Introduction to KINS Simulator
(Model APR-1400)

Dept. of Human Resource Development
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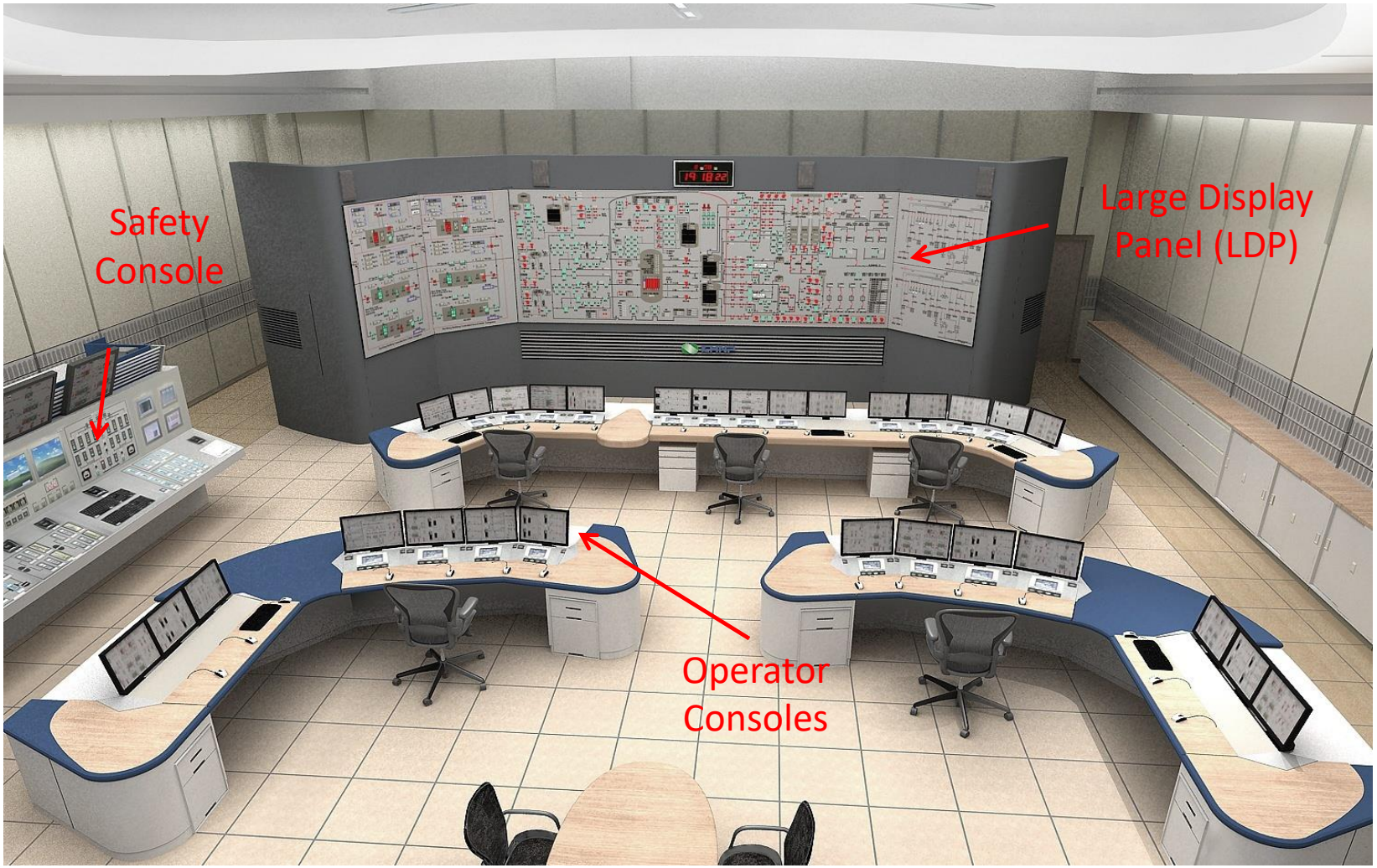
KINS
KOREA INSTITUTE OF NUCLEAR SAFETY

Overview

Reference Plant	• Shin-Kori Unit 3 (APR-1400)
Purpose	• Training and cultivating KINS regulators(inspectors)
Manufacturer	• S/W : KHNP CRI • H/W : KHNP CRI
Performance Test	• KHNP/KINS
Features	• MMIS(Man Machine Interface System) • CPS(Computerized Procedure System) • Full scope verification simulator
Development	• Period : 24 Months('13.1 ~ '14.12) • Cost : $ 5 Million

Overview



Overview

- **Large Display Panel(LDP)**
  - Be located at the forefront of simulator and consist of 14 screens
  - Displays major safety parameters such as overall plant status and alarms, etc

Overview

- **Operator consoles**
  - control and protect overall system of the plant
  - Consists of SS(Shift Supervisor), STA(Safety Technical Adviser), RO(Reactor Operator), TO(Turbine Operator), EO(Electrical Operator) console
  - Each console have mouse, keyboard, confirm switch
  - SS has all decision-making-authority over plant operation

Overview

- **Safety console**
  - Only being used when the operator console are not available to use and to make sure that the reactor system is functional(Make sure the reactor system safety)
  - Similar with OPR-1000 MCR which is previous model of APR-1400
  - Consists of analog instrumentations and controllers.

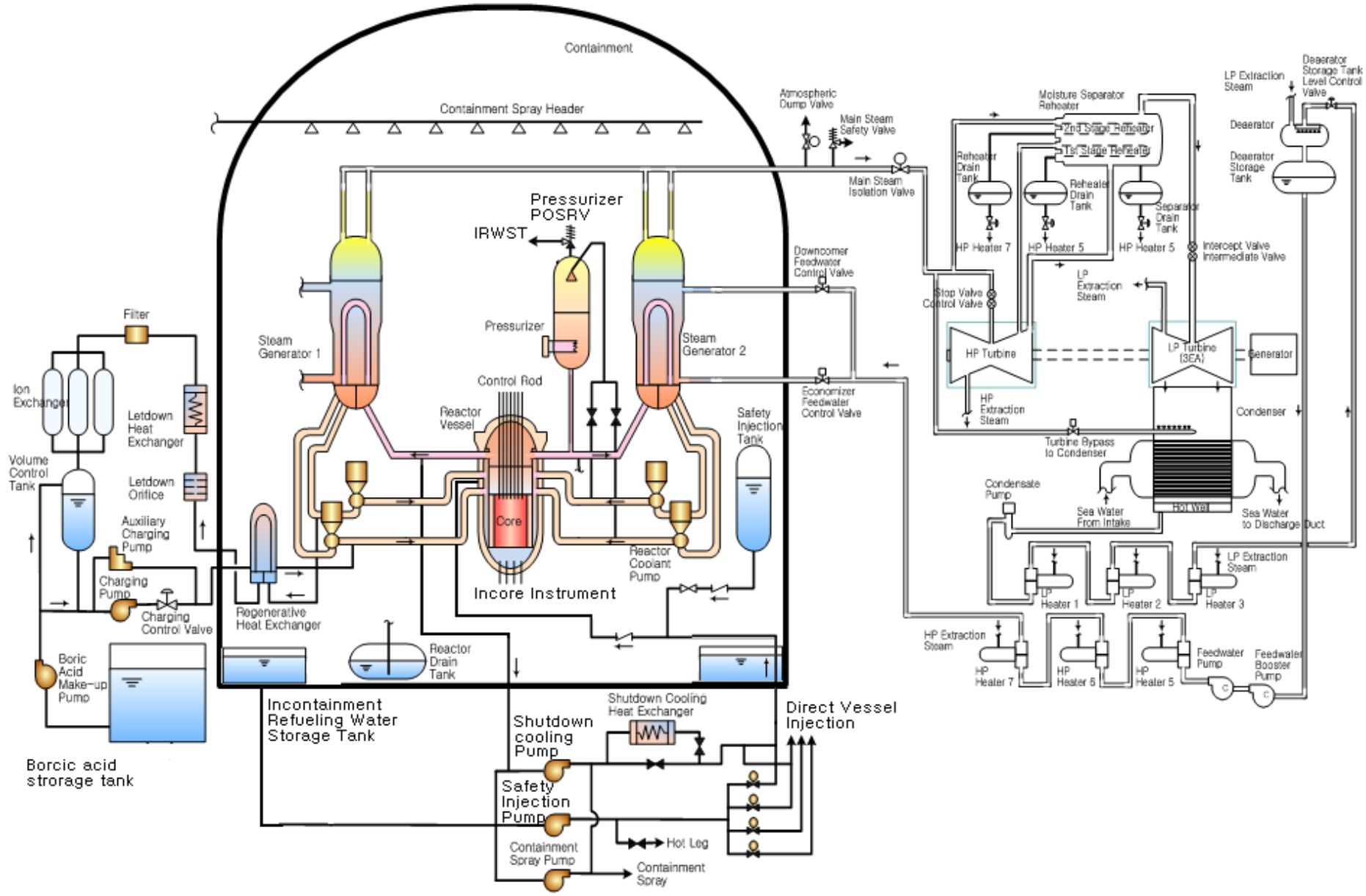
Overview

- **Instructor console**
  - Start/stop the simulator and performs various functions using a CRT and keyboards
  - Located in the instructor room and next to the STA console.
  - Using this consoles we can insert malfunction scenarios, etc

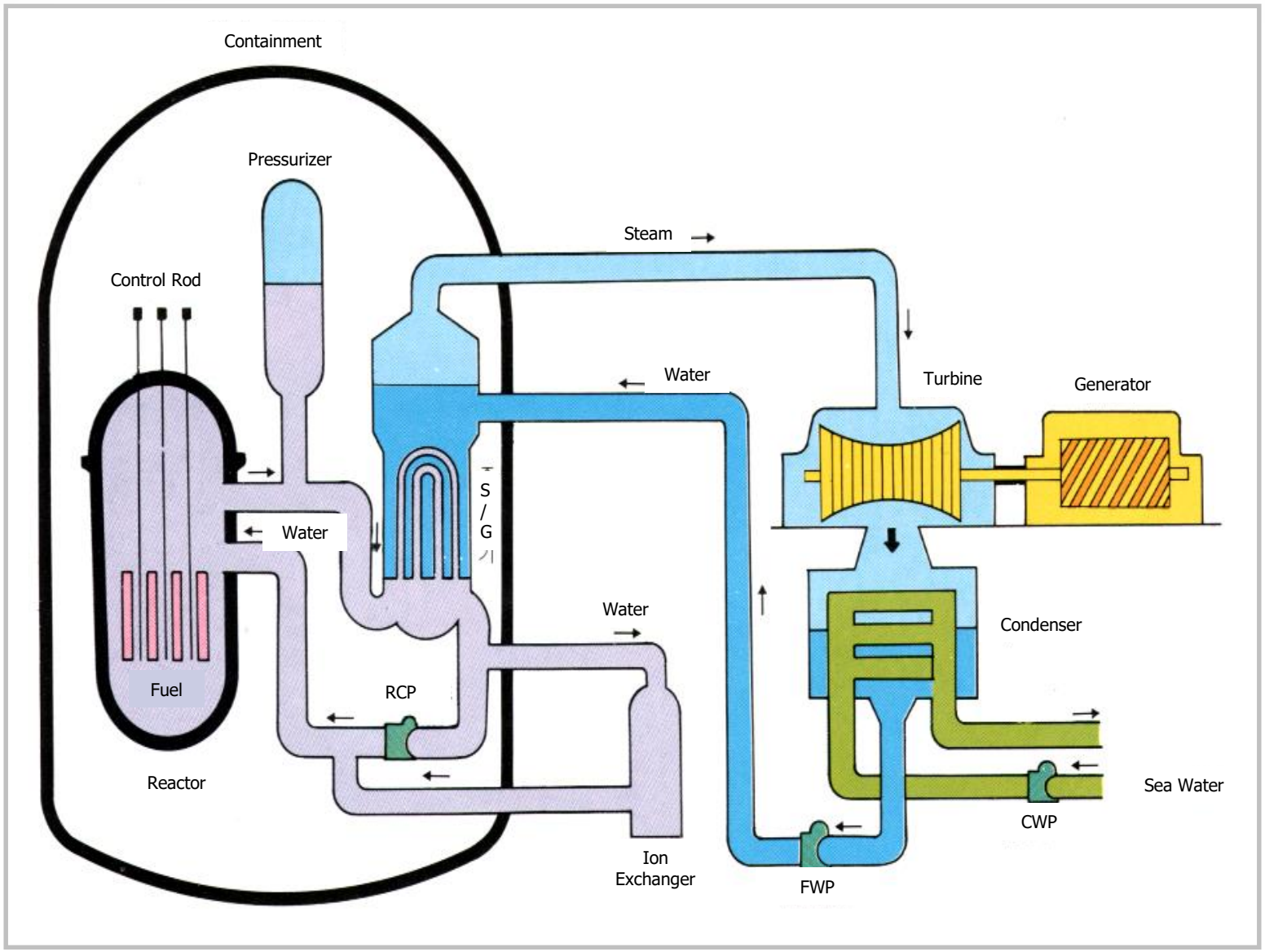
Overview

- **Core model**
  - Relap5-RT(the Reactor Excursion and leak Analysis Program5– RealTime)
  - Reactor core, control rod, CET, ICI
- **Thermal hydraulics model**
  - Relap5-RT
  - Reactor vessel, steam generator, pressurizer, spray nozzle
- **Neutron diffusion**
  - NESTLE(Nodal Eigenvalue, Steady-state, Transient, Le core Evaluator)
- **Aux. primary, secondary and electrical power system**
  - 3 Key master

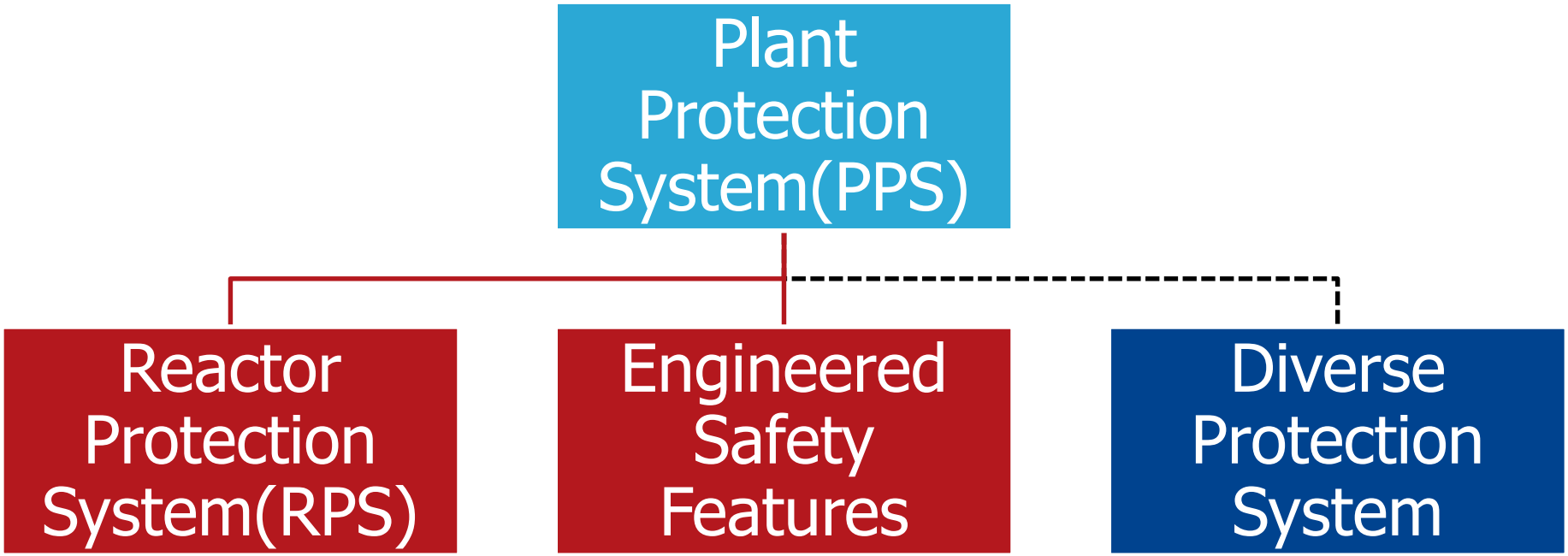
Nuclear power plant schematic Diagram



Nuclear power generation flow diagram



Srtucture of Plant Protection System



Overview of PPS

- **Function**
  - Keep Anticipated Operational Occurrences(AOO), Designed Basis Accident(DBA) results within limits
  - When safety related plant factors(Pressurizer pressure, Steam Generator water level etc.) reach the set values, it automatically operates to ensure the integrity of the nuclear reactor core and reactor coolant pressure boundaries
  - In the event of an accident, the Off-site reactor dose-rate should not exceed the standard value of 10 CFR 100 to mitigate or prevent accidents

Overview of RPS

- **Function**
  - **Quickly shut down the reactor** to prevent exceeding the safe threshold during Anticipated Operational Occurrence(AOO)
  - Support ESFAS in the event of an accident to mitigate the consequences

- **Reactor Trip**
  - Manual stop: Open serial/parallel installed breakers by optional 2/4 logic matrix
  - When the reference variable exceeds the set value, the reactor trip signal is generated by 2/4 logic matrix
  - Turbine trip signal generated by reactor trip
  - 1 channel bypass is possible in case of Bistable or sensor failure (Coincidence Logic 2/4 ⇒ 2/3 change)
  - Irrespective of reactor trip when 1 M-G set input power is loss

Overview of Engineered Safety Features

Prevent Radioisotope Material leakage

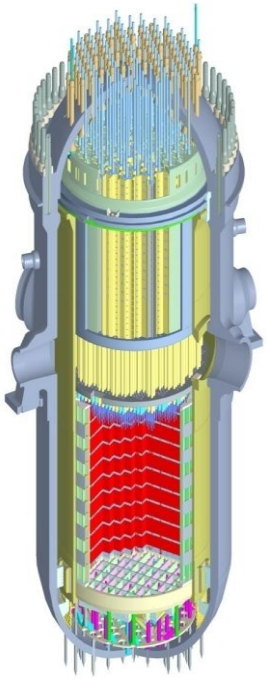
3 Physical Barriers

Engineered Safety Features

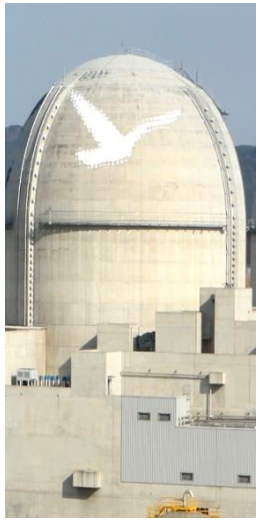
Human/Environmental Protection

Fuel Cladding

Reactor vessel



Reactor building



Overview of Engineered Safety Features

Function

Nuclear Fuel Cladding Protection	• Fuel Center Temperature ≤ 2590 ℃ • Cladding Surface Temperature ≤ 1204 ℃
Ensuring containment container integrity	• Hydrogen content in CV ≤ 4 v/o • Maintain below CV atmospheric design temperature/pressure
CV Radioactive Material Remove	• Maintain within limits of radioactive material content
Ensuring integrity of the main control room	• Maintain temperature/humidity/radioactive lever limits within the main control room
Gain inventory of Coolant	• Core cooling with lost coolant inventory during DBA
Natural Circulation & Primary Coolant	• Securing NSSS heat sink by supplying auxiliary feed water to S/G

Overview of Engineered Safety Features

When variable values reache a set value, the following operational signal is generated

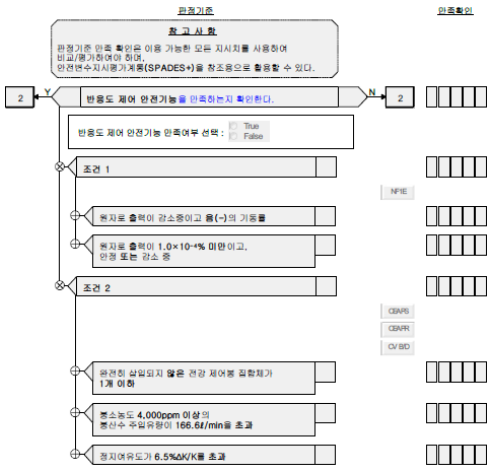
- Safety Injection Actuation Signal(SIAS)
  - → Supply boric acid water into the core
- Containment Isolation Actuation Signal(CIAS)
  - → Isolate piping through the reactor building
- Containment Spray Actuation Signal(CSAS)
  - → Spraying from the top of the building
- Main Steam Isolation Signal(MSIS)
  - → Shutting down the isolation valves of the Main Steam Line and Main Feed Line
- Auxiliary Feedwater Actuation Signal(AFAS)
  - → Supply of water to steam generator

Safety Functions

- **Safety Function**
  - maintain the reactor safe and respond to emergency
  - Critical function to minimize the damage to core and radioisotope material leakage
  - Based on the priority of incident response

Reactivity Control	RCS Heat Removal
Maintenance of Vital	CV Isolation
RCS Inventory Control	CV Press./Temp. Control
RCS Pressure Control	Combustion Gas Control
Core Heat Removal	

- **Safety Function Status Check**
  - While the emergency operation is conducted, check the status of safety function periodically to check the status of safety function operation (15minutes, Safety conductor)



Safety Function Status Check

Types of nuclear power plant accidents

- Loss of Coolant Accident(LOCA)
- Steam Generator Tube Rupture(SGTR)
- Excess Steam Demand Event(ESDE)
- Loss of All Feed Water(LOAF) ⇒ Not Design Basis Accident(DBA)
- Loss of Off-site Power (LOOP)
- Station Blackout(SBO) ⇒ Not Design Basis Accident(DBA)

Loss of Coolant Accident(LOCA)

- **Definition**
  - Loss of reactor coolant due to pipe break(or something) within the reactor pressure boundary
  - Loss of reactor coolant exceeding maximum charging flow rate

- **Symptoms**
  - PZR Pressure and Level decreasing
  - RCS Charging flow increasing
  - ESFAS(SIAS, CIAS, MSIS, CSAS) Actuating
  - RCS subcooling margine decreasing
  - IRWST Level, Temperature, Pressure increasing

Steam Generator Tube Rupture(SGTR)

- **Definition**
  - An accident in which the barrier between Reactor Coolant System (RCS) and Main Steam System is lost due to the rupture of the tube in the steam generator

- **Symptoms**
  - Secondary system radiation increasing
  - S/G level increasing
  - Feedwater/Steam flow not equivalent
  - PZR Pressure and Level decreasing
  - RCS Charging flow increasing
  - ESFAS(SIAS, CIAS, MSIS) Actuating
  - RCS subcooling margine decreasing

Excess Steam Demand Event(ESDE)

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Definition

- An accident resulting in unexpected S/G rapid increase in steam flow or loss of S/G inventory
- An accident in which the primary system is excessively cooled due to increased heat removal from the secondary system, and the core power increases with the insertion of the positive reactivity

Symptoms

- S/G pressure decreasing
- RCS Tavg decreasing
- PZR Pressure and Level decreasing
- Containment building temperature, pressure increasing(if break happen in CV)
- ESFAS(MSIS) Actuating
- RCS subcooling margine increasing

Loss of All Feedwater(LOAF)

- **Definition**
  - An accident in which loss of water supply for 2 units of S/G
  - Classified as heat removal reduction accidents by secondary systems

- **Symptoms**
  - Feedwater flow decreasing
  - Feedwater/Steam flow not equivalent
  - S/G Level decreasing
  - ESFAS(AFAS) Actuating

Loss of Off-site Power(LOOP)

- **Definition**
  - An accident in which power supply is lost from the off-site power grid and only CLASS 1E alternated power is supplied by Emergency Diesel Generator
- **Symptoms**
  - UAT & SAT Lo-Voltage alarm
  - EDG auto start
  - All RCP trip
  - All equipment from N-1E power inoperable
  - Lightning power of MCR is changed from ac power to battery power
  - RCS temperature remain by one phase natural recirculation

Station Blackout(SBO)

- **Definition**
  - An accident in which the reactor trip due to the lack of power to the distribution system and at the same time, all on-site alternating current power, including emergency diesel generators, is completely lost
  - Does not include loss of operability of AC power supplied to the bus through batteries, inverters or by AAC power sources
- **Symptoms**
  - All ac power sources are cut off
    - Generator Trip, UAT/SAT failure, EDG fail to start
  - All RCP trip
  - All equipment from AC power inoperable
  - Lightning power of MCR is changed from ac power to battery power
  - RCS temperature remain by one phase natural recirculation

Demonstration

- **Observe Symptoms**
- **Verify ESFAS Operation**
- **Operate some equipment**

THANK YOU

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