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An Accident Sequence Precursor Analysis during SGTR

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1. Introduction

Accident sequence precursor (ASP) analysis was performed for steam generator tube rupture (SGTR) occurred in Ulchin Unit 4 of April 2002. The quantitative analysis was done using AIMS-PSA Workstation developed in KAERI (Korea Atomic Energy Research Institute). The comparative measure on the time reliability correlation Model, being used in the current ASP on the basis of quantitative CCDP calculated measure and the ASEP method, which was simplified from the theory of Human Performance Models based on THERP were also been performed.

2. Accident Selection

About 20 numbers of accident failure history on the Korean standard nuclear reactors of Ulchin unit 3 & 4 was investigated and from those, it was analysed on the basis of ASP analysis on SGTR accident of Uljin No.4 which was been already modeled as an early stage event in PSA. The main event on the steam generator tube rupture accident of Uljin unit 4 is as follows.

Time of the event	The main event
17:50	Start of cooling operation on steam circuit control channel
18:33	Sudden drop of water level in the pressurizer - Assumed as SGTR accident
18:38	High pressure safety injection reset
18:42	Reached to the threshold level of pressurizer
18:46	Steam generator #2 isolated
18:49	Passive high pressure safety injection
19:00	Cooling operation of steam isolated valve by circuit valve
19:59	Reached to the pressure equilibrium of primary and secondary system.

Referring to the above table, the Uljin unit 4 SGTR accident, the operator had reset the related operating signal in order to prevent the safety injection system on the accordance with the pressure drop in the pressurizer during the cooling operation of steam circuit control channel, and thereby, the water level of pressurizer was suddenly decreased. The operator had verified the steam generator tube rupture from the alert of radiation observer(RE-152) and thus, isolated the tube ruptured steam generator(#2) in order to repress the release of radioactive material to the outside of containment building. Then, the water level of pressurizer was recovered by passive operation of high pressure safety injection and reached to pressure equilibrium by performing the cooling and de-pressurizing operation of primary and secondary system with steam circuit control channel and the main, sub sprinkle of the pressurizer.

3. Methodology & Recovery Action Model

3.1 ASP Analysing method

In this research, the analysis using fault tree, uncertainty, and failure probability of the basic accident from the result of AIMS-PSA Workstation of Uljin unit 3 & 4 was performed. In CCDP(Conditional Core Damage Probability), the frequency of preliminary accident on steam generator tube rupture was appointed as 1, and was able to analyse the effect on the risk of core damage in probabilistic manner. Also, by assuming the occurrence of preliminary accident and the failure of high pressure safety injection system, the change in CCDP was analysed. Through by analysing the fault tree, the precursor giving important influence to the risk on the basis of quantitative CCDP calculation was analysed. The process of which, the HPSI operation failure by operator being reset the safety injection, recognizing the occurrence of SGTR from SG#2 SGBD radiation alarm and safely injecting from HPSI through by passive controling of safety injection pump was analysed using restoration management model.

3.2 Recovery Action Model

The process of which, the HPSI operation failure by operator being reset the safety injection, recognizing the occurrence of SGTR from SG#2 SGBD radiation alarm and safely injecting from HPSI through by passive controling of safety injection pump was analysed using Recovery Action Model. The success of reliability correlation was assumed in such that de-pressurizing process starts after 30 minutes from the HPSI failure on the basis of PSA report of Uljin No.3&4, and was analysed using Time-Reliability Correlation model in NUREG/CR-4674, Vol.21 Appendix A and ASEP model.

4. Result of ASP analysis

The computation result of CCDP on SGTR accident of Uljin unit 4 was classified as Important Precursor (1.0×10^{-4} < CCDP < 1.0×10^{-3}) according to the ASP program.

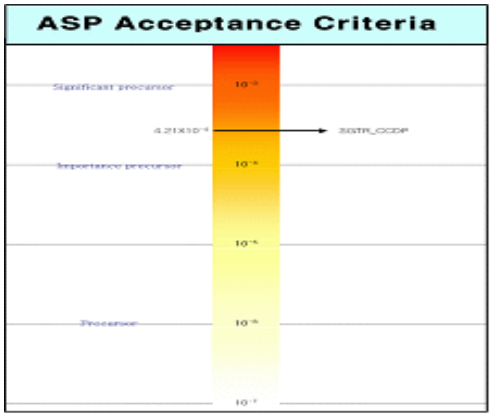

Fig. 1 ASP Acceptance Criteria

The result of analyzing the CCDP in accordance with probabilistic safety analysis report on Uljin unit 3&4, was in such that the basic event to influence largely influence CCDP during the steam generator tube rupture accident was contributed from the operator not being manage to perform enforce cooling the low pressure safety injection system in order to make the pressure of core cooling system in controllable condition. The accidental routine to influence the core damage during the SGTR accident was the failure of de-pressurizing the core cooling system for safety injection and high pressure injection system. Especially, it was found that human performance model and generic failure report used for delaying the de-pressurizing the core cooling system happened to give large influence on the computation result of CCDP. In order to analyze the same influence, the change in trend of CCDP by changing the failure probability of RCS used in low pressure safety injection was also examined. Here, the TRC and ASEP model used conventionally were also applied to measure the differences.

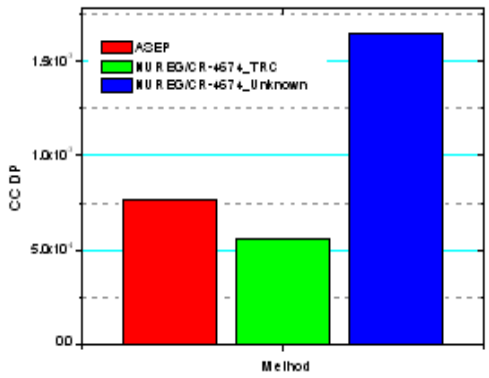

Fig. 2 CCDP Considering the Recovery Action

As referred in Fig. 2, some of difference between TRC model and ASEP model of restoration management failure probability from the same basic event are shown and thereby, gave much of influence in total CCDP result. Thus, it is estimated that CCDP can be relieved by re-analyzing the operator management failure probability considering the valuation on time of restoration management.

5. Conclusion

ASP(Accident Sequence Precursor) on steam generator tube rupture(SGTR) which happened in Uljin unit 4 on the basis of PSA models of Uljin unit 3 & 4 was analyzed by utilizing AIMS-PSA Workstation. The SGTR accident of Uljin unit 4 was classified as Important Precursor according to the ASP program. It was shown that after the failure of high pressure safety injection system, basic event on the failure of operator to manage to de-pressurize the core cooling system give large influence to enlarge the CCDP. Since the conventional model of TRC can be lodged on the problem of its reliability, it is estimated that CCDP can be decreased through by re-examining the operator restoration management error using standard HRA method which recently developed in Korea Atomic Energy Research Institute(KAERI).

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