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Development Process of Plant-specific Severe Accident Management Guidelines for Wolsong Nuclear Power Plants

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1. Introduction

A severe accident, which occurred at the TMI in 1979 and Chernobyl in 1986, is an accident that exceeds design basis accidents and leads to significant core damage [1]. The severe accident is the low possibility of occurrence but the high severity. To mitigate the consequences of the severe accidents, Korean Nuclear Safety Committee declared the Severe Accident Policy in 2001, which requested the development of Severe Accident Management Guidelines (SAMGs) for operating plants. SAMG is a symptom-based guidance that takes a set of actions to alleviate the outcomes of severe accidents and to get into the safe stable plant condition.

The purpose of this paper is to presents the strategic development process of the PHWR SAMG. The guidelines consist of 5 categories: an emergency guide for the main control room (MCR) operators, a strategy-implementing guide for the technical support center (TSC), six mitigation guides, a monitoring guide, and a termination guide.

2. Design Features of CANDU Plants

The core of a CANDU reactor consists of 380 horizontal fuel channels with 12 fuel bundles per channel. The heavy water coolant in a pressure tube is separated from the low-pressure heavy water moderator in a horizontal steel cylindrical calandria, as shown in Fig.1. The light water surrounding a calandria vessel is filled in a concrete reactor vault, as shown in Fig.2 [2].

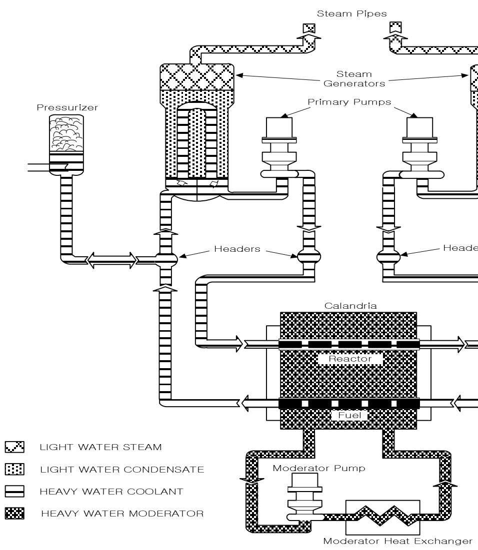

Fig. 1. Schematic Diagram of Primary Heat Transport System and Moderator System

CANDU plant has inherent safety design characteristics on the perspective of severe accident prevention. The large amount of cooling water surrounding core, e.g. coolant, moderator, and shield cooling water, may delay and mitigate the progression of severe accidents. Even the case of the emergency core cooling system (ECCS) failure, the heat removal of the moderator system provides alternative cooling function and can be used as an efficient tool to prevent a severe accident.

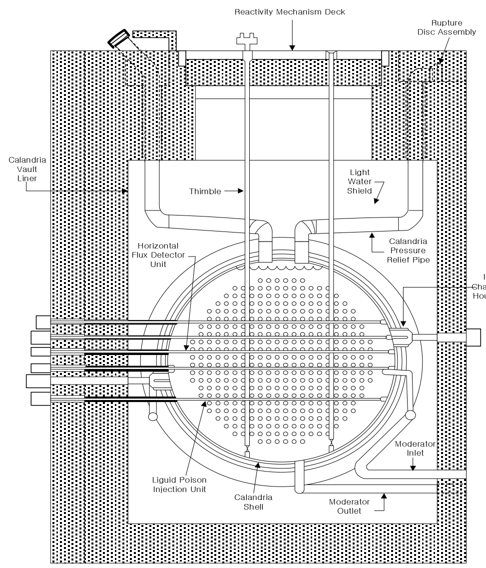

Fig. 2. Concrete Reactor Vault and Calandria Vessel

3. Overview of SAMG Development Process

The SAMG development process can be divided into three phases. First phase is to examine results of probabilistic safety assessment (PSA) for the CANDU plants to get the safety insight for severe accidents. The vulnerability of plants and detailed event scenarios leading to severe accidents were identified. Furthermore, thermal hydraulic results associated with possible accident response considering containment capability, hydrogen effect, and equipment survivability were reviewed. The Integrated Severe Accident Analysis code for CANDU plants (ISAAC), developed by KAERI [3], was used in the analysis. In the second phase, the information collected in the previous phase was consolidated and developed into an SAMG. Finally, the developed SAMG was verified by considering operators' usability and compatibility between emergency operating procedures (EOPs) and an emergency plan.

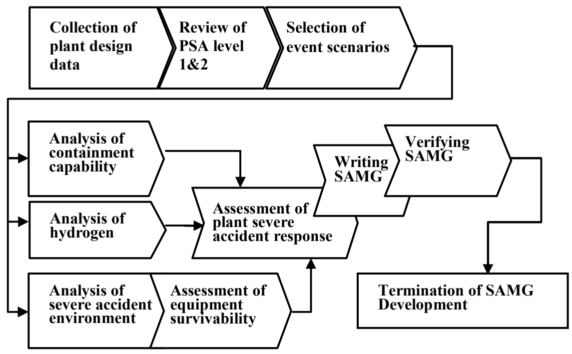

Fig. 3. Process of SAMG Development

4. Entry Conditions and Strategies of SAMG

Two important parameters in the SAMG to determine the entry condition are low sub-cooling margin and low moderator level. These two parameters can provide important information for operators to decide to transfer from EOP to SAMG.

Strategies to mitigate significant core damage can be implemented by defense-in-depth concept. Six effective strategies of mitigation guides for CANDU plants were ; (1) Inject into Reactor Coolant System, (2) Inject into Calandria, (3) Inject into Reactor Vault, (4) Control Fission Product Releases, (5) Control Reactor Building Pressure, and (6) Control Hydrogen Concentration in Reactor Building. [4]

5. Development of SAMG

The emergency guide was provided as a flowchart frame like that of EOP because it is familiar with MCR operators. The flowchart is divided into two stages. First stage is to provide the required actions for the integrity of containment until the TSC is organized. The second state is to monitor plant conditions by the TSC staff.

The strategy-implementing guide for TSC staff should provide systematic diagnosis of plant conditions and the clear set-points of key parameters for entrance of six mitigation guides. The key parameters were (1) reactor outlet header level, (2) moderator level, (3) reactor vault level, (4) fission product releases, (5) reactor building pressure, and (6) hydrogen concentration. Fission product releases, reactor building pressure, and hydrogen concentration should be monitored every fifteen minutes, because these three are the representative parameters that can reflect the status of containment integrity functions.

Mitigation guides are not a success-oriented procedure, but a mitigation procedure. Therefore, positive and negative effects may occur simultaneously by this action. Accordingly, the guides should include assessment of positive and negative effects. For example, if cooling water is injected into reactor coolant system, fuel can cool down but hydrogen can be generated by steam of supply.

A monitoring guide and a termination guide were needed to terminate SAMG.

6. Conclusions

The symptom-based SAMG for **CANDU** plants of the CANDU type was developed according to the Severe Accident Policy and CANDU specific design features, such as the large amount of cooling water, horizontal core and 380 channels, and isolation of coolant and moderator.

Developing process was divided into the three sequential phases. Entry conditions from EOPs to SAMG were more complicated than PWR SAMGs but provided the clearness for operators' determination. Furthermore, six strategies for mitigation guides were enough to prevent and mitigate severe accidents from a defense-in-depth standpoint. Each guide in SAMG is incorporated into the continuity of accident management and the consistency of the documents.

The developed SAMG is currently kept in MCR and TSC for plant staff and will contribute to mitigating severe accidents.

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