Empowering 'Power' with Automation

ISA Delhi Section

Thank You

PFBR & PHWR - C & I Perspective

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Introduction

Topics covered : include a comparison of C & I of PFBR & PHWR types of reactors in areas of

- Reactor Technologies
- Layout of C & I equipments
- Sensors & Instruments
- Control Systems
- Operator Information Systems
- C & I Architecture
- Data Communication

Reactor Technologies

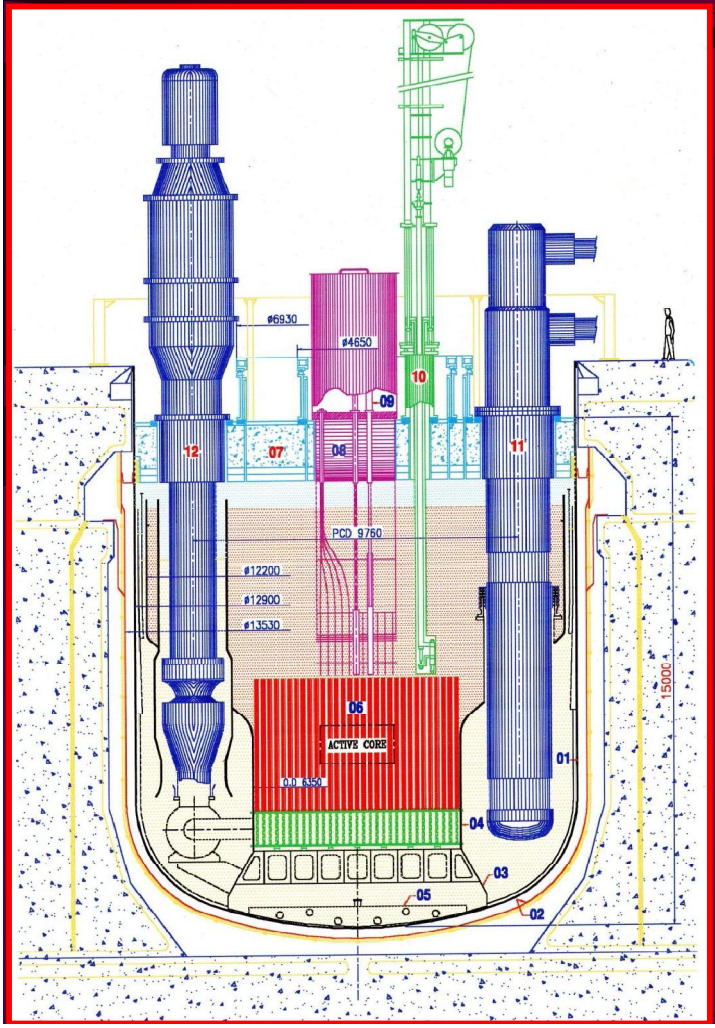
Reactor Technologies

PARAMETER	PFBR	PHWR
Fuel	Plutonium Oxide 23 to 27% enrichment	Natural Uranium 0.5 to 0.8% U^{235}
Coolant	Liquid Sodium	Heavy Water
Moderator	Not Required	Heavy Water
Type of Reactor	Pool Type	Channel type
Heat Transfer	Two Loop Concept: Primary Sodium / Secondary Sodium / Light Water	Single Loop Concept Heavy Water / Light Water
Coolant Temp.	550^{o}C	300^{o}C

Reactor Technologies

PARAMETER	PFBR	PHWR
Pressure	Normal Pressure	High Pressure
No. of Heat Exchangers	2 nos of IHX 4 nos of Steam Generators	IHX not required. 4 nos of Steam Generators
Type of Reactor	Fast Reactor	Slow Reactor
Fuel Breeder	Yes	No
Plant Operation	Base Load operation	Load following operation
Turbine Operation	Super saturated steam at 500^{o}C	Super saturated steam at 250^{o}C

PFBR Reactor Vessel



01 MAIN VESSEL

02 SAFETY VESSEL

03 CORE SUPPORT STRUCTURE

04 GRID PLATE

05 CORE CATCHER

06 CORE

07 TOP SHIELD

08 CONTROL PLUG

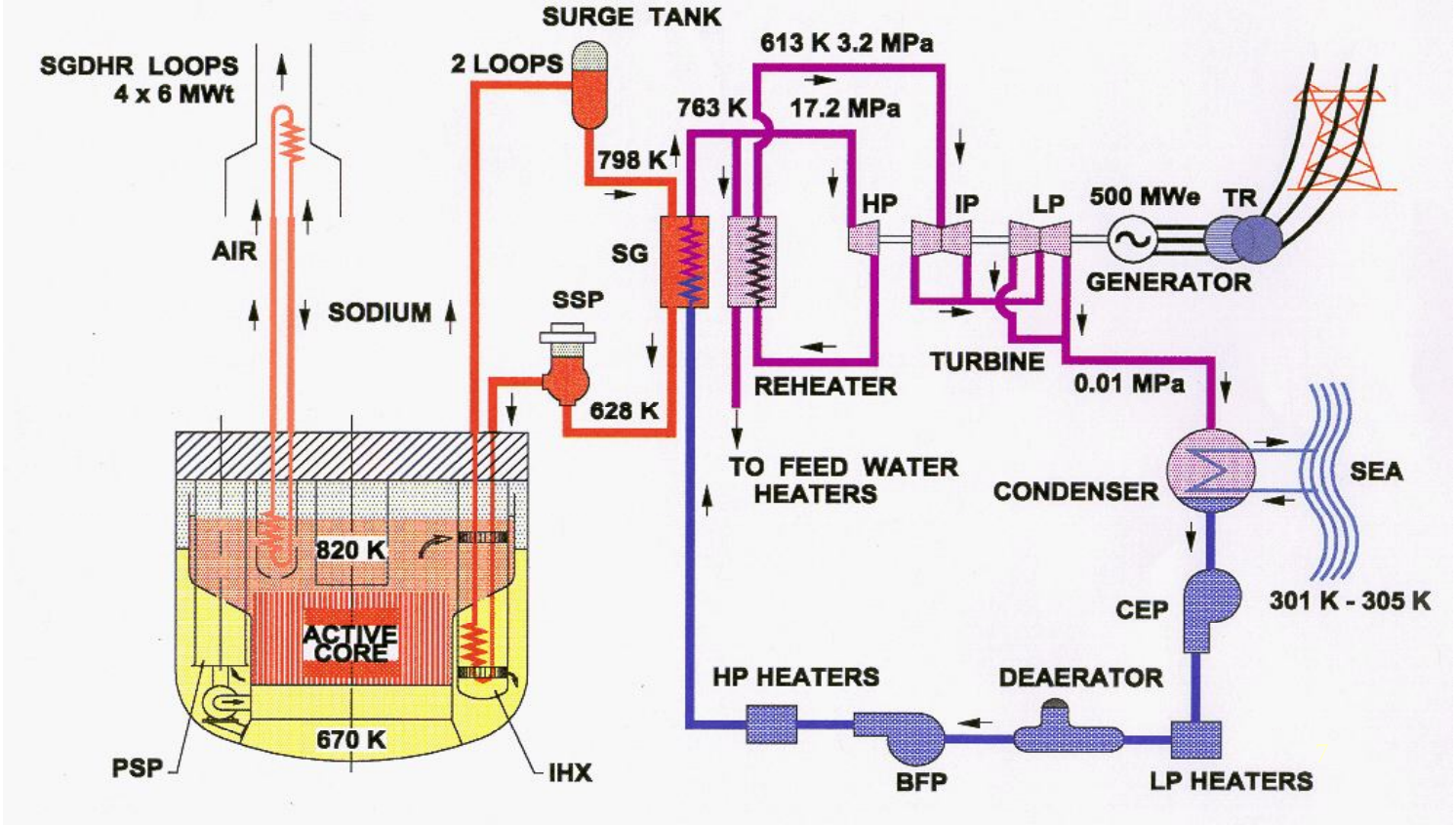
09 CONTROL & SAFETY ROD DRIVE MECHANISM

10 IN-VESSEL TRANSFER MACHINE

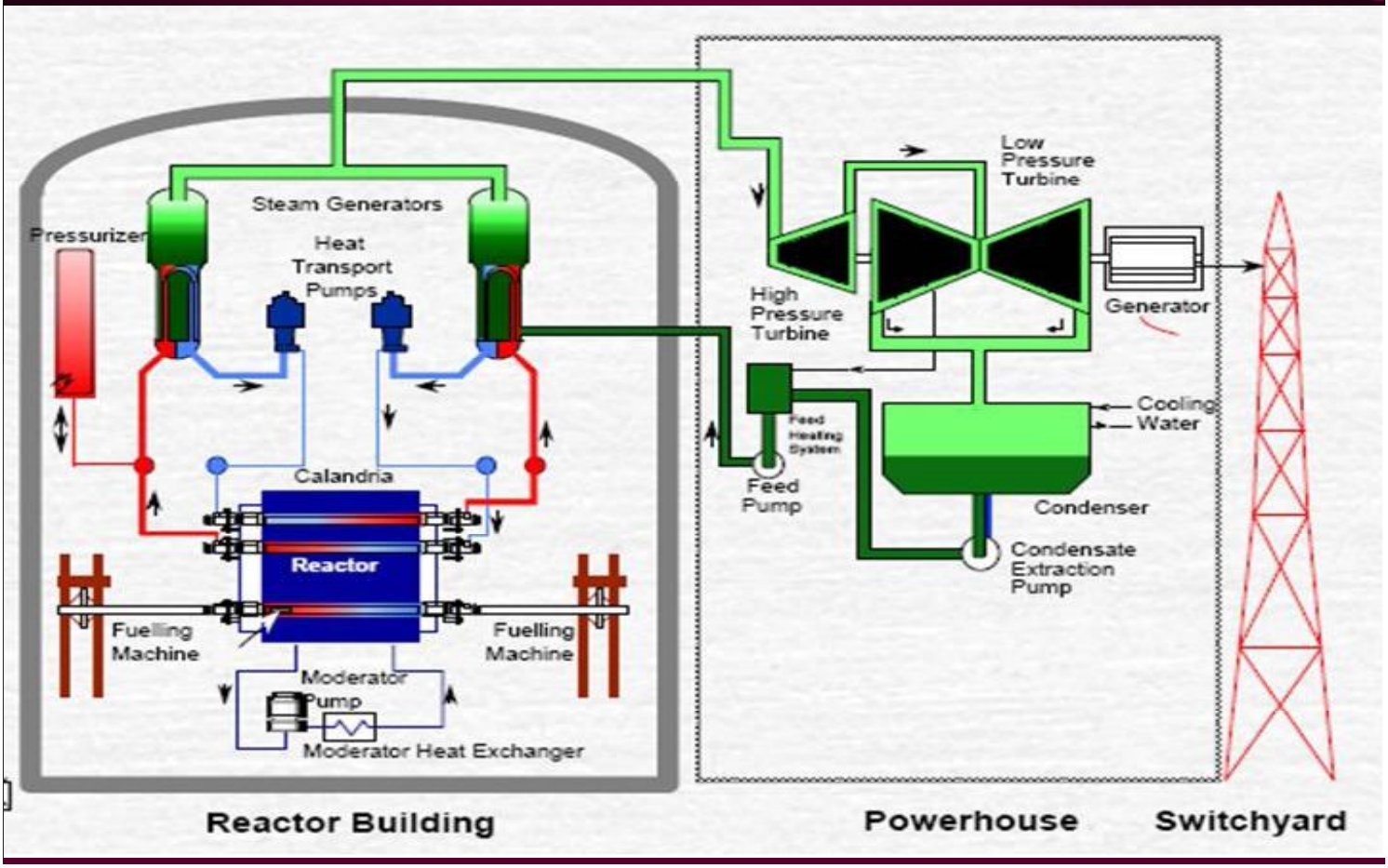
11 INTERMEDIATE HEAT EXCHANGER

12 PRIMARY PUMP & DRIVE

PFBR Process Flow



PHWR Process Flow



C & I Systems

Safety Classification

Safety Classification	PFBR	PHWR
Safety Systems	SC-1	Ia
Safety Related Systems	SC-2	Ib
Non Nuclear Safety Systems	NNS	Ic

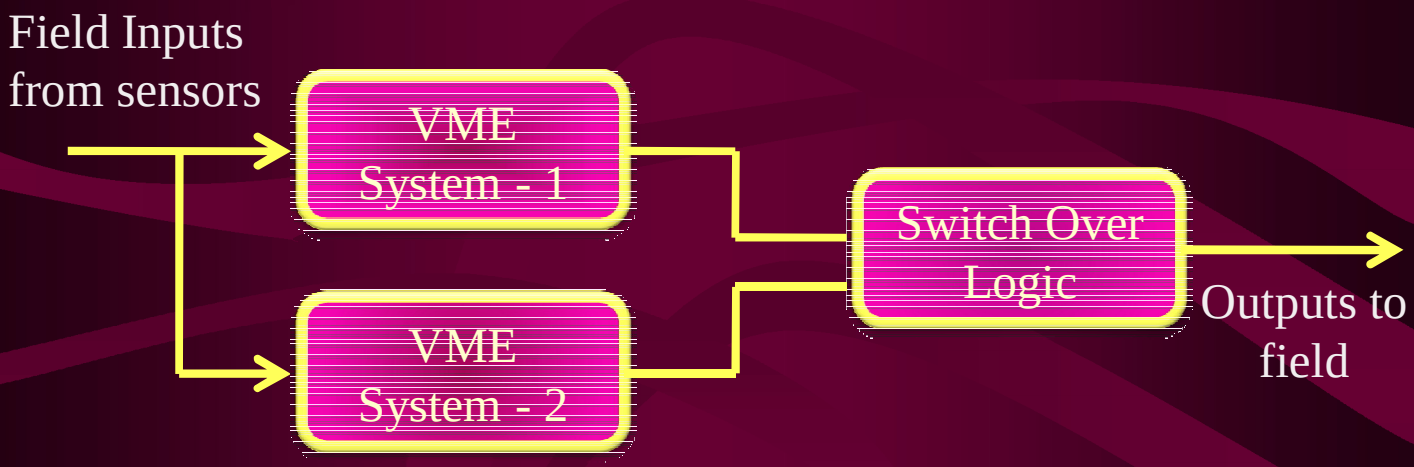
SC-1 Systems for PFBR

SC - 1 Systems	
PCSL System	Pulse Coded Technology
SLFIT System	Programmable Logic Devices based system
RCB Isolation Logic	Relay based logic
SGDHR System	Relay based logic
Neutron Flux Monitoring and Failed Fuel Detection System	Discrete Semiconductors & IC based Technology
CTM System	Triplicated VME System
Primary Coolant Flow	Discrete Semiconductor & IC based Technology

SC-2 Systems for PFBR

Safety Classification (SC)	Systems	C & I
SC-2 Systems	* Primary Sodium Systems * Secondary Sodium Systems * Operation Grade Decay Heat Removal (OGDHR) * Component Handling * CSRDM * DSRDM * Package System * Seismic Instrument * LCC Consoles * Radiation Monitoring & Post-Accident Monitoring Systems * Process Activity Monitoring System	Dual Redundant VME based system with Motorola Processor and Switch over logic

Dual Redundant VME based system



NNS Systems for PFBR

Safety Classification (SC)	Systems	C & I
NNS Systems	* Package Systems like AC & Ventilation systems * Tele-Alarm Systems * Certain leak and temperature parameters of Primary & Secondary Sodium systems * Video Monitoring Systems * Physical protection System	Micro controller based RTU systems

3 Tier Architecture of C & I Systems

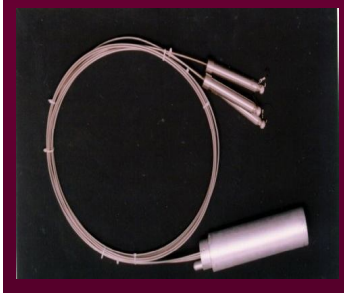
Operator Interface

Computerized Operator Information Systems	Control Panels

Control Equipment

Reactor Regulating	Process Control	Reactor Protection	Radiation monitoring
Core Temperature Monitoring	Fuel Handling Controls	Safety Interlocks	Electrical SCADA

Field Instrumentation



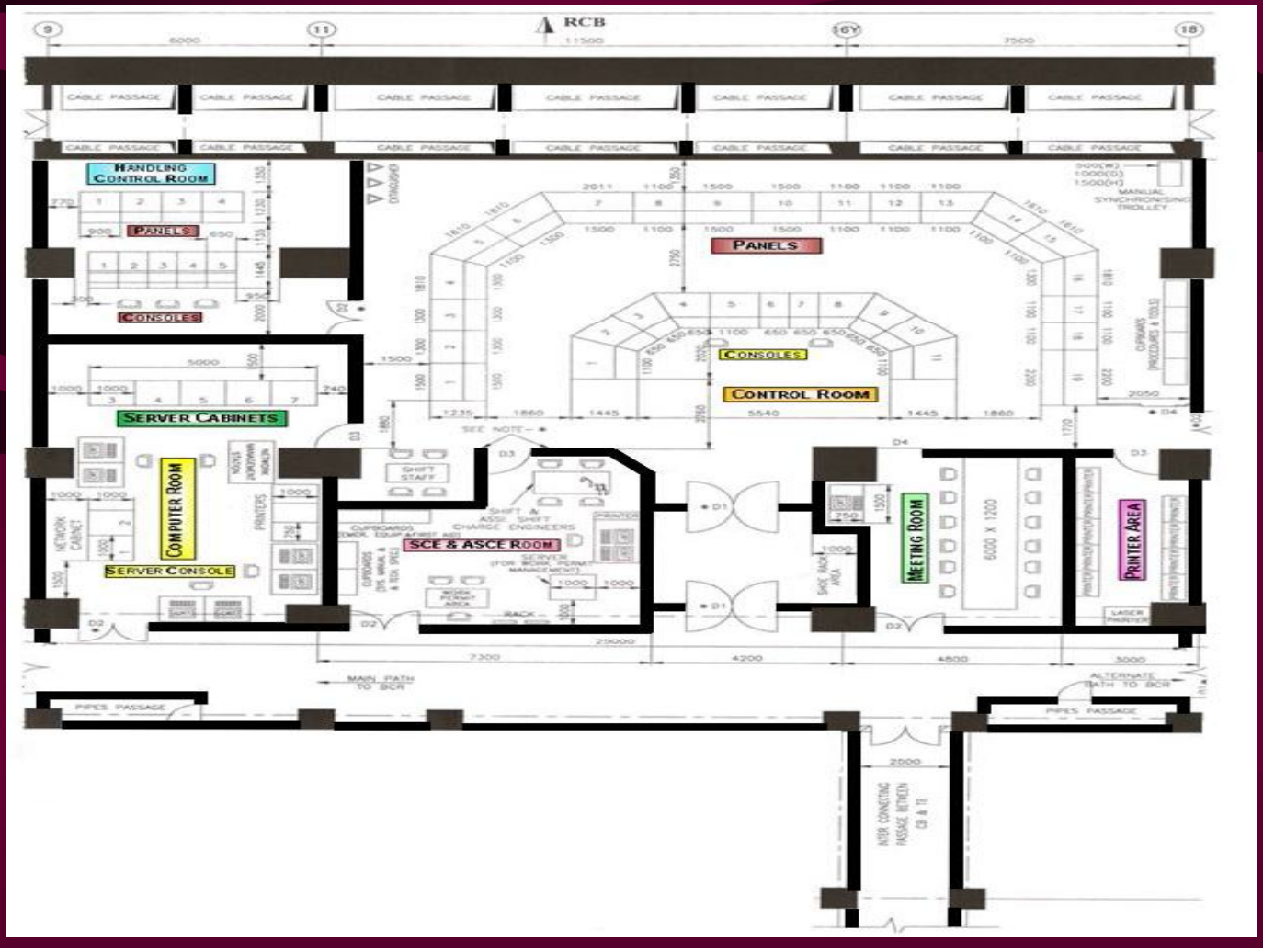
Thermo - couples RTD's	Pressure gauges and transmitters	Flow gauges and Transmitter	Field Relays	Solenoids Motors Valves
SPN Detectors	Ion Chambers	BF3 Counters	Potentiometer LVDT, RVDT & Synchros	Level switches

Layout of C & I Equipments

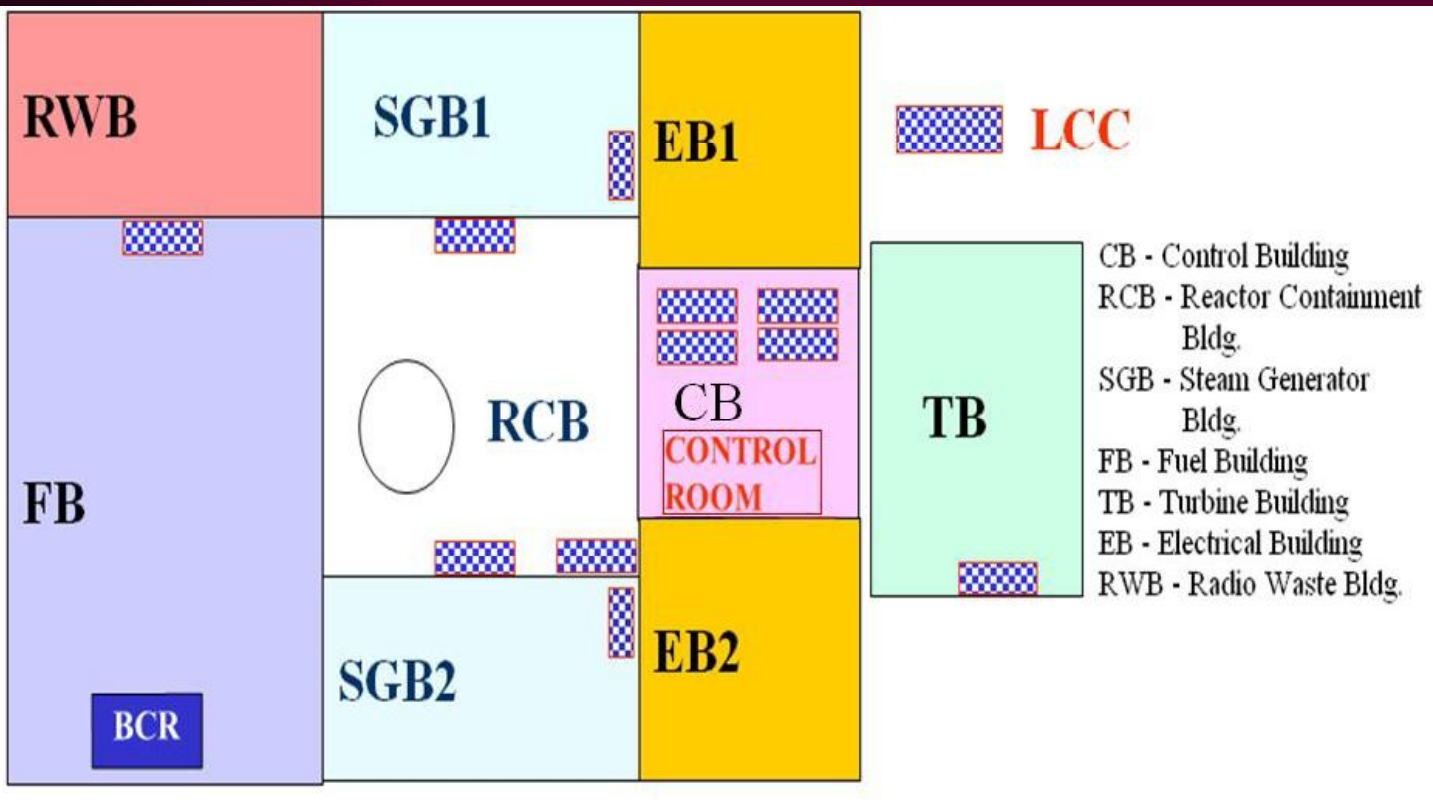
A comparison of Layout of C & I equipments

SL. No	PFBR	PHWR
1	Main Control Room	Main Control Room
2	Fuel Handling Control Room	Not required
3	Local Control Centres & Engineering Control Centres	Control Equipment Room & Channel Rooms
4	Backup Control Room (located in Fuel Building)	Supplementary Control Room (located in Reactor Auxiliary Building)
5	Computer Room	Computer Room

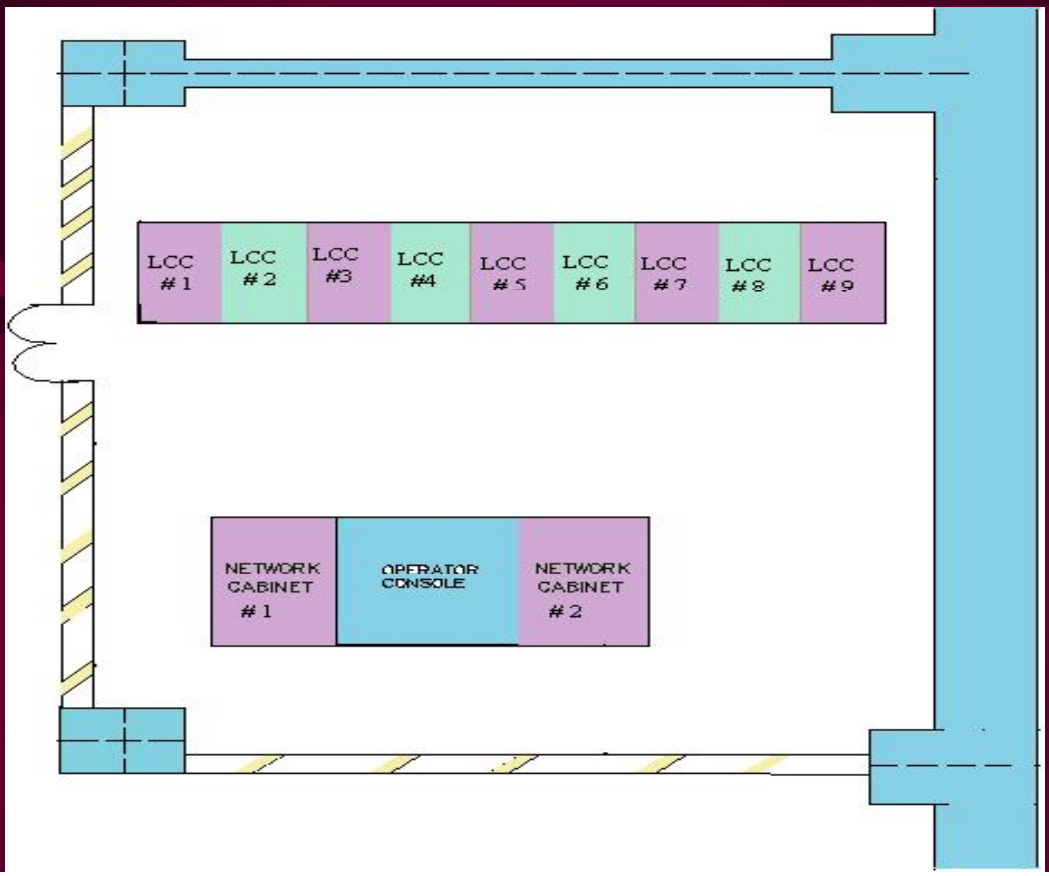
Layout of CR, HCR and Computer Room in PFBR



LCC Locations in PFBR



Layout of Electronic Cabinets in LCC Room (Typical)



Field Sensors & Instruments

Field Sensors & Instruments

Conventional Sensors: used in any process plant.

Ex: Temp., Flow, Pressure, Level etc.

Neutronic Sensors: used only in Nuclear Power Plants. Minor differences in sensors used in PFBR and PHWR reactors.

Sodium Sensors: unique to Fast Breeder Reactors.

Sensors & Instruments –

Neutronic Sensors

Required for: Neutronic Flux Monitoring (NFM), Failed Fuel Detection & Location and Radiation Monitoring

- PFBR utilises High Temperature Fission Chambers whereas in PHWR Self Powered Neutron Detectors are used.
- Ex core instrumentation for PHWR's utilize Ion Chambers whereas PFBR reactors utilize low temp fission chamber placed below the safety vessel.

Sensors & Instruments –

Neutronic Sensors

- Stack Monitoring, Post-Accident Monitoring, Contamination, Hand & Foot Monitors, Health Physics Survey Equipments, Environment Radiation Monitors, Area Radiation Monitors in shutdown and Accessible areas are used in both PHWR & PFBR.

Sensors & Instruments –

Sodium Instrumentation

Sodium Leak Detection:

- Wire Type Leak Detector
- MI Type Leak Detector
- Spark Plug Type Leak Detector
- Sodium Aerosol Type Leak Detector
- Cross Wire Type Leak Detector

Sensors & Instruments –
Sodium Instrumentation

Sodium Level Measurement:

- Continuous Level
- Discrete Level

Sodium Pump Flow Measurement:

- Eddy Current Flow Meters
- Permanent Magnet Type Flow Meters

Sodium Temperature Measurement:

- Thermocouples

Sensors & Instruments –
Sodium Instrumentation

Sodium Purity Measurement:

- Plugging Indicators
- Cold Trap

Sodium Water Leak:

- Hydrogen in Sodium Detection
- Hydrogen in Argon Detection

Control Distribution Frame & Buffer Terminal Cabinets

- In PHWR Reactors, field signals are interfaced to control & instrumentation systems through CDF
- Buffer Terminal Cabinets (BTC) are used to interface signals going to channel rooms and from channel rooms to upper level control system
- In PFBR, CDFs and BTCs are not required.

Control Systems

Safety Systems

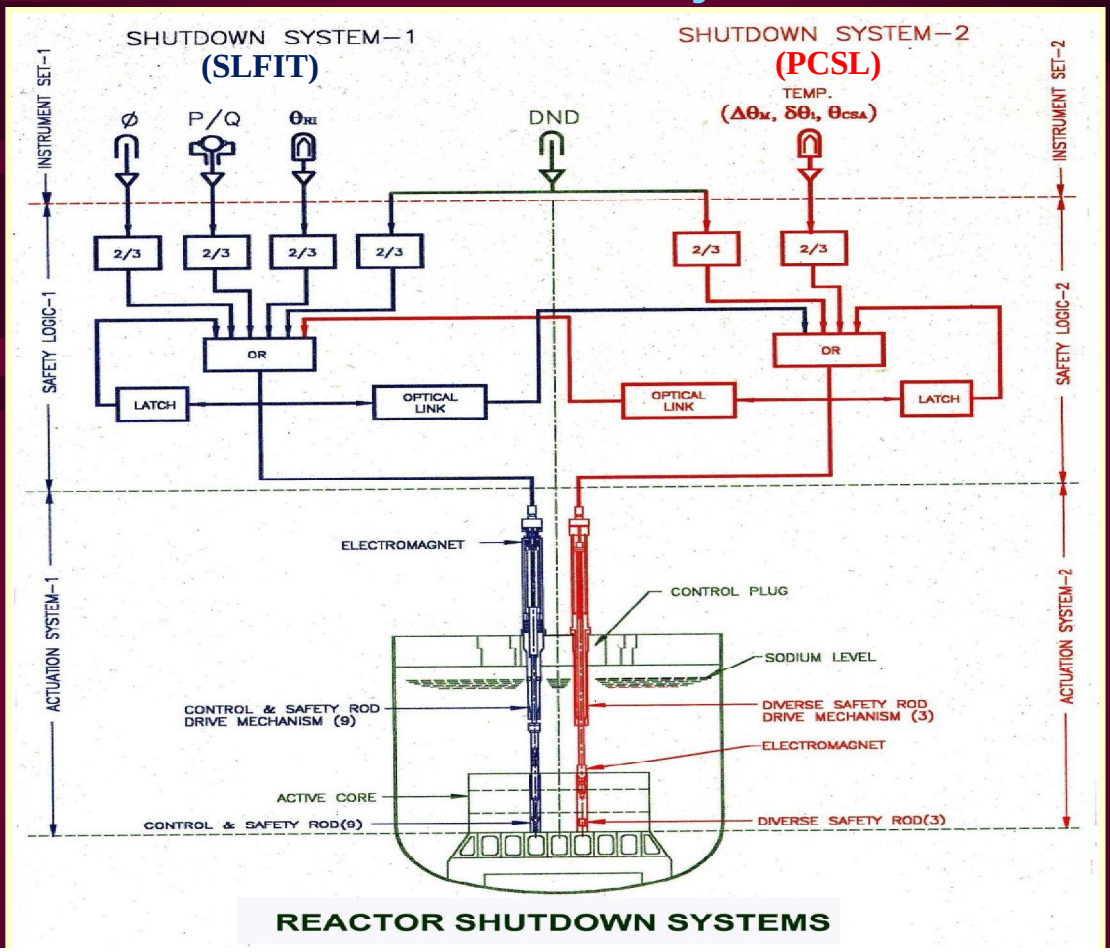
Reactor Protection Systems

PFBR: Pulse Coded Safety Logic (PCSL)
Safety Logic Fine Impulse Test (SLFIT)

PHWR: Primary Shutdown System (PSS)
Secondary Shutdown System (SSS)

Control Systems —

Reactor Shutdown System for PFBR



REACTOR SHUTDOWN SYSTEMS

Reactor Protection Systems for PFBR

Reactor shutdown is affected by two independent protection logics: Safety Logic with Fine Impulse Test (SLFIT) and Pulse Code Safety Logic (PCSL)

Receives SCRAM signals from NFM, DND, CTM and Primary Flow measurement systems.

SCRAM is affected by drive down of two classes of Control Rods: Control Safety Rods (CSR) and Diverse Safety Rods (DSR).

Reactor Protection Systems for PFBR

TYPE	RPS SYSTEM	C & I FEATURES
CSR Drive down	SLFIT	• Uses solid state logic with PLD's
		• Online Fine Impulse Test feature
DSR Drive down	PCSL	• Uses solid state logic with Pulse Coded Technology
		• Logic state '1' encoded as sequence of Pulses
		• Pulse train at output keeps DSR electromagnets energised. De-energises when output is 0 or 1
		• Self diagnostic feature

Reactor Protection Systems for PHWR

- **Reactor shutdown is affected by:**

  Primary Shutdown System (PSS) causes drive down of control rods

  Secondary Shutdown System (SSS) causes injection of liquid poison

TYPE	RPS SYSTEM	C & I FEATURES
Control Rods drive down	PSS	• Used Relay based logic
Liquid Boron Injection	SSS	• Uses Relay based logic

Safety Systems

Decay Heat Removal Systems

PFBR: **Safety Grade Decay Heat Removal System(SGDHR)**
Operation Grade Decay Heat Removal System (OGDHR)

PHWR: **Emergency Core Cooling System (ECCS)**