

PHWR Specific Safety Functions Determination Using Defense-in-Depth Concept to Develop Risk Monitor during Outage

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1. Introduction

As a part of project of Development of Risk Monitoring Technology for PHWR Using Defense in Depth Method, we extracted the PHWR specific safety functions from design documents based on defense in depth concept. To have the better understanding of the PHWR specific safety functions, we would like to introduce the defense in depth concept in PHWR plants and categorization results of specific safety functions based on defense in depth concept.

2. PHWR Specific Defense-in-Depth Concept

In this section PHWR specific defense-in-depth concepts are described. There are 5 elements to explain defense-in-depth concept in PHWR: ①Reliable Process Systems ②Reliable Safety Systems ③Physical Multiple Barriers ④Qualified Operation/Maintenance personnel ⑤Incident detection and calibration.

2.1 Process Systems

Process systems are systems that are performing their functions to generate electricity during normal plant operation with maintaining control, cooling and isolation.

2.2 Safety Systems

Safety systems are provided as the back-up for the failure of process systems and do the function of reactor shutdown, emergency core cooling and containment isolation.

2.3 Physical Multiple Barriers

Physical multiple barriers are designed to prevent from releasing of radioactive materials from fuel to the public. Figure 1 shows 5 passive multiple barriers: ① ceramic fuel ② fuel sheath ③ heat transport system ④ containment ⑤ exclusion zone.

2.4 Qualified Operation/Maintenance personnel

The safety systems are designed to be operated automatically with signal and 5 passive physical multiple barriers are provided as defense-in-depth concept. However, in defense-in-depth plant safety can not be relied on systems or components totally. The qualified operator has to perceive the symptom and mitigate the accident in time.

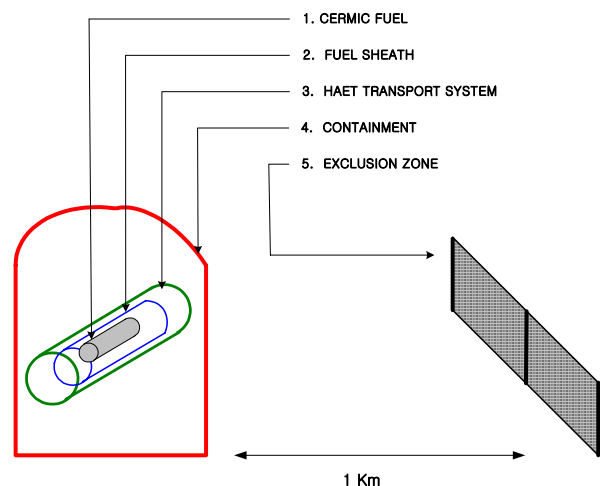


Figure 1. Passive Multiple Barriers

2.5 Incident detection and calibration

Reliable systems or components make it possible to detect incidents in time and take proper actions to prevent accidents and to mitigate the propagation of accidents.

3. Design Concept of Safety System of PHWR

Design concept of PHWR safety systems are based on defense-in-depth philosophy mentioned chapter 2. In addition to above philosophy, PHWR plant also has quantitative safety goals. Canadian RSAC (Reactor Safety Advisory Committee) proposed that the severe accident frequency be less than $1E-05$ and independent systems or component be required to obtain these goals. To meet these goals, they adopt 2 groups of safety systems for 3 major safety functions as shown in table 1.

Table 1. Safety System Groups

Safety Functions	Group 1 Systems	Group 2 Systems
Shutdown	Shutdown System #1	Shutdown System #2
Heat Removal	Auxiliary Feedwater	Emergency Water System
	Steam Generators	Steam Generators
	Normal Service Water	
	Normal Power Supply	Emergency Power Supply
	Shutdown Cooling System	
	Emergency Core Cooling	Containment System
Monitoring & Control	Main Control Room	Secondary Control Area
	Normal Power Supply	Emergency Power Supply
	Normal Instrument Air	Local Air Tanks

3. Determination of PHWR Specific Safety Functions Using Defense-in-depth Concept

PHWR specific safety functions are defined considering physical multiple barriers and defense-in-depth concept. Safety functions for PHWR are determined for the development of risk monitor during outage such as the following 7 functions. ①Reactivity Control ②Core Cooling ③Secondary Side Heat Removal ④PHTS Pressure and Inventory Control ⑤Reactor Building Integrity ⑥Essential Electric Power ⑦Cooling Water. Figure 2 shows relationship between defense-in-depth and specific safety functions for PHWR.

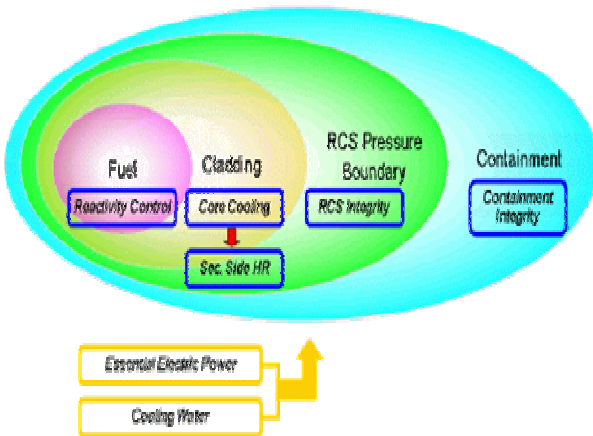


Figure 2. Relationship between defense-in-depth and safety functions

4. Conclusions

First of all, we studied defense-in-depth concept in PHWR and reviewed relationship between defense-in-depth and safety functions. And we categorized them into 7 safety functions as in chapter 3. 7 safety functions will be used to establish the safety function assessment trees (SFAT) for each plant operating status during outage. These 7 safety functions will be used as the basic filters to check plant risk on every plant configuration during outage.

REFERENCES

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