Transition from EOP to SAMG at Wolsong NPPs

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1. Introduction

Emergency Operating Procedures (EOPs) are provided for operators to respond properly when accident occurs in nuclear power plants. EOP does not cover severe accident which may cause core damage or core melt. It is trend to develop Severe Accident Management Guidance(SAMG) which gives guidance to staffs in technical support center (TSC) and operators in the main control room to control and make plant stable when severe accident is in progress. If operators fail to control and to make plant stable state in accordance with EOPs and accident progresses to severe accident, TSC staffs decide to stop use of EOPs and start use of SAMG. Core exit temperature is used to determine occurrence of severe accident in Light Water Reactors. The core of CANDU reactor consists of 380 fuel channels and each channel is submerged in moderator which is heavy water. Moderator can remove decay heat and does not lead to severe core damage even though coolant is not injected in the fuel channel by emergency core cooling system. Previous paper proposed that it is believed severe accident has occurred if fuel channels are not covered by moderator[1]. Pipe break in the moderator system may reduce moderator level even though the cooling is established. So in addition to the moderator level, new parameter is added to determine the occurrence of severe accident.

2. Severe Accident Analysis

2.1 Plant modeling

ISAAC code[2] is used to simulate severe accidents in Wolsong Plant which is CANDU6. Primary heat transport system (PHTS) consists of two loops and each loop has 190 fuel channel and 2 steam generators. 190 fuel channel is divided into 6 groups vertically and 12 node horizontally. Moderator system consists of calandria vessel which is filled heavy water, pump and heat exchanger. End shield cooling system consists two end shields, pump, heat exchanger and calandria vault which is filled with light water. Reactor building is divided into fuel exchange room, moderator room, basement, upper dome, dousing tank, degasser condenser tank, steam generator room, and access room.

2.2 Accident simulation

Plant behavior depends on the initiating events and status of engineering safety features. To investigate plant behavior for the high PHTS pressure accident, loss of feedwater accident and station blackout accident were analyzed. Small break LOCA and Large break LOCA were analyzed to study plant response for medium PHTS pressure and low PHTS pressure respectively.

3. Results and Conclusion

Engineering safety features are not actuated to accelerate accident progression. High PHTS pressure accidents show different plant behavior up to pressure tube failure compared to low and medium pressure accidents, but after failure of fuel channel accidents show similar behavior. When moderator is cooled through moderator heat exchanger, decay heat which is generated in the fuel channels, is removed and moderator level is maintained. When moderator system fails, the level of moderator decreases and core meltdown occurrs. As shown Figure 1, moderator level starts to drop about 1 hour earlier than the initiation of corium accumulation on the bottom of calandria vessel for Large LOCA. For other accidents, the time of initiation of moderator decrease and corium acculation on the bottom of calandria vessel is different, but trend is similar. Level of moderator in calandria vessel is key parameter which enables to identify the occurrence of core meltdown. While moderator system boundary is intact, moderator level is useful parameter which predicts the core meltdown. The pipe break in the moderator system may decrease the moderator level regardless of the state of core cooling. So additional parameter is required to identify the occurrence severe core damage. This new parameter is subcooling margin in the reactor outlet header(ROH). Two conditions must meet in order to occur the core melt; loss of cooling in the fuel channel and failure of moderator system. Subcooling margin in ROH indicates the status of cooling in the fuel channel. During normal operation subcooling margin in ROH exceeds 20 ^{o}C. As core cooling loses, the subcooling margin decreases. Less than 5 ^{o}C of subcooling margin may indicate that no more core cooling is established in the fuel channel. So when subcooling margin in ROH become less than 5 ^{o}C and the top fuel channel become uncovered by moderator, it is

determined that severe accident has occurred. The transition from EOP to SAMG should be made to manage severe accident properly and to maintain long term cooling of plant.

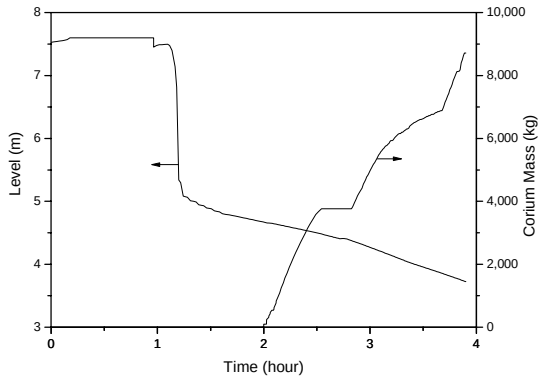

Fig. 1 Level of moderator and amount of corium on the bottom of the calandria

REFERENCES

[1] Y. Jin and S. Park, “Study on the Indication of Severe Accident in PHWR,” Proceedings of KNS Autumn Meeting, 2004

[2] Development of Computer code for the Level 2 PSA of PHWR, KAERI/RR-1573/95, KAERI, 1995