Development the DEC PIRT for APR1400 MSGTR

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1. Introduction

Since the Fukushima accident, the concern has increased internationally about the disaster and the severe accident. In particular, the importance of severe accidents prevention and mitigation has been highlighted. In June 2015, the KOREA revised the "Nuclear Safety Regulations[1]", the severe accident management has been included in the existing design basis accident management. Currently, KHNP is pushing for the development of integrated safety analysis codes applicable to multiple failure accident. It is necessary to the extension development of a code for apply the multiple failure accident to the SPACE which is developed for thermal analysis of domestic PWR. In order to apply the SPACE code to multiple failure accident, the PIRT(Phenomena Identification and Ranking Table) has to develop considering the physical phenomena expected in multiple failure accident.

2. Methods and Results

This paper deal with PIRT of MSGTR(Multiple Steam Generator Tube Rupture) in the accident management scope caused by multiple failures.

2.1 Definition of Accident

The MSGTR is an accident in which five tubes are broken at the same time in one steam generator, thereby damaging the barrier between the reactor coolant system and the main steam system. The evaluation shall be carried out for the purpose of restricting the radioactive materials to the outside air caused by accidents and confirming the appropriateness of the design characteristics and accident management measures to prevent nuclear fuel damage.

2.2 Major Scenarios and Characteristics

The sequence of event for MSGTR shows the table Ⅰ. The phase Ⅰ is the stem generator water level increase phase by the tube rupture. The phase Ⅱ is the main steam safety valve is opened phase by the steam generator pressure increase after the main steam isolation valve is closed. The main thermal-hydraulic trend of the system shows the fig 1~5[2].

Table Ⅰ: Sequence of Event for MSGTR

Phase	Time (sec)	Event	Set point
Phase Ⅰ	0.0	Tube rupture start	
	9	Pressurizer heater operation by pressurizer low pressure	154.68kg/㎠A (2,200psia)
	175	Reactor trip by hot leg saturation temperature	
		Turbine trip	
	176	Steam bypass control system operation	77.34kg/㎠A (1,100psia)
	220	The reactor coolant system pressure is at the safety injection operating set point	127.26kg/㎠A (1,810psia)
Phase Ⅱ	1,919	Main steam isolation signal start by broken steam generator high water level	91% wide water level
	2,154	Main safety valve open by broken steam generator high pressure	83.57kg/㎠A (1,188.7psia)

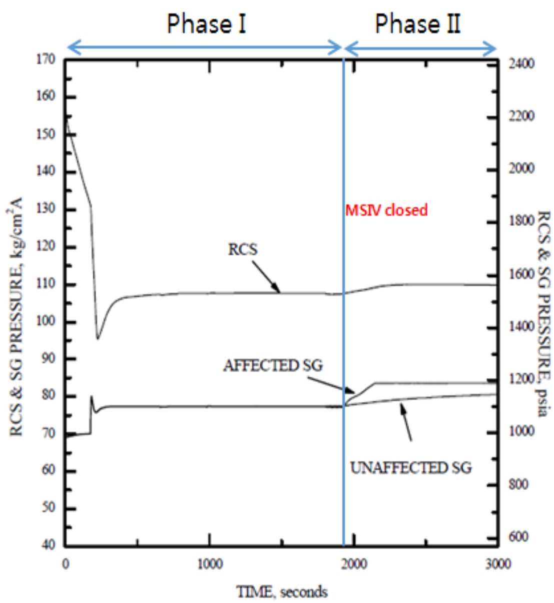

Fig. 1. System pressure trend (SKN 5,6 MSGTR).

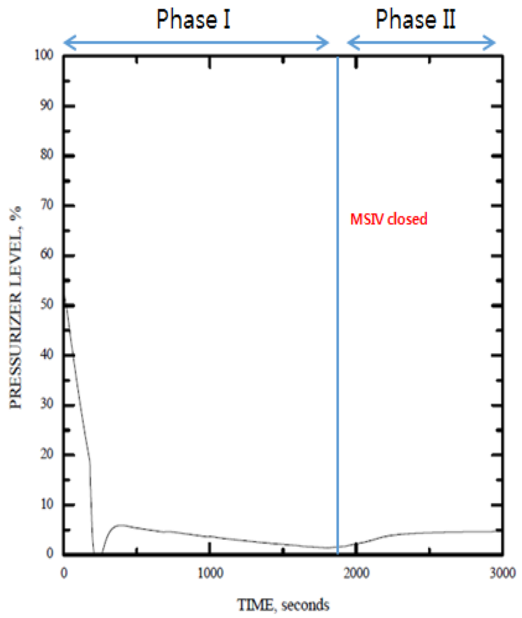

Fig. 2. Pressurizer water level trend (SKN 5,6 MSGTR).

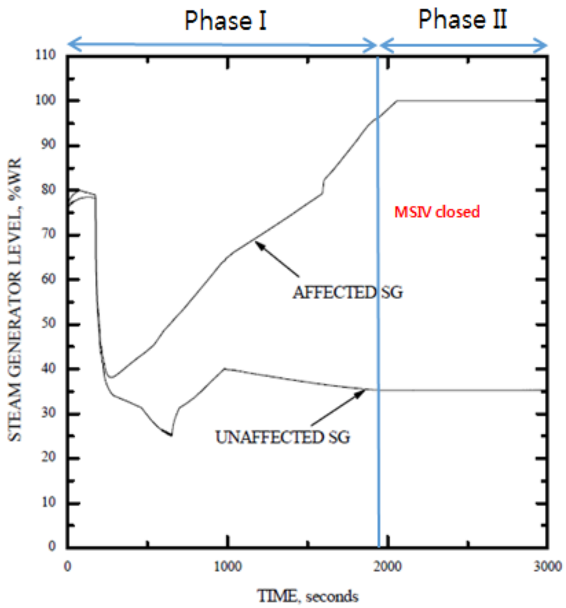

Fig. 4. Steam Generator water level trend (SKN 5,6 MSGTR).

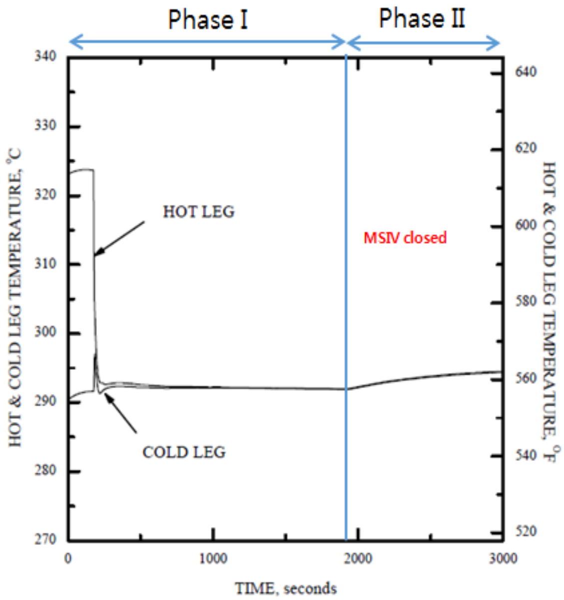

Fig. 3. Reactor coolant temperature trend (SKN 5,6 MSGTR).

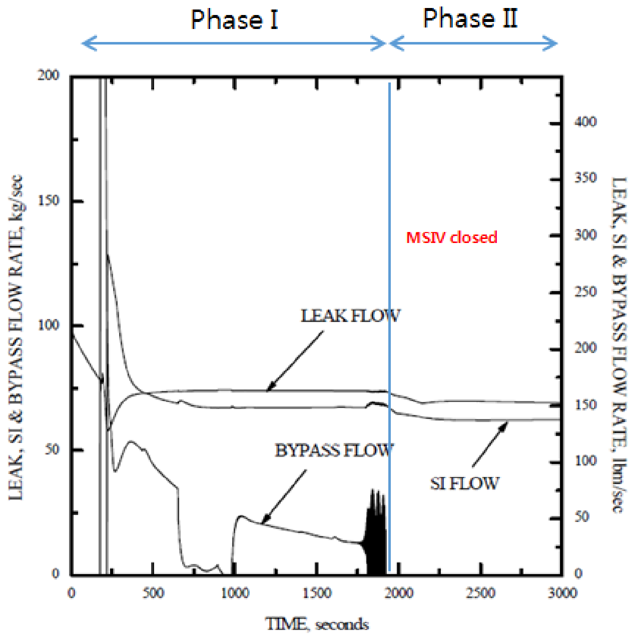

Fig. 5. Leak, SI, Bypass flow trend (SKN 5,6 MSGTR).

2.3 Safety Assessment Criteria

The acceptance criteria for MSGTR safety analysis are as follows. The main steam safety valve should not be open for 30 minutes in case of five tube rupture accident. It is designed to increase the initial opening time of main steam safety valve without operator intervention in the case of five tube rupture accident.

2.4 Major Thermal-Hydraulic Phenomenon

In addition to the accident scenarios and phase distinctions determined in the previous step, the system/the structure, and the components are categorized to help determined the ranking of major thermal-hydraulic phenomena. The major thermal-hydraulic phenomena in the component in the accident scenarios were identified and determined by the expert consultation.

2.5 PIRT

The MSGTR PIRT shows the table Ⅱ.

Table Ⅱ: MSGTR PIRT

<table>
<tr><th rowspan="2">System/ Structure</th><th rowspan="2">Component</th><th rowspan="2">Phenomena</th><th colspan="2">PIRT</th></tr>
<tr><th>Ⅰ</th><th>Ⅱ</th></tr>
<tr><td rowspan="2">RPV</td><td rowspan="2">Core</td><td>Decay heat</td><td>H</td><td>H</td></tr>
<tr><td>Fuel heat up (DNB)</td><td>H</td><td>-</td></tr>
<tr><td rowspan="2">Pressurizer</td><td>Vessel</td><td>Mixture level</td><td>L</td><td>L</td></tr>
<tr><td>Heater</td><td>Primary pressure heating</td><td>L</td><td>-</td></tr>
<tr><td>Primary Piping</td><td>Hot leg</td><td>Hot leg saturation</td><td>H</td><td>-</td></tr>
<tr><td>Safety Injection</td><td>SIP</td><td>SIP discharge flow</td><td>H</td><td>H</td></tr>
<tr><td rowspan="8">Steam Generator</td><td>U-tube</td><td>Break flow</td><td>H</td><td>H</td></tr>
<tr><td rowspan="2">Secondary Side</td><td>Collapsed level (downcomer)</td><td>H</td><td>H</td></tr>
<tr><td>Flashing fraction</td><td>H</td><td>H</td></tr>
<tr><td>TBV</td><td>Steam flow rate</td><td>-</td><td>H</td></tr>
<tr><td>MSIV</td><td>Steam flow Rate</td><td>M</td><td>-</td></tr>
<tr><td rowspan="2">MSSV</td><td>Critical flow</td><td>-</td><td>H</td></tr>
<tr><td>Liquid entrainment</td><td>-</td><td>L</td></tr>
<tr><td>Blowdown line</td><td>Blowdown flow</td><td>M</td><td>-</td></tr>
</table>

In this table, H means high influence on FOM(figure of merit). M means moderate influence on FOM. L means low influence on FOM.

As a result of developing PIRT, the core decay heat, safety injection pump discharge flow, U-tube break flow, steam generator secondary side downcomer collapsed level and flashing fraction in the steam generator secondary side were confirmed to be an important phenomenon.

3. Conclusions

It developed a major thermal-hydraulic phenomenon PIRT for MSGTR accidents for expanding the SPACE code to apply to the design extended conditions. The major scenarios and the major thermal-hydraulic phenomenon of the system/structure and the component were derived through the developing the PIRT. PIRT was able to derive the thermal-hydraulic model needed to expand the SPACE code.

Acknowledgements

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REFERENCES

[1] Nuclear Safety and Security Commission Regulation No. 17, "Regulation about the technical standard of reactor facility etc.", partial revision, June 30, 2016.

[2] Korea Hydro and Nuclear Power, "Shin Kori Nuclear Power Plant 5,6 Preparation Safety Analysis Report", revision 01, April 30, 2013