CANDU Design: Overview

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Learning Objectives

- Fundamental Concept of the CANDU Design

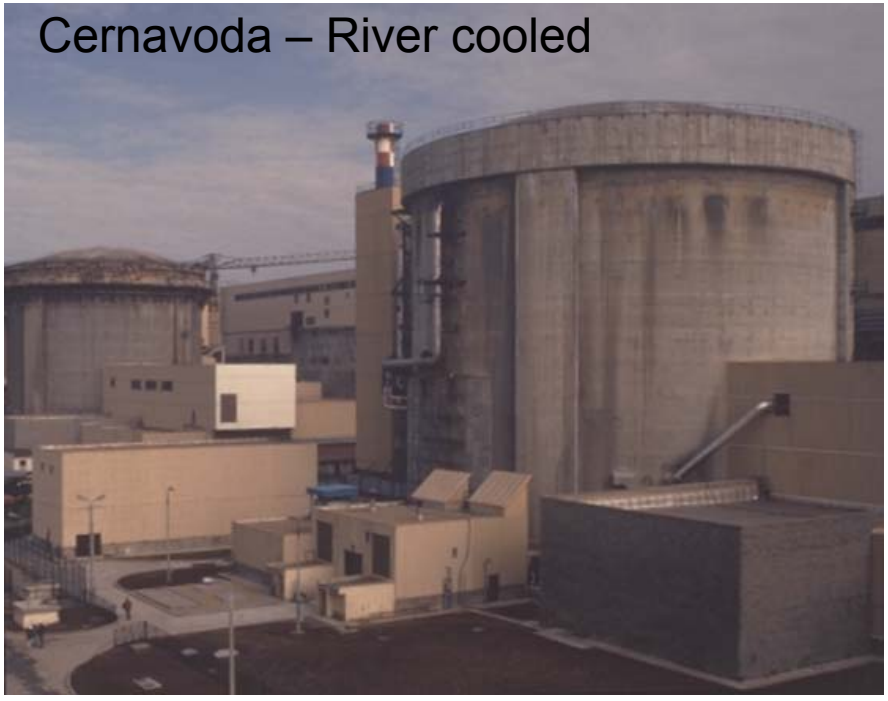
DARLINGTON NPP

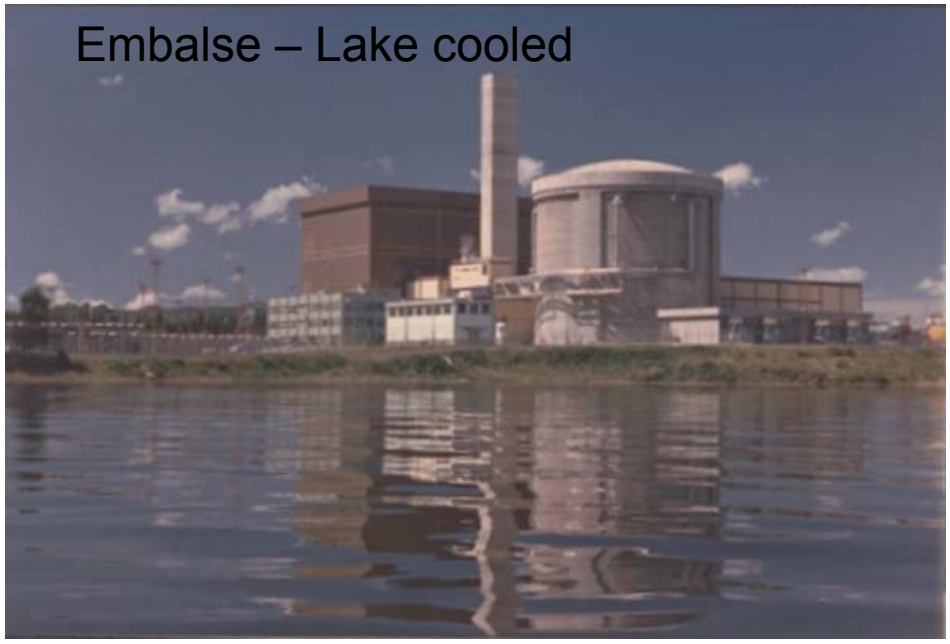
4X930MWe

Location;
Darlington, Ontario
Canada

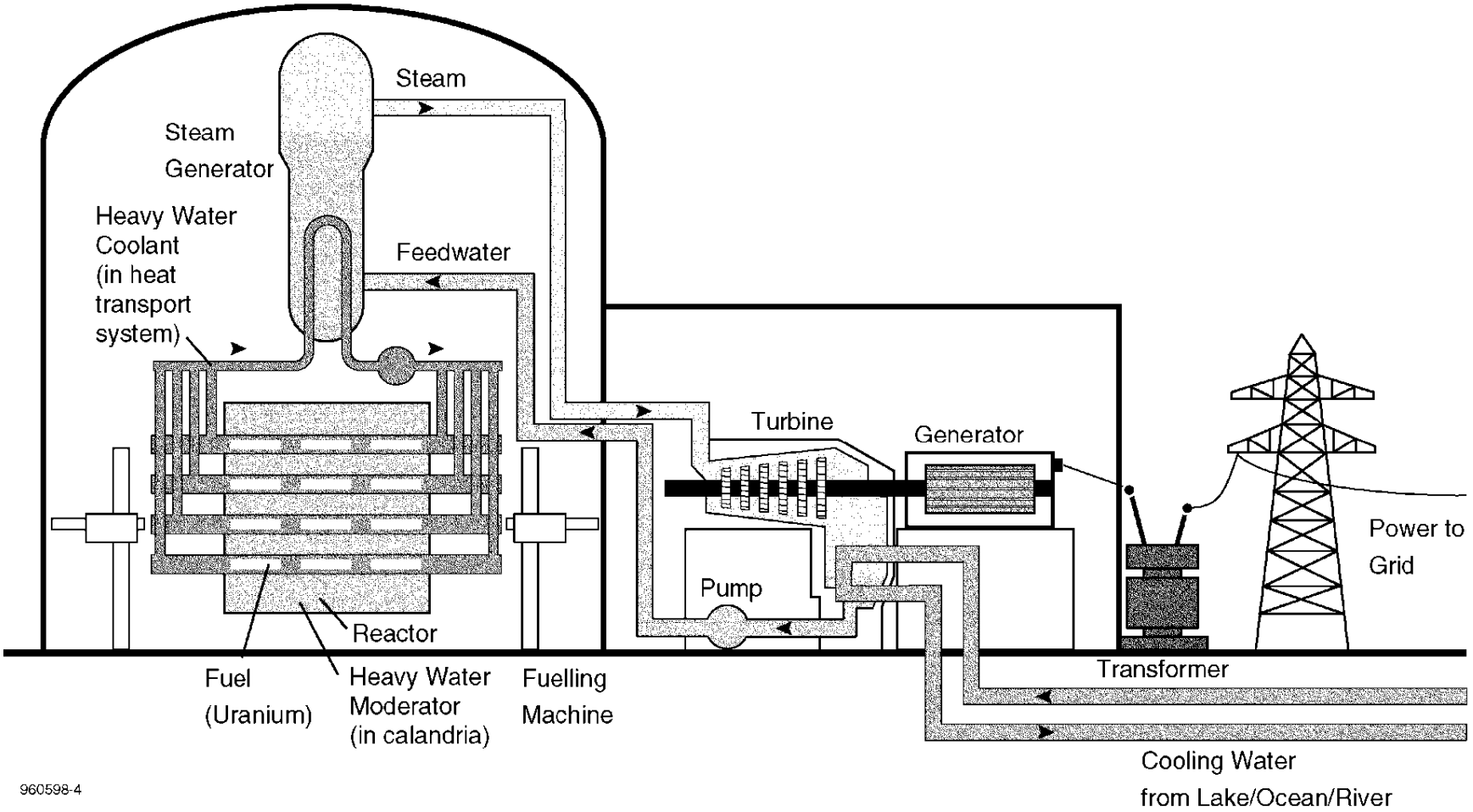

Qinshan – ocean cooled


Point Lepreau – Ocean cooled


Cernavoda – River cooled


Embalse – Lake cooled

Typical CANDU Production Systems



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Fundamental Design Features of a CANDU

- Purpose of a CANDU
  - Generate electricity
- Use Natural Uranium Fuel
  - No requirement for enrichment plant
- On-Line Refuelling

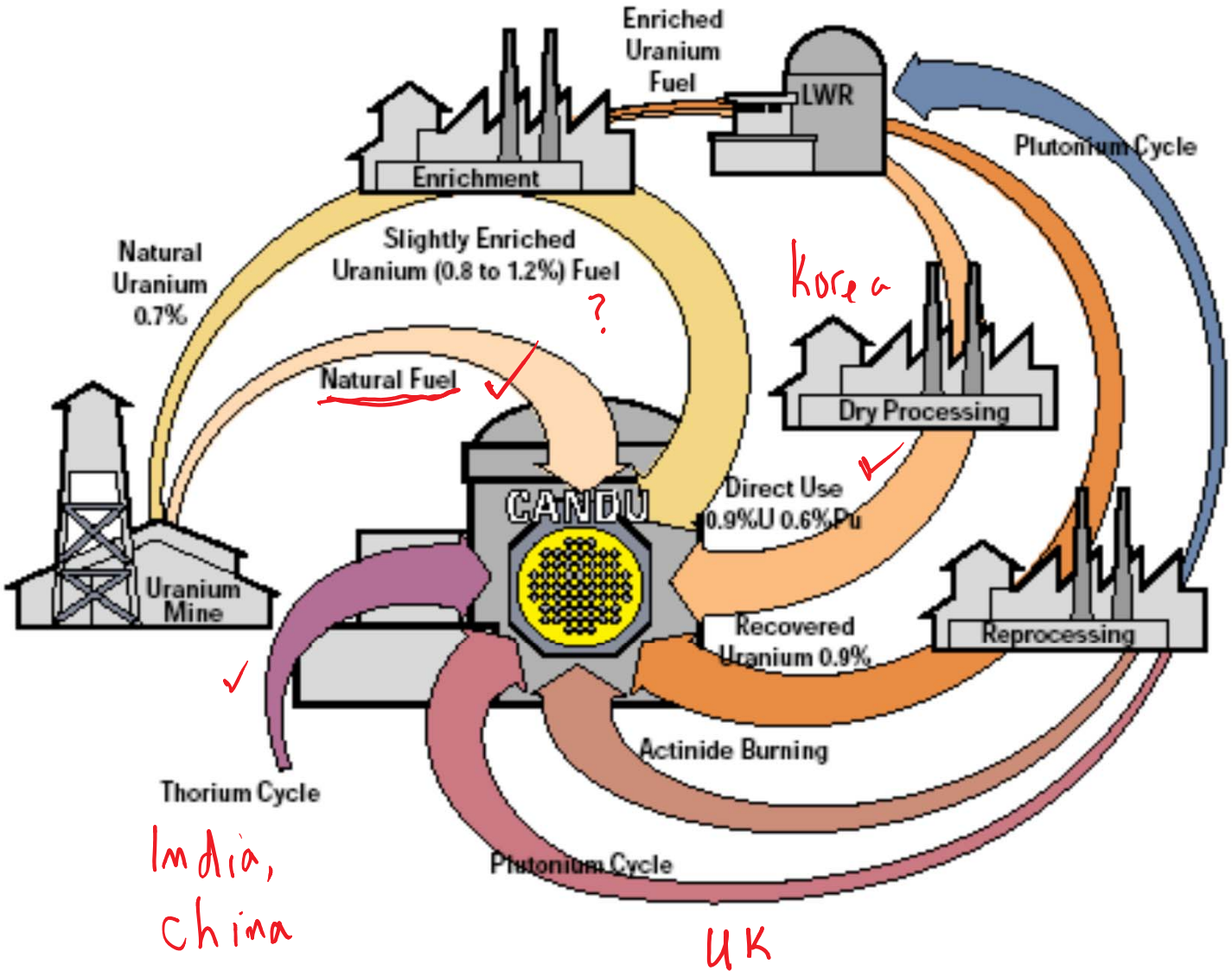
CANDU Reactors

Station Name	Type	Gross MWe	Net MWe	Start-up
Pickering A	Pickering	542	515	1971
Bruce A	Bruce	904 (including steam)	848	1977
Point Lepreau	CANDU 6	680	633	1983
Gentilly-2	CANDU 6	675	638	1983
Wolsong 1	CANDU 6	678	638	1983
Embalse	CANDU 6	648	600	1984
Pickering B	Pickering	540	516	1983
Bruce B	Bruce	915	860	1984
Darlington A	Darlington	936	881	1989
Cernavoda 1	CANDU 6	710	665	1996
Wolsong 2	CANDU 6	715	668	1997
Wolsong 3&4	CANDU 6	715	668	1998
Qinshan 1&2	CANDU 6	722	661	2003
Cernavoda 2	CANDU 6	710	665	2007

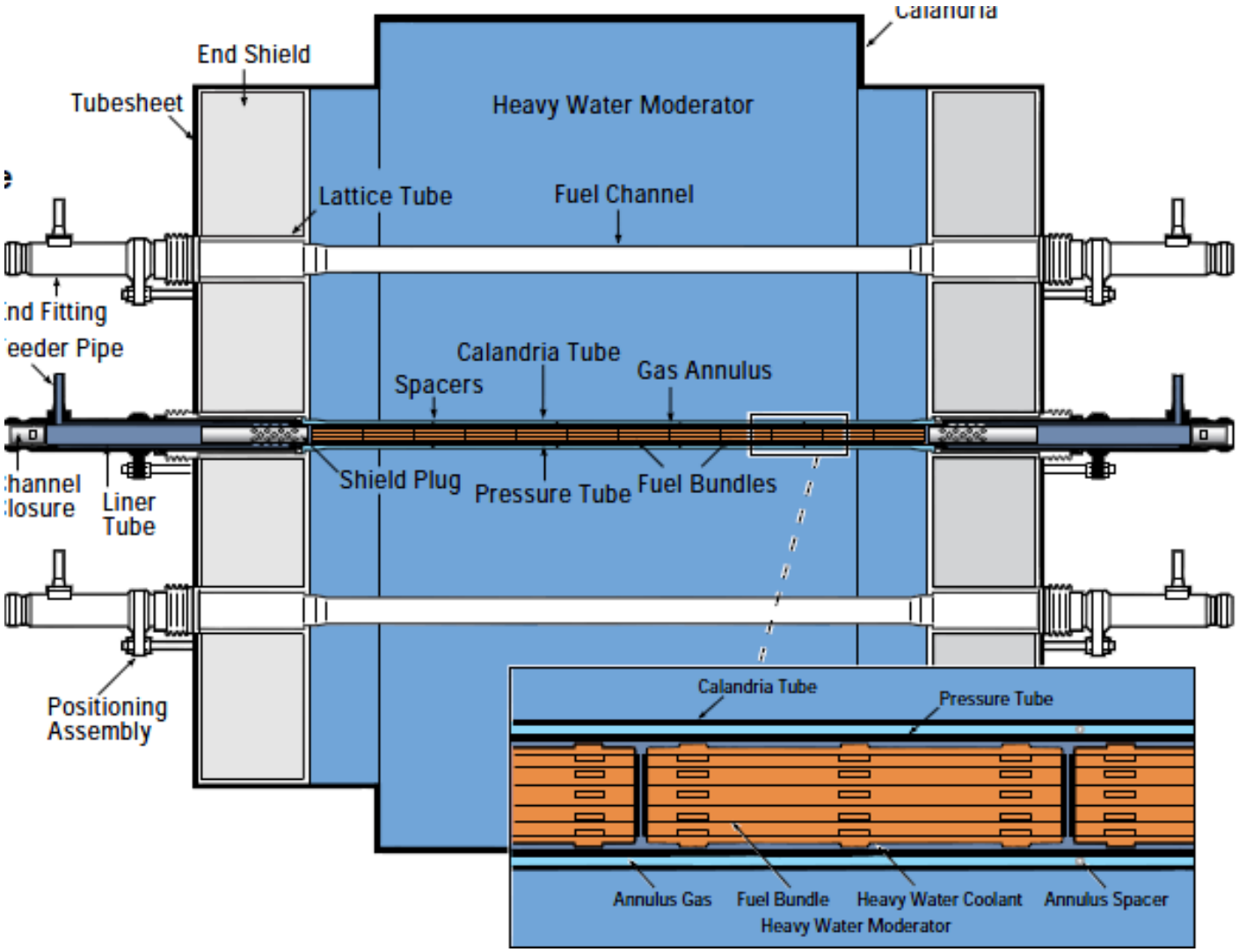
CANDU 6 Unit Data

Reactor Type	380 Horizontal Pressure Tubes
Reactor Coolant	Pressurized Heavy Water
Moderator	Heavy Water
Fuel	Compact and Sintered Natural UO_2
Form	37 element fuel bundle
Bundle Length and Outside Diameter	L = 495 mm; O.D. =102.4 mm
Bundle Weight	23.5 kg (includes 2.1 kg Zircaloy)
Bundles per Fuel Channel	12
Outlet Header Pressure (gauge)	9.9 MPa
Outlet temperature	310 °C
Coolant Flow	8600 kg/s
Steam Generators	4, Vertical U-tube with integral steam drum and preheater
Steam temperature	268 °C
Steam Pressure (gauge)	4.7 MPa
Steam Quality	99.75%
Pumps	4, Vertical Centrifugal single suction double discharge
Net Heat to Turbine	2064 MW_{th}
Electrical Output (gross)	725 MW_e (typ. For 18C Cooling Water)

CANDU Fuel


Enriched Uranium Fuel
LWR
Plutonium Cycle
Enrichment
Natural Uranium 0.7%
Slightly Enriched Uranium (0.8 to 1.2%) Fuel
?
Korea
Natural Fuel
Dry Processing
CANDU
Direct Use 0.9%U 0.6%Pu
Uranium Mine
Recovered Uranium 0.9%
Reprocessing
Actinide Burning
Thorium Cycle
India, China
Plutonium Cycle
UK

Calandria Structure – Side View



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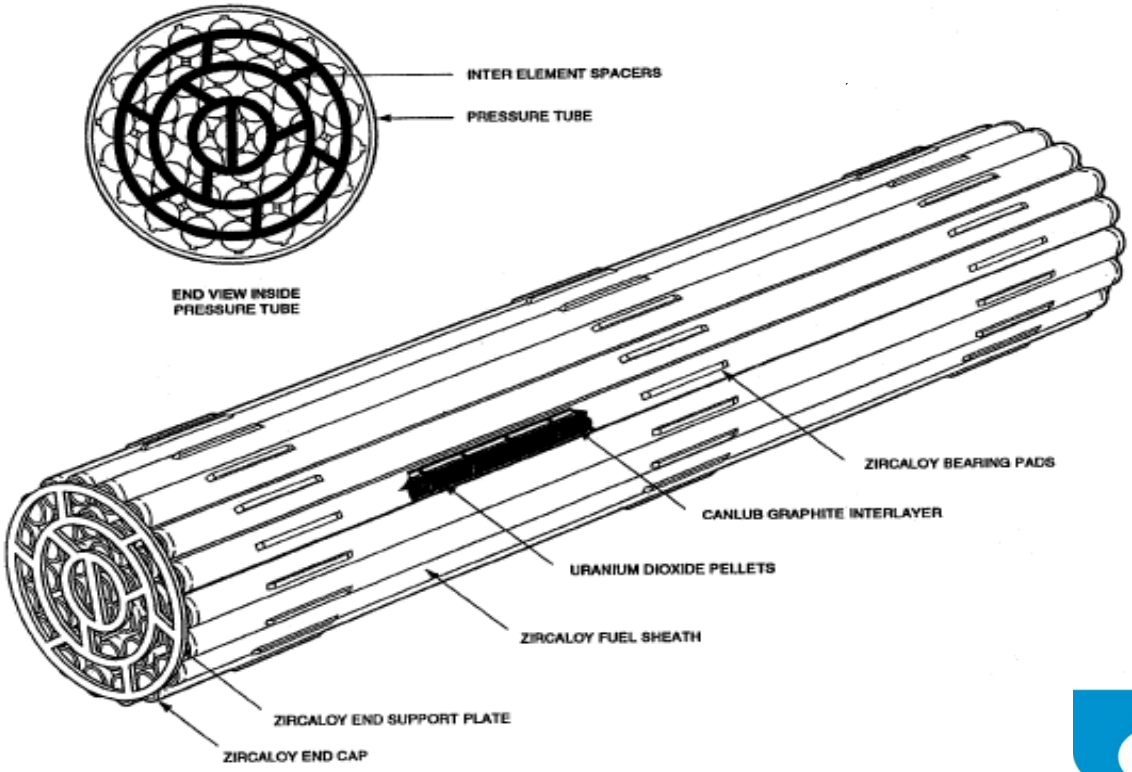
CHALLENGE INNOVATE CONNECT

Fuel – Heart of the Reactor



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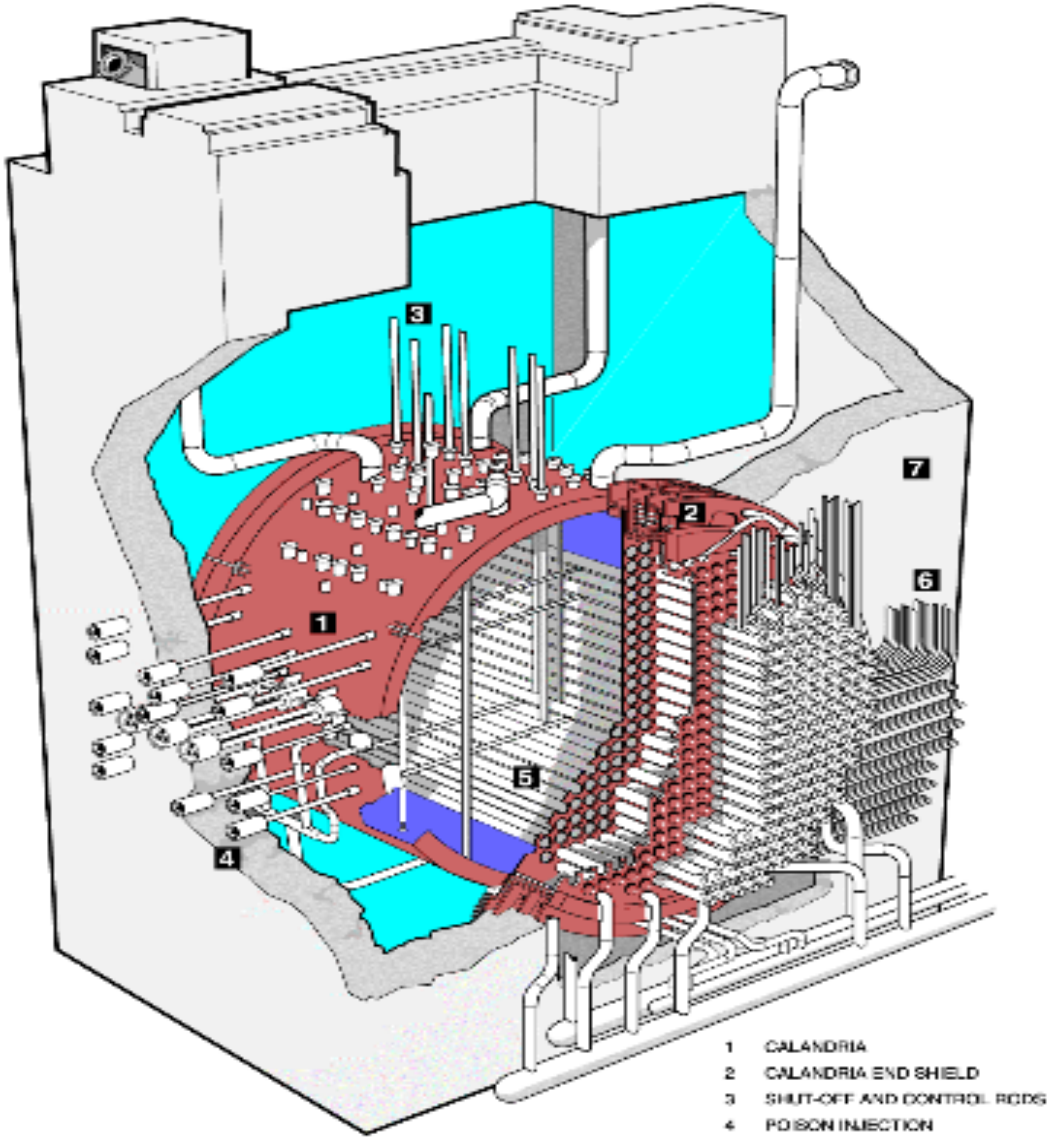
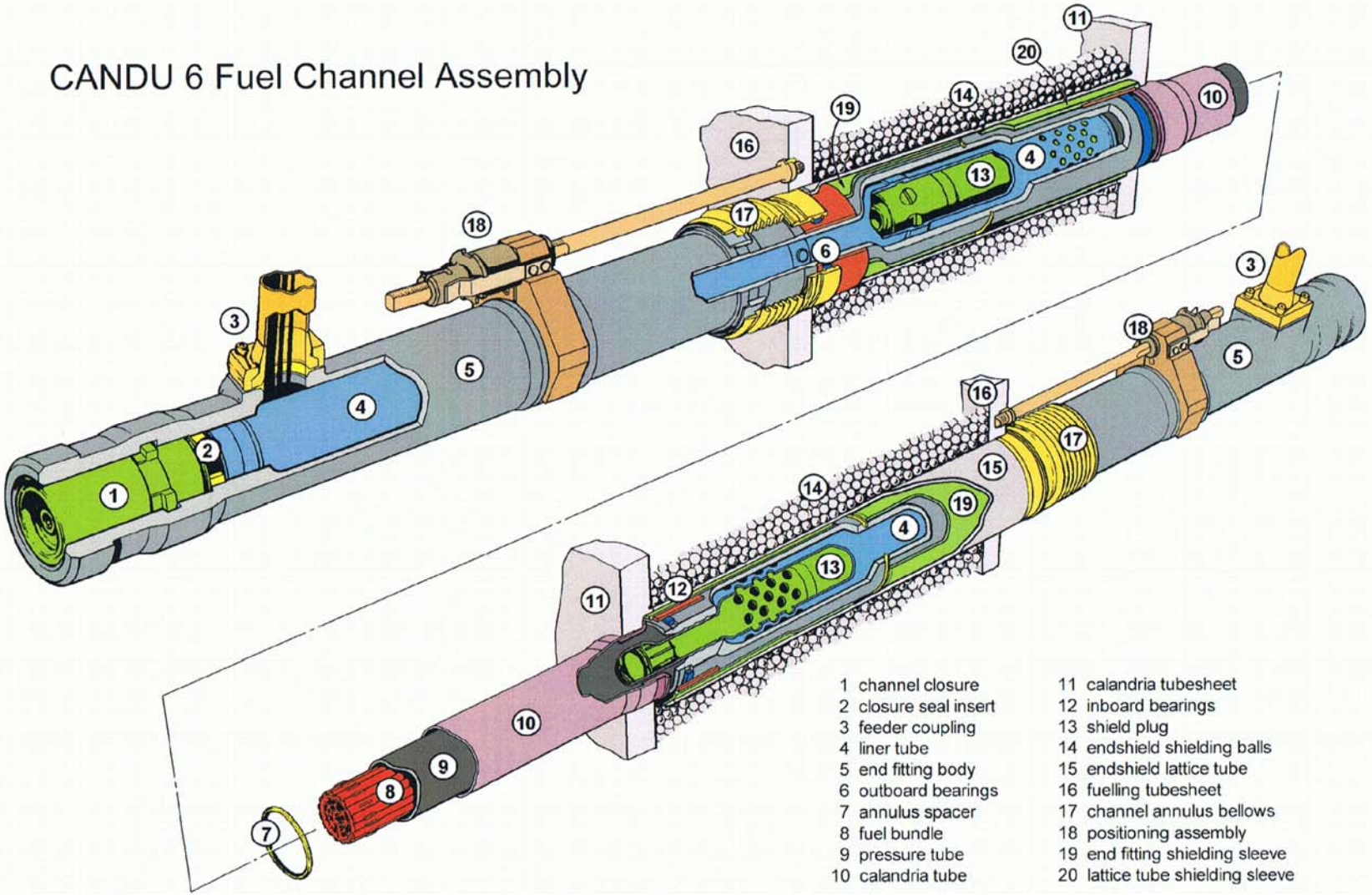
CHALLENGE INNOVATE CONNECT

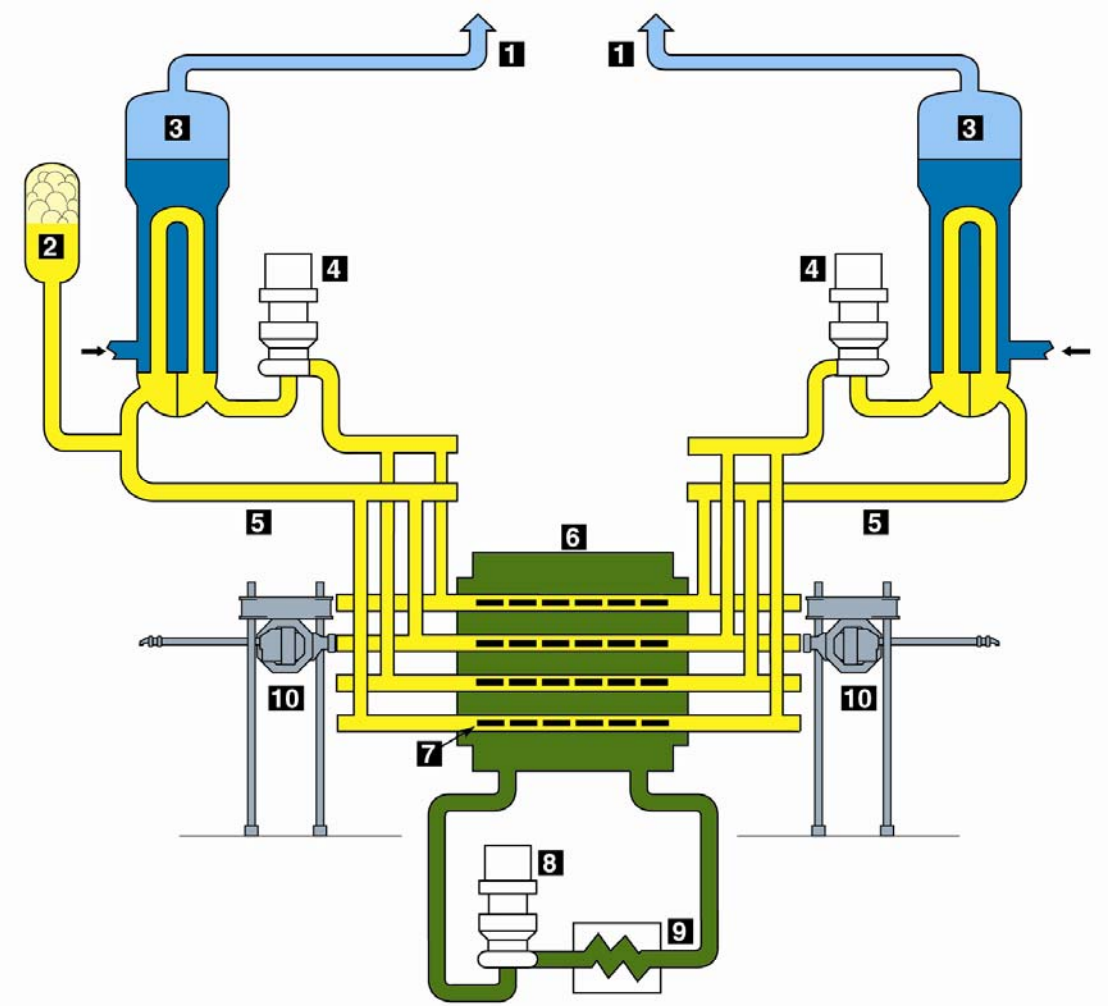
Calandria Structure – CANDU 6



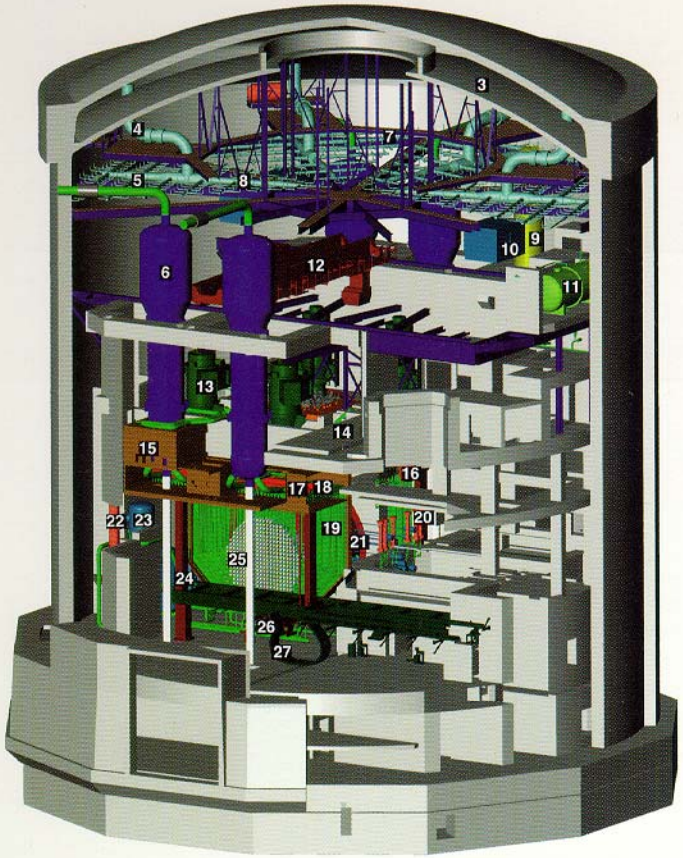
CANDU 6 Fuel Channel Assembly



Nuclear Steam Supply
(Primary Heat Transport System, Reactor Core, Moderator System)

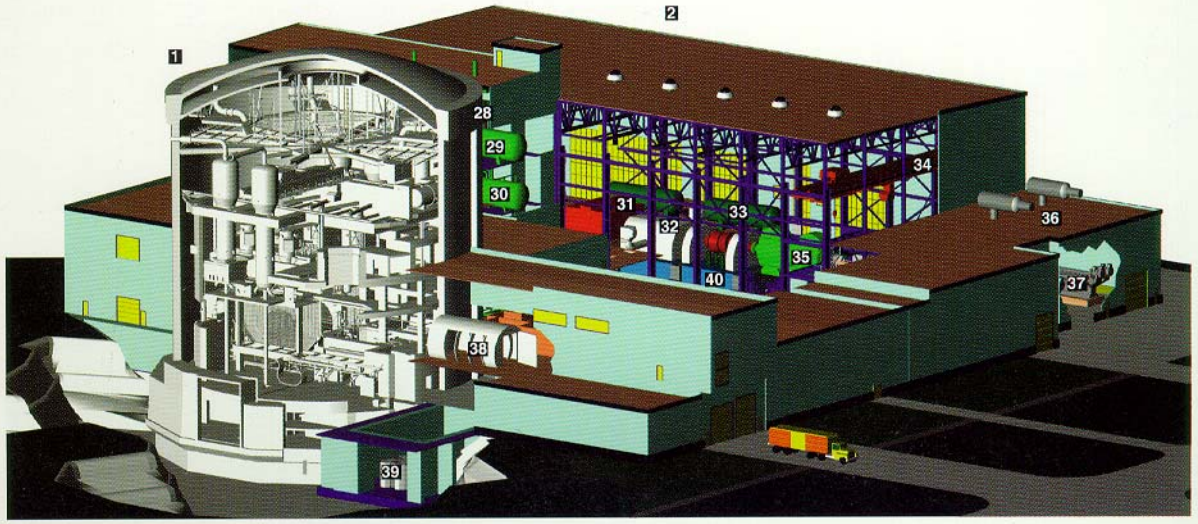


CANDU Nuclear Steam Supply System

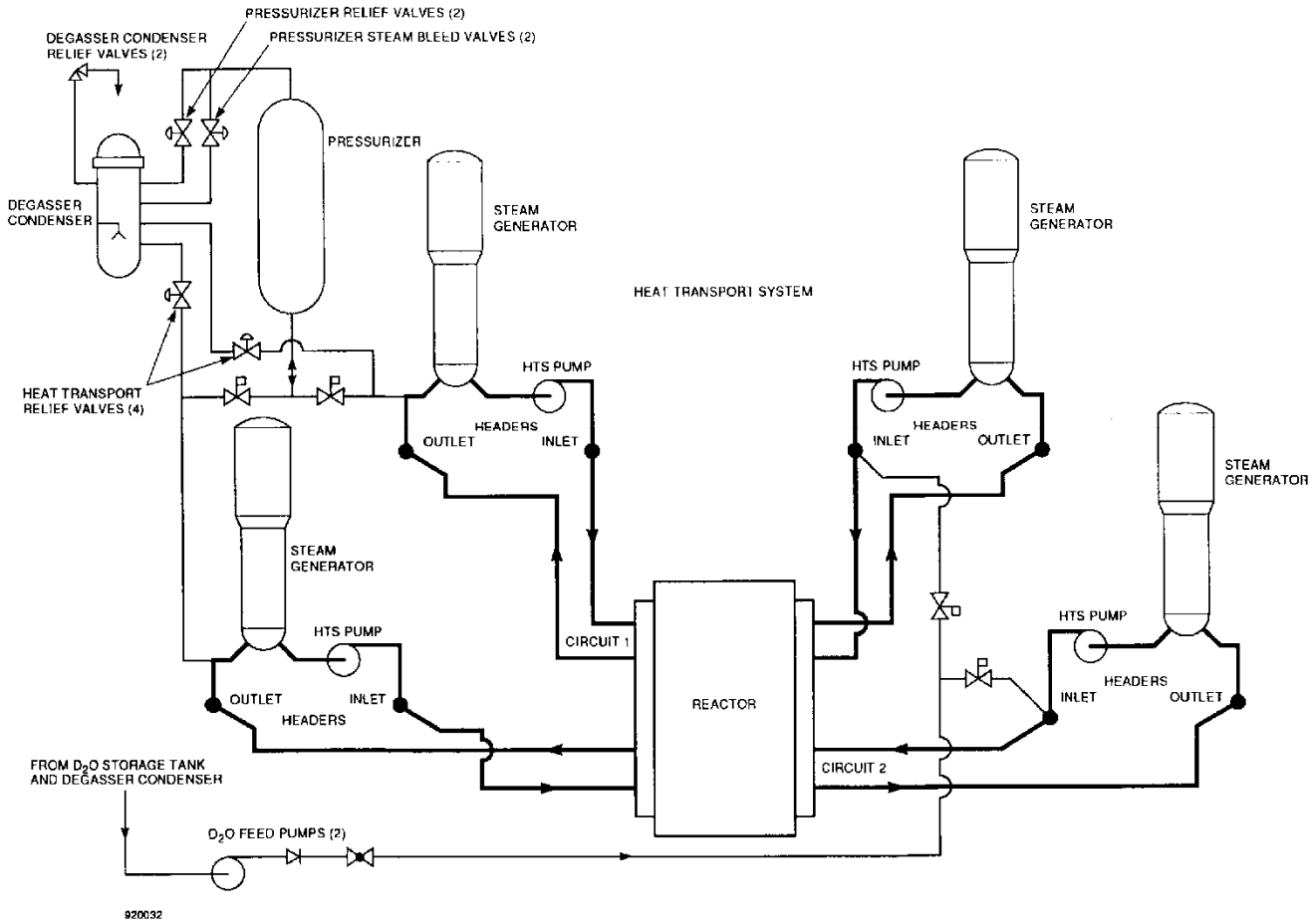


CANDU 6: CUTAWAY KEY

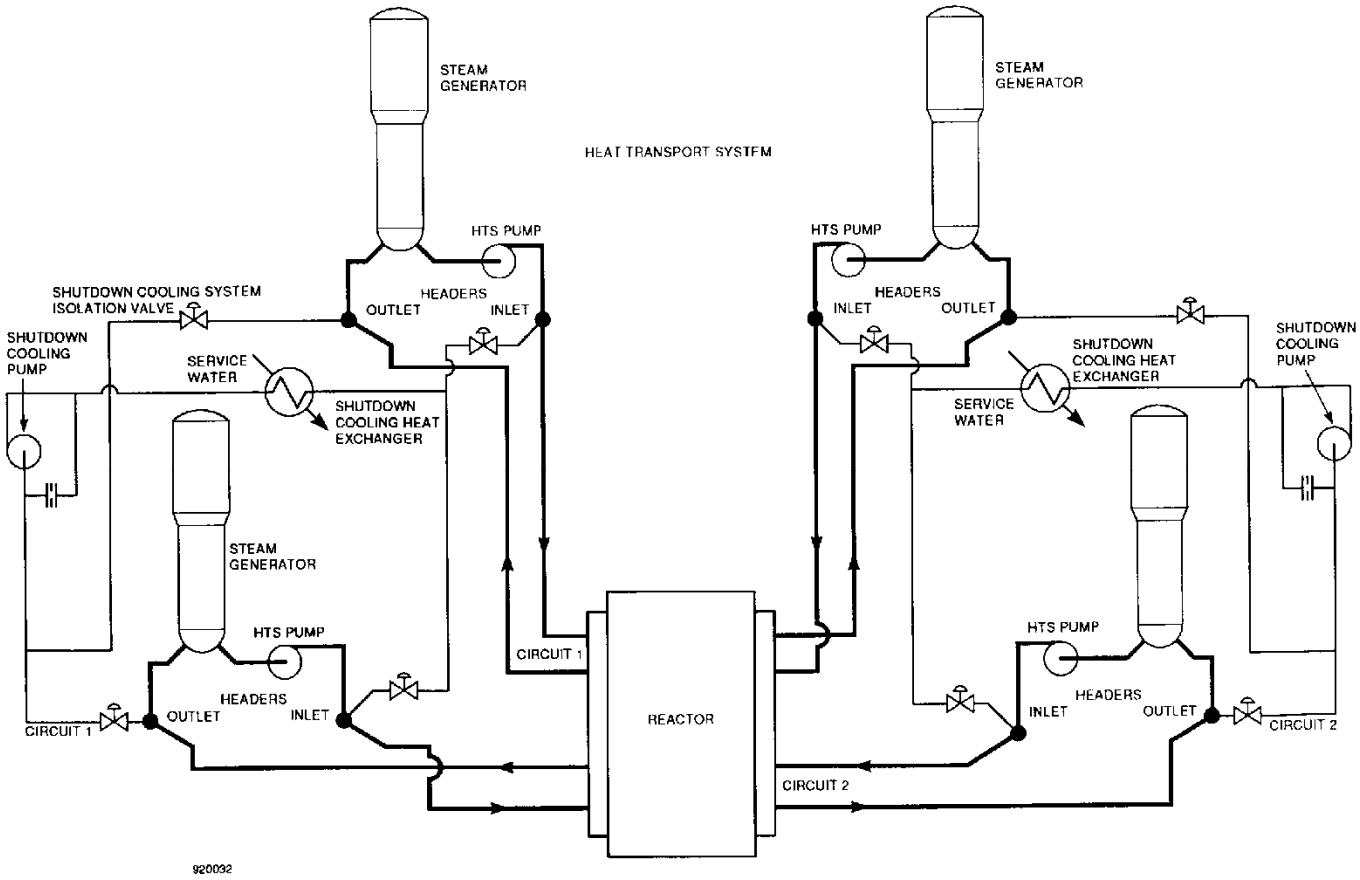
1. Reactor Building
2. Turbine Building
3. Dousing Tank
4. Dousing System Supply Pipe
5. Main Steam Line
6. Steam Generator
7. Walkway
8. Dousing Header & Nozzles
9. Pressurizer
10. Local Air Cooler
11. D_2O Storage Tank
12. Crane
13. Heat Transport Pump
14. Reactivity Mechanism Deck
15. Boiler Enclosure
16. Helium Supply Tank
17. Feeder Pipe Insulation Cabinet
18. Headers
19. Feeder Pipes
20. Gadolinium Pressure Vessel Liquid Injection System
21. Calandria
22. Shield Cooling Circuit Delay Tank
23. Main Moderator Heat Exchanger
24. Fuelling Machine Carriage & Bridge
25. End Shield
26. Fuelling Machine
27. Fuelling Machine Catenary
28. Deaerator
29. Deaerator Storage Tank
30. Reserve Feedwater Tank
31. H.P. Turbine
32. L.P. Turbines
33. Moisture Separator/ Reheater
34. Turbine Building Crane
35. Generator
36. Silencers
37. Standby Generator
38. Airlock
39. Spent Fuel Storage
40. Main Condenser



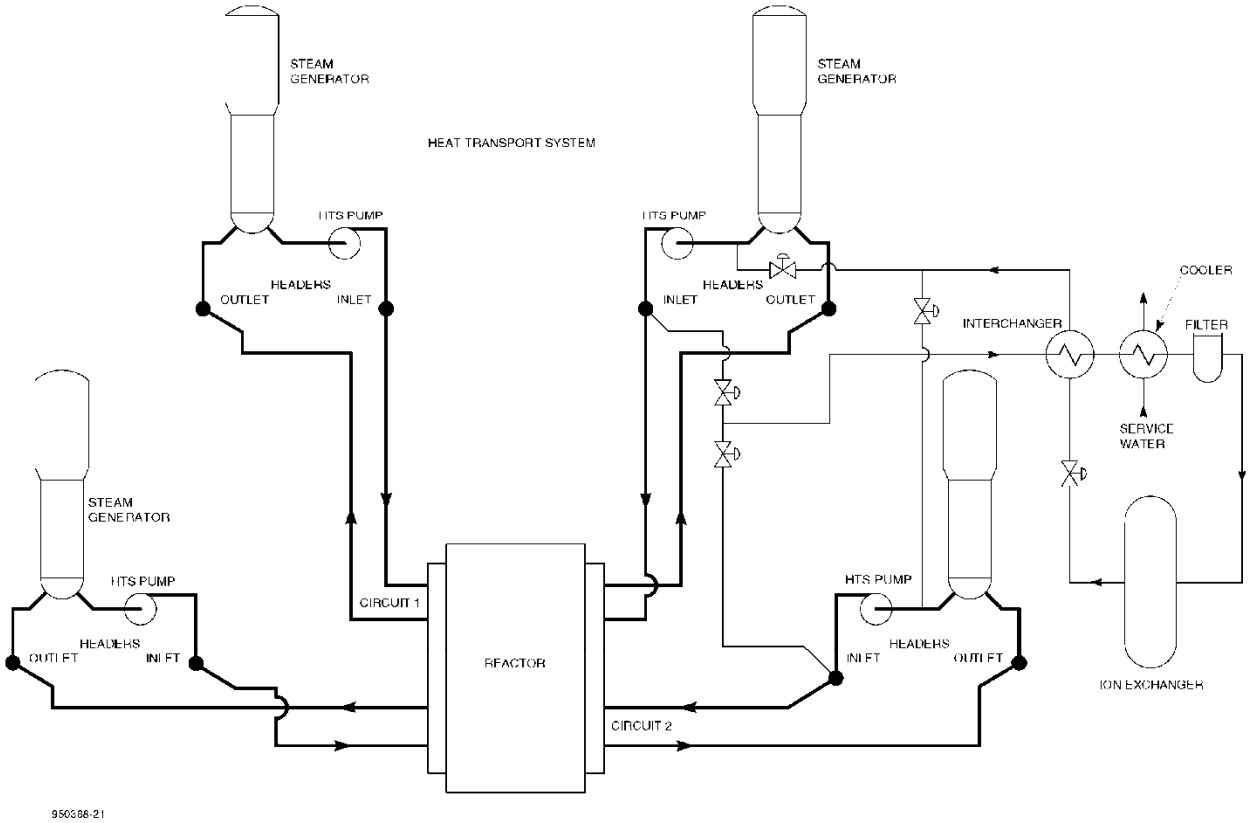
Pressure and Inventory Control



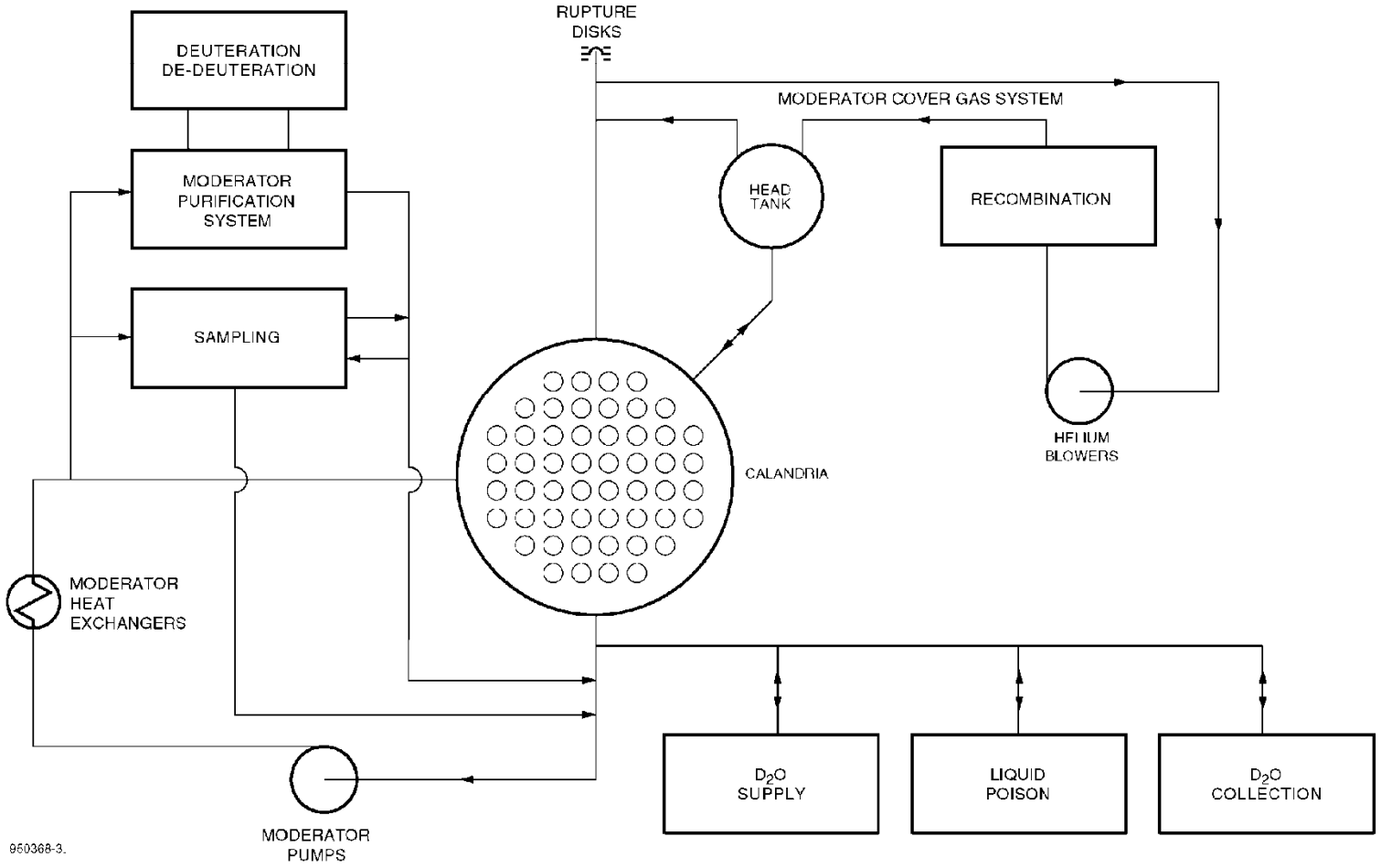
Shutdown Cooling System



HTS Purification System



Moderator System



Secondary Heat Transport System

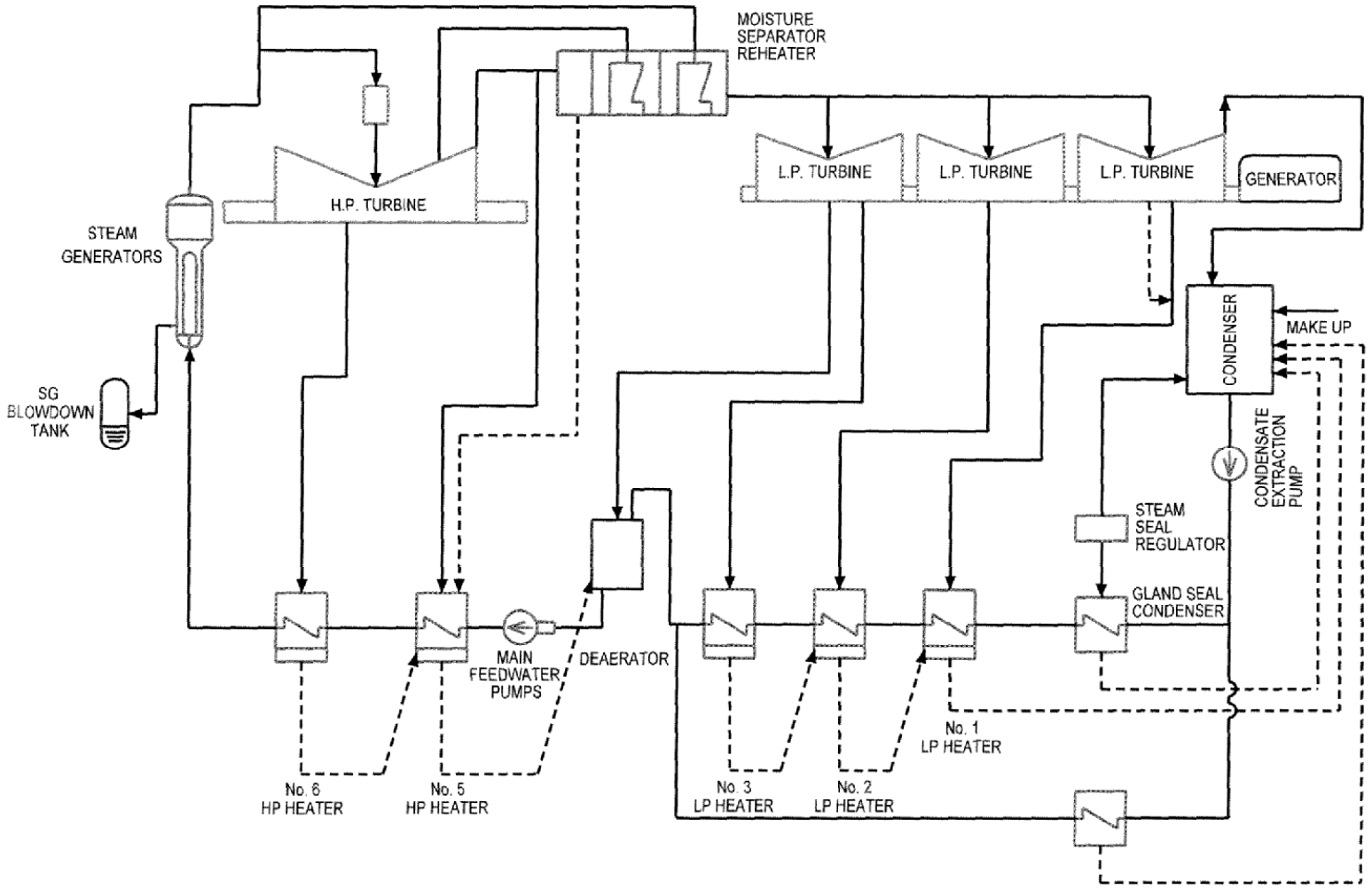
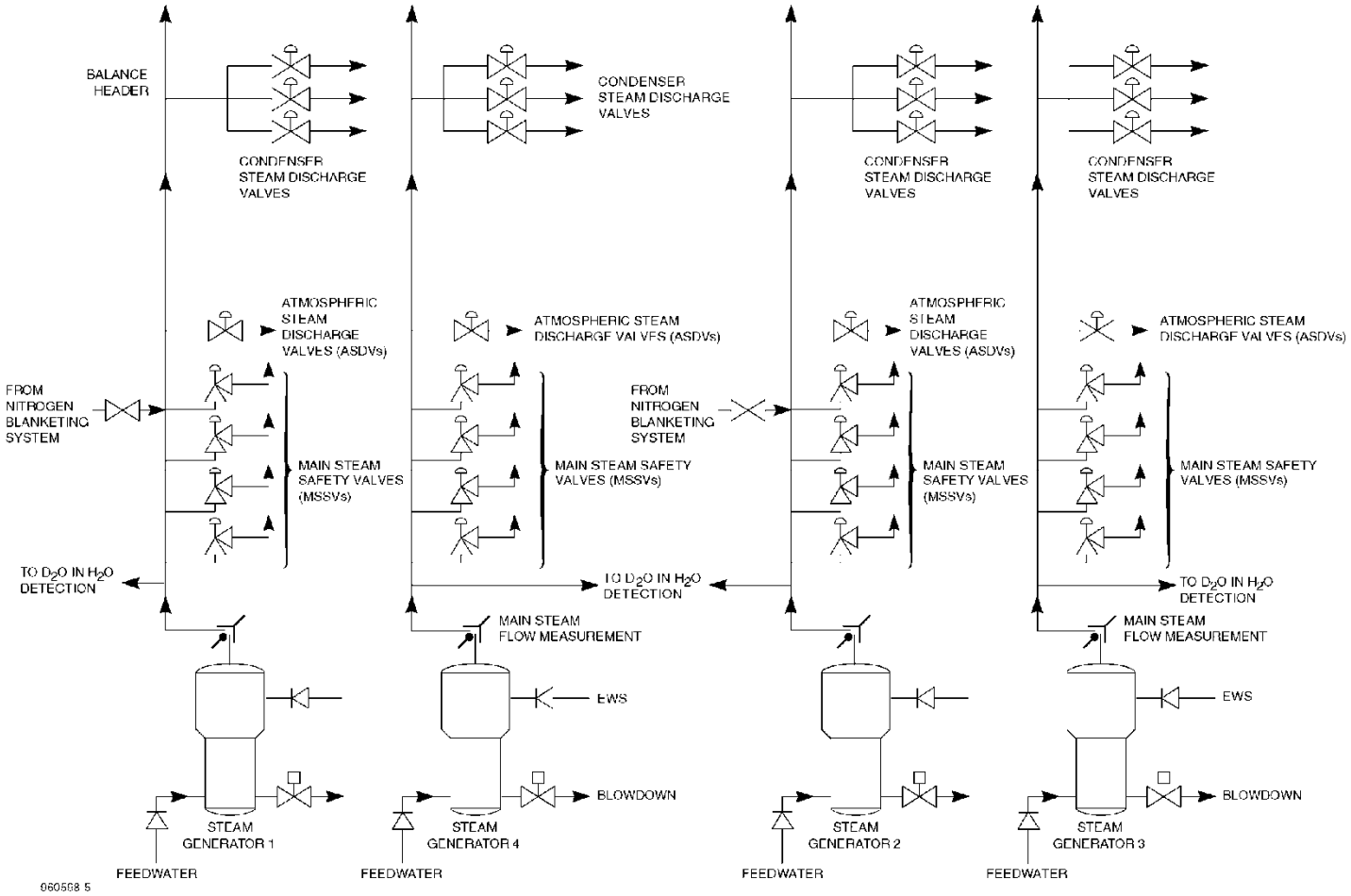
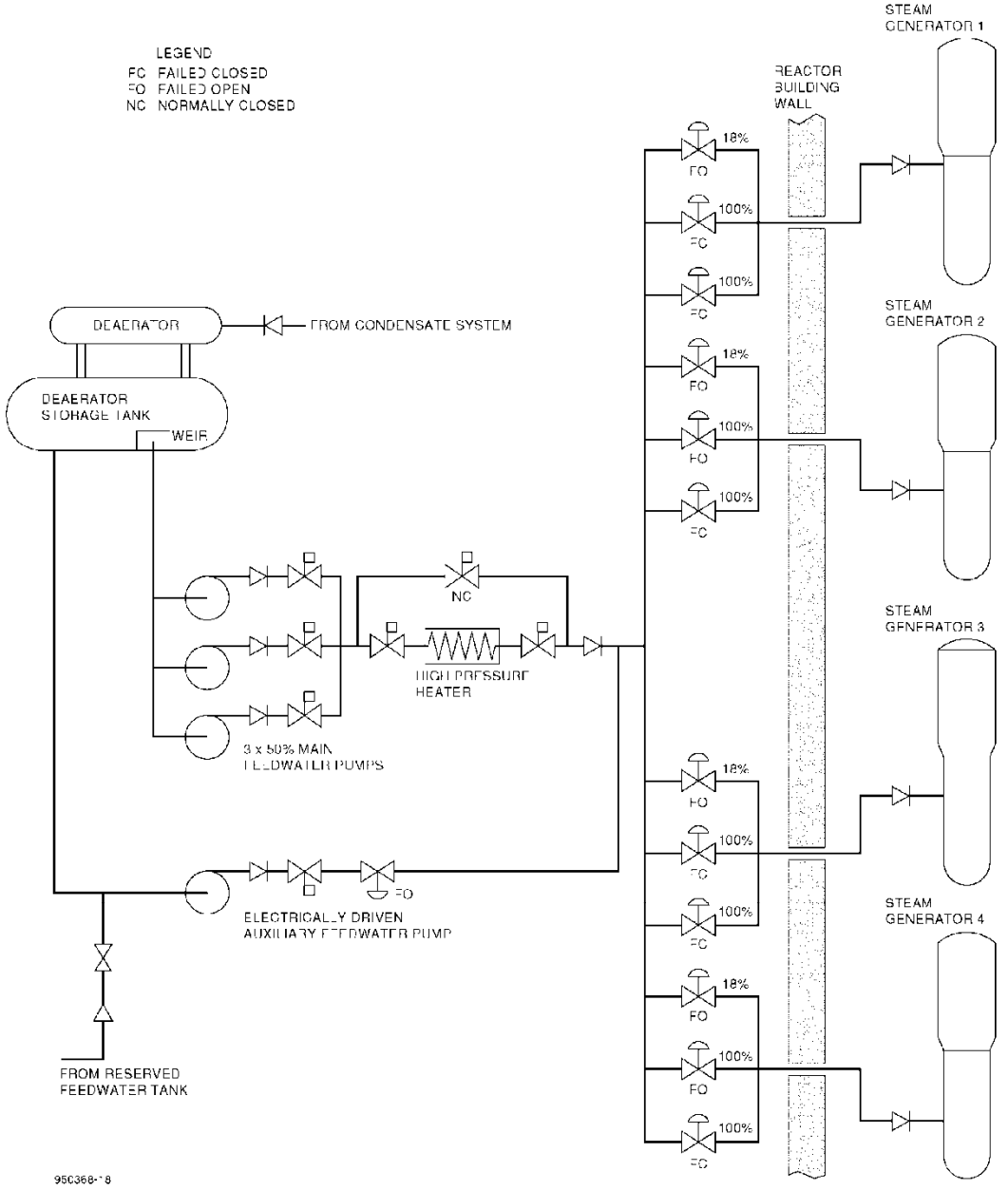


Figure 2-22 Turbine Generator and Auxiliaries Flow Diagram

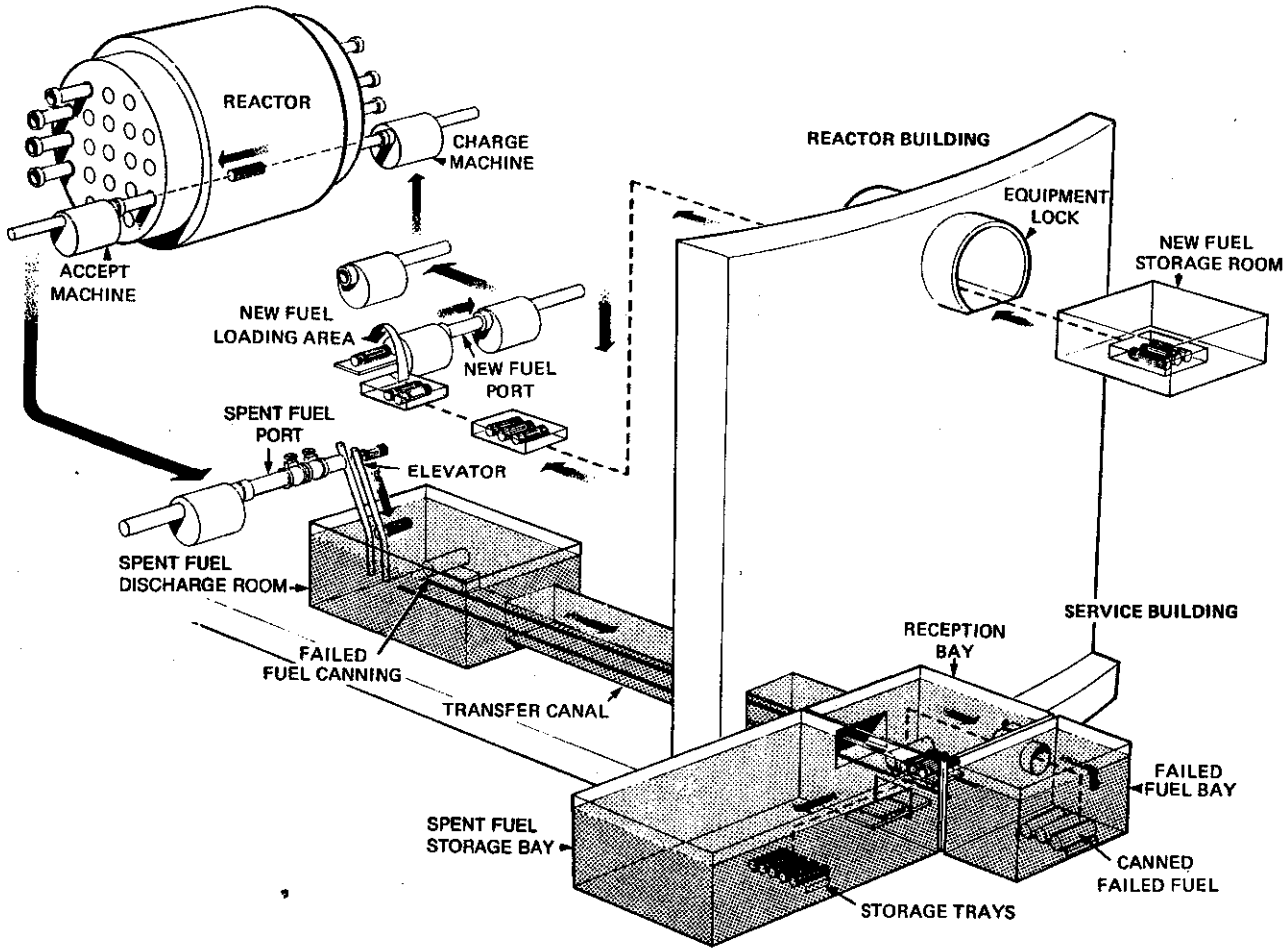
Main Steam Supply



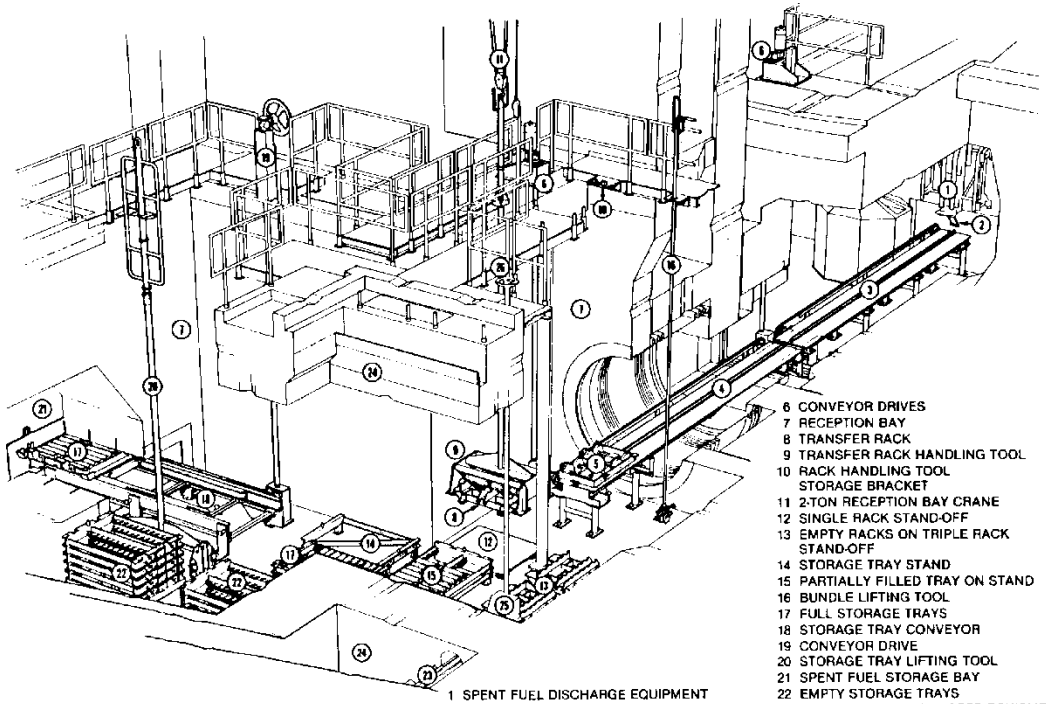
Feedwater System



Fuel Handling System



Fuel Transfer System



1 SPENT FUEL DISCHARGE EQUIPMENT (REF. ONLY)
2 TRANSFER RACK DETECTION SWITCH LEVER
3 DISCHARGE BAY CONVEYOR
4 TRANSFER CANAL CONVEYOR
5 TRANSFER CART
6 CONVEYOR DRIVES
7 RECEPTION BAY
8 TRANSFER RACK
9 TRANSFER RACK HANDLING TOOL
10 RACK HANDLING TOOL STORAGE BRACKET
11 2-TON RECEPTION BAY CRANE
12 SINGLE RACK STAND-OFF
13 EMPTY RACKS ON TRIPLE RACK STAND-OFF
14 STORAGE TRAY STAND
15 PARTIALLY FILLED TRAY ON STAND
16 BUNDLE LIFTING TOOL
17 FULL STORAGE TRAYS
18 STORAGE TRAY CONVEYOR
19 CONVEYOR DRIVE
20 STORAGE TRAY LIFTING TOOL
21 SPENT FUEL STORAGE BAY
22 EMPTY STORAGE TRAYS
23 DEFECTED FUEL TRANSFER EQUIPMENT (REF. ONLY)
24 DEFECTED FUEL STORAGE BAY
25 DEFECTED FUEL BAY ISOLATION VALVE (REF. ONLY)
26 ISOLATION VALVE DRIVE (REF. ONLY)

Next Steps

- Detailed Lecture Notes
  - PDF lecture manual
  - Simulator exercises for practice
- CANDU 9 Simulator
  - Simulates current CANDU technology
  - Good for overall understanding of plant operations
- ACR-700 Simulator
  - Simulates future CANDU concepts.
  - Includes more accident scenarios

Next Steps

CANDU-9 and ACR-700 Simulator

– Practise power maneuvers for Normal Operation Conditions

– Understand basic faults