

Country Report of Korea

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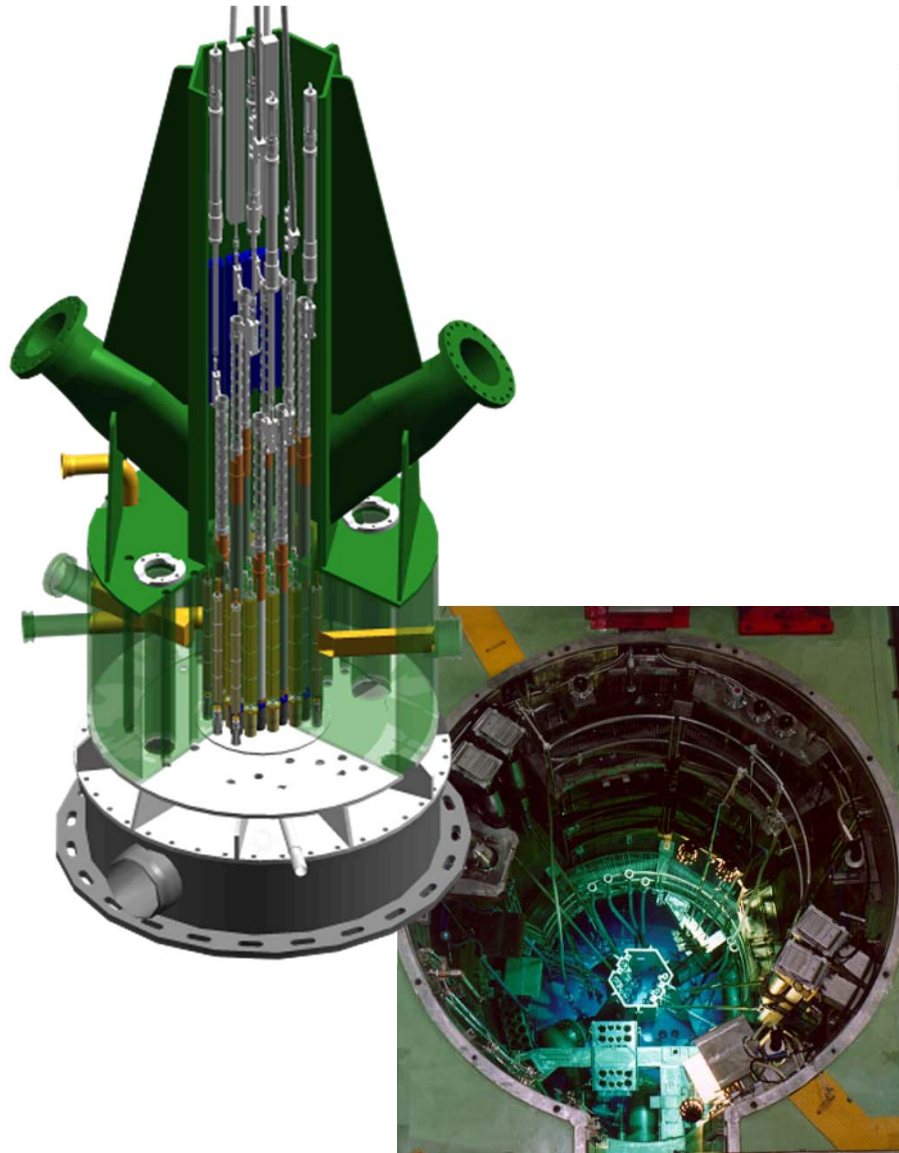
Contents

- 1 Overview of HANARO
- 2 PSR
- 3 Periodic Test/Inspection Program
- 4 Refurbishment
- 5 Incident against Fire Safety
- 6 Seismic Rehabilitation of Reactor Building

Overview of HANARO



Reactor Structure & Feature



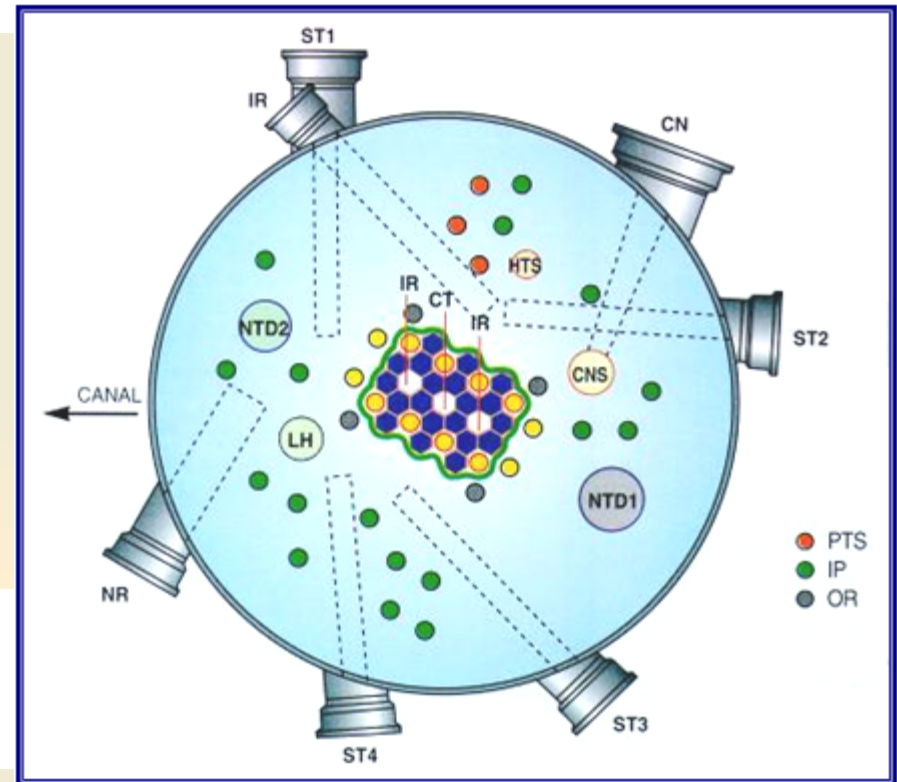
Features

- Type Open-tank-in-pool
- Power 30MWth
- Coolant Light Water
- Fuel Materials U_3Si , 19.75%
- Reflector Heavy water
- Absorber Hafnium
- Max Thermal Flux
 $5 \times 10^{14} \text{ n/cm}^2\text{s}$
- Typical flux at port nose
 $2 \times 10^{14} \text{ n/cm}^2\text{s}$
- 7 horizontal ports & 36 vertical holes
- Reactor Building
Confinement
- Operation Cycle
28 days@6 weeks

Irradiation Holes and Beams

Vertical Holes

- IR1 : Fuel Test Loop
- CT, IR2 : Capsule Irradiation & RI Production
- OR : Capsule Irradiation & RI Production
- IP : RI Production
- HTS : Hydraulic Transfer System for RI Production
- PTS : Pneumatic Transfer System for NAA
- NTD : Neutron Transmutation Doping of Silicon
- CNS : Cold Neutron Source



Horizontal Tubes

- NR : Neutron Radiography Facility
- IR : Ex-core Neutron-irradiation Facility for BNCT & Dynamic Neutron Radiography
- ST1 : Prompt Gamma Activation Analysis, RSI
- ST2 : High Resolution Powder Diffractometer, Four Circle Diffractometer
- ST3 : Bio Diffractometer, High Intensity Powder Diffractometer
- ST4 : Triple Axis Spectrometer
- CN : Cold Neutron Guide

PSR in HANARO



Motive

- PSR for a research reactor became a mandatory requirement pursuant to the National Nuclear Safety Act in 2014
 - National Nuclear Safety Act was amended to conform to the recommendation made at the 48th IAEA General Conference held in Sep. 2004
 - 1 RR (HANARO, 30MWt) & 1 training reactor (SGN 201, 0.1Wt) are enforced
- Lot of experience in PSR for power reactors but none for research reactor
- IAEA safety guide SSG-25 will be used as a guidance

Rationale and Objective

- Comprehensive safety review is required
 - Although routine in-service inspections and some special safety inspections for 19 years
 - Neither for license renewal nor for long-term operation
- The first opportunity to obtain an overall view of the actual plant safety and the quality of the safety documentation
- To determine reasonable and practical modification to ensure and improve the safety
- PSR for the research reactor operated for more than 10 years after the start of the plant operation shall be completed by the end of 2018

PSR Schedule of HANARO

		2015	2016	2017	2018	2019	2020
1	Establishment of a project management team, detail plan of the review, and preparation of budget	 Jun. 30, 2015					
2	Agreement between the KAERI and the Regulatory body on the general scope, requirements and outcome	 Oct. 31, 2015					
3	Preparation of PSR Basis Document						
4	Preparation of Technical Specifications for Safety Review Tendering & Order Placement						
5	Review of 14 safety factors - Review by internal staff - Review by contractors Preparation of Global Assessment Report						
6	Preparation of final PSR report including summaries from the safety reports, global assessment report and integrated implementation plan						
7	Submission of the final PSR report and summary report to the regulatory body					 Dec. 31, 2018	
8	Assessment of PSR reports submitted and preparation of assessment reports Approval by the regulatory body (End of the PSR)					 Dec. 31, 2019	
9	Execution of the integrated implementation plan						

- 14 (fourteen) safety factors in the law are consistent with those of IAEA Specific Safety Guide No. SSG-25 Periodic Safety Review for Nuclear Power Plants
- A graded approach should be applied
 - The article 1.5 of SSG-25 states a grade approach
 - Highest is safety class III in HANARO, comparing to power reactor with safety class I, II & III (ANSI/ANS-51.1-1983)

Present Issues

- Contractual work is under way with engineering companies
 - Lot of administrative work to the final contract
 - Categorized into two groups
 - Safety factors relating to the plant to be reviewed by KEPCO E&C, the original designer
 - Other safety factors to be reviewed by other 4-5 companies
- Safety factor 9: Use of experience from other plants and research findings
 - No reference plant and similar design for HANARO
 - Expect cooperation to get information with other country with the help of IAEA

Periodic Test/Inspection Program in HANARO

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Periodic Test/Inspection

- Periodic test/inspections for system, structures and components (SSCs) of reactor
 - Surveillance test/inspection
 - Safety grade components
 - Quality assurance procedure
 - Periodic test/inspection
 - Non-safety grade components
 - In-service inspection
 - Components classified as ASME Sec. III Safety Class III
 - Reactor structure, reactivity control units and safety related piping systems

● Periodic and Surveillance Test/Inspection

Total :86	Periodic Test/Inspection		Surveillance Test/Inspection		
	Operation Section	Maintenance Section	Operation Section	Maintenance Section	Other Section
Weekly			2		
Monthly	1	2	8	2	
Quarterly		8	1	4	
Bi-annually		1	2	9	1
Annually		12		15	
18 months		7		7	1
Start-up			3		
Total	1	30	16	37	2

In-Service Inspection

Component	Inspection Item	Period
Reactor Structure & Beam tube	Visual inspection - reactor structure & beam tube	5 year
	Measurement of vertical straightness - inner shell of reflector tank	10 year
	Measurement of diameter - flow tube	10 year
RCU	Visual inspection - CAR & SOR	5 year
	Wear inspection - carriage and track	10 year
	Measurement of diameter - shroud tube - CAR & SOR	10 year
Neutron detector housing	Torque test	5 year
Safety related piping system (ASME SEC. III) (Primary Cooling System, pipes, supports)Slide	Pressure - Leak - Flow rate @ performance curve Visual inspection - Corrosion - Wear - Crack, etc. NDT - Ultrasonic inspection	10 year

- Preventive and corrective maintenances
 - System, structures and components of reactor
- Upgrade of instrumentation and control (I&C) system
- Reinforcement
 - Reactor building, stack and cooling tower
- Maintenance matrix
 - Maintenance history
 - Recommendation of manufacturer

Example of Maintenance Matrix

System (PWBS)	Equipment	Categories	Components	sub-parts	Specification	Safety Class	Quality Class	Seismic Class	Ageing Mechanism	Design Life	Elapsed time (yr)	Recent Major Maintenance	Type of Maintenance	Replace/Overhaul Period (yr)	Spare Parts	Delivery Time	Maintenance time	Cost	Remarks
331	Primary Cooling System	Heat Exchanger	Plates (including gasckets)		AISI 316	3	Q	1			14	99.12.03	Replace	20					
					NBR	3	Q	1				05.5.16	Cleaning	20					
		Cooling Pump	pump	Case		3	Q	1			12	05.06.24	Overhaul	12					
				Mechanical Seal								06.01.27	Replace	5					
				Oiler		3	Q	1				11.03.10	Replace	5					
			Motor	Frame/Rotator							12	05.06.24	Overhaul	12					
				Fly-Wh eel		3	Q	1			16		Inspection	3					
		Valve	Check Valve	Disc							16	95.09.12	Replace	25					
				Link							16	97.02.27	Replace	15					
				Cyliner							16	95.09.12	Replace	25					
				Gasket									Replace	1					
			Isolation Valve		Wafere d butter fly	3	Q	1					Inspection	0.25					
													Inspection	0.25					
					glove	3	Q	1					Inspection	0.25					
						3	Q	1					Inspection	0.25					
			Relief Valve			3	Q	1					Replace	10					
		Strainer	Strainer		Cone type	3	Q	1			13	98.07.13	Inspection	0.25					
		Pipe			ASME	3	Q	1			16		Inspection	10					

Refurbishment in HANARO



Replacement of MMIS

- Duration of replacement (33 months)
 - Analysis of existing system & check out: 8 mo.
 - Fabrication of Interface hardware for computer and control rod, implementation of logic: 18 mo.
 - Testing of interface hardware: 5 mo.
 - unit test, integral test & factory acceptance test
 - Installation & commissioning: 2 mo.
 - Put in service for reactor control: Sep. 2013



Replacement of MMIS

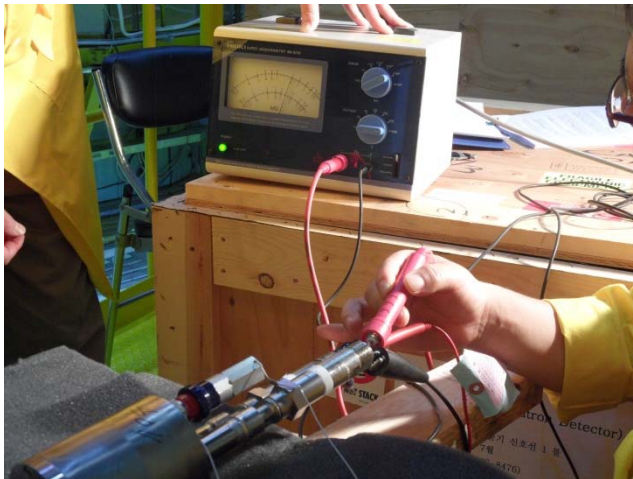


Comparison of characteristics

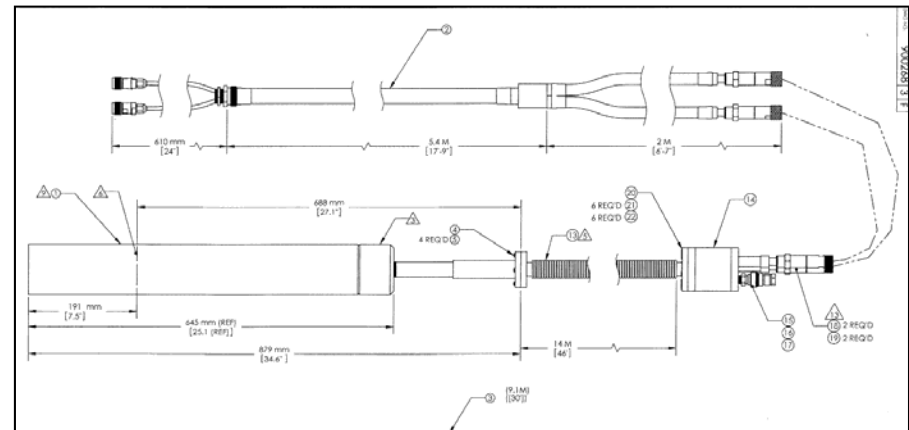
	MLC (Before)	New MMIS (After)
Processor	Duplication	Triplication
I/O	Duplication (1 to 1 communication between I/O and processor)	Duplication (2 to 3 communication between I/O and processor)
Power	duplication	duplication
Cycle time	200 msec	200 msec (up to 5 msec)
communication	Serial (500 kbps)	Ethernet (100 Mbps)
Surveillance of Event	N/A	Every 1 msec
Watchdog Timer	Hardware Watchdog Timer	Software Watchdog Timer
Resolution	12 bit A/D converter	16 bit A/D converter
Maintainability	Self diagnosis No on-line card exchange Technical Support & Spare part not available (obsolete)	Self diagnosis function On-line Hot Swapping Technical support and spare part available
Programming	customized function block	customized function block

Replacement of NMS (Neutron Measurement System)

- Neutron Measurement System for RRS & RPS was built in 1994.
- Consisting of neutron detector assembly with cable, wide-range neutron amplifier and a signal processor
- In 2006, found was the poor insulation resistances between the signal cable & shield cable, high voltage cable & shield cable etc.



Insulation Test for Neutron Detector with cable assembly

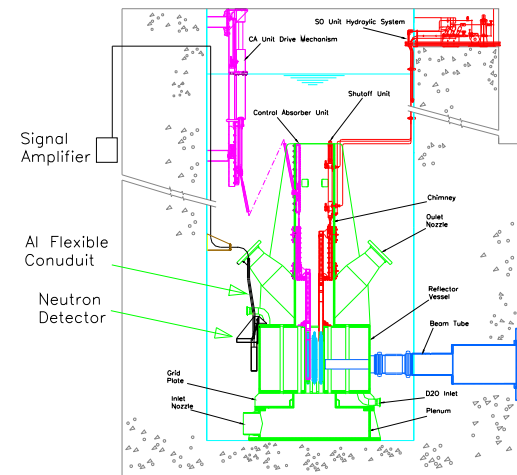


Detector and Cable Assembly

Replacement of NMS (Neutron Measurement System)

- Replacement of NMS was started in 2008 and finished in 2012
- Found satisfactory and gives a reliable neutron signal output

Year of Replacement	Channel
2008	RPS B, RRS A
2010	RPS A, RPS C, RRS B
2012	RRS C

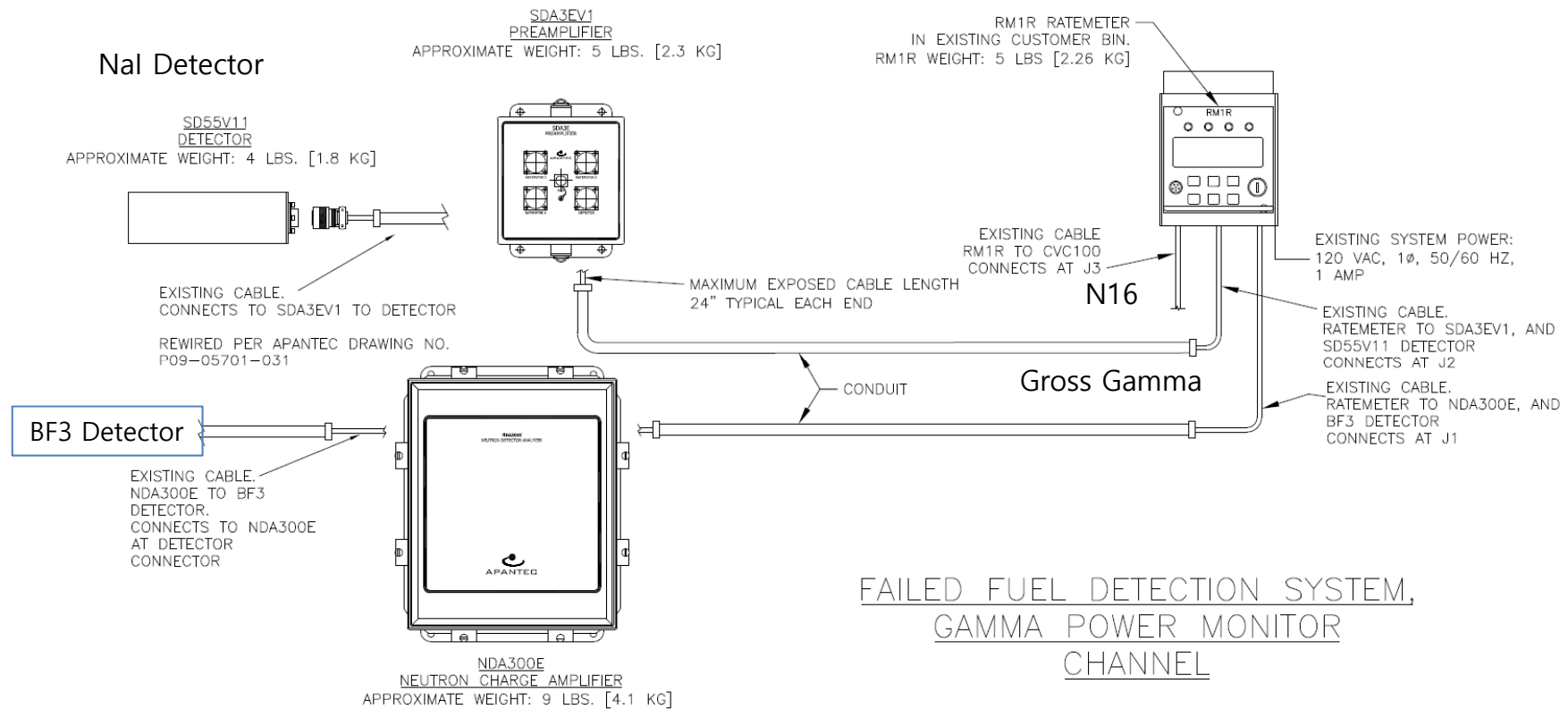


Location of Neutron Measurement System

Replacement of FFDS (Failed Fuel Detection System)

- Measurement of delayed neutron at the primary cooling pipe had been adopted for Failed Fuel Detection System since 2002 and used as a RPS trip parameter.
- In 2014, most of the components are replaced to employ the newly developed ones that were supplied from single vendor
 - FFDS had been consisting of the components supplied by 2-3 vendors.

Replaced components of FFDS



(a) SD55V1 detector



(b) NDA300E amplifier



(c) SDA3EV1 amplifier



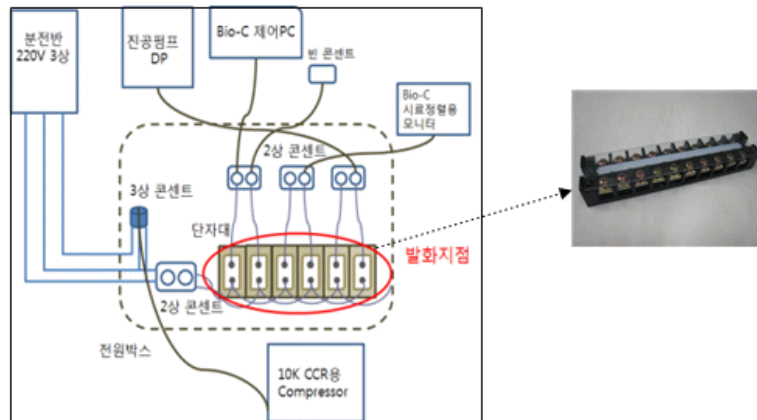
(c) RM1R Ratemeter

Incident against Fire Safety in HANARO

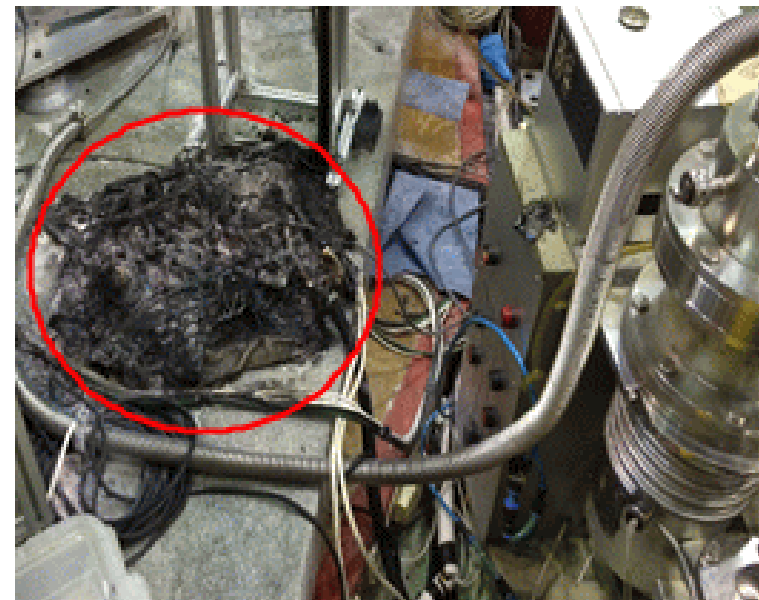
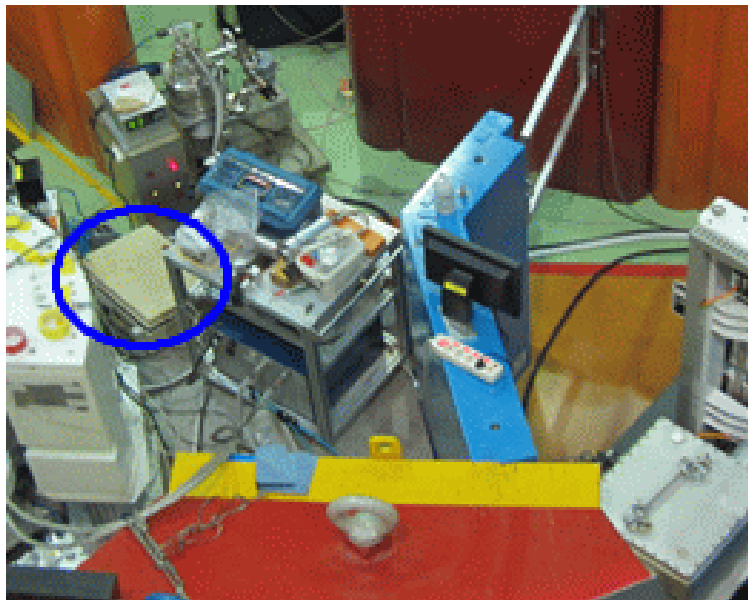
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Fire near the Bio-Diffractometer

- Experimental facility to study the structure of material by monochromatic beam of the neutron beam flux
 - requires cryostat consisting of a vacuum pump and He gas.
- On Jul 10th, 2014, Fire broke out at the terminal board of power supply box of the vacuum pump
 - Cause: loose connection made a greater contact resistance and result in fire.



- Plastic power supply box(50x45x15cm) burnt out



Lesson & Learned

- Frequent walk down by reactor operator enabled a prompt extinguishing fire
- Never leave inflammables near the experimental facility
- Revision of Technical Administration procedure regarding approval on usage of the electrical equipment and cables was made
- Special Safety Inspection made in 2014 by Korea Industrial Safety Association and reviewed by Regulatory body.
- Reporting System for hazards other than radiation hazard was revised to propagate immediately

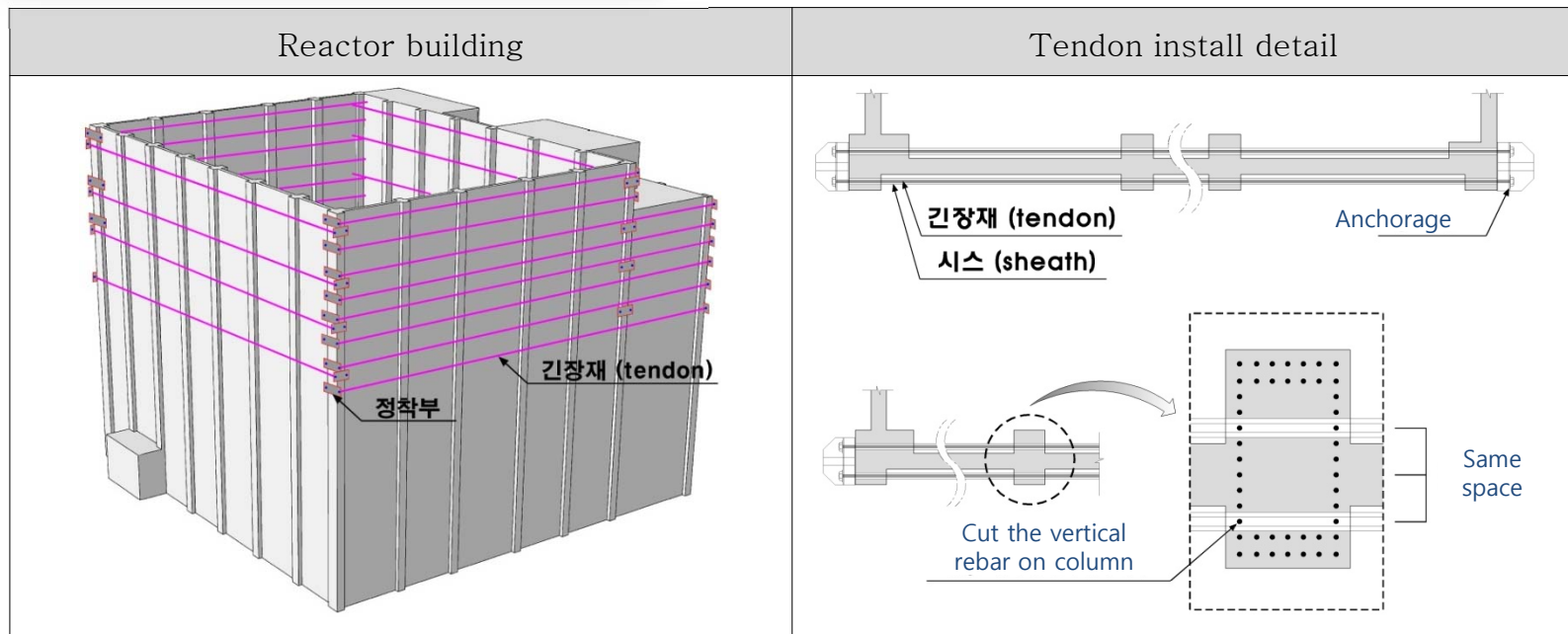
Seismic Rehabilitation of Reactor Building in HANARO



Overview

- After Fukushima accident, a special safety inspection for all operating nuclear power plants and nuclear facilities in Korea was performed by government and non-governmental specialists.
- Regulatory body requested evaluating seismic margin for the reactor building
- In the design stage of reactor building, it was seismically designed based on the design earthquake SSE 0.2g (horizontal)
- As a result of Seismic Margin Assessment, some parts of wall were found shy in the design criteria of 0.2g.
- In March, 2015, the regulatory body formally asked to reinforce the confinement wall.
- The reactor operation is expected after the seismic reinforcement of the confinement wall is completed.
- A basic and detailed design for the seismic reinforcement is now under way and the construction will be completed in the second half of next year.

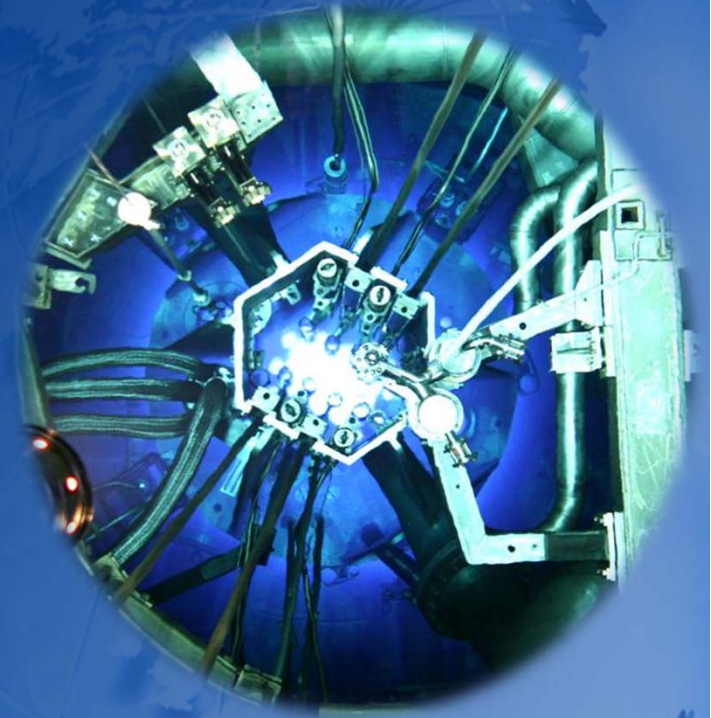
Concept of Reinforcement



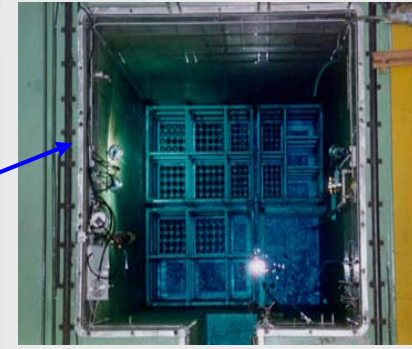
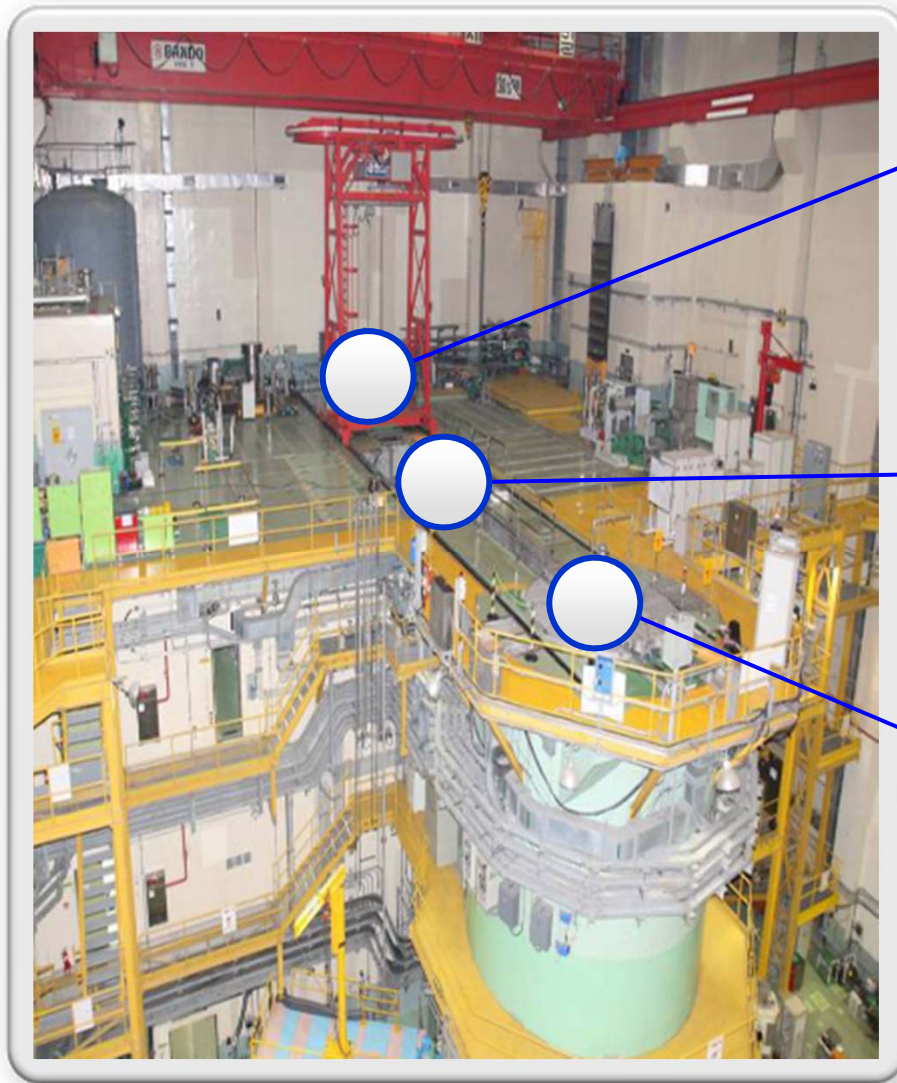
THANK YOU for Your ATTENTION!



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Reactor Pool

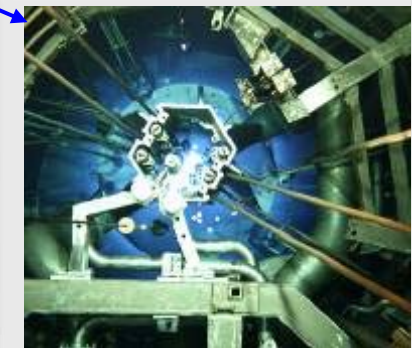


Spent Fuel
Storage Pool

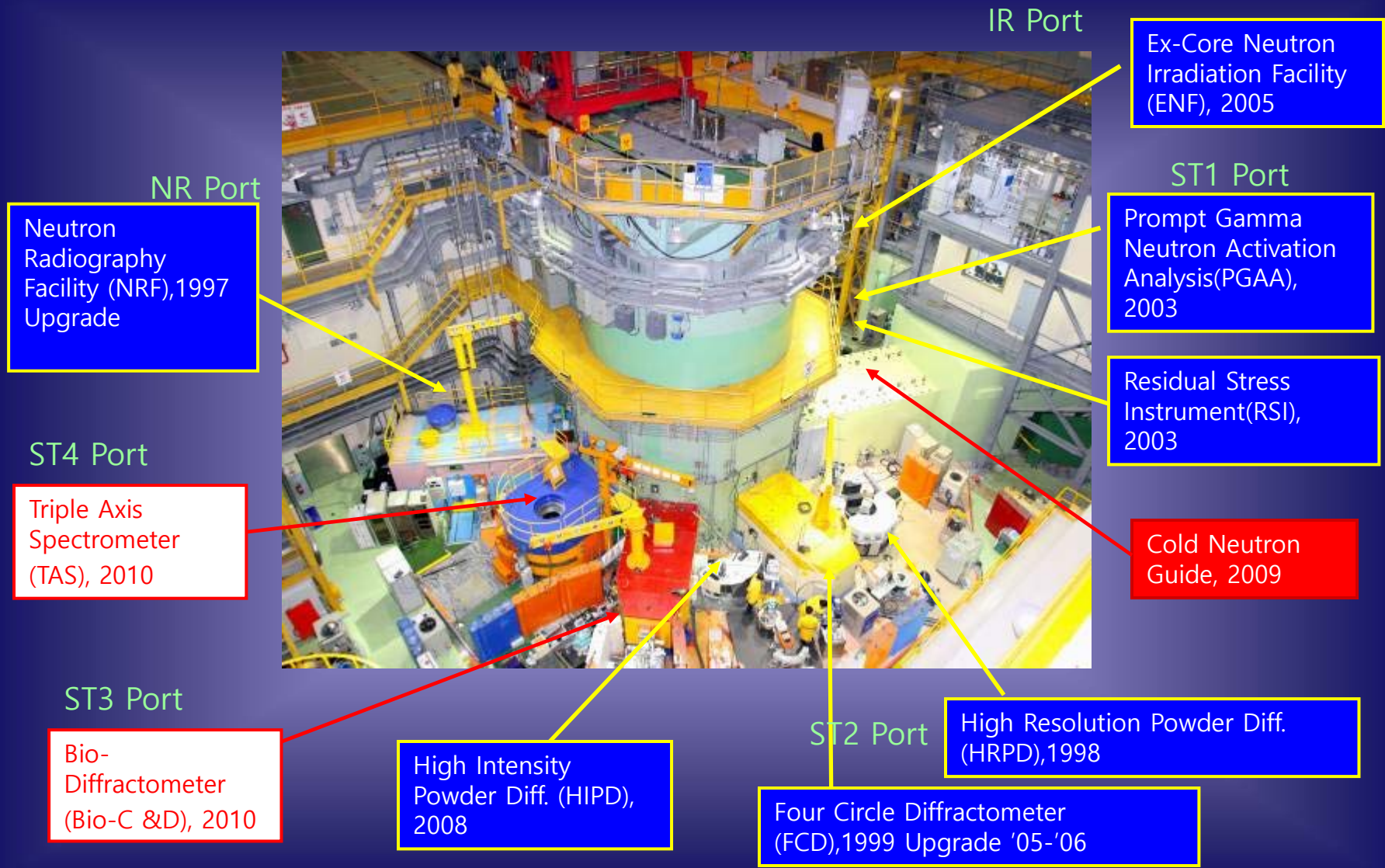
Service Pool



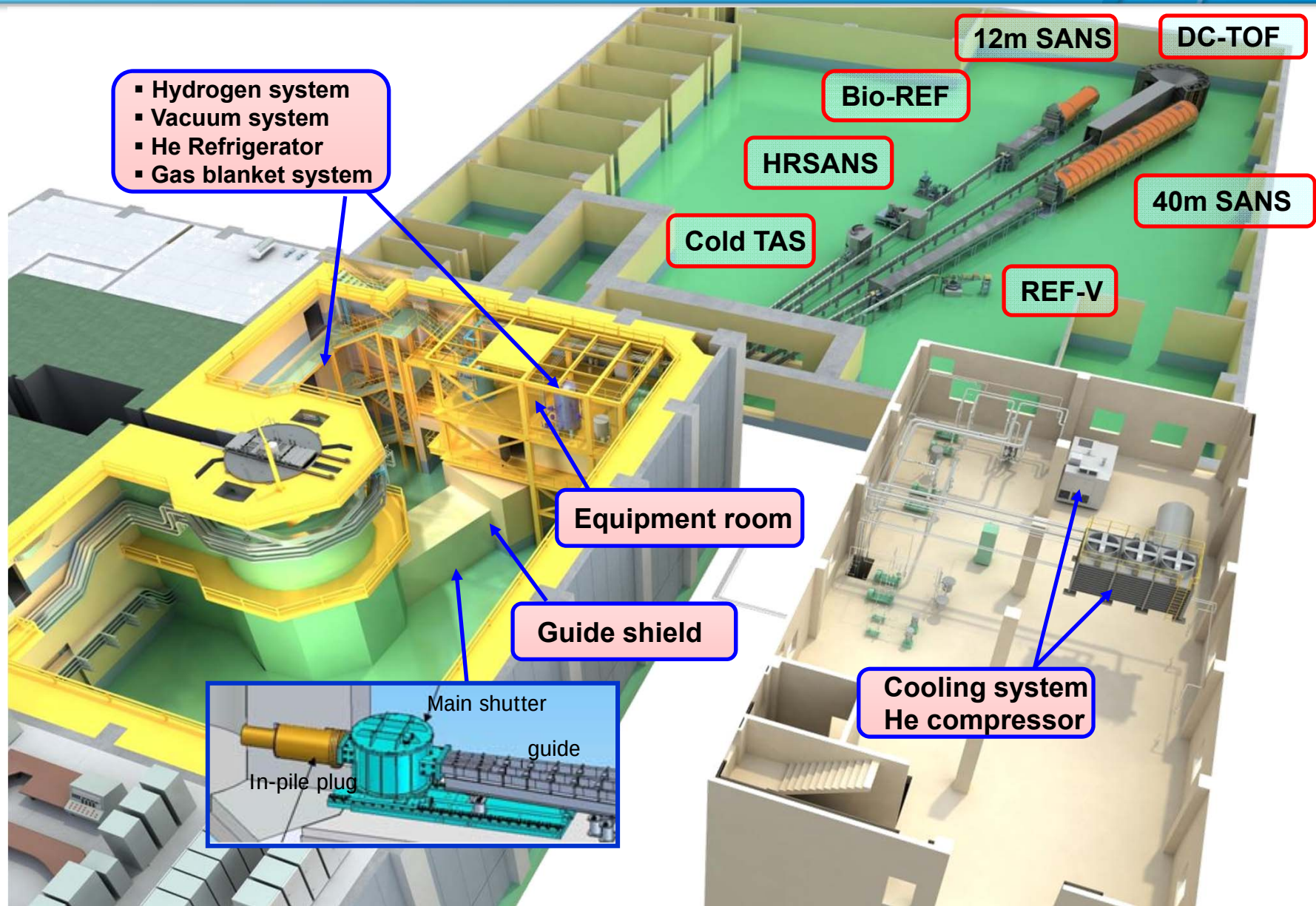
Reactor
Pool



Horizontal Beam Tubes



Cold neutron Research Facility



Maintenance History – Ageing Management

Year	Activities
1996	- Replacement of a secondary pump(P3)
1997	- Installation of a hot water layer system
1999	- Replacement of heat exchanger plate(HX1, HX2)
2000	- Replacement of filler for cooling tower
2002	- Installation of a Window-based Operator Work Station
2003	- Overhaul of diesel generator
2004	- Measurement of reactor vessel inner-shell straightness and visual inspection of SOR/CAR and fuel channels - Overhaul of a primary cooling pump(P2) - Removal of scale in the secondary side of primary heat exchangers(HX2) - Overhaul of a reflector pump(P2)

Maintenance History – Ageing Management

Year	Activities
2005	- Installation of a steel compartment to confine D₂O reflector system components - Replacement of entrance doors to the reactor hall for physical protection - Extended endurance test of SOR for life extension - Overhaul of a primary cooling pump(P1) - Removal of scale in the secondary side of primary heat exchangers(HX1) - Overhaul of a reflector pump(P2) - Replacement of the UPS system
2006	- Replacement of NaI detectors with delayed neutron detectors for a failed fuel detection system - Installation of gamma ion chambers for power measurement and a trip signal replacing the thermal power measurement system - Overhaul of the compressed air system - Safety review and repair of the reactor building and cooling tower buildings

Maintenance History – Ageing Management

Year	Activities
2007	- Upgrade OWS to integrate the FTL system - Installation of two large tanks in the reactor hall for the temporary storage of pool water - Re-structuring of the user rooms in the reactor hall for the improvement of fire-resistance - Installation of a voltage sag compensator to prevent the reactor trip due to a momentary interruption of electric power - Overhaul of the electrical system - Replacement of filler of cooling tower
2008	- Replacement of two neutron detectors(RPS-B, RRS-A) - Repair of most welding areas of service water supply piping line
2009	- Upgrade OWS to integrate the CNS system
2010	- Replacement of three neutron detectors((RPS-A,C, RRS-B)
2011	- Overhaul of a reflector pump(P1) - Replacement of two secondary pumps(P1,P2)
2012	- Replace of one neutron detector (RRS-C)
2013	- Replace of check valves in secondary cooling system - Fixation of the console, operation desk and all furniture in control room - Seismic strengthening of lighting fixture in control room