ANPP Unit 2 Response to Feedwater Restoration Techniques in Case of Ultimate Heat Sink Loss

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1. Background and Goal of the present work

Armenian Nuclear Power Plant (ANPP) is situated in seismic region, and there is a risk of complete station blackout and loss of heat sink due to seismic impact.

PSA studies performed for Armenian Nuclear Power Plant (ANPP) showed that dominating contributors in seismic risk is a group of scenarios in which seismic event causes loss of offsite power without any break in primary or secondary safety systems (56% of overall seismic induced CDF). Besides 90% of these scenarios involve loss of Diesel Generators for various reasons (i.e. Station Blackout). Thus, SBO contribution is about 50% of overall seismic CDF.

Thermal-hydraulic analyses using RELAP5 code were performed to assess ANPP behavior in case of loss of ultimate heat sink accident.

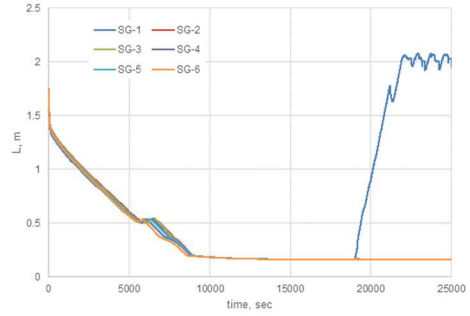
Results of thermal-hydraulic analyses of loss of ultimate heat sink accident, with implementation of bleed and feed procedure to maintain core cooling and further restoration of feedwater to steam generators are presented.

2. Introduction

The loss of feedwater to steam generators without loss of offsite power was considered in current analyses. The assumption that electrical power is available will shorten the time available until full drying of SGs because working main circulation pumps lead to more intensive heat transfer from primary circuit to secondary. Currently at ANPP there are several systems able to supply feedwater to steam generators:
Emergency feedwater system
Emergency high and low pressure cooling system
Diesel-driven emergency feedwater system .
First two systems are dependent from power supply, so during accident similar to Fukushima they will be unavailable. Third system is diesel-motor driven pump which is able to deliver water from two 600 m3 tanks directly to steam generators. In case personnel fails to restore feedwater to steam generators, primary side bleed and feed procedure should be implemented to stabilize primary circuit parameters and maintain core cooling. Bleed and feed procedure can be performed using either emergency core cooling system high pressure injection pumps or normal make up pumps for feeding and pressurizer safety valves or pressurizer steam dump valves for bleeding. In current analysis the bleed and feed procedure is performed with normal make up pumps and steam dump valves. However, long term core cooling using bleed and feed contains negative effects and operator should try to restore residual heat removal by secondary side. The objective of current study is assessment of phenomena that may arise during SGs reflooding in point of view of core cooling.

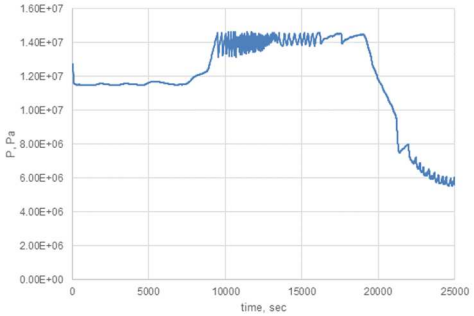
3. Results of analyses

After loss of all feedwater to SGs occurs up to 9000 second, the parameters of primary circuit are stable. On 9000 second, SG tubes are fully uncovered and heat transfer from primary circuit to secondary drastically reduces which leads to heat up of primary circuit.

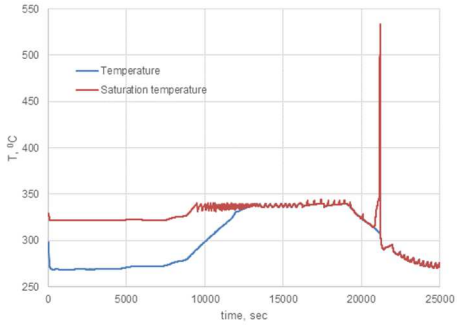


Water level in SGs

On 9800 second pressure in primary circuit reaches setpoint for pressurizer safety valve opening. The temperature rise in primary circuit continues and on 12000 second temperature reaches saturation.

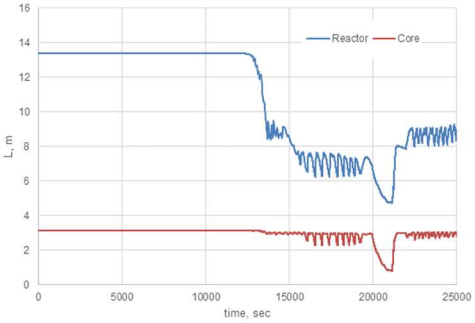


Pressure in primary circuit



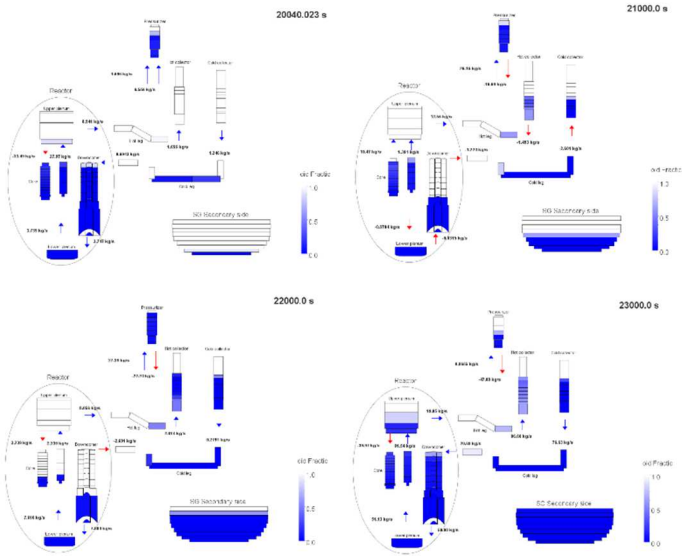
Temperature of coolant at core outlet

Boiling of coolant and release from pressurizer safety valve causes decrease of coolant level in reactor. At 13750 second level in reactor drops below hot leg nozzles and natural circulation of coolant stops.



Coolant level

Iteratively was determined the latest time point at which initiating of bleed and feed would be effective. According to results of analyses, the latest time point is 16000 seconds. Thus on 16000th second operator turns on all four normal make-up pumps and opens steam dump valves. Due to relatively small bleed pathway (Ø25mm) and small mass flow from pumps, the primary circuit is not cooled down but is kept stable at saturation temperature. This leads to generation of large steam fraction in upper part of primary circuit. On 19000th second operator manages to re-establish secondary side feedwater from one emergency feedwater pump to one SG. The rising water level in SG leads to rapid steam condensation in SG tubes, pressure and level decrease in primary circuit. Coolant level in reactor reaches bottom of the core and due to inadequate cooling fuel starts to heat up and temperature of cladding reaches 900^{0}C.



Therefore, additional analyses were performed to determine minimal flow from emergency feedwater system that will allow heat removal from primary circuit without rapid level decrease. Iteratively value of 40% from possible maximal flow was defined. Results of analysis showed that slow filling of SG prevents primary circuit level decrease and no heat up of fuel occurs.

4. Conclusions

- During SBO, when SG tubes are fully uncovered, refiling the SG while primary system relief valves are open leads to rapid steam condensation in the SG tubes and pressure and level decrease in primary circuit, which may cause uncovery of the fuel and core damage.
- Results of analysis showed that slow filling of SG prevents core level decrease and no heat up of fuel occurs.
- This phenomenon must be reflected in Emergency operating procedures. Corresponding training for operates is essential to successfully manage such event.

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