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Core Damage Event Tree Analysis for SFR-600 Level 2 PSA

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1. Introduction

The Korea Atomic Energy Research Institute has been developing Sodium-cooled Fast reactor (SFR) design technologies. Licensing procedures and regulatory requirements are also under establishment for the Gen-IV reactors by the domestic regulatory organization. One of the design requirements of SFR will be to apply the probabilistic safety assessment (PSA) to the design process. Consistent with the design requirements, the PSA would be carried out. On the other hand, there is no experience of the PSA domestically for a fast reactor with the metal fuel. Therefore, the objective of paper is to establish the methodologies of the core damage event tree analysis as a part of Level 2 PSA for the SFR-600 reactor.

2. Core Damage Event Tree Development

The interface between the Level 1 system analysis and the Level 2 analysis is the classification of accident sequences into core damage categories (CDC). Fig. 1 shows a process of PSA and interfaces of core damage event tree with Level 1 systems analysis and Level 2 analysis. Fig. 2 shows a sample of Level 1 system event tree of general transient initiated accident. Total of 10 system event trees are developed during Level 1 PSA for SFR-600, which include 46 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 core damage event tree defines the possible scenarios and end states (CDCs) of the transient phase. Therefore, the CDC definition and the CDC grouping parameters need be developed.

2.1 CDC Definition

The CDCs are defined by the set of parameters that are important to subsequent accident progression and source term analyses. The parameters are: (1) fission product release rate and location, (2) fuel release fraction, physical form, and location, (3) possibility of vessel or vessel seal damage, (4) primary sodium temperature. 12 CDCs are defined depends on the above parameters. A sample category is shown in Table 1. In this category, for example, the reactor is shutdown with 15 % of fuel molten, of which 1/3 (5%) is squirted out of the fuel rod to form coolable debris or partial coolable blockages. The remaining molten fuel stays within the fuel rod. The molten fuel release is preceded by a eutectic melt release involving 2% of the fuel. The PRISM[1] approaches of core damage response analysis are applied at this point because only the limited resources are available for the metal fuel fast reactor.

Table 1. An example of Core Damage Category

CDC C4 & C4S			
FP released	Fission Product	Relesed Fr. (%)	Location
	Xe, Kr	70	Cover Gas
	I, Br	20	Primary Na
	Cs, Rb	30	Primary Na
	Te	2	Primary Na
	Sr	0.2	Primary Na
	Others	0.05	Primary Na
Fuel released	5% in the form of coolable debris or blockages		
	2 % in the form of eutectic alloy in primary Na		
Vessel or Seal damage	None		
Primary sodium Temp.	800 ℃		

2.1 CDC Grouping Parameters

The CDC characteristics are defined by selecting key parameters considered to be important to the radionuclide source term. Following five parameters are selected for use in grouping the SFR-600 CDCs: (1) fuel/clad eutectic formation which impact on reactivity feedback, flow blockage, or flow stagnation, (2) shutdown by fuel/clad eutectic or sweepout which result in reactivity change, (3) bulk sodium boiling or voiding which result in a reactivity change, (4) core structural damage which impact on a fuel release fraction, physical form, and location., (5) vessel or vessel seal damage. A sample core damage event tree is illustrated in Fig. 3.

ACKNOWLEDGEMENTS

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REFERENCES

[1] GE, PRISM Preliminary PSA Report, GEFR-00793, May 1990.

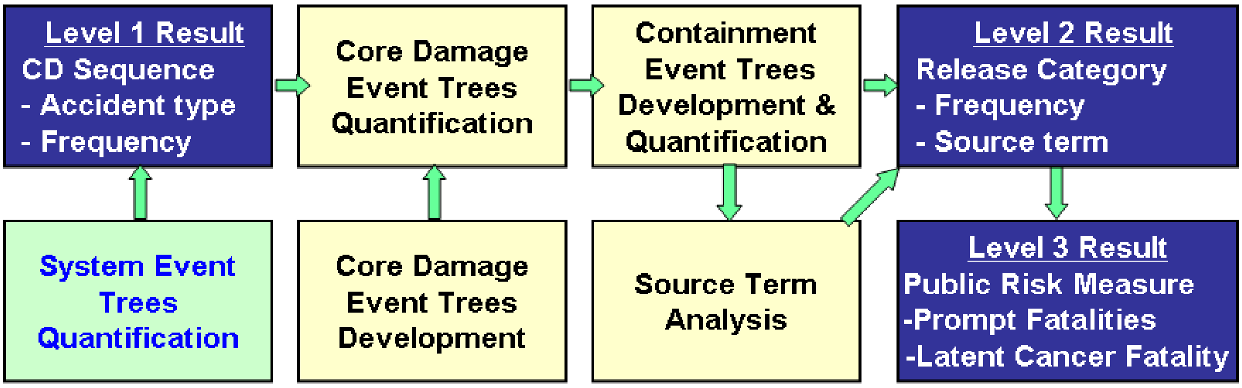

Fig. 1. A Process of PSA and Interfaces of Core Damage Event Tree with Level 1 and Level 2 Analysis for SFR-600

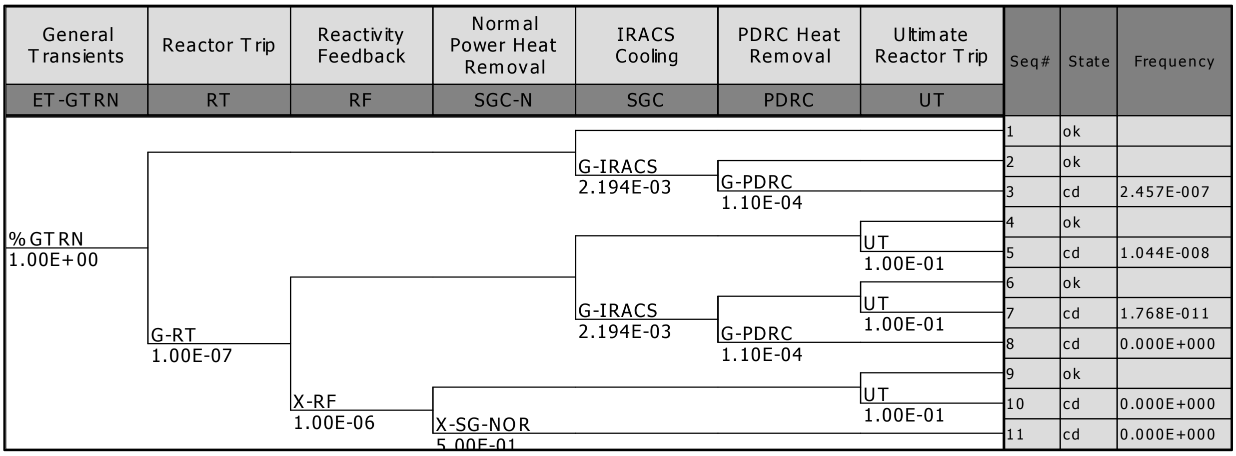

Fig. 2 An Example of Level 1 System Event Tree of General Transient Accident for SFR-600

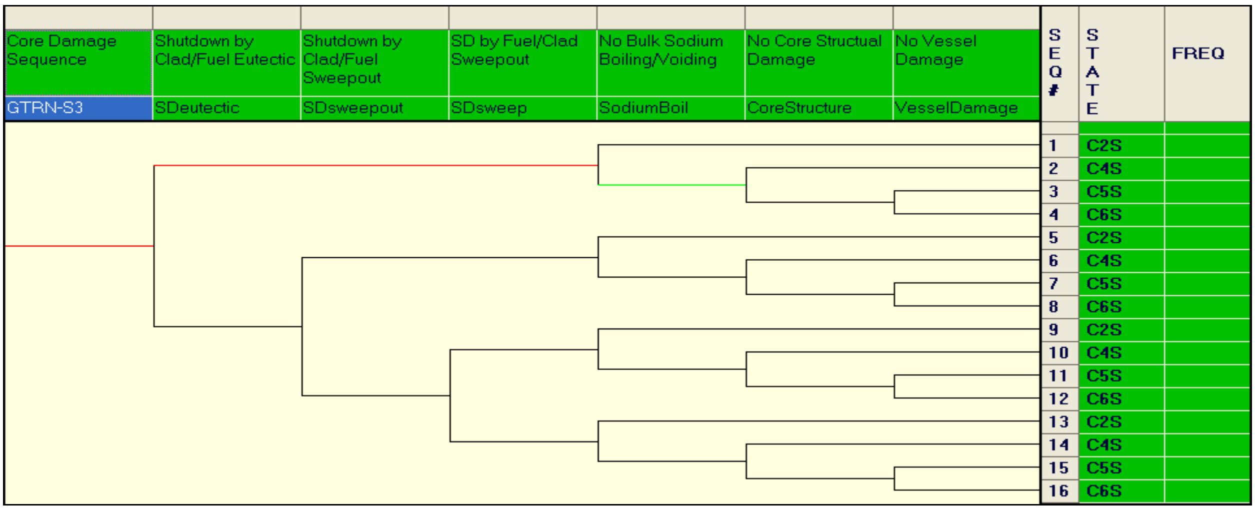

Fig. 3 An Example of Core Damage Event Tree as a part of Level 2 PSA for SFR-600