

Update of SMART Cooperation for Deployment in Saudi Arabia: Regulatory Activities

Man KIM

Severe Accident and Risk Assessment Department

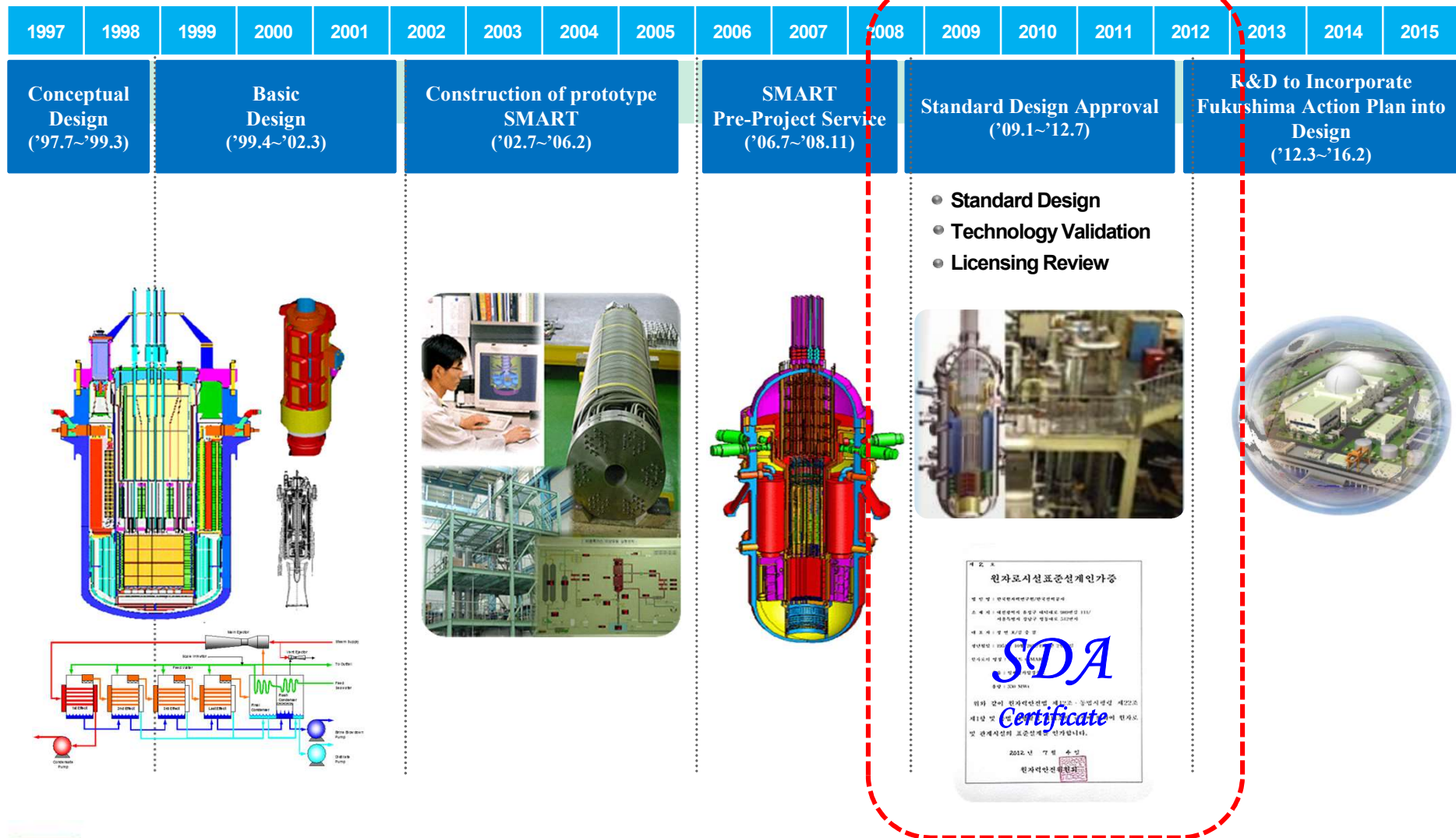
Safety Standards Department

Korea Institute of Nuclear Safety

Outlines

1. Background of SMART Development and Licensing
2. Regulatory Activities
 - 1) Preparation of Review and Assessment
 - 2) Provide HCB Programme for Regulatory Staffs of K.A.Care

1. Development of SMART Prototype



2. Application of SDA License for Prototype SMART

Licensing Process in and Review

Category	Construction	Operation	
Licensing	Construction Permit	Operating License	Continued Operation After Design Life
	Approval of Standard Design		
	Amendment of Permit or License Approval		
Regulatory Orders	Implementation of Severe Accident Policy		
		Periodic Safety Review	

3. Standard Design Approval issued on 7 July 2012

SDA Certificate

제 2 호

원자로시설표준설계인가증

법 인 명 : 한국원자력연구원/한국전력공사

소 재 지 : 대전광역시 유성구 대덕대로 989번길 111/
서울특별시 강남구 영동대로 512번지

대 표 자 : 정 인 호/김 중 겹

생년월일 : 1951년 10월 28일/1950년 2월 3일

원자로의 명칭 : 스마트 (SMART)

종류 : 일체형가압경수로

용량 : 330 MWt

위와 같이 원자력안전법 제12조·동법시행령 제22조
제1항 및 동법 시행규칙 제11조의 규정에 의하여 원자로
및 관계시설의 표준설계를 인가합니다.

2012 년 7 월 4 일

원자력안전위원회

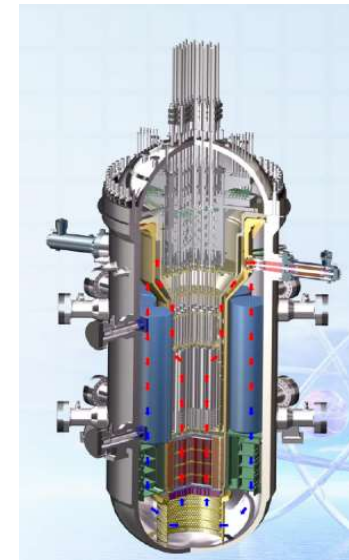
1.5 Years for Licensing Review

~2,000 Technical Q&As & RAIs

Satisfaction of Korean Regulatory Requirements

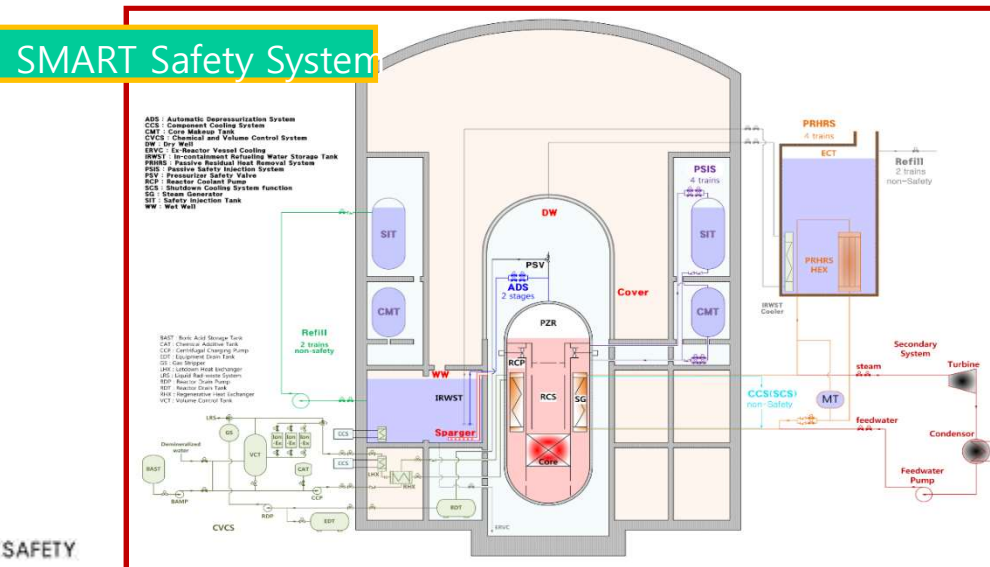
4. SMART PPE Project

- **FOAK Engineering Design** for SMART
 - Project Period: 2015.12 ~ 2018.11(3 Years)
 - Work Scopes for upgrading
 - Reactor System Design
 - Fuel Design
 - Balance of Power (BOP) Design
 - Main Component Design and Validation
- **Design Reference** for SMART Passive Safety Systems
 - Requirement : US NRC and Utility (URD) Requirements for Passive Safety Systems
 - Plant : Westinghouse AP1000



4.1 Overview of SMART Upgraded Safety Systems (1)

- Passive Safety Systems
 - To maintain a reactor in the safe condition for 72 hours without any operator action at the postulated design basis accidents
 - All safety systems can operate not depending on electrical power from emergency diesel generator for 72 hours
 - Safety-grade batteries provide necessary DC power for valve initiation and post accident monitoring.



4.1 Overview of SMART Upgraded Safety Systems (2)

System	SDA	PPE
PRHRS * passive residual heat removal system	- passive, ≥ 36 hours w/o refill - 50% x 4 trains : with single train failure	- passive, ≥ 72 hours w/o refill - 33% x 4 trains : eliminate the single train failure by valve rearranging
SIS * safety injection system	- active - 100% x 4 trains * electrically independent 2 trains, mechanically independent 4 trains	- passive, ≥ 72 hours w/o refill - 33% x 4 trains (CMT & SIT) * electrically and mechanically independent 4 trains, gravity driven tanks (CMT & SIT)
Containment Pressure Protection	- active : CSS - 100% x 2 trains * CSS : containment spray system	- passive : CPRSS * CPRSS : containment pressure and radioactivity suppression System
RCS Depressurization	- SDS - 2 trains, controlled by operators * SDS : safety depressurization system	- ADS - 2 trains, automatically actuating valves under DBA * ADS : automatic depressurization system
SCS * shutdown cooling sys.	- active, safety system - 100% x 2 trains	- active, non-safety system using SG and CCS * CCS : component cooling system
Emergency AC Power	- active, safety system - 100% x 2 trains	- Not applicable * non-safety DGs are equipped

For more details for PPE design, please contact to:



4.2 Future Application for Amendment of SDA: in 2019 planned

Category	Construction	Operation	
Licensing Review	Construction Permit	Operating License	Continued Operation After Design Life
	Approval of Standard Design		
	Amendment of Permit or License Approval		
Other Safety Review	Implementation of Severe Accident Policy		
		Periodic Safety Review	

Outlines

1. Background of SMART Development and Licensing
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2. Developing Supplementary Review Guidelines

- KINS has developed and used the Guidelines/ Procedures
 - **Review and Assessment Guidelines**
 - **Safety Review Guidelines for PWR**
 - **Add SRGs for new passive systems**
 - Safety Review Guidelines for Periodic Safety Review (PSR) of PWR
 - Safety Review Guidelines for Periodic Safety Review of PHWR (CANDU)
 - Safety Review Guidelines for Continued Operation (LTO) of PWR
 - Safety Review Guidelines for Continued Operation (LTO) of PHWR
 - R & A Procedures [Nuclear Power Reactor and Related Facilities]
 - Licensing Review Procedure
 - License Amendment Review Procedure
 - Periodic Safety Review Procedure
 - Topical Report Review Procedure

Example: Non-safety Systems for Passive Advanced Light Water Reactors

- For evaluating regulatory treatment of **non-safety systems in passive advanced light water reactors**
- Criteria for non-safety-related SSCs that perform risk-significant functions:
 - SSC functions relied on **to meet beyond design basis (BDBA)** for Anticipated Transients Without Scram (ATWS), Station Blackout (SBO), etc.
 - SSC functions relied on **to ensure long-term safety (beyond 72 hours) and to address seismic events.**
 - SSC functions relied on under power-operating and shutdown conditions
 - SSC functions needed to meet the containment performance goal, including containment bypass, during severe accidents.
 - SSC functions relied on to prevent significant adverse systems interactions between passive safety systems and active non-safety SSCs.



2. HCB E&T Programme for K.A.Care

- Objective
 - To contribute to establishing robust nuclear regulatory infrastructure of Saudi Arabia under NSSC-K.A.CARE MOU (2016.11.22)
 - Developed in accordance with the IAEA Nuclear Safety Guidelines and KINS specialized courses for regulators
 - Based on over 40 years of KINS experience on domestic regulatory activities and overseas projects



HCB Program Outline

- Training Structure

	Level 1 (Jan-April)	Level 2 (May-August)	Level 3 (Sep-)	Level 4
Course	Basic Course for Nuclear and Radiation Safety	Intermediate Course for Nuclear and Radiation Safety	Advanced Course for Nuclear and Radiation Safety	Specialized Regulatory Training
Objective	To know fundamental principles and requirements of nuclear and radiation safety	To understand overview of essential technologies for NPP design/operation and relative regulatory standards	To learn licensing process and workout licensing review and inspection activities	To be familiar with using analytical tools for regulatory audit calculation
Scope	Nuclear Safety Regulation, Design and Operation of NPP, Safety Assessment, Radiation Safety, etc.	Siting, Mechanical Engineering, I&C, Safety Assessment, QA, etc.	Licensing Review and Inspection and its On-the-Job Participation	Computer Code for Safety Analysis, PSA tools, etc.



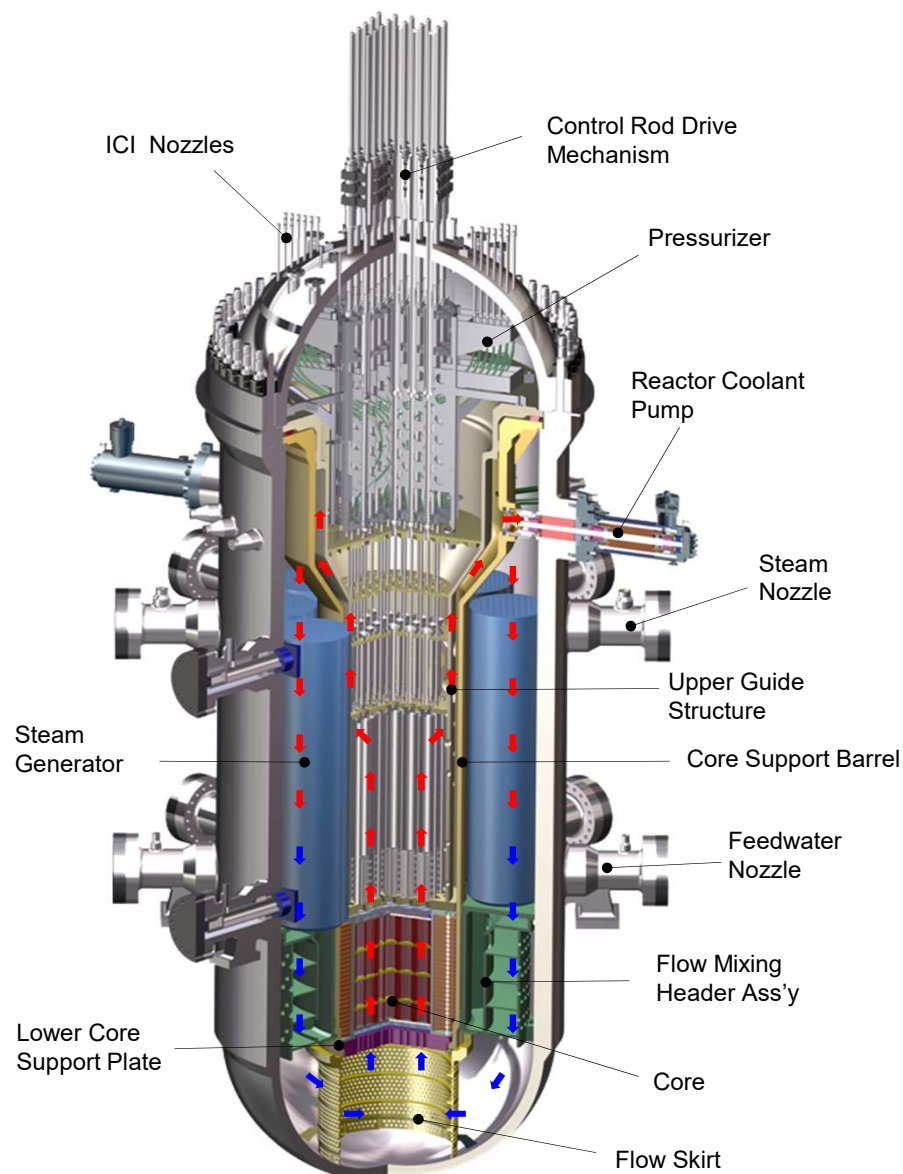
Thank you for your attention!
Question and Comments



SMART Reactor Coolant System

➤ RCS

- Large RCS inventory
- Small connecting pipes (≤ 2 inch) : remove LBLOCA
- Small RCS flow resistance : Natural circulation capability enhancement
- Flow path
Core $\rightarrow$ UGS $\rightarrow$ RCP(4) $\rightarrow$ Annulus $\rightarrow$ SG(8) $\rightarrow$ FMHA $\rightarrow$ Flow skirt $\rightarrow$ Core



SMART Reactor Coolant System

Parameter	Content	Remark
Thermal Power	365 MW	core thermal power
Design Pressure /Temperature	17.0 MPa / 360°C	operation pressure : 15MPa
Pressurizer	1 EA	steam pressurizer, without spray actuation for 100% power operation
Steam Generator	8 EA	- helical, one-through type - primary side : 320.9 / 295.5 °C - secondary side : 230 / 302.3 °C - superheated steam (≥ 30 °C)
RCP	4 EA	horizontal, canned motor type
RCP Flow Rate	$\geq 3,549 \text{ m}^3/\text{h}/\#$	minimum design flow rate per pump
CRDM	25 EA	external CRDM
ICI	29 EA	top-mounted
Fuel Assembly	57 EA	- std 17x17 UO₂ (<5 w/o U235) - H:2.0m/D:2.04m

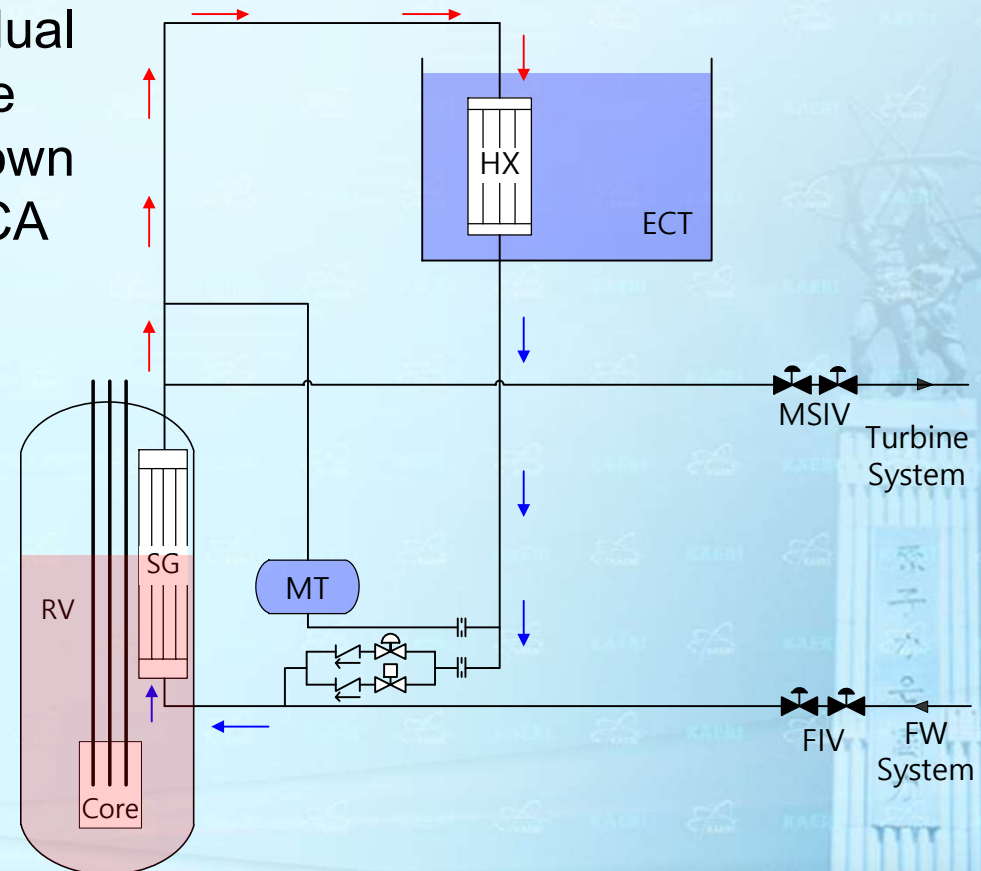
Passive Residual Heat Removal System

❑ Main Function

- Remove the RCS heat (residual and sensible heat) to achieve and maintain the safe shutdown condition mainly for non-LOCA design basis events

❑ Composition

- Independent 4 trains
- Design pressure: 17 MPa
- Heat exchanger (size: 0.62 m × 2.8 m)*
- Makeup tank (size: 1.1 m × 3.6 m)**
- Water injection line
- Steam discharge line
- Valves and Instrumentations, etc.



* diameter × vertical height

** diameter × horizontal length

SMART Passive Safety Injection System

□ Design Requirements

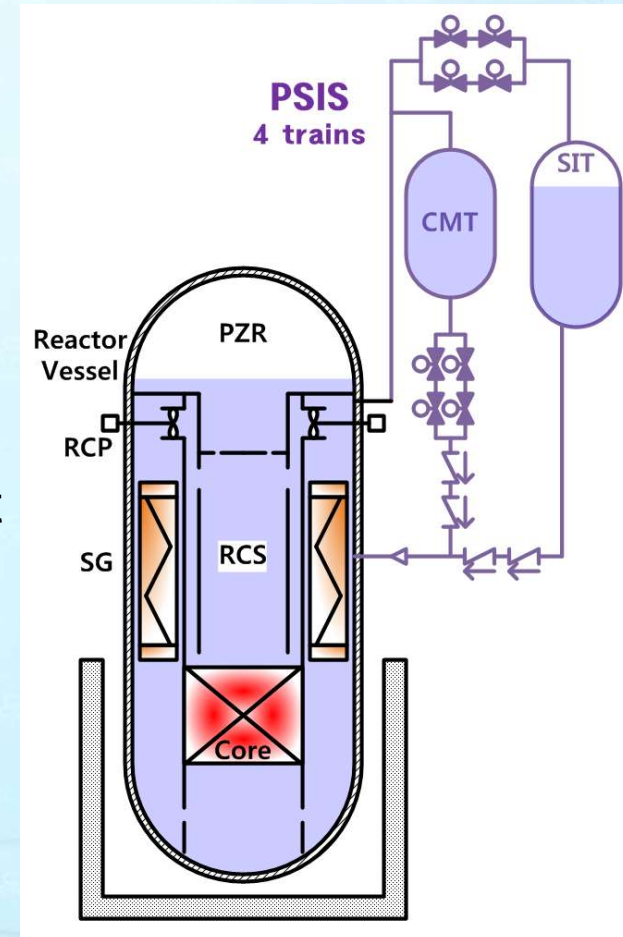
- The RCS water level shall be maintained above top of core for a minimum of 72 hours after LOCA even without AC power or operator action.

□ Main Function

- Safety injection using gravity to prevent core uncover in case of a loss-of-coolant accident (LOCA) by CMTs & SITs
- Borated water injection using gravity in case of Non-LOCA by CMTs.

□ Composition

- Independent 4 trains
- Core Makeup Tank (CMT)
 - Size: $\sim 35 \text{ m}^3$, Design P: 17 MPa
- Safety Injection Tank (SIT)
 - Size: $\sim 100 \text{ m}^3$, Design P: 3 MPa



Automatic Depressurization System

□ Main Function

- Depressurization of RCS in case of a loss-of-coolant accident (LOCA)
- Depressurization of RCS in case of a total loss of secondary heat removal (TLOSHR) accident. (Feed : PSIS, Bleed : ADS)

□ Composition

- Independent 2 trains
- Valves
 - 2 x 2 for each train
- Sparger
- Discharge Line
- Valves and Instrumentations, etc.

