The Quantification Process for the PRiME-U34i

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1. Introduction

In this paper, we introduce the quantification process for the PRIME-U34i, which is the merged model of ETs (Event Trees) and FTs (Fault Trees) for the level 1 internal PSA of UCN3&4.

PRiME-U34i has one top event. Therefore, the quantification process is changed to a simplified method when compared to the past one. In the past, we used the text file called a user file to control the quantification process. However, this user file is so complicated that it is difficult for a non-expert to understand it. Moreover, in the past PSA, ET and FT were separated but in PRiME-U34i, ET and FT were merged together. Thus, the quantification process is different.

This paper is composed of five sections. In section 2, we introduce the construction of the one top model. Section 3 shows the quantification process used in the PRiME-U34i. Section 4 describes the post processing. Last section is the conclusions.

2. Construction of the PRiME-U34i

We constructed the FT logic for each ET sequence and made one top model for total ETs by merging the FT logic as shown in figure 1.

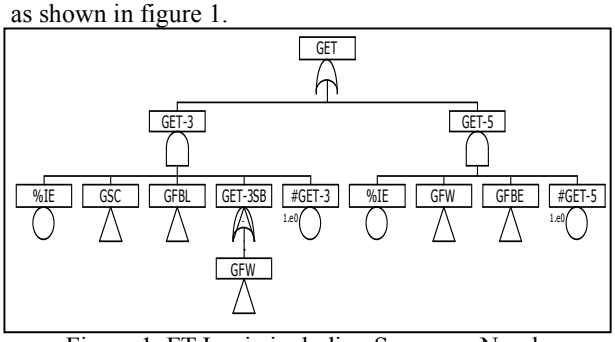

Figure 1. FT Logic including Sequence Number

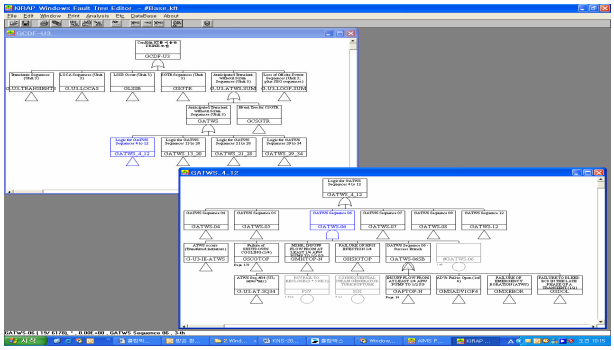

Figure 2. Top Logic for the PRiME-U34i

Then PRiME-U34i was constructed automatically with the system FT and FT logic for ETs through the AIMS (Advanced Information System Management System) PSA-Manager. To obtain the cutset information for each sequence, events with sequence information is included in each cutset. That is, the event representing a sequence number is added to the FT logic for an ET. Therefore, one top model can be used for a risk monitoring and each ET analysis simultaneously. Figure 2 shows the top logic for PRiME-U34i.

3. Quantification Process

This method treats the whole quatification process simultaneously by one button order. Therefore, the cutset calculation time for each sequnce is reduced tremendously. However, we should provide the user file called 'RecoveryFile.krc' for a post processing to treat the nonsence cutset, human error dependency and recovery action.

3.1 Event Tree Quantification

The following describes the ET quantification method being carried out in KAERI (Korea Atomic Energy Research Institute) by using the AIMS PSA manager.

Each sequence is expressed as a multiplying Initiating Event by a Branch.

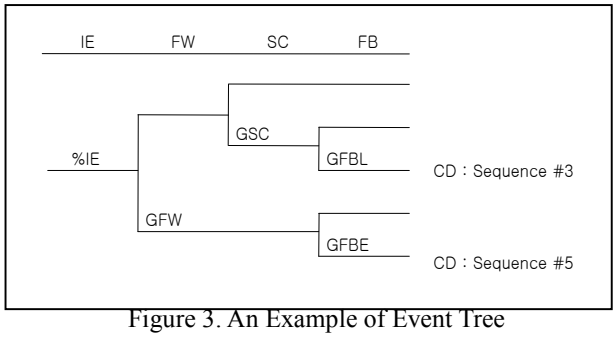

Figure 3. An Example of Event Tree

In figure 3, sequence 3 and 5 induce the core damage, and the equations for these sequences are expressed as follows.

$$\text{Seq - 3} = \%IE * \overline{GFW} * GSC * GFBL \quad (1)$$

$$\text{Seq - 5} = \%IE * GFW * GFBE \quad (2)$$

Where, $\overline{GFW}$ is the complement event for the GFW as a success branch.

To resolve Seq-3 accurately, we should evaluate equation (1) by including a complement event. However, the technology of the present FT quantification engine cannot

support this problem. Therefore, the approximation method by applying a 'Delete Term' function is used for the quantification.
The following is the quantification steps for the PRiME-U34i.

- ✓ Step 1: Construction of the equation by not considering the Success Branch and Cut Set calculation
- ✓ Step 2: Delete a Cut Set existing in the success branch by applying a 'Delete Term' function.
- ✓ Step 3: Minimization among the Sequences: Cutsets, which can be minimized by a subsumption or absorption among the sequences, can exist after carrying out a "Delete Term' because the 'Delete Term' is also an approximation. Accordingly, a minimization is performed to resolve this problem. If the same cutset exists in two sequences or more, the lowest sequence is assumed to the severest sequence and the cutest, which is in the lowest sequence, remains.

3.2 Expample of Quantification for PRiME-U34i

In the case of sequence 2 for Medium LOCA ET, cut sets were reviewed after performing each step. The equation for Medium LOCA Seq-2 can be expressed as follow:

$$\%U3 - MLOCA * \overline{HPI} * \overline{HPR} * \overline{HPH} * CSR .$$

Where,
HPI: High Pressure Safety Injection System Injection
HPR: HPSIS Recirculation
HPH: Hot and Cold leg Recirculation
CSR: Recirculation Cooling
After carrying out step 1, the number of cutsets is 332. However, after step 2 is performed, the number of cutsets is reduced to 60. Here, there was no effect by step 3. Figure 4 shows the cut set results after the performance of each step.

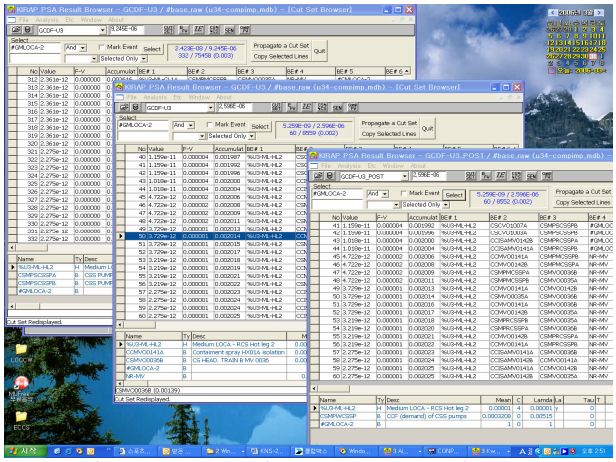

Figure 4. Cut set for MLOCA Seq-2 by Step

4. Post Processing

After the cut sets are obatined through the quantification process of section 3, a quantification is performed once more by considering the recovery action, non-sense cut set and dependency among human errors. This process is called a post processing.
For the post processing, a simplified user file called 'RecoveryFile.krc' is used.

(1) Non-sense Cutset treatment: Non-sense Minimal cut sets are produced such as a simultaneous maintenance of Train A and B for a system in the quantification process. These non-sense MCS should be deleted from the final results.
(2) Dependency treatment among the human errors: When dependent human errors are in the same MCS, we should reflect the dependency degree among the human errors on the MCS.
(3) Recovery action treatment: To make a decision whether each MCS inducing a core damage is possible for a recovery or not, each MCS is reviewed. If the operator can carry out an action to recover the component failure included in the cutset to prevent core damage, the core damage MCS is regared as recoverable.

4. Conclusions

It turned out that the 'Delete Term' and 'Minimization' functions to overcome the limitation of the present quantification engine work appropriatly.
The quantification process for the PRiME-U34i by combining the ET and FT is simpler and easier than the past process. Therefore, even though someone who is not an expert performs the quatification process, he/she can obtain the PSA results. In addition, we can obtain a total CDF and CDF by a sequence simultaneously.

Acknowledgments

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References

1. Hwang, M., U34-1FI-MM-QU-0002-R1-2005, Quantification Process for the PRiME-U34i