Comparative Analyses on OPR1000 Steam Generator Tube Rupture Event Emergency Operational Guideline

Sang Won Lee, Yeon Kyoung Bae and Hyeong Teak Kim
Korea Hydro & Nuclear Power Co., Ltd., Munji-Dong Yusung-Gu, Daejeon, 103-16, Korea
Tel:+82-42-865-7669 , Fax:+82-42-865-7604 , Email:sangwon@khnp.co.kr

1. Introduction

The Steam Generator Tube Rupture (SGTR) event is one of the important scenarios in respect to the radiation release to the environment. When the SGTR occurs, containment integrity is not effective because of the direct bypass of containment via the ruptured steam generator to the MSSV and MSADV. To prevent this path, the Emergency Operational Guideline of OPR1000 indicates the use of Turbine Bypass Valves (TBVs) as an effective means to depressurize the main steam line and prevent the lifting of MSSV. However, the TBVs are not operable when the offsite power is not available (LOOP). In this situation, the RCS cool-down is achieved by opening the both intact and ruptured SG MSADV[1]. But this action causes the large amount of radiation release to the environment. To minimize the radiation release to the environment, KSNP EOG adopts the improved strategy when the SGTR concurrently with LOOP is occurred. The simplified diagram is shown in figure 1. However, these procedures show some duplicated procedure and branch line that might confusing the operator for optimal recovery action.

So, in this paper, the comparative analysis on SGTR and SGTR with LOOP is performed and optimized procedure is proposed.

2. Comparative Analysis on SGTR EOG

Two different cases are examined to determine the optimal procedure. One is the SGTR without LOOP and the other is SGTR simultaneously with LOOP case. The major concerns on these analyses are;

- the amount of radiation release
- SG overfill probability
- the occurrences of MSSV lifting

The RETRAN-3D code is used and the best estimate approach is applied.

2.1 SGTR without LOOP Event Scenario

As shown in the figure 1, the procedure without LOOP event is different between two strategies.

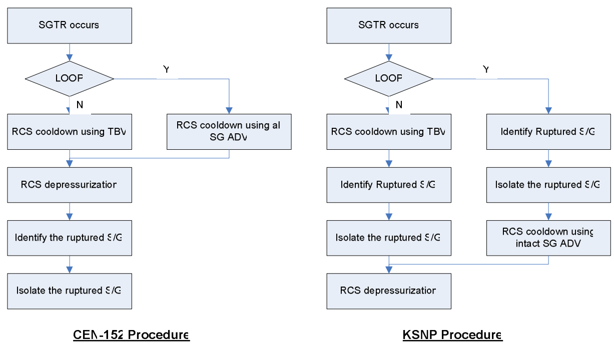

Fig. 1 Comparison of EOP of SGTR event

So, the comparative analyses on two scenarios are performed to identify the advantage/disadvantage of each procedure shown below;

- case 1 : cool-down → identification → isolation → depressurization
- case 2 : cool-down → depressurization → identification → isolation

At time 0.0sec, SG 1 single tube guillotine rupture is initiated. From that time, the RCS inventory is discharged through the broken SG tube continuously. The reactor trip signal is generated by the low pressurizer pressure at ~550sec. The operator enters into the EOP process after the reactor trip condition. From this time, the operator should implement the SPTA (Standard Post Trip Action) and DA (Diagnosis Action). The operator action time for performing SPTA and DA is assumed about 15min. After then, the operator should implement cool-down using TBV.

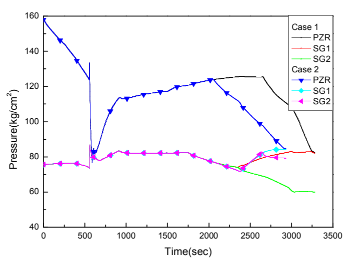

Fig. 2 Pressure of PZR and SG of SGTR without LOOP

After the cool-down achieved, the operator should implement identification and isolation of ruptured SG (case 1) or depressurization procedures (case 2). In this calculation, 5 min is assumed separately for each operator action.

Fig. 2 shows the comparison of the PZR and SG pressure between two procedures. As shown in the figure, the pressure of case 2 is decreased rapidly rather than the case 1. This is due to the RCS depressurization action and it lead to the more rapid pressure equilibrium than case 1. MSSV is not opened for both scenario and there are no significant difference is respect to the radiation release to the environment.

Parameter	Case 1	Case 2
MSSV opening	0	0
Integrated Steam discharge (to condenser)	56,693kg	57,586kg
Max. PZR level (WR)	63.0%	63.06%
SG liquid vol.(%)	82%	72%

Table 1. Comparison of two case analyses results of SGTR without LOOP

3.2 SGTR with LOOP Event Scenario

When the LOOP is occurred simultaneously with the reactor trip, the TBV are not available and the RCS cool-down process is implemented using SG ADV. Two scenarios shown below are examined;

- case 3 : identification → isolation → cool-down → depressurization
- case 4 : identification → depressurization → cool-down → isolation

The scenario until the identification of ruptured SG is same as previous SGTR without LOOP case. And identification of ruptured SG is performed prior to cool-down by SG ADV. So cool-down is performed only by intact SG ADV.

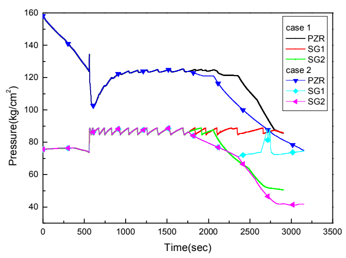

Fig 4. Pressure of Pressurizer and SG of SGTR with LOOP

Fig. 4 shows comparison of the PZR and SG pressure with case 3 and case 4. MSSV lifting frequency of case 4 is more than that of case 3 due to the earlier depressurization procedure. The liquid volume of ruptured SG inventory is far below the SG total inventory as shown in table 2. However, radiation release mass of case 4 is nearly 33% more than the case 3 because late isolation procedure that leads to the steam release via common header from ruptured SG to the intact SG ADV. So, When the SGTR occurs simultaneously with LOOP, it is profitable that isolation of ruptured SG is prior to cool-down procedure as case 3.

Parameter	Case 3	Case 4
MSSV opening	18	14
Integrated steam discharge (to atmosphere)	22,553kg	30,074kg
Max. PZR level	52.6%	68.8%
SG liquid vol.(%)	63%	63%

Table 2. Comparison of two case analyses results of SGTR with LOOP

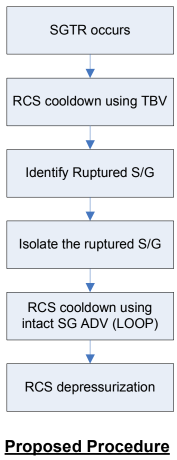

Fig. 5 Proposed SGTR procedure including LOOP

4. Conclusion

Based on the comparative analysis results, the modified SGTR procedure is proposed as shown in figure 5. This procedure implements the case 2 for SGTR event and the case 3 for SGTR with LOOP scenario. And there is no branch line or duplicated step and can be used for the overall SGTR EOG.

REFERENCES

[1] S.W.Lee et. al, Investigation of Applicability of Emergency Operational Procedure of Steam Generator Tube Rupture Event using Nuclear Plant Analyzer, Proceeding of KNS meeting, May. 2005.