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A study on the improvement of a Automatic Seismic Trip System in Hanbit Unit #1, 2

Hyun-Jin Song[a], Goung-Jin Lee[a*]
[a*]Chosun University,357, Seoseok-dong, Dong-gu, Kwangju 501-759, Korea
[*]Corresponding author: kjblee@chosun.ac.kr

1. Introduction

Severe accident that is evaluated 7th grade of International Nuclear Event Scale occurred on March 11th, 2011 in Fukushima NPP due to the tsunami followed by Tohoku earthquake. Concerning 6 kinds of field, 50 cases of short and long term improvement countermeasures are deducted by Post Fukushima Inspection group consisted of professionals in government and academia in Korea. Constructing Automatic Seismic Trip System(ASTS) was the first measure. ASTS is a facility that automatically actuate reactor trip system when earthquake exceeding seismic design criteria of NPP occurs. Installation of ASTS will reinforce emergency response capabilities against earthquake. Currently, all the NPPs in korea equipped with the facility, however Hanbit Unit #2 experienced unexpected transient event during testing the operability of ASTS. This paper include the analysis of transient event, improvement for stable operation of NPP in the case of ASTS actuate and procedure revisal for procuring testability of ASTS by reviewing operation experience of Hanbit Unit #2,

2. Methods and Results

2.1 Composition of ASTS Control Loop

When seismic sensor sense earthquake exceed its set point, ASTS actuate reactor trip system. ASTS is non-safety system consisted of 4 seismic sensor modules and two channels of trip logic adapting coincidence logic of 2/4. In case coincidence logic of ASTS decides reactor trip, circuit breaker of M-G Set block the power supply of control rod which leads to reactor trip.

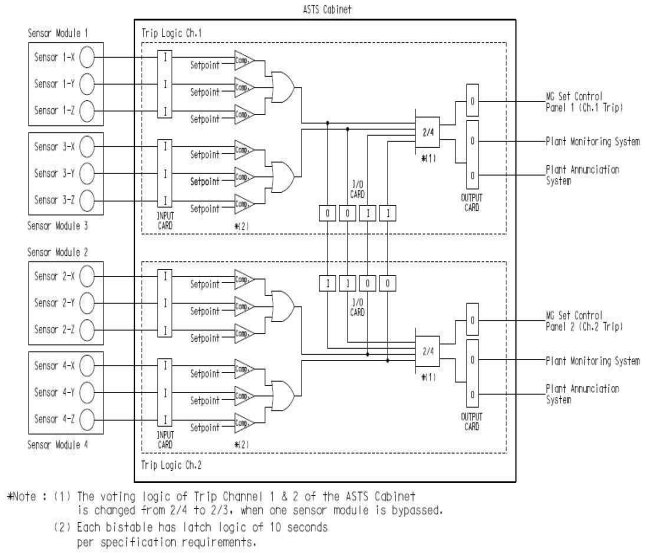

Fig. 1 ASTS Control Logic Diagram

2.2 Behavior of NPP during ASTS occurrence

Loss of power supply of control rod caused by inappropriate opening of M-G Set circuit breaker leads to control rod drop during the functional test which is to be implemented by semi-annual period. Though reactor was tripped, steam supply to the operating turbine had been continued. Actual pressure of Steam Generator drops from 64.6 kg/㎠ to 61.4 kg/㎠ and Lead/Lag Compensator Function calculated compensated steam generator pressure lower than set point which actuate safety injection(Main Steam Line low pressure set point 41.14 kg/㎠). Subsequently, safety injection(SI) signal occurred.

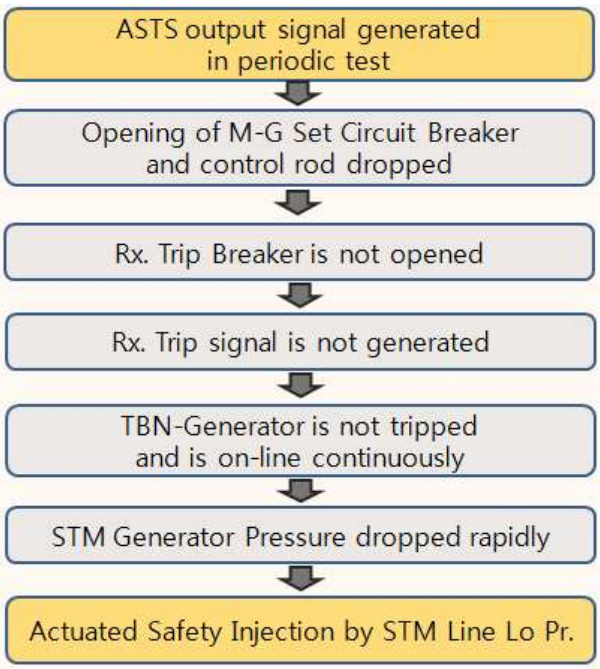

Fig. 2 Fault Tree for inappropriate ASTS actuation

2.3 Measurement for prevention of SI signal

Since turbine trip signal which actuated after reactor protection signal doesn't occurred, SI signal actuated. Alteration of ASTS logic diagram to actuating turbine trip signal simultaneously for eliminating unnecessary SI signal occurrence is inevitable.

2.4 Simulation

By using educational simulator of Hanbit Unit #1,2, simulate that operator`s action which actuate turbine trip signal manually can affect upon actuation of SI or not. At Fig. 3. if there is not immediate TBN trip, it shows the drop of Steam Generator pressure and actuation of SI just like the operation event of Hanbit Unit #2.

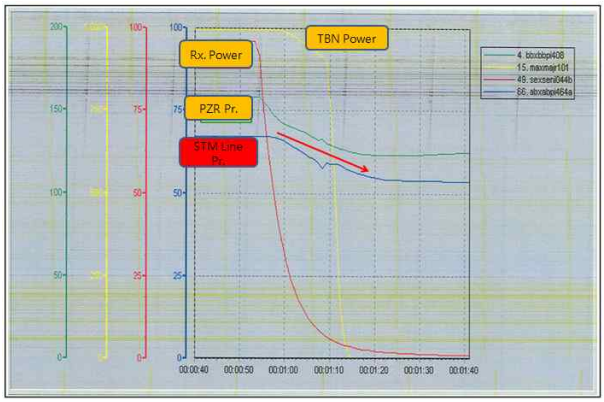

Fig. 3 Result of ASTS Actuation simulation

But if operator actuated turbine trip signal manually just after the drop of control rod by ASTS operation, simulator shows that NPP is stabilized to Hot-Standby without actuation of SI at Fig. 4.

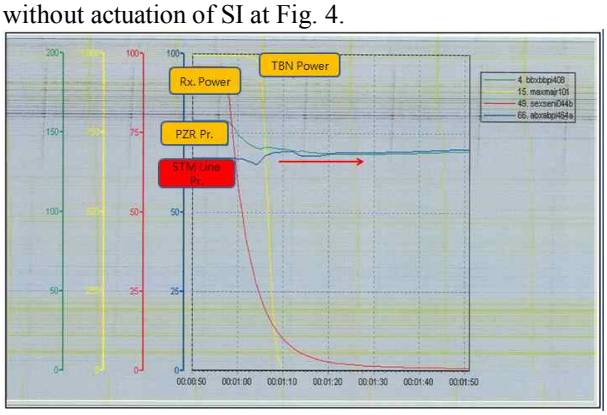

Fig. 4 Result of manual turbine trip simulation

2.5 Analysis using safety analysis computer code

Analysis based on RETRAN-3D which is optimum thermal-hydraulics safety analysis computer code developed by EPRI results in same outcome compared to analysis performed by simulator. If operator actuate TBN trip signal manually after 3seconds of ASTS actuation, it is not occurring SI.

Time	Event	Comment
0.000000E+00	SCRAM by ASTS	On the assumption that TBN trips after ASTS actuated
3.010000E+00	TBN Trip by ASTS	
3.822219E+01	SG1 HI-HI LVL	SI signal is not generated
4.523219E+01	FW Iso. By SG HI-HI LVL	
1.008939E+03	SG3 LO-LO LVL	
1.011489E+03	Rx. Trip by SG LO-LO LVL	
1.068989E+03	AFW On by SG LO-LO LVL	
1.800000E+03	END of PROBLEM	

Fig. 5 Result of manual turbine trip analysis

2.6 Optimization of testability of ASTS facility

The contents of ASTS functional test procedure expected to be clarified and modified. First of all, alternating ASTS testing procedure as a high level test is inevitable to make person who qualified and has sufficient technological background on ASTS performing the procedure. Second, Present pre-job briefing needs to be altered to high level pre-job briefing. Third, whether the M-G Set circuit breaker is fully closed or not needs to be confirmed through the field component by test performer before and after the test. Furthermore, the rules, responsibilities and limitations of test performer and related personnel need to be clarified. Such efforts enable testability of ASTS functional test to be optimized.

3. Conclusions

Though most of the United states and European NPP are not equipped with ASTS facility since low possibility of earthquake occurrence, Korean NPPs faithfully reflected the lessons of Fukushima accident by installing the ASTS facility which leads to more safety and quick emergency response capabilities. This paper comes to conclusion that simultaneous turbine trip signal actuation with reactor trip signal as a countermeasure to prevent repetition of transient event during ASTS functional test by utilizing educational simulator and RETRAN-3D safety analysis. Furthermore, revision proposals on ASTS functional test procedure enables optimized testability. Adapting such improvement countermeasures expected to increase the reliability and safety of NPP.

REFERENCES

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