Major Outcomes of the Second Phase of OECD-ATLAS International Joint Project

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CONTENTS

01 BACKGROUND AND OVERVIEW (1)

Backgrounds

- **Design Extension Conditions (DECs)**
  - DECs are considered as multiple high-risk failures as safety concerns and should be taken into account in view of the 'defense-in-depth' concept.
- **Post-Fukushima Action**
  - The Fukushima accident attracted international attention to the integrity of containment.
  - A passive safety system is being revisited to reinforce safety.
- **Enhancement of Safety Analysis Technology**
  - Precise multi-dimensional integral effect test (IET) database (DB) can contribute to improvement of safety analysis code and methodology.
- **Resolution of Scaling Issues**
  - In spite of accumulated IET DB, 'scaling issue' is debated and still remain unresolved, thus they are now being seriously reviewed in WGAMA.
  - Scaling issue is very important to enhance the reliability of safety analysis methodology which can be applied to the nuclear power plants (NPPs).

01 BACKGROUND AND OVERVIEW (2)

Project History

- Sept. 2016 : official proposal at WGAMA
- Dec. 2016 : official proposal at CSNI
- Nov. 13~14, 2017 : kick-off meeting at Paris
- April 17~18, 2018 : 2nd PRG/MB meeting at Abu Dhabi
- Oct. 10~12, 2018 : 3rd PRG/MB meeting at Daejeon
- April 23~24, 2019 : 4th PRG/MB meeting at Brussels
- Oct. 16~18, 2019 : 5th PRG/MB meeting at Jeju
- Nov. 3~5, 2020 : 6th PRG/MB meeting (video conference)

01 BACKGROUND AND OVERVIEW (3)

Project Overview

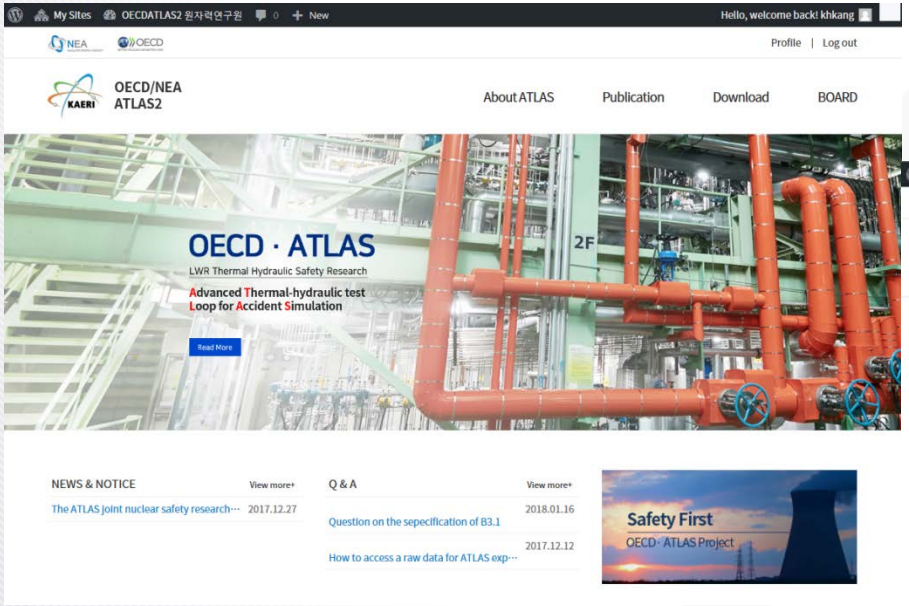
- **Period**
  - October 1, 2017 ~ December 31, 2020 (3 years and 3 months)
- **Budget**
  - 3.0 million Euro
- **Promising project partners**
  - Belgium (BelV, Tractabel), China (SPICRI, NPIC, CNPRI), Czech (UJV), France (EDF, CEA), Germany (GRS), Spain (CSN), Switzerland (PSI), UAE (FANR), USA (NRC), Korea (KAERI, KINS, KHNP CRI, KEPCO E&C)
  - Japan (JAEA, as in-kind contribution)

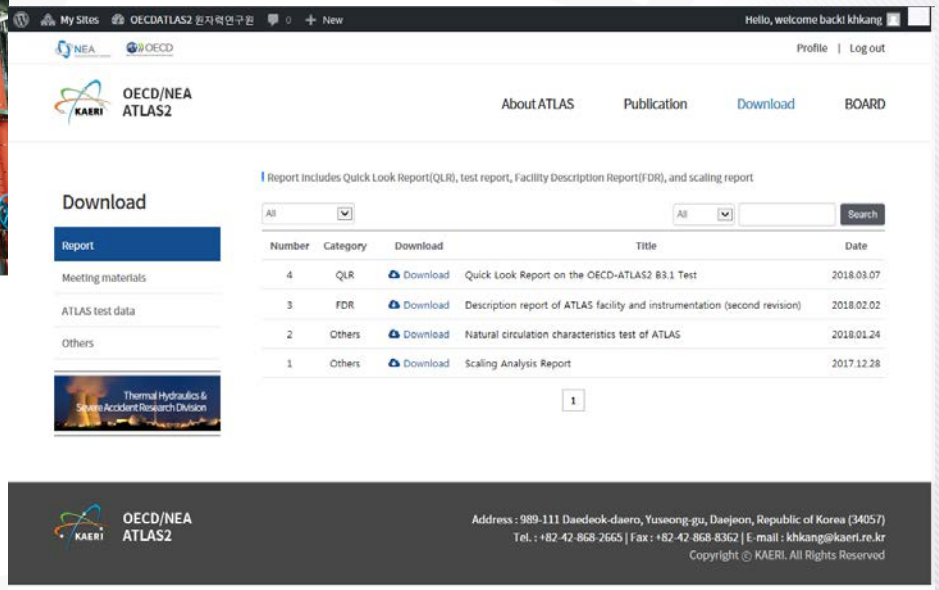
➔ **11 countries, 18 organizations**

01 BACKGROUND AND OVERVIEW (4)

Operation of Download Server

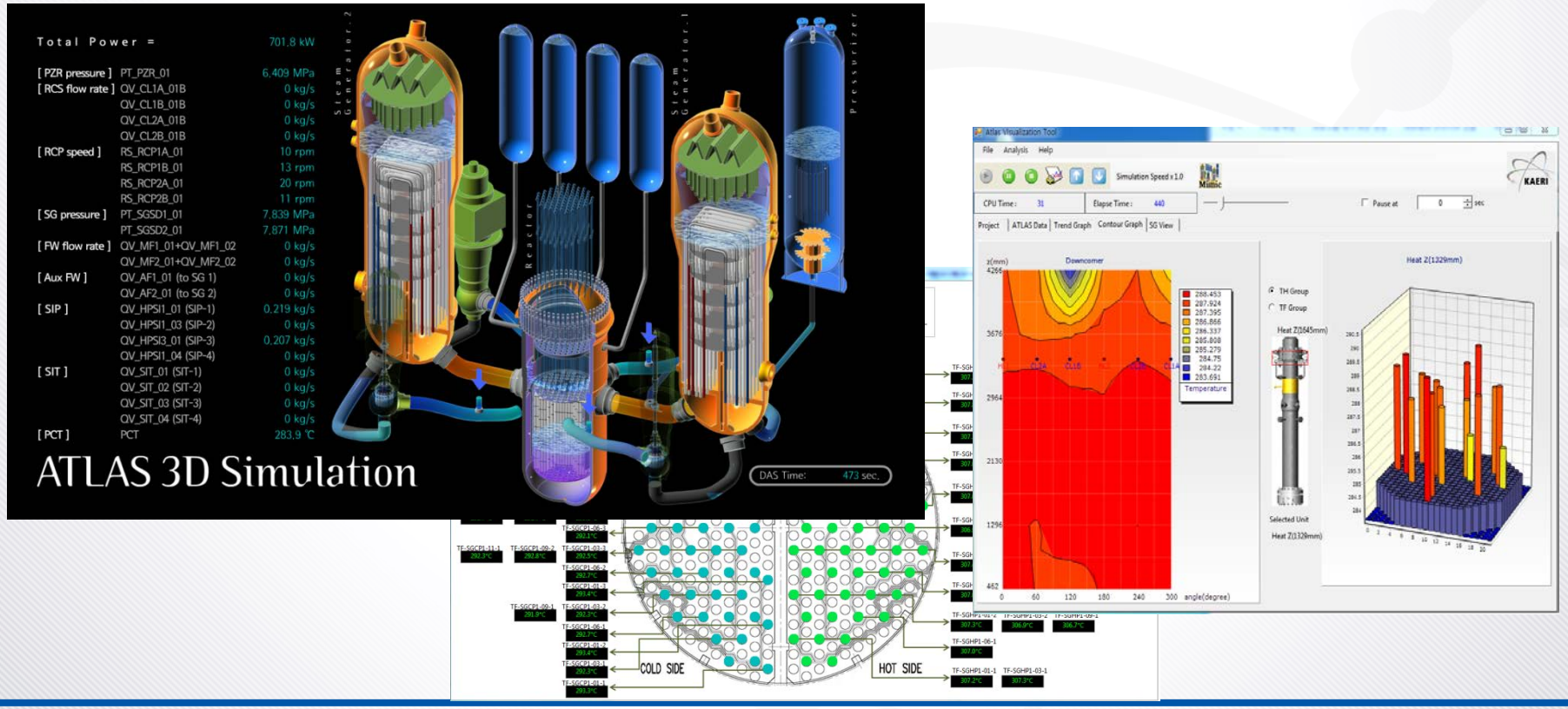
- **www.thsard.re.kr/atlas**





New Version of Data Visualization Tool

- **Reflection of new RPV and core heater**
  - Two kinds of version are activated depending on the date of test data.



02 STATUS OF PROJECT (1)

Status of Test & Report

- Total 8 tests in 5 different topics were successfully completed.
- Regarding 8 tests, quick-look reports and test reports were distributed on time.
- Executive summary was submitted to CSNI for approval.
- Final integration report was under review by the project participants and it will be issued no later than December 31, 2020.

Topics	Number of tests	Remarks
B1-SBLOCA		
- SBLOCA w/o SIP under PAFS operation	1	Resolving the safety issues
B2-Passive Core Makeup		
- SBO with Hybrid SIT	1	
- SBLOCA with PECCS	1	Condensation model, w and w/o nitrogen
B3-IBLOCA		
- PZR Surgeline Break	1	Effect of break position and ECC injection
- DVI Line Break	1	Cliff Edge Effect
B4-Design Extension Conditions		
- SLB with SGTR	1	Long-term core PCT behavior during multiple failure accident
- Shutdown Coolability w/o RHRS	1	Effect of reflux condensation, accident sequence modeling
B5-Counterpart Test		
- Counterpart Test of LSTF SB-PV-07 (1% RPV top break SBLOCA)	1	Addressing the scaling issue
Total	**8**	

02 STATUS OF PROJECT (2)

Overall Test Details

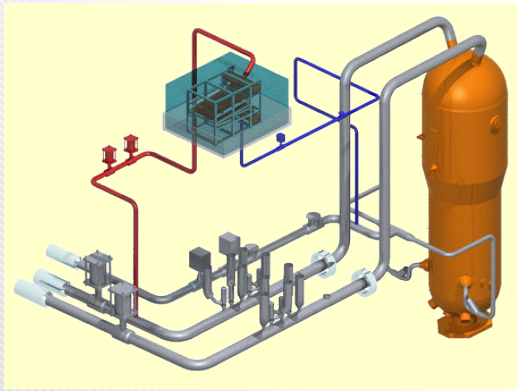
: Pre-test Analysis
: Post-test Analysis
: Test
: PRG/MB Meeting

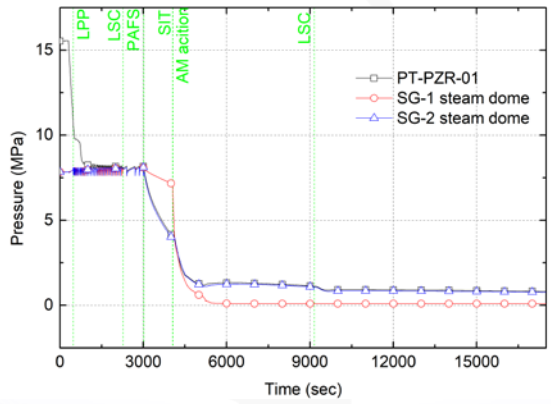
Tests	Number of tests
B1-SBLOCA	
(B1-1) SBLOCA w/o SIP under PAFS op.	1
B2-Passive Core Makeup	
(B2-1) SBO with Hybrid SIT	1
(B2-2) SBLOCA with PECCS	1
B3-IBLOCA	
(B3-1) PZR Surge Line Break	1
(B3-2) DVI Line Break	1
B4-Design Extension Conditions	
(B4-1) SLB with SGTR	1
(B4-2) Shutdown Coolability w/o RHRS	1
B5-Counterpart Test	
(B5-1) Counterpart test of LSTF SB-PV-07	1
Total	**8**

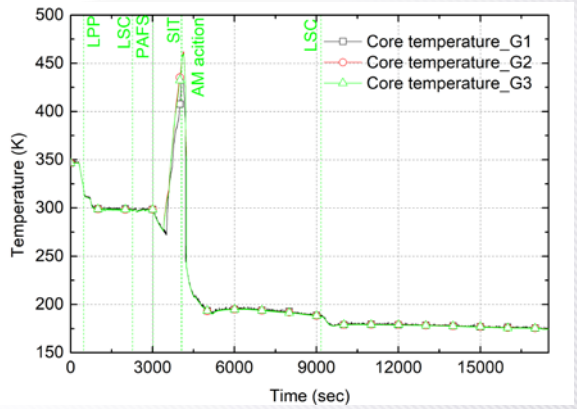
03 LESSONS FORM THE TESTS (1)

Test B1.1

- **Target scenario: CL SBLOCA + Total failure of SIP + PAFS**
  - 2” cold leg break with total failure of SIP.
  - Total 4 SITs were available.
  - PAFS was operated at 25 % of wide range water level at SG-2.
- **During a 2 inch cold leg break SBLOCA with total failure of safety injection pump the reactor core was quenched after an operation of PAFS and accident management action of opening of atmospheric dumping valve.**



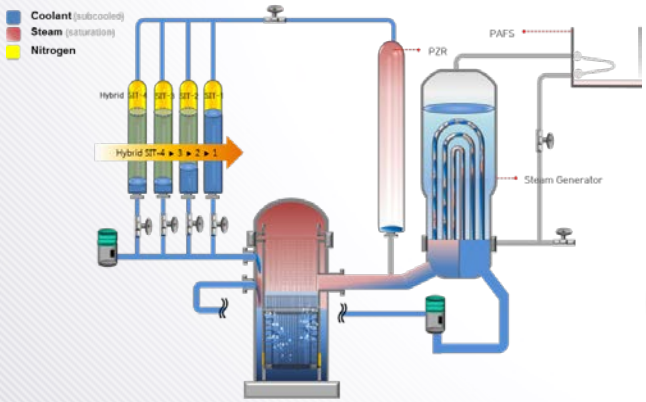


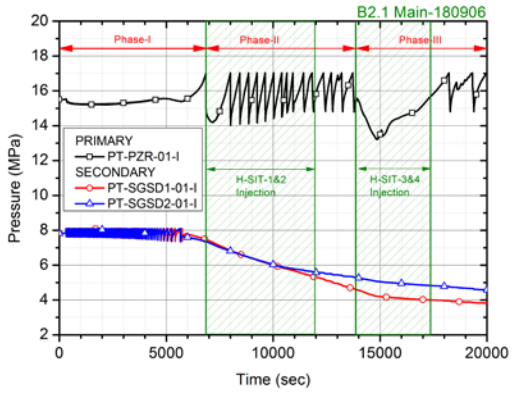


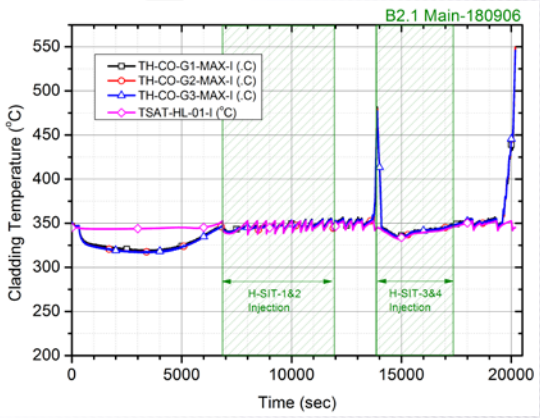
03 LESSONS FORM THE TESTS (2)

Test B2.1

- **Target scenario: SBO with Hybrid-SIT**
  - With the 1st opening of POSRV, H-SIT-1 and 2 started to be injected.
  - When the max. clad temperature increased more than 450 °C, H-SIT-3 and 4 started to be injected.
- **Typical events of an SBO scenario were well reproduced. The H-SITs had an effective core cooling performance as a passive safety feature.**



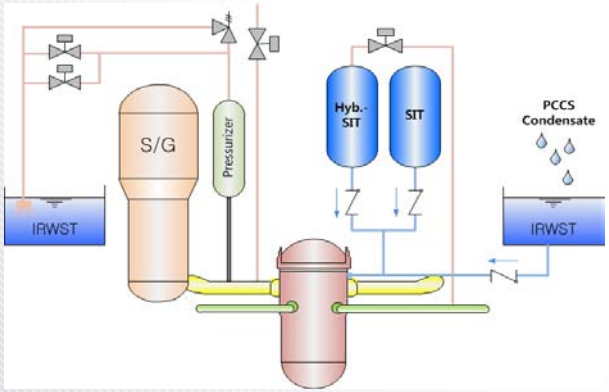


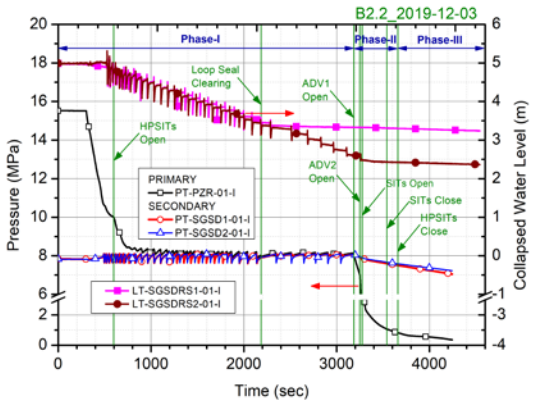


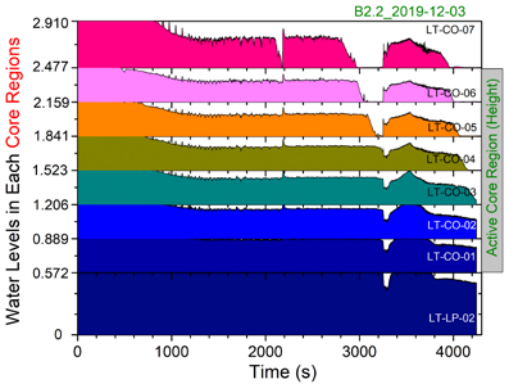
03 LESSONS FORM THE TESTS (3)

Test B2.2

- **Target scenario: SBLOCA with PECCS**
  - 2” SBLOCA in the cold leg-1A is assumed to occur with the start of the transient.
  - High pressure SIT: connected to the cold leg with pressure balance line
  - Set point of SIT: < 4.2 MPa
- **With safety injection from the HP-SITs and depressurization through automatic depressurization valves (ADVs), the primary system pressure abruptly decreased below the activation set point of the SIT, 4.2MPa.**



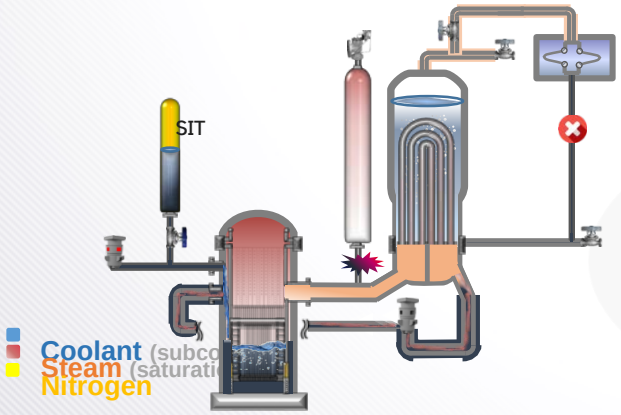


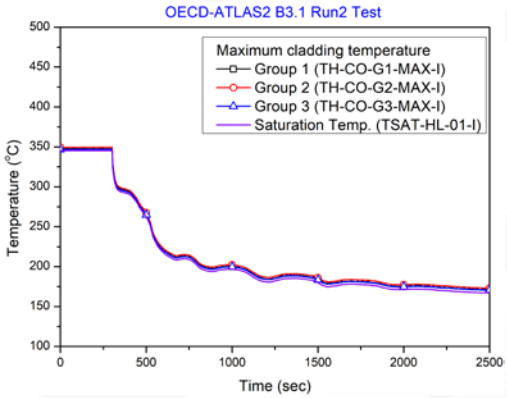


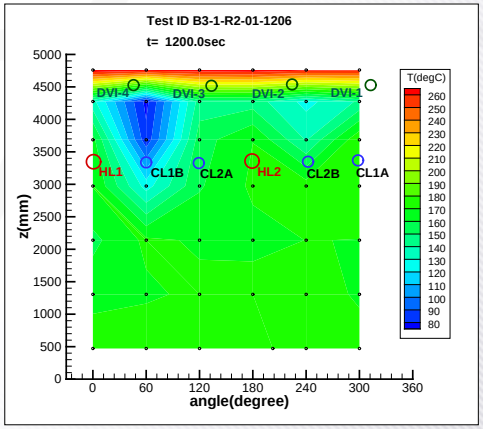
03 LESSONS FORM THE TESTS (4)

Test B3.1

- **Target scenario: PZR surgeline IBLOCA**
  - Run1: using 4 SITs
  - Run2: using 3 SITs
    - ✓ SIT-2 was intentionally not used to investigate asymmetric injection of ECC water.
- **Confirmation of sufficient cooling capacity of SIS during the PZR surgeline IBLOCA.**
- **Asymmetric temperature distribution in an upper downcomer in the Run2 test.**



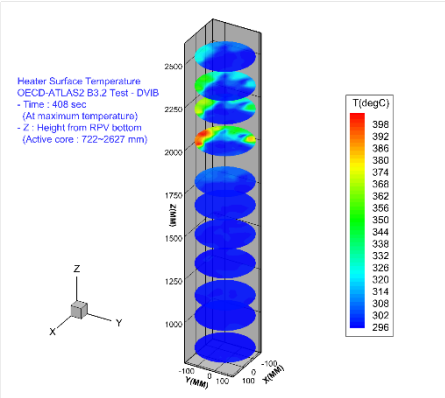


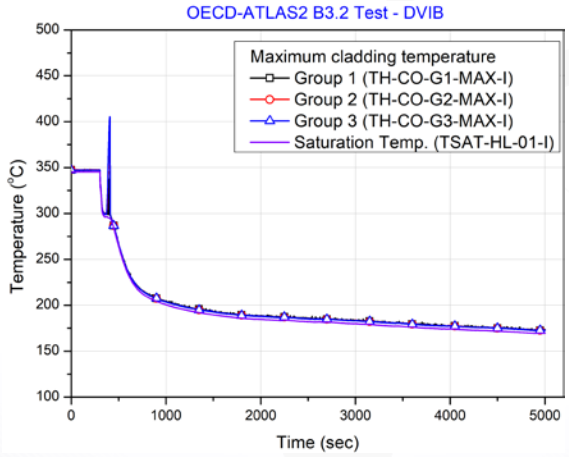


03 LESSONS FORM THE TESTS (5)

Test B3.2

- **Target scenario: DVI line break IBLOCA (Witness test)**
  - 100% break of DVI line (corresponding to 8% of CL flow area).
  - The maximum cladding temperature was measured but the safety injection system was effective to cool down the core after quenching.
- **While an excursion of the cladding temperature did not occurred in the B3.1 test even with a larger break area than the DVI line, the simulation of the DVI line break scenario showed a core heat-up until the clearance of a loop seal and an upper down-comer.**

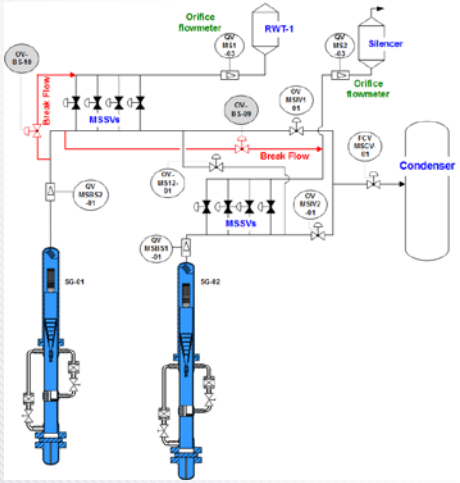


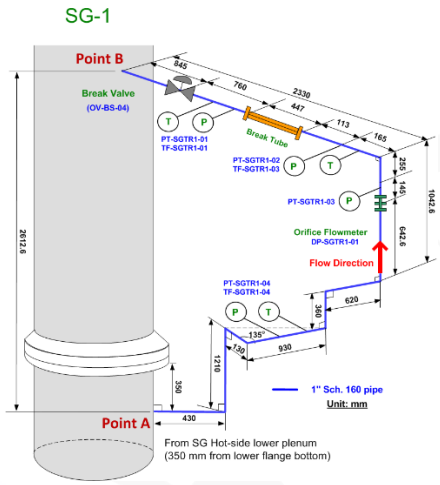


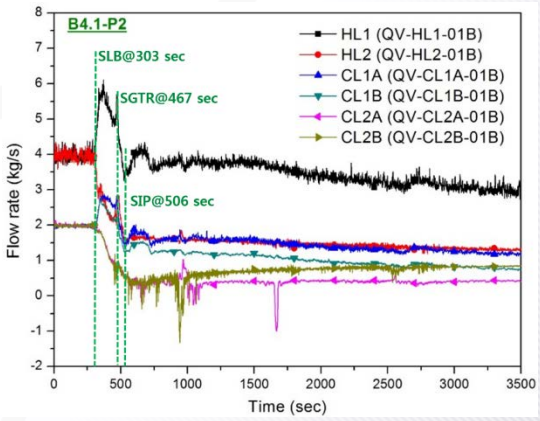
03 LESSONS FORM THE TESTS (6)

Test B4.1

- **Target scenario: SLB accompanied by SGTR**
  - SLB: Guillotine break at the upstream of the MSIVs
  - SGTR: Multiple (5 SG tubes) rupture on SG-1 hot side coincident with SG-1 dry-out
- **In spite of a multiple accident of an SLB accompanied by a SGTR, the reactor coolant system was successfully cooled-down with an operation of SIP and auxiliary feedwater system.**



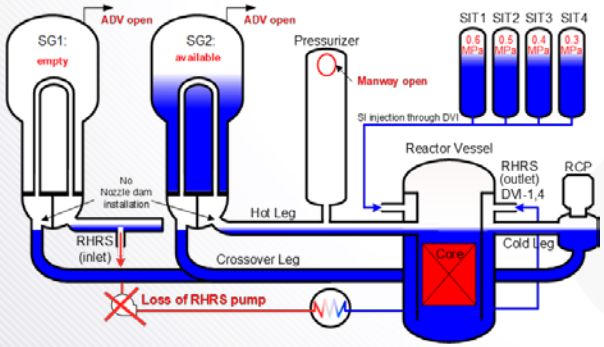


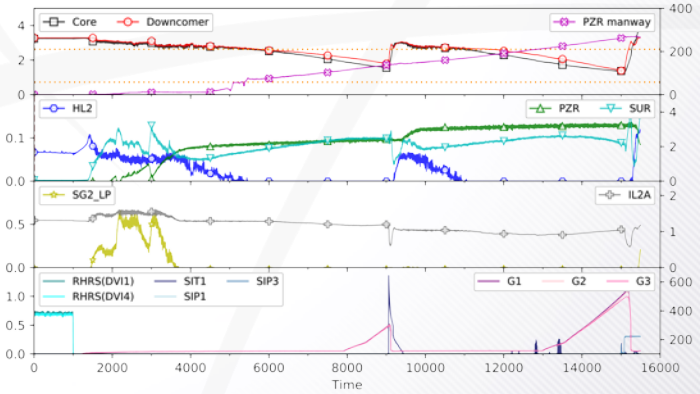


03 LESSONS FORM THE TESTS (7)

Test B4.2

- **Target scenario: Shutdown coolability w/o RHRS**
  - To investigate shutdown coolability without RHRS with respect to the reflux condensation phenomenon: Asymmetric available secondary inventory in SG
- **The existence of secondary system inventory and the location of the pressurizer cause the asymmetric thermal-hydraulic behavior in the RCS.**
- **Safety injection from SIT and SIP can make up the uncovered core with the coolant and cool down the RCS during a mid-loop operation with a loss of RHRS.**

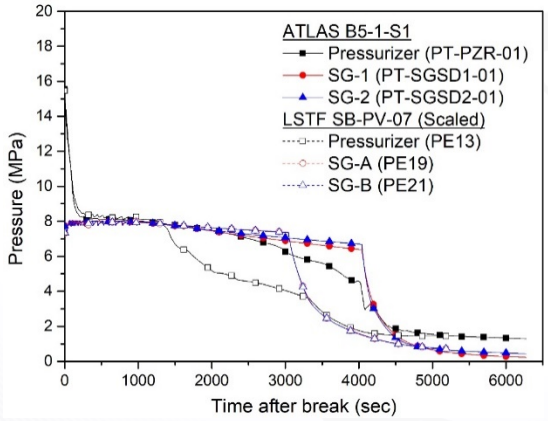


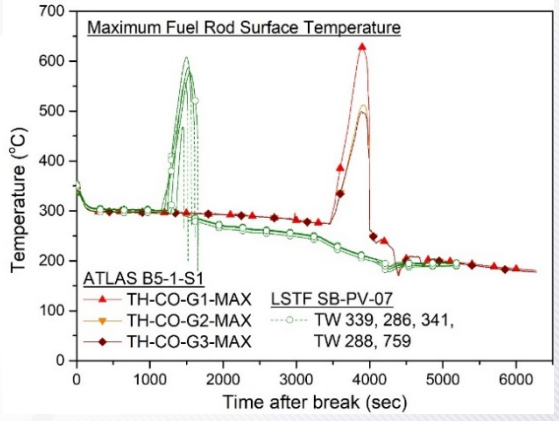


LESSONS FORM THE TESTS (8)

Test B5.1: Counterpart test of LSTF SB-PV-07 test

- **Target scenario: 1% SBLOCA at RPV upper head + total failure of HPSI**
  - Manual injection of HPI system as the first accident management action
  - Secondary system depressurization as the second accident management action
- **Very similar thermal-hydraulic behaviors were reproduced. Some differences were observed as follows;**
  - The break flow rate and collapsed water level in the RVP showed different behaviors between two tests: The upper head design of RPV is different.
  - Difference of loop seal clearing phenomenon can be attributed to the different design of intermediate leg and the location of the active core between two facilities.





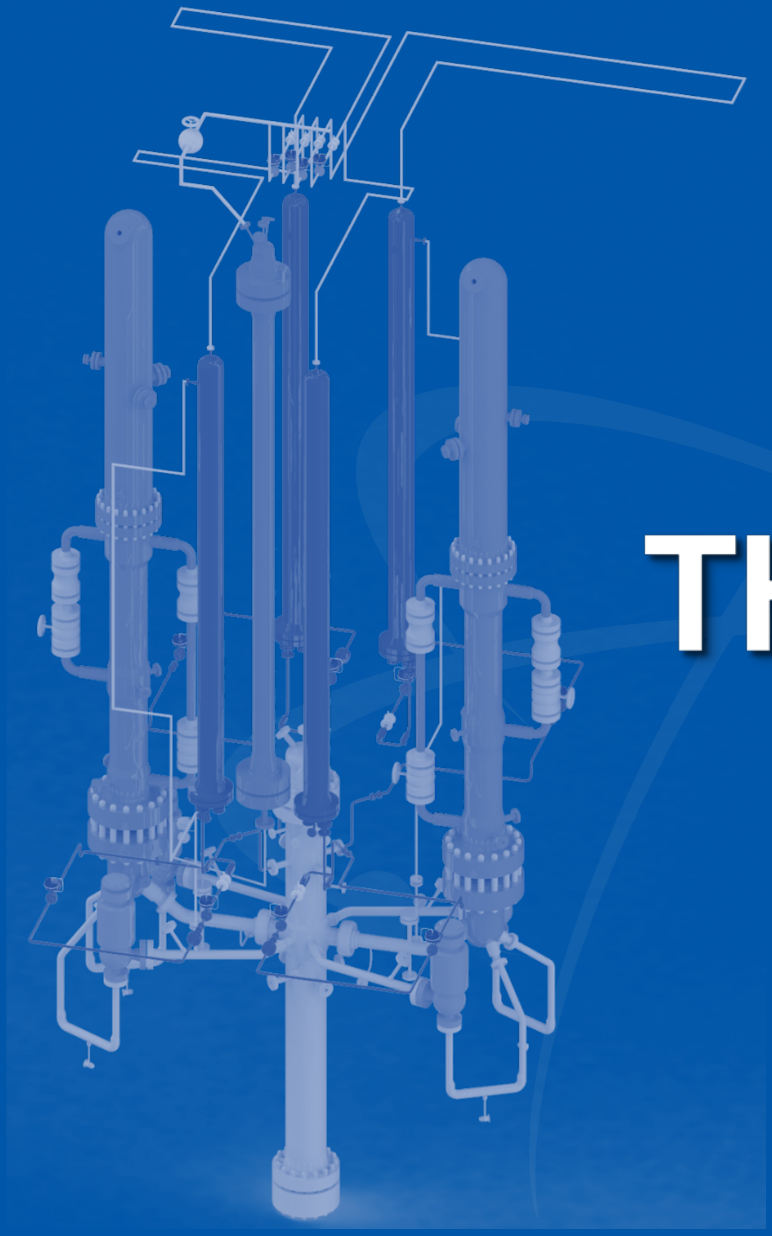
04 SUMMARY

The OECD/NEA ATLAS-2 joint project was successfully completed by conducting 8 integral effect tests in 5 different topics to address the safety issues and to enhance the safety analysis technology.

- Final integration report was under review by the project participants and it will be issued no later than December 31, 2020.

Special Remarks

- Very active pre- and post-test analyses were done by the project participants with their analysis codes: RELAP, TRACE, CATHARE, ATHLET, MARS, SPACE, etc.
- The ATLAS follow-up project (OECD/NEA ATLAS-3) will start from 2021 to further address the safety relevant issues and to enhance the safety analysis technology.



THANK YOU