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Development of IPRO-ZONE to Determine Component Failure Modes Affected by a Fire Event

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1. Introduction

A Fire PSA requires a PSA analyst to select internal initiating events and to determine component failure modes for fire occurrence event of each fire compartment. The component failure modes caused by a fire depend on the several factors. These factors are whether components and their relating equipment and cables are located at fire initiation and propagation compartments or not, fire effects on control and power cables for components and their relating equipment, designed failure modes of component, success criteria in a PSA model, etc.

Up to the present, a PSA analyst has been manually determining component failure modes based on criteria mentioned above. This task is one of the difficult works required for fire PSA expertise. In addition, since it requires much information, a fire PSA analyst may have difficulty in maintaining consistency for determining the component failure modes and documentation for them. After determining the component failure modes, internal PSA basic events corresponding to the component failure modes are selected and fire events are modeled for the selected basic events if required.

KAERI has been developing the IPRO-ZONE (interface program for constructing zone effect table) to determine component failure modes affected by a fire, to select the internal PSA basic events, and to generate fire events to be modeled. In this paper, we introduce the overview of the IPRO-ZONE and approaches for determining component failure modes implemented in the IPRO-ZONE.

2. Overview of IPRO-ZONE

2.1 Main function of IPRO-ZONE

The main function of the IPRO-ZONE is to produce the SIMA [1] input file to be read in the AIMS-PSA for the construction of one top fire event PSA model. With one top internal event PSA model and the SIMA input file for fire PSA, the AIMS-PSA build the one top fire event PSA model. Figure 1 shows the relation between the IPRO-ZONE, the AIMS-PSA, and one top fire event PSA model.

2.2 Input of IPRO-ZONE

The IPRO-ZONE needs four kinds of information as follows:

- iZONE: Information on compartment fire occurrence frequency, internal PSA initiating events, propagation path, barrier failure probability, propagation compartment, severity factor, and non-suppression probability
- iZoneEquip: Information on equipment and cables for each zone. Information is represented as follows:
  - ✓ EL: Components are located at area of fire initiation or propagation
  - ✓ PE: Electrical equipment relating to motive power for PSA equipment is placed at ZONE
  - ✓ PC: Motive power cables for PSA equipment are routed through ZONE
  - ✓ CC: Control power cables for PSA equipment are routed through ZONE
  - ✓ CE: Electrical equipment relating to control power for PSA equipment is placed at ZONE. If the electrical equipment fails, control power for PSA equipment is lost
- iEquipEvent: Information on internal PSA basic events relating to equipment
- iSelectionRule: Information on rules to determine component failure modes affected by a fire

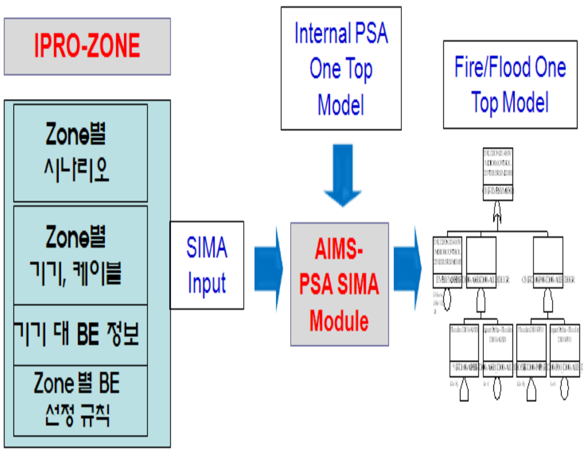

Figure 1. Relation between the IPRO-ZONE, the AIMS-PSA, and one top fire event

3. Determination of component failure modes

3.1 Rules for determining the component failure modes

The rules for determining component failure modes due to a fire are based on general fire PSA approach. The basic assumptions to determine the fire induced component failure modes are as follows:

- All equipment and cables in the fire compartment or zone are assumed to fail due to a fire

- Types of component failure modes are no failure, complete function loss, and spurious operation.
- Effects of instrumentation failures are not considered. Because they may introduce new accident sequence logics not shown in the internal PSA model.
- If equipment or cables relating to motive power and control power for component exist simultaneously in the same zone, motive power for component is assumed to be available when the failure of control cable is considered for the spurious operations.

The rules for determining the component failure modes are classified according to its operation characteristics, normal status, desired status in PSA, etc. Figure 2 shows one example of rules for motor operated valves. Each variable of Table 1 can be modified by user of IPRO-ZONE.

3.2 Modeling of fire induced component failure events

After identifying fire induced component failure modes, a PSA analyst is to model them to PSA logic structures. As shown in Figure.1, IPRO-ZONE automatically generates fire induced component failure events as the SIMA input file. Detailed modeling approaches are presented in references [2, 3, 4]. Following general criteria were applied for modeling fire induced component failure events.

- If fire induced component failure probability is one, set internal PSA basic event true.
- If fire induced component failure probability is not one and greater than zero, fire induced component failure events are modeled with information on the fire compartment.
- If more than one fire induced component failure event for the same component for the same zone/ fire occurrence event are considered and the largest component failure probability is one, leave the largest component failure event and delete the other fire induced component failure event

4. Concluding Remarks

The use of IPRO-ZONE could help a PSA analyst maintain consistency in determining component failure modes affected by a fire and may reduce the working hours of him/her in fire PSA. More studies are required for computerization works for the calculation of severity factors and for uncertainty analysis in fire PSA.

ACKNOWLEDGEMENTS

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Table 1. Example of rules for the determination of fire induced component failure modes

ID	Category	Flag-SE	Equipment Type	Location	NormalPosition	FailedPosition	DesiredPosition	FailureMode	Failure Probability	Failure Code Order	FailureCode
4	Fire	real	MV	CE, CC, PE^CE, PE^CC, PC^CC, PC^CE, CC^CE	OPEN	FL	OPEN	SO	0.1	5	T
5	Fire	real	MV	CE, CC, PE^CE, PE^CC, PC^CC, PC^CE, CC^CE	OPEN	FL	CLOSE	FF	1	5	C
6	Fire	real	MV	CE, CC, PE^CE, PE^CC, PC^CC, PC^CE, CC^CE	OPEN	FL	OPERATING	FF	1	5	O