Evaluation of Multiple Steam Generator Tubes Rupture for SMART

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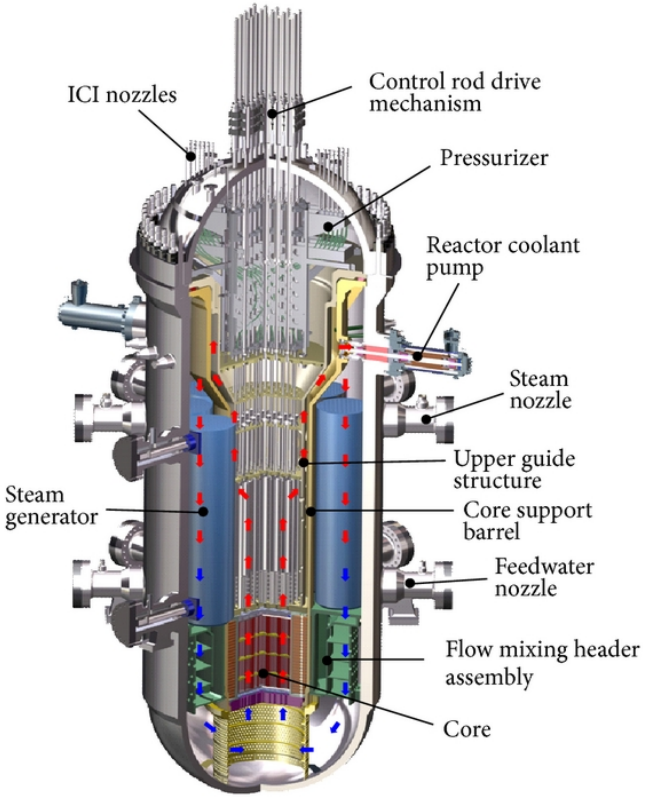
Objective

- Introduction
  - SMART Description
  - Accident Description
- Accident Analysis
  - Objectives
  - Assumptions and Procedures
  - Sequence of Events
  - Results
- Conclusion

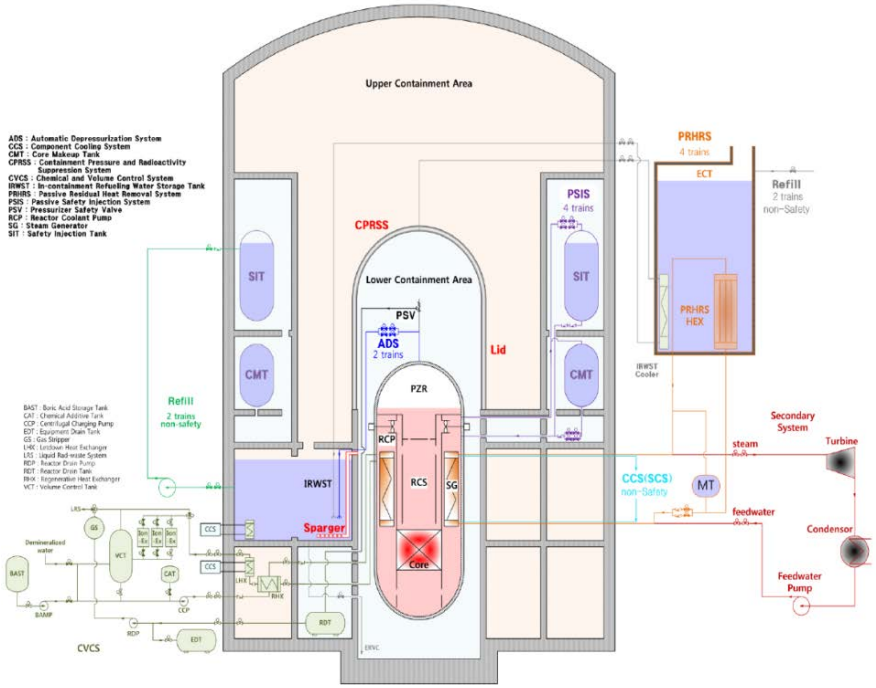
Introduction SMART Description

- SMART is an advanced integral pressurized water reactor with 365 MWt.
- The primary components are integrated into a single Reactor Pressure Vessel (RPV) without any pipe connections between those components.
- 4 Reactor Coolant Pumps (RCPs)
- 8 Steam Generators (SGs)
- Pressurizer (PZR)
- 17x17 fuel assembly
- Maximum Inner diameter of the pipes penetrating the RPV is restricted to 50 mm.



Introduction SMART Description

- Operator’s action after the accident initiation is not required for 72 hours.
- Core residual heat can be removed by the Passive Residual Heat Removal System (PRHRS)
- The Passive Safety Injection System (PSIS) compensates any abnormal decrease in the reactor coolant inventory

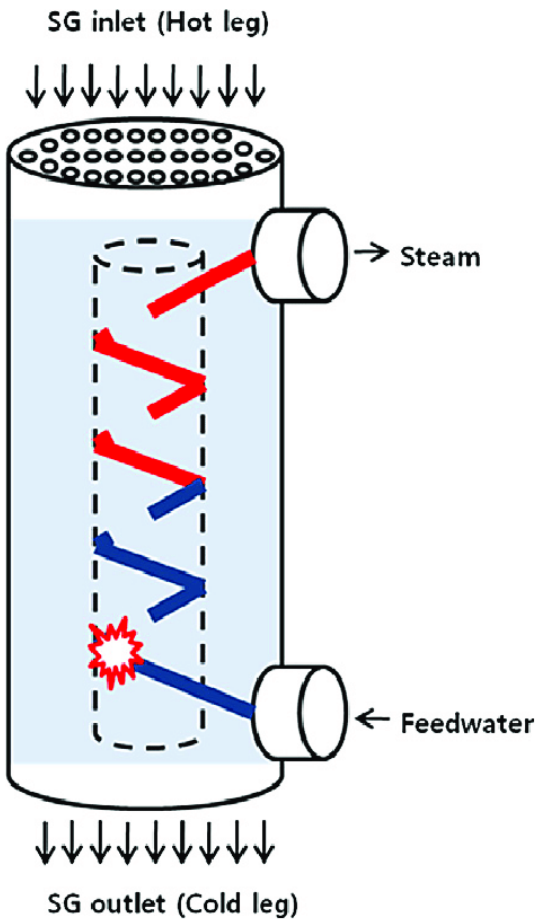


Introduction Accident Description

Criteria	Steam Generator Tube Rupture (SGTR)	Multiple Steam Generator Tubes Rupture (MSGTR)
Description		
Classification		
Analysis Method		
Analysis Objective		

Introduction Accident Description

- Once through helical tube SG (376 tubes).
- High compressive stress
- Less tensile stress
- SGTR occurrence is expected to be less in SMART
- According to NRC: It is unlikely that more than one SG tube to break at the same time, but it is desirable to investigate the MSGTR for evolutionary Advanced Light Water Reactors (SECY-93-087)
- After suggestion by the NRC staff , the ABB-CE performed an investigate about the radiological consequence resulting from the MSGTR for the System 80+ assuming up to five tubes break.
- AP600, APR1400



Accident Analysis Objectives

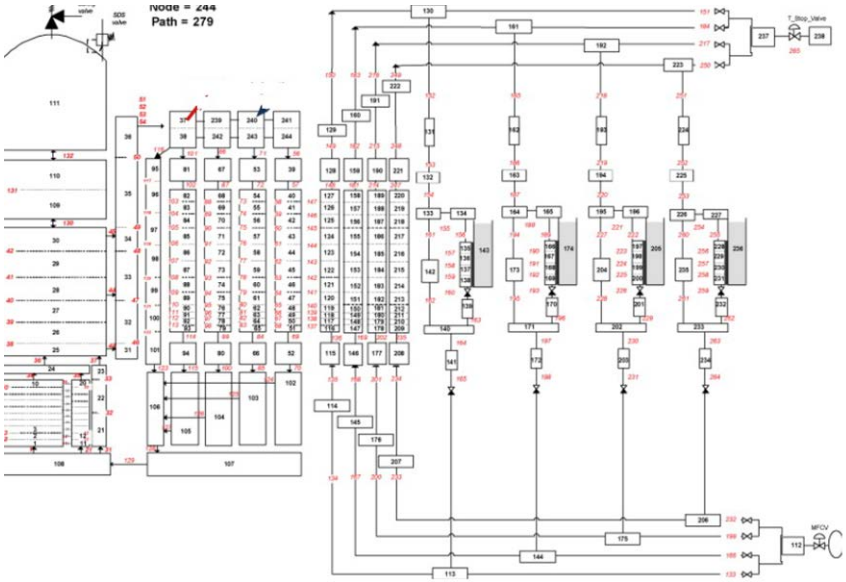
- The MSGTR analysis is performed to analyze two major concerns:
  1. Release of radioactive material outside the containment. **The safety margin is measured by**:
     A. Large NPPs: **Time for operator** to take action before opening the MSSV
     B. SMART: **Set-point** of PRHRS safety relief valves. (NO MSSVs in SMART)
  2. Decrease in reactor coolant inventory.

Accident Analysis Assumptions and Procedures

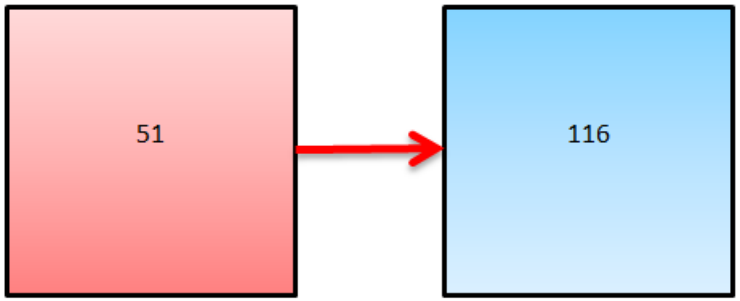
- Analysis is performed using the TASS/SMR-S
- The following best-estimate assumptions are considered in the analysis to maximize the pressure in the secondary system:
  1. No operator action for 72 hours.
  2. Loss of Offsite Power (LOOP).
  3. The control systems (safety and non-safety) such as pressurizer level control system and pressurizer pressure control system are in automatic mode.
  4. Control systems actuations during the transient are assumed to be at nominal set-point values.
  5. One and up to five tubes break is considered during the analysis.

Accident Analysis Assumptions and Procedures

SMART Nodalization

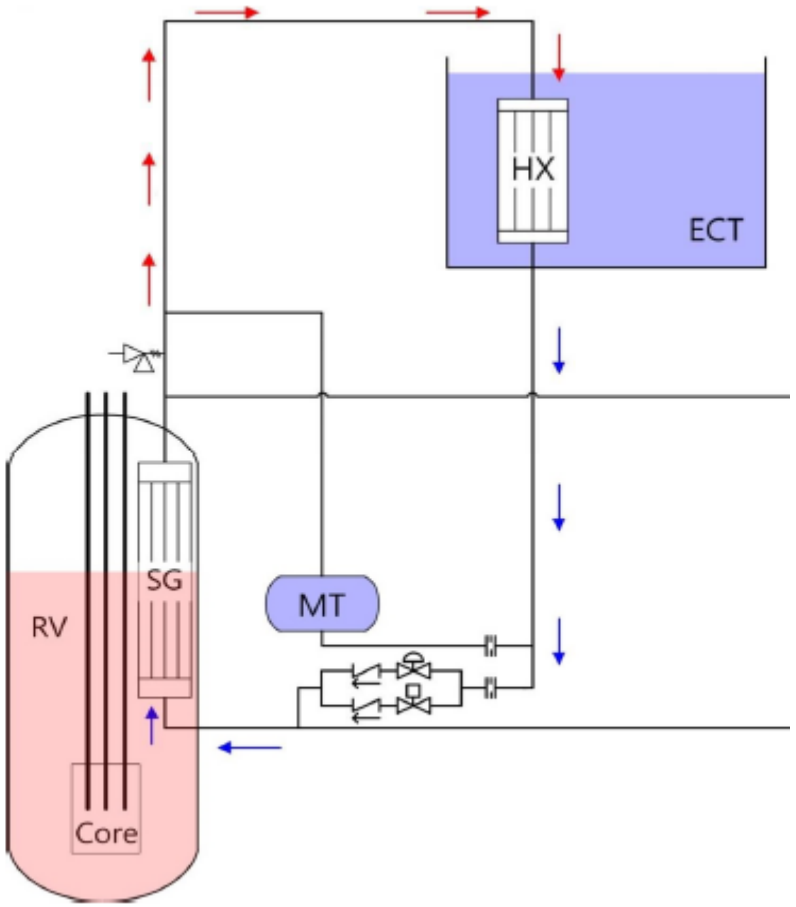


Break Modeling



Accident Analysis Sequence of Events

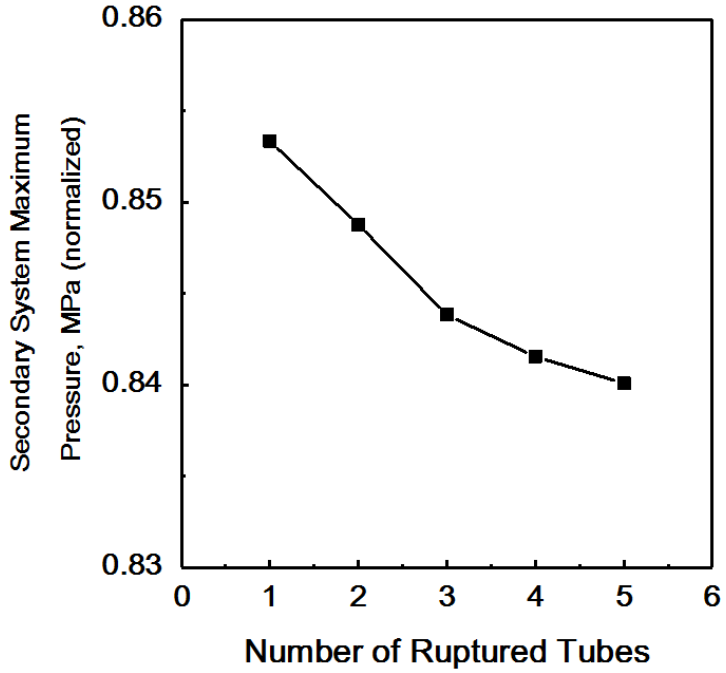
1. MSGTR occurs
2. Auxiliary heaters are turned on due to low pressurizer pressure
3. Auxiliary heaters are turned off due to low pressurizer level
4. Reactor trips by low pressurizer level and :
   - Turbine trips
   - LOOP occurs
   - RCPs and feedwater pump start coasting down
5. PRHRS is actuated to cooldown the reactor, Passive Safety Injections System (PSIS) is actuated to compensate the lost coolant.



Accident Analysis Results

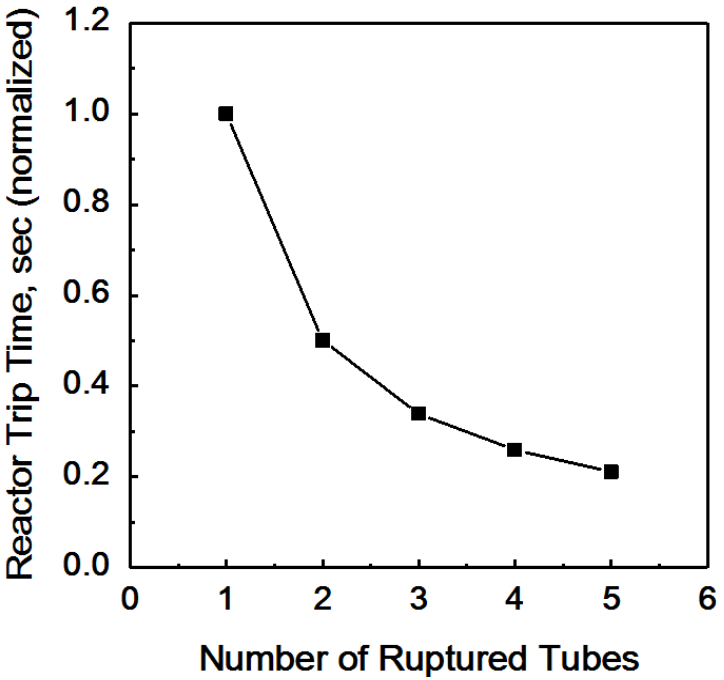
Secondary System Pressure

- Maximum pressure of the secondary system during the MSGTR accident versus the number of ruptured tubes.



Reactor Trip Time

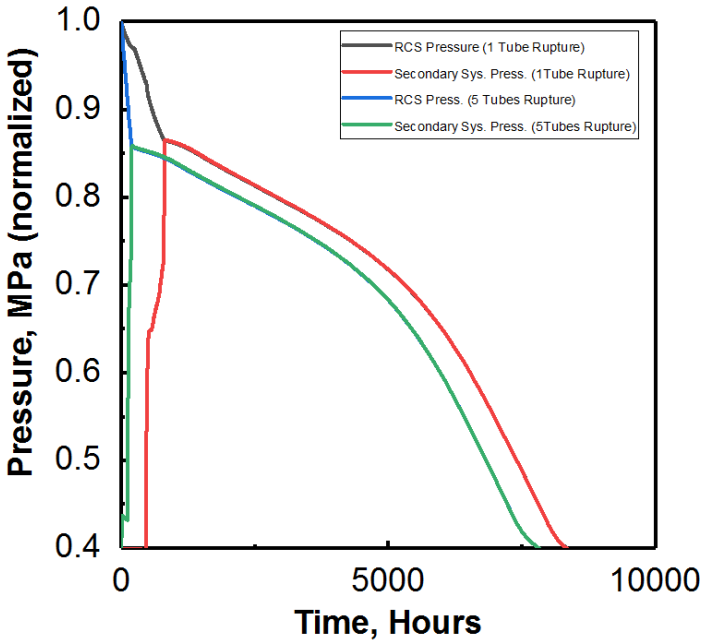
- Reactor trip time during the MSGTR accident versus the number of ruptured tubes.



Accident Analysis Results

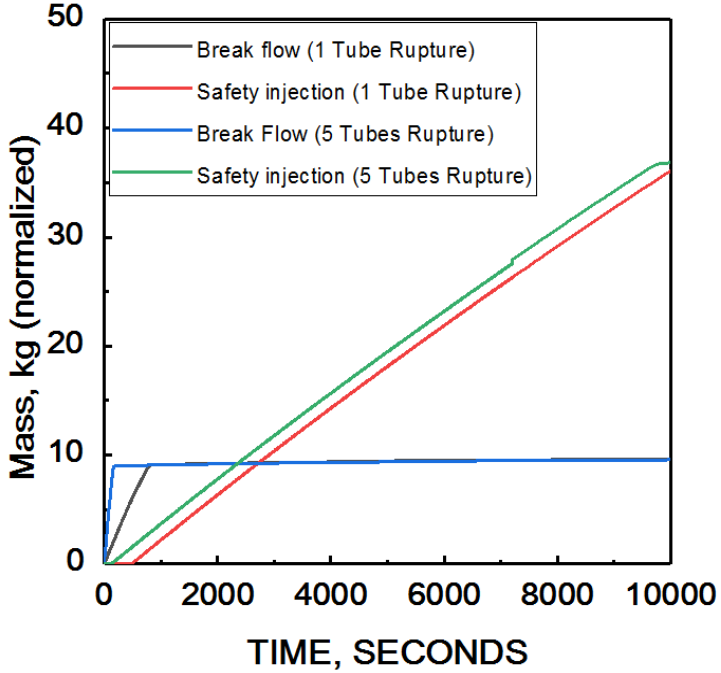
Pressure Behavior

- Pressures of the RCS and secondary system are uniformly decreasing .



Integrated Break and Safety Injection Flow

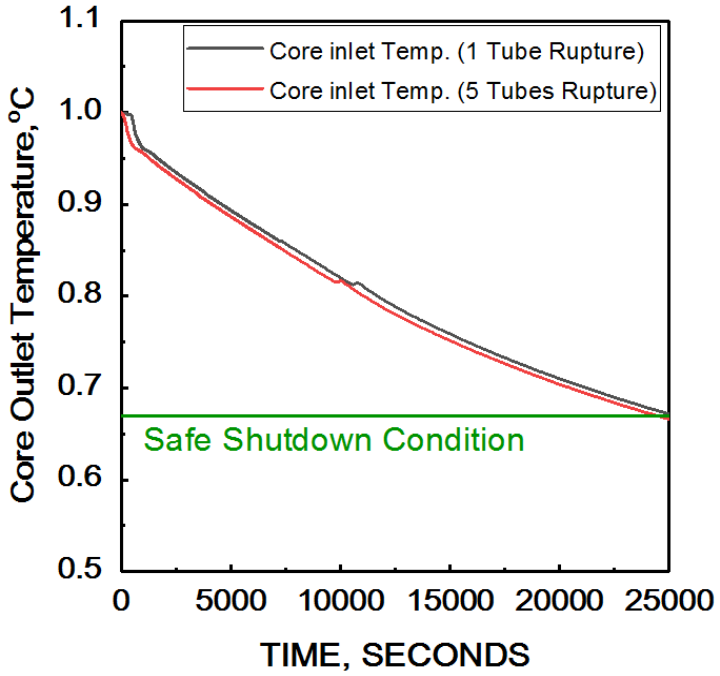
- Safety injection mass to make up the coolant lost during the accident for one and five SGTR cases.



Accident Analysis Results

RCS Temperature

- Core outlet temperature decreases due to the reactor trip and initiation of the safety systems.



Conclusion

- The secondary system maximum pressure reached was **below** the PRHRS safety relief valve set-point.
- Therefore, there is **no possibility** of reactor coolant bypass outside the containment (environment) through the PRHRS safety relief valves during the MSGTR accident.
- The RCS was cooled down to the **safe shutdown condition**.

감사합니다
Thank you

Questions ?