

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

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1. Introduction

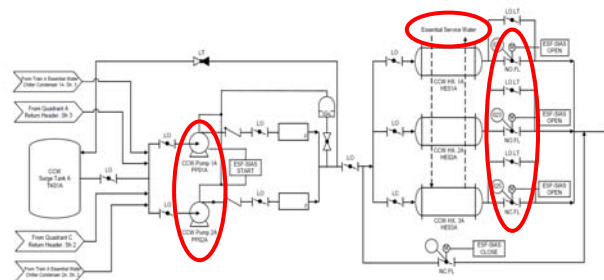
Fire PSA is a part of PSA that quantitatively evaluates the core damage frequency in the plant fire condition. In the quantifying task, initiating event caused from specific fire scenario is firstly estimated. After determining the initiating event, quantification is accessed according to mitigation 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.

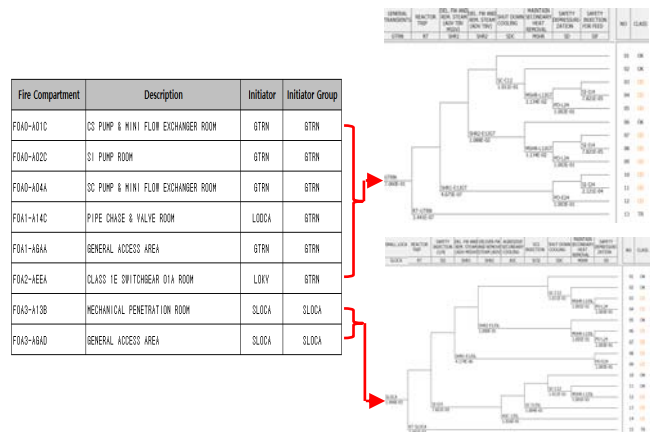


Fig 2. Mapping Fire scenario with Fire PSA model

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.

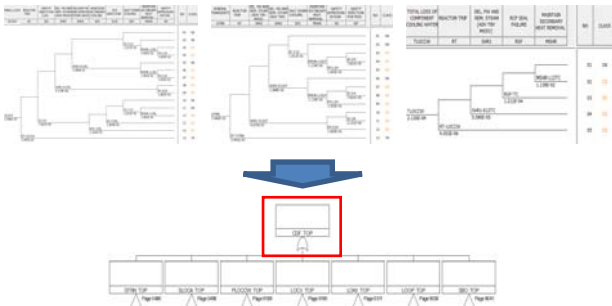


Fig 3. Integrated one top fault tree

Index	Prob	Event1	Event2	Event3	Event4
001	8.219144E-06	SEPP-S-DRVST			
002	4.898460E-06	WOCHPS-CHS1B/C/D/E			
003	3.320000E-06	SMH1B-PP02B	SIOPV-S-PP1A/BCD	WOCHM-D-CH1D	X50-POS9VC-A-200
004	3.320000E-06	SMH1B-PP02B	WOCHN-D-CH1D	WOOPV-S-ECVH-HS	X50-POS9VC-A-200
005	2.294943E-06	VEAHQD-AH07B-ABCD			
006	2.195279E-06	VEAHQD-AH08BCD/PA/BCD			
007	1.999372E-06	WOCHM-CHS1B/C/D			
008	1.666143E-06	WOCHP-D-CH1D	WOCHB-B-CH1E	WOOPV-S-ECVH-HS	X50-POS9VC-A-200
009	1.666143E-06	SIOPV-S-PP1A/BCD	WOCHD-D-CH1D	WOCHB-B-CH1E	X50-POS9VC-A-200
010	1.603360E-06	SMH1B-PP02B	WOCHM-D-PP01D	WOOPV-S-ECVH-HS	X50-POS9VC-A-200
011	1.603360E-06	SMH1B-PP02B	SIOPV-S-PP1A/BCD	WOCHM-D-CH1D	X50-POS9VC-A-200
012	1.527895E-06	SMH1B-PP02B	SIOPV-S-PP1A/BCD	WOCHS-D-CH1D	X50-POS9VC-A-200
013	1.527895E-06	SMH1B-PP02B	WOCHS-D-CH1D	WOOPV-S-ECVH-HS	X50-POS9VC-A-200
014	1.313460E-06	COHEM-D-H01D	SMH1B-PP02B	WOOPV-S-ECVH-HS	X50-POS9VC-A-200
015	1.313460E-06	COHEM-D-H02D	SMH1B-PP02B	SIOPV-S-PP1A/BCD	X50-POS9VC-A-200
016	1.313460E-06	COHEM-D-H01D	SMH1B-PP02B	SIOPV-S-PP1A/BCD	X50-POS9VC-A-200
017	1.313460E-06	COHEM-D-H02D	SMH1B-PP02B	WOOPV-S-ECVH-HS	X50-POS9VC-A-200
018	1.030860E-06	SMH1B-PP02B	WOCHM-D-PP01D	WOOPV-S-ECVH-HS	X50-POS9VC-A-200
019	1.030860E-06	SMH1B-PP02B	SIOPV-S-PP1A/BCD	WOCHM-D-PP01D	X50-POS9VC-A-200
020	9.900000E-07	SIOPV-S-V21B	WOCHM-D-CH1D	WOOPV-S-ECVH-HS	X50-POS9VC-A-200
021	9.900000E-07	SIOPV-S-V21B	SIOPV-S-PP1A/BCD	WOCHM-D-CH1D	X50-POS9VC-A-200
022	8.717901E-07	VEAHQD-AH05A/B/C/D	WOCHB-B-CH1E	WOOPV-S-ECVH-HS	X50-POS9VC-A-200
023	8.047471E-07	SIOPV-S-PP1D	SIOPV-S-PP1A/BCD	WOCHB-B-CH1E	X50-POS9VC-A-200
024	7.943326E-07	SMH1B-PP02B	WOCHM-D-CH1D	WOOPV-S-ECVH-HS	X50-POS9VC-A-200
025	7.943326E-07	SMH1B-PP02B	SIOPV-S-PP1A/BCD	WOCHM-D-CH1D	X50-POS9VC-A-200
026	7.667747E-07	SIOPV-S-PP1A/BCD	WOCHB-B-CH1E	WOCHS-D-CH1D	X50-POS9VC-A-200
027	7.667747E-07	SIOPV-S-PP1A/BCD	WOCHS-D-CH1D	WOCHS-D-CH1D	X50-POS9VC-A-200
028	7.667747E-07	WOCHB-B-CH1E	WOCHS-D-CH1D	WOOPV-S-ECVH-HS	X50-POS9VC-A-200
029	7.484974E-07	VEAHQD-AH03A/BCD			
030	7.403600E-07	COHEM-D-PP01D	SMH1B-PP02B	SIOPV-S-PP1A/BCD	X50-POS9VC-A-200
031	7.403600E-07	COHEM-D-PP01D	SMH1B-PP02B	WOOPV-S-ECVH-HS	X50-POS9VC-A-200
032	6.089733E-07	SIOPV-S-PP1A/BCD	SIOPV-S-PP1A/BCD	WOCHB-B-CH1E	X50-POS9VC-A-200
033	6.089733E-07	COHEM-D-H02D	WOCHB-B-CH1E	WOOPV-S-ECVH-HS	X50-POS9VC-A-200
034	6.089733E-07	COHEM-D-H02D	SIOPV-S-PP1A/BCD	WOCHB-B-CH1E	X50-POS9VC-A-200
035	6.089733E-07	COHEM-D-H02D	WOCHB-B-CH1E	WOOPV-S-ECVH-HS	X50-POS9VC-A-200
036	5.788133E-07	VOHWQ-AH14A/14B/14C/14D	WOCHB-B-CH1E	WOOPV-S-ECVH-HS	X50-POS9VC-A-200
037	5.511200E-07	SMH1B-PP02B	SMH1B-PP02B	WOOPV-S-ECVH-HS	X50-POS9VC-A-200
038	5.511200E-07	SMH1B-PP02B	SMH1B-PP02B	SIOPV-S-PP1A/BCD	X50-POS9VC-A-200
039	5.435640E-07	VOHVS-B-HV13B	WOCHM-D-CH1D	WOOPV-S-ECVH-HS	X50-POS9VC-A-200
040	5.435640E-07	SIOPV-S-PP1A/BCD	VOHVS-B-HV13B	WOCHM-D-CH1D	X50-POS9VC-A-200
041	5.173374E-07	WOCHB-B-CH1E	WOCHM-D-PP01D	WOOPV-S-ECVH-HS	X50-POS9VC-A-200
042	5.173374E-07	SIOPV-S-PP1A/BCD	WOCHB-B-CH1E	WOCHM-D-PP01D	X50-POS9VC-A-200
043	5.173374E-07	WOCHB-B-CH1E	WOCHM-D-PP01D	WOCHM-D-PP01D	X50-POS9VC-A-200
044	5.173374E-07	WOCHPS-CHS1A/B/C/D/E	X50-POS9VC-A-200		

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