

Low Power and Shutdown PSA Modeling using AIMS-PSA and SIMA Script

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1. Introduction

KAERI has been developing an integrated PSA (Probabilistic Safety Assessment) software package, called OCEANS. OCEANS includes software for Level-1, 2 & 3 PSAs, fire PSA, seismic PSA, and shutdown PSA [1]. OCEANS is being developed to simplify and automate the modeling and quantification procedures in PSA. The AIMS-PSA software [2] plays a key role in OCEANS, which takes charge of the event tree and fault tree modeling, as well as automates the quantification procedure.

The first low power and shutdown (LPSD) PSA in Korea was performed for the purpose of estimating the risk during the LPSD operation for YGN 5&6 [3] in 2000. The LPSD PSA requires a lot of time and effort for the following 2 reasons:

1) The risk is analyzed for 14 POSs (Plant Operating States). A PSA for each POS corresponds to a full power PSA. The size of a LPSD PSA can be as large as 14 times a full power PSA.

2) The states of systems/components are changed for every overhaul. The LPSD PSA should be revised for every overhaul to reflect the overhaul schedule.

Another study was performed to improve the quality and enhance the methodology for the LPSD PSA in 2006 [5]. A method to use the conditioning gate was introduced for the purpose of handling a change in the state of a component. This approach has a benefit compared with the previous one, but still requires modifying the model manually.

An approach has been developed in this study to simply the modeling of the LPSD PSA by using a script, called SIMA (Script Interpreter for Mapping Algorithm), in conjunction with AIMS-PSA. The SIMA script consists of a series of script commands to describe the changes in the fault tree model, which enables modifying the system fault trees of a full power PSA automatically to incorporate the situation of LPSD, so as not to modify the fault tree manually.

The approach developed in this study was tested and verified for the LPSD PSA model developed in 2006.

2. LPSD PSA using AIMS-PSA and SIMA Script

2.1 SIMA Script to Modify the PSA Model

The LPSD PSA requires modifying the model of a full power PSA to reflect the state changes in systems or components. Typical patterns of the modification are categorized as shown in Table 1.

Table 1. SIMA Scripts

Category	Script Example	Remark
Add	Add+ A B	Add an event B to an event A
Multiple Add	Add+ A B Add+ A D	Add events B and D to an event A
Desc	Desc B Description	Insert the description of B
Set	Set A C	Replace A with C
Gate	Gate G + I1 I2	Insert the fault tree logic : G = I1 + I2

A SIMA script to add a fault tree to the existing event, AFTPR02AB, is shown below:

Add+	SIMPS01A	GT
GT	+ A1	A2
Value	A1	0.01
Value	A2	0.02
Desc	GT	Gate Created
Desc	A1	Event A1
Desc	A2	Event A2

The SIMA script interpreter of AIMS-PSA takes the script and modifies the fault tree as below:

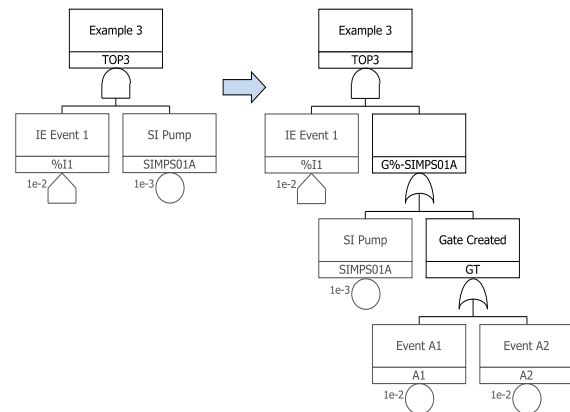


Fig. 2. Example of fault tree modification using SIMA script

2.2 SIMA Script Table

The number of items to be modified is large in the LPSD PSA. An alternate approach is developed to prepare the SIMA script in the form of a table, so as to categorize the items and input the rationale for them.

The essential fields are 'SIMA Model' and 'Apply'. The other fields are used for reference. The contents used to modify the PSA model are inputted into the 'SIMA Model'. Each script will be applied if its 'Apply' field is Y. The analyst can prepare the model for each configuration and select which item will be used for a POS.

Table 2. Example of SIMA script table

Item	SIMA Model	Apply	Rationale
IE Data	Value %LOOP-P3 3.9e-4 Value %LTOP-P3 6.7e-6	Y	The initiating event frequency
LOOP IE	Set %LOOP %LOOP-P3	Y	Replace %LOOP in FP model
SCS Train A	Set FLAG-ARBS False	Y	Configuration: SCS A operating
EDG B OOS	Set EGDGM01B True	Y	EDG B maintenance
Battery 1B OOS	Set EDBYMBT01B True	N/A	Not used in this POS
No UET	Set MTC False	Y	No UET in LPSD

2.3 LPSD PSA modeling

The PSA model consists of event trees and fault trees describing an accident scenario and system failure, respectively. The event trees should be developed for a LPSD PSA because of its unique accident scenario compared to a full power PSA.

Meanwhile, the fault tree for most safety systems has already been developed for a full power PSA. Thus, most fault trees can be reused with modifications incorporating the characteristics of the LPSD PSA. The modification can be inputted using a SIMA script table. However, additional fault trees should be developed for certain functions, which are not modeled in a full power PSA.

The reliability data may be reevaluated for each POS, especially for initiating event frequency or human error probability. The reevaluated data is also described by the SIMA script.

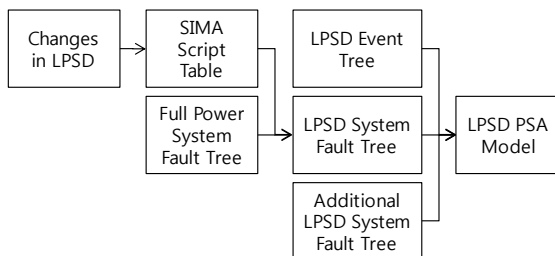


Fig. 2. LPSD PSA modeling using AIMS-PSA and SIMA script table

2.4 UCN 3&4 LPSD PSA Model using AIMS-PSA & SIMA Script Table

The LPSD PSA model of the 2006 study is converted using the AIMS-PSA and SIMA script table. Models for 14 POSs, for which the fuel exists in the reactor, are developed. The quantification results are almost the same as the previous results. For a few POSs, small differences are found because of the minor update of this study.

Fig. 3 illustrates how the model is handled in the AIMS-PSA. The left side is the project explorer, which manages 12 event trees, 2 fault trees, and data files such as a recovery file, flag file, and SIMA script table (POS3.sima.xls) for POS3. The full power PSA model is located in the 'Base' folder, which is also incorporated into the POS3 model.

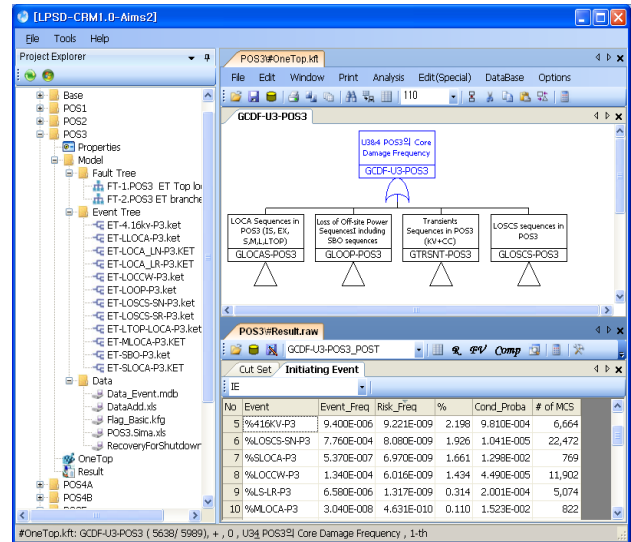


Fig. 3. Example screen of AIMS-PSA for POS3 model

3. Conclusions

The LPSD PSA should be performed for a large number of POSs, where a PSA for each POS corresponds to the PSA for full power. Furthermore, the LPSD PSA may be revised for every overhaul to reflect the overhaul schedule if the living PSA is required. This takes a lot of time and effort.

An approach was developed to simplify the modeling of the LPSD PSA by introducing the SIMA script table, which provides an easy means to incorporate the changes in states of systems/components into system fault trees. Modification of the PSA model due to changes of the overhaul schedule can be modeled without massive effort. The capability to input the rationale has a benefit in enhancing the documentation quality required for PSA quality.

Acknowledgement

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