Introduction of Fire PSA tool: ProFire-PSA

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1. Introduction

KAERI has been developing computerization tool for the fire probabilistic safety assessment (PSA) to facilitate fire PSA works for identifying and modeling fire-induced component failure modes and to construct a fire PSA model. KAERI developed the IPRO-ZONE (interface program for constructing zone effect table)[1] for the construction of a one-top fire event PSA model with its output, the AIMS-PSA (advanced information management system for PSA)[2] and a one-top internal event PSA model. The developed IPRO-ZONE, however, has some limitations in the use of cable data and the determination of a target set damaged by a fire. In an effort to overcome these limitations, KAERI is currently developing an improved fire PSA program named ProFire-PSA (Program for Fire PSA)[3]. In this paper, the ProFire-PSA is introduced and its application result is presented.

2. Methods and Results

2.1 Overview of the ProFire-PSA

The main function of the ProFire-PSA is to produce the SIMA [4] or the RID[5] file to be read in the domestic PSA programs. Fig. 1 below shows the relationship between the ProFire-PSA and AIMS-PSA[2]/SAREX[5]. The ProFire-PSA produces the SIMA (AIMS:KAERI) and the RID (SAREX: Industry) files to insert fire scenario-related input data into internal event PSA models built with the AIMS-PSA and the SAREX, which are PSA tool for building and quantifying internal event PSA models. Using the SIMA or the RID file, the pre-built internal event PSA model is changed into a fire PSA model.

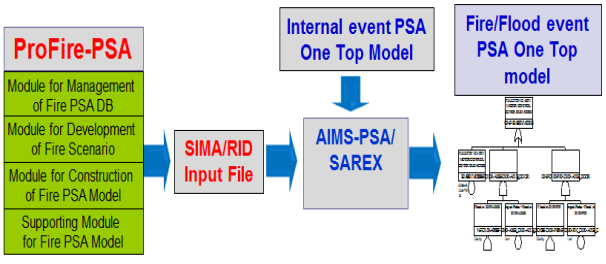

Fig. 1 Relation between the ProFire-PSA and AIMS-PSA/SAREX

Compared with the IPRO-ZONE, the new features of the ProFire-PSA are as follows:

- Use for domestic PSA software
- Direct use of cable data for fire scenarios
- Easy creation of fire scenarios

As mentioned above, the ProFire-PSA will be used in conjunction with the SAREX as well as the AIMS-PSA. In the IPRO-ZONE, the analyst had to manually identify the equipment considered in each fire zone or fire scenario. Through direct use of cable data in the ProFire-PSA, the equipment to be included in the fire scenarios can be automatically selected. The fire scenarios can be easily created from ignition frequency data and fire zone analysis results.

The ProFire-PSA program development started in 2017. As of 2019, ProFire-PSA:AIMS used in conjunction with AIMS-PSA is being developed. ProFire-PSA:SAREX used in conjunction with SAREX and ProFire-PSA:Support will be developed in 2020. In 2021, all of these programs will be integrated and validated.

2.2 Modules of the ProFire-PSA

The ProFire-PSA consist of the following four modules:

- Module for Management of Fire PSA DB: DB module
- Module for Development of Fire Scenario: Scenario module
- Module for Construction of Fire PSA Model: PSA module
- Supporting Module for Fire PSA Model: Supporting module

Each module relationship of the ProFire-PSA is shown in Fig. 2 below. In DB module, Access data such as zones and raceways are read and structured so that these data are available in Scenario and PSA modules. The Scenario module identifies the equipment and cables to be included in the fire scenario. The PSA module generates the SIMA or the RID file to be used as input to the AIMS-PSA or the SAREX. The Supporting module creates fire scenarios with room information and fire ignition analysis results.

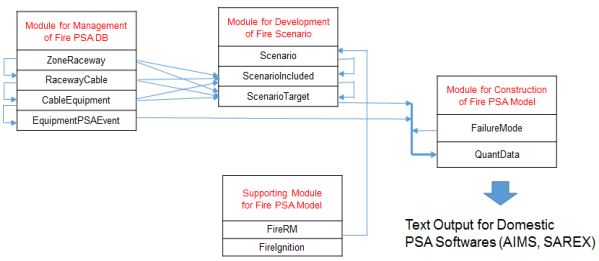

Fig. 2 Relation between the modules for the ProFire-PSA

2.3 Execution of the ProFire-PSA

The program module above is implemented as shown in Fig. 3. As shown in Fig. 3, the ProFire-PSA is performed in three steps. When determining the failure modes of equipment affected by a fire, there are two options (default and realistic). If the default option is selected, the fire-induced equipment failure probability is one. If the realistic option is selected, fire-induced equipment failure probability is estimated differently depending on the cable type, equipment type, desired and failed states, etc. When creating the SIMA or the RID file, the analyst can determine the fire event types (three events (ignition, severity, and non-suppression) or one event including three events) and modeling types (addition or replacement of fire-induced failure events to the pre-existing internal events). The execution example of each step is presented in Fig.4, 5, and 6, respectively. The SIMA file generated from the ProFire-PSA will be applied to the construction of fire PSA model for the reference nuclear power plant (NPP).

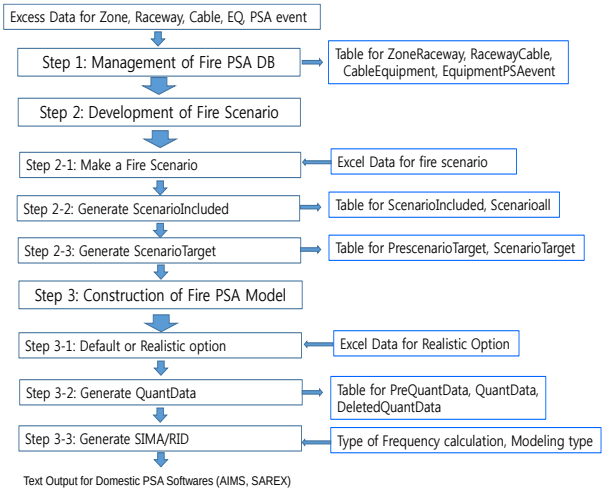

Fig. 3 Execution process of the ProFire-PSA

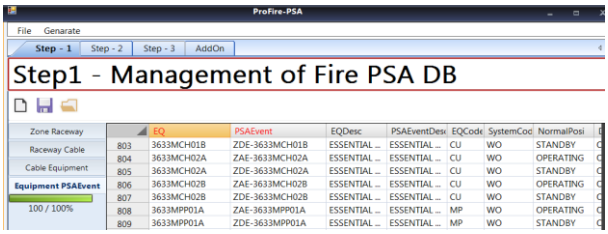

Fig. 4 Execution example of step 1

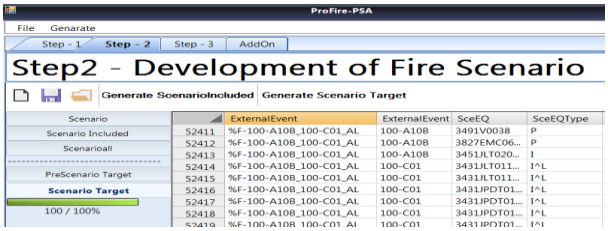

Fig. 5 Execution example of step 2

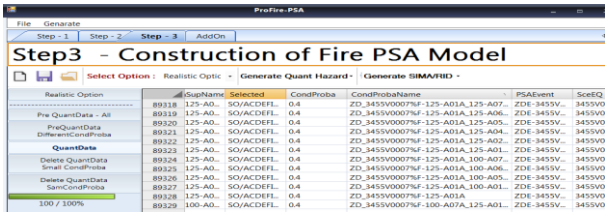

Fig. 6 Execution example of step 3

3. Conclusions

KAERI is currently developing an improved fire PSA program named ProFire-PSA to save working hours for a fire PSA in identifying fire-induced component failures and modeling them and to construct fire PSA model. In this paper, the ProFire-PSA is introduced and its application result is presented. In the near future, full applications of the ProFire-PSA to reference NPP will be performed for finding the items to be corrected. Also, the domestic expert meeting will be held for the improvement of the ProFire-PSA.

Acknowledgments

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