



# ***CANDU Safety #6 - Heat Removal***

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## *Overview*

- λ the steam and feedwater system is similar in most respects to that of other reactor types
- λ 4 steam generators
  - 2 in each heat transport system loop, in series
- λ 3 main and 1 auxiliary feedwater pumps
- λ overpressure protection provided by 16 Main Steam Safety Valves (MSSVs), 4 on each steam line
- λ Atmospheric Steam Dump Valves (ASDVs) can dump 10% steam to atmosphere (if condenser is unavailable)
- λ Condenser Steam Discharge Valves can dump 100% transient and 60% steady steam to the condenser

☐ Check Valve (NO)

⊖ Steam Safety Relief Valve (NC)

⊗ Main Steam Isolation Valves (NO)

⊕ Atmospheric Steam Discharge Valves (NC)

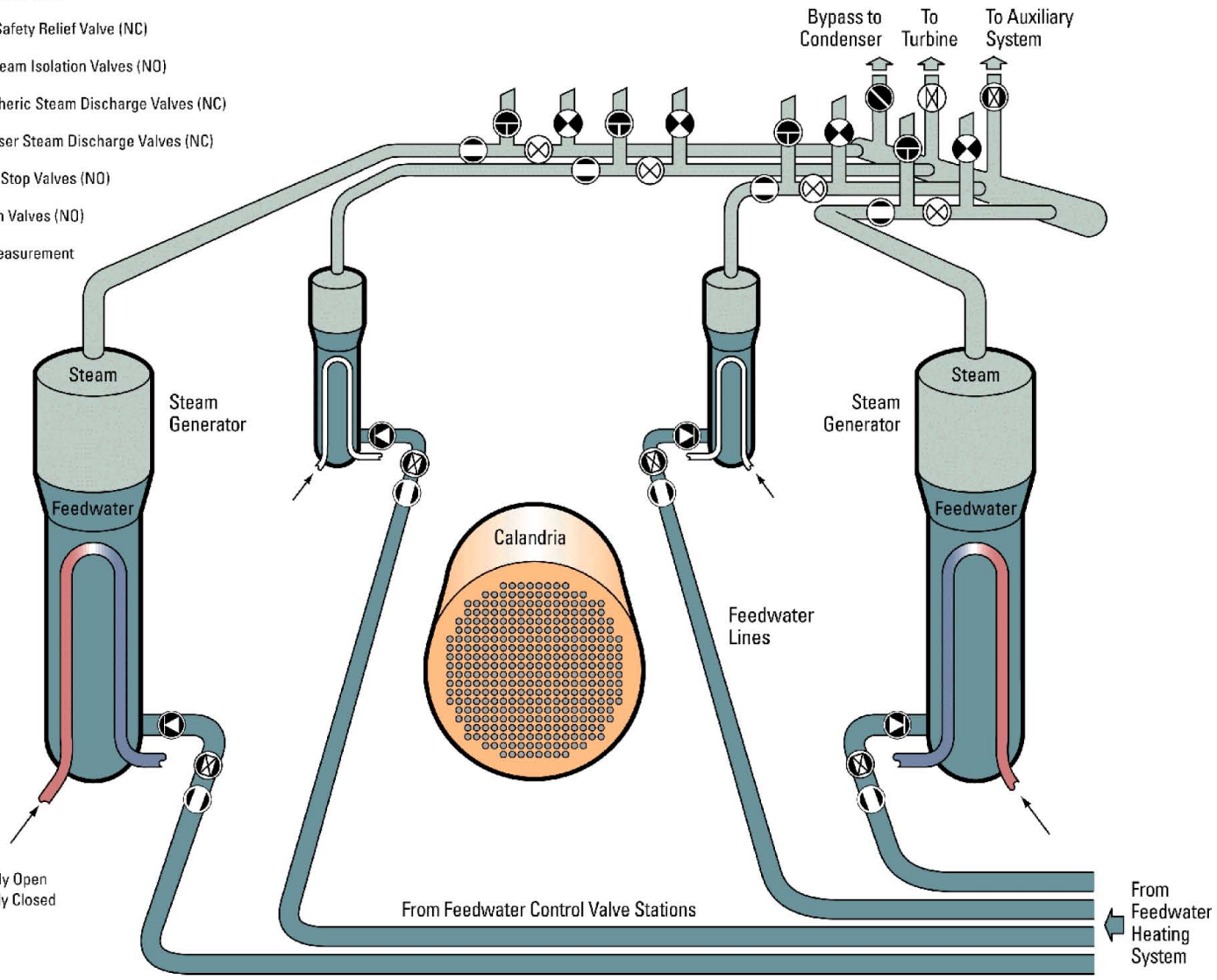
⊖ Condenser Steam Discharge Valves (NC)

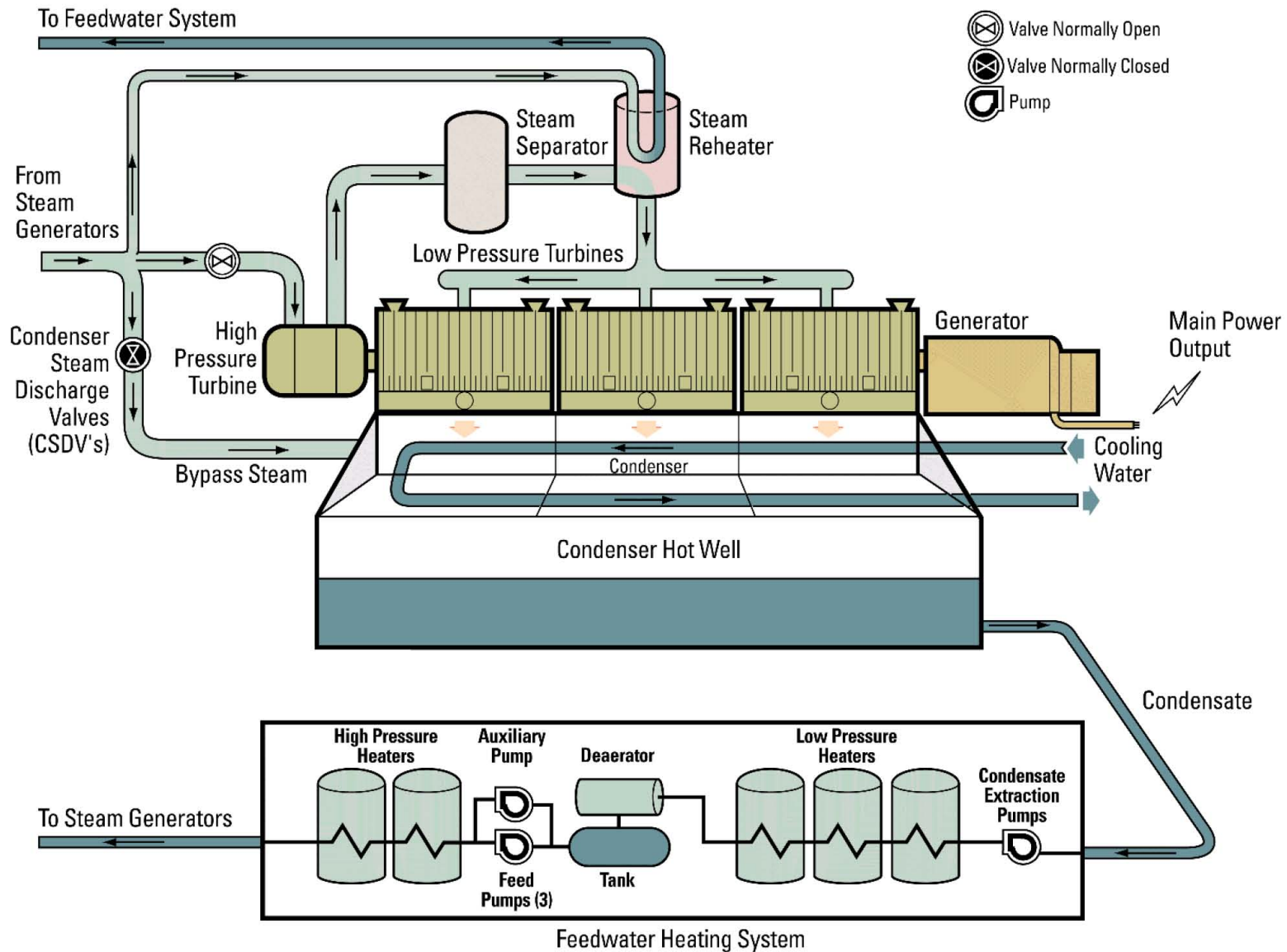
⊗ Turbine Stop Valves (NO)

⊗ Isolation Valves (NO)

○ Flow Measurement

NO - Normally Open  
NC - Normally Closed





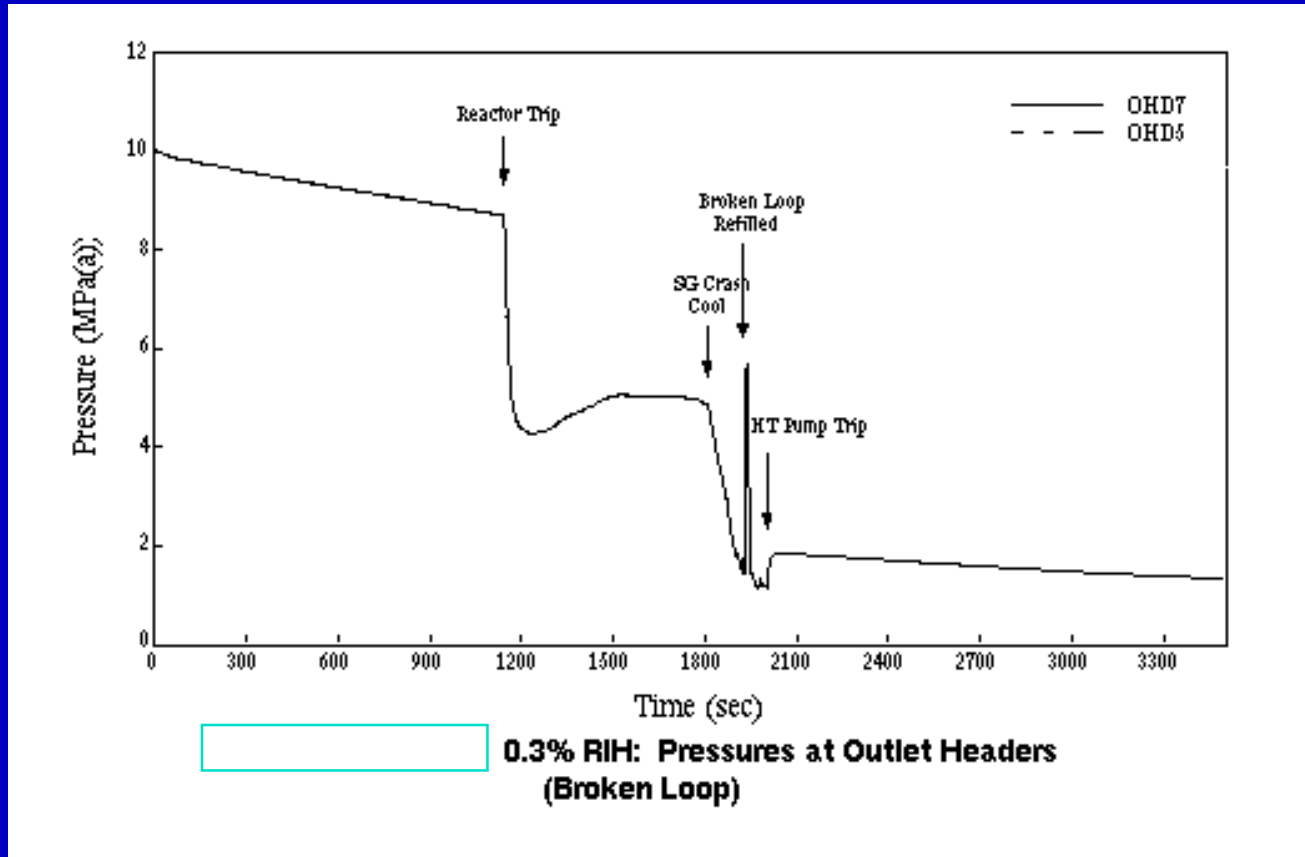


## ***Steam Removal***

- λ Main Steam Safety Valves sized to remove 115% of full steam flow (12 / 16 valves)**
- λ dual actuation:**
  - spring loaded for overpressure protection**
  - pneumatic actuators for controlled opening**
- λ used for forced rapid depressurization of steam generators (“crash cooldown”) for:**
  - LOCA**
  - loss of heat sink**



# Small LOCA





## ***Forced Depressurization***

- $\lambda$  prevents heat transport system pressure in a small LOCA from “hanging up” at the boiler pressure and blocking ECC**
- $\lambda$  allows rapid depressurization of the heat transport system following a loss of heat sink, so low-pressure heat removal systems can be used**
- $\lambda$  does not add reactivity (cooldown reduces reactivity)**
- $\lambda$  does not require opening valves on the primary side (converting a small LOCA or a loss of heat sink into a larger LOCA)**
- $\lambda$  signals are fully duplicated & diverse (two subsystems) for increased reliability**



## *Steam Main Isolation*

- $\lambda$  tradeoff:
  - provide reliable heat removal pathway, or
  - stop escape of radioactivity through leaking boiler tube
- $\lambda$  CANDU has a low radioactive inventory in heat transport system and a good record on boiler tube integrity, so prefer assured heat removal
- $\lambda$  in long term, if there is a leaking boiler tube, can manually isolate the affected boiler through Main Steam Isolation Valve (MSIV)





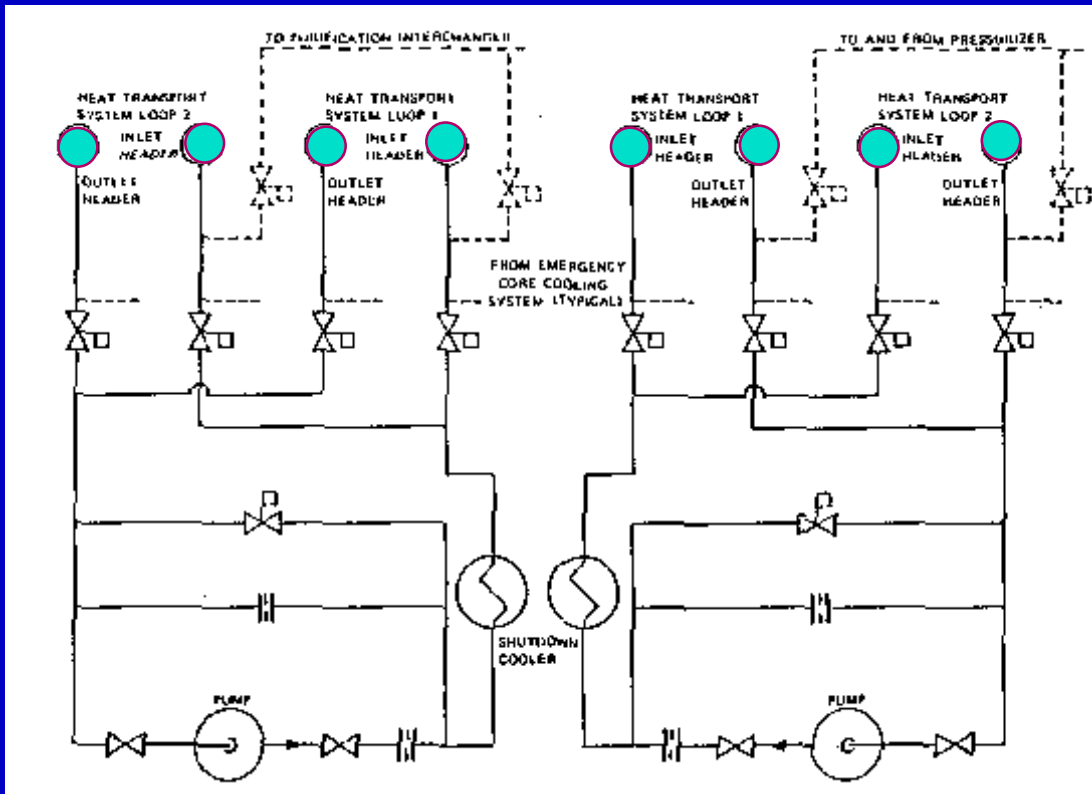
## *High Pressure Heat Sinks*

- λ 3 × 50% main feedwater pumps, Class IV power
- λ 1 × 4% auxiliary feedwater pump, Class III power (diesels)
- λ shutdown cooling system:
  - can remove decay heat and cooldown the heat transport system without requiring depressurization
  - normal operation:
    - λ cooldown via steam generators to 177°C
    - λ cooldown via shutdown cooling system from 177°C to 54°C and hold it there
  - maintenance: remove decay heat when heat transport system is open for maintenance



# Shutdown Cooling System - Emergency

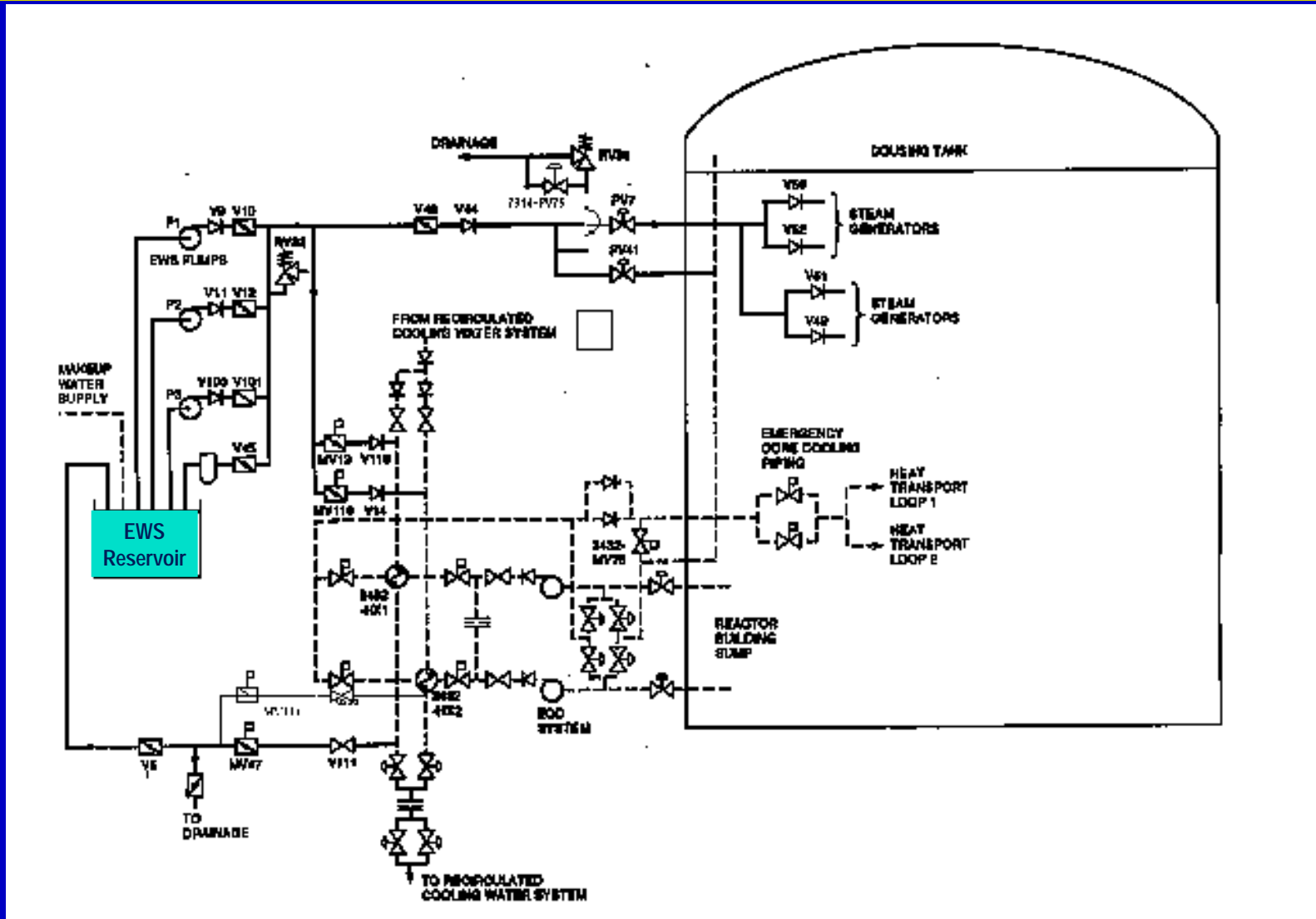
- λ can cool down heat transport system from 260°C
  - no depressurization required





## *Low Pressure Heat Sinks Emergency Water System*

- λ seismically qualified
- λ supplies water to:
  - steam generators
  - heat transport system
- λ powered by separate seismically-qualified diesel generators
- λ draws from dousing tank or external pond



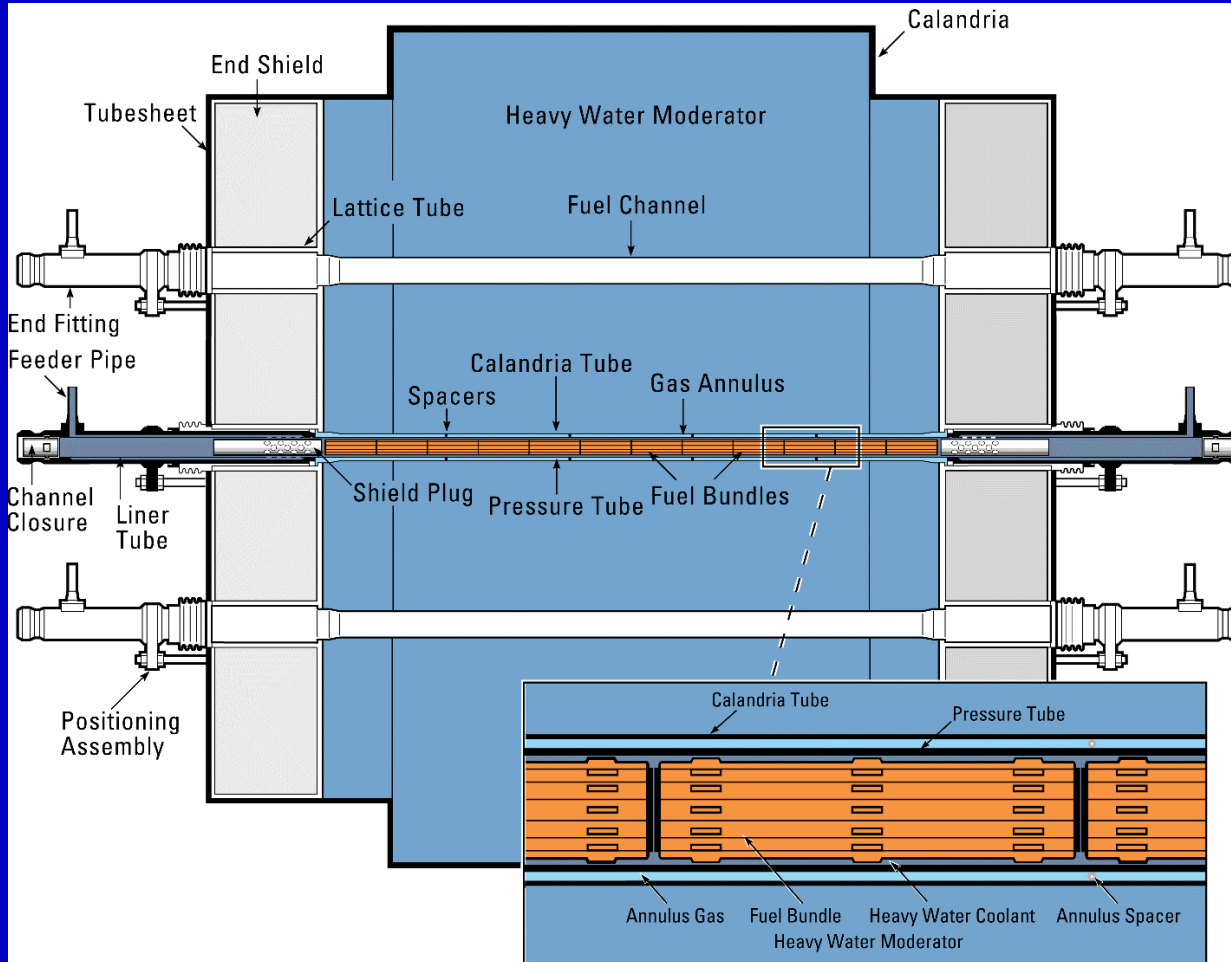


## *Low Pressure Heat Sinks - Moderator*

- λ moderator normally removes 5% thermal power
- λ separate pumps and heat exchangers
- λ short pathway from fuel to moderator liquid
- λ can remove decay heat from fuel without melting the  $\text{UO}_2$  following an accident which leaves NO water in the channel (LOCA + LOECC)
- λ can remove heat from fuel without failing fuel sheaths after a month or so, with NO water in the channel
- λ can be used after a very long shutdown



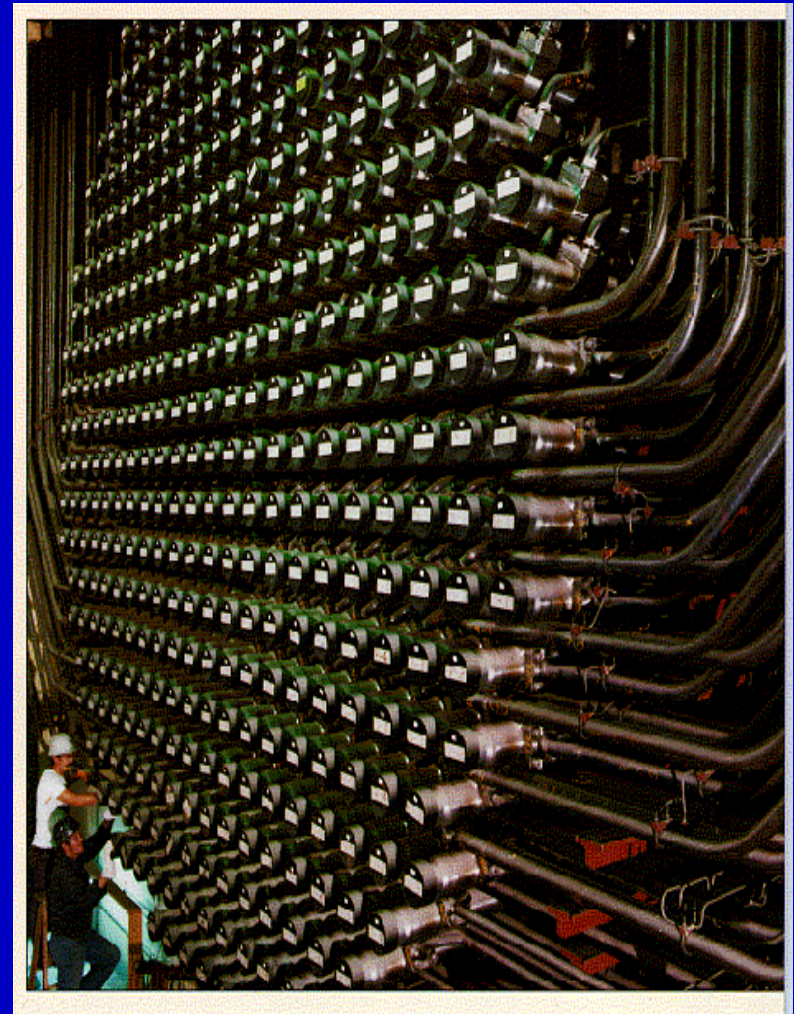
# Moderator





## *Feeder Pipes*

- λ 2 long feeder pipes connected to each channel give a huge surface area
- λ with water in the channels, decay heat can be rejected to air in the reactor vault after a long shutdown (without primary side heat removal or circulation)
- λ used at Point Lepreau during the long shutdown after wood was left in the boiler





## *Summary*

- λ conventional secondary side heat removal (main and auxiliary feedwater pumps)
- λ atmospheric discharge of steam for LOCA or loss of heat sink to depressurize steam generators
- λ shutdown cooling system which can be used at high pressure
- λ low pressure emergency water system to remove heat from steam generators in earthquakes and other accidents
- λ moderator as backup to ECC for severe accidents
- λ very long-term heat removal to moderator and/or feeder pipes