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An OECD-ATLAS Project for Thermal-Hydraulic Safety Improvement after the Fukushima Accident

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1. Introduction

An international joint project promoted by the OECD/NEA/CSNI (hereafter OECD-ATLAS) is being planned based on the ATLAS facility to meet the international interests in the multiple high-risk design extension conditions raised after the Fukushima accident. In the OECD-ATLAS project, such design extension conditions that are either more severe than DBAs or involve additional failures will be experimentally investigated to identify the major thermal-hydraulic scenarios to be addressed in the design and to further contribute to the safety analysis technology of nuclear power plants.

2. Overview of the Project

2.1 Background

Since 2007, the ATLAS facility has been extensively utilized to address the major design basis accidents of the APR1400. It has also contributed to a verification of the safety of operating or advanced nuclear power plants as well as to a validation of the system-scale safety analysis codes such as MARS-KS and SPACE. ATLAS has been recognized as one of the important IET facilities worldwide since the ISP-50 was successfully completed in 2011, where 14 organizations from 11 OECD countries participated. The unique strengths of ATLAS can be best used to contribute to the IET working area through an OECD International project.

2.2 Objectives

The design extension conditions (DEC), which are not seriously considered from a design basis, such as a station blackout (SBO), an anticipated transient without scram (ATWS), or a total loss of feed water (TLOFW), are considered as multiple high-risk failure accidents as safety concerns regarding severe accidents have magnified after the Fukushima accident [1]. In the OECD-ATLAS project, such design extension conditions that are either more severe than DBAs or that involve additional failures will be experimentally investigated to identify the major thermal-hydraulic scenarios to be addressed in the design and to further contribute to the safety analysis technology of nuclear power plants.

After the Fukushima accident, a passive safety system has received widespread attention to reinforce safety as well as to make nuclear power plants economically competitiveness. Passive safety systems will be key features of advanced PWRs. One of the new safety improvement concepts to mitigate an SBO accident efficiently, such as a passive aux. feedwater system, can be investigated in the framework of the OECD/NEA ATLAS project to produce clearer knowledge of the actual phenomena and to provide the best guidelines for accident management.

A rulemaking to add a new section to 10CFR Part 50 is being prepared to provide an alternative, risk-informed set of requirements for an emergency core cooling system. The proposed rule will divide the current spectrum of LOCA break sizes into two regions, and the division between the two regions is determined by a “transition break size (TBS)” [2]. Thus, a medium break LOCA (MBLOCA) will be experimentally investigated to characterize the major thermal-hydraulic behavior, and will support the current ECCS rule-making.

2.3 Schedule and Financial Aspects

The project is scheduled for March 2014 to February 2017 (3 years). The proposed overall expenditure is 2.5 million € taking into account human resources, facility modification, instrument upgrades, etc.

2.4 Potential Project Partners

The OECD/CSNI endorsed the OECD-ATLAS project in December 2012, and an expert meeting was held in June 2013 to discuss the topics of interests and attract potential project partners. Eighteen organizations from thirteen OECD member countries have shown great interest in the proposed test items, and have confirmed their intention to join this project. At the moment, the confirmed project partners are as follows: USA (USNRC), France (IRSN, CEA, EDF), Finland (VTT, FORTUM, LUT), Germany (GRS, AREVA-NP), Spain (CSN), Italy (UNIPI), Belgium (BelV), Sweden (SRSA), Hungary (MTA-EK), Republic of Czech (UJV), Japan (JAEA), China (SNPTC), and Korea (KAERI, KINS, KHNP, KNF).

2.5 Proposed Test Matrix

In the OECD-ATLAS project, a tentative test matrix was proposed, as shown in Table 1. It consists of five different topics: (1) prolonged SBO, (2) SBLOCA during SBO, (3) TLOFW, (4) MBLOCA, and (5) open items.

Table 1 Proposed Test Matrix

Topics	Details
A1- Prolonged SBO - Asym. 2^{nd} cooling - Asym. passive cooling	with additional failures
A2-SBLOCA during SBO - SBO+RCP seal failure - SBO+SGTR	effects of leakage flow TISGTR
A3-TLOFW	with additional failure
A4-MBLOCA	surge line and cold leg
A5-Open items	counterpart tests

3. Topics of Interests

3.1 Prolonged SBO

Primary natural circulation characteristics at high pressure conditions will be investigated especially when a turbine-driven auxiliary feedwater is injected to one steam generator to remove the decay power. The performance of the heat removal by natural circulation is of prime interest in terms of safety. In particular, flow instability and/or a cease in natural circulation depending on the water level of the hot and cold legs have great uncertainties in code modeling and simulation. During decay heat removal by a turbine-driven feedwater supply, stuck-open MSSVs can deteriorate the cooling capability, eventually leading to a severe accident. In addition, the operational performance of a passive secondary cooling system coupled with the reactor coolant system (RCS) through steam generators under an asymmetric condition during an SBO will be investigated.

3.2 SBLOCA during SBO

SBO has been recognized as one of the risk-contributing sequences when combined with an additional failure of components, especially SBLOCAs such as a RCP seal failure and a steam generator tube rupture (SGTR) [3]. The effects of the leakage flow rate include a lot of uncertainties in a safety analysis, as the liquid hold-up in the core, natural circulation performance, and loop seal clearing are significantly dependent on the leakage flow rate.

During an SBO, the components can be heated to the extent that an induced rupture might occur as a result of the combined effects of pressure and temperature. In particular, an SGTR during an SBO (TISGTR) has been shown to be a potentially important risk contributor [4]. The high velocity of a steam jet that would be expected on a neighboring SG tube during an SBO can result in multiple ruptures. One or multiple steam generator tube ruptures during an SBO condition will be simulated.

3.3 TLOFW

A TLOFW accident was considered to be important since it was identified as one of the major contributors to the severe core damage frequency in a WASH-1400. A TLOFW event with the primary feed and bleed will be tested, and an additional failure of ATWS may be included after considering its safety importance.

3.4 MBLOCA

Core uncovery, ECC bypass, and loop seal clearance characteristics during a MBLOCA transient may be different from those during a SBLOCA and LBLOCA transient. Detailed thermal-hydraulic data obtained in the ATLAS test will help expand our understanding of the thermal-hydraulic system response, and to validate the present safety analysis methodology. Loop asymmetric characteristics and multi-D mixing behavior in the annulus down-comer region will be investigated in the ATLAS test, which will provide a precise database for validation of the prediction capability against MBLOCA transients and a suggestion of model improvement, if any, in current safety analysis codes

3.5 Open items

The scaling issue is one of the remaining major safety issues under debate between regulatory authorities and utilities. The scaling inherent in a certain facility needs to be justified before its data is used for a safety analysis. Such scaling issues and the scaling distortions embedded in the previous IET database can be evaluated by performing counterpart tests of ATLAS. Previous tests of LSTF and /or PKL performed at well-defined initial and boundary conditions can be good candidates for a counterpart test in ATLAS.

4. Conclusions

An OECD-ATLAS project is planned to start in the beginning of 2014 to address safety issues relevant to design extension conditions. A total of ten tests among five subjects were proposed and obtained great support from the potential project partners. This OECD project will contribute to enhance the safety and improve safety analysis codes by providing well-qualified IET database.

REFERENCES

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