ACR-700™
Reactor Coolant System, Moderator and Major Auxiliary Systems

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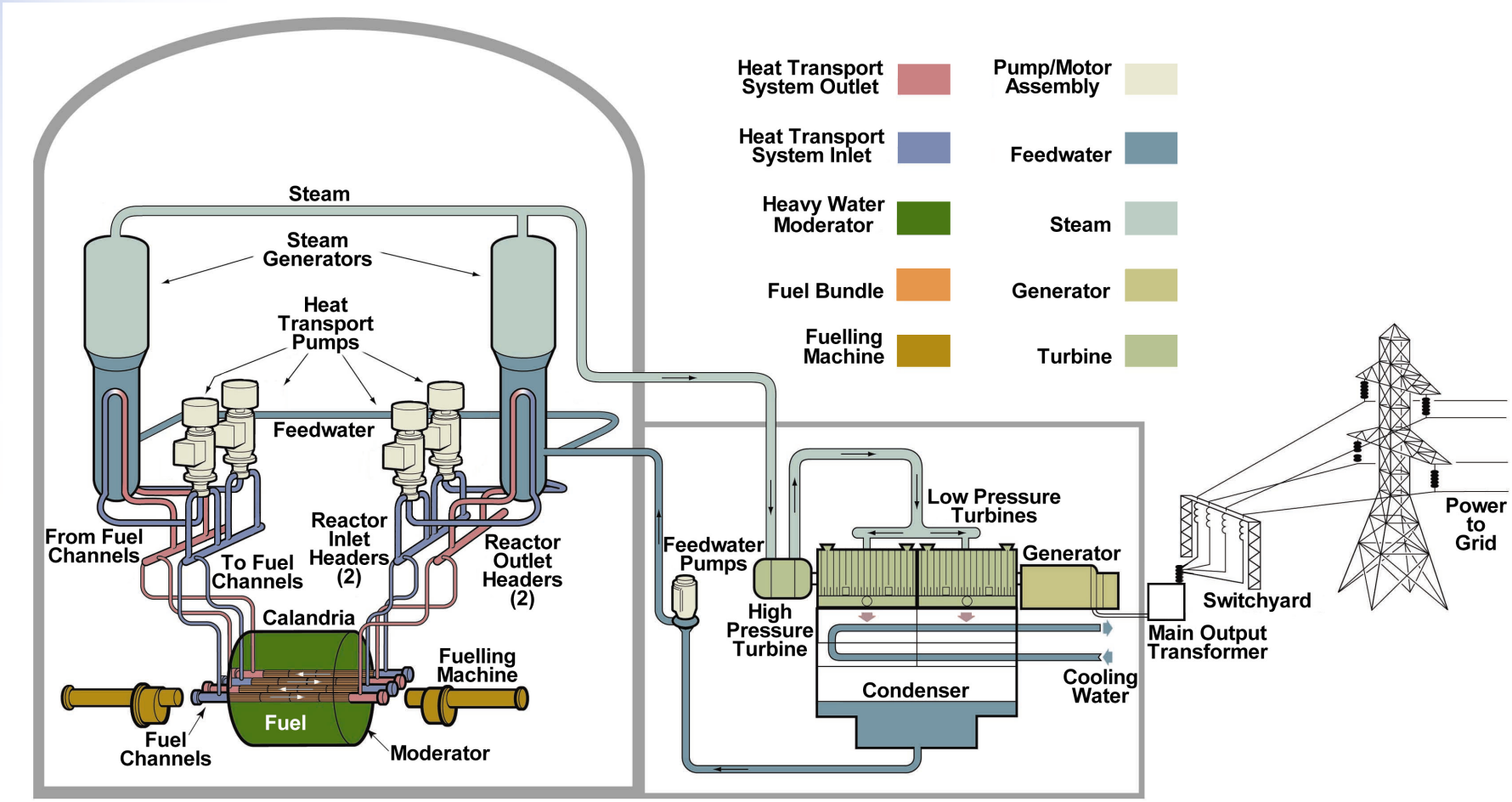
AECL TECHNOLOGIES INC.

Outline

- ACR-700 Design Basis
- Reactor Coolant System and Auxiliary Systems
- Moderator and Auxiliary System
- Major Auxiliary Systems
- Balance of Plant

Features of ACR CANDU

- Heavy water moderator
- Light water coolant
- Modular horizontal fuel channels
- Simple, economical fuel bundle design
- On-power fueling
- High neutron efficiency



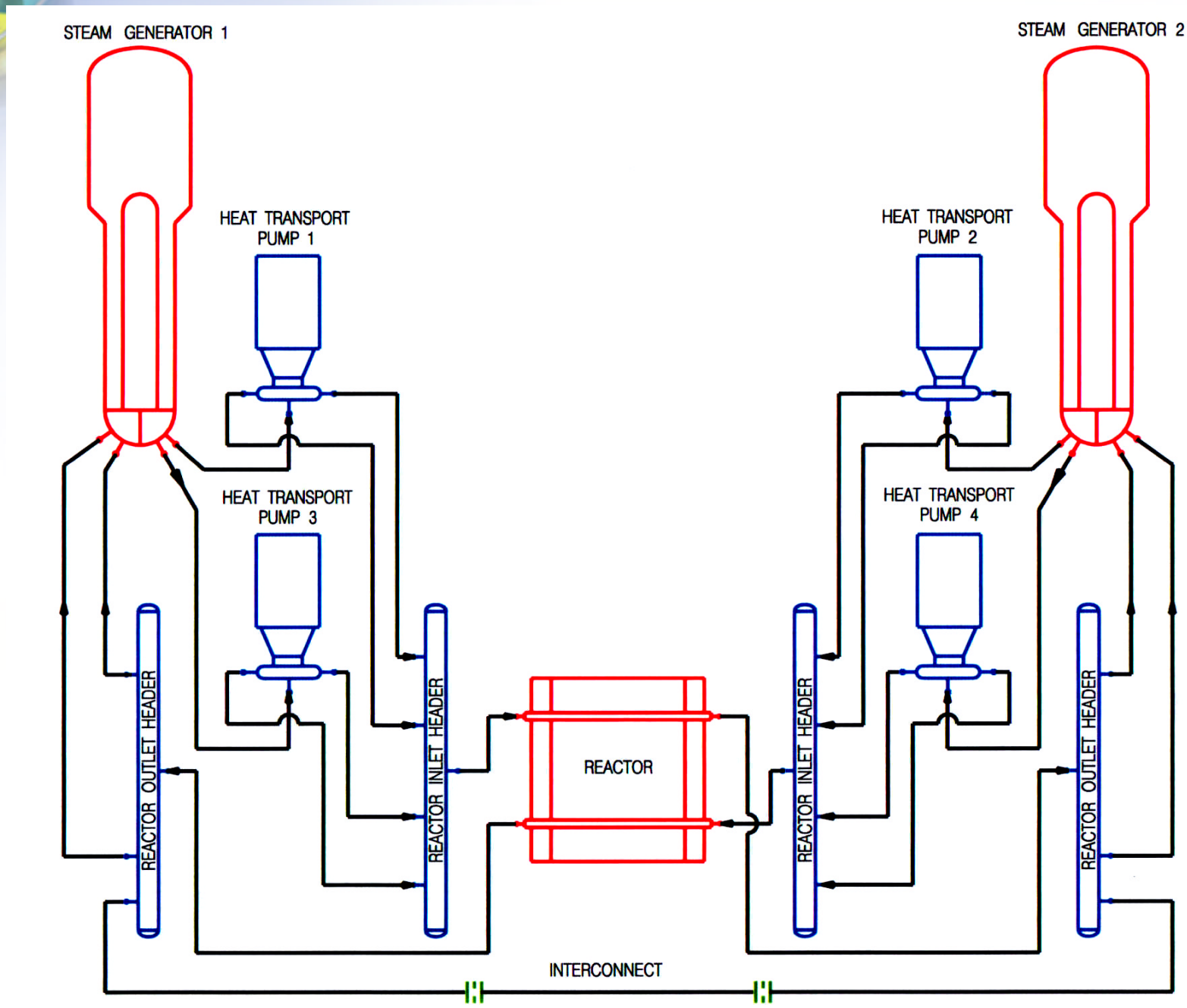
Basis of ACR Design

- Retained traditional CANDU features:
  - Modular horizontal fuel channels
  - Simple, economical fuel bundle design
  - Heavy water moderator reactor core
  - On-power fueling
  - High neutron efficiency
- Feedback from CANDU plants
  - Operating CANDU plants
  - Construction/Commissioning feedback from CANDU 6 Qinshan III project

Basis of ACR Design . . .

- Innovations integrated into the ACR design.
  - Compact core design
  - Reduced inventory of D_2O due to light water reactor coolant and reduced core size
  - SEU fuel in ACR CANFLEX bundles with increased burn-up
  - Enhanced safety margins
  - Higher coolant and steam conditions resulting in improved turbine efficiency
  - Reduced emissions
  - Improved performance through use of advanced operational and maintenance information systems

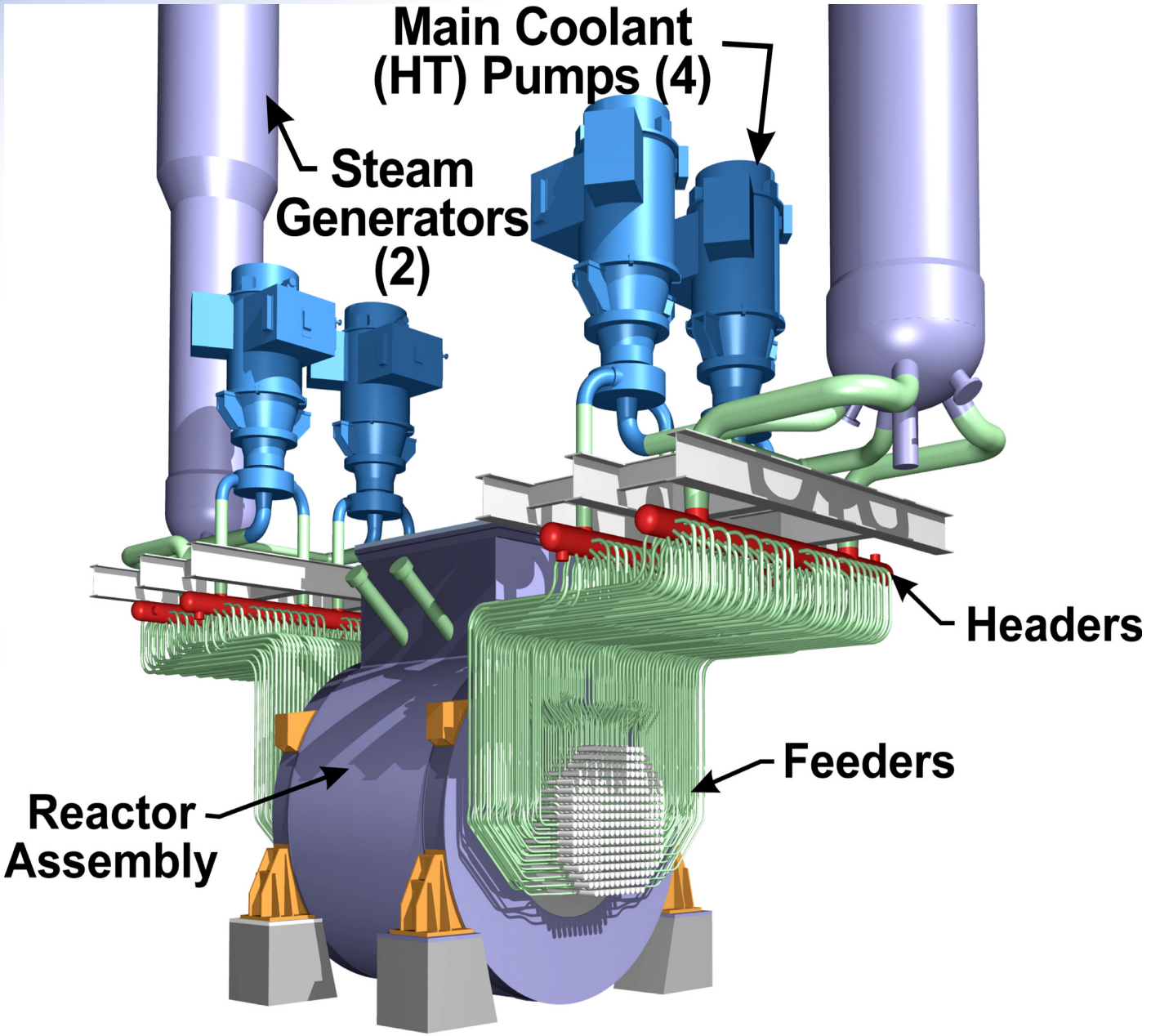
Reactor Coolant System (RCS)



Reactor Coolant System (RCS)

- The reactor coolant system in CANDU circulates light water (H_2O) coolant through the reactor fuel channels.
- The RCS arrangement is similar to a single loop of the two loop C6 design ("Figure - eight" loop configuration).
- Steam Generators are similar in design and size to PWR SGs.
- Main Coolant Pumps are similar to the CANDU 6 design.
- No valves in the reactor coolant circuit.
- All components are above core for effective thermosyphoning
- Design to CSA N285.0 and ASME Section III Class I
- Fast power maneuvering (0 to 100% full power within 5 minutes) and heatup/cooldown (5°F/min) capability.
- Lower feeder material is stainless steel to prevent flow assisted corrosion.
- Feeder header assemblies are pre-assembled & modularized.

Reactor Coolant System (RCS)



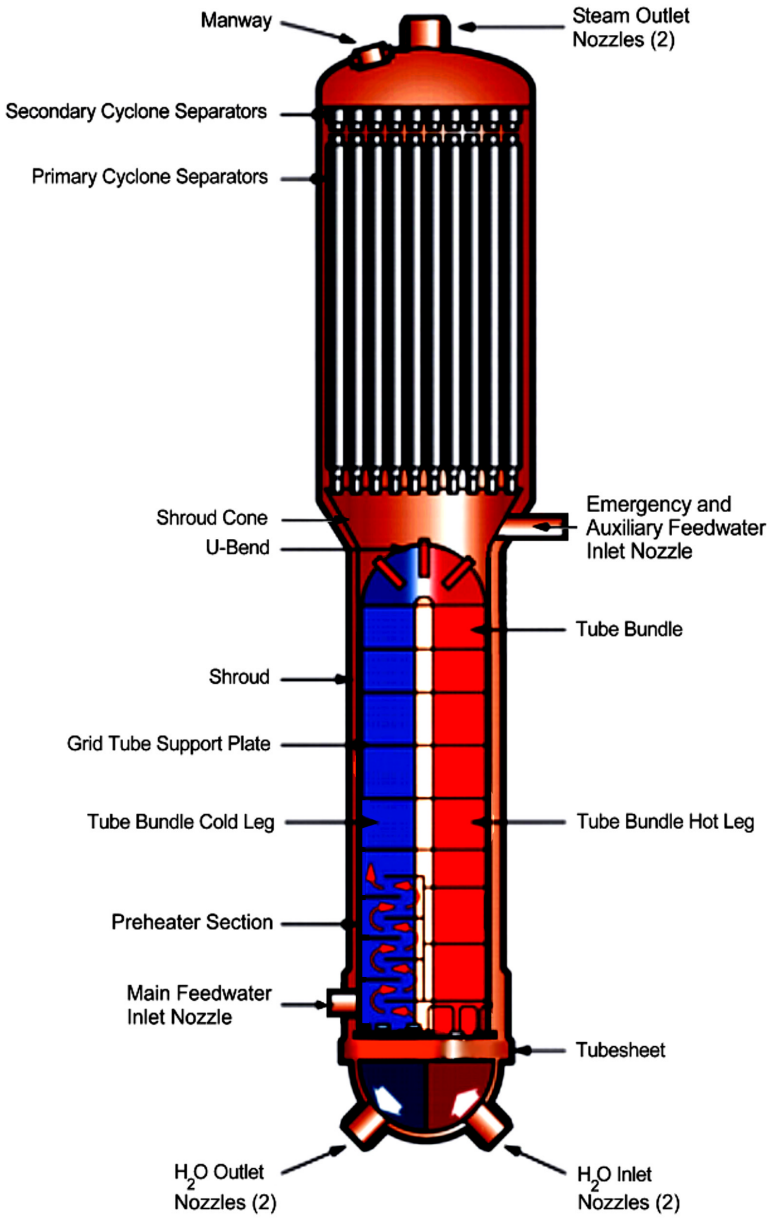
Comparison of C6 and ACR-700 Design

Parameters	C6	ACR-700
Max. time-averaged channel power,MWth	6.7	7.5
Number of fuel channels	380	284
Reactor powerto steam generators MWth	2064	1982
Maximum channel flow, kg/s (lb/s)	28 (62)	26 (57)
Reactor outlet header pressure, Mpa(g) (psig)	9.9 (1436)	11.9 (1726)
Reactor outlet header temperature, °C (°F)	310 (590)	325 (617)
Reactor Outlet Quality, %	4	2
Reactor inlet header pressure, Mpa(g) (psig)	11.2 (1624)	13.1 (1900)
Reactor inlet header temperature, °C	266 (511)	278.5 (533)
Steam drum pressure, Mpa(g) (psig)	4.6 (667)	6.4 (928)
Steam drum temperature, °C (°F)	260 (500)	281 (538)
Feedwater temperature, °C	187 (3686)	218 (424.4)
Electric output(gross) MWe	728	731
Condenser vacuum, kPa(a) (psia)	4.9 (0.7)	4.9 (0.7)
Thermal Efficiency	35.3	36.9

Enhanced Safety Margins

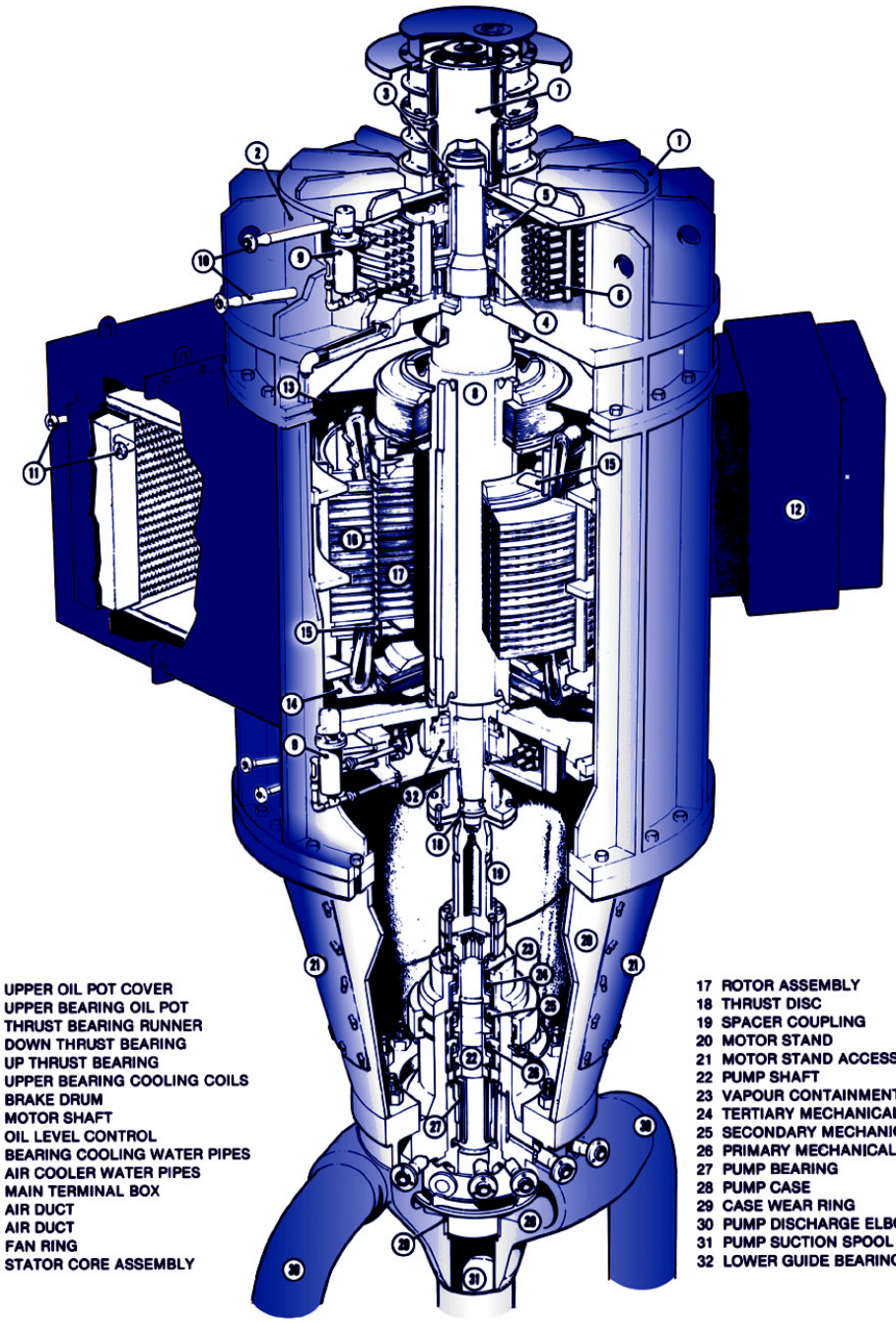
- Use of ACR CANFLEX fuel bundle with Critical Heat Flux (CHF) enhancements improves Critical Channel Power (CCP) margin.
- Max. instantaneous linear element rating is less than that of C6 (51kW/m for ACR-700 versus 57 kW/m for C6)
- Aging effects of PT creep and SG fouling are considered in the RCS design.
- Verification of ACR CANFLEX fuel design is underway, including planned irradiation and CHF tests.
- Effectiveness and reliability of heat sinks improved (i.e., emergency core cooling system, reserve water system, recirculated cooling water and raw service water systems)

Steam Generator



Parameters	C6	ACR- 700
No. of SGs	4	2
Tube Bundle Area, m^2 ($ft^{2)}$	3200 (34,000)	9350 (100,640)
Overall Height, m (ft)	19.5 (64)	23.8 (78)
Shroud Diameter (m) (ft)	2.7 (8.9)	3.8 (12.5)
Steam Drum Diameter (m)	3.8 (12.5)	4.7 (15.4)

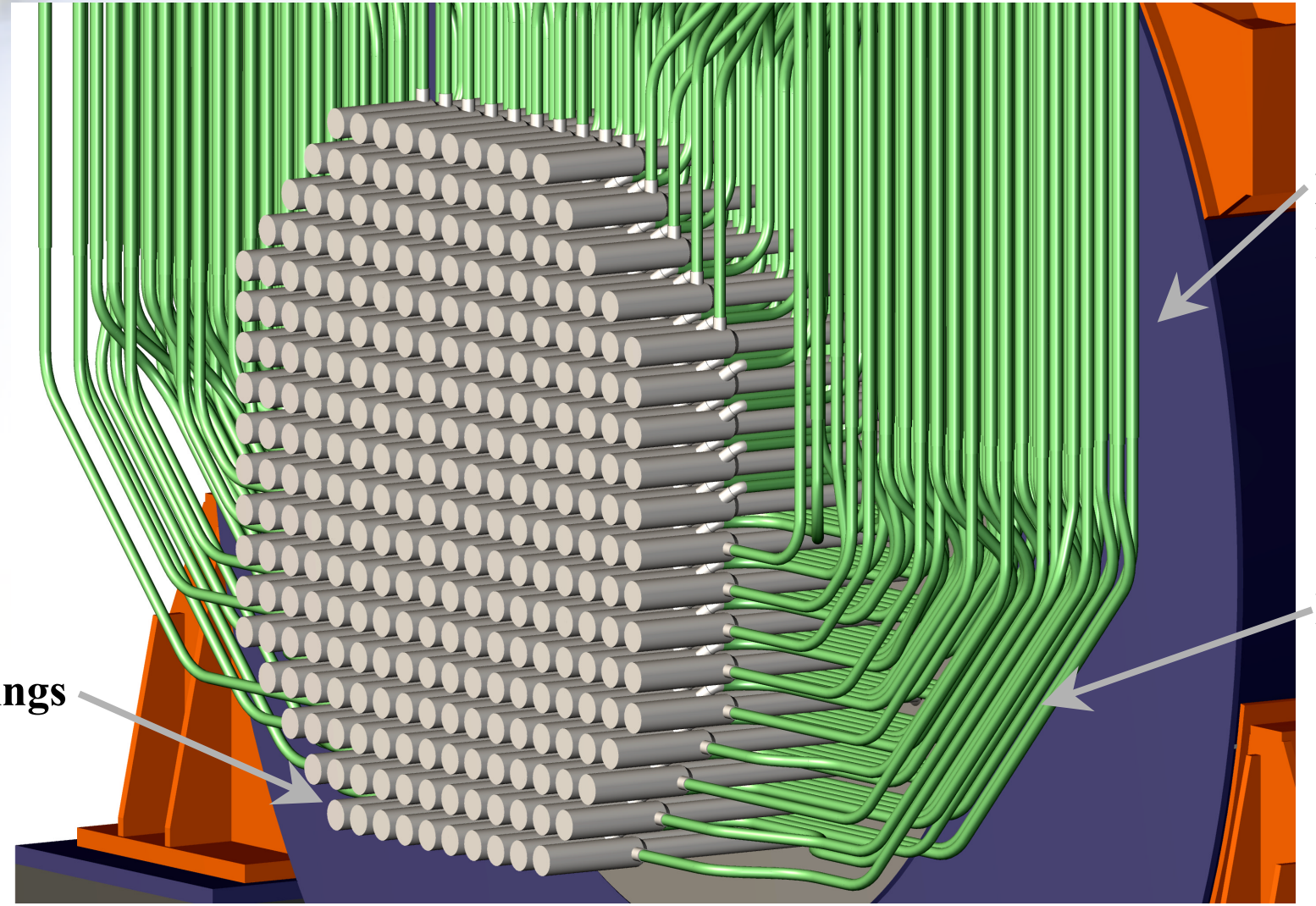
Main Coolant Pump



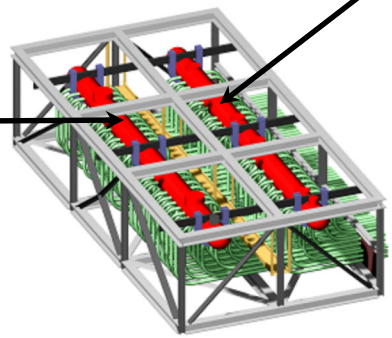
1 UPPER OIL POT COVER
2 UPPER BEARING OIL POT
3 THRUST BEARING RUNNER
4 DOWN THRUST BEARING
5 UP THRUST BEARING
6 UPPER BEARING COOLING COILS
7 BRAKE DRUM
8 MOTOR SHAFT
9 OIL LEVEL CONTROL
10 BEARING COOLING WATER PIPES
11 AIR COOLER WATER PIPES
12 MAIN TERMINAL BOX
13 AIR DUCT
14 AIR DUCT
15 FAN RING
16 STATOR CORE ASSEMBLY
17 ROTOR ASSEMBLY
18 THRUST DISC
19 SPACER COUPLING
20 MOTOR STAND
21 MOTOR STAND ACCESS DOORS
22 PUMP SHAFT
23 VAPOUR CONTAINMENT SEAL
24 TERTIARY MECHANICAL SEAL
25 SECONDARY MECHANICAL SEAL
26 PRIMARY MECHANICAL SEAL
27 PUMP BEARING
28 PUMP CASE
29 CASE WEAR RING
30 PUMP DISCHARGE ELBOWS
31 PUMP SUCTION SPOOL PIECE
32 LOWER GUIDE BEARING ASSEMBLY

Parameters	C6	ACR- 700
No. of Pumps	4	4
Discharge Nozzles Dia, m (inch)	2 x .04 (2 x 16”)	2 x 0.4 (2 x 16”)
Pump Suction Dia, m (inch)	0.5 (20”)	0.5 (20”)
Overall Height, m (ft.)	7 (23)	7.4 (24)
Motor Rating (MWe)	6.7	6.9

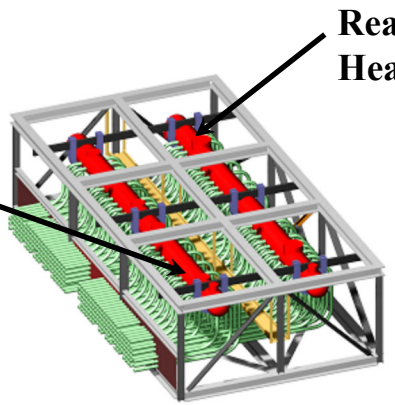
Feeder Layout



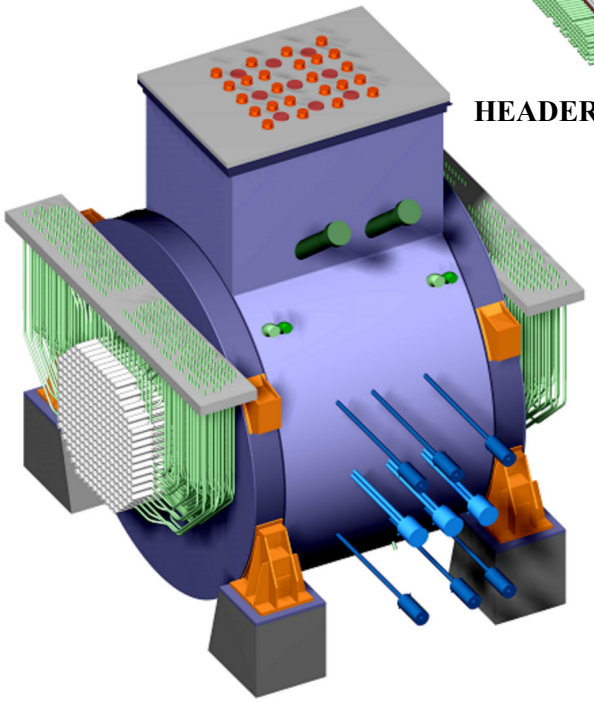
Header/Upper Feeders Modules



HEADERS / UPPER FEEDERS MODULE 2



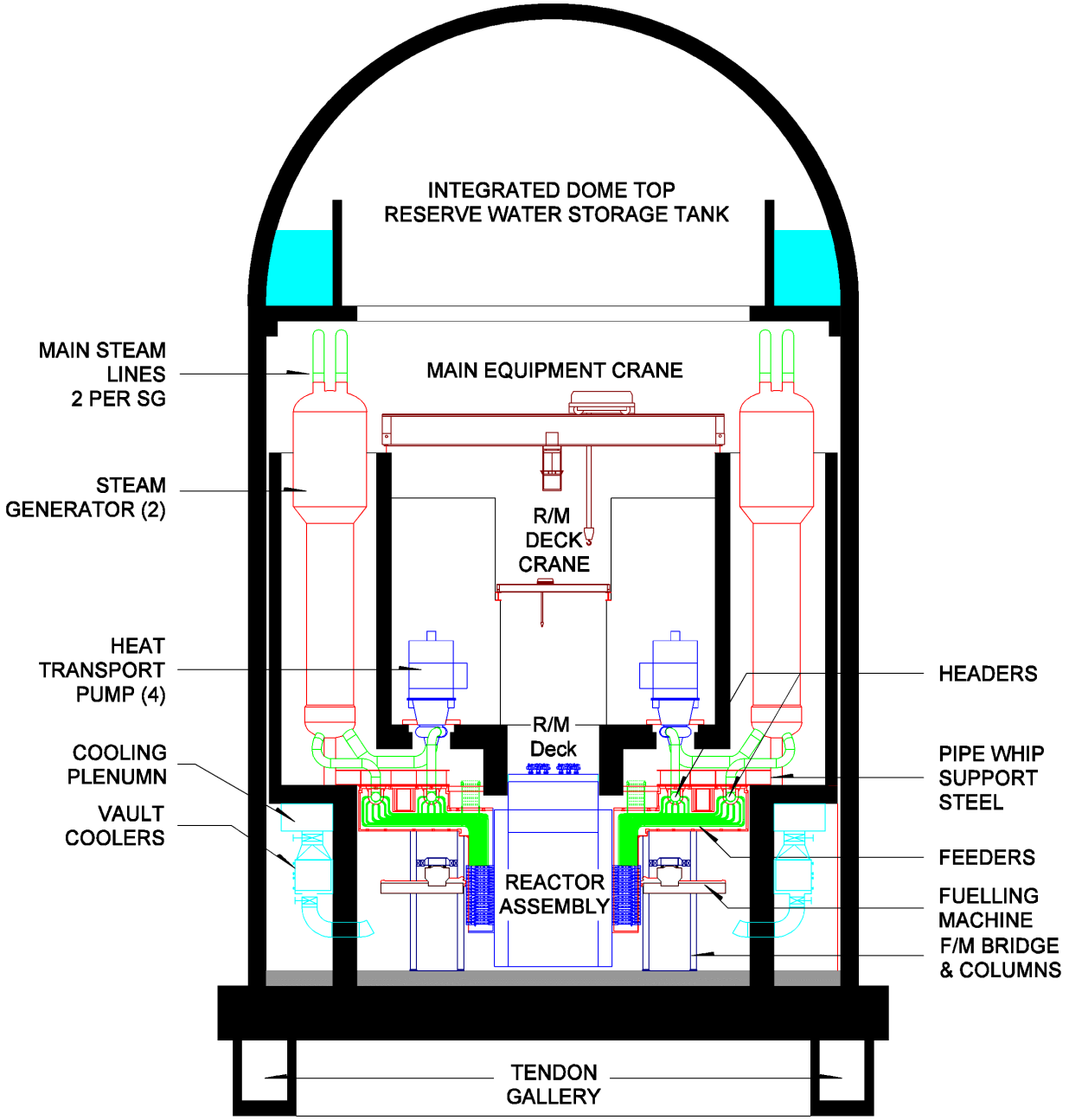
HEADERS / UPPER FEEDERS MODULE 1



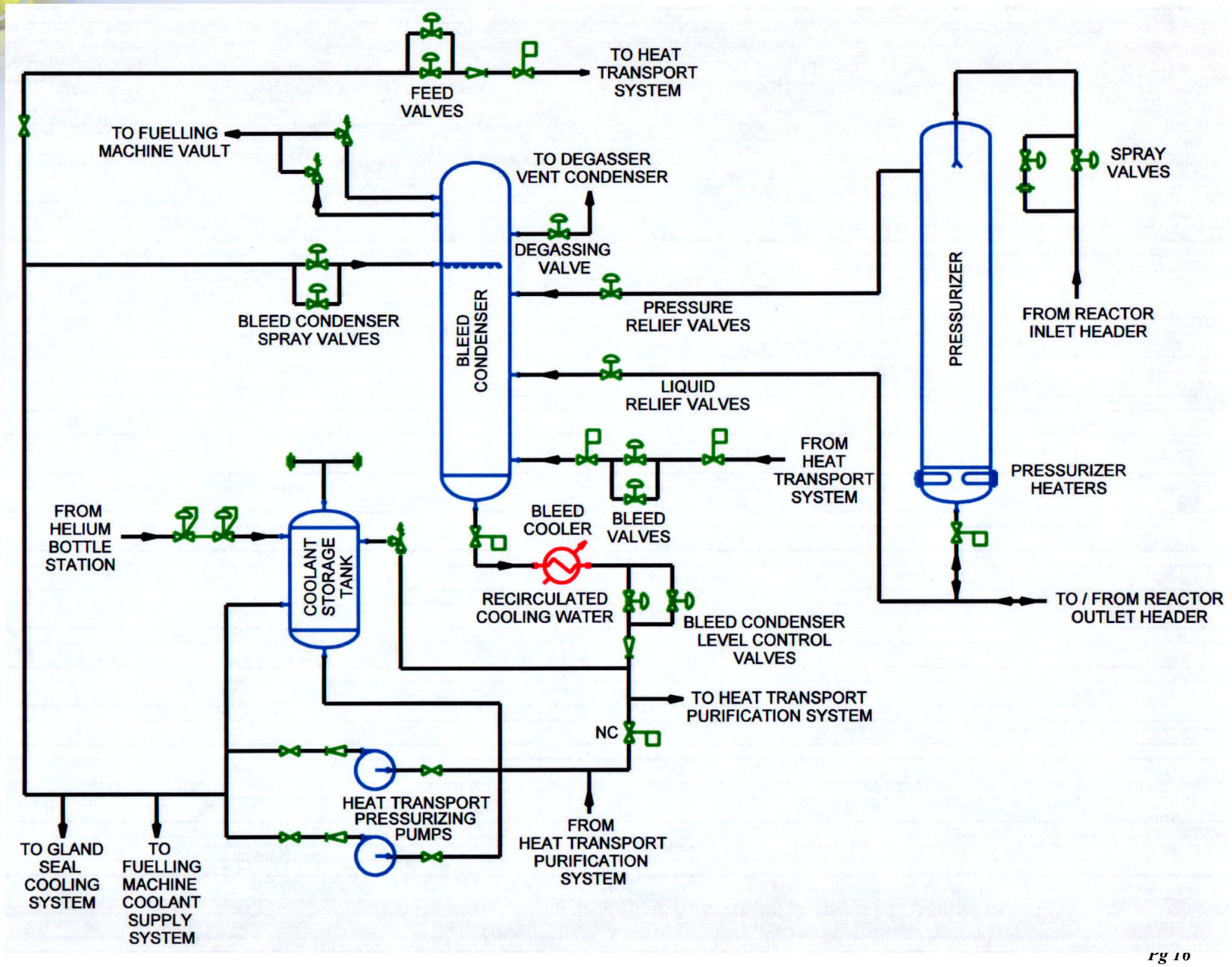
REACTOR ASEMBLY MODULE

Parameters	C6	ACR-700
Number of Headers RIH ROH	 4 4	 2 2
RIH ID mm, (in.)	370 (14.6)	470 (18.5)
RIH OD mm, (in.)	482 (19)	630 (24.8)
ROH ID mm, (in.)	406 (16)	495 (19.5)
ROH OD mm, (in.)	533 (21)	640 (25.2)
RIH Length m, (ft.)	6.4 (21)	11 (36)
ROH Length m, (ft.)	6. 5 (21.3)	11 (36)

Reactor Building Section



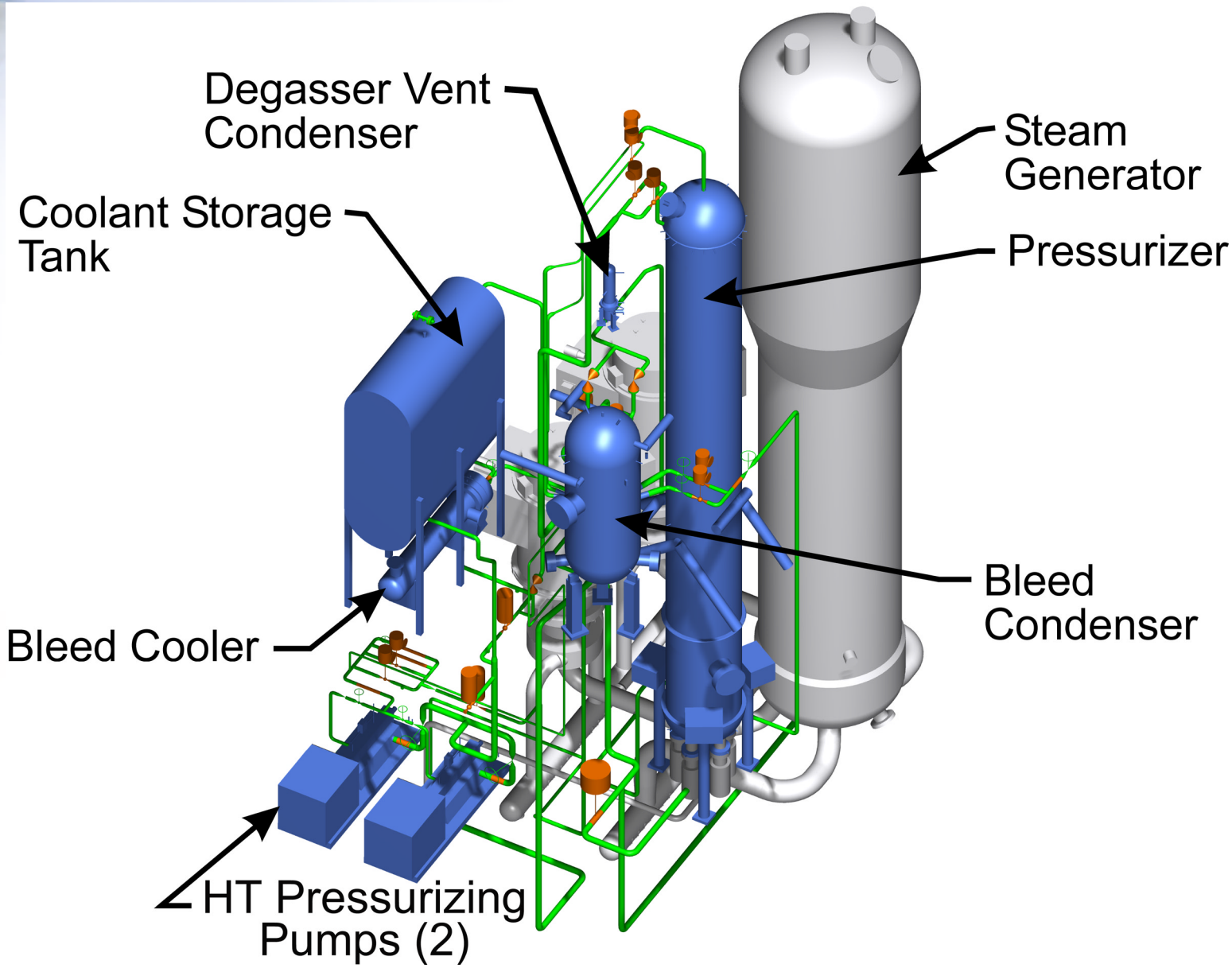
Pressure & Inventory Control System



Pressure & Inventory Control System (P&IC)

- Based on CANDU 6 design with improvements and simplification incorporated
- Controls RCS pressure through pressurizer spray and heaters
- Controls RCS inventory through bleed condenser/ cooler and RCS pressurizing pumps
- Provides means of degassing the coolant
- Provides overpressure protection for RCS
- Facilitates transfer of H_2O to RCS from interfacing systems (sampling, collection, recovery)

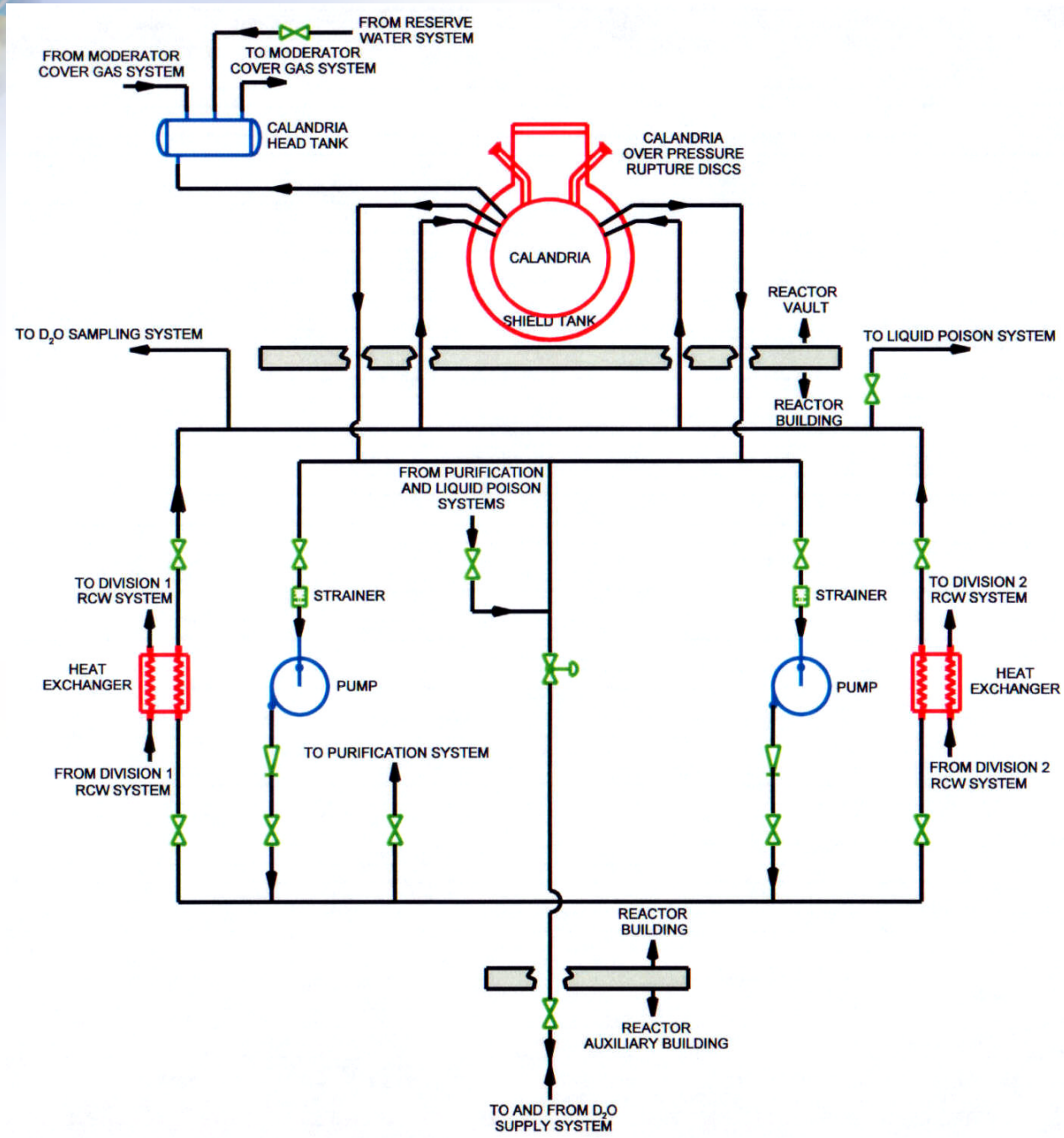
P&IC System Layout



Key Reactor Coolant (HT) Auxiliary Systems

- HT Purification System
  - Design based on Darlington
  - Reduces radiation levels in the coolant and auxiliary systems to minimize dose exposure
  - Maintains coolant chemistry within specified limits (pH, O_2, H2, Li, etc.)
- HT Pump Seal Cooling system
  - Design based on CANDU 6
  - Provides normal and backup cooling (H_2O) to HT pump seals

Main Moderator System

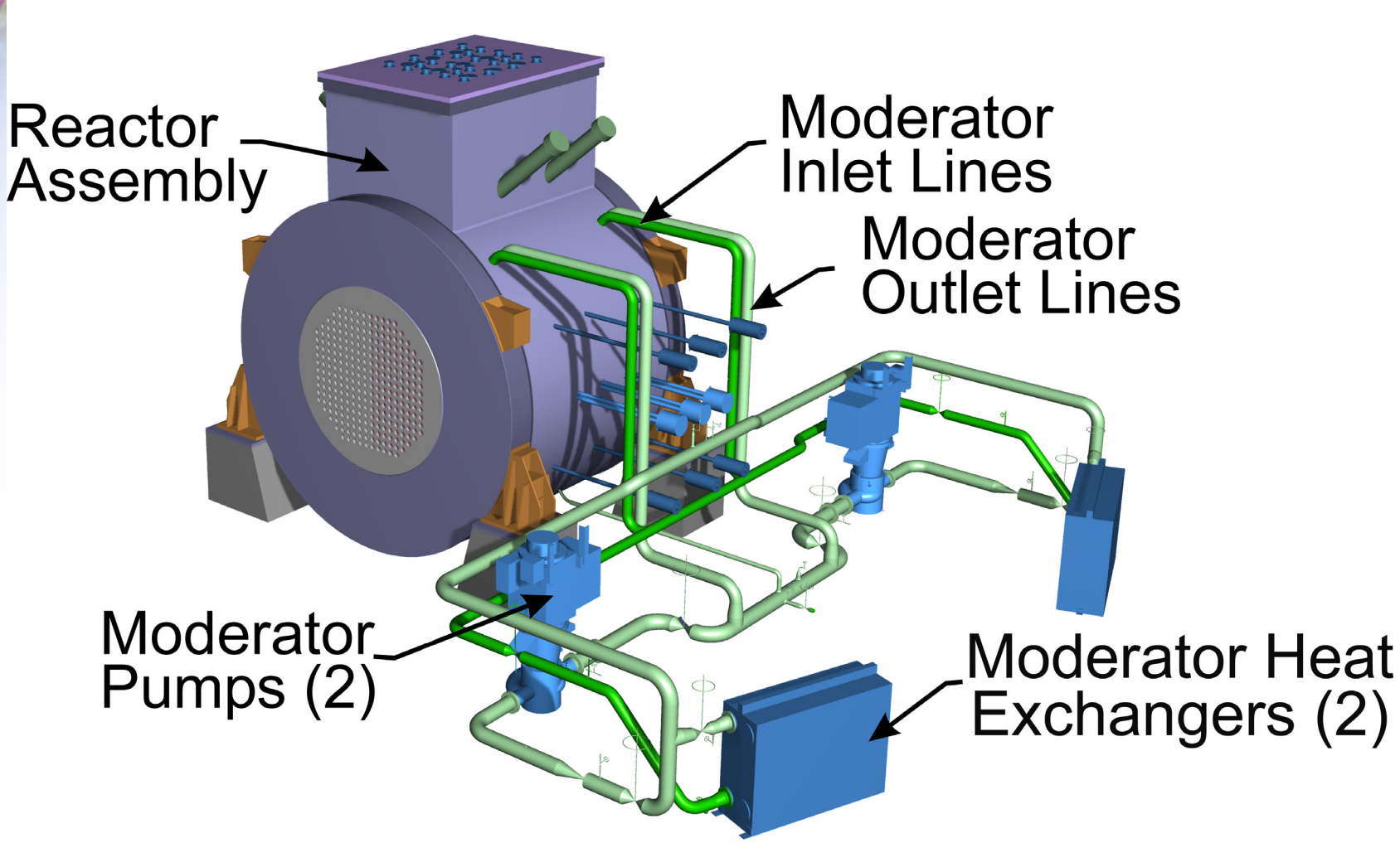


- **Low pressure & temperature system**
- **2x100% pumps**
- **2x50% HXs**
- **Uniform flow & temperature distribution in calandria**
- **All Stainless Steel System**

Moderator System

- Heavy Water (D_2O) is used as the moderator in the ACR core
- Removes heat generated in moderator during normal operation from:
  - neutron moderation
  - heat transfer from pressure tubes
  - heat transfer from reactor structures
- Serve as a means for dispersion of chemicals to control activity
- Provides a back up heat sink following severe accidents
- Design based on CANDU 6 with improvements in calandria circulation and layout for installation and maintenance

Main Moderator System Layout



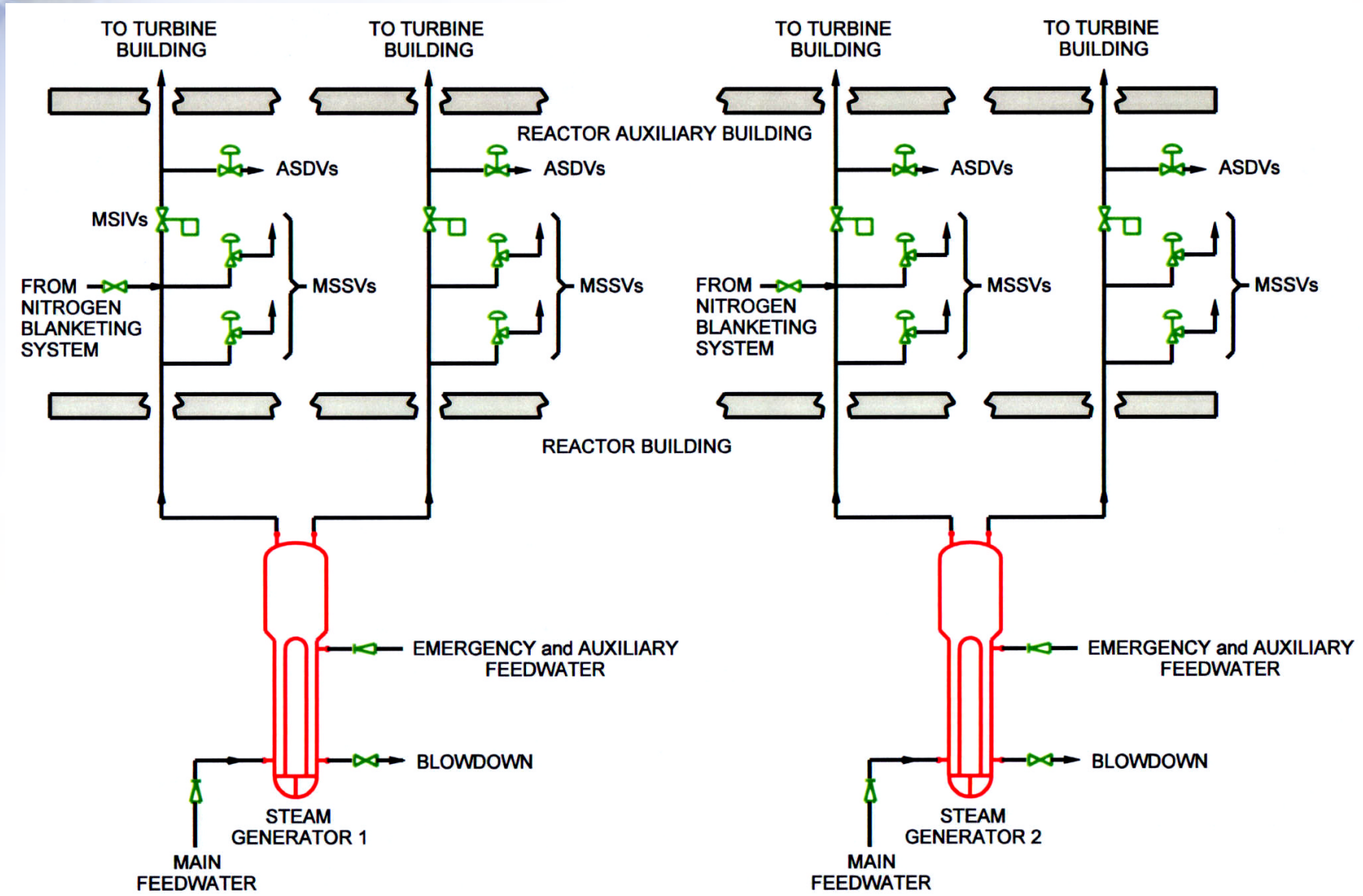
Moderator Auxiliary Systems

- Moderator auxiliary systems are based on CANDU 6 design with feedback improvements included in design.
- Moderator auxiliary system include those required for purification, reactivity control and sampling of heavy water.
- All are housed within one area of RB to improve D_2O recovery.

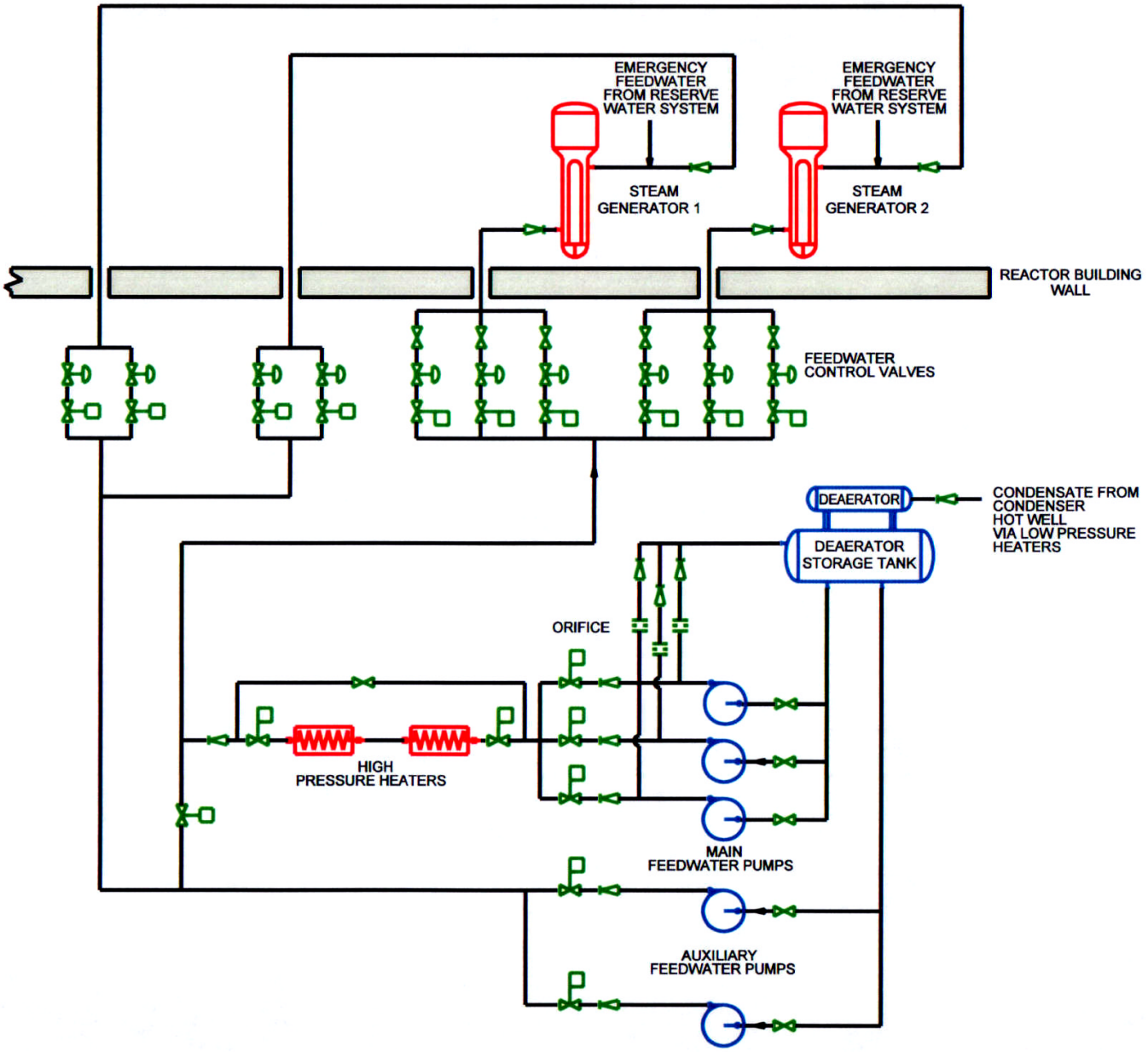
Major Auxiliary Systems

- Main Steam System
- Main Feedwater System
- Service Water Systems

Main Steam System

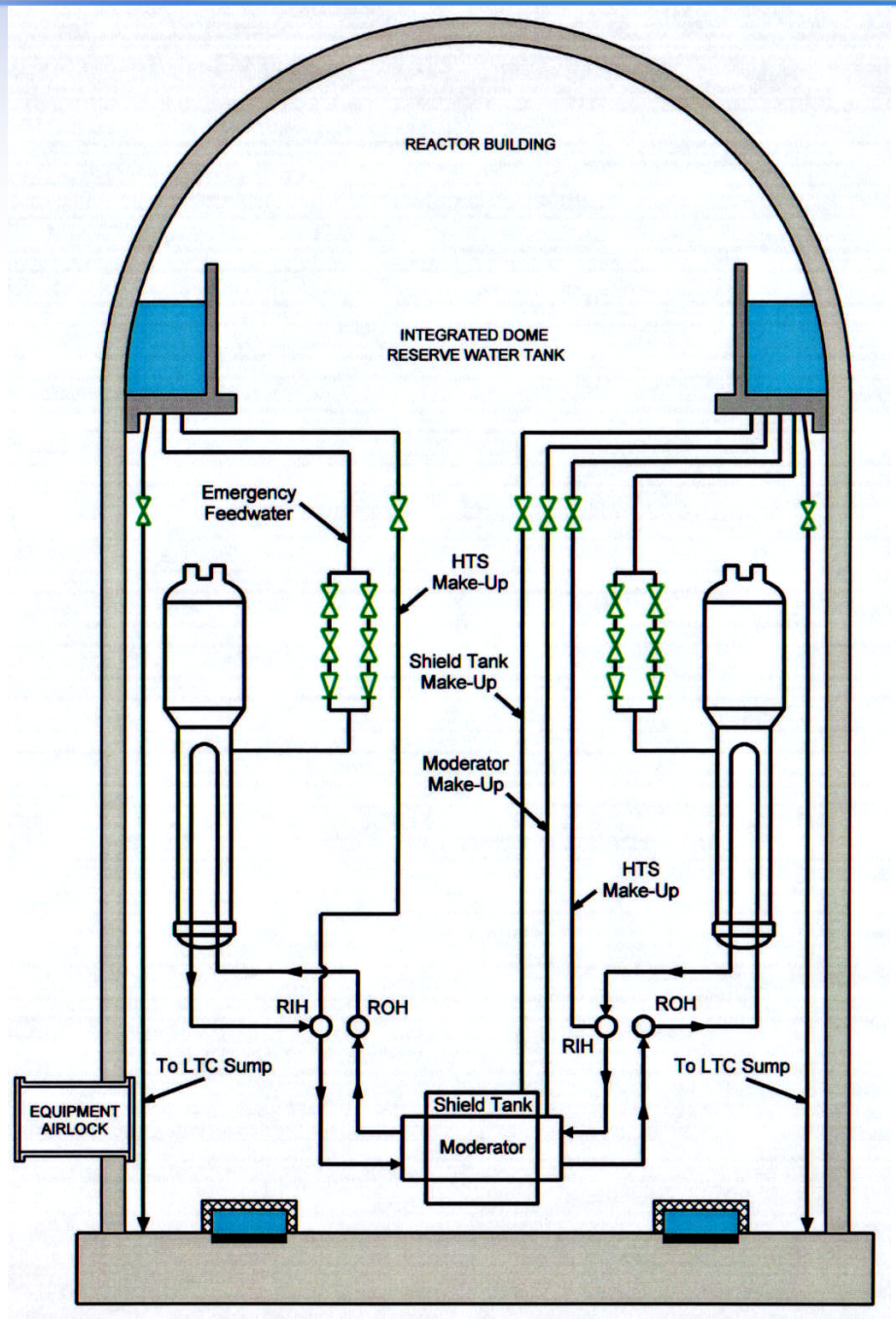


Main Feedwater System



- 3x50% Feed Pumps
- 2 Auxiliary Feed Pumps
- Separate connections to SGS for Energy Feedwater
- Emergency Feedwater supply from seismically qualified RWS

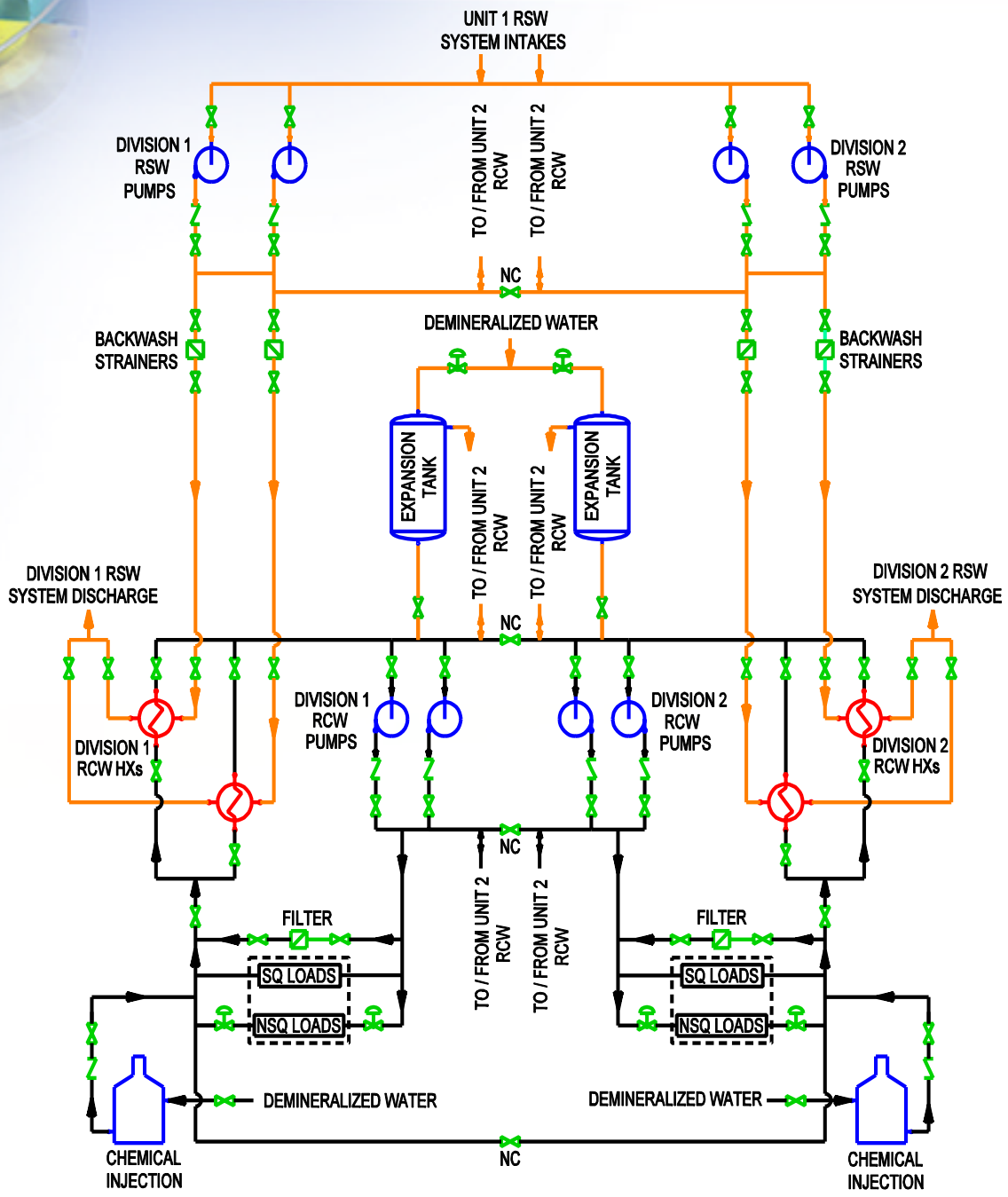
Passive Emergency Feedwater Supply



Main Steam & Feedwater Systems

- Main Steam System based on CANDU 6 design with improvements in layout to ensure postulated steam line failures do not impact on Main Control Room.
- Main steam valves (MSSVs, ASDVs, MSIVs) are housed above RAB in seismically qualified structure.
- Main Feedwater System, is based on CANDU 6 design and located in Turbine Building.
- Portion of Feedwater system inside RB / RAB is seismically qualified.
- Passive emergency feedwater supply is provided from Reserve Water System (RWS) to improve SG back-up heat sinks.

Service Water Systems



- RCW / RSW shown for 1 unit
- Two seismically qualified RSW/RCW divisions
- 4 RCW / RSW pumps and 10 RCW HXs/unit
- 2 RCW / RSW pumps and 6 HXs for normal operation
- 1 RCW / RSW pump & 4 RCW HXs/unit for safety loads following shutdown

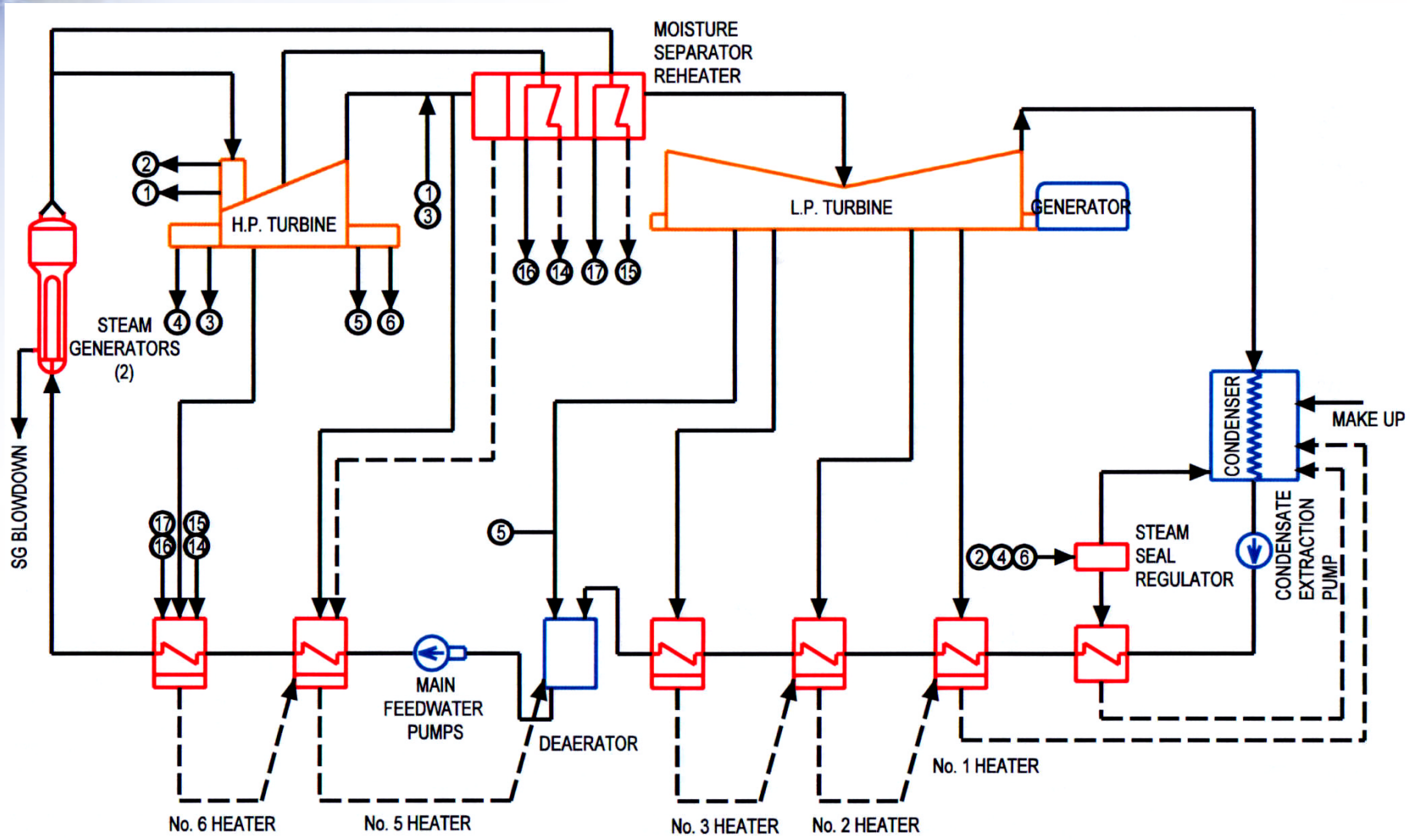
Service Water Systems

- Significant changes from the CANDU 6 design have been implemented to improve reliability and separation.
- Removes the need for EWS.
- RCW / RSW system in each ACR unit supplies cooling water to all safety and non-safety loads in NSP / BOP.
- RCW / RSW system is seismically qualified to ensure supply to all safety support loads.
- Each unit has two separate divisions. Each division can service all safety related cooling loads following shut down.
- Interconnections with other unit are provided to enhance overall reliability.

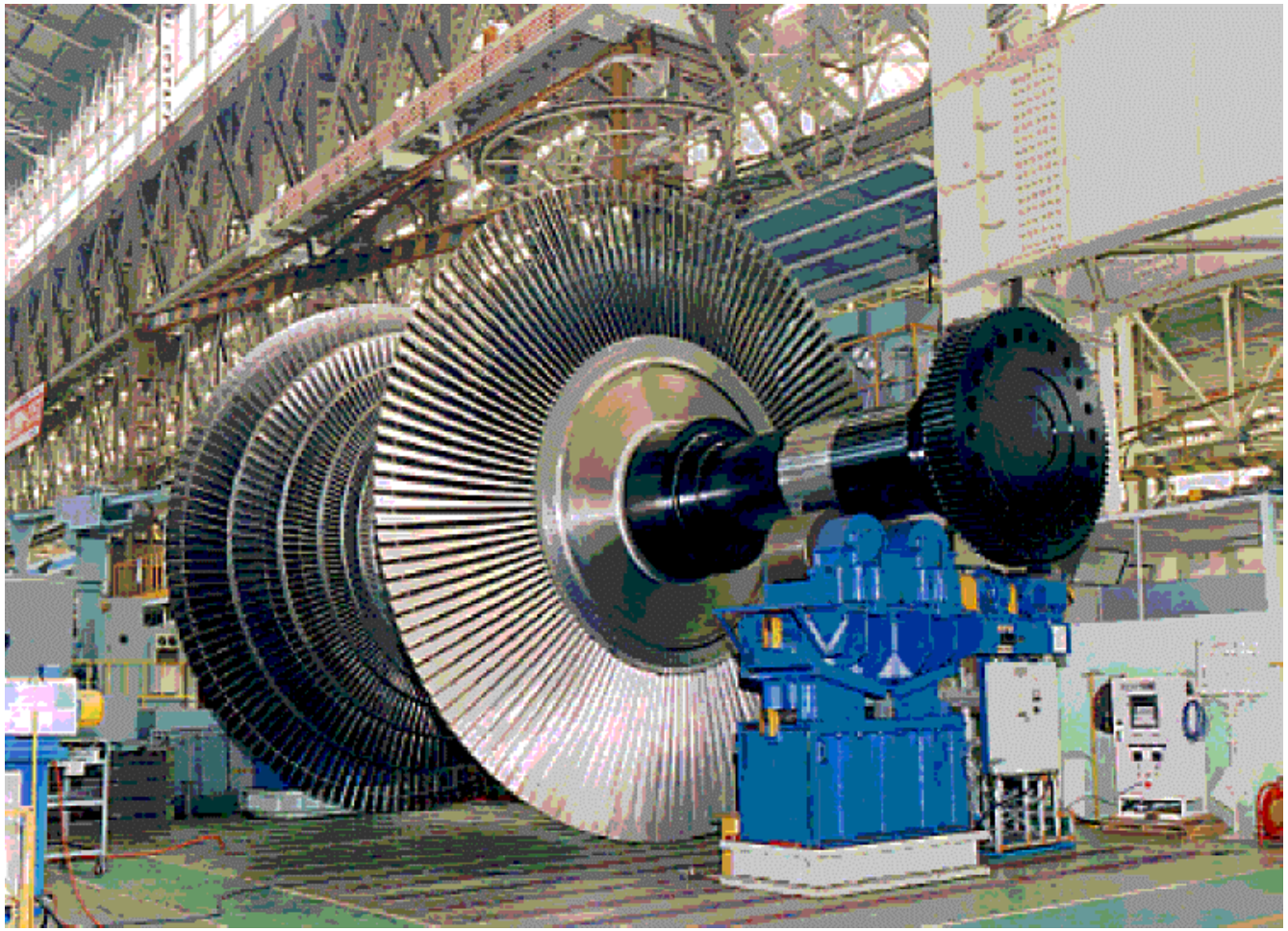
Balance of Plant (BOP)

- Design has been optimized to improve turbine efficiency and overall plant performance
- Reference turbine for ACR 700 plant
  - Single flow HP cylinder & two double flow LP cylinders with 52” last stage blade.
  - Net heat to turbine 1980 MWth
  - Gross electrical output 731 MWe
  - Turbine generator efficiency 36.9%
- Heat cycle equipment optimized to reduce size.
- Turbine Building size reduced from CANDU 6 due to use of 1 stage HP turbine and optimized layout.

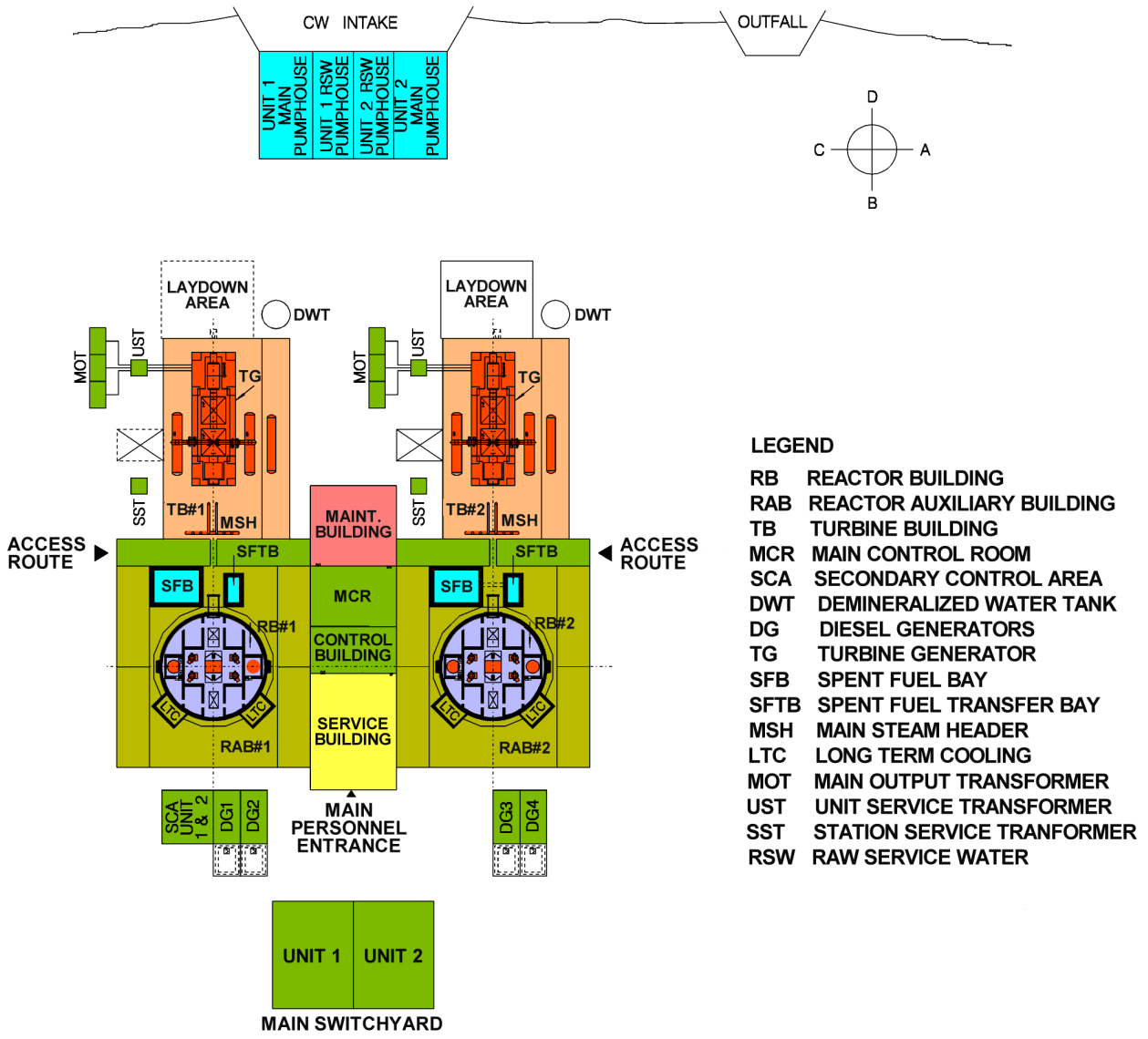
Turbine Generator and Auxiliaries



Qinshan Low-Pressure Turbine Rotor with 52 inch Last Blade Length



2 Unit ACR-700 Plant Layout



LEGEND

RB	REACTOR BUILDING
RAB	REACTOR AUXILIARY BUILDING
TB	TURBINE BUILDING
MCR	MAIN CONTROL ROOM
SCA	SECONDARY CONTROL AREA
DWT	DEMINERALIZED WATER TANK
DG	DIESEL GENERATORS
TG	TURBINE GENERATOR
SFB	SPENT FUEL BAY
SFTB	SPENT FUEL TRANSFER BAY
MSH	MAIN STEAM HEADER
LTC	LONG TERM COOLING
MOT	MAIN OUTPUT TRANSFORMER
UST	UNIT SERVICE TRANSFORMER
SST	STATION SERVICE TRANFORMER
RSW	RAW SERVICE WATER

Summary

- Reactor Coolant System design is based on “one loop” of CANDU 6 with enhanced safety margins.
- Major RCS components are within the range of CANDU experience except for the SGs, which are similar in size to PWRs.
- Moderator System design is based on CANDU 6 with improvements in calandria circulation and layout for installation and maintenance.
- Moderator Auxiliary systems are all located within one area of Reactor Building to improve D_2O.

Summary…..

- Passive emergency feedwater supply from reserve water tank located in dome of Reactor Building provides back-up cooling to SGs.
- Operating conditions have been optimized to improve turbine efficiency and plant performance.
- Major systems design and layout has taken into consideration the feedback from the operating CANDU plants and from Qinshan III CANDU 6 project.

Pictorial View of a Two Unit ACR-700 Plant Arrangement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