68E-03	1.00E+00	2.68E-03

Fig. 5. The CDF comparison between CCDP and IPRO-ZONE method