Transient Analysis in CVCS for APR1400

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1.0 INTRODUCTION

The design improvements for the Chemical and Volume Control System (CVCS) of the Advanced Power Reactor 1400 (APR1400) include a rearrangement of the letdown heat exchanger (LHX) and the letdown orifices and its related valves and piping. The LHX in APR1400 is relocated into the inside of the containment whereas in the Korean Standard Nuclear Power Plant (KSNP) it is located in the Secondary Auxiliary Building. This relocation has advantage to minimize the high energy piping runs outside containment, consistent with ALARA goals. Also this relocation can reduce the cavitation of letdown orifices and their related valves because they are installed in the low temperature region.

In this study, the transient analysis for the letdown system is performed by using the Modular Modeling System-Real Time Capable (MMS-RTC) Code which has been developed by the Electric Power Research Institute (EPRI)[1]. Main purpose of this analysis is to evaluate the thermal-hydraulic performance of the letdown system in APR1400 under dynamic operating condition.

2.0 DESCRIPTION

The letdown system with charging system maintains a water level in the RCS pressurizer at a programmed level, thus maintains proper reactor coolant inventory during all phases of normal plant operation. This is achieved by means of continuous feed and bleed operation. The bleed flowrate can be automatically controlled by the Pressurizer Level Control System (PLCS) with the proper combination of letdown orifices in the letdown flow path. The PLCS provides on/off signals to control the letdown orifice isolation valves.

The letdown system transients are analyzed for several severe transients induced by the Reactor Coolant System (RCS) and the CVCS. Before the MMS model was applied to the APR1400, the MMS model was verified by modifying some models in accordance with the KSNP and comparing simulation results of the letdown system with field test results during the hot functional test. The results of the MMS model and the field test are provided in Figure 1. In response to the pressurizer level 10%-step decrease, the PLCS closes the third letdown orifice isolation valve(CH-110Z) to change the letdown flow from maximum to normal. The peak value of the letdown line backpressure predicted by the MMS Code model is 307 psig. As shown in Figure 1, the prediction of the MMS Code model agrees well with the field test on the KSNP.[2][3].

The letdown system performance of APR1400 is evaluated by simulating the CVCS transients using the verified MMS Code model with the same control parameters as the KSNP's to compare the system transients between the KSNP and APR1400. The letdown flow step changes from maximum to normal, and then minimum are selected for this analysis. These are the RCS-induced transients in the CVCS. Table 1 shows the letdown flow ranges of the APR1400 and the KSNP during normal operation.

3.0 RESULTS

Figure 2 shows the analysis results. The peak values of the letdown line backpressure for the APR1400 during the letdown flow step changes are 330 psig for the case of the letdown flow step change from maximum to normal, and 441 psig for the case of the letdown flow step change from normal to maximum. The peak values for the APR1400 are about 7% less than those for the KSNP. The reason for the reduced peak values is mainly due to the temperature independent volumetric flow in the orifices originated from the relocation into the low temperature region in the downstream of the LHX. In addition, the relative ratio of the letdown flow changes is slightly decreased compared to the KSNP design. This may mitigate the letdown transients for each letdown flow step change. In conclusion, the analysis results show that the letdown system for APR1400 is maintained within the acceptable operating range and the possibility of the cavitation in letdown line is further reduced.

4.0 REFERENCES

1. FramatomeTechnologies,"MMS-RTCCodeManual",1996.
2. J.S.Park,C.K.Chung,E.K.Kim,etc.,"TransientAnalysisofLetdownSystemforYGN5&6usingMMS-RTC",ProceedingsoftheKoreanNuclearSocietySpringMeeting,KoreanNuclearSociety(May.1998)
3. H.S.Park,C.K.Chung,E.K.Kim,etc,"TransientAnalysisinCVCSduringPressurizerLevelStepChange",Proceedingsofthe 13th PBNC,October2002.

Table 1. Letdown Flow* Ranges for KNSP and APR1400

	Minimum	Normal	Maximum
APR1400	40 gpm	80 gpm	140 gpm
KSNP	30 gpm	75 gpm	135 gpm

* based on 120℉

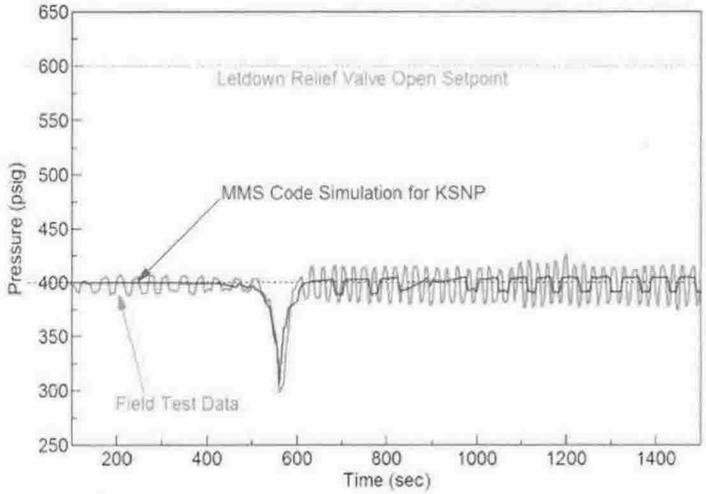

Figure 1. Letdown Line Backpressure in case of the Letdown Flow Step Decrease for KSNP

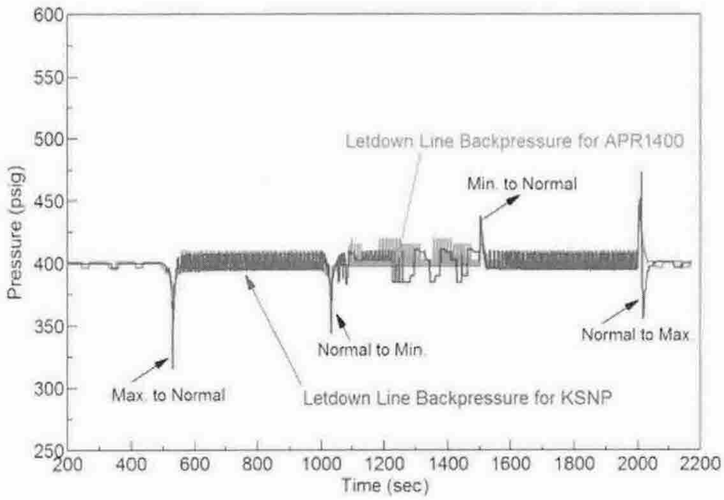

Figure 2. Comparison of Letdown Line Backpressure between KSNP and APR1400 in case of the Letdown Flow Step Changes