# A Study on Multiple Initiating Events in Fire PSA

Kilyoo Kim*, DaeIl Kang, Seung-Cheol Jang

*Integrated Safety Assessment Division, Korea Atomic Energy Research Institute,*
*P.O. Box 105, Yuseong, Daejeon 305-600, South Korea,*
**Corresponding author: kykim@kaeri.re.kr*

## 1. Introduction

In traditional internal PSA, we assume that only one initiating event (IE) occurs, and multiple IEs are very seldom event. Also, if a multiple IEs modeling is required in internal PSA, then the event can be separately modeled by checking the actual plant response.

However, in developing a fire PSA based on an internal PSA, there are multiple IEs issues since the multiple IEs caused by fire are not separately modeled by reflecting the real plant response, but modeled by just manipulation of internal PSA model.

Also, multiple spurious operation (MSO) induced by fire could be one of multiple IEs, and it is discussed in this paper.

## 2. Multiple IEs issues in Fire PSA

In this section, multiple IEs issues in the fire PSA is described.

### *2.1 Multiple IEs in internal PSA model*

Let's assume that SBO and LOCCW occurs simultaneously. Even though we may manipulate the two IE models to depict the multiple IEs, we currently do not have any solution without modeling the actual plant response. Fortunately, the modeling of multiple IEs is not often required in the internal PSA.

### *2.2 Multiple IEs in Fire PSA model*

Fire in a compartment could damage multiple components and induce multiple IEs. Since a fire PSA model is usually developed based on an internal PSA, and the number of fire compartments is usually more than 100, it is impossible to depict the actual plant response for the multiple IEs, and unfortunately multiple IEs very often occurs in the fire PSA.

Currently, it is recommended that only the largest CCDP (Conditional Code Damage Probability) IE could be used among multiple IEs. Various attempts is tried to use multiple IEs in a compartment.

In compartment ABB-144H, 3 pairs of multiple IEs are tested as shown in Table 1. Three pairs are distinguished with three colors such as yellow, blue, and green. The following three cases are tested;

1) normal case - it is assumed that two IEs (i.e., SLOCA and LSSBOUT) occurs in ABB-144H compartment fires. In this case, iZone of IPRO-ZONE is prepared as shown in Table 1.
2) SLOCA case - it is assumed that only SLOCA occurs in ABB-144H compartment fires. In this case, iZone of IPRO-ZONE is prepared as shown in Table 2.
3) LSSBOUT case - it is assumed that only LSSB occurs in ABB-144H compartment fires. In this case, iZone of IPRO-ZONE is prepared as shown in Table 3.

The CDFs for 1) normal case, 2)SLOCA case, and 3) LSSBOUT case are 2.81E-8, 2.56E-8, and 1.69E-8, respectively. Since the CCDP of SLOCA is larger than that of LSSBOUT, the CDF of case 2) is larger than that of case 3). The case 1) could be an overestimation.

### *2.3 Multiple IEs induced by MSO*

An example of IE induced by a MSO is described in Fig, 1, and multiple IEs which consist of the MSO IE and non-MSO IE are discussed.

Actually, MSO-23 scenario could occur in 165-A01A compartment since there are the cables for ADV 171, 172, and 173 in the compartment. However, since the atmosphere dump valve (ADV) for UCN 3[1] has 3 parts as mentioned in Table 4, all parts should be spuriously open before the ADV fails closed (fail-safe). With the data given in Ref[2], for 3 minutes duration, the conservative conditional probability of LSSBOUT (= Large Secondary Side Break, OUTside of containment) induced by the fire of 165-A01A compartment is 6.96-3, and thus, the LSSBOUT induced by MSO in 165-A01A compartment is conservatively 3.19E-6(=6.96E-3 * 4.59E-4) by multiplying the ignition frequency of 165-A01A compartment. In Table 6, ADV 173 was neglected since their tray was well insulated.

## 3. Conclusions

Multiple IEs in a fire PSA are discussed. Multiple IEs induced by MSO are also discussed. Additional study is required.

## Acknowledgement

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## REFERENCES

[1] ENERTECH, "Installation, operation, maintenance manual for Electro-Hydraulic Actuator (for Atmosphere Dump Valves) for Ulchin Nuclear Power Plant", MA 21901, June 2011.
[2] NRC, "SUPPLEMENTAL INTERIM TECHNICAL GUIDANCE ON FIRE INDUCED CIRCUIT FAILURE MODE LIKELIHOOD ANALYSIS", Feb. 2014

Table 1. iZone for normal case

| Zone | Path | Transfer Zone | Frequency | EventTree | Barrier Proba | NonSup Proba |
|---|---|---|---|---|---|---|
| PABB-144H | | | 0.00000889 | %ILOFW | | |
| PABB-144H | CAB | 144-A02B | 0.00000889 | %ILSSBOUT-AB-FIRE | 0.0012 | 0.897 |
| PABB-144H | CAB | 144-A02B | 0.00000889 | %ISL | 0.0012 | 0.897 |
| PABB-144H | CAB | SAB | 0.00000889 | %ILOFW | 0.0012 | 0.897 |
| PABB-144H | DAM | SAB | 0.00000889 | %ILOFW | 0.0027 | 0.897 |
| PABB-144H | DOO | SAB | 0.00000889 | %ILOFW | 0.0074 | 0.897 |
| PABB-144H | CAB | PABB-165 | 0.00000889 | %ILSSBOUT-B-FIRE | 0.012 | 0.897 |
| PABB-144H | DAM | PABB-165 | 0.00000889 | %ILSSBOUT-B-FIRE | 0.027 | 0.897 |
| PABB-144H | CAB | PABB-125 | 0.00000889 | %ILSSBOUT-B-FIRE | 0.012 | 0.897 |
| PABB-144H | DAM | PABB-125 | 0.00000889 | %ILSSBOUT-B-FIRE | 0.027 | 0.897 |
| PABB-144H | CAB | PABB-125 | 0.00000889 | %ISL | 0.012 | 0.897 |
| PABB-144H | DAM | PABB-125 | 0.00000889 | %ISL | 0.027 | 0.897 |

Table 2. iZone for SLOCA case

| Zone | Path | TransferZone | Frequency | Event Tree | Barrier Proba | NonSup Proba |
|---|---|---|---|---|---|---|
| PABB-144H | | | 0.00000889 | %ILOFW | | |
| PABB-144H | CAB | 144-A02B | 0.00000889 | %ISL | 0.0012 | 0.897 |
| PABB-144H | CAB | SAB | 0.00000889 | %ILOFW | 0.0012 | 0.897 |
| PABB-144H | DAM | SAB | 0.00000889 | %ILOFW | 0.0027 | 0.897 |
| PABB-144H | DOO | SAB | 0.00000889 | %ILOFW | 0.0074 | 0.897 |
| PABB-144H | CAB | PABB-165 | 0.00000889 | %ILSSBOUT-B-FIRE | 0.012 | 0.897 |
| PABB-144H | DAM | PABB-165 | 0.00000889 | %ILSSBOUT-B-FIRE | 0.027 | 0.897 |
| PABB-144H | CAB | PABB-125 | 0.00000889 | %ISL | 0.012 | 0.897 |
| PABB-144H | DAM | PABB-125 | 0.00000889 | %ISL | 0.027 | 0.897 |

Table 3. iZone for LSSB case

| Zone | Path | Transfer Zone | Frequency | EventTree | Barrier Proba | NonSup Proba |
|---|---|---|---|---|---|---|
| | | | | | | |
| | | | | | | |
| PABB-144H | | | 0.00000889 | %ILOFW | | |
| PABB-144H | CAB | 144-A02B | 0.00000889 | %ILSSBOUT-AB-FIRE | 0.0012 | 0.897 |
| PABB-144H | CAB | SAB | 0.00000889 | %ILOFW | 0.0012 | 0.897 |
| PABB-144H | DAM | SAB | 0.00000889 | %ILOFW | 0.0027 | 0.897 |
| PABB-144H | DOO | SAB | 0.00000889 | %ILOFW | 0.0074 | 0.897 |
| PABB-144H | CAB | PABB-165 | 0.00000889 | %ILSSBOUT-B-FIRE | 0.012 | 0.897 |
| PABB-144H | DAM | PABB-165 | 0.00000889 | %ILSSBOUT-B-FIRE | 0.027 | 0.897 |
| PABB-144H | CAB | PABB-125 | 0.00000889 | %ILSSBOUT-B-FIRE | 0.012 | 0.897 |
| PABB-144H | DAM | PABB-125 | 0.00000889 | %ILSSBOUT-B-FIRE | 0.027 | 0.897 |

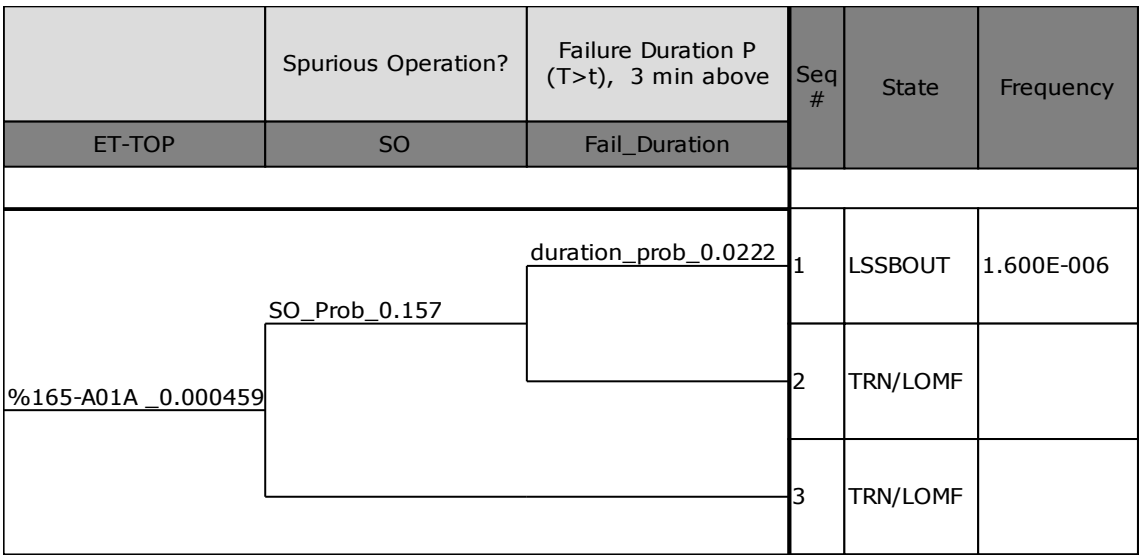


Fig. 1. %LSSBOUT IE

Table 4. Initiating Events for MSO Compartments

| Room | IE | Equip. ID | Raceway type | Required Parts Failure | | | Conservative Success criteria | SO Prob. | 3 min. duration | combined |
|---|---|---|---|---|---|---|---|---|---|---|
| 165-A01A | LSSB-AB | 9521V0171 | MCT | AC pump circuit | Solenoid VV 1 | Solenoid VV 2 | AC*SV | 1.57E-01 (=0.28*0.56) | 2.22E-02 (=0.149*0.149) | 3.48E-03 (=1.57E-01 *2.22E-02) |
| | | 9521V0172 | MCT | AC pump circuit | Solenoid VV 1 | Solenoid VV 2 | AC*SV | 1.57E-01 (=0.28*0.56) | 2.22E-02 (=0.149*0.149) | 3.48E-03 (=1.57E-01 *2.22E-02) |
| | | | | | | | | | | 6.96E-03 |