Pipe Break Accident Analysis of STELLA-2 using MARS-LMR

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Introduction

Pipe Break Accident DBE of SFR

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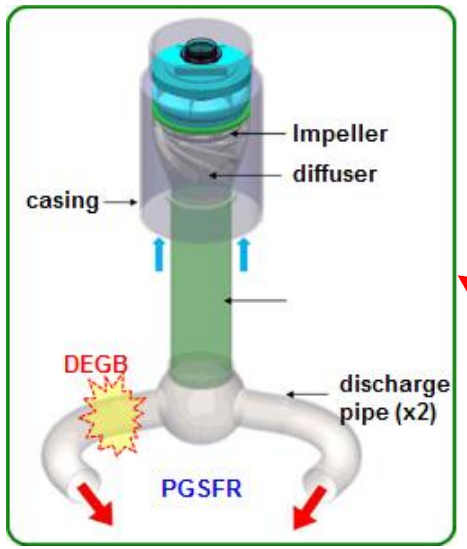
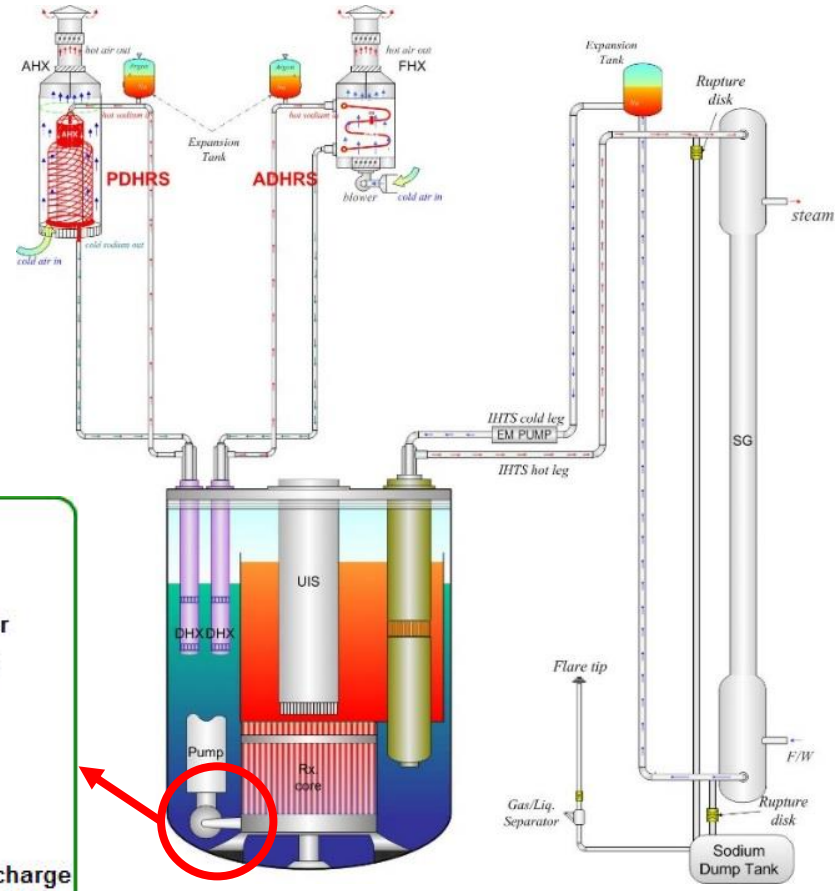
Pipe Break Accident in SFR

- Primary pump discharge line failure
- Effect on the natural circulation flow path
- One of the DBEs of pool-type SFR

- For conservatism, Double-ended Guillotine Break(DEGB) is assumed
- Sodium from both sides flows out to cold pool



Pipe Break Position



PGSFR Reactor Schematic

- 2 Mechanical Pumps

- 4 Discharge Lines

STELLA-2 Facility

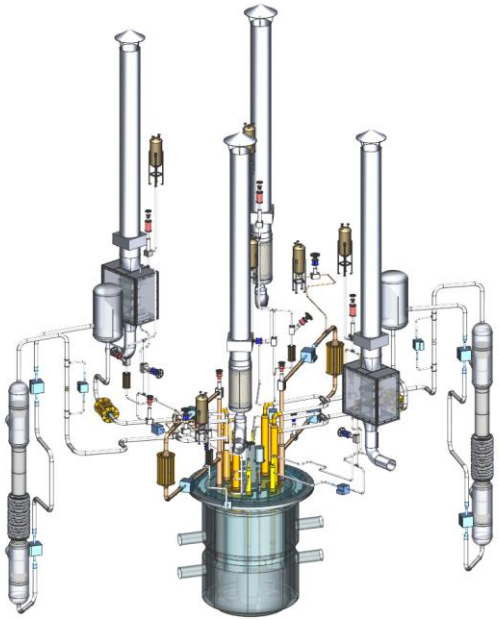
Integra Effect Test Facility for PGSFR

02

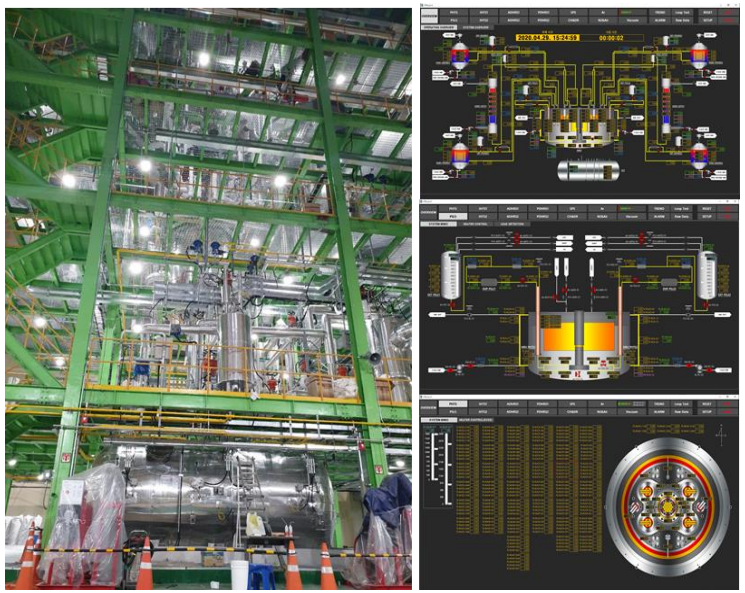
STELLA-2 Facility

- Large-scale sodium test facility
- Focus on transient and integral effect
- Main purpose
  - ✓ Verification of DHRS performance
  - ✓ V&V for safety analysis code

- Includes all major components of PGSFR
- Difference
  - Nuclear core → Electric heaters
  - SG → sodium-to-air HX
  - Mechanical pump → EMP



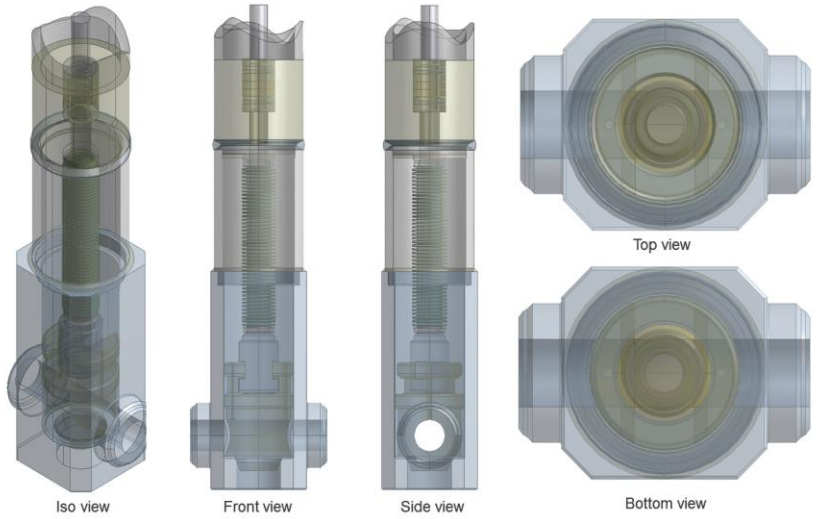
STELLA-2 3D Drawing



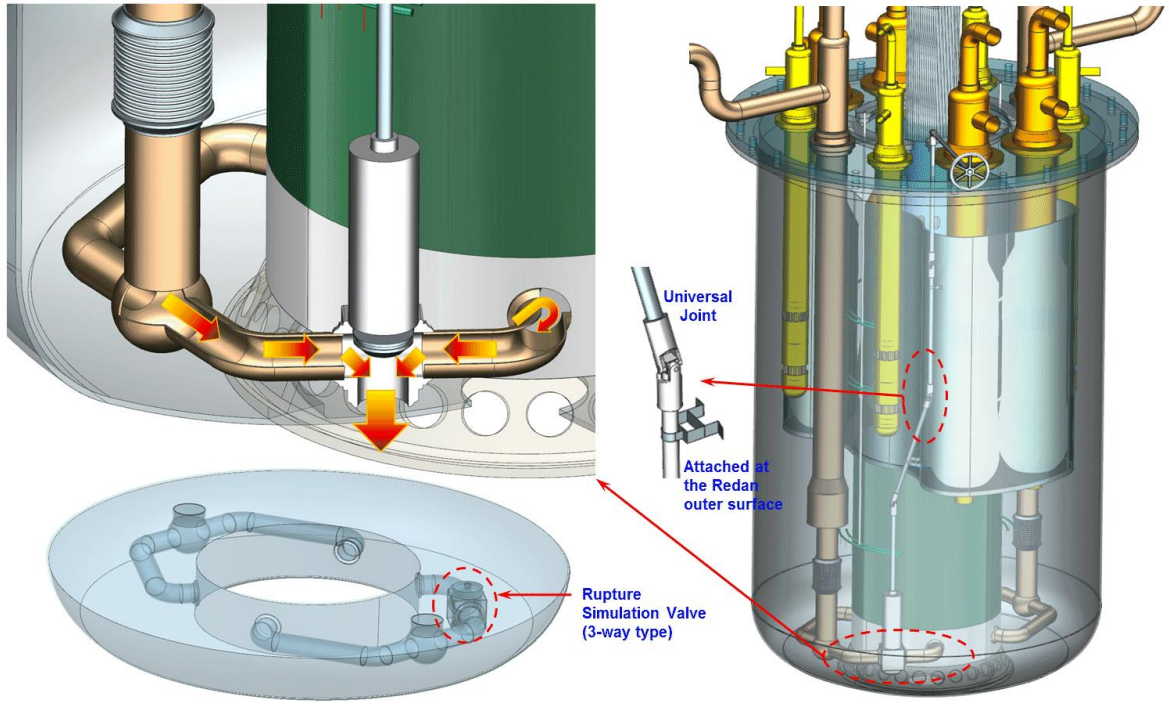
STELLA-2 Installation & Control System

STELLA-2 Pipe Break Simulation

- Using special 3-way valve
- Universal joint long-reach arm
- Short actuation time



Pipe Break Simulation Valve



STELLA-2 3D Drawing

MARS-LMR Analysis

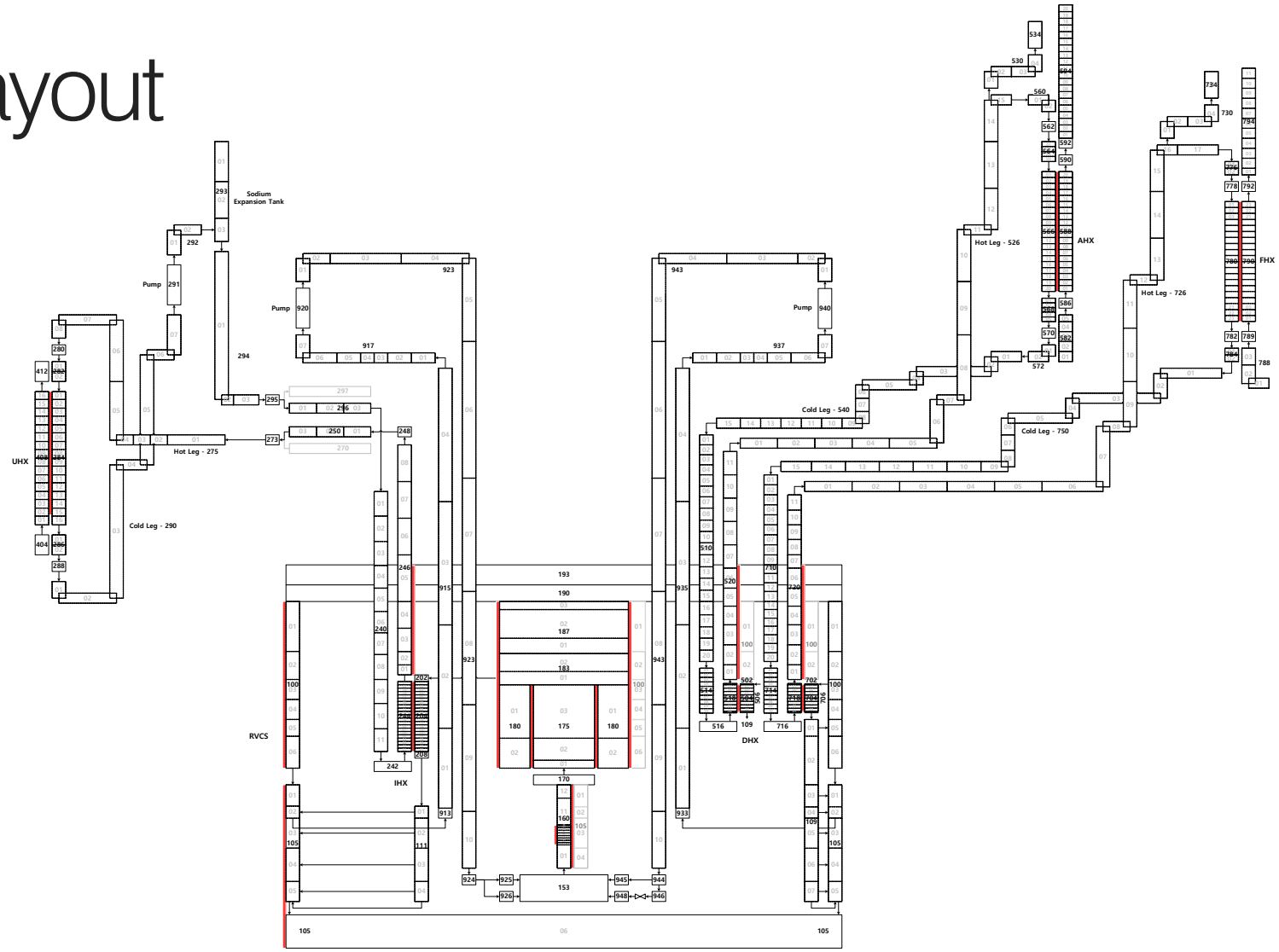
Node Layout and Assumptions
Pipe Break Accident Sequence
Test Matrix

03

MARS-LMR Node Layout

- Basic assumptions
  - ✓ Steady-state is set to match the temperature distribution
  - ✓ Loss of off-site power (LOOP)
  - ✓ Pumps stop and core heater follows the decay heat curve

- DHRS working option
  - ✓ 1 PDHRS + 1 ADHRS working
  - ✓ 2 PDHRS + 2 ADHRS working
  - ✓ 1 PDHRS + 2 ADHRS working
  - ✓ 2 PDHRS + 1 ADHRS working



STELLA-2 MARS-LMR Node Layout

Pipe Break Sequence

- 4.47 sec
  - ✓ Simulation valve open
  - ✓ Pump trip
  - ✓ UHX air flow stops
- 5.81 sec
  - ✓ Reactor trip (decay curve)
- 8.26 sec
  - ✓ DHRS starts to operate

STELLA-2 Pipe Break Test Matrix

PHTS Pump Discharge Pipe Break	- Rx Trip - with LOOP - 1 line Break - IHTS Na is not considered	- PHTS pump 1&2 stops - Break Simulation Valve On - IHTS pump 1&2 stops - DHRS working condition: · 2 passive + 2 active
	- Rx Trip - with LOOP - 1 line Break - IHTS Na is considered	- IHTS sodium inventory consideration: · SG F/W dryout simulation using UHX blower
PHTS Pump Discharge Pipe Break + DHRS 1 loop fail	- Rx Trip - with LOOP - 1 line Break - IHTS Na is not considered	- PHTS pump 1&2 stops - Break Simulation Valve On - IHTS pump 1&2 stops - DHRS working condition: · 2 passive + 1 active · 1 passive + 2 active
	- Rx Trip - with LOOP - 1 line Break - IHTS Na is considered	- IHTS sodium inventory consideration: · SG F/W dryout simulation using UHX blower
PHTS Pump Discharge Pipe Break + DHRS 2 loops fail	- Rx Trip - with LOOP - 1 line Break - IHTS Na is not considered	- PHTS pump 1&2 stops - Break Simulation Valve On - IHTS pump 1&2 stops - DHRS working condition: · 2 passive · 2 active · 1 passive + 1 active
	- Rx Trip - with LOOP - 1 line Break - IHTS Na is considered	- IHTS sodium inventory consideration: · SG F/W dryout simulation using UHX blower

Results

Flowrate Trend
Temperature Trend
Heat Removal Trend

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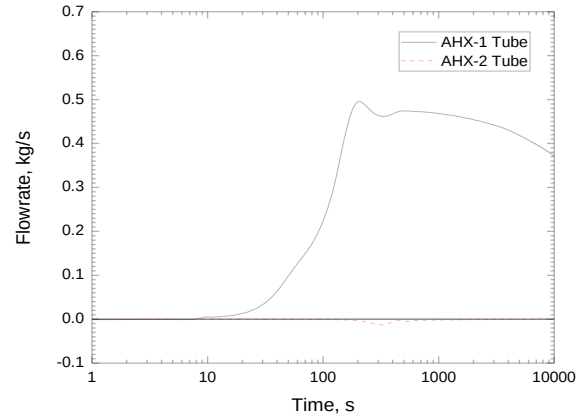
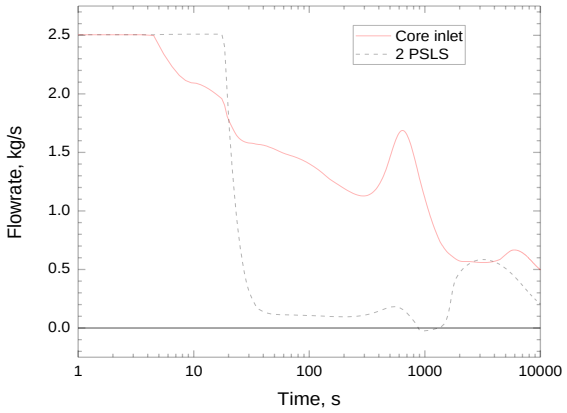
Flowrate Trend

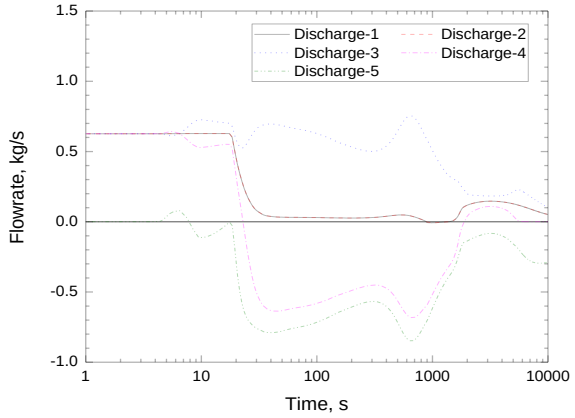
- 1 passive + 1 active DHRS case (the least heat removing condition)
- Sudden peak flow at ~600 sec
- Negative value for discharge line flow



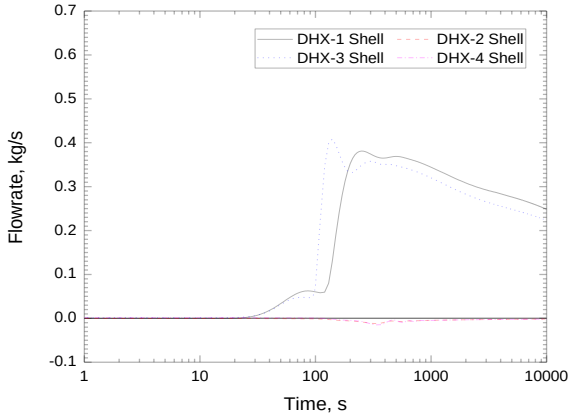
AHX Tube-side



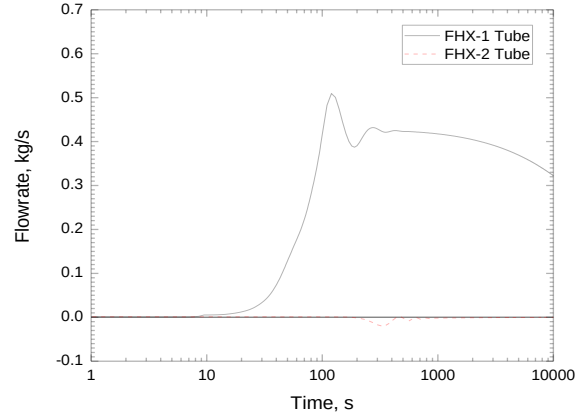
Core & Pump Inlet



Pump Discharge Line



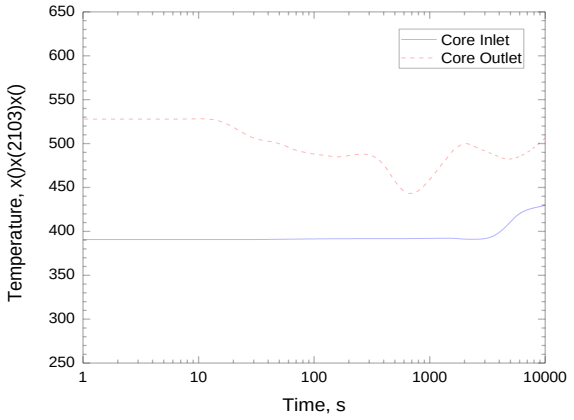
DHX Shell-side



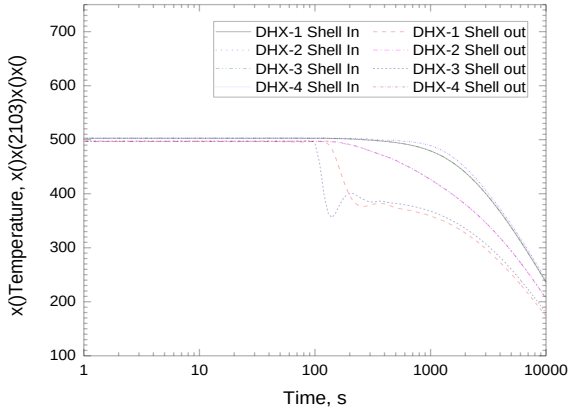
FHX Tube-side

Temperature Trend

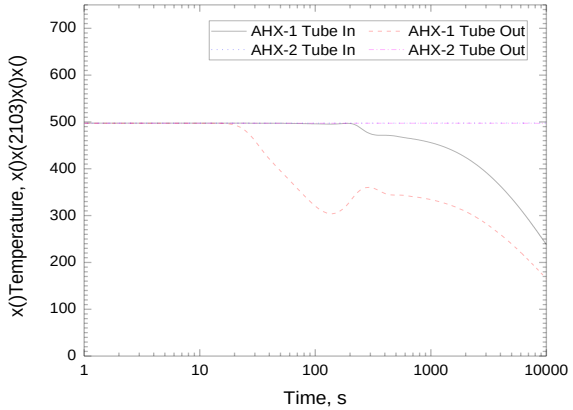
- 1 passive + 1 active DHRS case (the least heat removing condition)
- Sudden drop at ~600 sec due to flow peak
- Slowly increasing as time goes



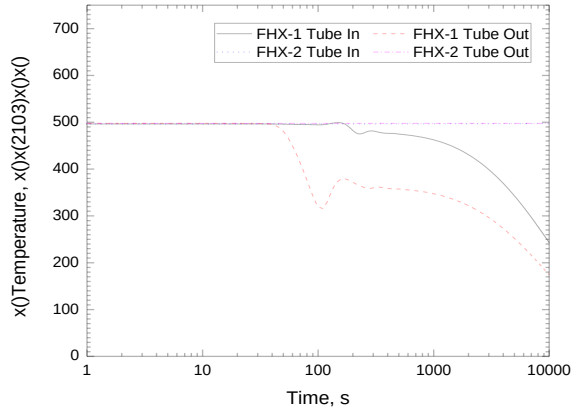
Core In & Out



DHX Shell-side In & Out



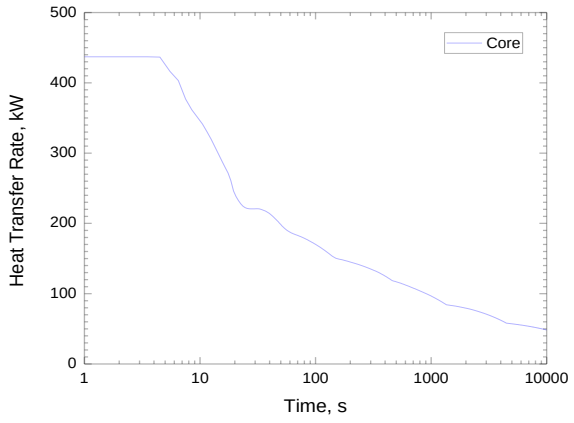
AHX Tube-side In & Out



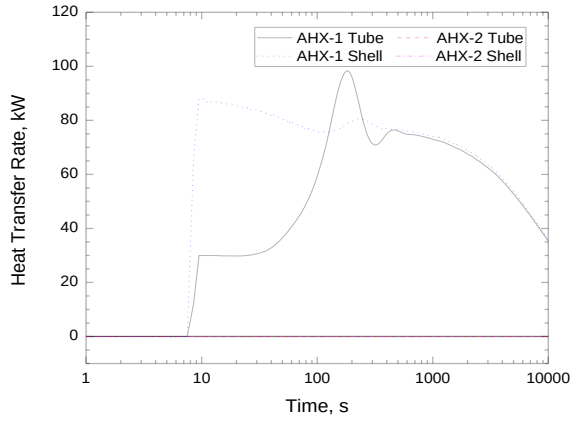
FHX Tube-side In & Out

Heat Removal Trend

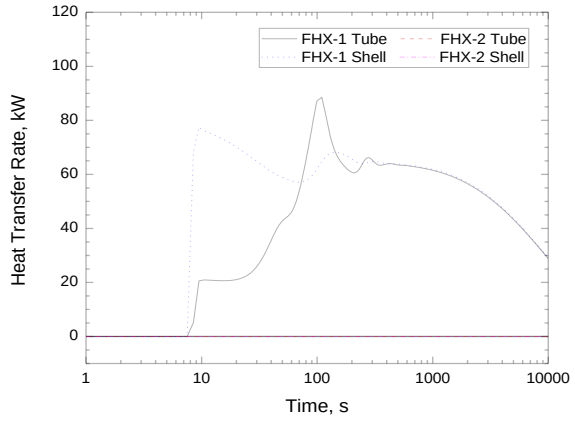
- 1 passive + 1 active DHRS case (the least heat removing condition)
- At the end of calculation, heat removal balance is not saturated
- More calculation is on-going



Core In & Out



DHX Shell-side In & Out



AHX Tube-side In & Out

Trend Summary

- Developed natural circulation flow at 10,000 sec for
  - ✓ Core : 0.5 kg/s
  - ✓ Passive DHX : 0.25 kg/s
  - ✓ Active DHX : 0.22 kg/s

- Flow through DHX shell-side is a local path flow within the cold pool
- Almost same as the main heat removal path (~94%)

- In early stage, the core decay heat is larger than DHRS heat removal
- At 190 sec, it balances and reverses
- At 1,360 sec, max difference
- It slowly decreases upto 10,000 sec

Conclusion

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Conclusion

- Pipe break events of STELLA-2 were analyzed
- Back flow from inlet plenum to the cold pool occurs
- At early stage, the decay heat removal is not significant
- But, long-term behavior is negative

- Further study of comparison with experiment data will show more realistic results

- It will be able to provide feedback to the safety design of the reference reactor