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Identification of Initiating Events for PGSFR

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1. Introduction

The Sodium-cooled Fast Reactor (SFR) is by far the most advanced reactor of the six Generation IV reactors. The SFR uses liquid sodium as the reactor coolant, which has superior heat transport characteristics. It also allows high power density with low coolant volume fraction and operation at low pressure.

In Korea, KAERI has been developing Prototype Generation-IV Sodium-cooled Fast Reactor (PGSFR) that employs passive safety systems and inherent reactivity feedback effects. In order to prepare for the licensing, it is necessary to assess the safety of the reactor. Thus, the objective of this study is to conduct accident sequence analysis that can contribute to risk assessment. The analysis embraces identification of initiating events and accident sequences development.

2. Methods and Results

2.1 Plant Description

PGSFR is to test and demonstrate the performance of transuranic (TRU)-containing metal fuel required for a commercial SFR, and to demonstrate the TRU transmutation capability of a burner reactor as a part of an advanced fuel cycle system [1]. It is a sodium-cooled pool type fast reactor with a 150MWe capacity. The key design features are summarized in Table I.

Table I. Key design features of PGSFR

Item	Specification
Reactor type	Pool-type
Plant size	150MWe
Fuel type	Initial core: U-Zr metal Reloading core: U-TRU-Zr metal
Core I/O Temperature	390/540℃
DHR System	PDHRS / ADHRS

The heat transport system of PGSFR consists of PHTS and IHTS, steam generation system, and decay heat removal system composed of two Passive Decay Heat Removal Systems (PDHRS) and two Active Decay Heat Removal Systems (ADHRS). PHTS mainly delivers the core heat to IHTS and IHTS works as the intermediate system between PHTS and steam generation system. PHTS is a pool type in which all the primary components and primary sodium are located within a reactor vessel. Two mechanical PHTS pumps and four Intermediate Heat Exchangers (IHXs) are immersed in the primary sodium pool. IHTS has two loops, and each loop has two IHXs connected to one steam generator and one IHTS pump [1]. The conceptual design of PGSFR that was used for the analysis is shown in Fig. 1.

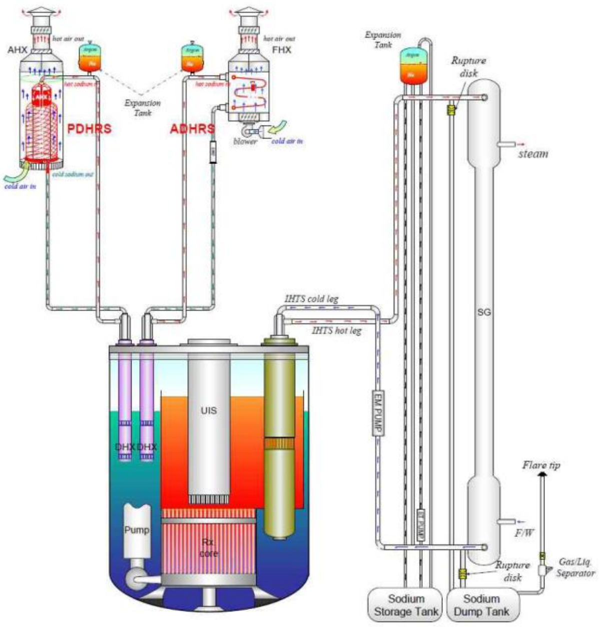

Fig. 1. Conceptual design of PGSFR [2]

2.2 Initiating Events Identification

Based on the conceptual design, initiating events that might occur in PGSFR were identified. A Master Logic Diagram (MLD) was used to identify initiating events systematically and to ensure to a high degree of the completeness of the analysis. The MLD is similar to a fault tree. It presents a model of a plant in terms of individual events and their combinations. It develops into a plant level logic structure whose basic input events are the initiating events. The particular advantage of the MLD method is that the issue of completeness is put into a more tangible perspective compared to other methods [3].

The top event was normally defined as abnormal release of radioactive material to the environment. The initiating events taken into consideration in this study were restricted only to internal initiating events that can cause radioactive release from the reactor core when the reactor is in operation. These events cause the reactor to trip and can lead to core damage if certain safety systems fail to work effectively. The first level of decomposition was divided into the two causes that could lead to core damage, namely loss of cooling and excess core power. Loss of cooling then could be caused from loss of heat transfer and pressure boundary breach, as shown in Fig. 2.

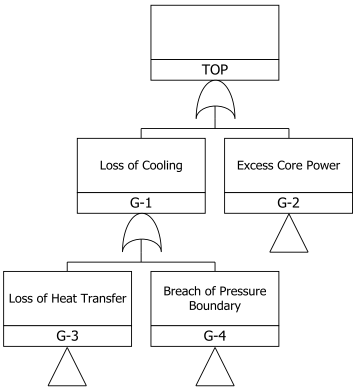

Fig. 2. MLD used for identifying initiating events (1/2)

Finally, the initiating events were identified as the events that cause loss of heat transfer, breach of pressure boundary, and excess core power. The final MLD is shown in Fig. 3.

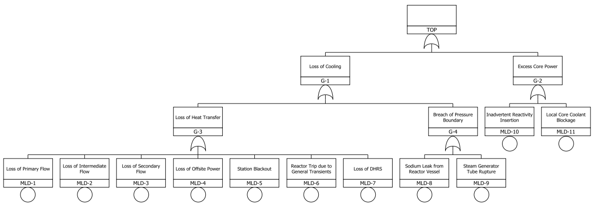

Fig. 3. MLD used for identifying initiating events (2/2)

The initiating events that were identified through the MLD method:

1. Loss of primary flow;
2. Loss of intermediate flow;
3. Loss of secondary flow;
4. Loss of offsite power;
5. Station blackout;
6. General transients;
7. Loss of DHRS;
8. Sodium leak from reactor vessel;
9. Steam generator tube rupture;
10. Inadvertent reactivity insertion;
11. Local core coolant blockage.

General transients above were defined as transients causing the reactor shutdown automatically or manually without any failure of safety systems or components. Transients induced by loss of flow and inadvertent reactivity insertion were excluded and they were considered as independent initiating events because accident sequences of them may progress differently than those of general transients. This list includes the initiating events considered in the past analysis that was conducted for PRISM-150 [4].

3. Conclusions

Initiating events that can happen in PGSFR were identified through the MLD method. This method presents a model of a plant in terms of individual events and their combinations in a systematic and logical way. The 11 identified initiating events in this study include the events considered in the past analysis that was conducted for PRISM-150. The result shown in this study will be used as basic data for future risk assessment for PGSFR and also contribute to safety enhancement.

Acknowledgement

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