EOP Improvement Proposal for SGTR based on The OPR PSA Update

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1. Introduction

After Fukushima accident, the full scope PSA (Probabilistic Safety Assessment) for OPR (Optimized Power Reactor) is performing for all types of risks from internal and external events and for all plant operational modes in Korea. For the purpose of this project, the basic PSA models for all types of risks from internal and external events were updated. This updating process was also focused to enhance the PSA quality and to respect the as built and as operated conditions of target plants. For this purpose, the EOP(Emergency Operating Procedure) and AOP(Abnormal Operating Procedure) of target plant were reviewed in detail and various thermal hydraulic(T/H) analysis were also performed to analyze the realistic PSA accident sequence model. In this paper, the unreasonable point of SGTR (Steam Generator Tube Rupture) EOP based on PSA perspective was identified and the initial proposal for EOP change items from PSA insight was proposed.

2. SGTR Accident sequences analysis

In this section, the SGTR transient progression and accident sequence analysis are addressed.

2.1 SGTR Transient analysis for OPR Plants

The SGTR event is the rupture of one or more tubes in one steam generator causing primary coolant to leak to the secondary system at a rate in excess of primary system charging capability. This event is a similar and special case of a small LOCA. It is treated separately because of the potential for a direct RCS leakage path to the environment.

The main mitigation action for the SGTR accident of OPR is summarized as follows.

(1) Confirm Reactor Trip & ECCS actuation
(2) Cooldown and depressurize the RCS and secondary side to below the MSSV opening setpoint to protect leakage to environment
(3) Identify and isolate the affected steam generator
(4) Stabilize the RCS to below the MSSV Set point.
(5) Cooldown the RCS to shutdown cooling entry conditions

The current SGTR event tree(ET) for OPR plant is presented in Figure. 1 developed based on SGTR EOP.

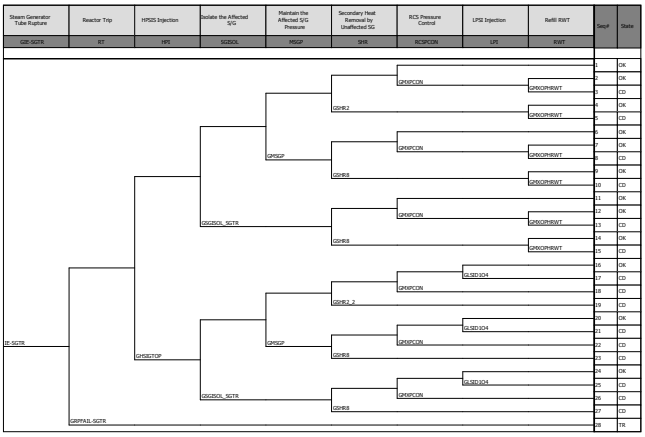

Figure 1. Current SGTR event tree for OPR

The basic assumptions for current SGTR event tree for target plant are as follows.

- SBCS(stream bypass control system), FWCS(feedwater control system) are not credit by conservatism and EOP(after initial cooldown, affected S/G must be isolated).
- After isolated affected S/G, the main steam isolation valve bypass valve could be opened to protect over filling to affected S/G.
- Feed & bleed operation is not credit by EOP limiting condition & T/H analysis
- Aggressive cooldown for LPSI(low pressure safety injection) is not credit after HPSI(high pressure safety injection) failed condition by EOP.

2.2 The change of SGTR accident progression model

The SBCS and FWCS are not credit by conservatism and EOP. To check the SBCS availability during transient, total of 32 cases of transient(except SBCS unavailable case such as loss of function on main feed water & main steam system) experiences were reviewed in detail. All of transient cases were stabilized the the target plant from power operation to hot shutdown condition by SBCS & FWCS without any abnormal transient condition such as AFWS(auxiliary feedwater system operation) operation, MSSV lifting, ADV lifting, ECCS operation and etc. So, SBCS operation could be credited for mitigation function for OPR.

The T/H analysis and the SGTR at OPR experience noted that the SG isolation could not protect the affected S/G overfilling on time.

As the T/H analysis for SGTR, the SG secondary pressure could not maintained to below the MSSV lift pressure because of reactor coolant flow from the primary into secondary side of the affected S/G and high pressure injection flow.

As the OPR SGTR experience, the operator opened the main MSIVBV(main steam isolation valve bypass valve) of main steam line on affected S/G to protect overfilling after the MSIV(main steam isolation valve) isolation of that S/G.

So, the forth heading in fig. 1 "MSGP(Isolated the affected S/G) is meaningless to protect MSSV lifting on SGTR event.

The feed & bleed operation(credited in Ref. 3) by operator using SDS (safety depressurization system) valve and HPSI system after secondary cooling system failed condition as a mitigation function also considered. But, there is a prerequisite process to perform the feed & bleed operation in EOP. The essential prerequisite is to check the PSV open condition by operator. According to the specific T/H analysis, the PSV is not challenged because of RCS inventory release to break point on SGTR. If the EOP were changed, the feed & bleed operation could be credited for mitigation function for OPR.

The aggressive cooldown(credited in Ref. 3) by operator, to inject LPSI after HPSI system failed condition as a mitigation function for SGTR, is not considered because the mitigation function is not described definitely on EOP. If the EOP were changed, the aggressive cooldown operation could be credited for mitigation function for OPR.

According to the items mentioned above, the EOP and SGTR accident progression model might be changed for the plant safety and to provide convenience for operator as presented in figure 2.

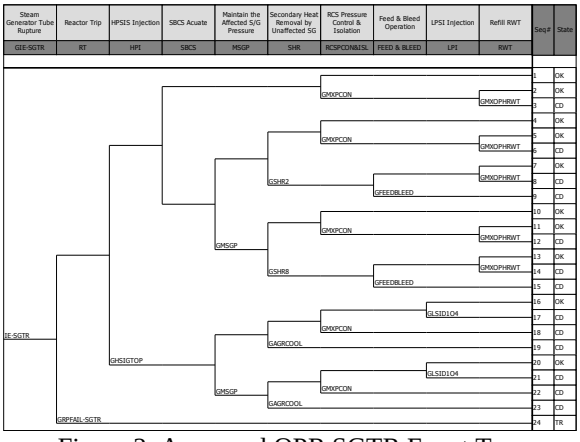

Figure 2. Approved OPR SGTR Event Tree

The SBCS, feed & bleed operation and aggressive cooldown operation are credit to improve the plant safety. The credit of SBCS operation is based on experiences of target plant. It also could provide convenience to operator to mitigation for SGTR event.

The feed & bleed operation and aggressive cooldown operation for LPSI for SGTR event could improve the target plant safety directly.

2.3 EOP improvement items for SGTR

The EOP improvement items are proposed to enhance safety and operator's convenience for the target plant as follows.

- Apply the SBCS operation state(fail or success) for SGTR mitigation strategy
- Adoption feed & bleed operation for SGTR
- Adoption aggressive cooldown operation for LPSI definitely

3. Conclusions

The OPR PSA Updating, for all types of risks from internal and external events and for all plant operational modes, has performed after Fukushima accident. This updating process was also focused to enhance the PSA quality and to respect the as built and as operated conditions of target plants. In this paper, the unreasonable point of SGTR EOP based on PSA perspective was identified and the EOP improvement items are proposed to enhance safety and operator's convenience for the target plant.

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