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Optimization for Limitation and Condition for operation (LCO) of Rod Drop Accidents in Hanul Nuclear Power Plants Units 1&2

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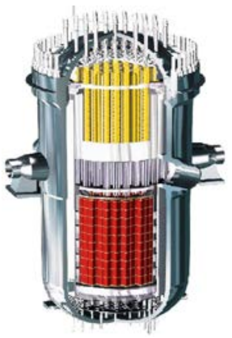
1. Introduction

This paper is to evaluate a reactor safety when the plant is eliminated the manual trip by quadrant power tilt ratio (QPTR) of technical specification value, 1.09 during the dropped rod assembly event for Hanul 1&2 units. Dropped rod assembly does not cause reactor trip per the current design methodology by elimination of NFRT but manually trip in 2 hours by technical specification and eventually it reduces the plant power availability. However, the plant safety can be guaranteed by applying new LCO (Limit operation for operation) methodology even though a manual reactor trip is not taken after rod drop[1]. Therefore, the plant availability can improve and prevent unnecessary plant transient by eliminating the manual reactor trip in 2 hours by QPTR after rod drop. A fuel safety in case that the plant eliminates the manual reactor trip by QPTR can be achieved through the operating data analysis of related event experiences using LCO of the improved technical specification[2,3].



2. Comparison of Technical specifications

Hanul 1&2 old technical specification requires to go to hot standby in 2 hours if during normal operation, the quadrant power tilt ratio remain above 1.09. However, Hanul 1&2 propose that new technical specification will reduce reactor power to 50% of rated reactor power and check heat flux hot channel factor and enthalpy rise hot channel factor more frequently if QPTR(Quadrant power tilt ratio)s remain above 1.02. Therefore, the fuel thermal safety for DNBR and LPD will be guaranteed if the hot channel factors remain within safety analysis assumption. The plant will not go reactor trip even though QPTR go above the limit of 1.09.

3. Evaluation Methodology

Those analyses are required for the evaluation of dropped rod event, which are transient evaluation for operating parameter in point view of thermal hydraulic analysis and nuclear design analysis. In dropped rod accidents, the plants are required to meet the acceptance criteria of fuel design limit and RCS pressure boundary integrity. Also, plants should remain in subcritical. These operating experience data are reviewed and evaluate to change Technical specification from reactor trip to 50% reactor power reduction.

4. Evaluation Results

Hanul Unit 1 experienced the accident of dropped rod assembly in June 2016. In accidents of Fig.1, QPTR increases as reactor power decreases. Rector power tripped in two hours after QPRT goes over 1.09.

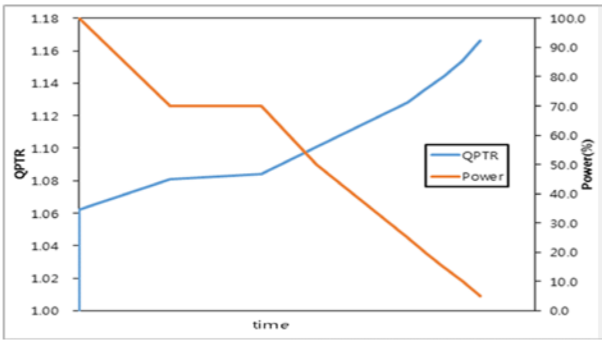


Fig. 1. QPRT and power in dropped rod accidents

DNB design criteria must be confirmed as safety evaluation using those experience data in Hanul Units 1&2. Fig.2 shows that enthalpy rise hot channel factor remained within technical specification limit value. Therefore, we conclude that DNB design criteria have met during the accidents.

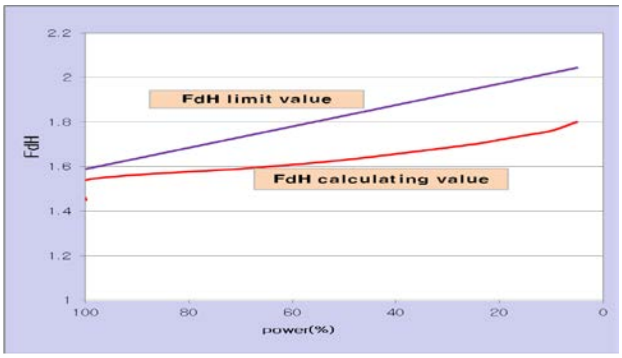


Fig. 2. FdH in dropped rod accidents

We also should confirm RCS pressure boundary integrity and the possibility of return-to-power during the accidents. Fig. 3-5 shows reactor power, RCS temperature and pressure. Reactor power decreases smoothly by manual action after dropped rod and abruptly in reactor trip. The behaviors of RCS Temperature and pressure are similar to reactor power. All parameters of thermal hydraulic parameter in reactor coolant system remained below design criteria after the dropped rod event. Therefore, we confirmed that integrity of RCS pressure boundary was remained in this event by evaluating these parameters.

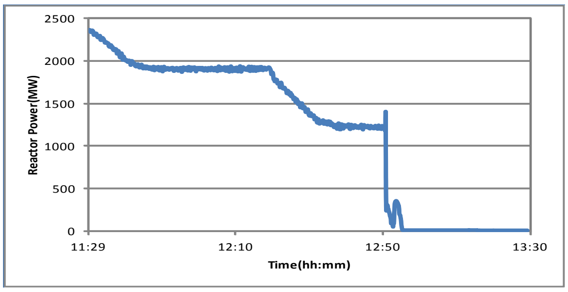


Fig. 3. Reactor power in dropped rod accidents

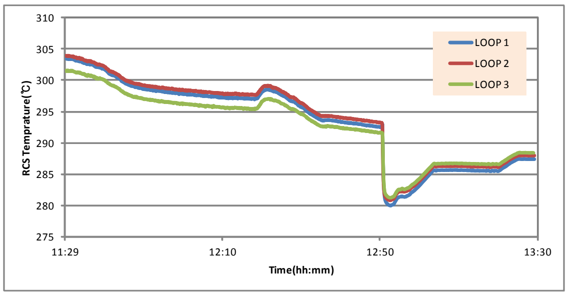


Fig. 4. RCS Temperature in dropped rod accidents

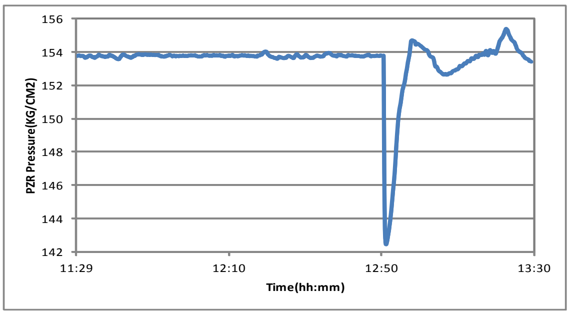


Fig. 5. PZR Pressure in dropped rod accidents

5. Safety Analysis

The goal of this paper is to prevent a manual reactor trip due to minor dropped rod event. Dropped rod causes manual reactor trip per the current technical specification and eventually it reduces the plant availability. The elimination of manual reactor trip can maintain at the 50% level of rated reactor power after rod drop. The analyses are required for the evaluation of dropped rod event, which are transient analysis, thermal-hydraulic analysis and nuclear design analysis. The analysis of system dynamic transient after rod drop was performed in the transient analysis and verified that reactor core was safe after rod drop without reactor trip[4,5].

6. Development of Improved Technical Specification Hanul Units 1&2

If QPTR exceed 1.02, the plant reduces reactor power in 2 hours and performs surveillance for hot channel factor periodically. The plant reevaluates safety analysis to confirm the condition of reactor core and fuel. If the plant cannot meet this condition, the plant should reduce 50% of rated power in 4 hours after the condition.

Table2 Improved Technical Specification

Item	CTS	ITS
When a control rod exceed the alignment limit	Reactor trip in 2 hours after QPTR exceeds 1.09	NA
QPTR	NA	Reactor power 50% reduction if QPTR exceeds 1.02 (possibly)

7. Conclusions

In order to keep the hot channel factors within limits compatible with the design criteria, reactor operation in the event of quadrant power tilt should be reduced to certain limit of reactor power.

The power reduction in the event of quadrant power tilt have been determined under the principle that the limit value of quadrant power tilt ratio increases as reactor power decreases. Time limits for various operational circumstances with a radial power tilt are incorporated in order to prevent the core from a non uniform depletion.

The 50% power reduction if the power tilt ratio exceeds 1.02 is a consequence of this methodology. We confirm that fuel damage will be prevented and fuel safety will be assured if the plants reduce reactor power to 50% during dropped rod assembly events. Also manual reactor trip by hot channel factors adds the fuel safety as being challenged in reactor core parameter.

REFERENCES

[1] NUREG-1431, Standard Technical Specifications, Westinghouse Plants
[2] 10 CFR 50.36 “Technical specifications”, Nuclear Regulatory Commission, 2008. 9.
[3] 10 CFR 50.65 "Requirements for monitoring the effectiveness of maintenance at nuclear power plants", Nuclear Regulatory Commission, 2007. 8.
[4] 7. WCAP 12282, Dropped rod methodology for negative flux rate trip plants, 1983.6, WESTING HOUSE CORP.
[5] KEPRI, Chang-sup Lee, et al, Study on Negative Flux Rate Trip Setpoint Modification for Kori 3&4 Units, 1995.3