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Plant Damage State Logic Diagram for the Preliminary Level 2 PSA of KALIMER-600

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1. Introduction

The interface between the Level 1 system analysis and the Level 2 analysis in the probabilistic safety analysis (PSA) of nuclear power plants is the classification of accident sequences into plant damage states (PDS). The purpose of this classification is to reduce the number of accident analyses required while retaining the essential spectrum of probable accident progression. This can be accomplished by grouping the relatively large number of core damage sequences into a small set of states, each representing a similar plant status at the time of core damage. Fig. 1 shows a process of PSA and interfaces of plant damage event tree with Level 1 systems analysis and Level 2 analysis. The objective of this paper is to develop the plant damage state logic diagram as a part of preliminary Level 2 PSA for the sodium-cooled fast reactor (KALIMER-600) which is being designed by Korea Atomic Energy Research Institute.

2. PDS Logic Diagram Development

Fig. 2 shows a sample of Level 1 system event tree of general transient initiated accident for KALIMER-600[1]. Total of 9 system event trees are developed during Level 1 PSA, which include 45 core damage sequences. Given one of the core damage sequence is defined in the Level 1 analysis results, the reactor will go through a transient phase until neutronic shutdown is accomplished. The plant damage event tree defines the possible scenarios and end states (PDS) of the transient phase. Therefore, the PDS definition and the PDS grouping parameters need to be developed.

2.1 PDS Definition

The PDSs are defined by developing all possible combinations of possible values for each of the PDS parameters (core-melt bins and containment safeguard states). These combinations are then reviewed to delete combinations not physically possible or counter to other definitions used in this analysis. To bin core-damage sequences into PDSs systematically, the PDS logic diagram is used. A PDS logic diagram is constructed with PDS grouping parameters as decision branches, to aid in the assembly of specific PDS characteristics from the matrix of all possible combinations allowed by the grouping parameters.

2.2 PDS Grouping Parameters

The PDS characteristics are defined by selecting key parameters considered to be important to the radionuclide source term. Eight parameters are selected for use in grouping PDSs for KALIMER-600, and two or three branches are considered for each parameter. The grouping parameters and branch point considerations are shown in Table 1. And the PDS logic diagram developed for preliminary Level 2 PSA is illustrated in Fig. 3.

Table 1. Grouping Parameters and Branch Point Considerations of PDS Logic Diagram

Grouping Parameters	Branch Point Consideration
Containment bypass	No containment bypass
	Containment bypass
Containment Isolation	Containment isolated
	Containment not isolated
Initiating Event Type	Transient
	Loss of coolant (Vessel leak)
	Sodium-water reaction in SG
Reactor Trip	Ultimate reactor trip
	No ultimate reactor trip
Normal Power Heat Removal	Normal power heat removed
	Normal power heat not removed
Decay Heat Removal	Decay heat removed
	Decay heat not removed
Containment Cooling	Containment cooled
	Containment not cooled
Hydrogen Control	Hydrogen controlled
	Hydrogen not controlled

ACKNOWLEDGEMENTS

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REFERENCES

[1] T.W.Kim, PSA Methodology Applicability to Support the Design of an Advanced SFR, Gen. IV International Forum, SFR Safety and Operation Project Deliverable, SFR-SO-2009-016, March 2010.

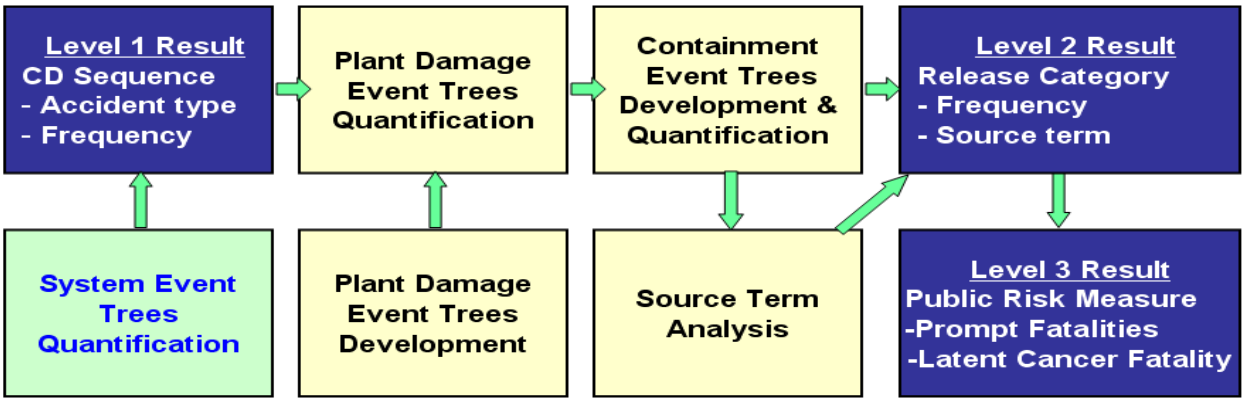

Fig. 1. A Process of PSA and Interfaces of Plant Damage Event Tree with Level 1/ Level 2 Analysis for KALIMER-600

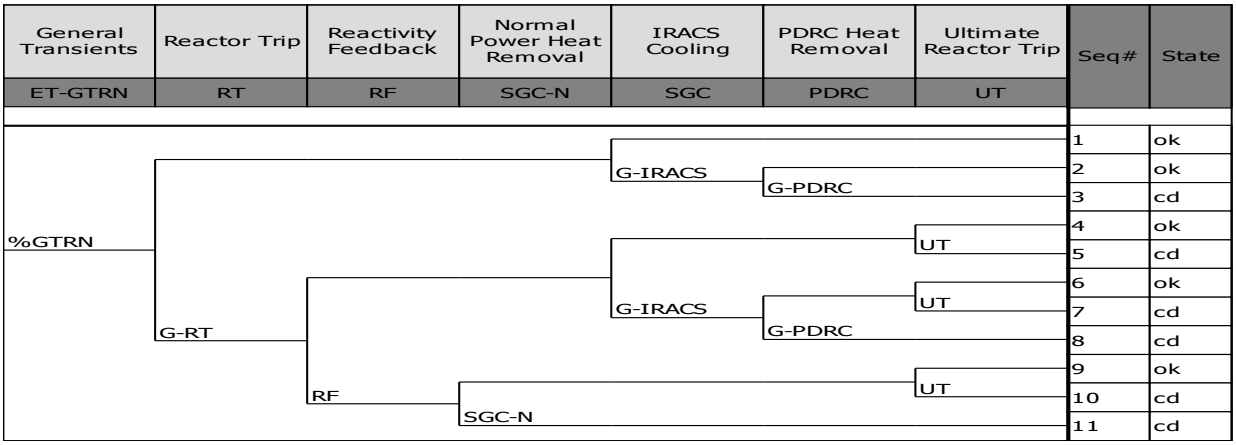

Fig. 2. An Example of Level 1 System Event Tree of General Transient Accident for KALIMER-600

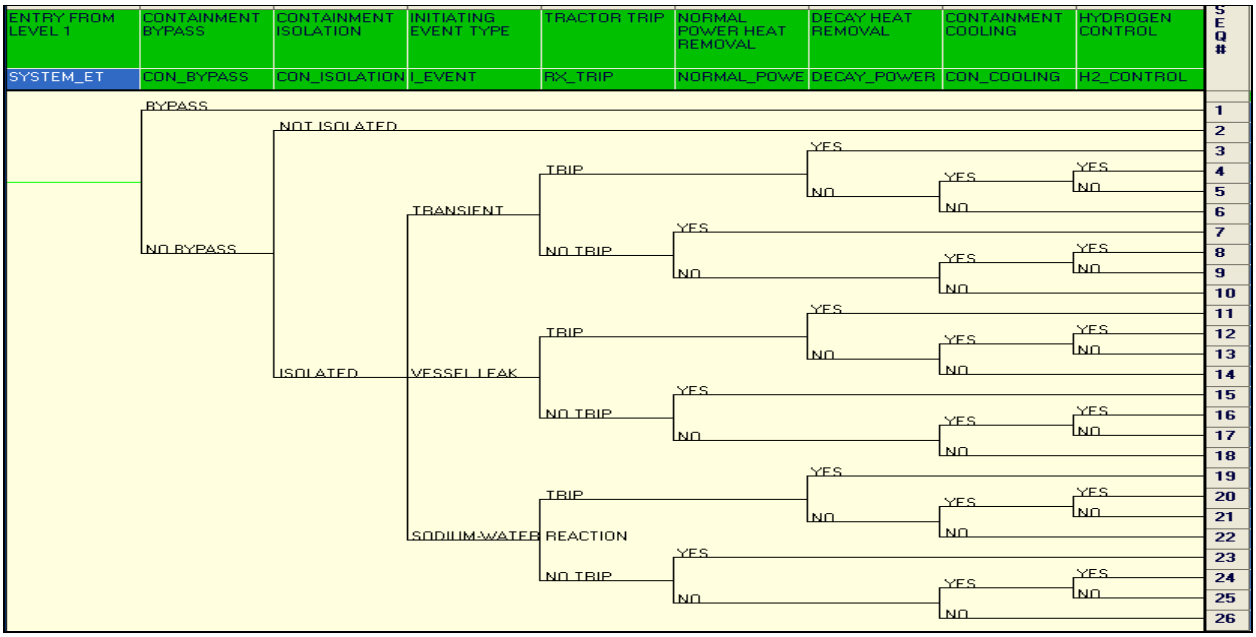

Fig. 3. PDS Grouping Logic Diagram of Preliminary Level 2 PSA for KALIMER-600