Study for Fire PSA Quantification Method for simultaneous fire-induced initiating event

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1. Introduction

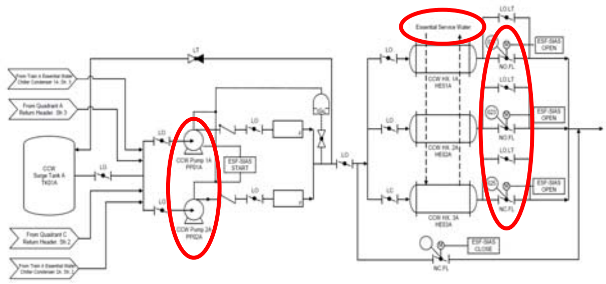
Fire PSA is a part of PSA that quantitatively evaluates the core damage frequency in the plant fire condition. In the quantifying task, initiating event caused from specific fire scenario is firstly estimated. After determining the initiating event, quantification is accessed according to mitigation sequences for each initiating event. It means only one initiating event is considered for each fire scenario. However, it leads to ignore of possibility of multiple initiating event for each fire scenario. To compensate this weakness, a study about quantification method for simultaneous fire-induced initiating event was conducted.

2. Existing Method

In this section some of the techniques used to determine fire-induced initiating event and quantify fire scenarios are described.

2.1 Determination of fire-induced initiating event

Each fire scenario includes specific equipment or cables damaged from fire. These damaged instruments induce system failure and eventually cause core damage. In fig 1, three scenarios inducing loss of component cooling system is introduced. When the fire event induced one of these scenarios, loss of cooling water initiating event(LOCCW) is occurred.



Initiator	IniGroup	Equipment	Memo
LOCCW	LOCCW-1	1-461-M-PP01A	CCW PP 01A Unavailable
LOCCW	LOCCW-1	1-461-M-PP02A	CCW PP 02A Unavailable
LOCCW	LOCCW-2	1-462-M-PP01A	ESW PP 01A Unavailable
LOCCW	LOCCW-2	1-462-M-PP02A	ESW PP 02A Unavailable
LOCCW	LOCCW-3	1-461-M-MV021	CCW HX 01A Outlet Valve Spurious Close
LOCCW	LOCCW-3	1-461-M-MV023	CCW HX 01A Outlet Valve Spurious Close
LOCCW	LOCCW-3	1-461-M-MV025	CCW HX 03A Outlet Valve Fail to Open

Fig 1. Fire scenario inducing LOCCW

2.2 Mapping fire scenario to fire PSA model

Before accessing quantification, each fire scenarios have to be mapped to corresponding fire PSA quantification model after determining fire-induced initiating event. Fig 2 shows mapping of fire scenario with fire PSA model.

Fire Compartment	Description	Initiator	Initiator Group
F0A0-A01C	CS PUMP & MINI FLOW EXCHANGER ROOM	GTRN	GTRN
F0A0-A02C	SI PUMP ROOM	GTRN	GTRN
F0A0-A04A	SC PUMP & MINI FLOW EXCHANGER ROOM	GTRN	GTRN
F0A1-A14C	PIPE CHASE & VALVE ROOM	LODCA	GTRN
F0A1-AGAA	GENERAL ACCESS AREA	GTRN	GTRN
F0A2-AEEA	CLASS 1E SWITCHGEAR 01A ROOM	LOKV	GTRN
F0A3-A13B	MECHANICAL PENETRATION ROOM	SLOCA	SLOCA
F0A3-AGAD	GENERAL ACCESS AREA	SLOCA	SLOCA

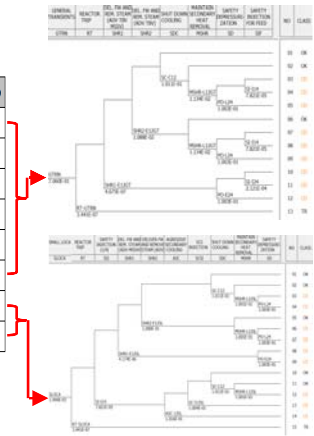


Fig 2. Mapping Fire scenario with Fire PSA model

2.3 Weakness of the existing method

If the multiple fire-induced initiating events are generated, there are some difficulties to quantify fire scenario because the fire scenario is mapped to only one specific fire PRA model. In this case, more significant initiating event was generally selected. But from the perspective of accurate risk insight, there are need for a method to consider multiple simultaneous initiating event.

3. New Method

3.1 New Method

To complement the existing method, new quantifying method for multiple fire-induced initiating events is introduced in this study. At first, as shown in fig 3, make a one top fault tree involving all kinds of fire-induced initiating event. Then conduct quantification at the top. This method results in massive cutset including all credible initiating events for one fire scenario. In existing method, most conservative initiating event is selected for cutset. But in new method, compact the repeated cutsets appeared for multiple initiating events. For example, at a cutset described in fig 4, delete initiators to find repeated cutsets. Cutset no 35 for LODCA and 2 for SLOCA are same cutsets. Then delete one of the repeated cutset.

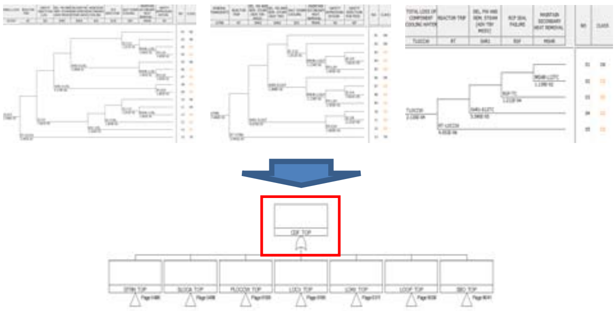


Fig 3. Integrated one top fault tree

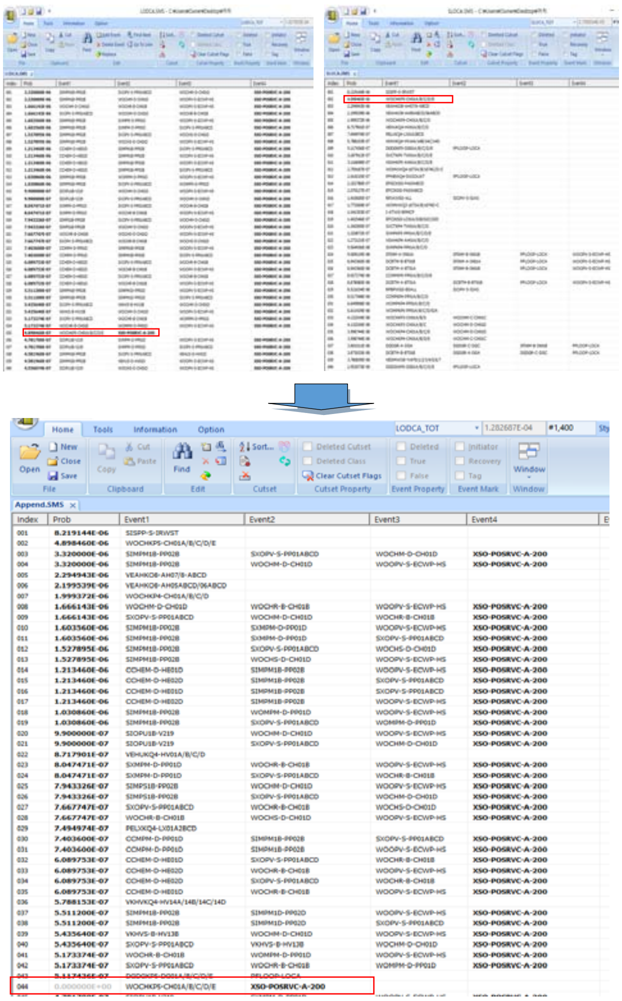


Fig 4. Compacting repeated cutsets

3.2 Features

The new quantifying method results in all scenarios from multiple fire-induced initiating events without conservative assumption considering only one initiating event. But even though removing repeated cutsets, it is confirmed that overall value is still conservative. As shown in fig 4, CDF of LODCA and SLOCA are 1.03E-04 and 2.71E-05 respectively. Overall value for both 2 cutset are 1.30E-04. But by compacting repeated cutset, it is shown that CDF is lowered to 1.28E-04. Even though the value has decreased slightly, the value is still close to the sum of LODCA and SLOCA. So, it is confirmed that overall value is still conservative. In addition, since many initiating events are assigned to one fire scenario and initiating event tag is deleted from cutset, there is difficulty to specify one representative initiating event for each fire scenario.

3. Conclusions

In this study, new quantifying method to consider simultaneous fire-induced initiating events for fire PSA is conducted. It is found that the new method has a merit that all possible initiating events can be considered. But at the same time, it is found that there is a complementary point that it is still conservative. Efforts should be made to produce better results by continuing study on this subject.

REFERENCES

[1] U.S. NRC, 'NUREG/CR-6850 : Fire PRA Methodology for Nuclear Power Facilities', Sep 2005