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# Development of a Phenomena Identification Ranking Table (PIRT) for a Station Black Out (SBO) Accident of the APR1400

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## 1. Introduction

KAERI (Korea Atomic Energy Research Institute) is endeavoring to launch an OECD/NEA project by utilizing a thermal-hydraulic integral effect test facility, ATLAS (Advanced Thermal-hydraulic Test Loop for Accident Simulation) [1]. In the OECD-ATLAS project, design extension conditions (DECs) such as a station black out (SBO) and a total loss of feed water (TLOFW) will be experimentally investigated to identify the major thermal-hydraulic phenomena of high risk multiple failure accidents considering magnified safety concerns after the Fukushima accident.

SBO is one of the most important DEC in that without any proper operator actions, a total loss of heat sink leads to core uncover, to core damage, and ultimately a core melt-down scenario under high pressure. Due to this safety importance, SBO is considered to be a base test item of the OECD-ATLAS project.

In this study, Phenomena Identification Ranking Table (PIRT) has been developed for identifying the major parameters affecting the thermal-hydraulic phenomena in SBO transients. Development of PIRT for SBO transient is expected to contribute to making strategy for performing a thermal-hydraulic integral effect test with ATLAS which includes determination of proper test conditions and improvement of measurements. The PIRT process used in this study follows the methodology previously applied in the Passive Auxiliary Feedwater System (PAFS) of the APR+ (Advanced Power Reactor Plus) [2].

## 2. Methodology of PIRT Development

In general, the PIRT process can be widely used to improve a safety analysis code for a new application and to establish experimental programs and to support the resolution of the licensing issues [3]. The PIRT can serve as guides to planning a cost-effective experimental program and code improvement and also to developing test and validation matrix. In this study, based on the general process of the PIRT development as shown in Fig. 1, the PIRT has been developed by consensus of Korean expert panellists from industry, regulatory commission, academia, and research institute, etc.

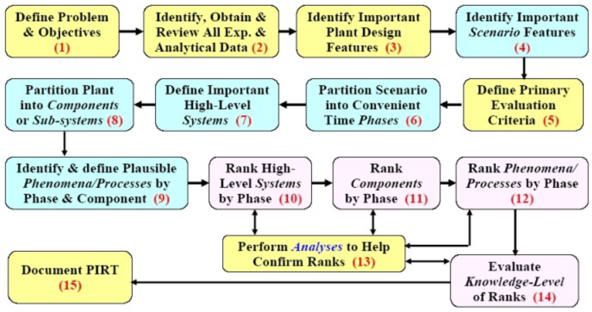


Fig. 1. Typical process of the PIRT development.

### *2.1 Scoping Analysis*

In order to provide information for the development of PIRT, scoping analysis using MARS code [4] was performed. The objectives of scoping analysis were to determine the time phase during a SBO transient, to identify the major thermal-hydraulic phenomena, to determine the primary safety criteria (PSC), and to provide information for determining the rank of each phenomenon.

Prolonged SBO without actuation of turbine-driven auxiliary feedwater system was selected as scenario for scoping analysis. As a base sequence of SBO transient, seal failure of reactor coolant pump (RCP) was not considered and passive components such as pilot-operated safety relief valve (POSRV) and main steam safety valve (MSSV) were assumed to be available.

Major thermal-hydraulic phenomena were selected from scoping analysis as follows;

- Single phase natural circulation in the primary loop
- Secondary inventory loss of steam generator through MSSV
- Primary inventory loss through POSRV
- Wall heat transfer between primary and secondary sides to remove decay heat
- RCP seal leakage: Even though it was not considered in scoping analysis due to its uncertain occurring time, it is also important during SBO transient.

Three temporal phases of SBO transient were identified from scoping analysis. Temporal phases were determined by considering the primary system pressure and collapsed level in the secondary side as shown in Fig. 2.

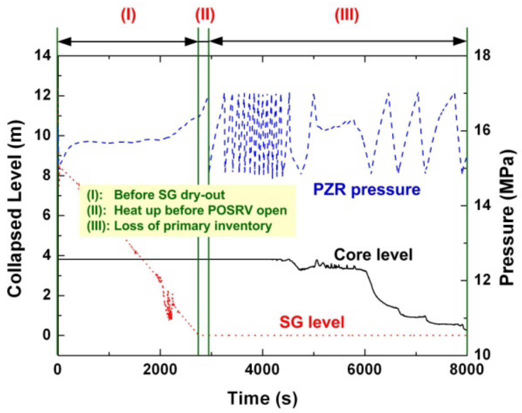


Fig. 2. Temporal phases of SBO transient.

### *2.2 Generation Process of the PIRT Development*

Based on the scoping analysis results, it was agreed by the expert panelists that PSC of the PIRT should be "core mixture level". The PSC, used for judging the relative importance of the phenomena in the plant behaviour of interest, are generally based on key parameters that affect major safety issues. The rank of a system, component, process or phenomena is a measure of its relative influence on the PSC [5].

The relative importance of the phenomena is time-dependent as an accident proceeds. For the convenience of the determination on the dominant phenomena, SBO transient was partitioned into three temporal phases as shown in Fig. 2. The importance and the knowledge level were ranked for the individual phenomenon in the specific temporal phases.

## 3. Result of the PIRT

The final PIRT for the SBO transient is presented in Table 1. As for the major components of the nuclear power plant, the rank of the importance and the knowledge level were summarized for each of the three temporal phases. Higher importance rank means the relative importance of each phenomenon. And the highest knowledge level rank means that the phenomenon is fully known and has small uncertainty.

Table 1: Result of the PIRT for a SBO transient

| System | Component | Phenomena | Importance Rank according to Temporal Phase | | | Knowledge Level Rank |
|---|---|---|---|---|---|---|
| | | | I | II | III | |
| RPV | Core | Decay heat | 5 | 5 | 5 | 5 |
| | | Pressure drop | 4 | 3 | | 5 |
| | | Phase separation | | | 5 | 3 |
| | | Wall heat transfer | 5 | 5 | 5 | 4 |
| PZR | Vessel | Liquid entrainment | | | 5 | 2 |
| | | Phase separation | 2 | 2 | 5 | 3 |
| | Surge line | Liquid entrainment | | | 4 | 2 |
| | | Counter-current flow limit (CCFL) | | | 4 | 2 |
| | POSRV | Critical flow | | | 5 | 4 |
| SG | 2nd Side | Dry out | 5 | | | 5 |
| | | Wall heat transfer | 5 | | | 4 |
| | Inlet Plenum | Thermal mixing | | | 3 | 3 |
| | U-tube | Phase separation | | 4 | | 3 |
| | MSSV | Critical flow | 5 | | | 4 |
| Primary piping | Hot leg | Natural circulation | 5 | 4 | | 4 |
| | | Liquid entrainment | | | 4 | 2 |
| | Cold leg | Natural circulation | 5 | 4 | | 4 |
| | Intermediate leg | Natural circulation | 5 | 4 | | 4 |
| RCP | Seal | Seal leakage flow | 4 | 4 | 3 | 4 |

According to the results of the PIRT as summarized in Table 1, following phenomena were relatively important during a SBO transient.

- Wall heat transfer and phase separation in the core
- Critical flow at the POSRV and the MSSV
- Natural circulation in the primary loop
- Dry out and wall heat transfer at the secondary side of steam generator

Considering the above important phenomena during a SBO transient, it can be confirmed that ATLAS has a capability of simulating most important phenomena and is also equipped with the instruments appropriate to measure them.

## 4. Conclusions

The PIRT has been developed for identifying the major parameters affecting the thermal-hydraulic phenomena during a SBO transient. The PSC was determined to be the core mixture level from the expert panel discussion. As for the major components of the nuclear power plant, the rank of the importance and the knowledge level were summarized for each of the three temporal phases. Taking into account the important phenomena from the PIRT result, it can be confirmed that ATLAS has a capability of simulating the major thermal-hydraulic phenomena during a SBO transient as realistically as possible. The present PIRT is expected to contribute to making strategy for performing a thermal-hydraulic integral effect test with ATLAS in the framework of the OECD-ATLAS project.

## REFERENCES

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