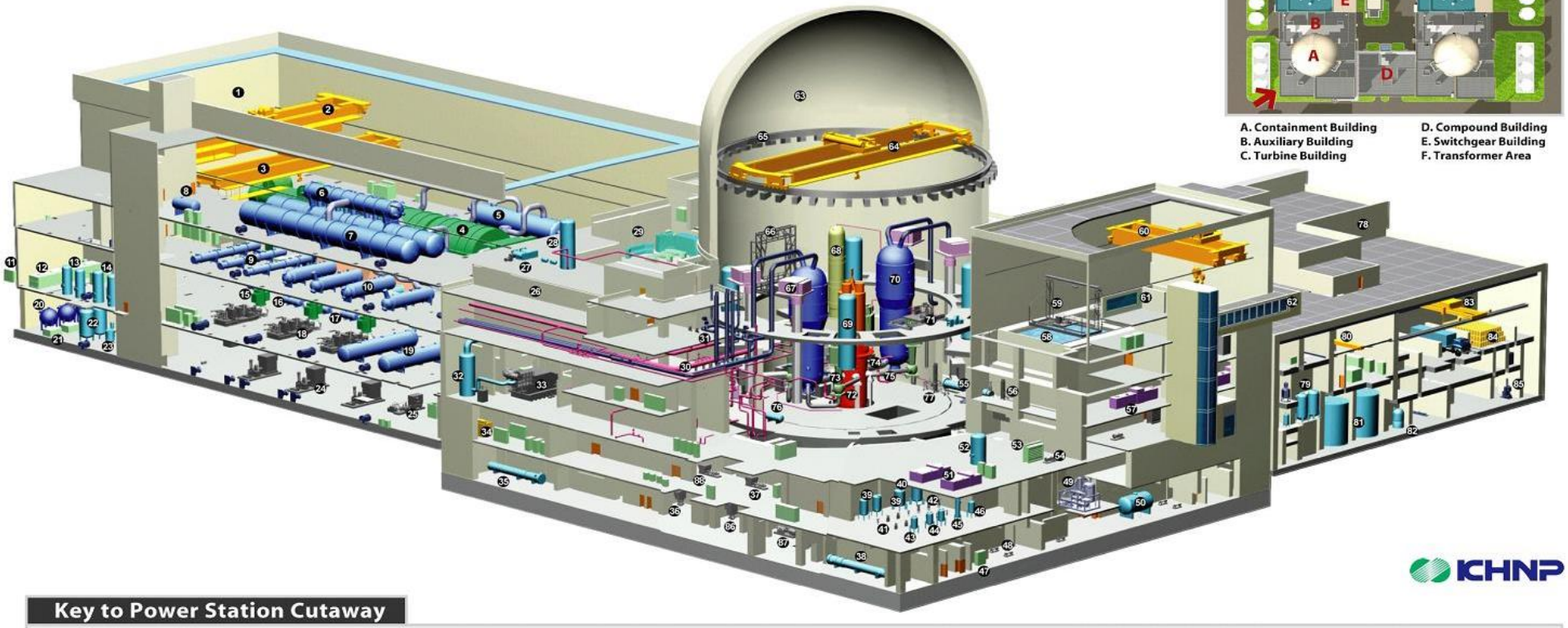
Contents

Main Steam System
Condensate System
Main Feedwater System

Steam and Power Conversion System



Site Plan Key

A. Containment Building
B. Auxiliary Building
C. Turbine Building
D. Compound Building
E. Switchgear Building
F. Transformer Area

KHNP

Key to Power Station Cutaway

1. Turbine Building
2. Main Overhead Crane
3. Aux. Overhead Crane
4. Generator
5. Moisture Separator Reheater
6. Deaerator
7. Deaerator Storage Tank
8. TBCCW Surge Tank
9. LP Feedwater Heaters
10. HP Feedwater Heaters
11. Closed Loop Cooling System
12. Air Compressor
13. Air Receivers
14. Service Air Receiver
15. Feedwater Pumps Turbine Driven
16. Moisture Separator Drain Tank
17. Stage Reheater Drain Tank
18. Feedwater Pumps Turbine "A""B""C"
19. HP Feedwater Heaters
20. Cond. Polishing Mixed Bed Vessels
21. Cond. Polishing Resin Traps
22. Cation Regen. & Hold Tanks
23. Ammonia Day Tank
24. Feedwater Booster Pumps
25. Start-up FW Pump
26. Auxiliary Building
27. D/G Room Emergency Exhaust Fan
28. CCW Surge Tank
29. Main Control Room
30. Main Steam Line
31. Main Steam Safety Valve
32. Exhaust Silencer
33. Diesel Generator
34. 480V PNS Loadcenter
35. CS Heat Exchanger
36. CS Pump
37. Motor Driven Aux. Feedwater Pumps
38. SC Heat Exchanger
39. Spent Fuel Pool Clean-up Demin
40. SG Blowdown Mixed Bed Demin
41. Reactor Drain Filter
42. SGBD Filter
43. Pre-Holdup Ion Exchanger
44. Purification Ion Exchanger
45. Boric Acid Cond Ion Exchanger
46. Deborating Ion Exchanger
47. Process Radiation Monitor
48. Holdup Pump
49. Boric Acid Conc.
50. Equip. Drain Tank
51. Aux. Bldg. Controlled Area Exhaust ACU
52. Volume Control Tank
53. SFP Cooling Exchanger
54. SFP Cooling Pump
55. Fuel Transfer Tube
56. Fuel Transfer Carriage & Upender in Fuel Handling Area
57. Fuel Handling Area Emer Exhaust ACU
58. Spent Fuel Pool
59. Spent Fuel Handling Machine
60. Fuel Handling Area Overhead Crane
61. Viewing Area
62. Walkway
63. Containment Building
64. Polar Crane
65. Crane Rail
66. CEA Change Platform
67. RCFC Duct
68. Pressurizer
69. Safety Injection Tank
70. Steam Generator
71. Refueling Machine
72. Reactor Vessel
73. Reactor Coolant Pump
74. Reactor Coolant Piping Hot Leg
75. Reactor Coolant Piping Cold Leg
76. RCP Lube Oil Collector Tank
77. Fuel Transfer System Upender
78. Compound Building
79. Charcoal Delay Beds
80. Suspension Crane
81. Long Term Storage Tank
82. Low Activity Spent Resin
83. Traveling Bridge Crane
84. Waste Drum Storage Area
85. Solid Waste Compactor
86. SC Pump
87. SI Pump
88. Turbine Driven Aux. Feedwater Pump

Steam and Power Conversion System

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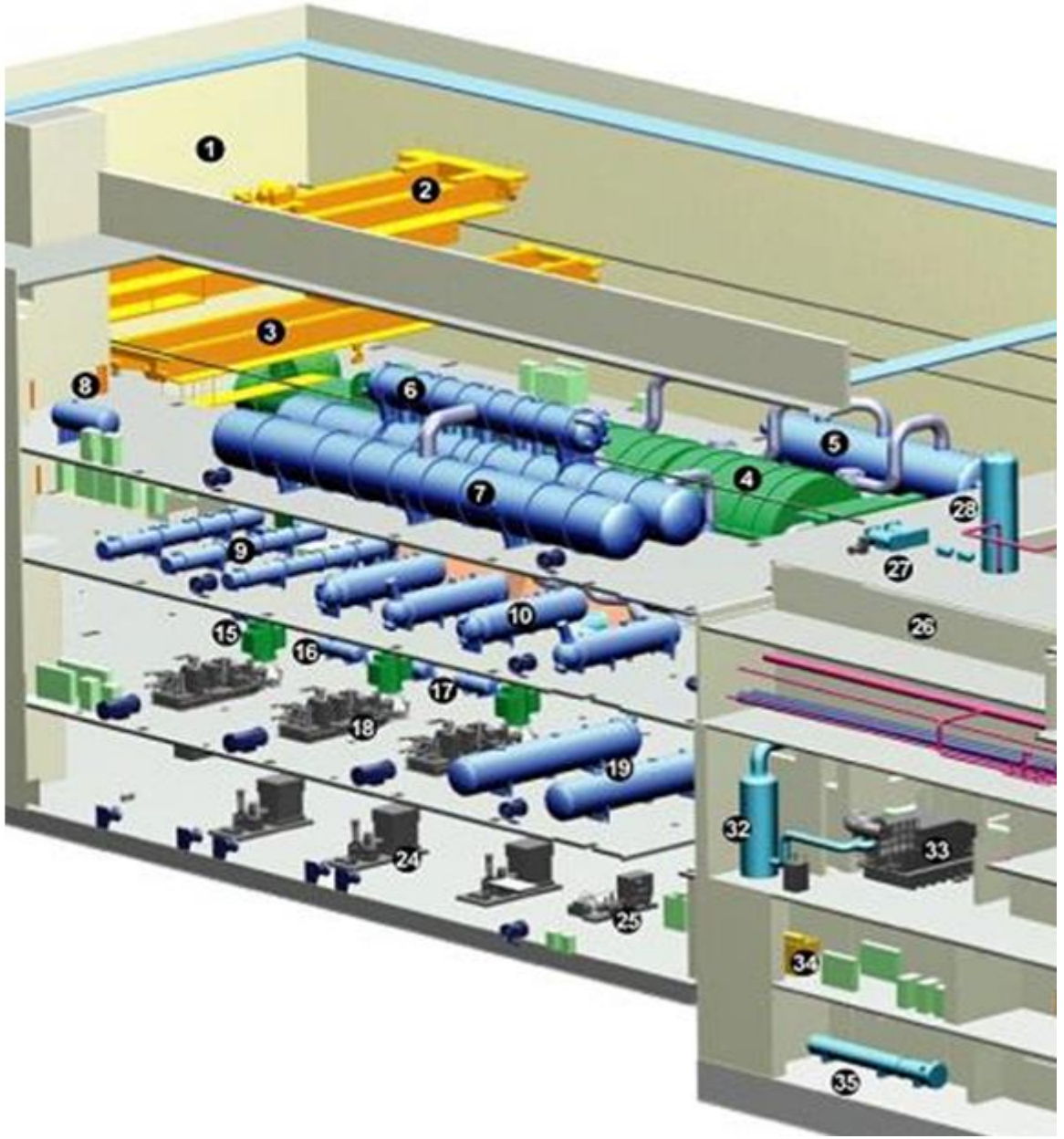

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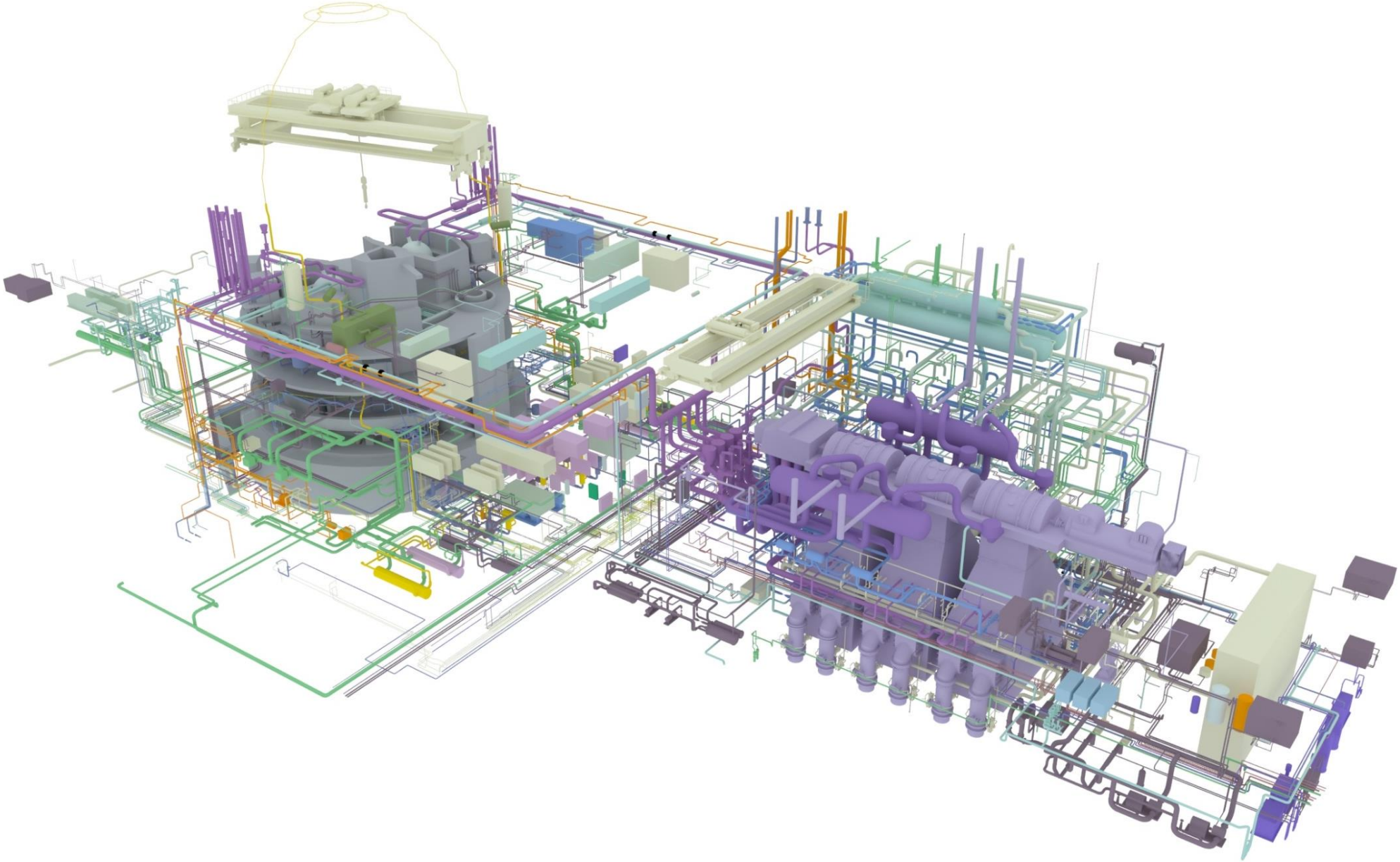

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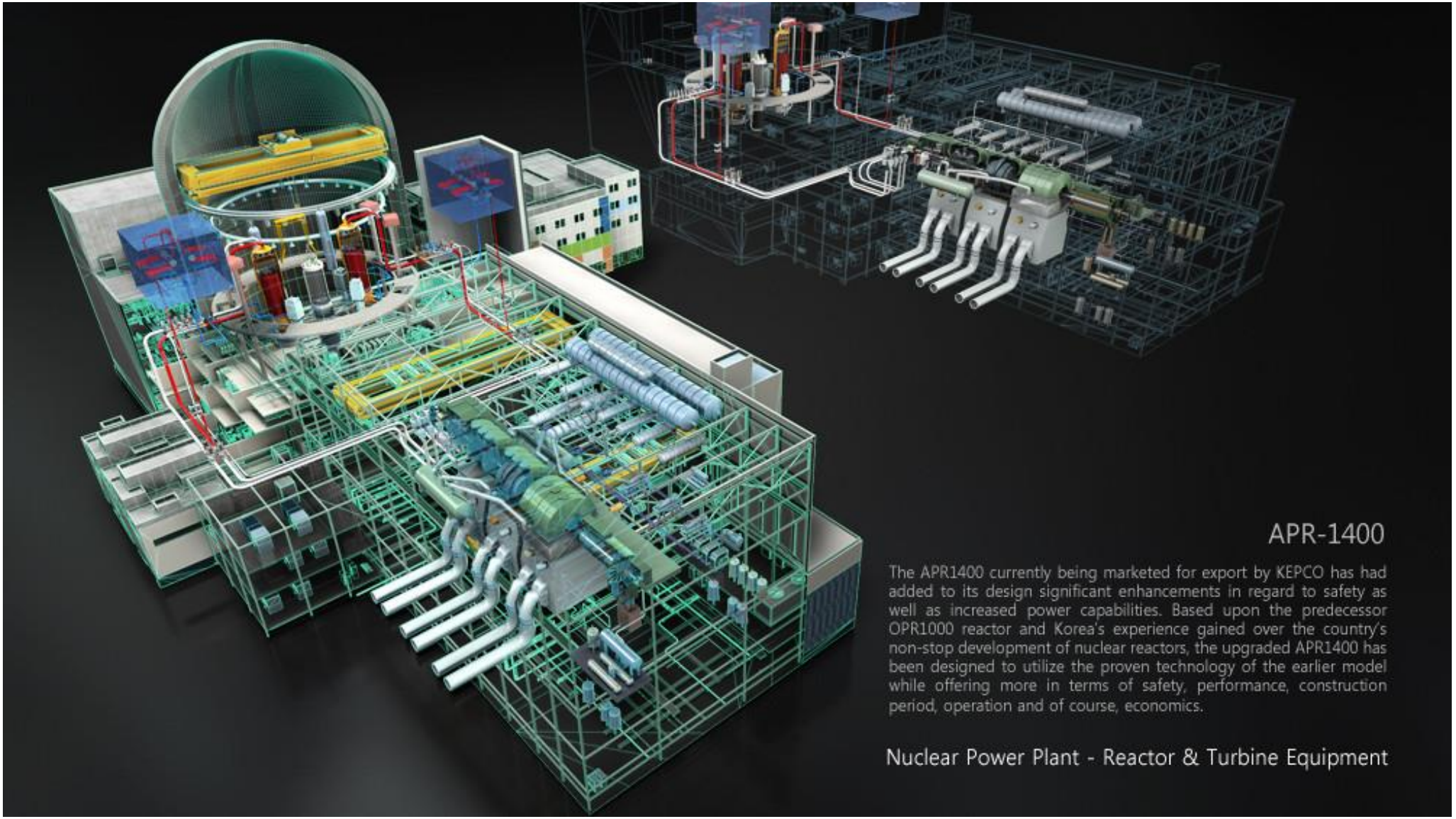
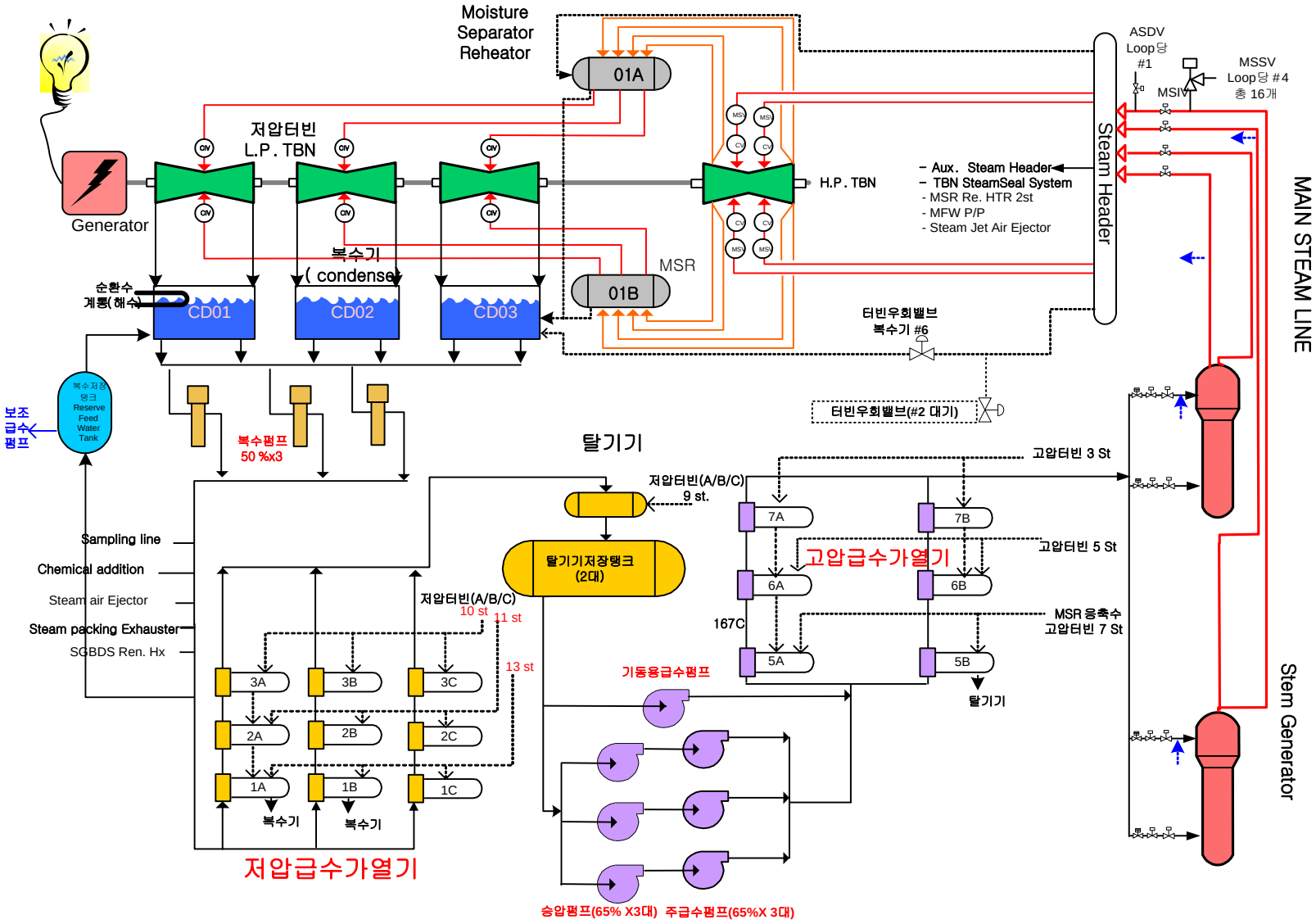


❖ Condensate / main feedwater system (복수 및 주급수 계통)



Steam and Power Conversion System

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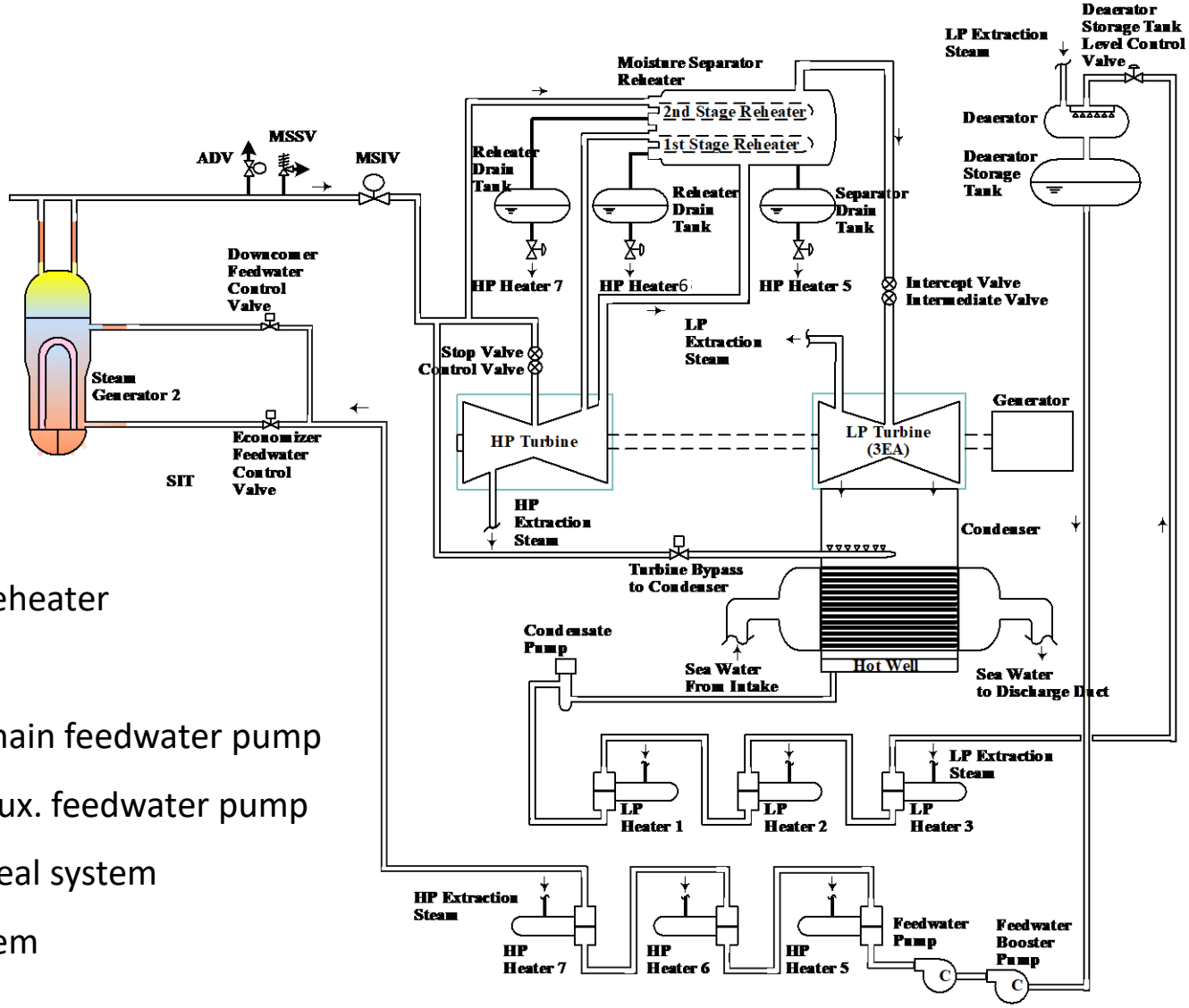


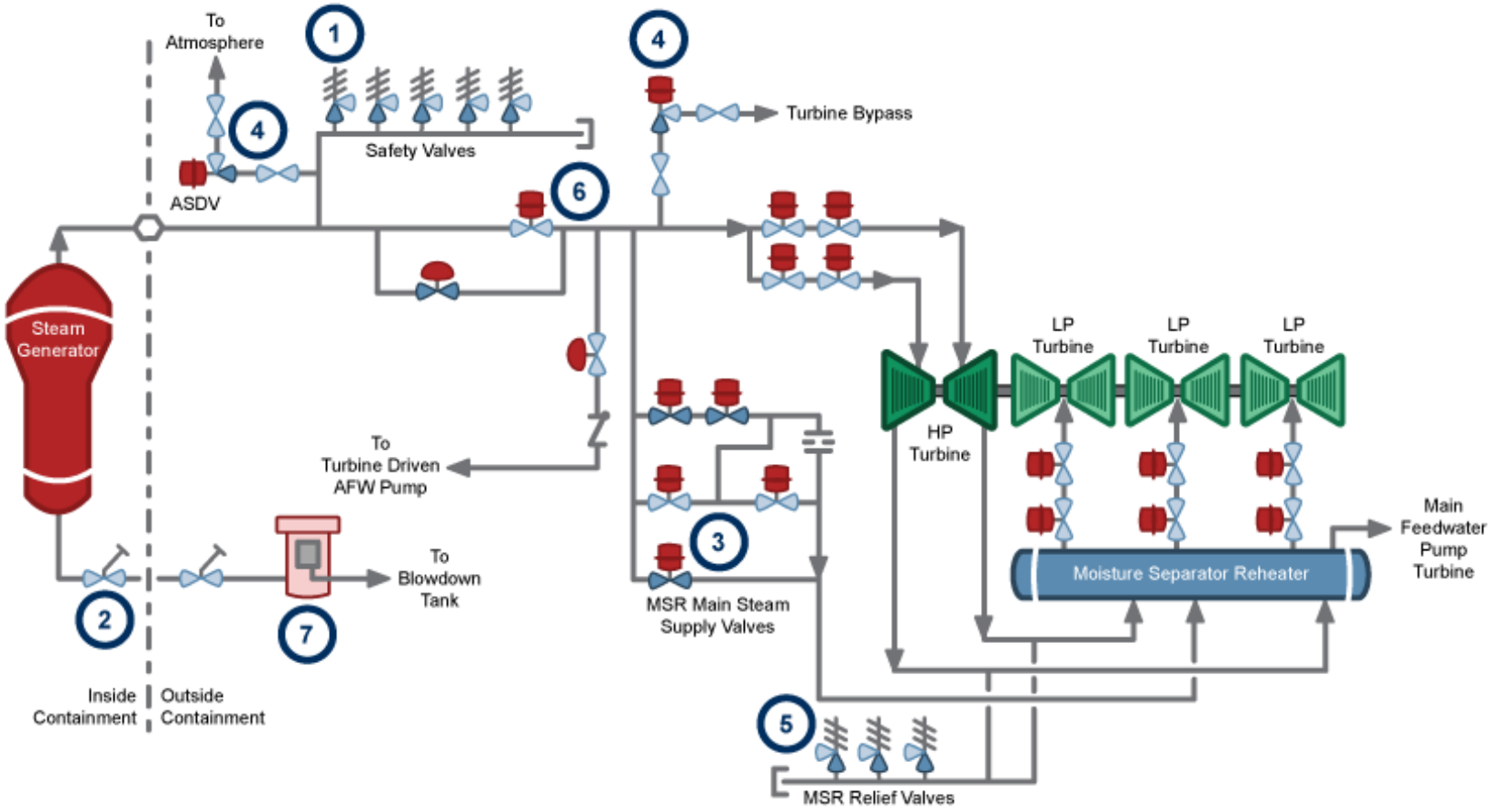
- HP Turbine
- MSR 2nd stage reheater
- Turbine bypass
- Turbine of the main feedwater pump
- Turbine of the aux. feedwater pump
- Turbine steam seal system
- Aux. steam system
- Sampling line

Steam and Power Conversion System

❖ Main steam system

- Main steam line ⇒ High pressure turbine ⇒ Moisture separator/reheater

  ⇒ low pressure turbines (3) ⇒ main condenser (operated at a vacuum)



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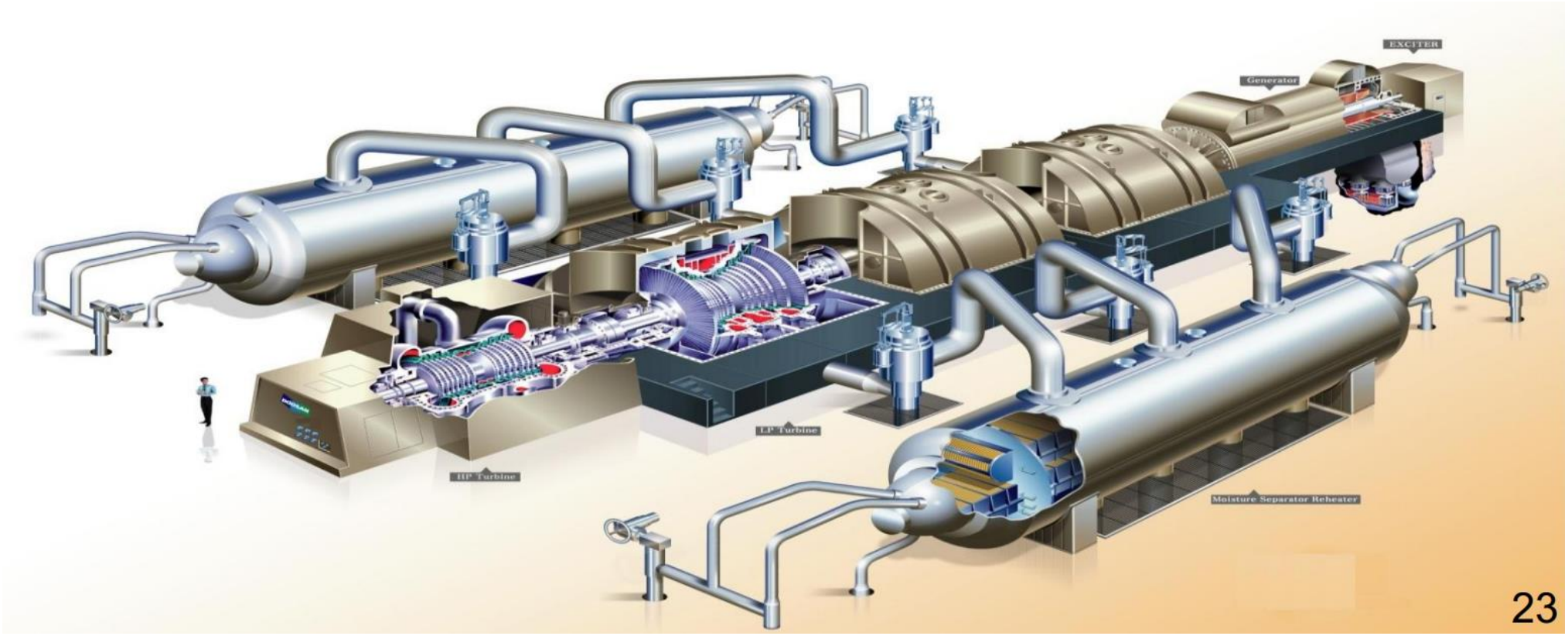
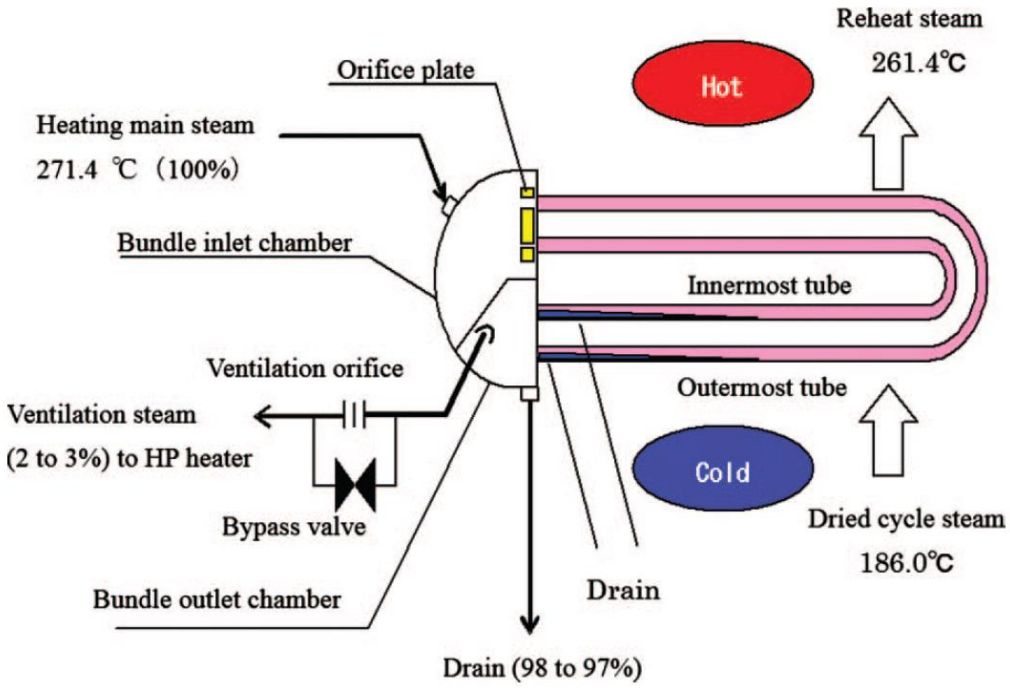
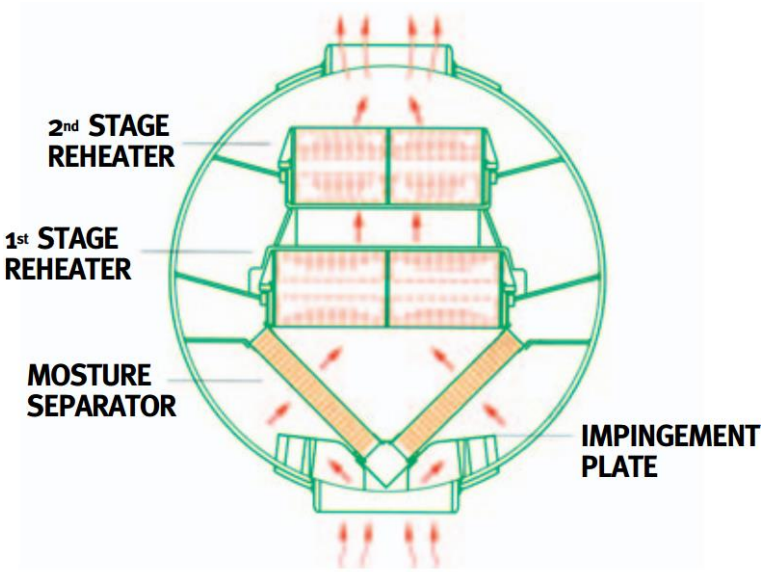


❖ Main steam system

- Moisture separator/reheater

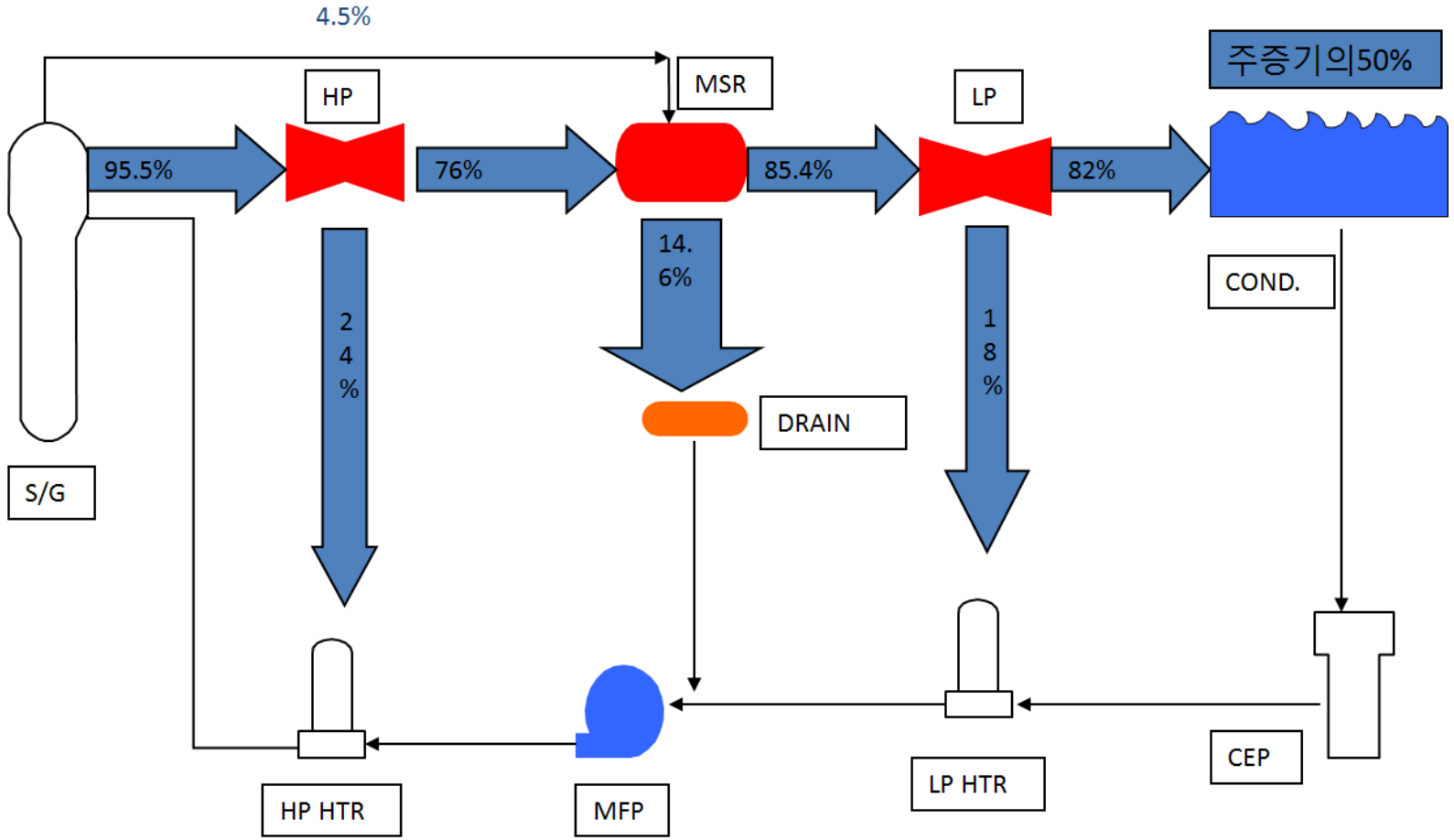




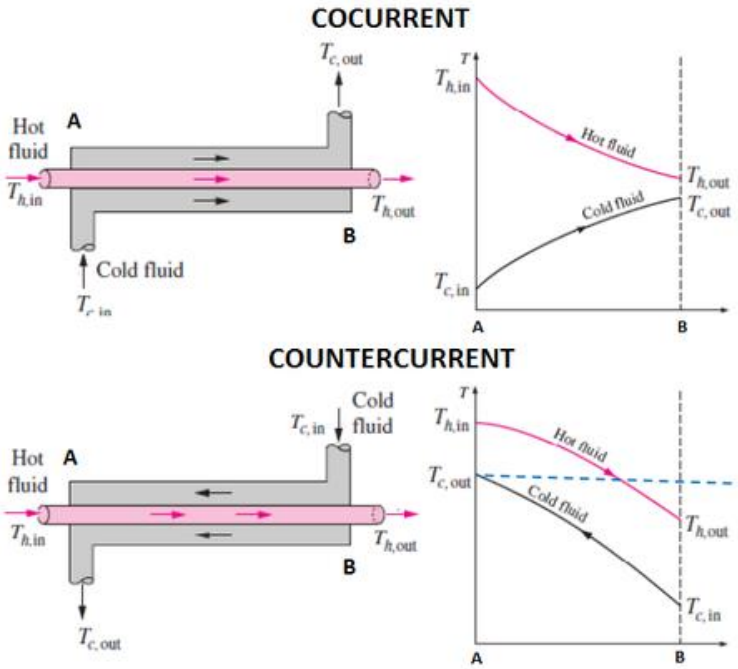
Steam and Power Conversion System

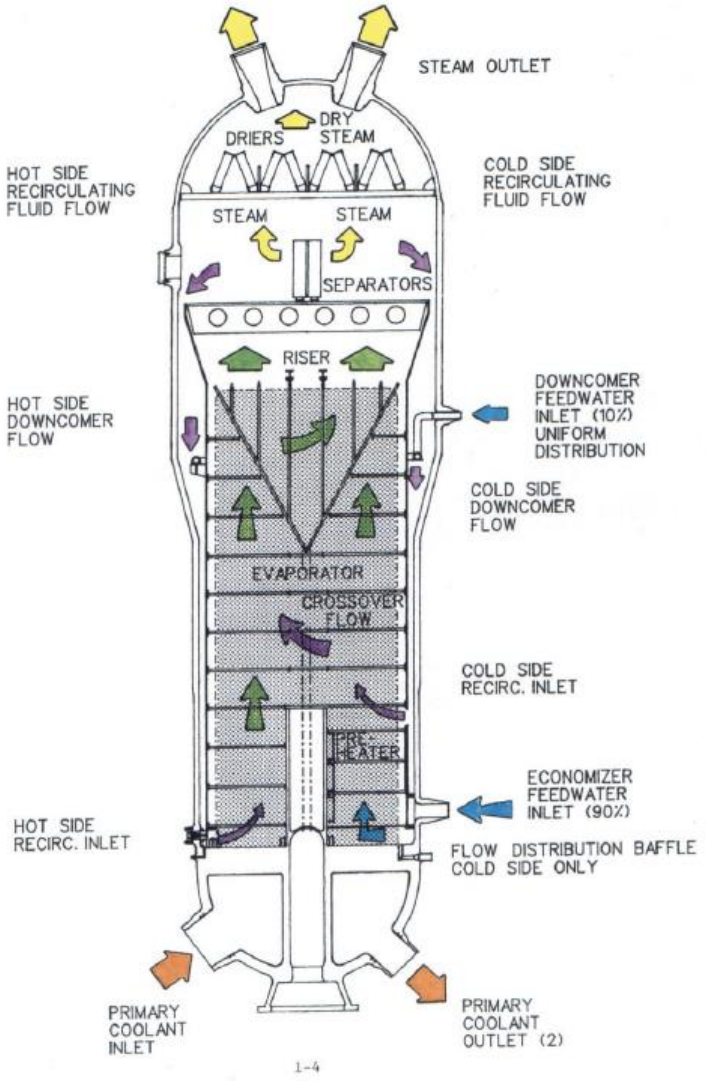
❖ Main steam system

- High pressure turbine



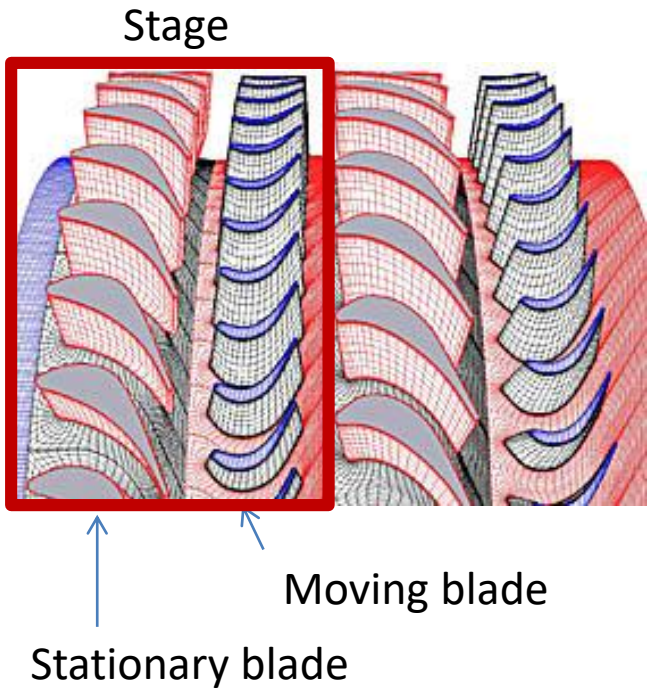
- **Counter-current heat exchanger**
  - **Why is it better ? (explain using LMTD)**
  - **Check the following heat exchangers' flow directions**
    - Steam generator
    - Moisture separator reheater
    - Feedwater heater
    - Deaerator

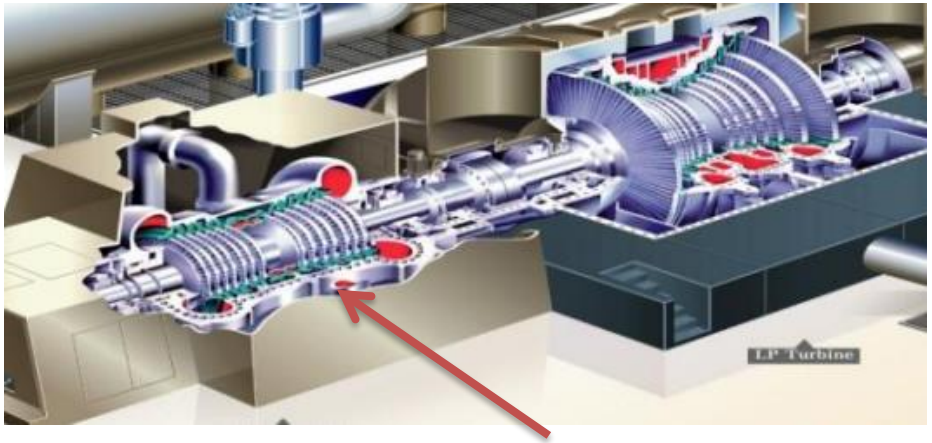




Steam and Power Conversion System

❖ Turbine





HP Turbine: 7 stages (OPR1000)

- 3rd or 10th stage: steam extraction for MSR / high pressure feedwater heater #7
- 5th or 12th stage: high pressure feedwater heater #6
- 7th or 14th stage: high pressure feedwater heater #5

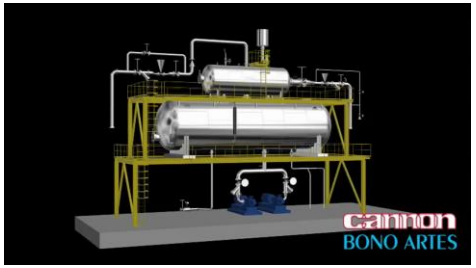
LP Turbine: 7 stages (OPR1000)

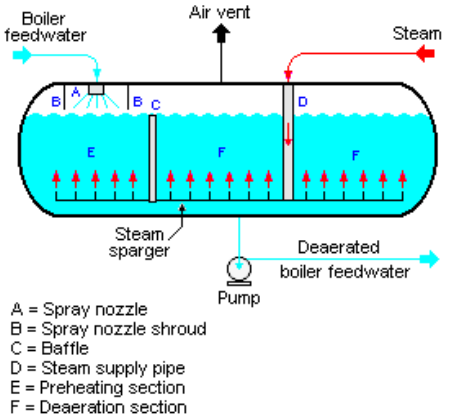
- 2nd or 9th stage: for deaerator
- 3rd or 10th stage: for low pressure feedwater heater #3
- 4th or 11th stage: for low pressure feedwater heater #2
- 6th or 13th stage: for low pressure feedwater heater #1

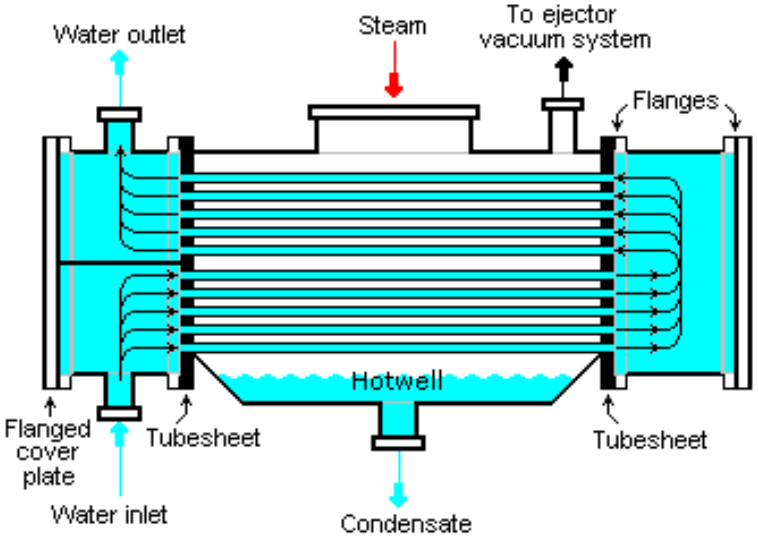
Steam and Power Conversion System

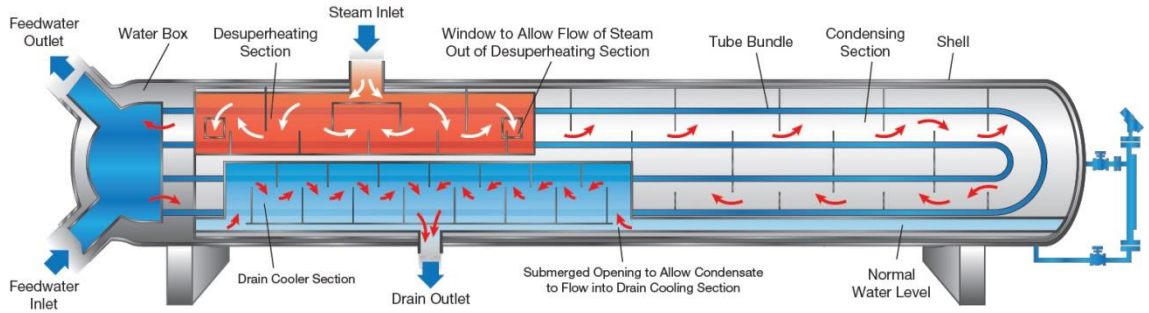
❖ Condensate system

- Main condenser/ Condenser vacuum system/ Condensate pump
- Condensate polishing system (복수탈염계통)
- Low pressure feed water heater
- Deaerator (탈기기)







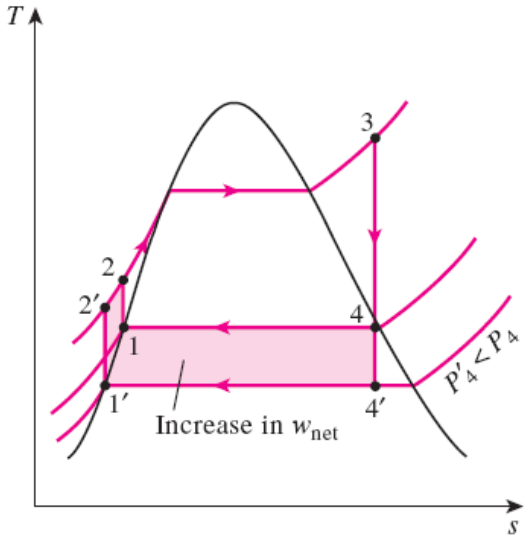


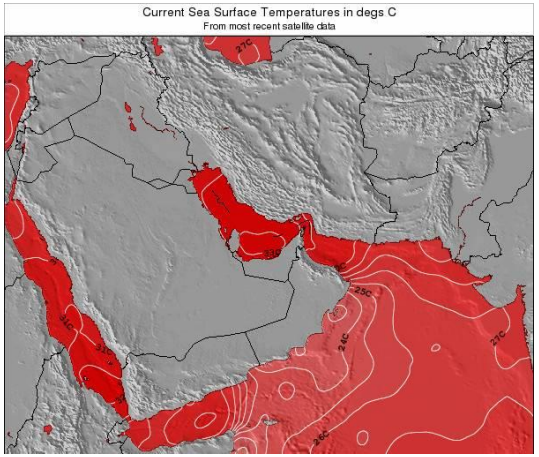
Condenser

- To condense the exhaust steam from the turbine and recover the high-quality feedwater for reuse in the cycle
- To create a low back pressure (vacuum, 5 kPa, 33 °C)
  - The enthalpy drop, and hence,

    turbine work, per unit pressure drop
    - At low pressure >> at high pressure
  - Increased plant efficiency
  - Important to use cooling-water temperature

    that are the lowest available
- Heat sink: sea water, circulating water system





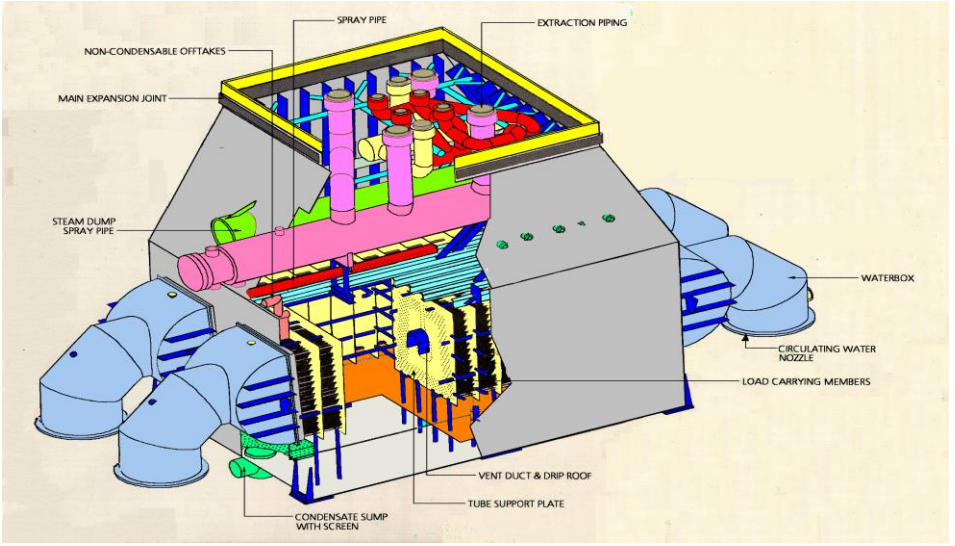
Type of condenser

- Direct-contact condenser
- Surface condenser

Surface condenser

- Most common type used in powerplants
  - Shell-and-tube heat exchangers
  - Condensing of saturated steam on the outside of the tubes
  - Forced-convection heating of the circulating water inside the tube
- Schematic of a surface condenser
  - Steel shell with water boxes
  - Tube sheets and support plates to prevent tube vibration

- OPR1000 main condenser
  - 3 shells
  - Single-pressure, single pass, surface condenser
  - Located below the low pressure turbines
  - Tubes are arranged perpendicular to the turbine shaft

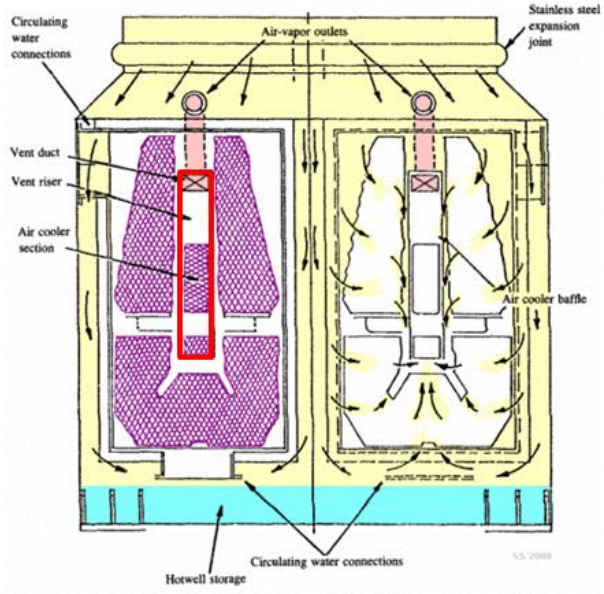


Deaeration in condenser

- Deaeration (탈기)
- Removal of air molecules (usually meaning oxygen) from another gas or liquid
  - Deaerator (탈기기)
  - To remove the non-condensable gases
    - Otherwise, it can accumulate in the system.
- Non-condensable gases
  - Leak from atmosphere into the cycle
    - Condenser: operates below atmospheric pressure
    - Decomposition of water into oxygen and hydrogen by thermal or influence of nuclear radiation
    - Chemical reactions between water and materials
- Effect of non-condensable gases
  - Raise the total pressure of the system ⇒ lower plant efficiency
  - Blanket the heat transfer surfaces (condenser outside surface) ⇒ decrease condensing HTC
  - Cause various chemical activities ⇒ corrosion (most severely in SG), hydriding by hydrogen, combustible

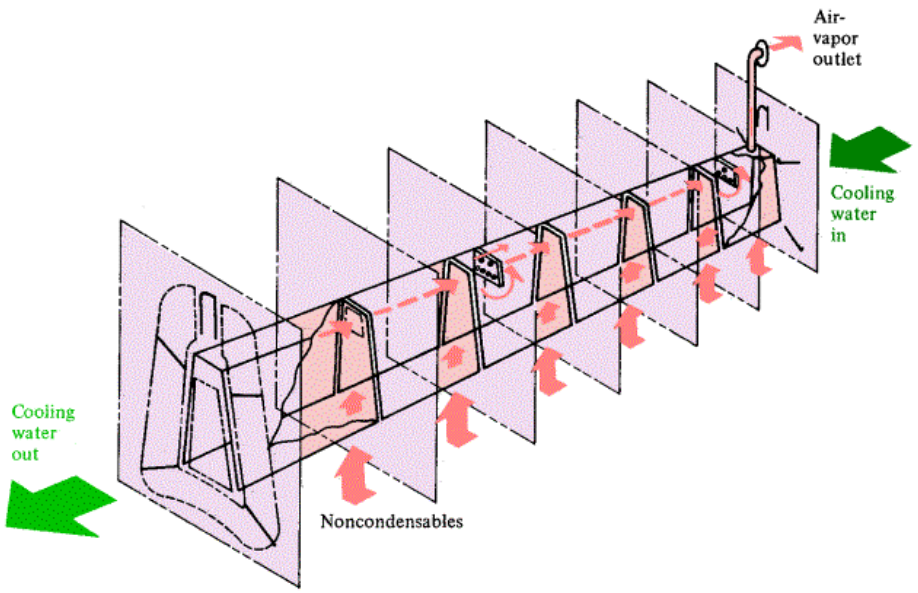
Deaeration in condenser

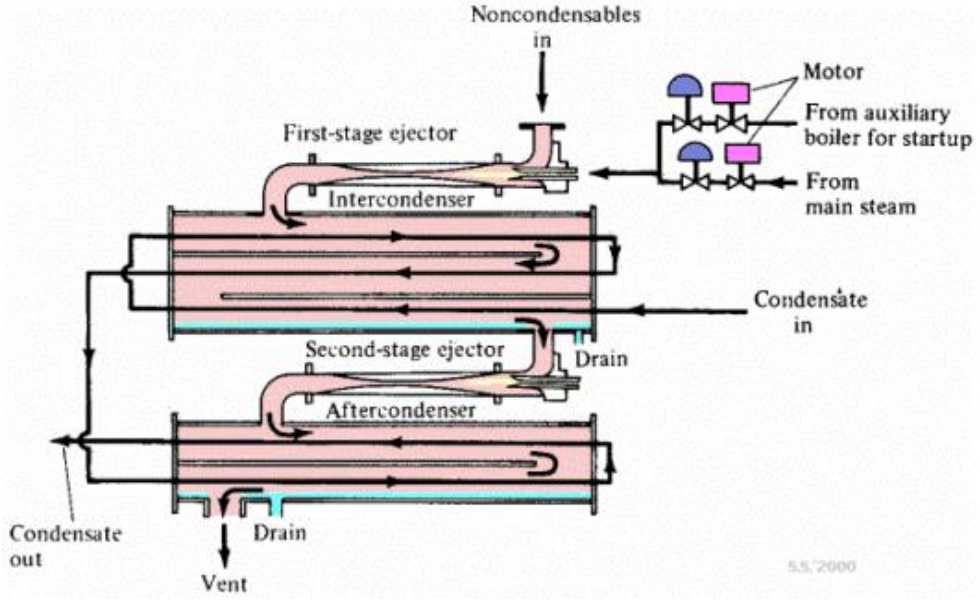
- Condenser
  - It is essential that the condenser itself be the place of good deaeration.
- Procedure
  - The cold condensate falling from the lower tubes with sufficient falling height and scrubbing steam
  - The scrubbing steam reheats the condensate.
    - Non-condensables are more easily released from a hotter than a colder liquid.
  - The released non-condensables are cooled to reduce their volume before being pumped out
    - 6~8 % of tubes are set aside
    - Air cooler section, baffled to separate the NCs from the main steam flow.
    - NCs flow toward the cold end of the condenser.
    - Connected to a vent duct
  - Venting equipment
    - Jet pump
    - Universal acceptance because of simplicity and lack of moving parts
    - Low maintenance and good reliability



Deaeration

- Jet pump used on condensers: Steam-Jet Air Ejector (SJAE)
  - The condensed steam: returned to a low-pressure part of the cycle.
  - Second stage ejector
    - Compressed further and passed to an after condenser
  - Third stage ejector
    - May or may not necessary
    - To bring the system to the off-gas system in nuclear power plants





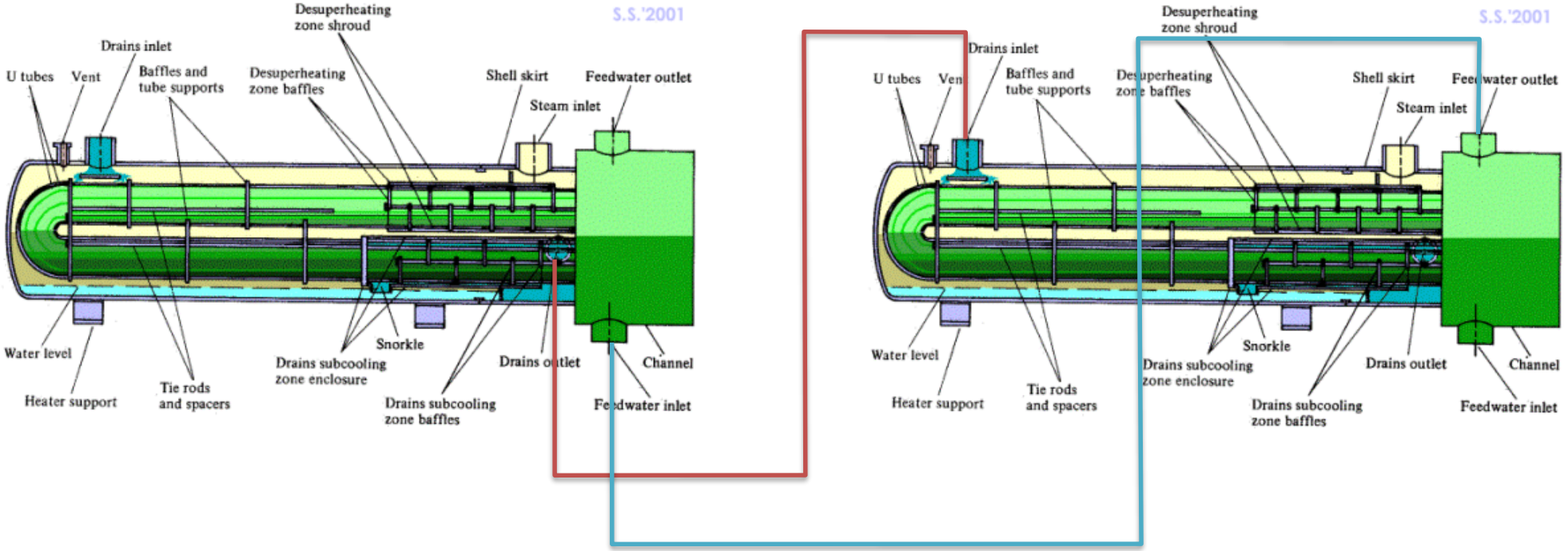
Deaeration

- Jet pump used on condensers: Steam-Jet Air Ejector (SJAE)
  - Uses steam as their motive or driving flow
  - Usually two or three stages

- Principle
  - Steam enters a driving-flow nozzle in the first-stage ejector.
    - Exits with high velocity and momentum and reduced pressure.
  - Reduced pressure draws in the NCs from the condenser.
    - By a process of momentum exchange, the gases are entrained by steam jet
  - The combined flow of steam and NCs is compressed in the diffuser.
  - Discharged into a small intercondenser
    - Steam is condensed by passing across cooling pipes.
    - Cooling is accomplished by the main condenser condensate.
    - Part of the feedwater heating system
    - Improvement in efficiency

❖ Condensate system

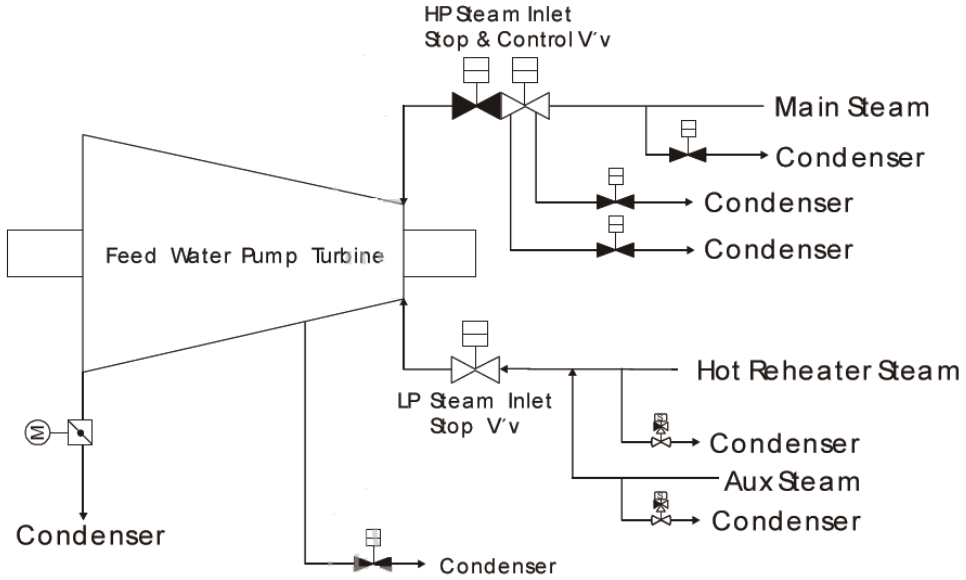
- Main condenser/ Condenser vacuum system/ Condensate pump
- Condensate polishing system (복수탈염계통)
- Low pressure feed water heater
- Deaerator (탈기기)



Steam and Power Conversion System

Main feedwater system

- Feedwater booster pump (급수승압펌프)
- Main feedwater pump (주급수펌프)
  - 2 Turbine driven pumps, 1 motor driven pump
  - Steam: from main steam line (power<40%), from MSR (otherwise)
- Startup feedwater pump (기동용 급수 펌프)
- High pressure feedwater heater
- Steam generator feedwater line
  - Downcomer feedwater
  - Economizer feedwater



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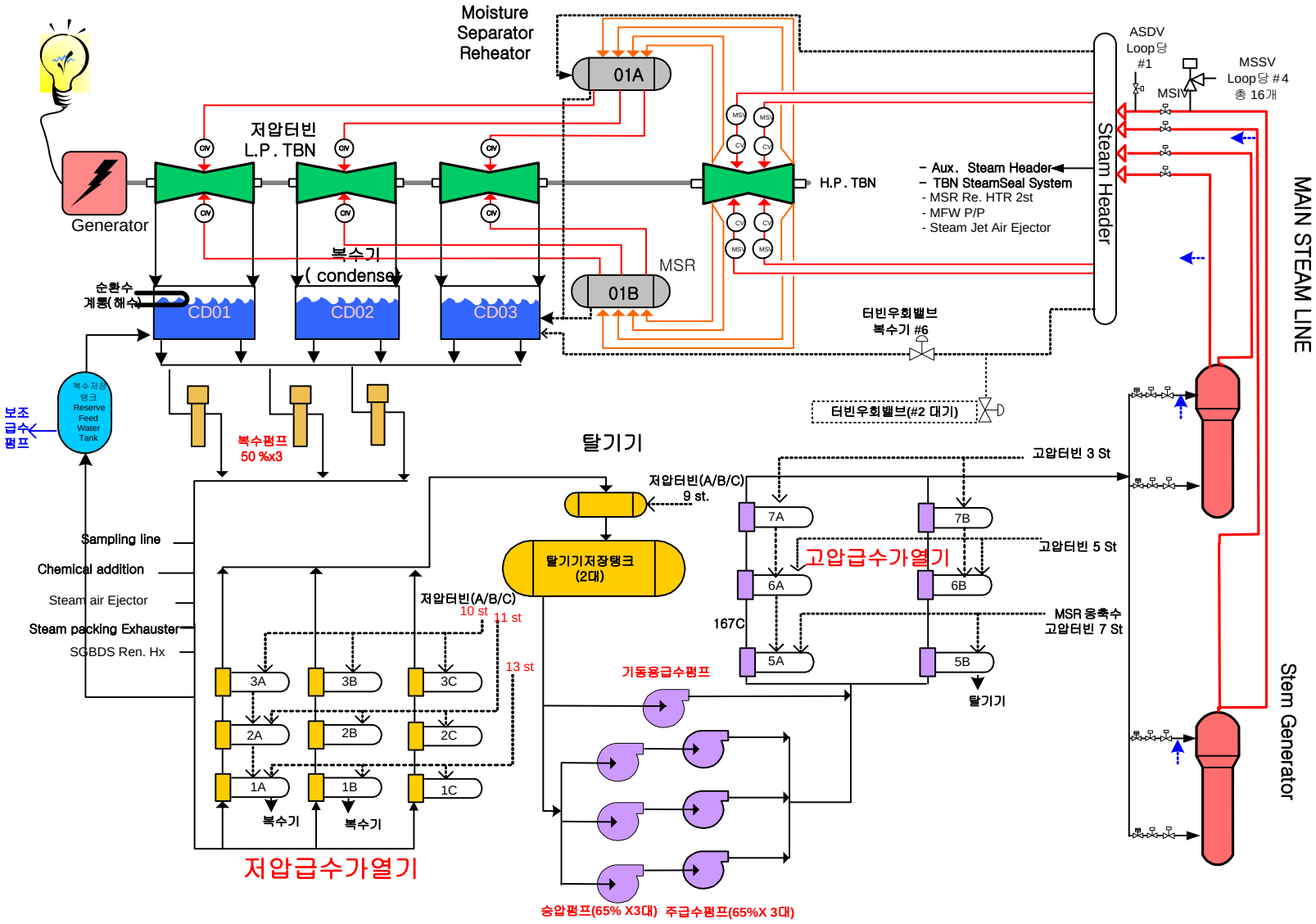
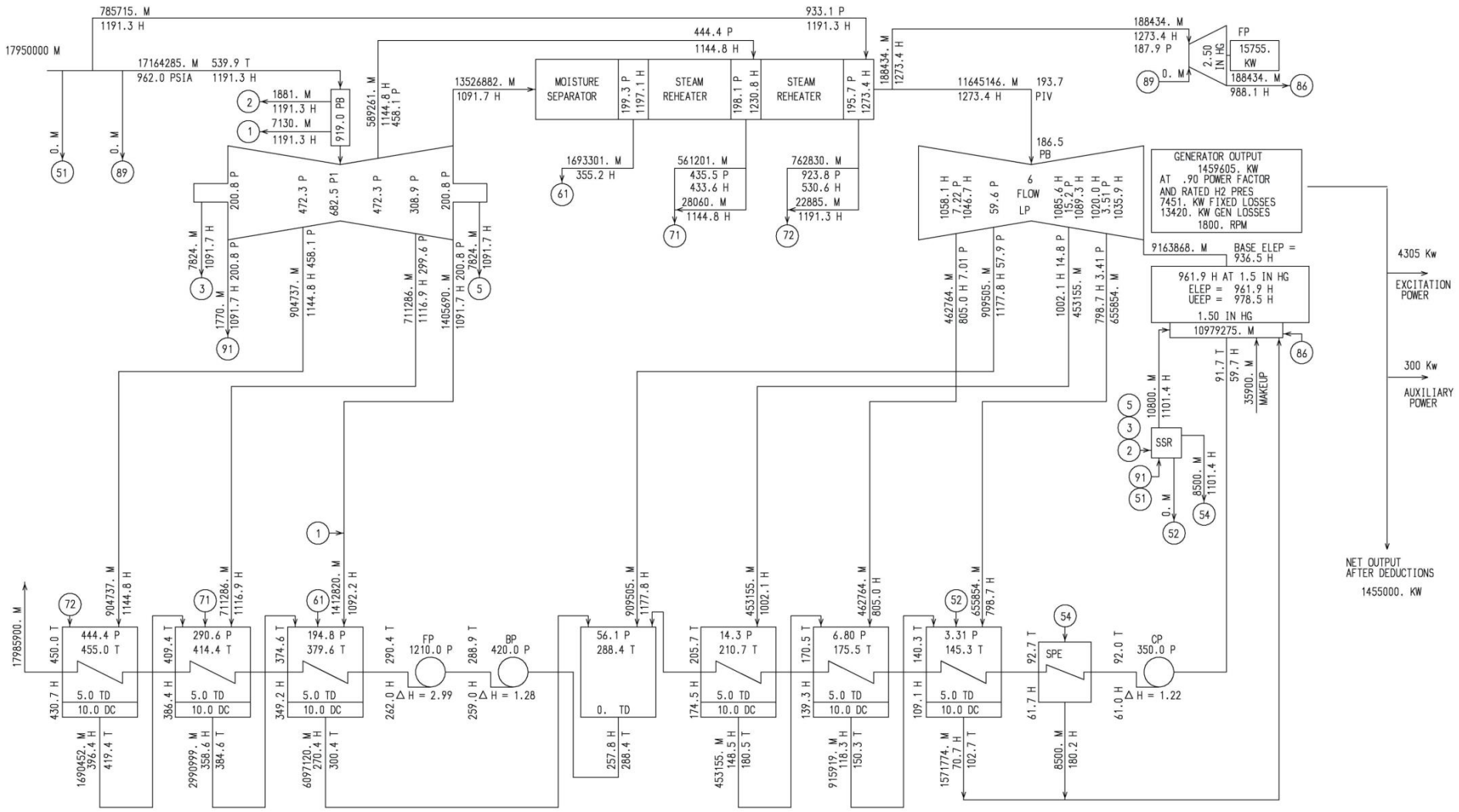


APR1400 Steam and Power Conversion System



Contents

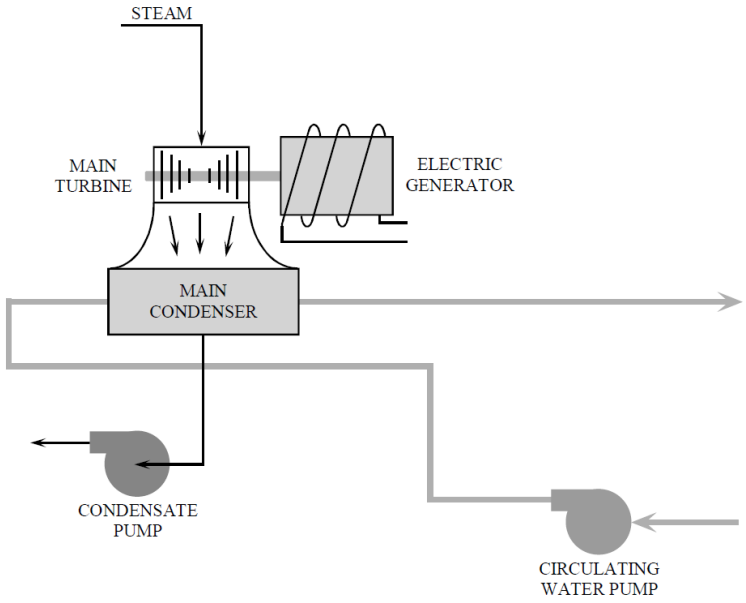
- History of PWR
- Plant Overall
- Reactor Coolant System
- Steam and Power Conversion System
- Auxiliary System
- Plant Protection System
- Other systems

Main Steam System
Condensate System
Main Feedwater System

CWS
CVCS
CCWS
ESWS
Fuel Storage and Handling System
Spent Fuel Pool Cooling and Clean up System (SFPCCS)
ESF (Engineered Safety Features)

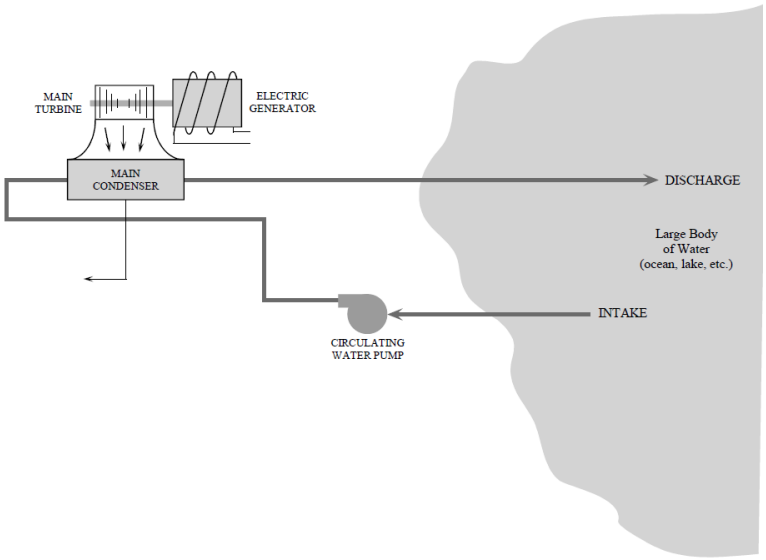
Circulating water system

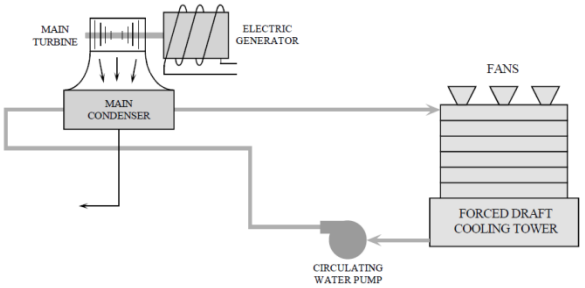
- To condense the steam and transfer that heat to the environment
- Main condenser
  - Steam condensation on thousands of condenser tubes
  - No physical contact between steam and the environment
  - In vacuum: any tube leakage will produce an inflow of water into condenser

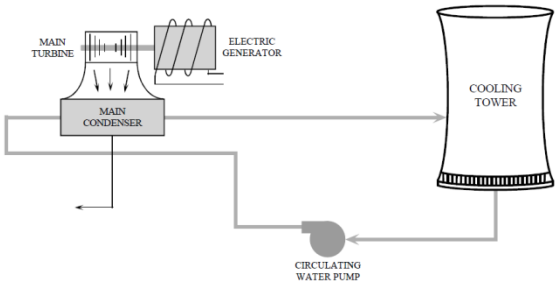


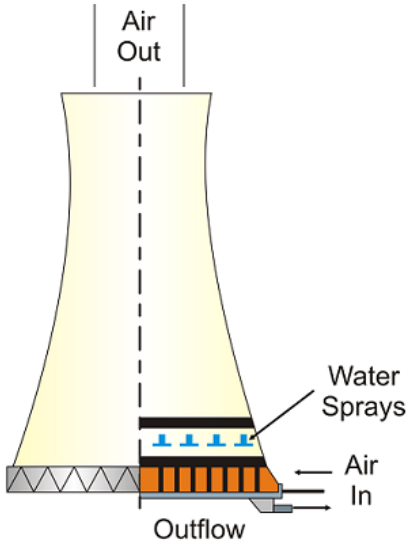
Circulating water system

- Takes water from the ocean/lake and discharges back into it
  - Expected temperature increase: 5~10°C (for 1000 MW)
  - Flow rate: ~ 50 ton/sec.
- Cooling tower
  - Forced draft cooling tower
  - Natural convection cooling tower



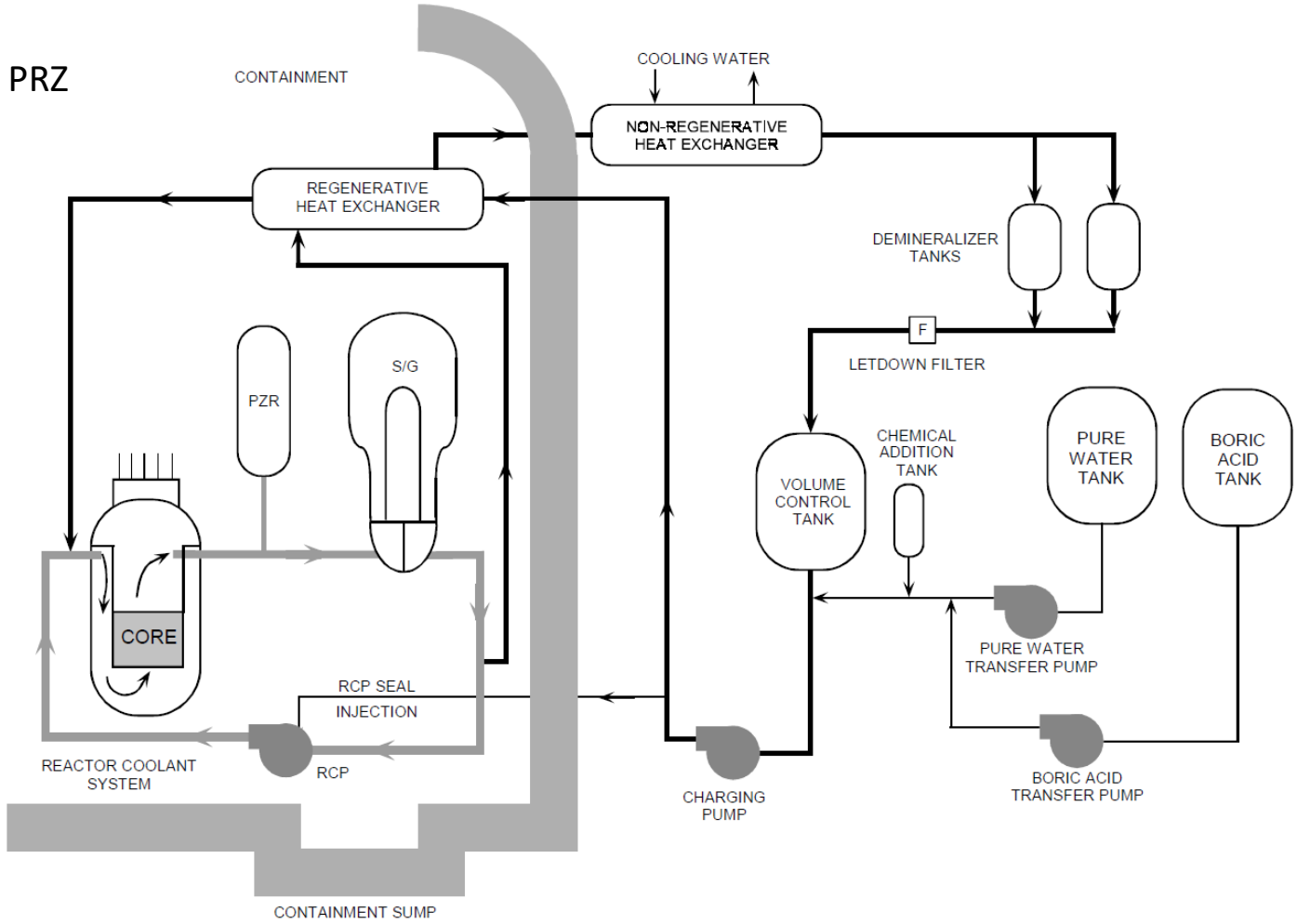






CVCS (Chemical and Volume Control System)

- Major support system for RCS
  - Purify RCS using filters and demineralizers, minimize the amount of radioactive material in coolant
  - Add/remove boron
  - Maintain the level of PRZ
- Volume control tank
- Letdown line
- Charging line



❖ CCWS (Component Cooling Water System)

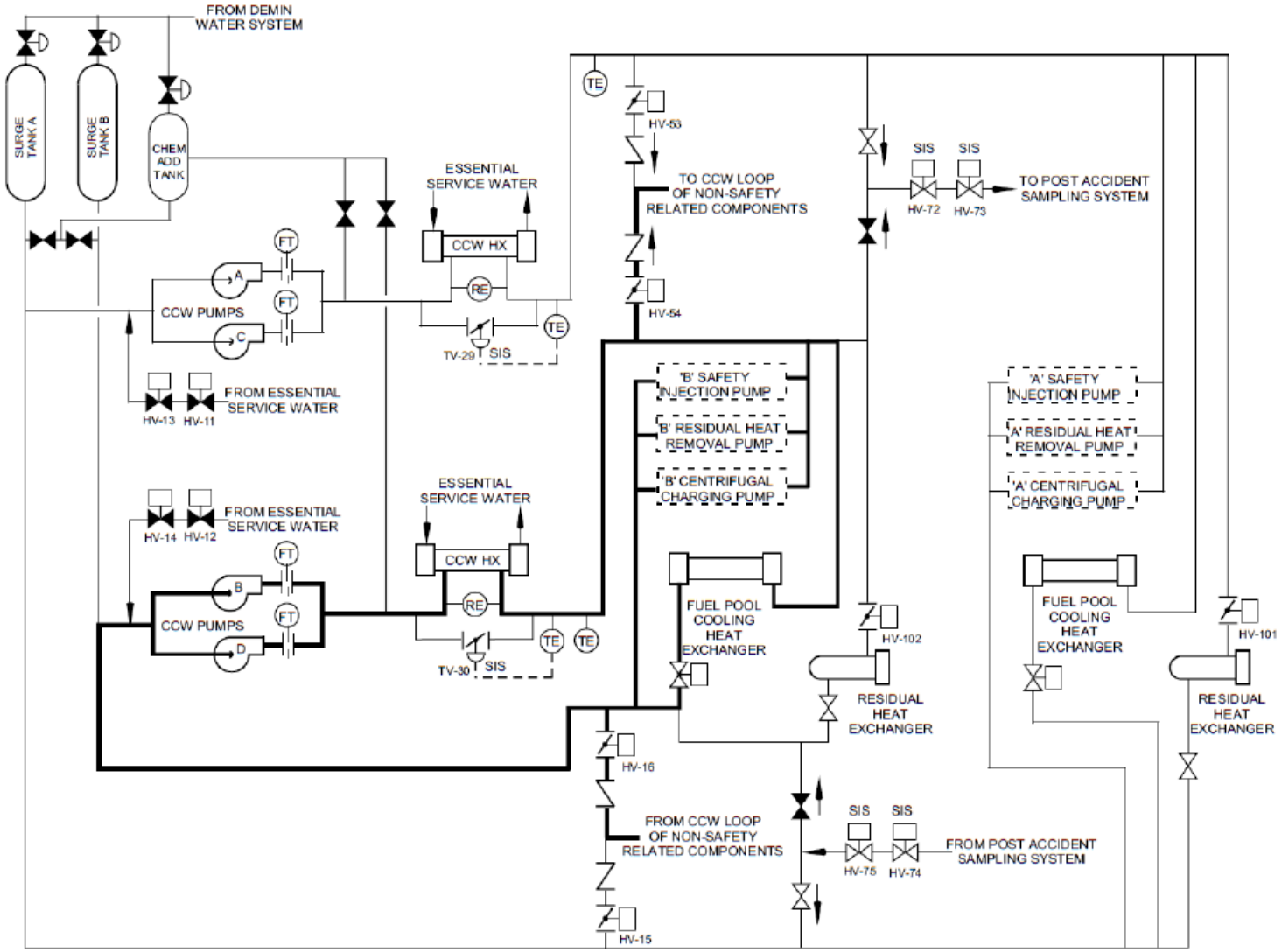
- Closed loop, two independent trains
- Provide coolant to components
- Cooled by ESWS (Essential Service Water System)
- CCW pumps
- CCW heat exchanger
  - Tube: ESWS
  - Shell: CCW
- Surge tank (완충 탱크)

발전소 기기냉각수 요구 설비 [울진5,6호기]

기기냉각수가 요구되는 설비	1차 기기냉각수		2차 기기냉각수
	안전등급	비안전등급	
1. 격납건물 살수 열교환기[주1]	✓		
2. 정지냉각 열교환기[주2]	✓		
3. 안전주입 펌프 모타 냉각기	✓		
4. 보조급수 펌프 모타 냉각기	✓		
5. 기기냉각수 펌프 모타 냉각기	✓		
6. 비상디젤 발전기 냉각기	✓		
7. 필수냉동기 응축기	✓		
8. 사용후연료저장조 열교환기	✓		
1) 원자로냉각재펌프 밀봉수 냉각기[주3]		✓	
2) 유출수 열교환기		✓	
3) 탈기기		✓	
4) 붕산농축기		✓	
5) 일차시료채취계통 시료 냉각기(정상 및 사고후 시료냉각기)		✓	
6) 방사선감시기 열교환기		✓	
7) 격납건물 냉동기 응축기		✓	
8) 복수회수탱크 배기 응축기		✓	
9) 증기발생기 취출 비재생열교환기		✓	
10)방사성폐기물건물 냉동기 응축기		✓	
11)충전펌프 최소유량 열교환기		✓	
12)액체방사성폐기물계통 밀봉수 열교환기		✓	
13)기체방사성폐기물계통 냉동기 스키드		✓	
① 공정시료채취계통 냉각기			✓
② 터빈건물 냉방기			✓
③ 2차측 기기냉각해수 펌프 전동기 베어링 냉각기			✓
④ 급수펌프 터빈 윤활유 냉각기			✓
⑤ 급수 승압펌프 윤활유/기계적 밀봉 냉각기			✓
⑥ 동기구동 급수펌프 윤활유/작동유 냉각기			✓
⑦ 기동 급수펌프 윤활유/기계적 밀봉 냉각기			✓
⑧ 복수펌프 전동기베어링 냉각기			✓
⑨ 공기압축기 중간냉각기, 후단냉각기 및 윤활유 냉각기[주4]			✓
⑩ 주 터빈 윤활유 냉각기			✓
⑪ 발전기 수소 냉각기			✓
⑫ 발전기 고정자 냉각기			✓
⑬ 상분리모선 덕트 냉각기			✓

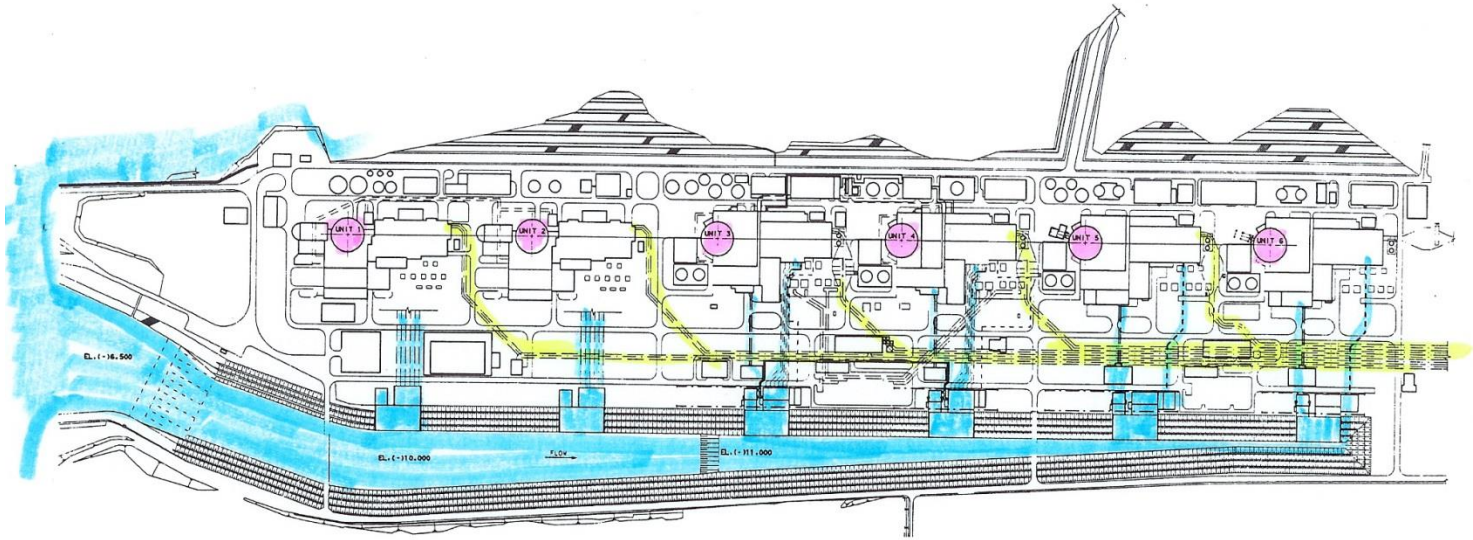
주 1) RHR : 펌프 모타 열교환기, Miniflow 열교환기 포함
2) CV : 격납용기 살수펌프 모타 열교환기, Miniflow 열교환기 포함
3) RCP : 오일냉각기, 고압냉각기, 펌프모터 오일냉각기, 펌프모터 공기냉각기 포함
4) IA : 1대의 공기압축기 냉각수 제공을 위한 독립적인 폐회로 냉각계통 포함

❖ CCWS (Component Cooling Water System)

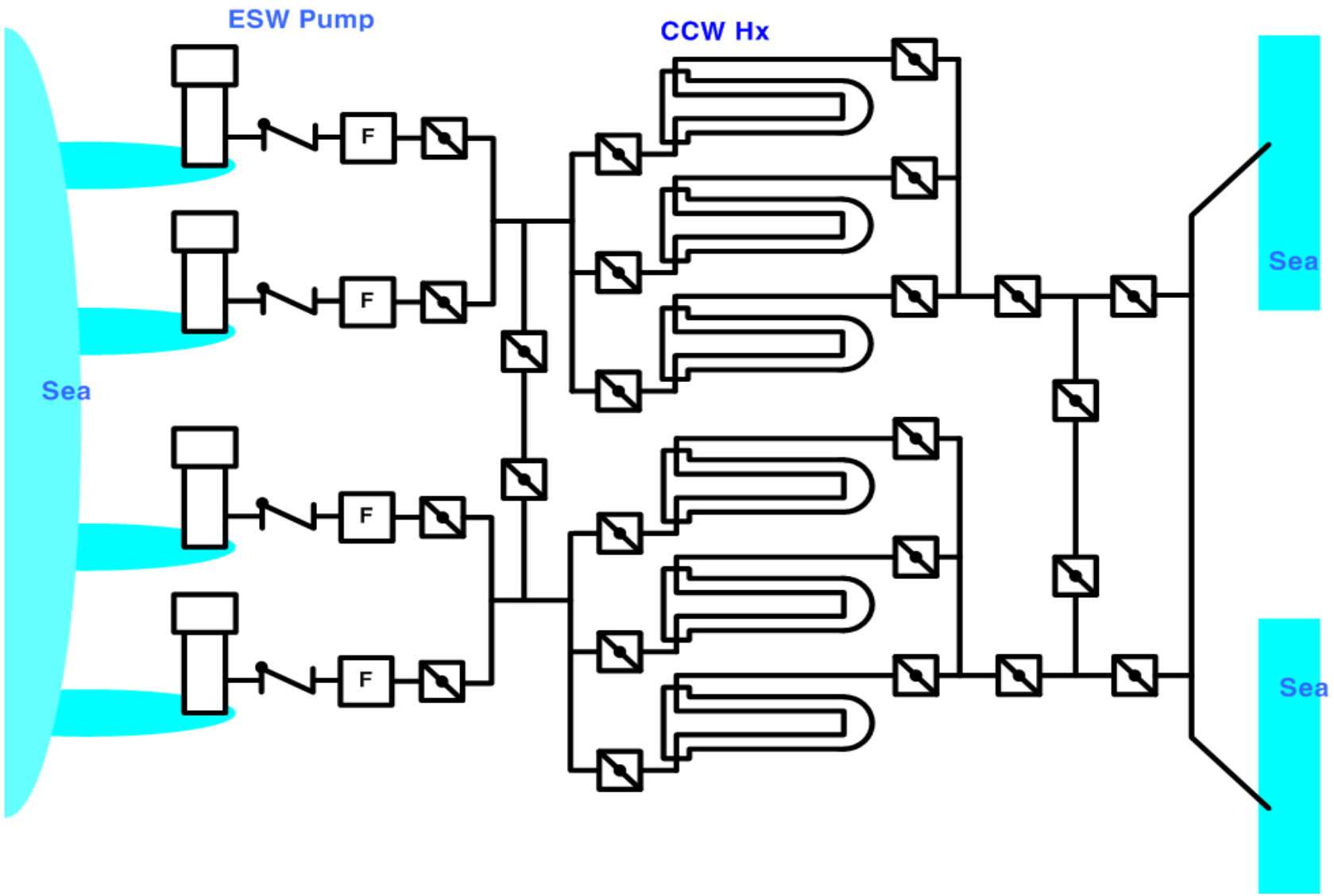


ESWS (Essential Service Water System)

- Open loop, two independent trains
- Provide cooling water
  - CCWS HX, emergency diesel generator HXs, ESW pump room coolers
- Since the water is frequently drawn from an adjacent river, the sea, or other large body of water, the system can be endangered by large volumes of seaweed, marine organisms, oil pollution, ice and debris.
- In locations without a large body of water in which to dissipate the heat, water is recirculated via a cooling tower.

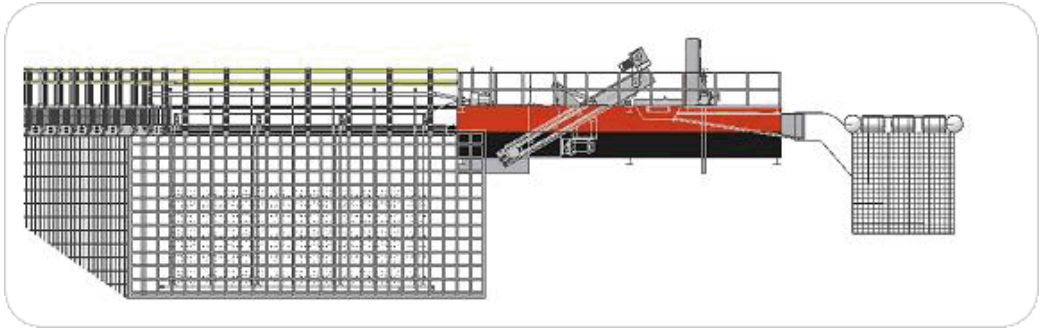


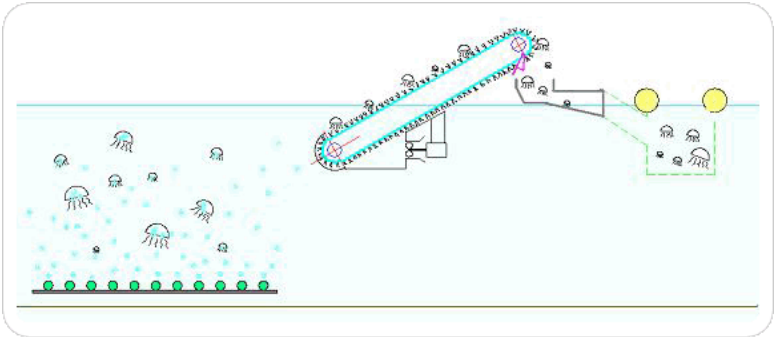
ESWS (Essential Service Water System)



ESWS (Essential Service Water System)

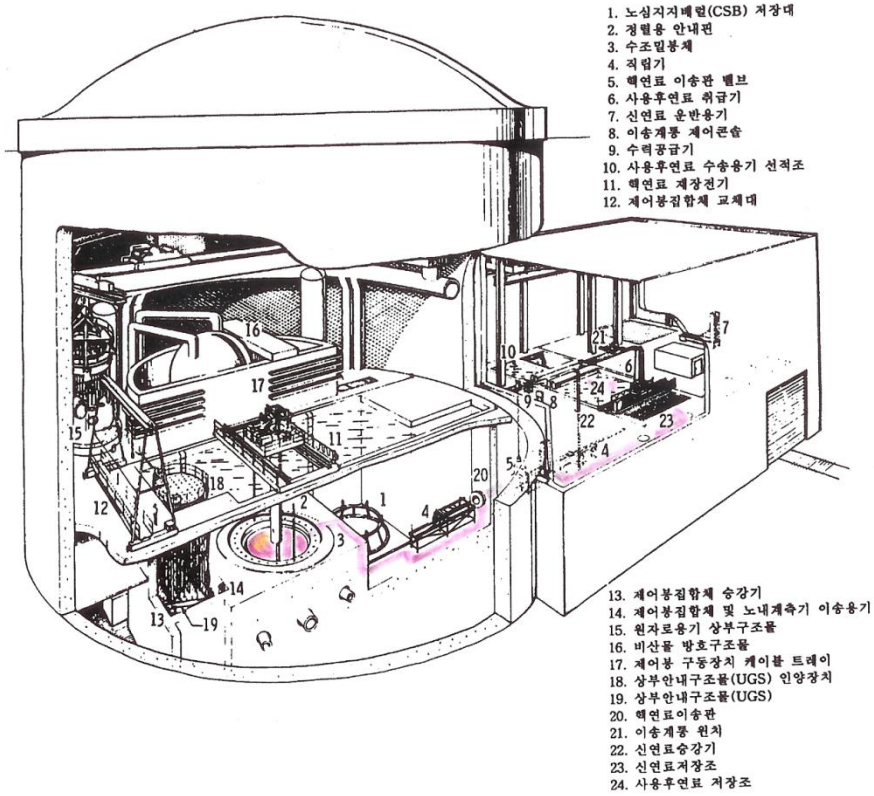
- 운전경험
  - 해수 취수구 이물질, 가시고기, 해파리, 새우 떼 유입에 의한 발전정지 및 원자로 정지
  - 1988 고리4호기
    - 가시고기떼 유입으로 순환수계통 압력 상승 ⇒ 원자로 수동정지
  - 1991 고리4호기
    - 태풍 글래디스의 영향으로 취수구에 다량의 오물이 유입
    - 2차 기기냉각해수 유량상실 ⇒ 2차측 기기온도 증가 / 복수기 진공 저하 ⇒ 터빈 및 원자로 정지
  - 2001 울진1,2호기, 2006 울진1,2호기
    - 새우떼 취수구 유입 ⇒ 순환수펌프 정지 ⇒ 복수기 진공 저하 ⇒ 주급수펌프 정지 ⇒ 원자로 정지
  - 2014 월성 3호기
    - 월성3호기 계획예방정비 중 취수구 잠수작업자 인명사고 발생



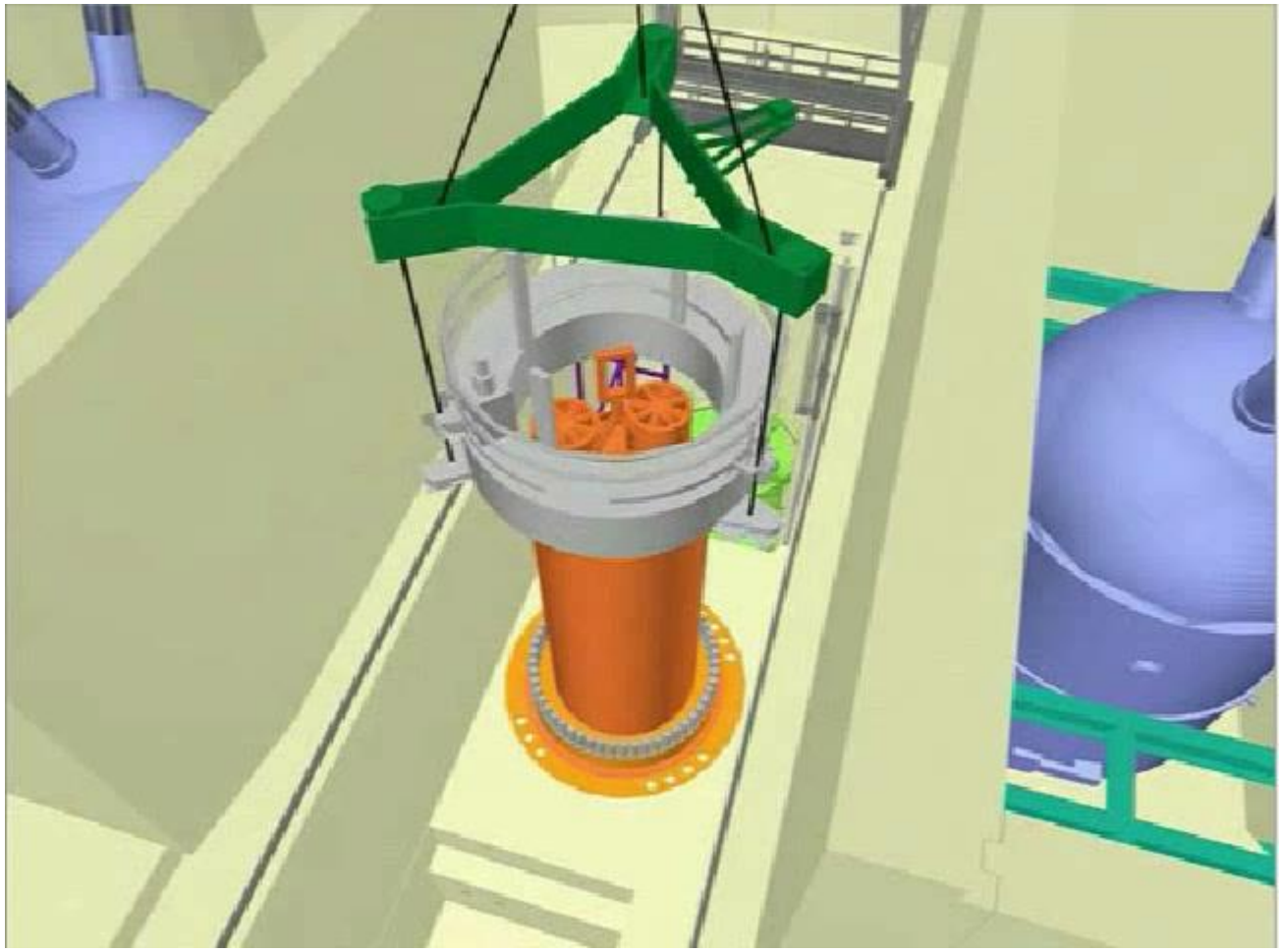


Fuel Storage and Handling System

- Nuclear fuel
  - Contains fissile material and, after irradiation, highly radioactive fission and activation products.
- The most significant design features
  - Provide the necessary assurances that the fuel and core components can be received, handled, stored and retrieved without undue risk to health, safety or the environment.
  - Maintaining subcriticality of the fuel
  - Ensuring the integrity of the fuel
  - Cooling irradiated fuel
  - Ensuring radiation protection and safety in accordance with the Basic Safety Standards
  - Preventing unacceptable releases of radioactive material to the environment.

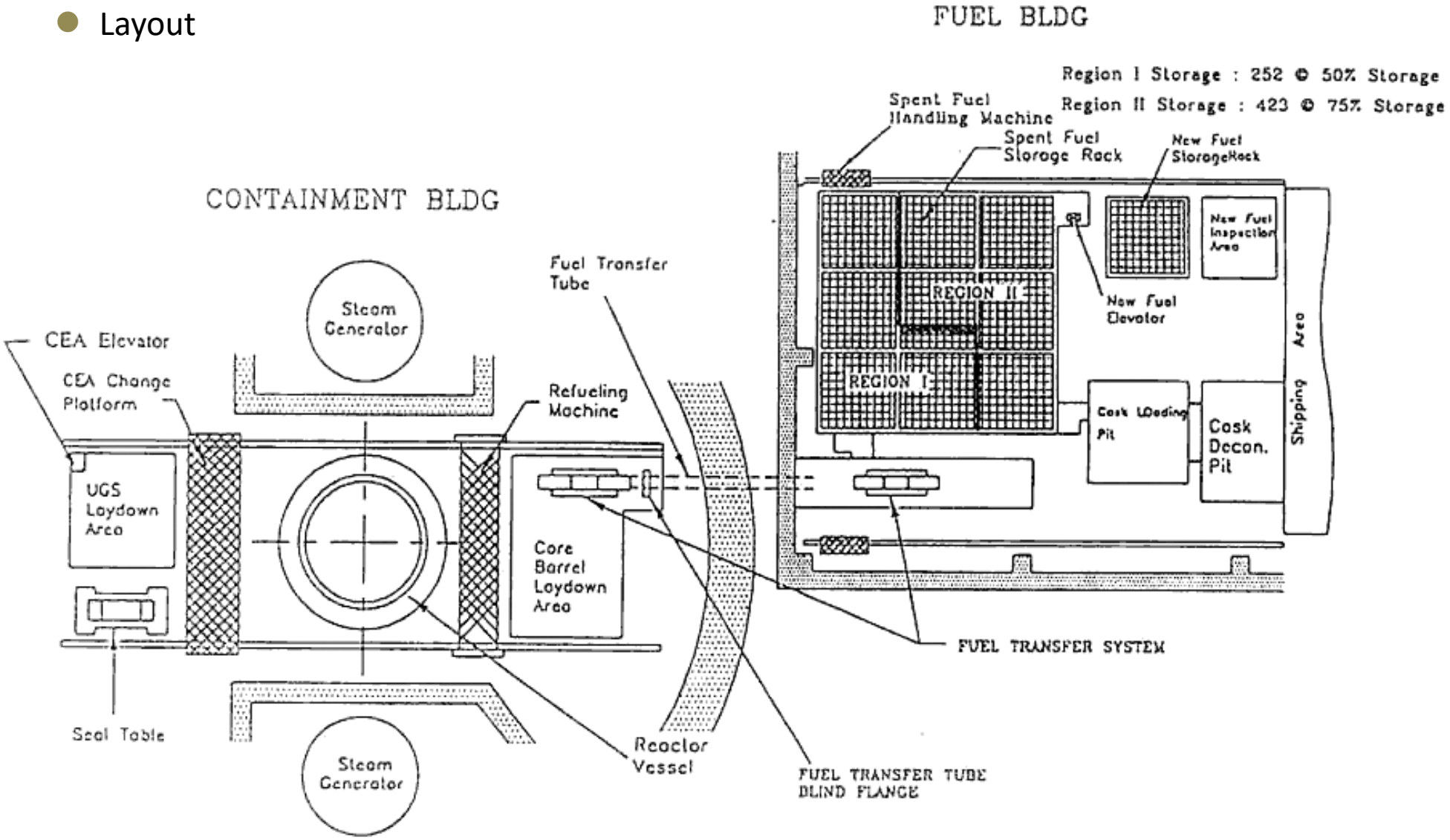


❖ Fuel Storage and Handling System

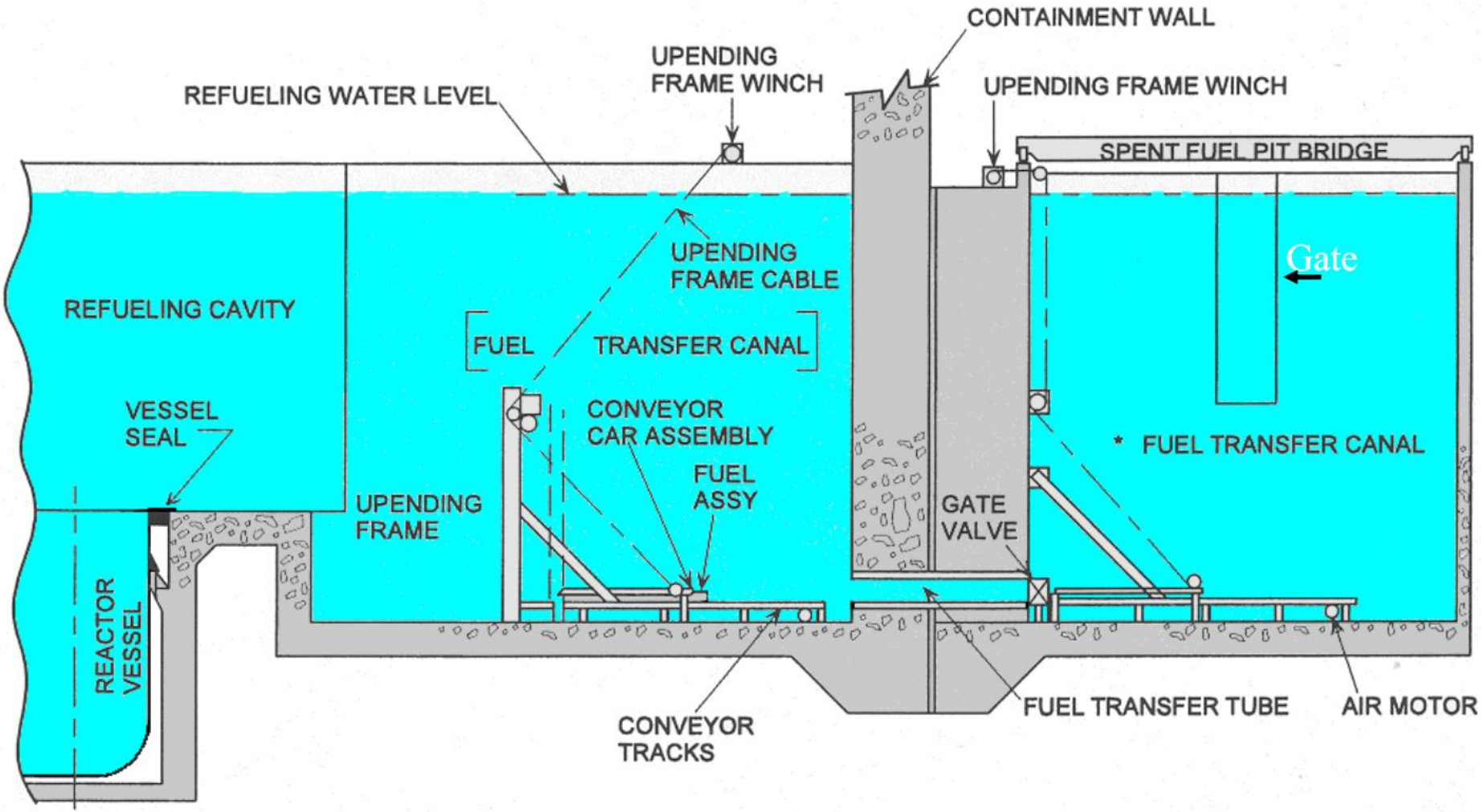


Fuel Storage and Handling System

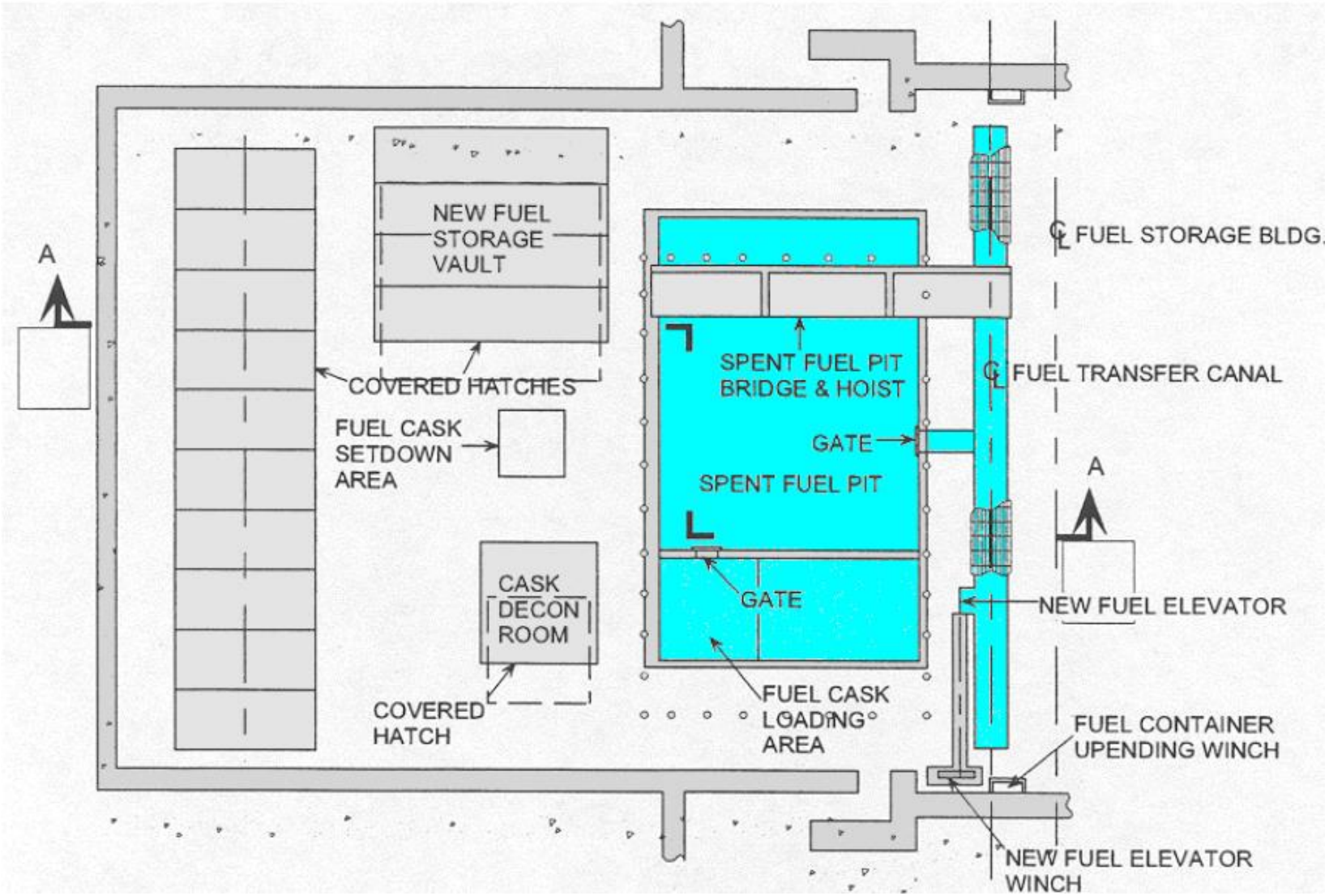
- Layout



❖ Fuel Storage and Handling System

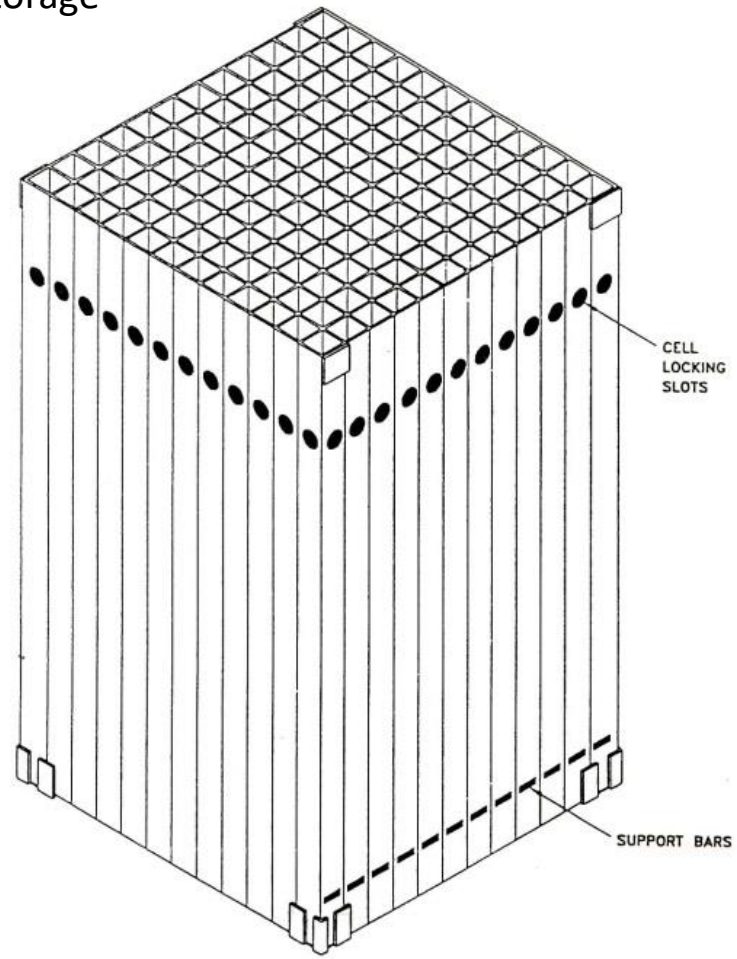


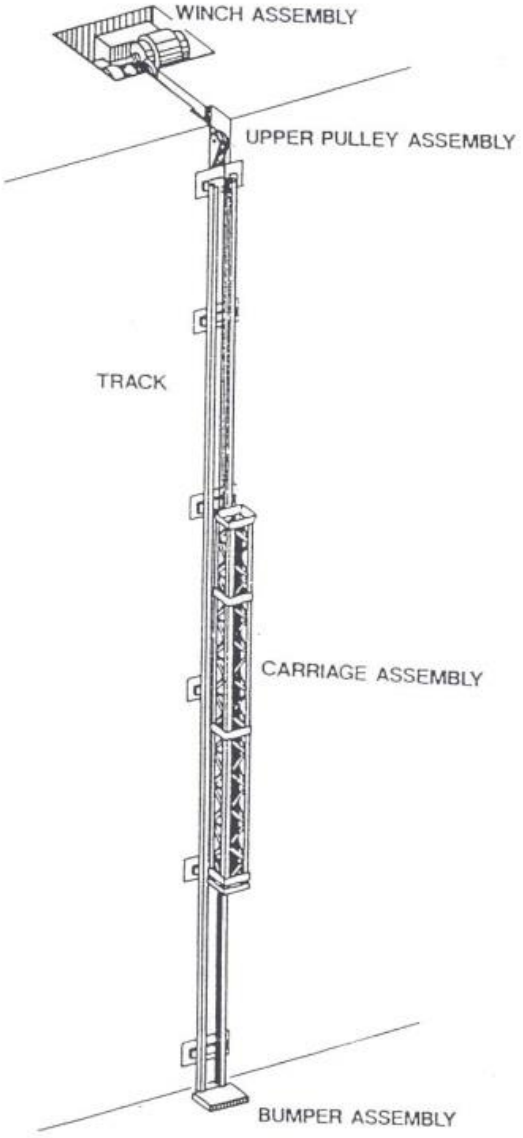
❖ Fuel Storage and Handling System



Fuel Storage and Handling System

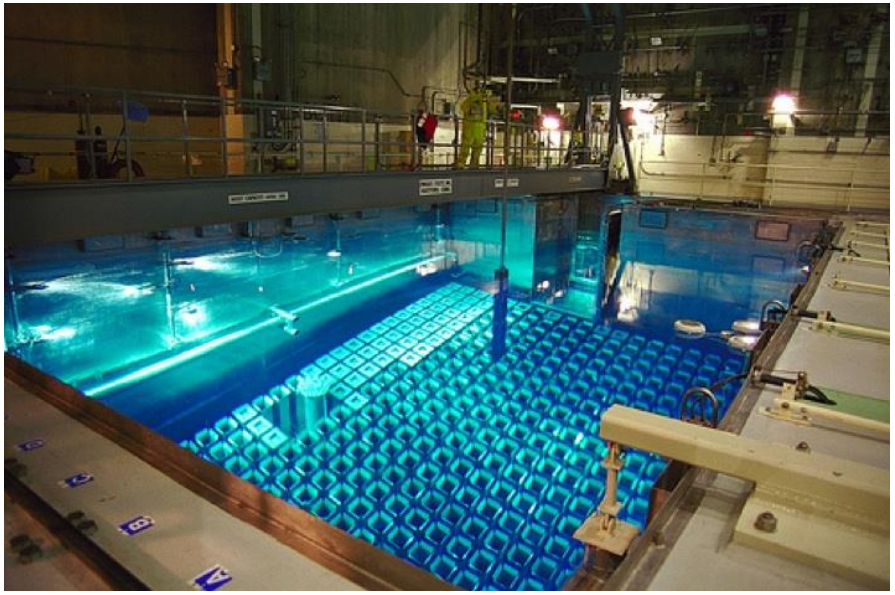
- Fresh fuel (new fuel)
  - Fuel storage racks/ New fuel elevator
  - Dry storage

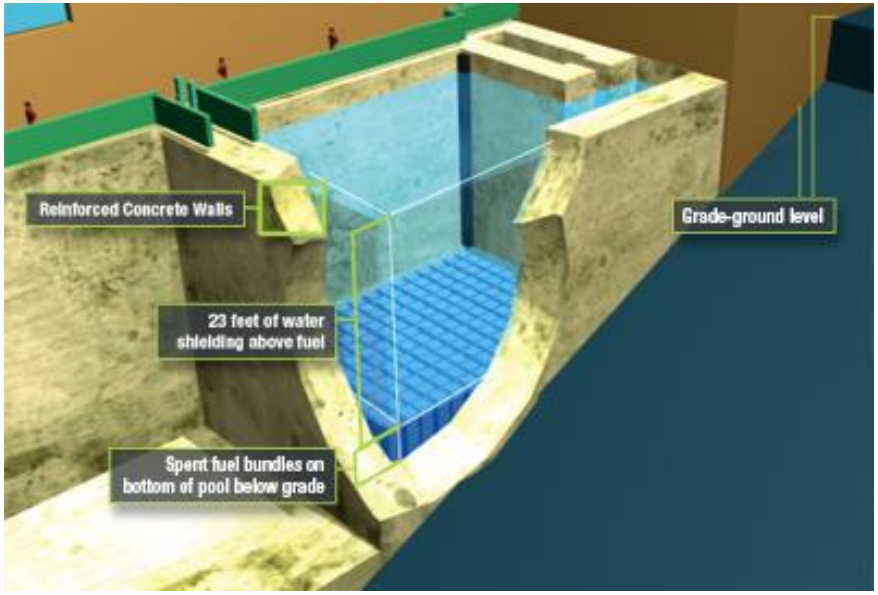




Fuel Storage and Handling System

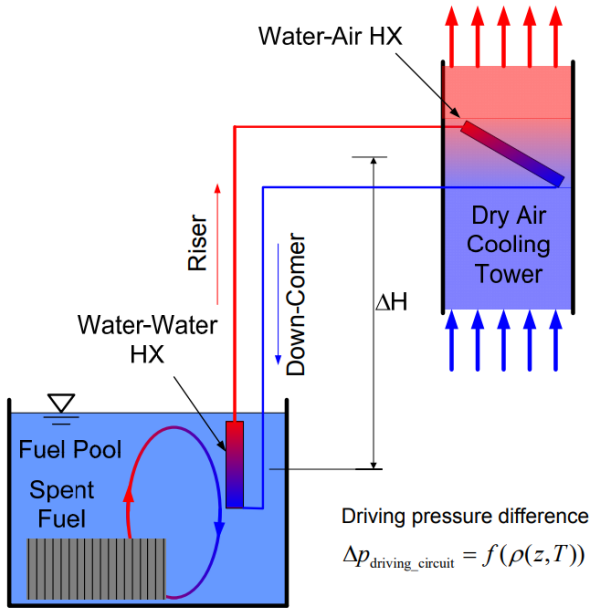
- Spent fuel pools
  - Located inside the plant's protected area.
  - Contain an enormous quantity of water, which acts to cool the fuel and provide radiation shielding.
  - Have no drains that would allow the water to drain out. Can be filled using a variety of water sources, if needed.
  - Have large safety margins, including about 20 feet of water above the top of the fuel
  - Are robust, with very thick, steel-reinforced concrete walls and stainless-steel liners.
  - May be located below ground level, shielded by other structures, or surrounded by walls that would protect the pool from a plane crash or other impact.

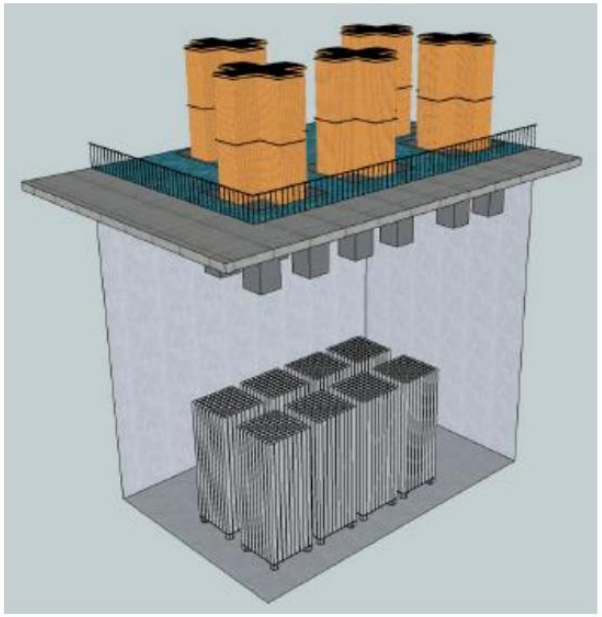


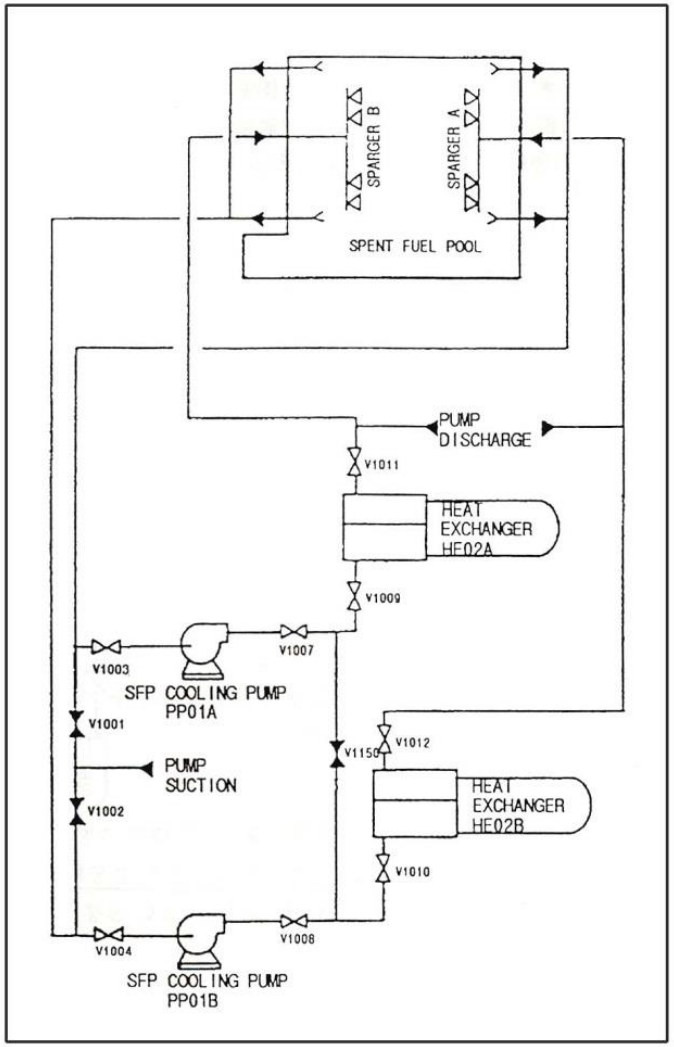


Spent Fuel Pool Cooling and Clean up System (SFPCCS)

- Spent fuel pool cooling
  - To remove decay heat from the spent fuel
  - To maintain the water pool temperature, T_{bulk}<60°C







Contents

- History of PWR
- Plant Overall
- Reactor Coolant System
- Steam and Power Conversion System
- Auxiliary System
- Plant Protection System
- Other systems

Main Steam System
Condensate System
Main Feedwater System

CWS
CVCS
CCWS
ESWS
Fuel Storage and Handling System
Spent Fuel Pool Cooling and Clean up System (SFPCCS)
ESF (Engineered Safety Features)

Engineered Safety Features

ESF (Engineered Safety Features)

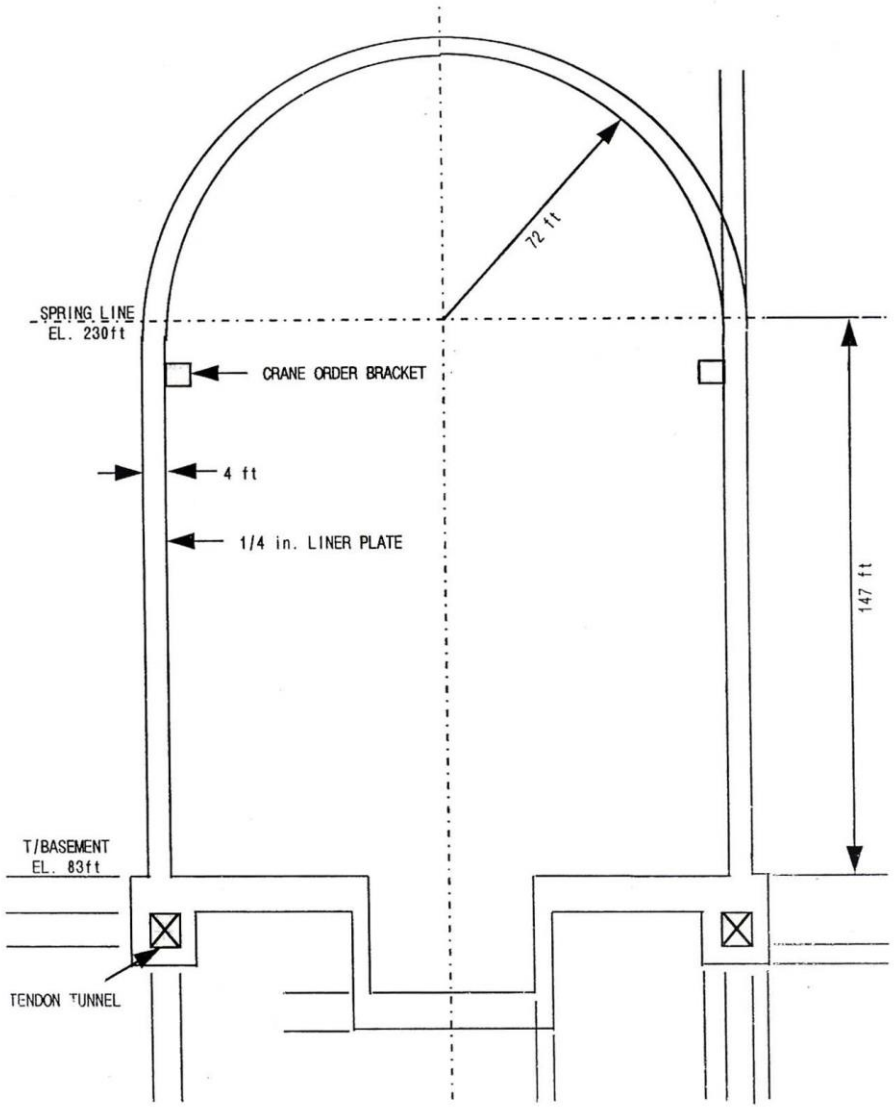
- Reactor shut down
- Remove decay heat
- Minimize the radioactivity release

- Functions
  - To localize, control, mitigate and terminate accidents
  - To hold exposure levels below the limits
- Containment system
  - The containment structure which forms a virtually leak tight barrier to the escape of fission product
- Containment spray system
  - To reduce containment pressure and remove iodine from the containment atmosphere after a primary or secondary pipe break inside containment.
- Safety injection system
  - To provide borated water to cool the reactor core in the event of an accidental depressurization
  - The combination of control rods and the boron in the injection water provides the necessary negative reactivity to maintain the reactor shutdown.
- Shutdown cooling system
  - To maintain the RCS at refueling temperature for extended period.
- Auxiliary feedwater system
  - To provide emergence heat removal capability upon loss of normal feedwater.
- Safety depressurization system
  - To provide a manual means of rapidly depressurizing the RCS

Engineered Safety Features

ESF (Engineered Safety Features)

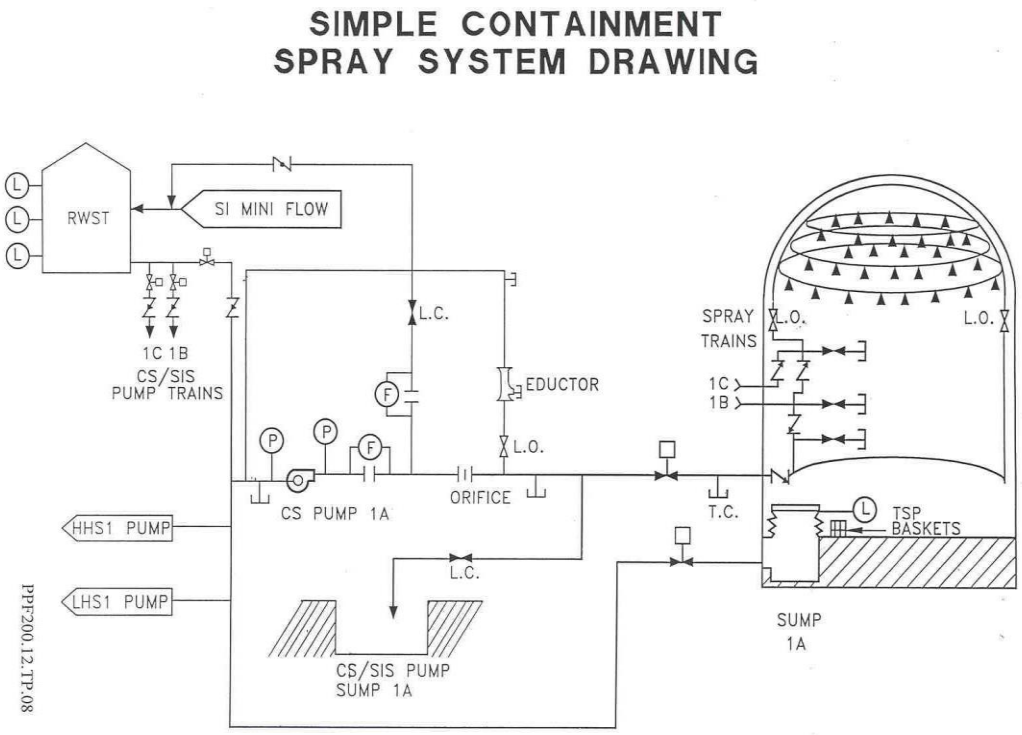
- Containment system
  - Design pressure: ~ 4 bar
  - Internal diameter: ~ 44 m, thickness: ~ 1.2 m
  - Dome radius: ~ 21.9 m
  - Height: ~ 66 m

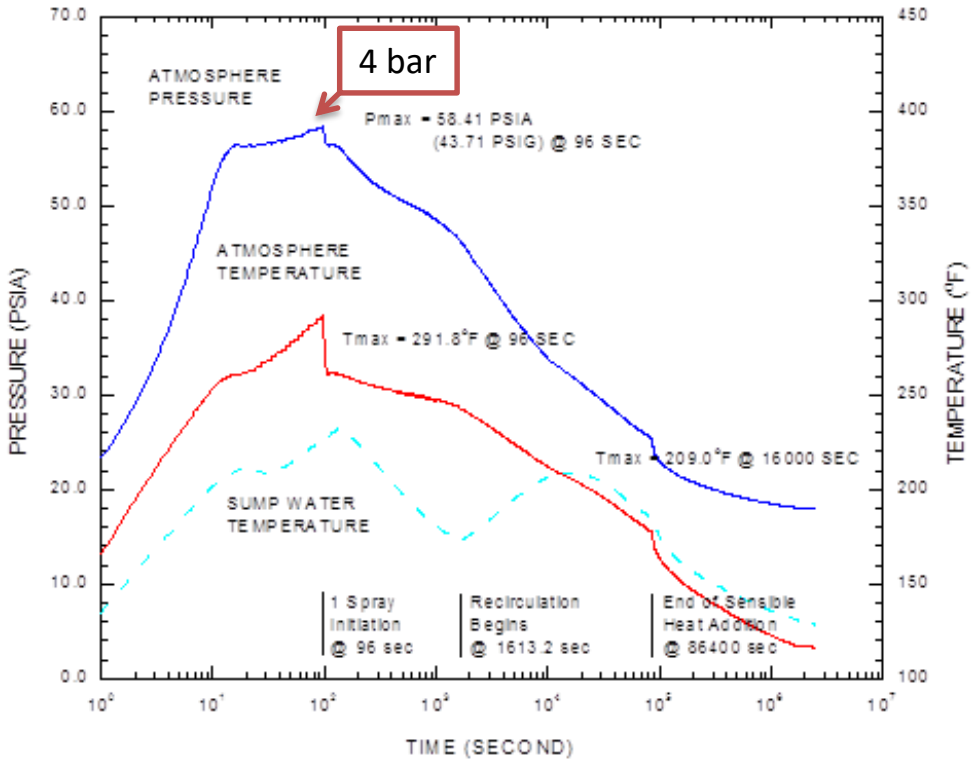


Engineered Safety Features

ESF (Engineered Safety Features)

- Containment spray system

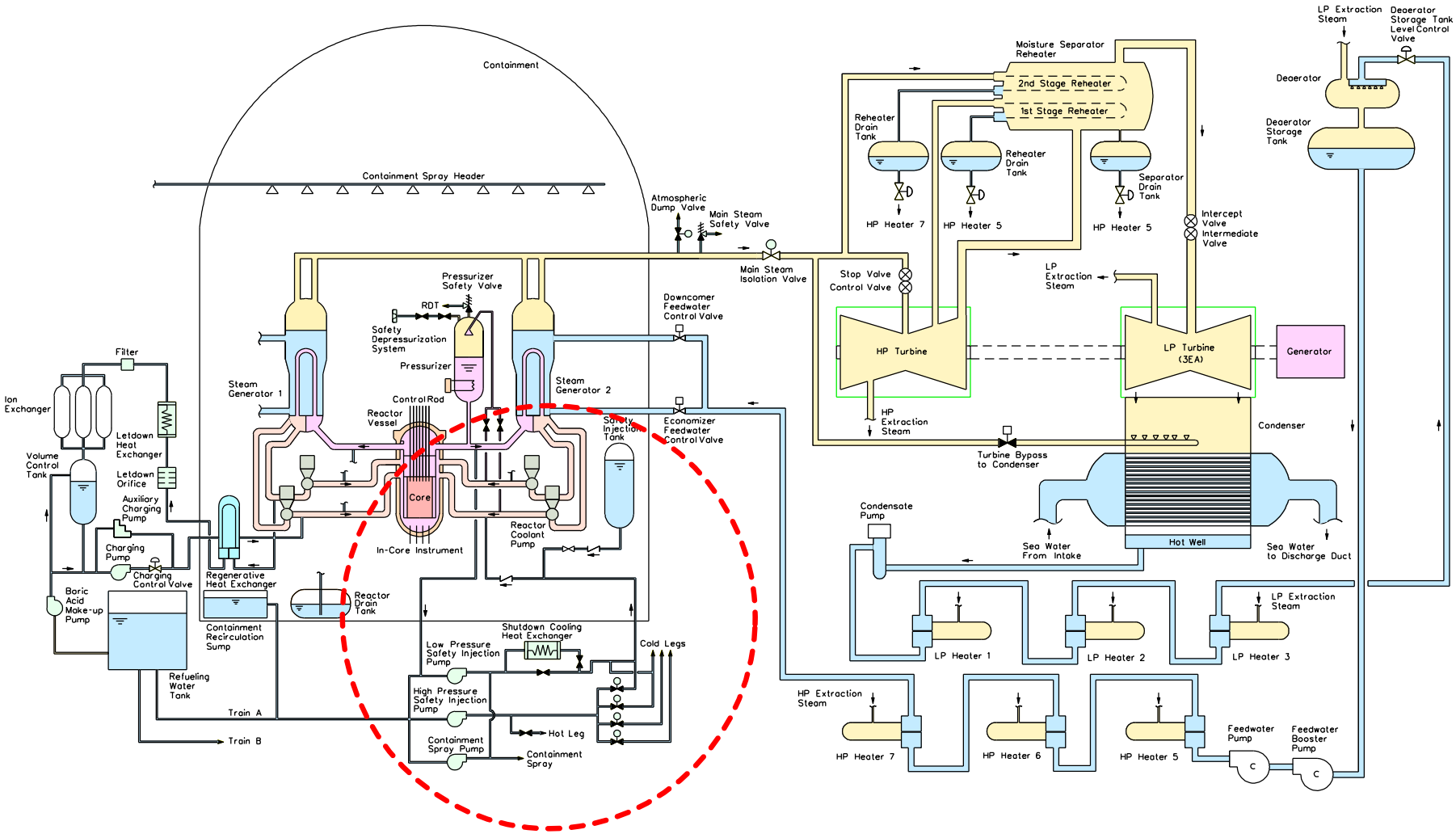




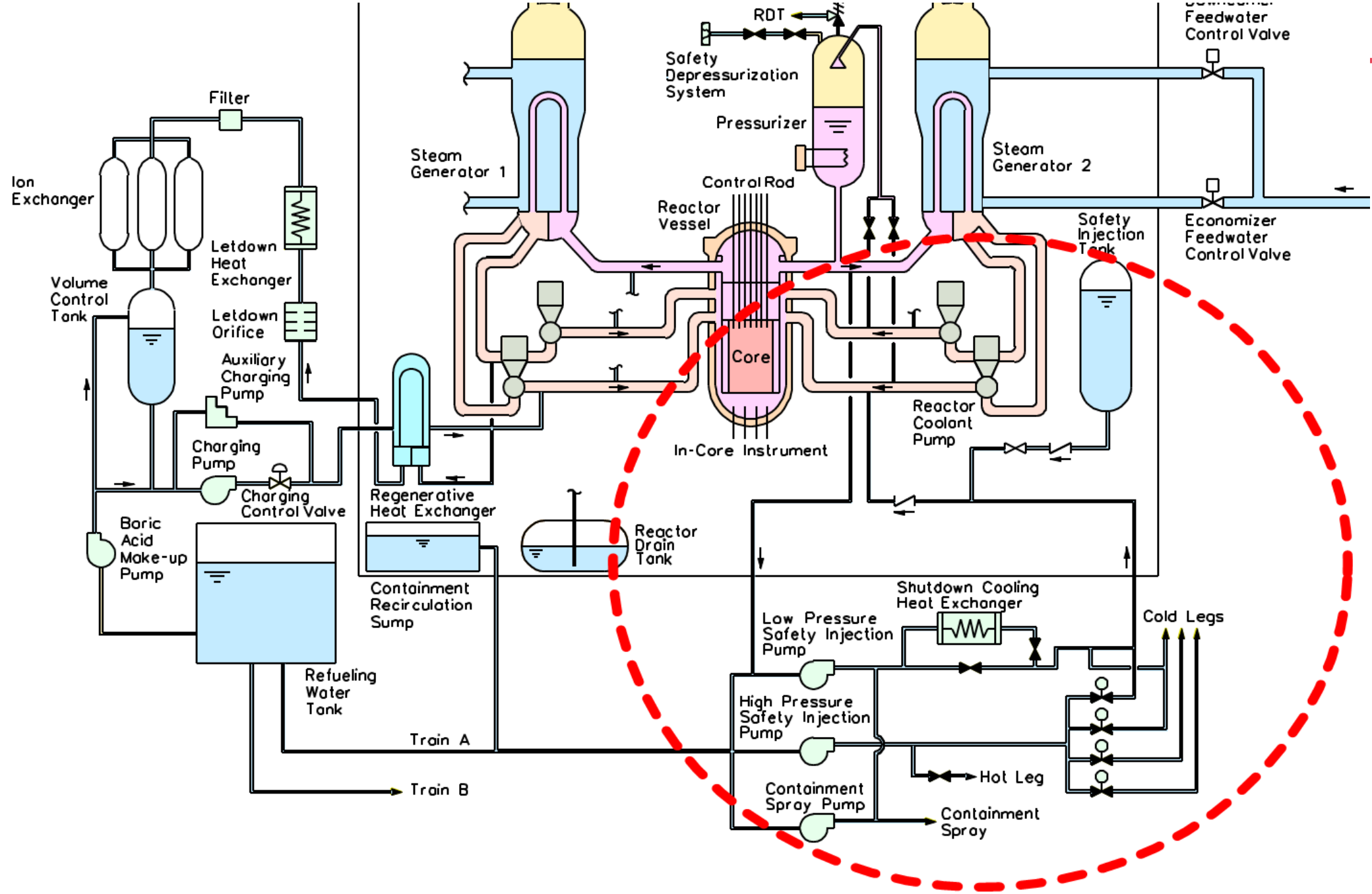
Engineered Safety Features

ESF (Engineered Safety Features)

- SIS (Safety Injection System)/ ECCS (Emergency Core Cooling System)



Safety Injection Systems


RDT
Safety Depressurization System
Pressurizer
Steam Generator 1
Steam Generator 2
Control Rod
Reactor Vessel
Core
In-Core Instrument
Reactor Coolant Pump
Safety Injection Tank
Feedwater Control Valve
Economizer Feedwater Control Valve
Filter
Ion Exchanger
Letdown Heat Exchanger
Letdown Orifice
Volume Control Tank
Auxiliary Charging Pump
Charging Pump
Charging Control Valve
Regenerative Heat Exchanger
Reactor Drain Tank
Baric Acid Make-up Pump
Containment Recirculation Sump
Refueling Water Tank
Train A
Train B
Shutdown Cooling Heat Exchanger
Low Pressure Safety Injection Pump
High Pressure Safety Injection Pump
Containment Spray Pump
Containment Spray
Hot Leg
Cold Legs

Engineered Safety Features

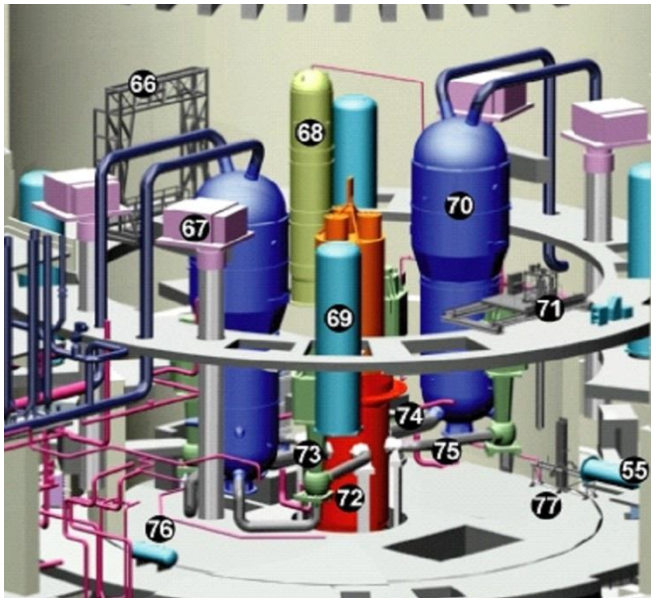
ESF (Engineered Safety Features)

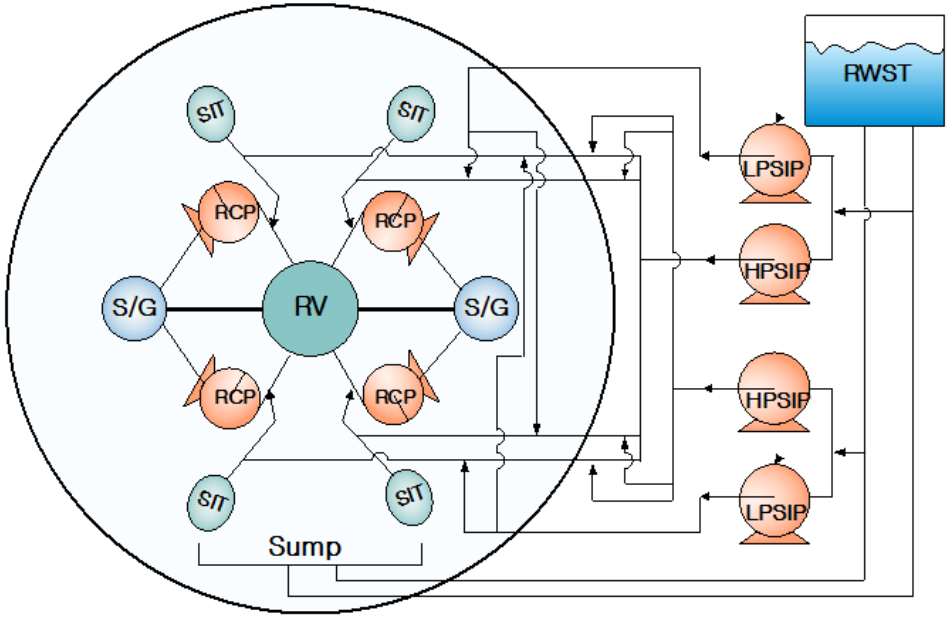
- SIS (Safety Injection System)
  - OPR1000: HPSI, SIT, LPSI
  - APR1400: HPSI, SIT

- High pressure safety injection pump
  - 1 pump: connected to 4 cold legs & 1 hot leg

- Safety injection tank
  - 1 tank: connect to 1 cold leg
  - D=2.74 m
  - H=13.6 m

- Low pressure safety injection pump
  - 1 pump: connected to 2 cold legs

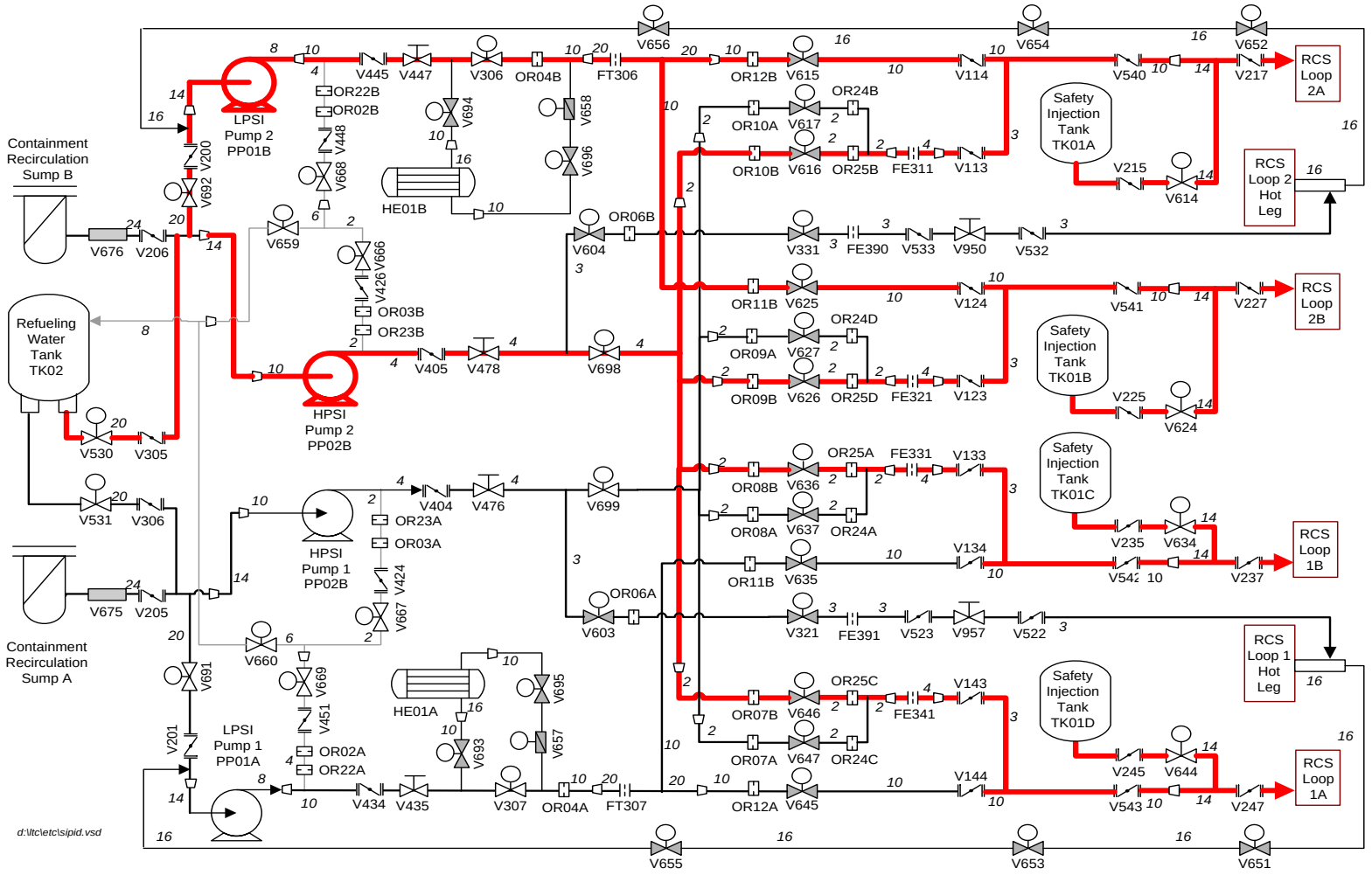




Engineered Safety Features

ESF (Engineered Safety Features)

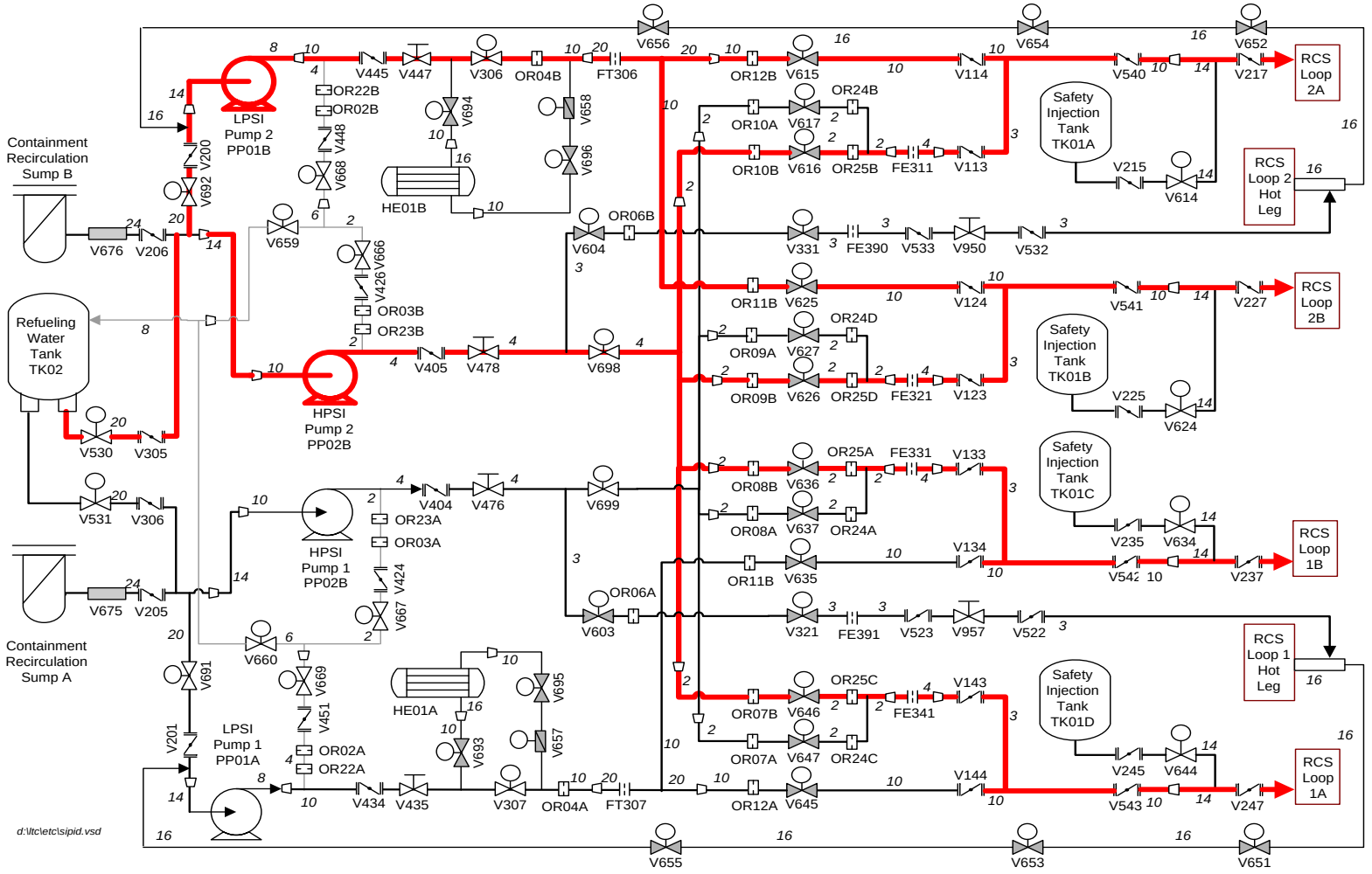
- SIS (Safety Injection System)/ ECCS (Emergency Core Cooling System)



Engineered Safety Features

ESF (Engineered Safety Features)

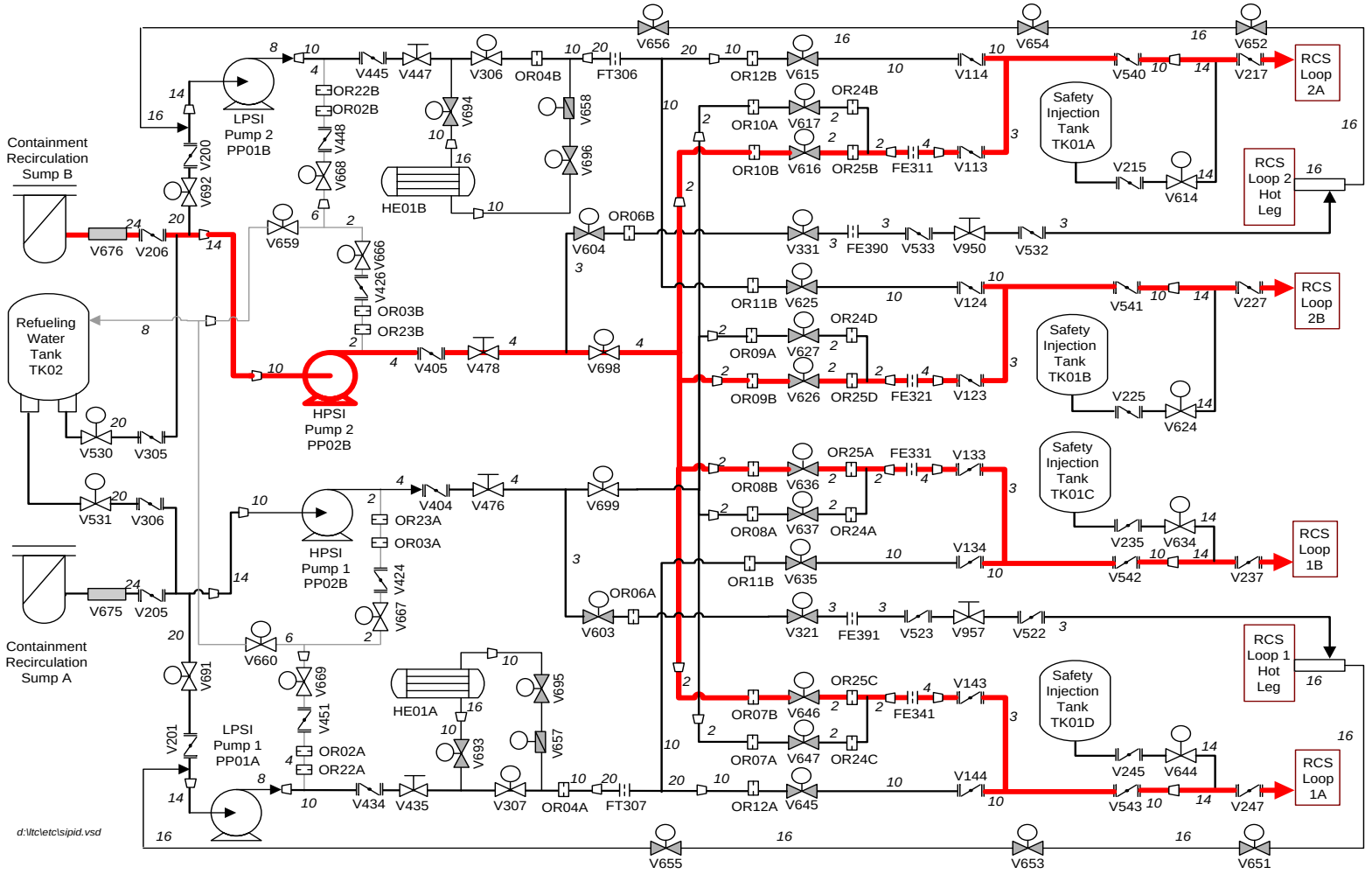
- SIS (Safety Injection System)/ ECCS (Emergency Core Cooling System)



Engineered Safety Features

ESF (Engineered Safety Features)

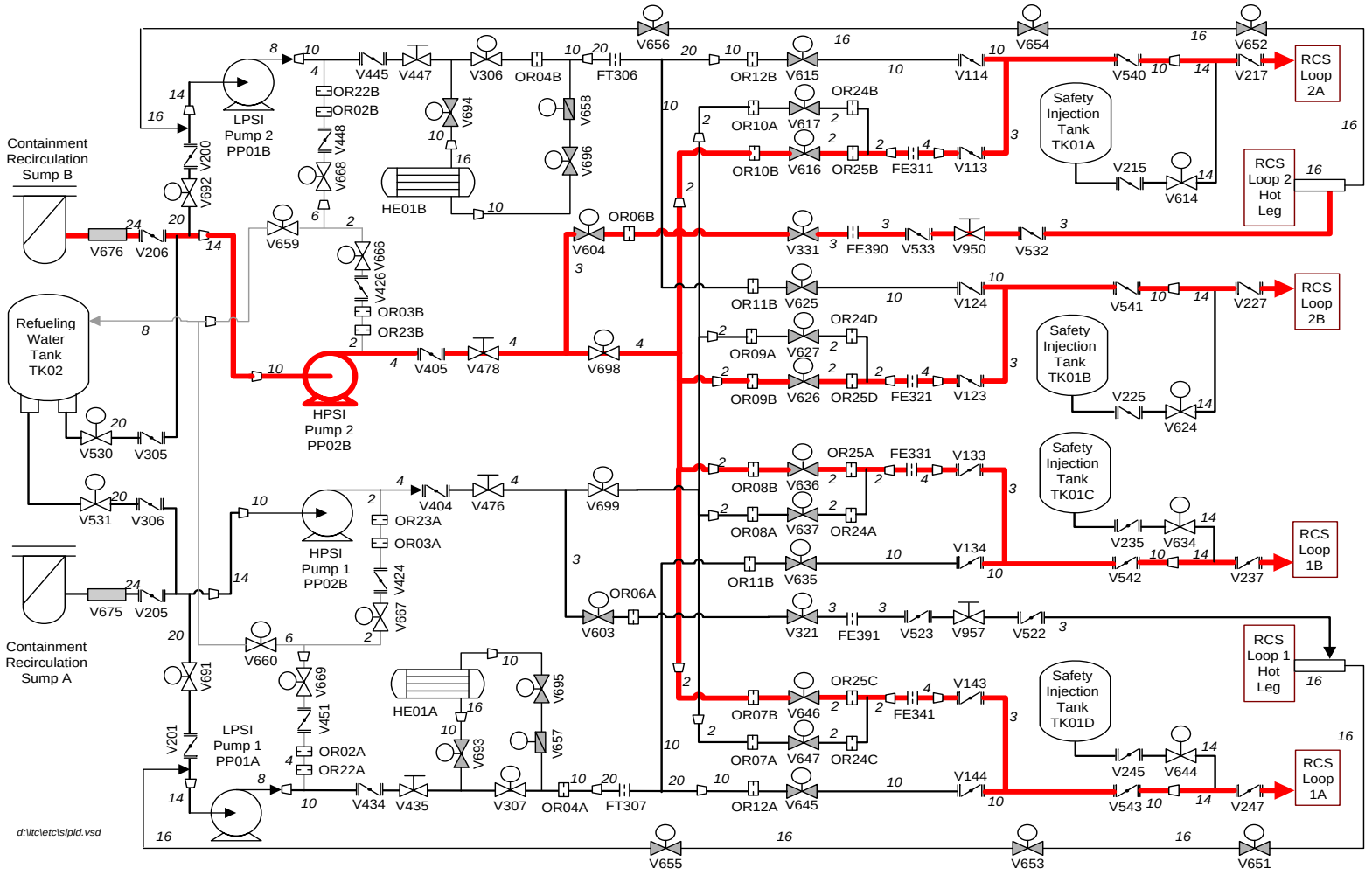
- SIS (Safety Injection System)/ ECCS (Emergency Core Cooling System)



Engineered Safety Features

ESF (Engineered Safety Features)

- SIS (Safety Injection System)/ ECCS (Emergency Core Cooling System)



Safety injection mode

- Injection mode
  - HPSI : 안전주입신호로 기동, 124 bars
  - SIT: 42~44 bars
  - LPSI: 안전주입신호로 기동, 14 bars

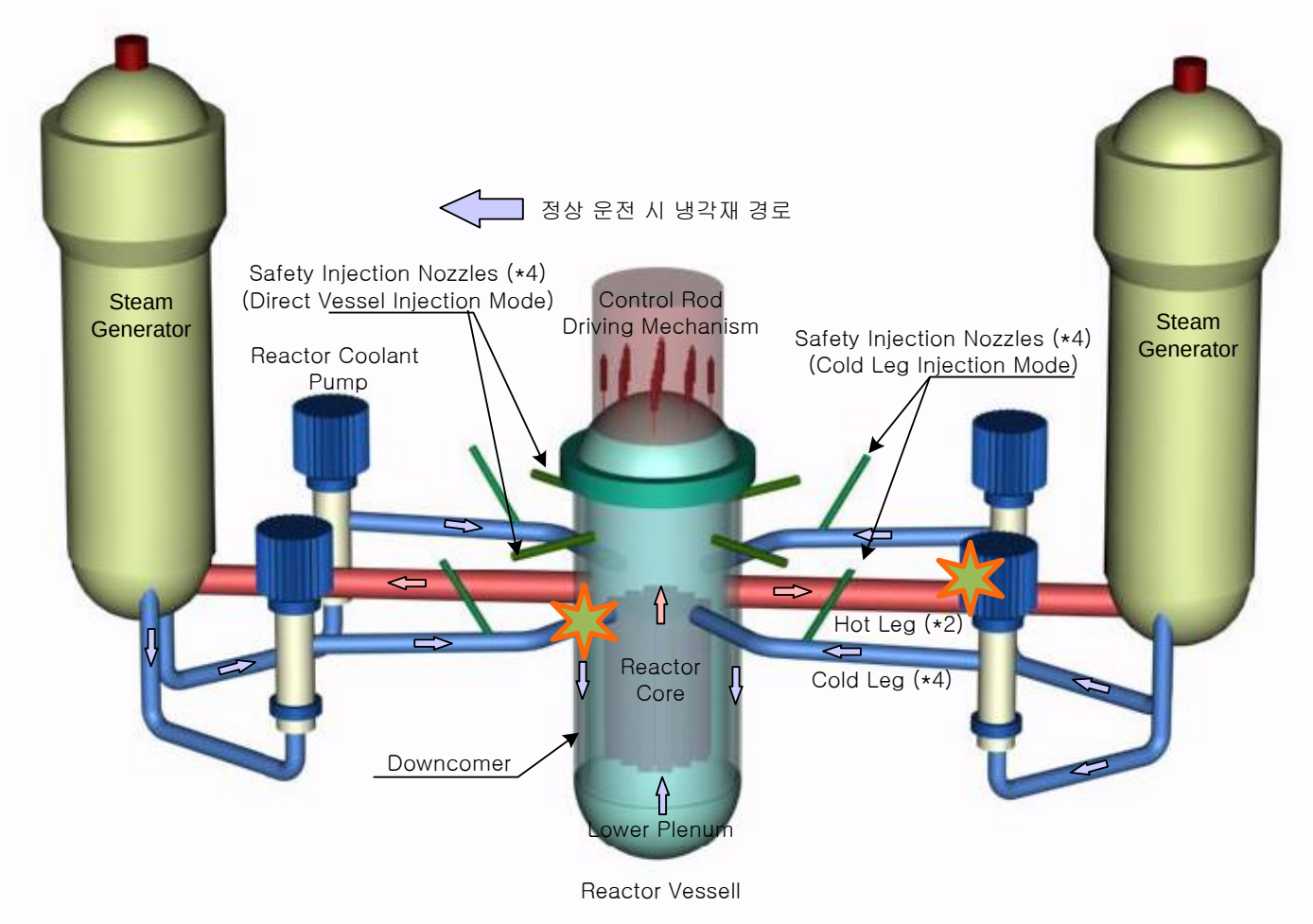
- Short-term recirculation mode
  - RWT 저수위 (7.6 %)
  - HPSI: cold leg injection
  - LPSI 정지

- Long-term recirculation mode
  - 안전주입 발생 후 4시간 이내에 정지냉각 불만족 시
  - HPSI: simultaneous injection

안전주입신호(SIAS)			
작 동 신 호	설 정 치	동시성	비고
격납용기 고-압력	133㎝H_2O	2/4	
가압기 저-압력	124kg/cm^2a	2/4	WR
수 동	수동 스위치	2/4	

ESF (Engineered Safety Features)

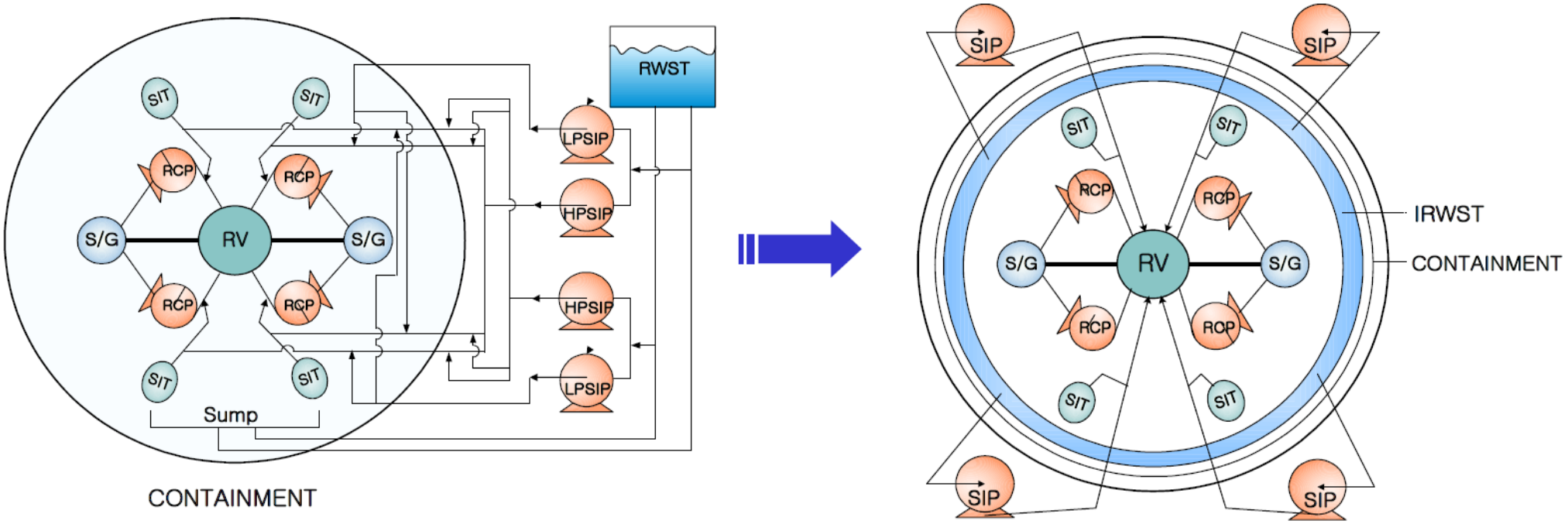
- SIS (Safety Injection System)/ ECCS (Emergency Core Cooling System)
  - OPR1000: HPSI, SIT, LPSI
  - APR1400: HPSI, SIT



Engineered Safety Features

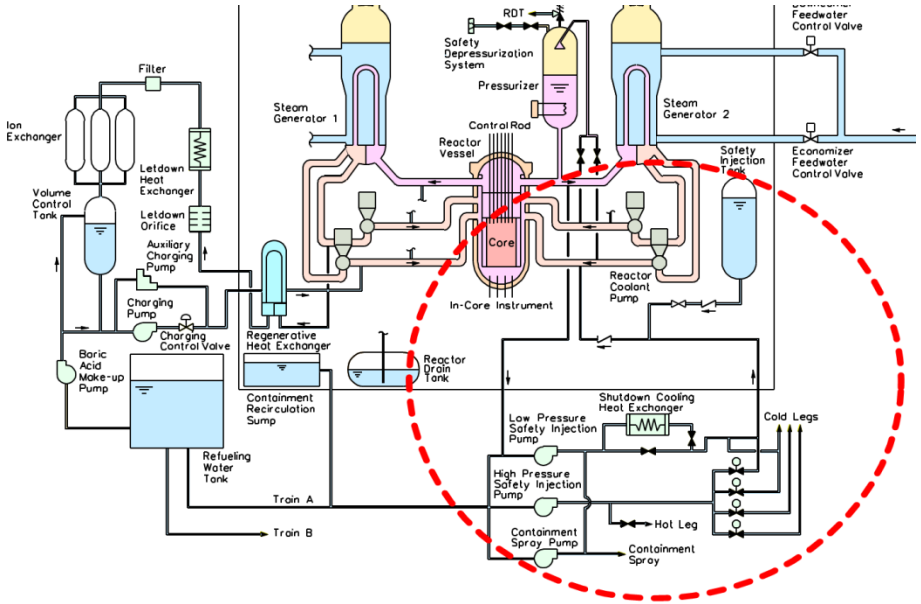
ESF (Engineered Safety Features)

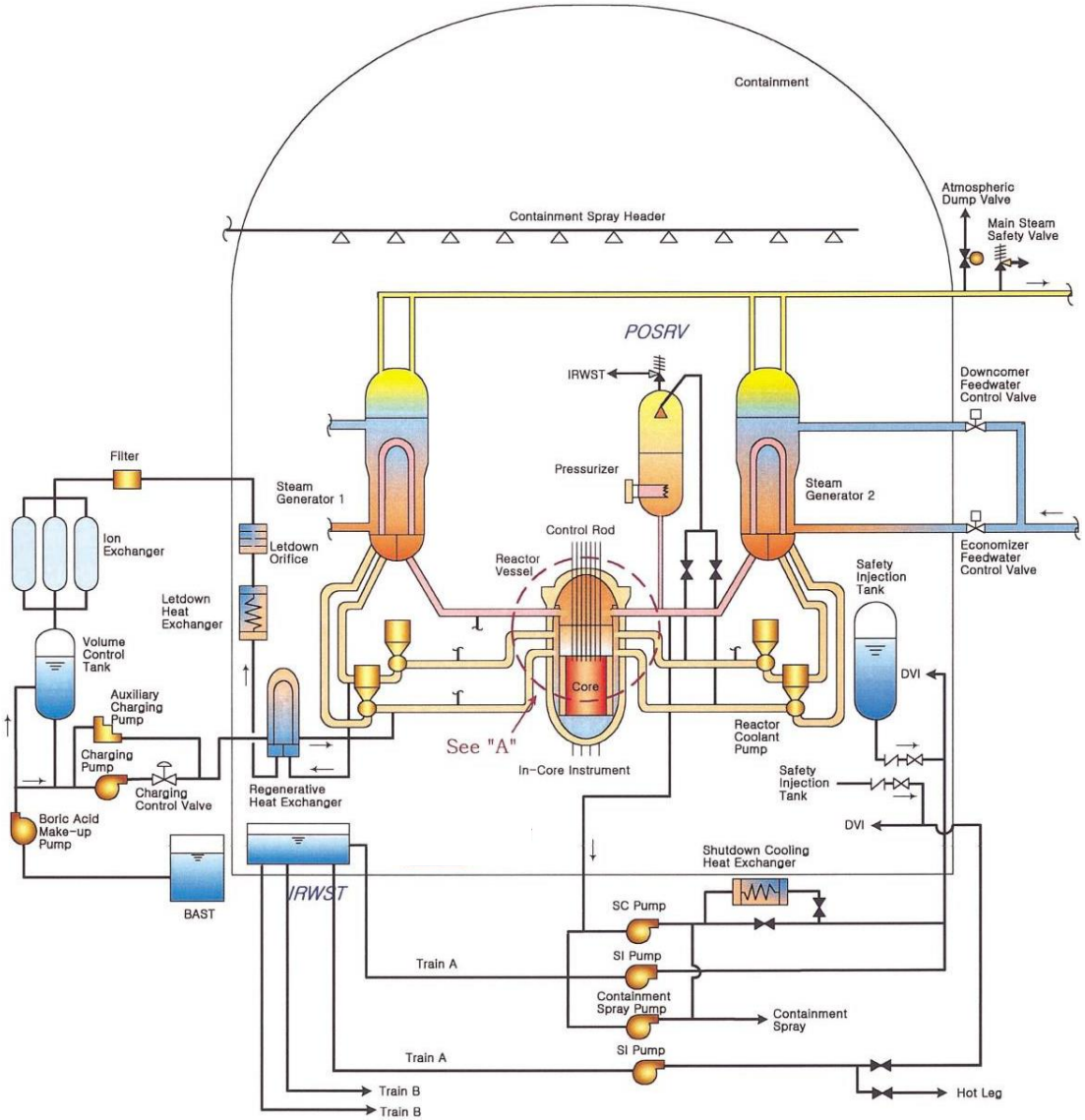
- SIS (Safety Injection System)/ ECCS (Emergency Core Cooling System)
  - OPR1000: HPSI, SIT, LPSI
  - APR1400: HPSI, SIT
  - Simplified SIS
  - 4 mechanical trains with 2 electrical trains



Engineered Safety Features

- **ESF (Engineered Safety Features)**
  - OPR1000 vs. APR1400

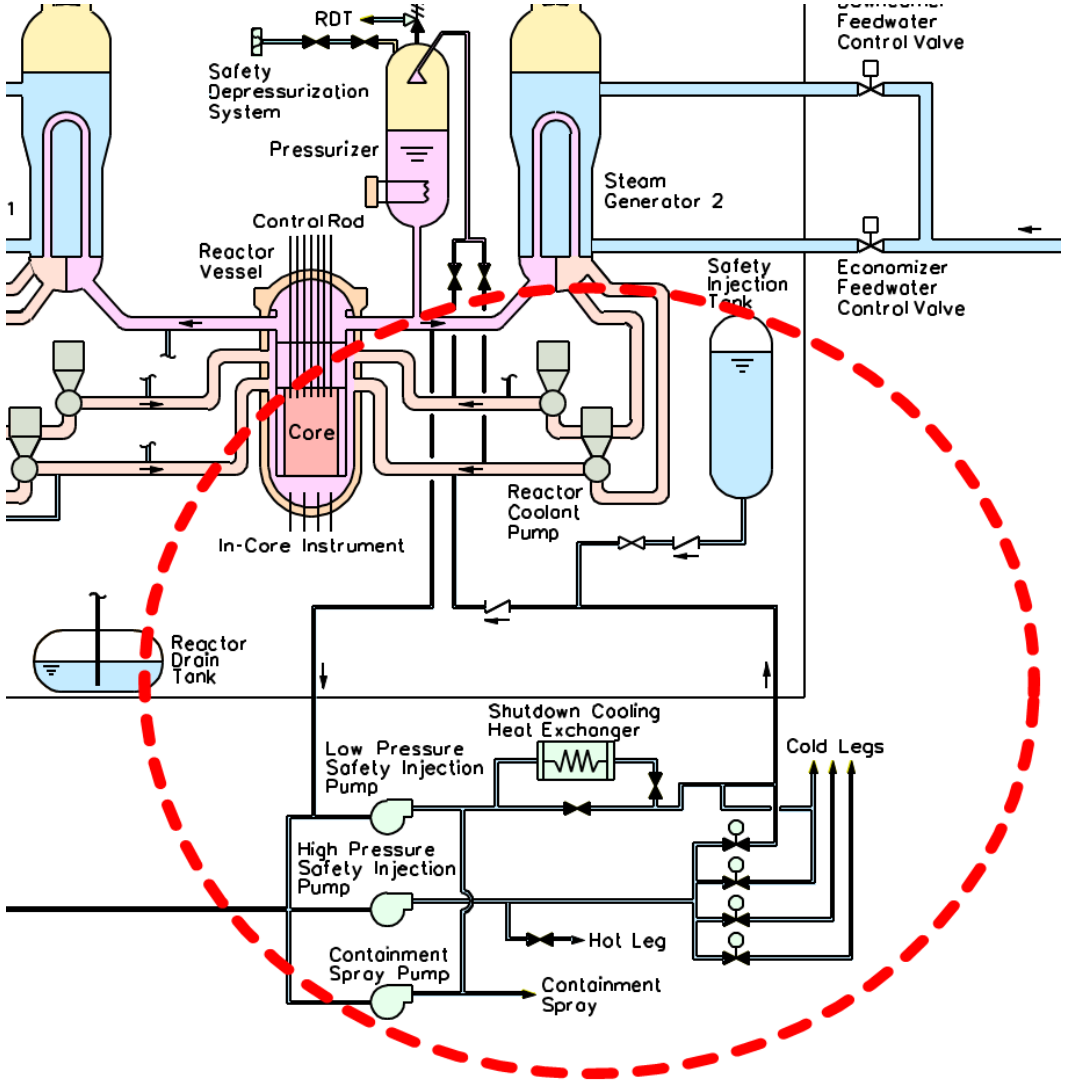




Engineered Safety Features

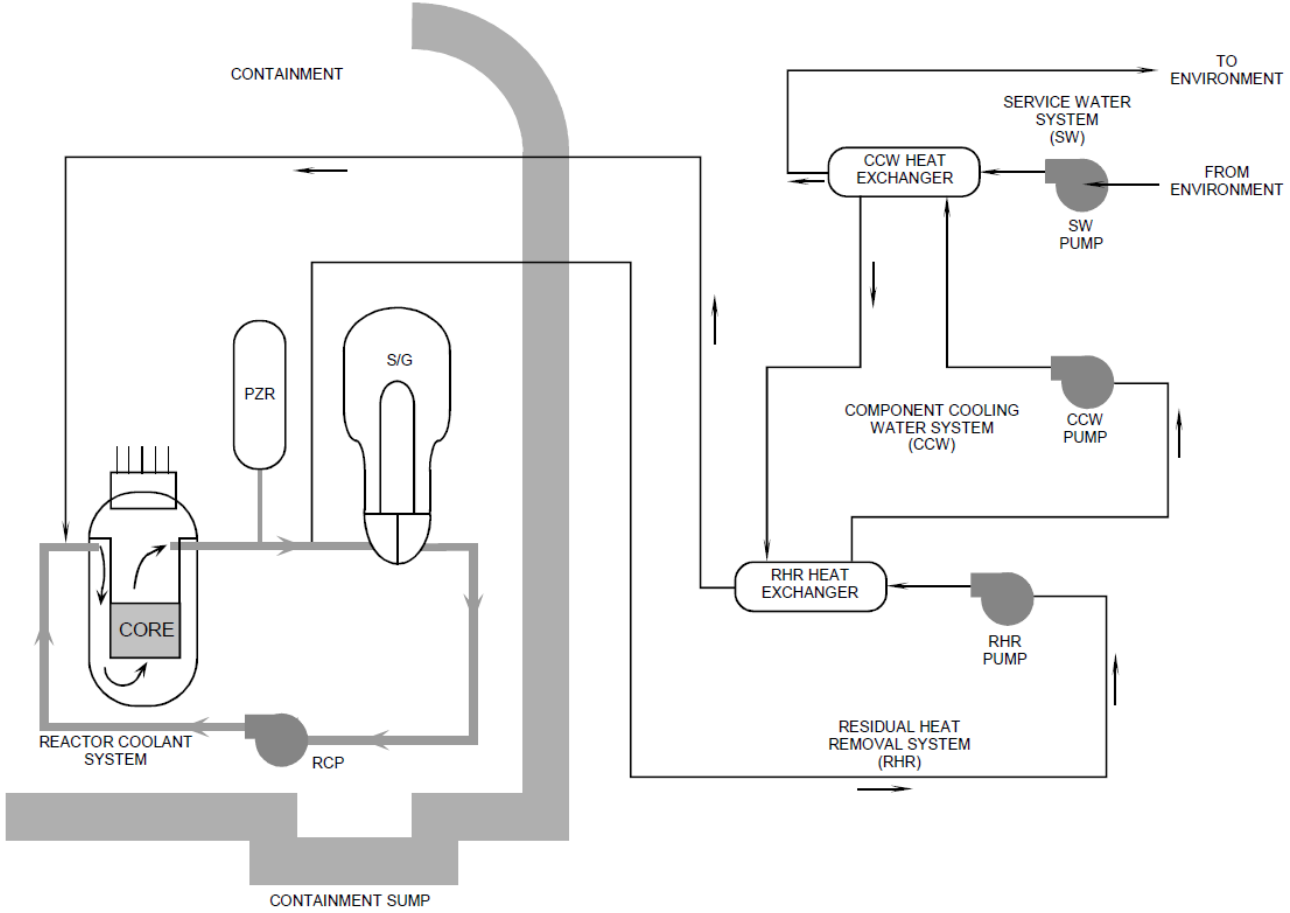
ESF (Engineered Safety Features)

- SCS (Shutdown Cooling System)/ RHRS (Residual Heat Removal System)



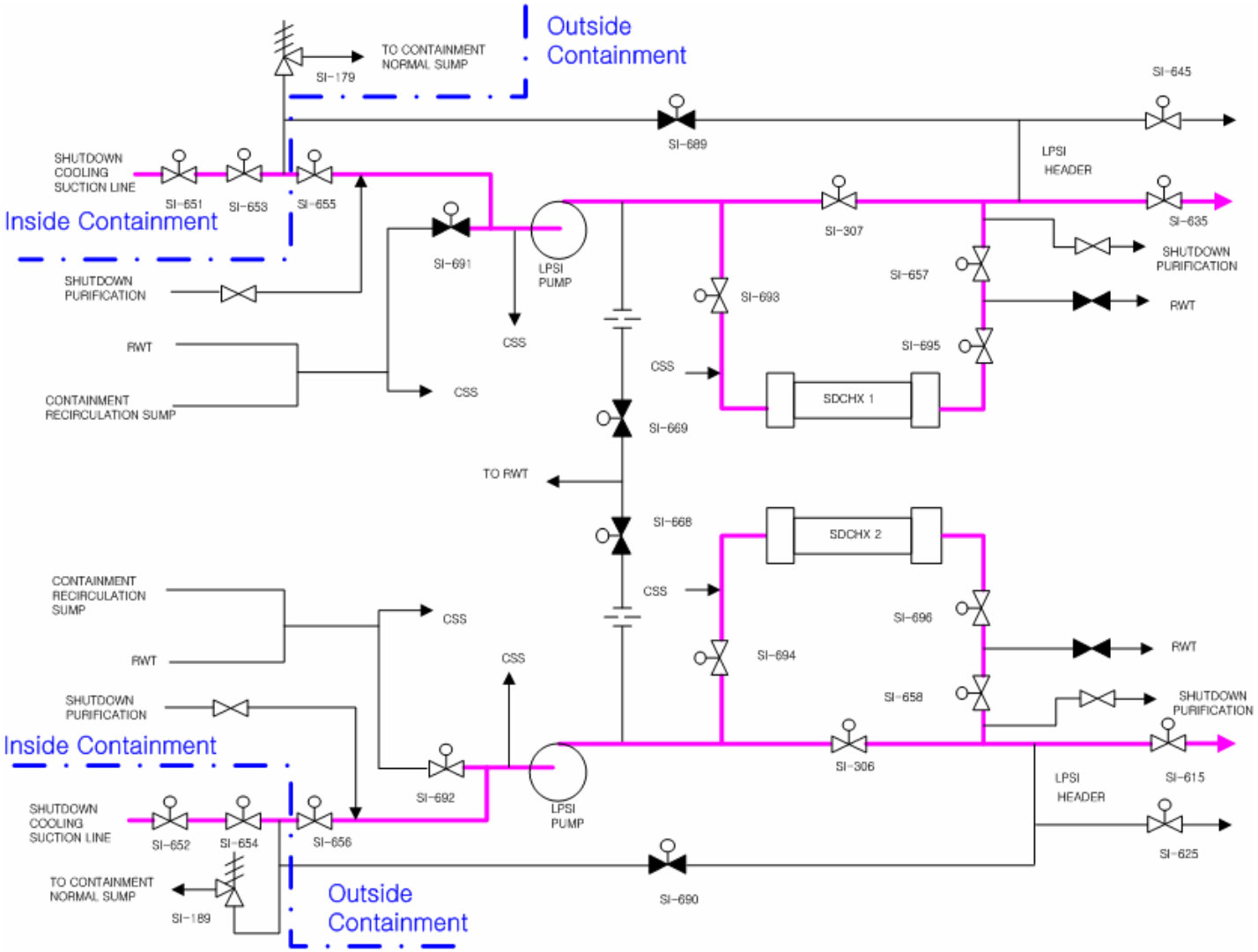
ESF (Engineered Safety Features)

- SCS (Shutdown Cooling System)/ RHRS (Residual Heat Removal System)
  - To continue the cooldown by removing heat from the core and transferring it to the environment.



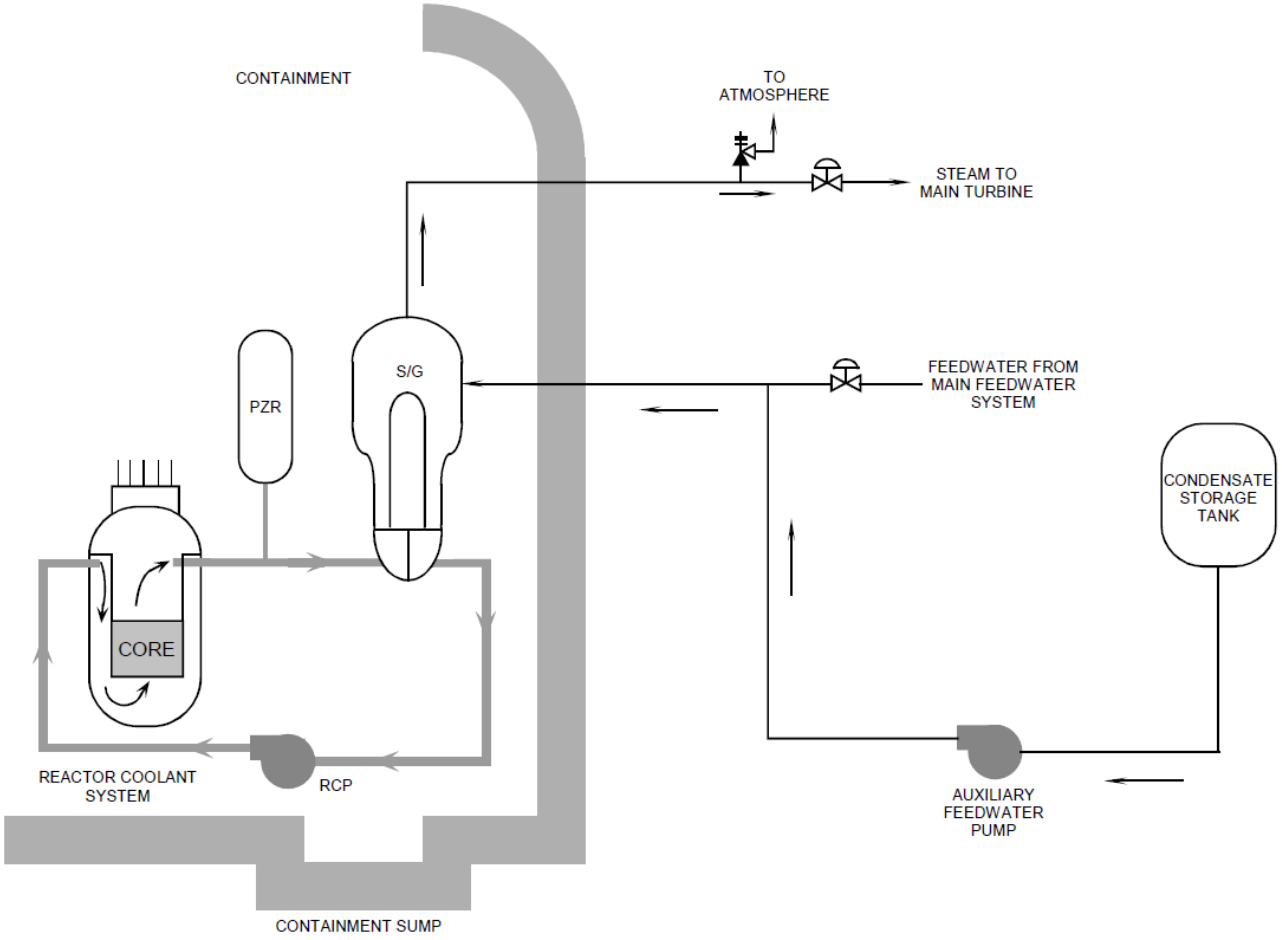
ESF (Engineered Safety Features)

- SCS (Shutdown Cooling System)/ RHRS (Residual Heat Removal System)



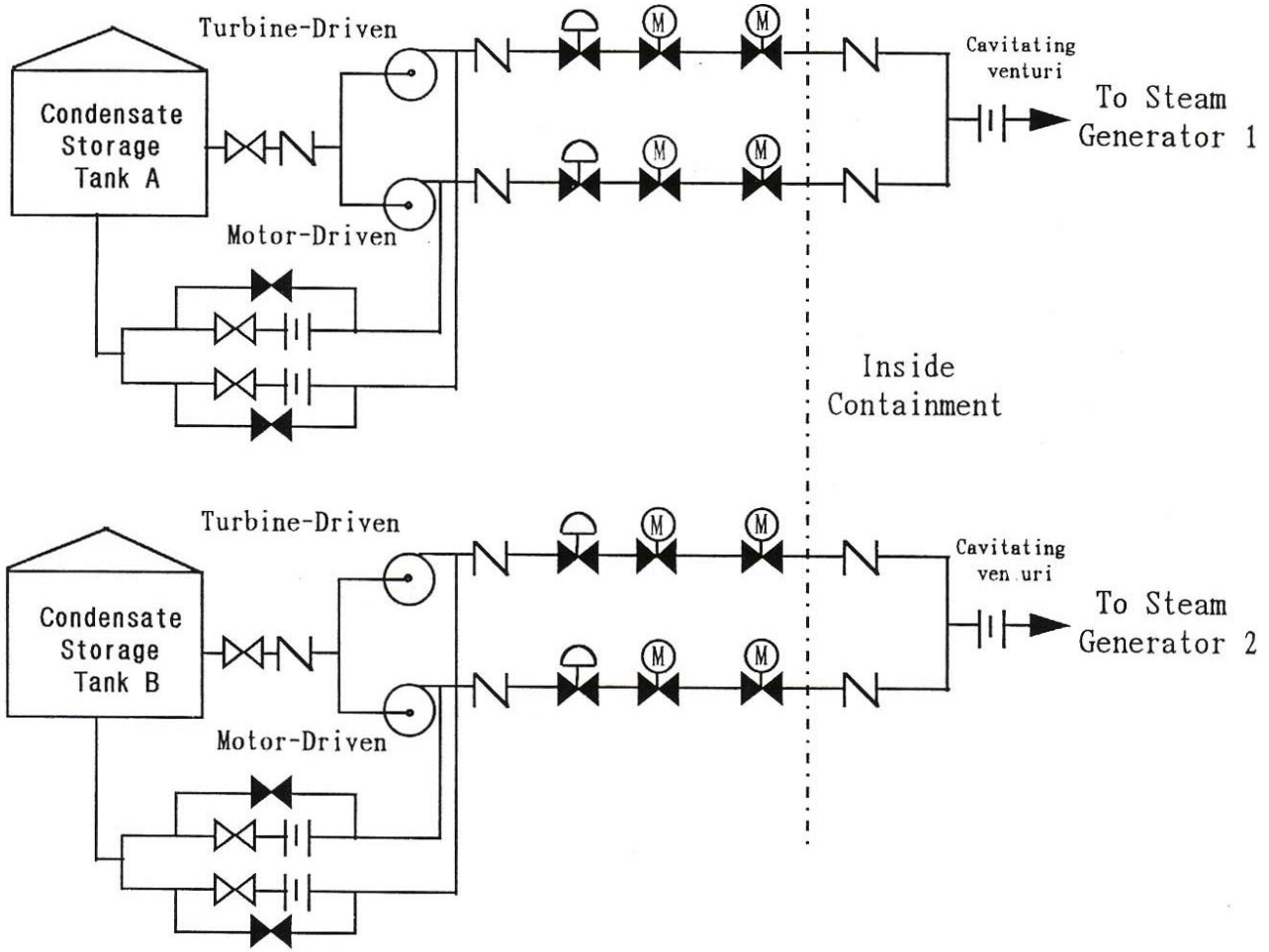
ESF (Engineered Safety Features)

- Auxiliary feedwater system
  - To provide emergence heat removal capability upon loss of normal feedwater.



ESF (Engineered Safety Features)

- Auxiliary feedwater system
  - To provide emergence heat removal capability upon loss of normal feedwater.
  - Replaced by PAFS in APR+



Plant Protection System

PPS (Plant Protection System)

- RPS(Reactor Protection System)
  - To provide an emergency shutdown of the reactor to protect the core and the reactor coolant system pressure boundary
- ESFAS(Engineered Safety Features Actuation System)
  - To provide those functions required to prevent the release of significant amounts of radioactive material to the environment in the event of pressure boundary rupture.
- The PPS continuously monitors selected safety-related parameters
  - Such as neutron flux, pressurizer pressure, steam generator pressure and level
- The PPS automatically initiates plant protective action in the form of initiation of the appropriate function whenever a monitored plant parameter reaches a predetermined level.
  - RPS trip and/or ESF actuation

Plant Protection System

PPS (Plant Protection System)

- Monitored parameters
  - Core power (neutron flux and core inlet/outlet temperatures)
  - Reactor coolant system pressure
  - Departure from nucleate boiling ratio (DNBR) in the limiting coolant channel of the core
  - Peak local power density in the limiting fuel pin of the core
  - Steam generator water level
  - Steam generator pressure
  - Containment pressure
  - Refueling water tank water level
  - Reactor coolant system flow
    - Reactor coolant pump speed and steam generator primary differential pressure

PPS (Plant Protection System)

- Trip functions
  - Variable Overpower
    - To limit the plant's maximum steady state power level, in conjunction with the DNBR/LPD trips.
  - High Logarithmic Power Level
    - To ensure the integrity of the fuel cladding and coolant system boundary in the event of unplanned criticality from a shutdown condition, resulting from either dilution of soluble boron or withdrawal of CEAs.
  - High Local Power Density
    - To prevent the linear heat rate (kW/ft or w/cm) in the limiting fuel pin in the core from exceeding the fuel design limit in the event of defined anticipated operational occurrences.
  - Low Departure From Nucleate Boiling Ratio (DNBR)
    - To prevent the DNBR in the limiting coolant channel in the core from exceeding the fuel design limit in the event of defined Anticipated Operational Occurrences.
  - High Pressurizer Pressure
    - To help assure the integrity of the Reactor Coolant Pressure Boundary for design basis events
  - Low Pressurizer Pressure
    - To assist the Engineered Safety Features System in the event of a coolant accident and to provide a reactor trip in the event of reduction in pressurizer pressure.
  - Low Steam Generator Water Level
    - To assist the Engineered Safety Features System by assuring that there is sufficient time for actuating the auxiliary feedwater pumps to remove decay heat from the reactor in the event of a reduction of steam generator water inventory.

PPS (Plant Protection System)

- Trip functions
  - High Steam Generator Water level
    - To provide protection in conjunction with the MSIS to protect Main Steam System components from being damaged by excessive moisture carryover from the steam generators.
  - Low Steam Generator Pressure
    - To provide protection against excess secondary heat removal events
  - High Containment Pressure
    - To assist the Engineered Safety Features System by tripping the reactor coincident with an event which results in significant mass and energy releases into the containment.
  - Low Reactor Coolant Flow
    - To limit the consequences of a sheared reactor coolant pump shaft and steam line break.
  - Manual Trip

Plant Protection System

PPS (Plant Protection System)

- ESFAS Functions
  - Safety Injection Actuation Signal (SIAS)
  - Containment Isolation Actuation Signal (CIAS)
  - Containment Spray Actuation Signal (CSAS)
  - Recirculation Actuation Signal (RAS)
  - Main Steam Isolation Signal (MSIS)
  - Auxiliary Feedwater Actuation Signal (AFAS)

Other Systems

Plant Monitoring System

- Core operating Limit Supervisory System
- In-core Instrumentation System
- Ex-core Neutron Flux Monitoring System
- Inadequate Core Cooling Monitoring
- NSSS Integrity Monitoring System
- Radiation Monitoring System
- Containment Vessel Monitoring System
- Post Accident Monitoring System
- Bypass and Inoperable Status Indications

Other Systems

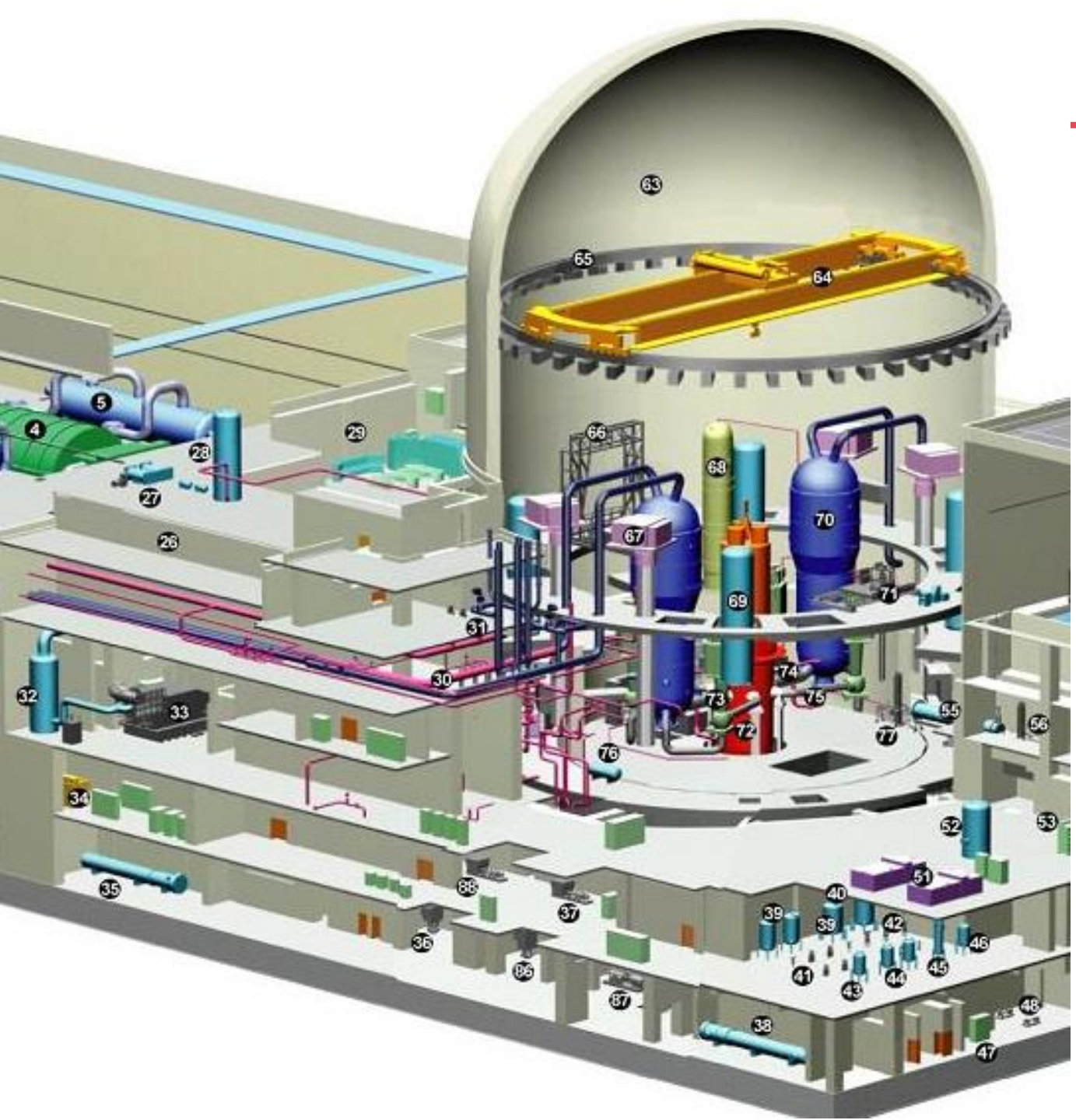
Plant Control System

- Reactor Regulating System
- Control Element Drive Mechanism Control System
- Main Feedwater Contorl System
- Steam Bypass Control System
- Reactor Power Cutback System
- Pressurizer Pressure Control System
- Pressurizer Level Control System

Other Systems

- **Radioactive Waste Management System**
  - Gaseous Radioactive Waste System
  - Liquid Radioactive Waste System
  - Solid Radioactive Waste System

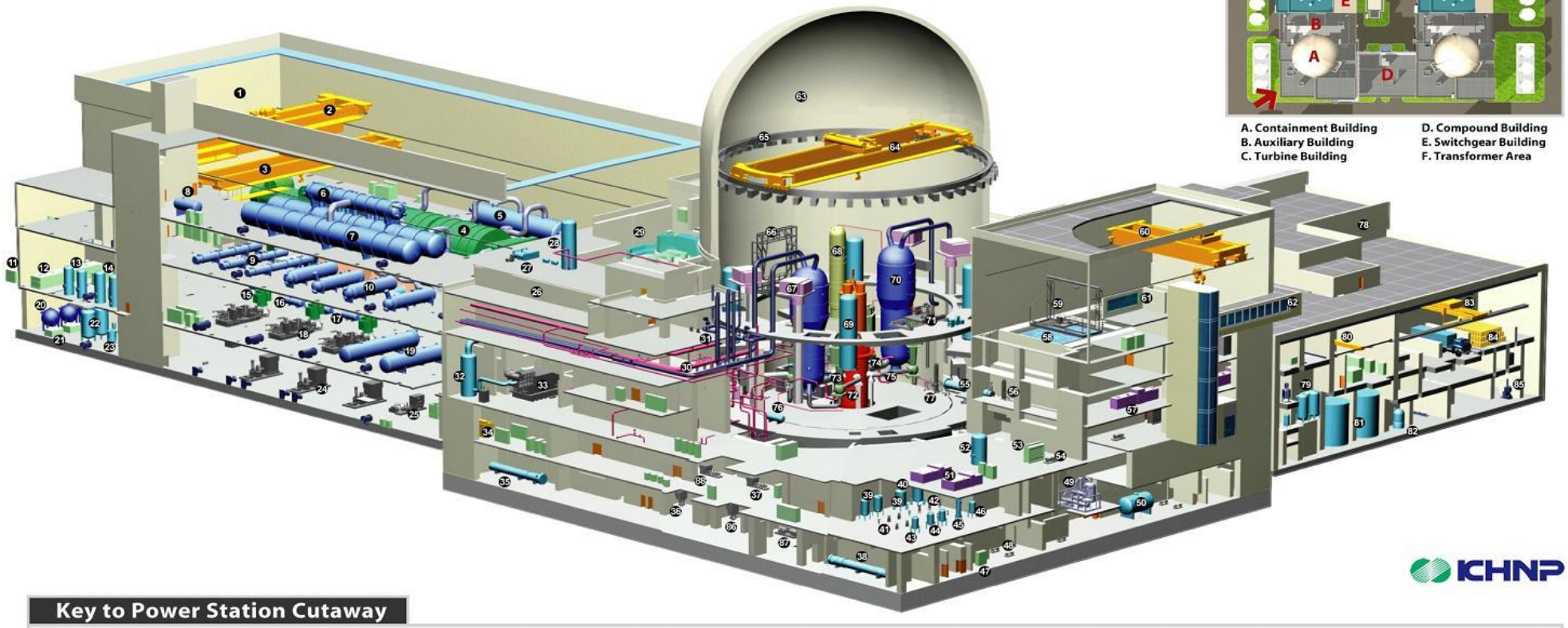
- **Compressed Air System**
- **Chilled Water System**



31. Main Steam Safety Valve
32. Exhaust Silencer
33. Diesel Generator
34. 480V PNS Loadcenter
35. CS Heat Exchanger
36. CS Pump
37. Motor Driven Aux. Feedwater Pumps
38. SC Heat Exchanger
39. Spent Fuel Pool Clean-up Demin
40. SG Blowdown Mixed Bed Demin
41. Reactor Drain Filter
42. SGBD Filter
43. Pre-Holdup Ion Exchanger
44. Purification Ion Exchanger
45. Boric Acid Cond Ion Exchanger

46. Deborating Ion Exchanger
47. Process Radiation Monitor
48. Holdup Pump
49. Boric Acid Conc.
50. Equip. Drain Tank
51. Aux. Bldg. Controlled Area Exhaust ACU
52. Volume Control Tank
53. SFP Cooling Exchanger
54. SFP Cooling Pump
55. Fuel Transfer Tube
56. Fuel Transfer Carriage & Upender in Fuel Handling Area
57. Fuel Handling Area Emer Exhaust ACU
58. Spent Fuel Pool
59. Spent Fuel Handling Machine

75. Reactor Coolant Piping Cold Leg
76. RCP Lube Oil Collector Tank
77. Fuel Transfer System Upender
78. Compound Building
79. Charcoal Delay Beds
80. Suspension Crane
81. Long Term Storage Tank
82. Low Activity Spent Resin
83. Traveling Bridge Crane
84. Waste Drum Storage Area
85. Solid Waste Compactor
86. SC Pump
87. SI Pump
88. Turbine Driven Aux. Feedwater Pump



A. Containment Building
B. Auxiliary Building
C. Turbine Building
D. Compound Building
E. Switchgear Building
F. Transformer Area

KHNP

Key to Power Station Cutaway

1. Turbine Building
2. Main Overhead Crane
3. Aux. Overhead Crane
4. Generator
5. Moisture Separator Reheater
6. Deaerator
7. Deaerator Storage Tank
8. TBCCW Surge Tank
9. LP Feedwater Heaters
10. HP Feedwater Heaters
11. Closed Loop Cooling System
12. Air Compressor
13. Air Receivers
14. Service Air Receiver
15. Feedwater Pumps Turbine Driven
16. Moisture Separator Drain Tank
17. Stage Reheater Drain Tank
18. Feedwater Pumps Turbine "A""B""C"
19. HP Feedwater Heaters
20. Cond. Polishing Mixed Bed Vessels
21. Cond. Polishing Resin Traps
22. Cation Regen. & Hold Tanks
23. Ammonia Day Tank
24. Feedwater Booster Pumps
25. Start-up FW Pump
26. Auxiliary Building
27. D/G Room Emergency Exhaust Fan
28. CCW Surge Tank
29. Main Control Room
30. Main Steam Line
31. Main Steam Safety Valve
32. Exhaust Silencer
33. Diesel Generator
34. 480V PNS Loadcenter
35. CS Heat Exchanger
36. CS Pump
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55. Fuel Transfer Tube
56. Fuel Transfer Carriage & Upender in Fuel Handling Area
57. Fuel Handling Area Emer Exhaust ACU
58. Spent Fuel Pool
59. Spent Fuel Handling Machine
60. Fuel Handling Area Overhead Crane
61. Viewing Area
62. Walkway
63. Containment Building
64. Polar Crane
65. Crane Rail
66. CEA Change Platform
67. RCFC Duct
68. Pressurizer
69. Safety Injection Tank
70. Steam Generator
71. Refueling Machine
72. Reactor Vessel
73. Reactor Coolant Pump
74. Reactor Coolant Piping Hot Leg
75. Reactor Coolant Piping Cold Leg
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