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# Assessment of the Negative-Impact following Implementing the RCS Depressurization strategy during SBO

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## 1. Introduction

In addition to the benefits that can be achieved by depressurizing the RCS, there are several drawbacks associated with depressurizing the RCS during a severe accident. These drawbacks have the potential to negatively impact the accident progression by accelerating the release of fission products to the atmosphere.

Especially, the pressurizer POSRVs relieve steam from the RCS to the IRWST as designed. However, the discharge path of the POSRV should be diverted to prevent the accumulation of the hydrogen in the IRWST by actuating the 3-way valves to divert the discharge path to the SG compartment after the core exit thermocouples indicate greater than 1200°F in accordance with Severe Accident Management Guideline (SAMG). Therefore, manual opening of the POSRVs will result in the release of mass and energy to the SG compartment connected with the containment atmosphere, if no containment heat removal systems are available, the containment will pressurize.

If RCS depressurization may result in a severe challenge, then the TSC may consider the impact unacceptable and may want to perform mitigative actions.

In this study, the Negative-Impact associated with depressurizing the RCS during Station Blockout (SBO) is evaluated quantitatively by utilizing the Modular Accident Analysis Program (MAAP5) computer code [1] that can analyze the containment pressure.

## 2. Evaluation of the Negative Impact

### 2.1 Rapid Depressurization during Severe Accident

In APR1400 design, if the operator could open two POSRVs at appropriate timings after core exit temperature (CET) exceed 1200°F, the RCS pressure would decrease below the Direct Containment Heating (DCH) cutoff pressure in compliance with SECY-93-087[2].

In the event of a high pressure meltdown scenario, as like SBO, the POSRVs can be used to depressurize the RCS to ensure that the High Pressure Melt Ejection (HPME) does not occur, thereby this minimizes the potential for the DCH following a reactor vessel

Since lowering RCS pressure during a severe accident is one of the top priorities of severe accident management, if the core exit thermocouples are indicating greater than 1200°F then the operators are directed to open POSRVs, which may cause the containment pressure increase.

### 2.2 Selection of the Accident Scenario

The Plant input (the parameter file) of the Advanced Pressurized Reactor1400 (APR) was utilized for this evaluation. The SBO scenario was selected as the severe accident scenario for the evaluation.

It is assumed in this scenario that secondary heat removal is provided by the Turbine-driven AFW (TDAFW) pump for 8 hours, and the cooling subsequently fails. Rapid depressurization is implemented by manual opening of the POSRVs that are located in the upper side of the Pressurizer. The operator can open one or two POSRVs at the same time.

The operability of the POSRVs can be assured only when the valve temperature is lower than its design temperature. In other to satisfy this criterion, The POSRV’s temperature should not exceed the design temperature at the time when these valves are opened manually.

The Negative-Impact was evaluated for the cases wherein the one or two POSRVs are opened after 0.5h, 1h and 1.5h subsequent to the CET exceeding 1200°F until the Vessel failure time.

The details of the analyses for the SBO accident simulations are presented in Table 1.

| Case | Number of the POSRV manually opened | Time of CET, 1200°F (sec) | Time of POSRV manual opening (sec) | Initial Containment pressure ($cmH_2O$) |
|---|---|---|---|---|
| base | - | 44143 | - | 1031 |
| 1 | 2 | 44143 | 45943 | 1031 |
| 2 | 2 | 44143 | 47743 | 1031 |
| 3 | 2 | 44143 | 49543 | 1031 |
| 4 | 1 | 44143 | 45943 | 1031 |
| 5 | 1 | 44143 | 47743 | 1031 |
| 6 | 1 | 44143 | 49543 | 1031 |

Table 1. Rapid Depressurization analysis for SBO

2.3 Results of Analyses

The maximum pressure of the containment has been investigated to determine if the negative impact associated with depressurizing the RCS may result in a severe challenge to the plant. If the pressure increase is not negligible, TSC staff may consider implementing the action that can be taken to mitigate the negative impact. The results are presented in table 2.

As shown in Fig. 1, the analysis results showed that the CET exceeded 1200°F at 44143 sec, and the RCS was depressurized below the DCH cutoff pressure in case 1 through 6.

In case 1, the opening of two POSRVs was implemented after 1800 sec subsequent to the CET exceeding 1200°F, the maximum pressure of the containment was about 3052 $cmH_2O$ after 1114 sec (18 min) of two POSRVs opening as shown in Fig. 2. The containment pressure was increased about 2021 $cmH_2O$ (about 2.02 $kg/cm^2$) from initial containment pressure. In other cases, the containment pressure after POSRVs opening was lower than that in case 1.

With these results, since the containment pressure after POSRVs manual opening wouldn't reach to the point where containment integrity may be jeopardized, TSC staff could decide to implement this strategy.

| Case | Maximum Containment pressure after opening POSRVs ($cmH_2O$) | Time of containment pressure, Maximum (s) | Time of the RV Failure (sec) |
|---|---|---|---|
| base | - | - | 56276 |
| 1 | 3052 | 47057 | 57865 |
| 2 | 3020 | 48557 | 57731 |
| 3 | 2967 | 50207 | 58701 |
| 4 | 2972 | 47807 | 58100 |
| 5 | 2912 | 49157 | 57075 |
| 6 | 2865 | 50807 | 58599 |

Table 2. Results of analysis for cases

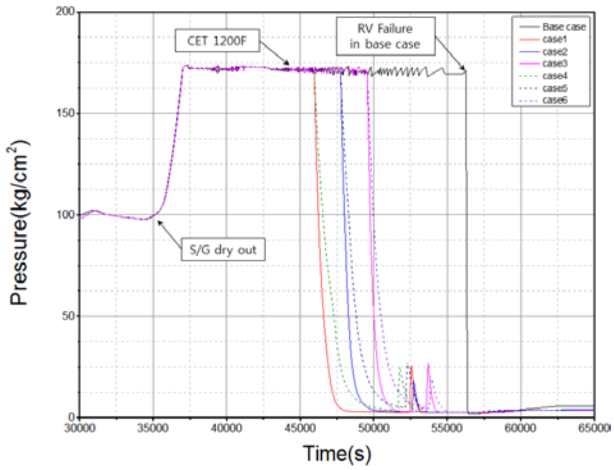


Fig.1 RCS pressure during SBO

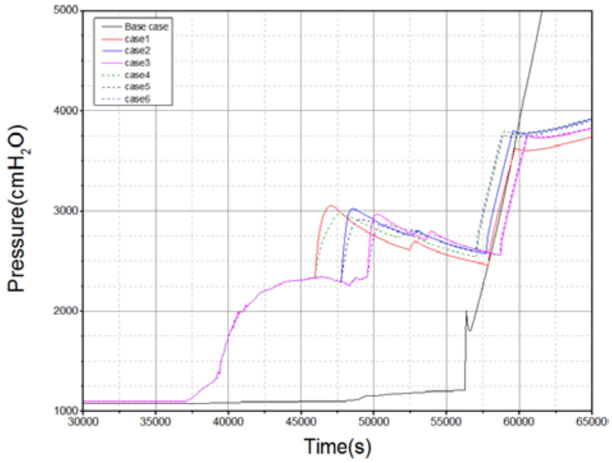


Fig.2 Containment pressure during SBO

### 3. Conclusions

The Negative-Impact associated with depressurizing the RCS has been evaluated during SBO.

In this study, the analysis results for the RCS depressurization strategy after the CET exceeds 1200°F indicate that the containment pressure would maintain at a lower pressure than the severe challenge setpoint.

But, since the containment pressure when the POSRVs are opened is expected to increase about 2021$cmH_2O$, the opening of the pressurizer POSRVs may result in a severe challenge to the plant for high containment pressure condition.

It is necessary that additional evaluation be performed in diverse accident scenario, and the data from those studies will provide technical background for TSC to make a decision whether the strategy should be performed or not.

### REFERENCES

[1] "Modular Accident Analysis Program (MAAP 5) Version 5.0.3 - Windows," Electric Power Research Institute, August 2014.

[2] SECY-93-087, "Policy, Technical, and Licensing Issues Pertaining to Evolutionary and Advanced Light-Water Reactor (ALWR) Design", USNRC, April 2. 1993.