Transactions of the Korean Nuclear Society Autumn Meeting
Gyeongju, Korea, October 24-25, 2013

Comparison of Severe Accident Monitoring Parameters for OPR1000 and CANDU

Lee Youngseung *, Kim Hyeongtaek , Shin Jungmin
Central Research Institute, 70, 1312-gil, Yuseong-daero, Yuseong-gu, Daejeon
**Corresponding author: 94104882@khnp.co.kr*

1. Introduction

Severe accident management is composed of three elements; one is guides for implementing severe accident strategies, another is equipment for coping with severe accidents, and the other is the experienced staff for achieving the objective of severe accident mitigation. Monitoring for severe accident management guidelines (SAMG) is important in view of overall process of SAMG. That is, the information is necessary for confirmation of entry and terminated conditions for SAMG as well as strategy-implementing decision.

The purpose of this paper is to compare instrumentation needs for severe accident management by reactor type and to explain additional considerations following Fukushima accident.

2. Methods and Results

In this section, selected information needs for severe accident management were described. To accomplish goals of SAMG such as core cooling, containment integrity and minimization of fission product (FP) release, instruments were reasonably selected. Selected parameters were related to severe accident management strategies.

Information of SAMG can be classified into the major and minor parameters. The main variables were used to identify entry conditions, terminating criteria, and severe accident strategy's implementing points. The auxiliary parameters were supporting success of executed plans.

2.1 Instrumentation Needs for OPR1000

Core exit thermocouples (CET) were chosen as a precursor of severe accident. CETs located at the top of the core to measure the temperature of the fluid exiting a fuel assembly shown in Fig.1 were assessed as the most direct instruments for fuel temperature measurement.

The entry conditions transferred from emergency operating procedure (EOP) to SAMG should be prudently chosen, because philosophy of EOP differs from that of SAMG. The target of EOP is to prevent core damage, while that of SAMG is to mitigate core damage.

Strategies for severe accident management should be selected for the objective of SAMG such as core cooling, containment integrity, and minimization of FP release. The plans should also reflect severe accident phenomena, as an occurrence of phenomena may cause a breach of containment.

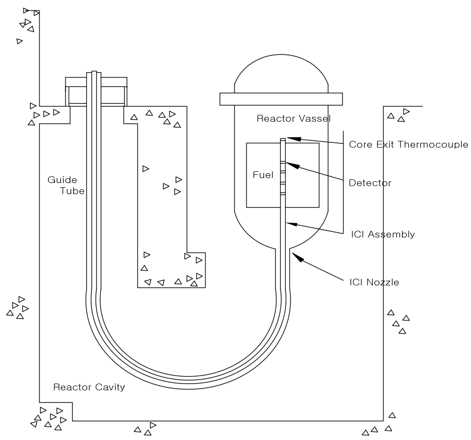

Fig.1. CET in core

Methods for core cooling were direct injecting cooling water into core and indirect injecting cooling water into steam generators (SG) transferring core heat. Accordingly, CET was chosen as an instrument for confirming core cooling using direct core cooling water and SG level was selected as a one for identifying core cooling using indirect SG cooling water.

Reactor coolant system (RCS) pressure and containment water level were related to severe accident phenomena. High pressure in RCS may cause high pressure melt ejection (HPME) and direct containment heating with creep rupture. RCS pressure should be monitored for RCS depressurization. Containment water level for cooling the corium after reactor vessel damage should be checked for mitigating molten corium concrete interaction.

Hydrogen explosion and long-term steam pressurization resulting in Containment failure should be blocked. Hydrogen concentration in containment related to hydrogen explosion and pressure in containment should be identified for the strategy-implementing.

Dose at site boundary for monitoring of FP release should be observed and additional information such as radiation in release area should be known for release path.

For termination of severe accident management, monitoring parameters were some of seven strategy-implementing variables. Four information needs for termination were temperature in reactor vessel, Dose at site boundary, containment pressure, and hydrogen concentration in containment [1].

2.2 Instrumentation Needs for CANDU

Because CANDU plants as a PHWR separates coolant and moderator, core melt does not occur until both are lost. Accordingly, entry conditions of CANDU SAMG should determine loss of coolant and moderator. A sign of deficient coolant was subcooling margin and one of deficient moderator was moderator level in calandria.

The goals of CANDU SAMG were identical to those of OPR 1000 SAMG. However, strategies were a bit different from those of OPR1000 SAMG. CANDU core cannot cool through SG during severe accident and HPME owing to high pressure in RCS cannot occur because of low pressure process in RCS with outbreak of severe accident.

Methods for core cooling were three ways; one was to inject cooling water into RCS, another was to feed water into calandria, the other was to put water into reactor vault. Reactor vault water can function core cooling because reactor vault water was designed to remove core heat and cover core under normal operation. Reactor header level, moderator level, and reactor vault level were chosen for injection into RCS, supply into calandria, and storage of reactor vault respectively.

Information selected for containment integrity and minimization of FP release was identical to that of OPR1000.

Monitoring parameters for terminal criteria of SAMG were four variables of six strategies which were moderator level, Dose, containment pressure, and containment hydrogen concentration [2].

2.3 Comparison of Information by Reactor Type

As shown Table1, information needs during whole phase of OPR1000 SAMG and CANDU SAMG were compared. An indicator for an entry of OPR1000 SAMG was CET as a sign to turn up loss of coolant in RCS. On the other hand, entry conditions of CANDU SAMG were subcooling margin as a symptom of coolant loss in RCS and moderator level as a moderator loss.

In view of strategies for mitigating severe accident, SG injection and RCS depressurization in CANDU plants were unnecessary. Core cannot cool down in spite of covering SG U-tube with water, and HPME cannot occur due to four calandria rupture discs. Therefore two monitoring parameters as RCS pressure and SG level were unnecessary in CANDU SAMG.

Plant status for termination of SAMG should be stable and steady. Safe state of the plant should meet continuous core heat removal, no containment challenge elements, and minimum FP release. The checking parameters in OPR1000 SAMG were four variables which were CET, dose at site boundary, containment pressure, and containment hydrogen. Moderator level in CANDU SAMG was used instead of CET in OPR1000 SAMG.

Table1. Comparison of information between OPR1000 and CANDU SAMG

Function	OPR1000 SAMG	CANDU SAMG
	Parameter	Parameter
Entry conditions	CET	Subcooling margin & Moderator level
Goal of SAMG		
Core cooling	SG level	-
	RCS pressure	-
	CET	Reactor header level
		Moderator level
Containment integrity	Containment level	Reactor vault level
	Containment pressure	Containment pressure
	Containment hydrogen	Containment hydrogen
Minimum FP release	Dose at site boundary	Dose at site boundary
Termination conditions	CET	Moderator level
	Dose at site boundary	Dose at site boundary
	Containment pressure	Containment pressure
	Containment hydrogen	Containment hydrogen

3. Conclusions

The purposes of SAMG are to remove core heat, to accomplish containment integrity, and to reduce release of FP. To achieve the purposes, necessary parameters during whole process of SAMG are monitored.

For severe accident management, information needs should be known. Monitoring these parameters is necessary to know plant status and degree of severe accident progression, also to check success of strategies.

Needed variables according to reactor type are a bit different, but those are adequately monitored to sufficiently achieve goals of SAMG.

REFERENCES

[1] Shin-Wolsong #1&2 Severe Accident Management Guidelines, KHNP, 2010.

[2] Wolsong#1 Severe Accident Management Guidelines, KHNP, 2009