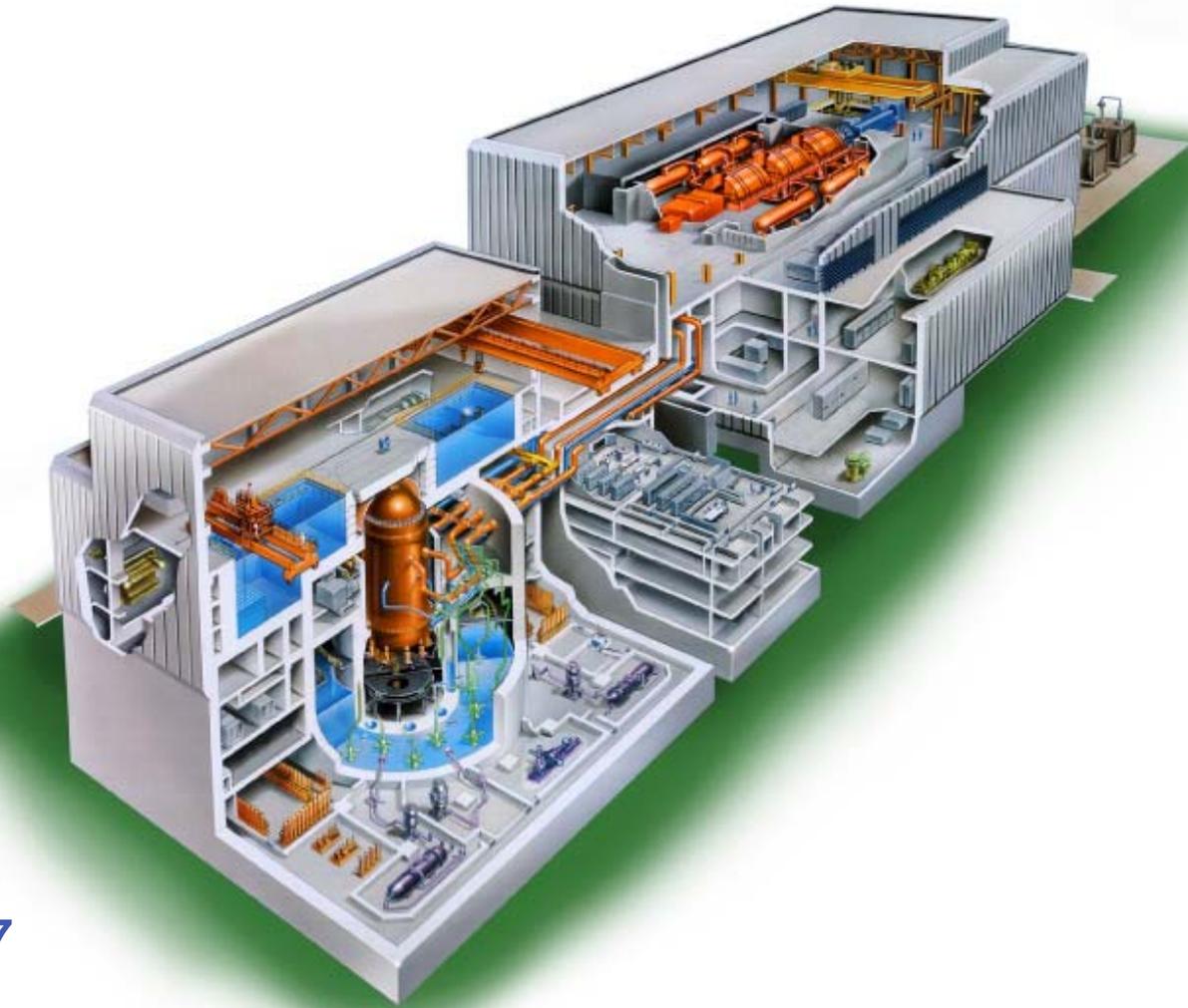


# ABWR Auxiliary Systems



J. Alan Beard  
April 13, 2007

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- Reactor Water CleanUp (RWCU)
- Control Rod Drive Hydraulics (CRDH)
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- Atmosphere Control System (ACS)
- HVAC Emergency Chilled Water (HECW)
- Standby Liquid Control System (SLCS)

# Reactor Water CleanUp (RWCU)

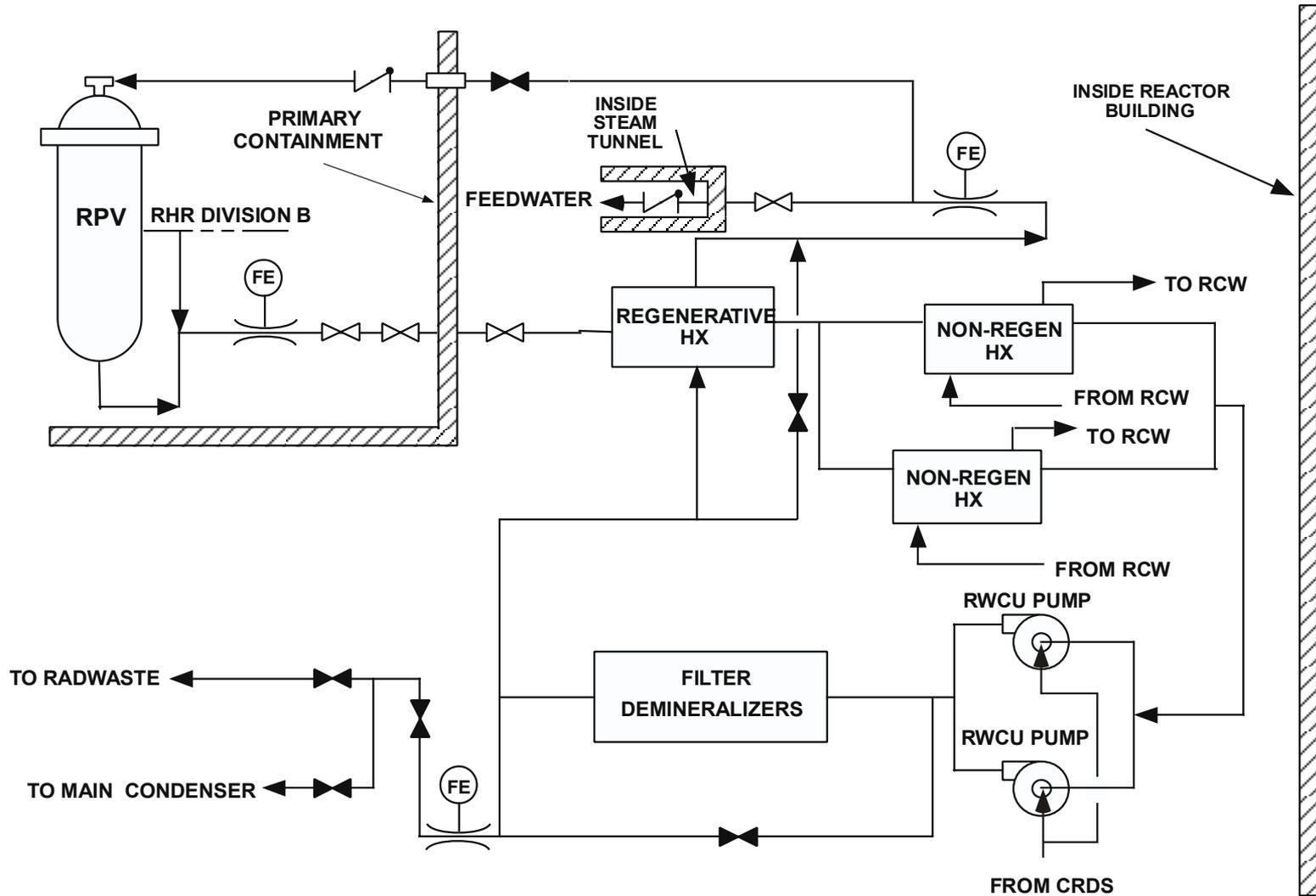
- **Purposes:**

- Remove impurities from coolant to maintain water quality within limits
- Assist in control of RPV water level during Startup, Shutdown

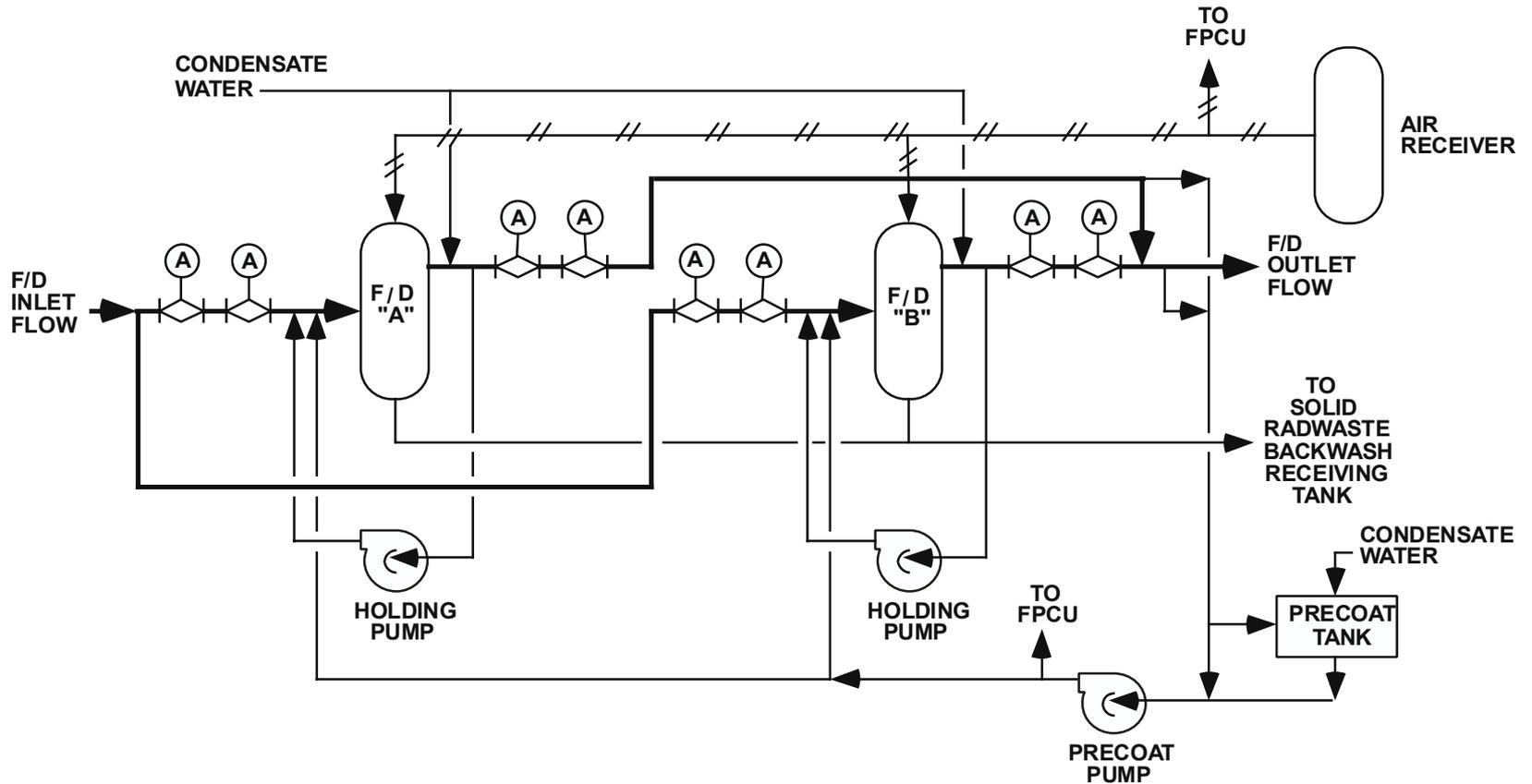
- **Two 100% pumps & Two 100% Demineralizers**

- Each pump = 2% rated FeedWater flow
- Maintains water chemistry and clarity
- Provides high pressure heat removal capability
- Prevents thermal stratification in RPV

# ABWR RWCU



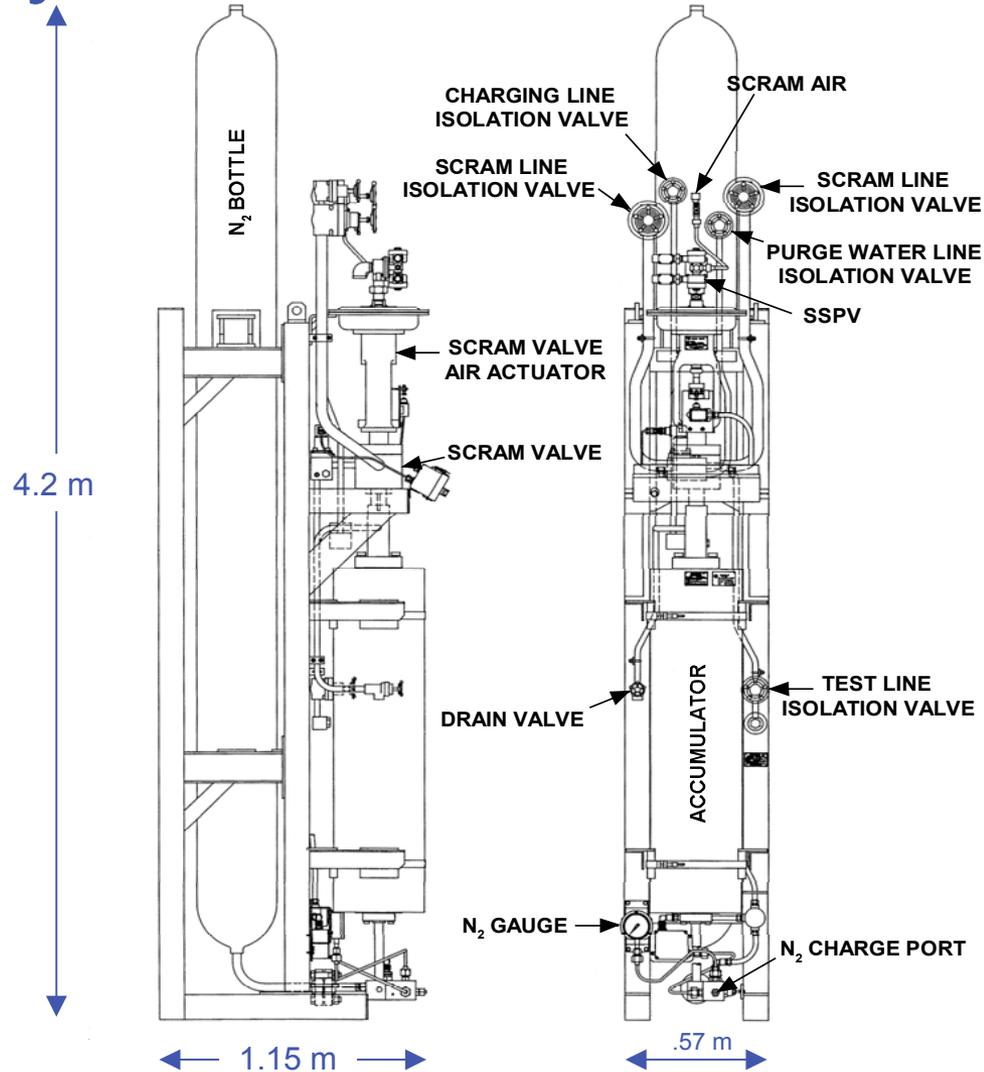
# ABWR RWCU F/D



# CRD Hydraulic Subsystem

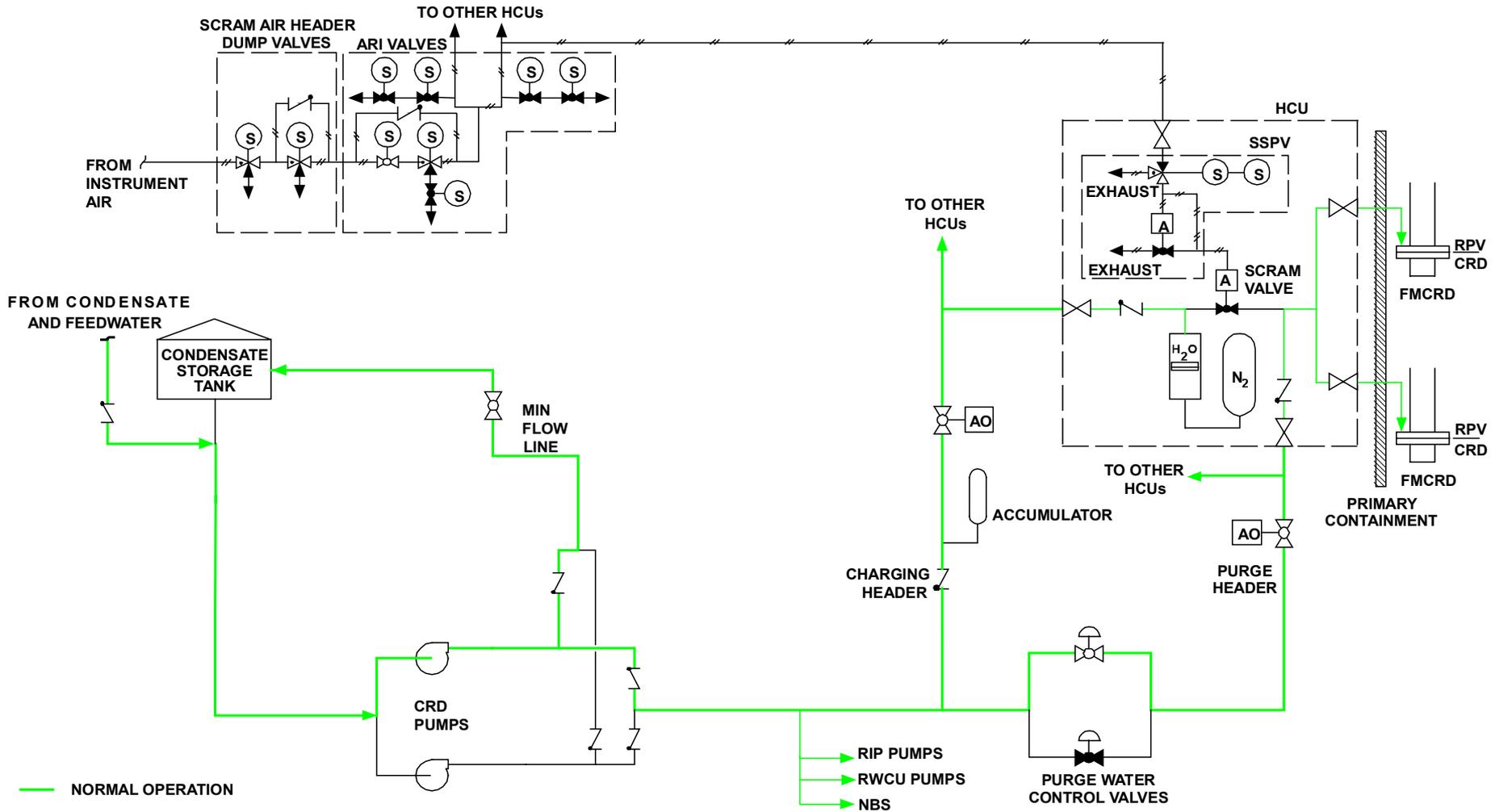
- Non-safety
- Provides purge flow for CRDs to keep contamination (radiation levels) down
- Provides purge flow for RIPs & RWCU pumps
- Provides keep fill water for NBS reference leg Water level instruments
  - Purge of non-condensables from reference legs
- Provides charging pressure for HCUs
- Provides Scram function water
- 2 CRD pumps, one in standby with auto start on low line pressure
- Provides some high pressure Feedwater backup

# Hydraulic Control Unit (HCU)

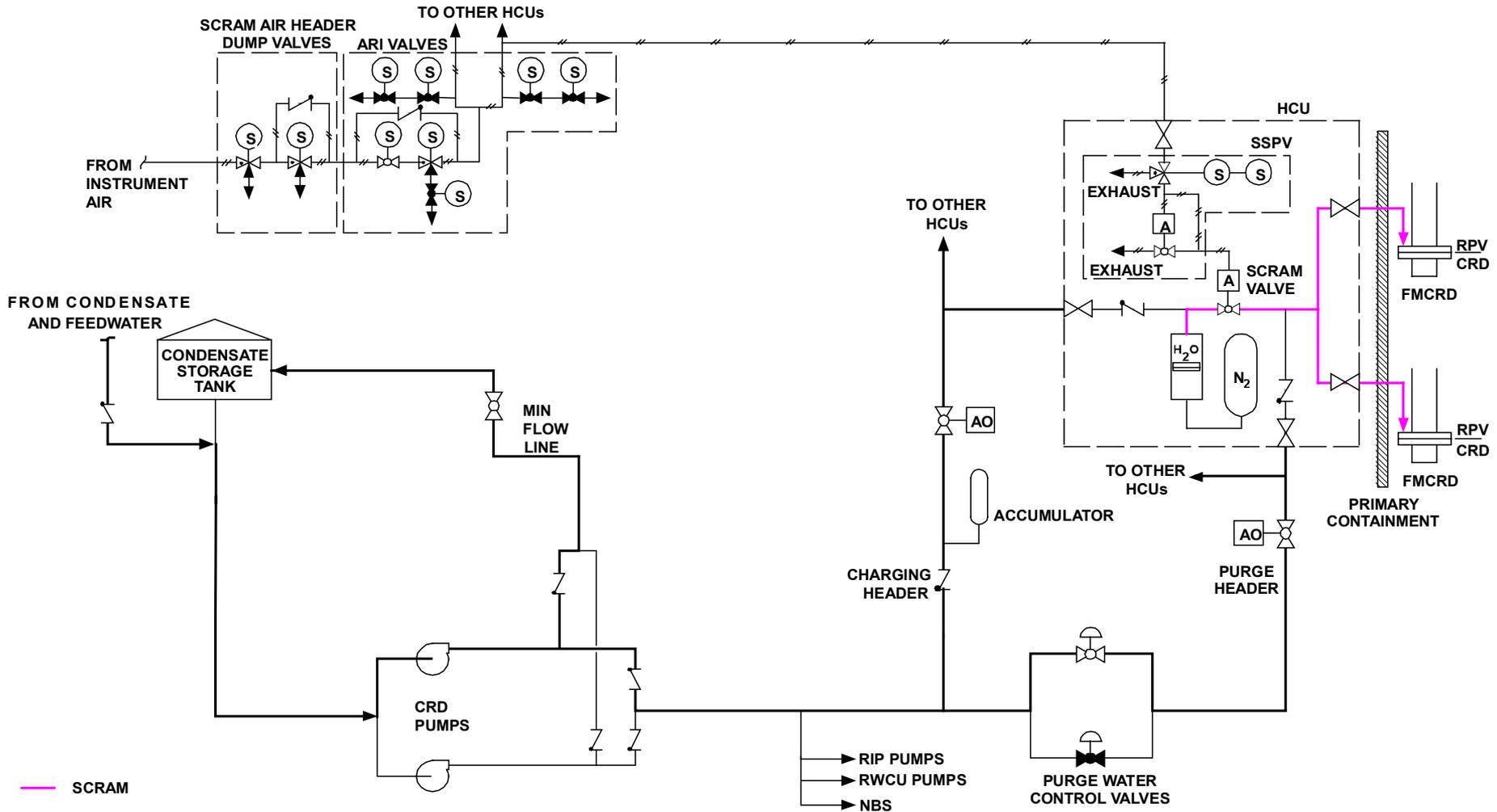


- Stored energy for hydraulic SCRAM
  - Nitrogen gas tank
  - Water Accumulator
- 2 FMCRDs per HCU
  - Widely separated in core
  - No additional loss of shutdown margin if HCU fails

# CRDHS Normal Mode



# CRDHS Scram Mode



# Fuel Pool Cooling & CleanUp (FPCU) Suppression Pool CleanUp (SPCU)

- **Purposes:**

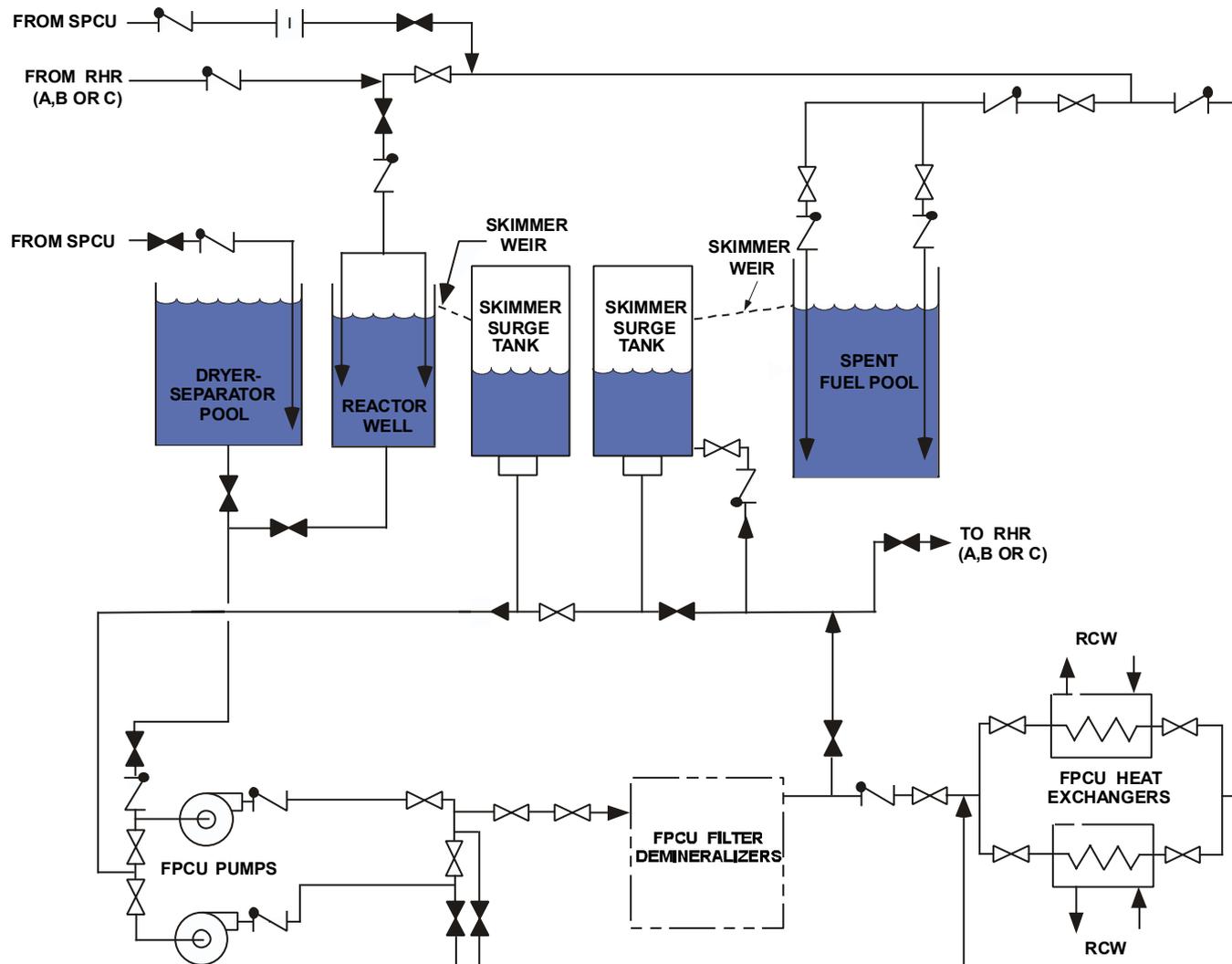
- Remove decay heat from Spent Fuel Storage Pool
- Remove impurities from water in pools to maintain water quality within limits
  - » Spent Fuel Storage Pool
  - » Dryer / Separator Pool
  - » Suppression Pool

# Fuel Pool Cooling & CleanUp (FPCU)

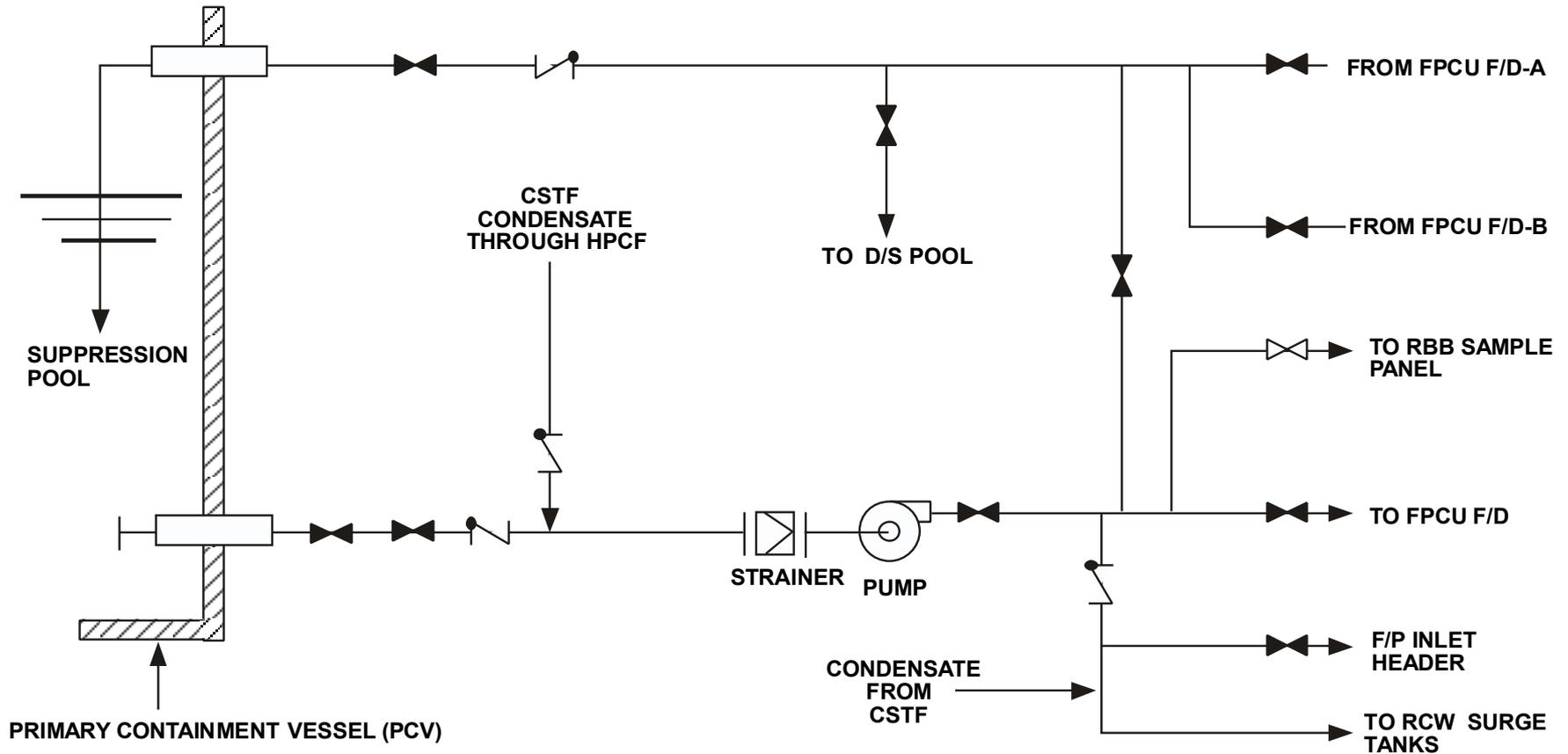
## Suppression Pool CleanUp (SPCU)

- FPCU
  - Two 100% pumps
  - Two 100% Demineralizers
  - Two 50% Heat Exchangers (HXs)
- SPCU
  - One 100% pump
  - Shares FPCU Demineralizers & HXs

# ABWR FPCU System



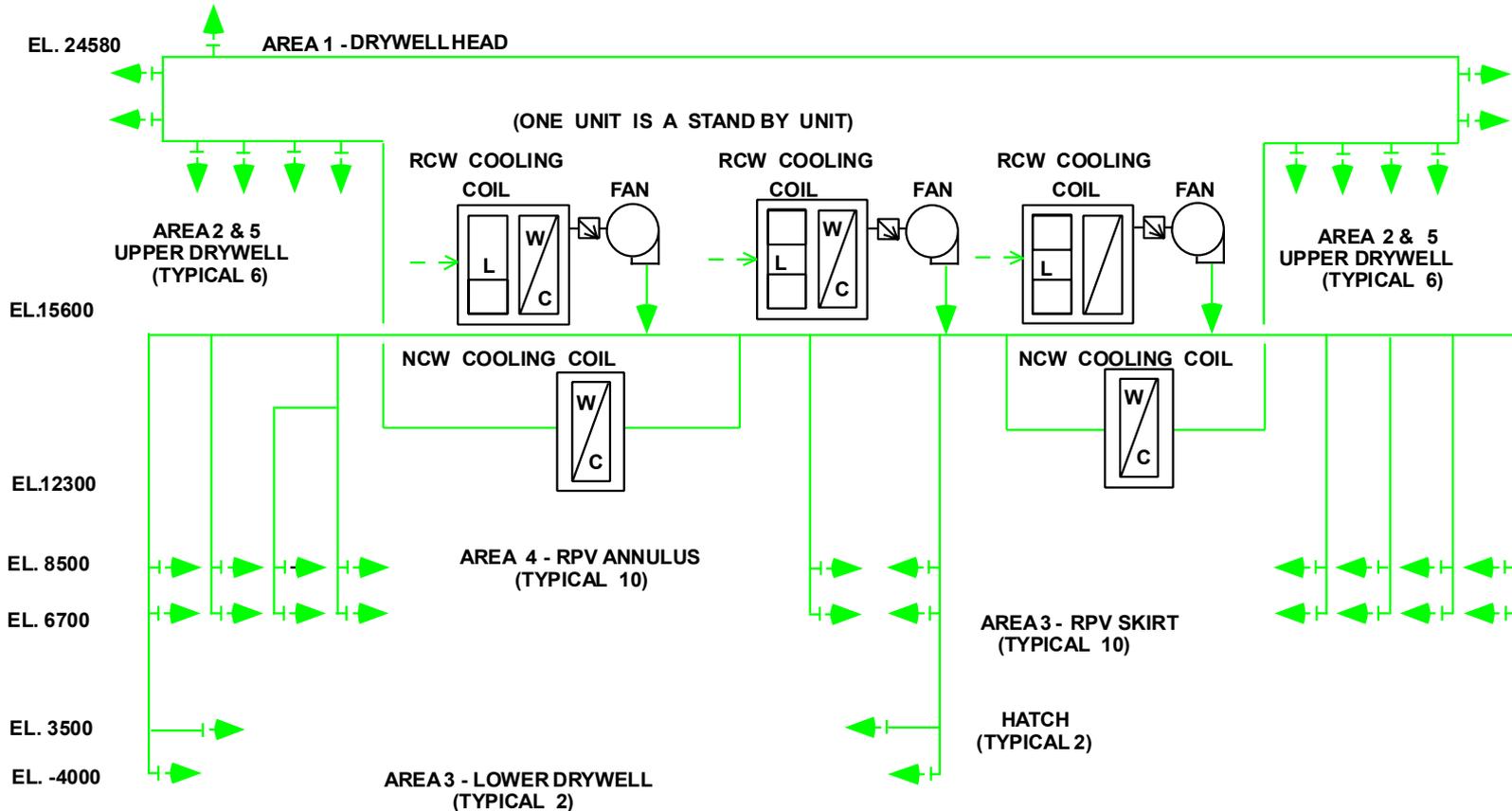
# ABWR SPCU



# DryWell Cooling System (DWC)

- Purposes:
  - Provides conditioned air / Nitrogen during normal operation, Refueling Outages, & normal operation transients to:
    - » DW Head Area
    - » Upper DW & Lower DW
    - » Shield Wall Annulus
- Three Fans
- Three 1st Stage Cooling Coils supplied by RCW
- Two 2nd Stage Cooling Coils supplied by Normal Chilled Water system (NCW)

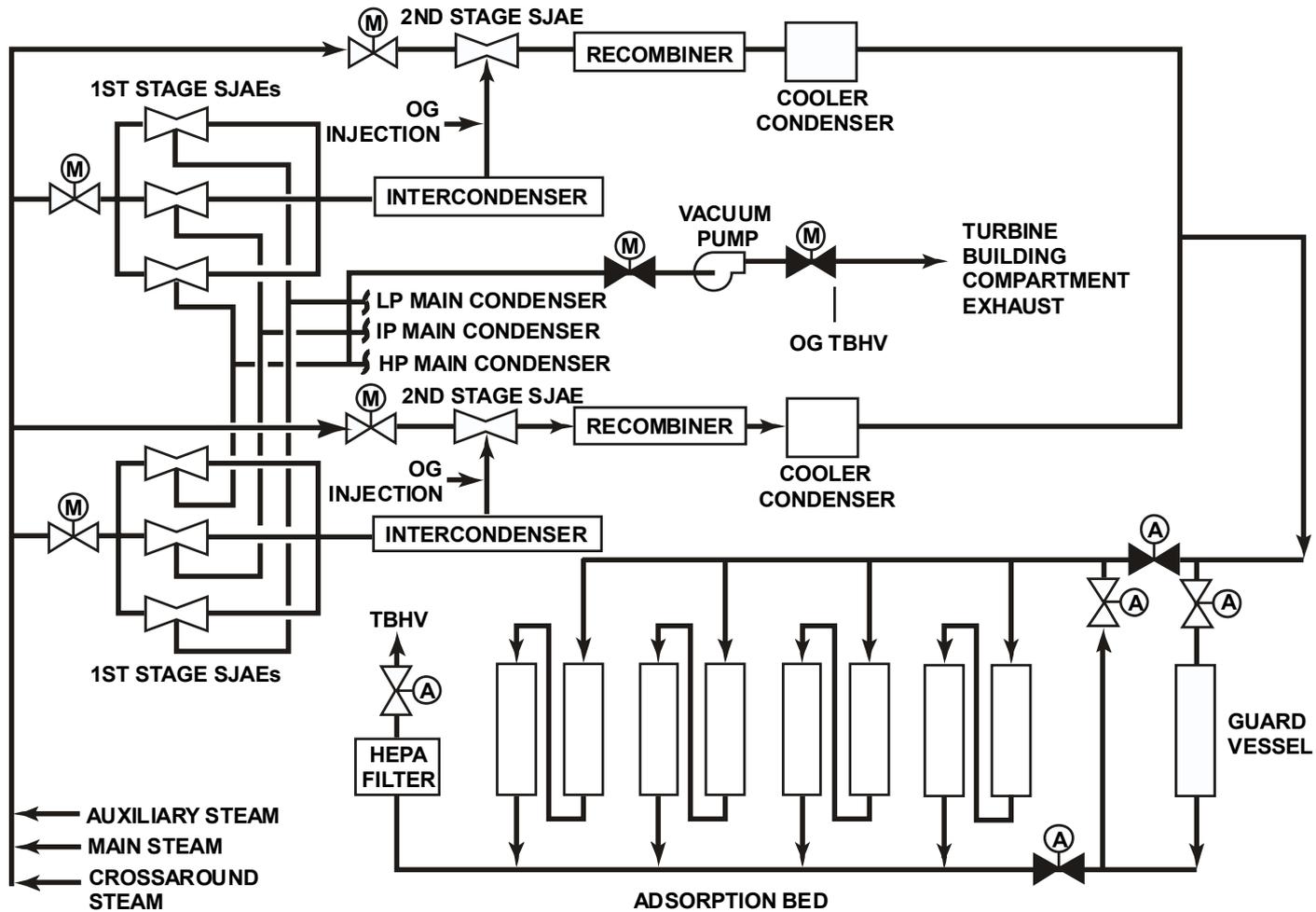
# ABWR DWC



# OffGas System (OG)

- Purposes:
  - Reduces explosion possibility from buildup of stoichiometric H<sub>2</sub> & O<sub>2</sub> produced by radiolysis
  - Processes & controls release of gaseous radioactive effluents
  - Maintains exposure of persons outside controlled area & persons working near systems As Low As Reasonable Practicable
- Two 100% two-stage Steam Jet Air Ejectors (SJAEs)
- One Mechanical Vacuum Pump used during plant startup
- Two Catalytic Recombiners
- Activated Charcoal Beds - at ambient temperature
- Effluent flow to Plant Stack monitored

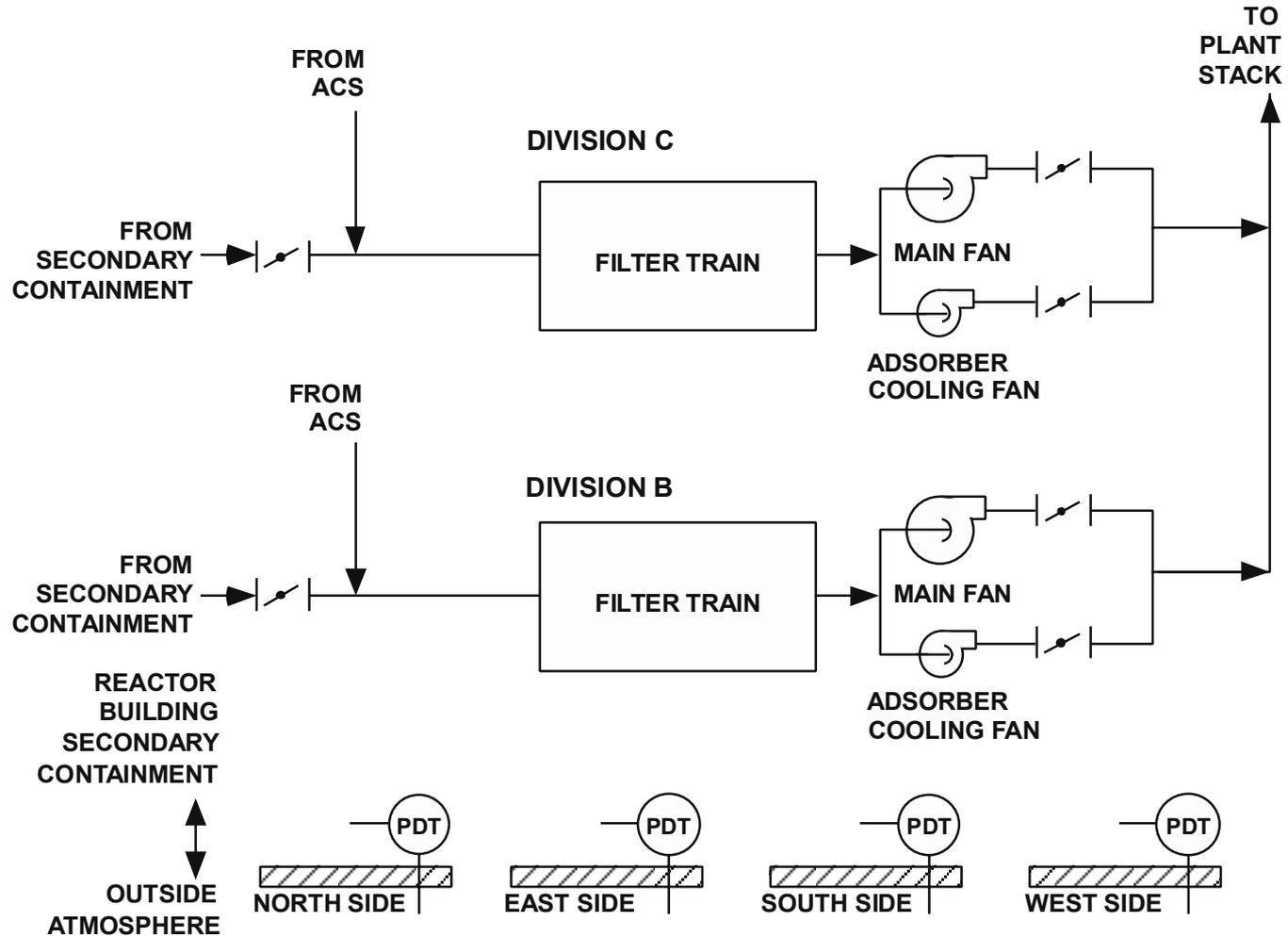
# ABWR OffGas



# Standby Gas Treatment System (SGTS)

- **Purpose:** Treat & discharge Primary Containment or Secondary Containment air to Plant Stack
- Safety grade
- Two 100% Divisions
- Automatic starts:
  - LOCA signal
  - High radiation signal on Refuel Floor
- Maintains negative pressure in Secondary Containment
- HEPA & activated charcoal filters remove >99% elemental or methyl iodide

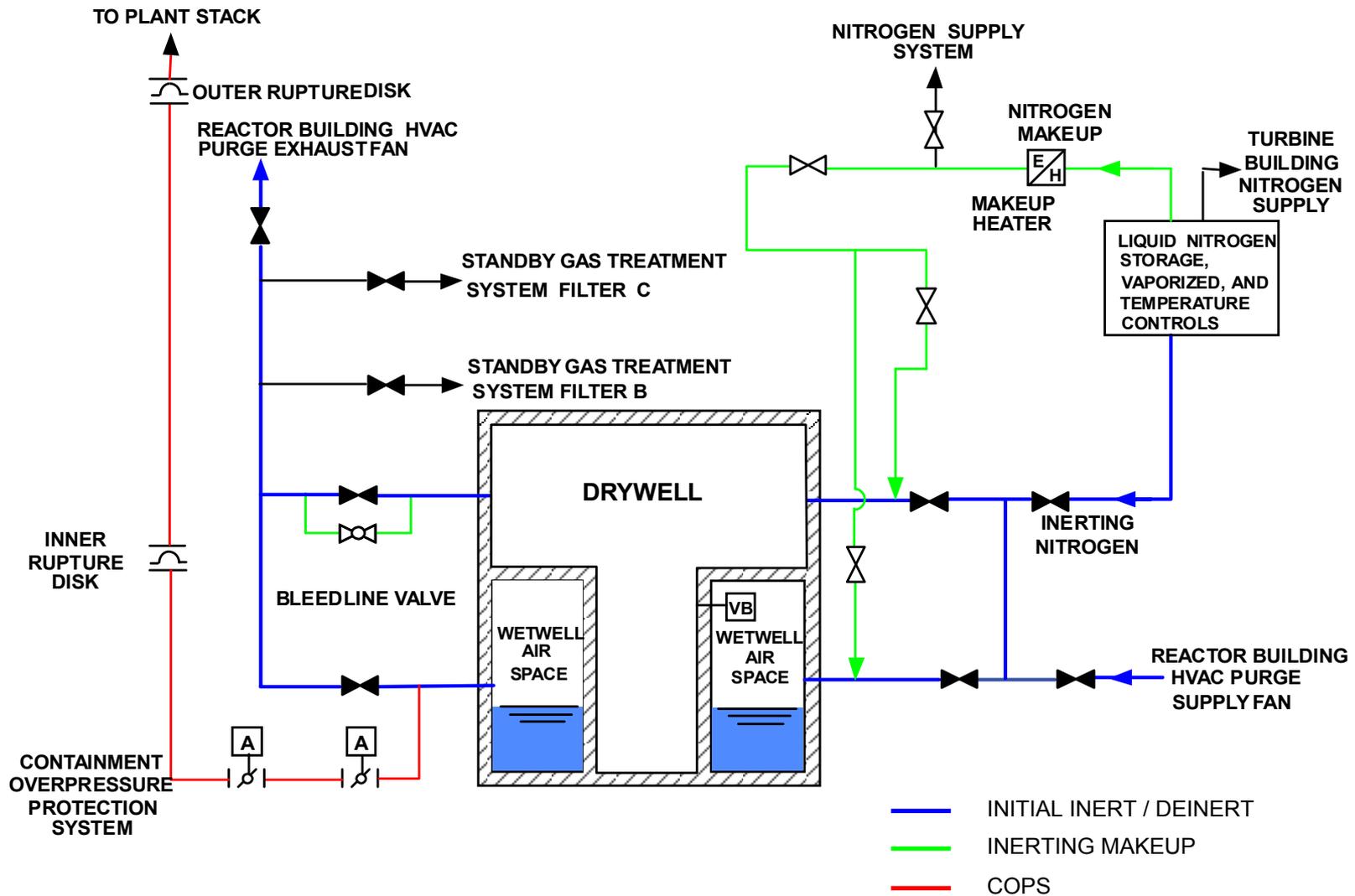
# ABWR SGTS



# Atmospheric Control System (ACS)

- **Purpose:** Establish & maintain inert atmosphere within Primary Containment Volume (PCV)
- Reduces Oxygen in Primary Containment to <3.5% oxygen) in less than 4 hours
- Maintains slightly positive pressure to preclude in-leakage of air from Secondary Containment
- Containment Overpressure Protection System (COPS)
  - Rupture disks which can relieve Primary Containment pressure for rare severe accident sequences
  - Isolation can be re-established

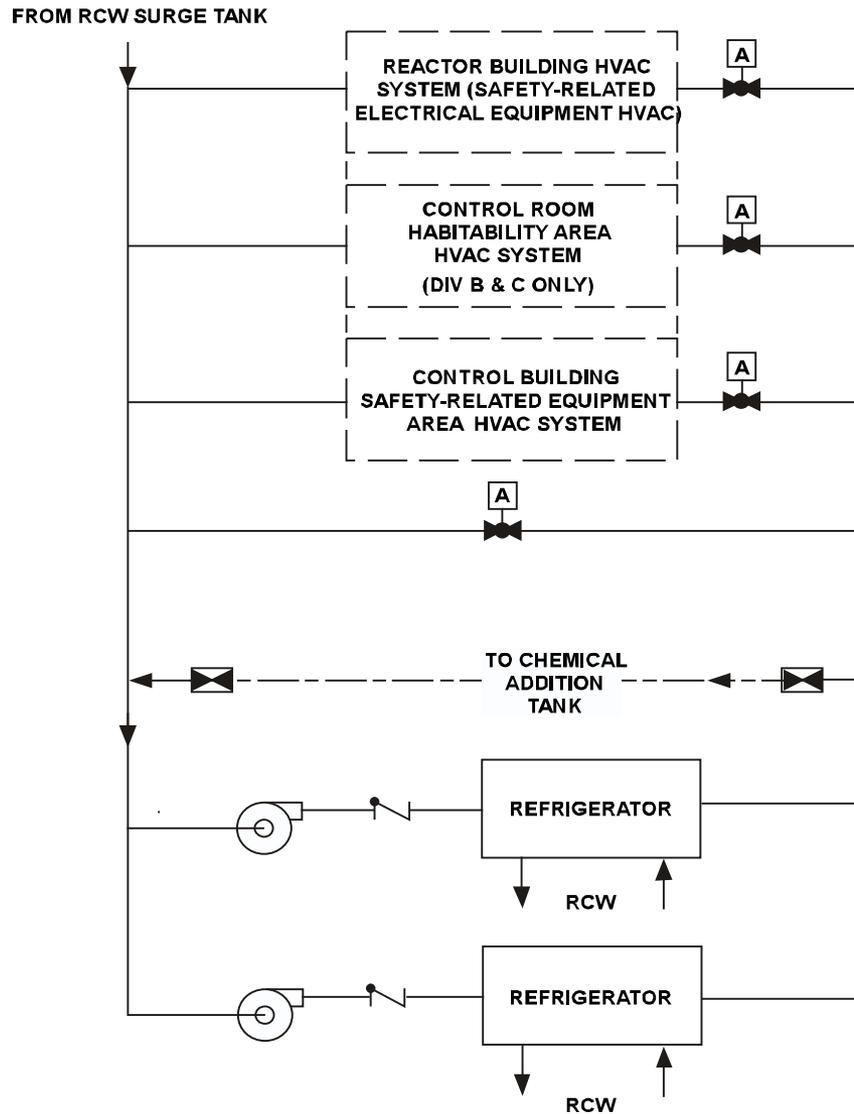
# ABWR ACS



# HVAC Emergency Chilled Water

- **Purpose:** Delivers chilled water to the Reactor Building safety related electrical equipment HVAC System, Control Building safety related equipment area HVAC System and the control room habitability area HVAC System
- 3 divisions
- 2 100% pumps and refrigerators in each division
- Cooled by RCW

# ABWR HECW



# Standby Liquid Control (SLCS)

- **Purpose:** backup to Control Rods to bring & maintain core sub-criticality (Cold Shutdown)
- Two 100% Motor-driven Positive Displacement High Pressure Pumps
  - Injects liquid neutron poison into RPV
    - » Sodium Pentaborate (enriched is optional)
    - » Enters RPV via HPCF B
- Either Control Rods or SLCS ensure reactor shutdown at cold conditions
- Reactor Water CleanUp system (RWCU) automatically isolates

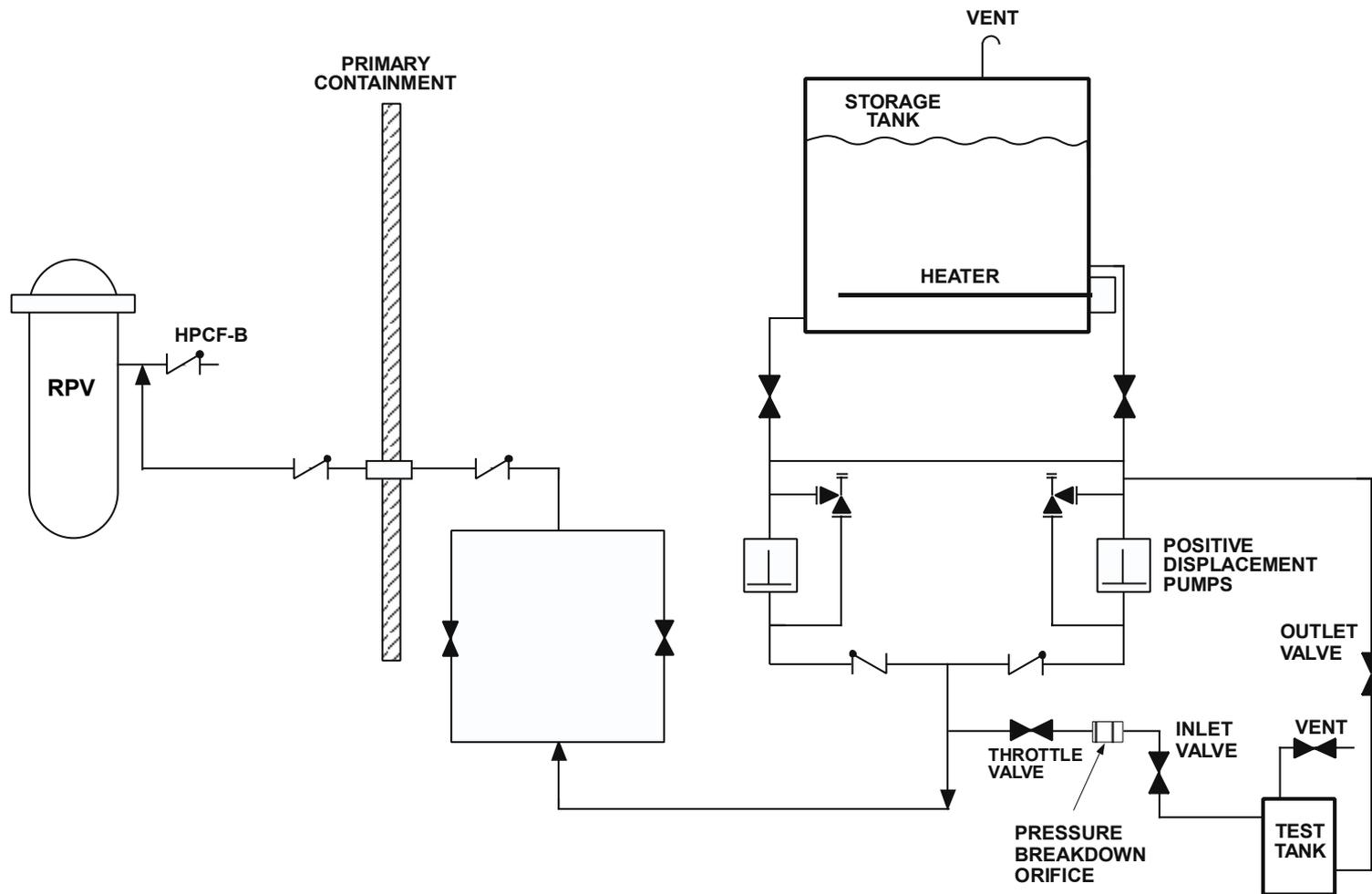
# SLCS Reactivity Requirements

- To shutdown Rx with all Control Rods withdrawn.
- Must have enough negative reactivity to overcome:
  - Elimination of all steam Voids
  - Cool temperatures ( $\sim 51.7^{\circ}\text{C}$ ;  $\sim 125^{\circ}\text{F}$ ; water more dense & reduced Doppler effects)
  - Xenon free conditions
  - Dilution (to Residual Heat Removal (RHR) system)
  - Shutdown margin requirements

# SLCS Initiations

- Manual from Main Control Room
  - Keylock switch for each division
- Automatic: Both divisions automatically initiate if Anticipated Transient Without Scram (ATWS) signal received
  - ATWS Signal: any of following conditions with 2 of 4 logic:
    - » High RPV Pressure (1125 psi); or low RPV water level (Level 2); or manual ARI/FMCRD run-in
  - and
  - » Startup Range Neutron Monitor (SRNM) ATWS Permissive signal (i.e., 6% RTP or higher) for 3 minutes

# ABWR SLCS

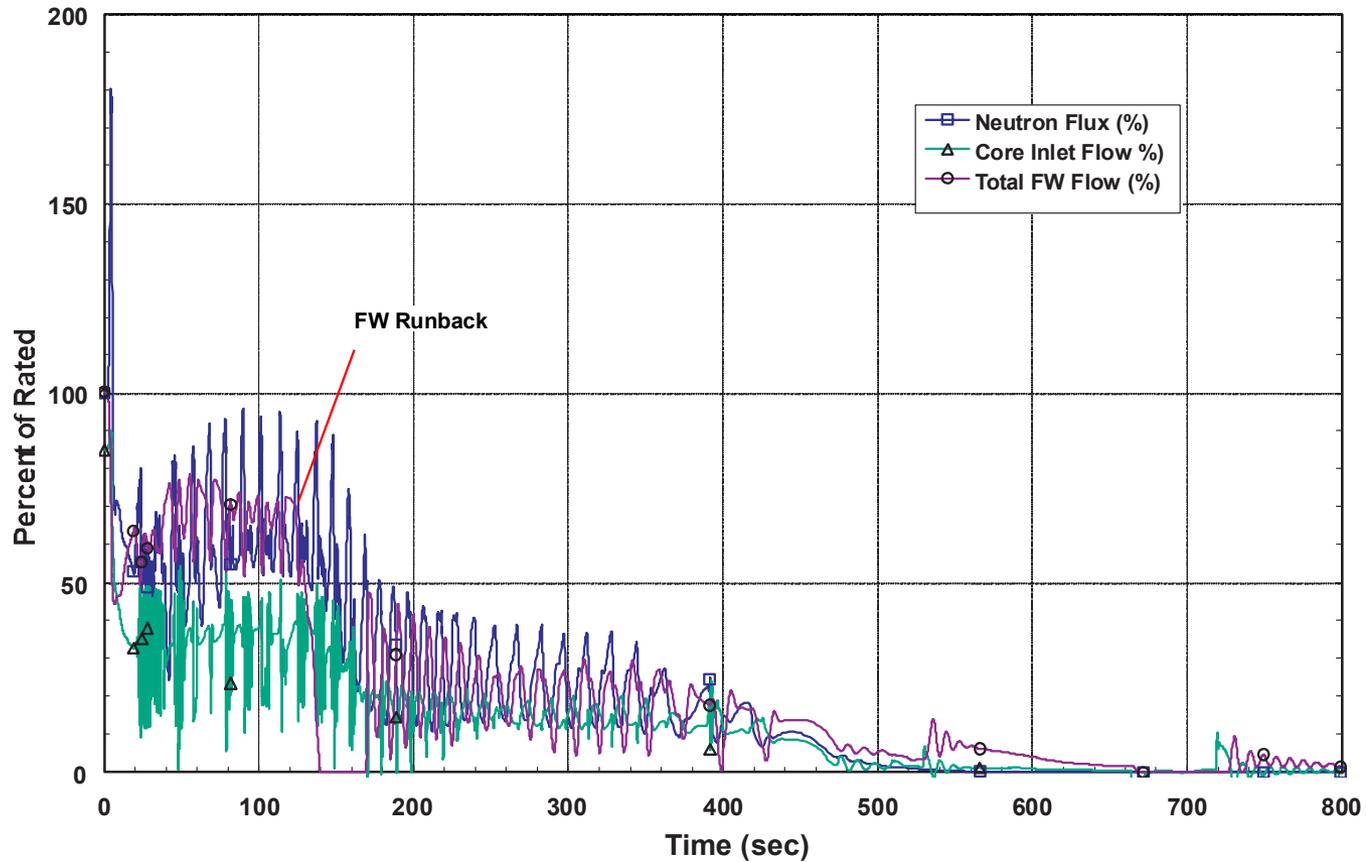


# ABWR Safety Challenges Reduced

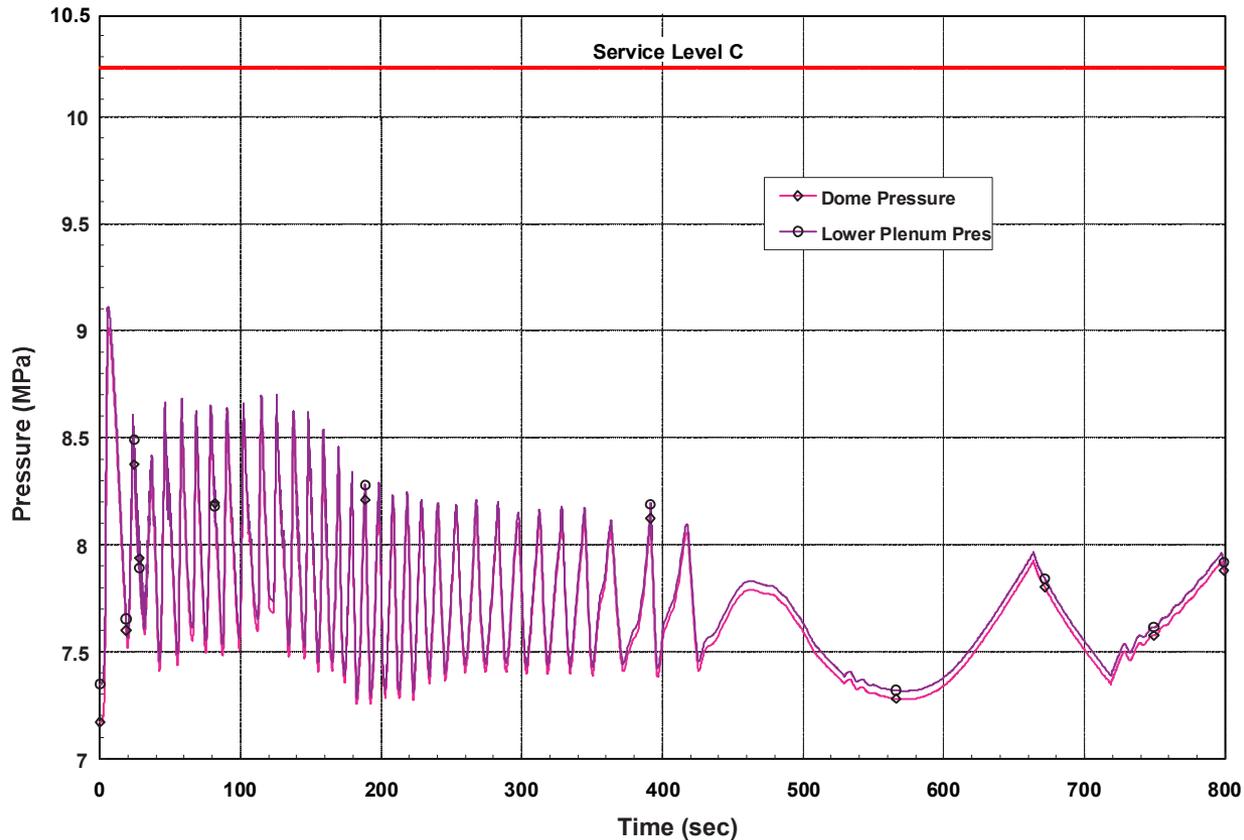
## ATWS challenges reduced

- Prevention
  - Accumulator-driven Scram without Scram Discharge Volume
  - Alternate Rod Insertion (ARI)
    - » Diverse logic for Scram function
  - FMCRD electric run-in
- Automated mitigation
  - Recirculation pump trip (RPT)
    - » 6 on water level 2
    - » 4 on high reactor pressure or water level 3
    - » All on any scram or ARI
  - Feedwater runback
    - » High reactor pressure and SRNM ATWS permissive for 2 minutes
  - Boron injection

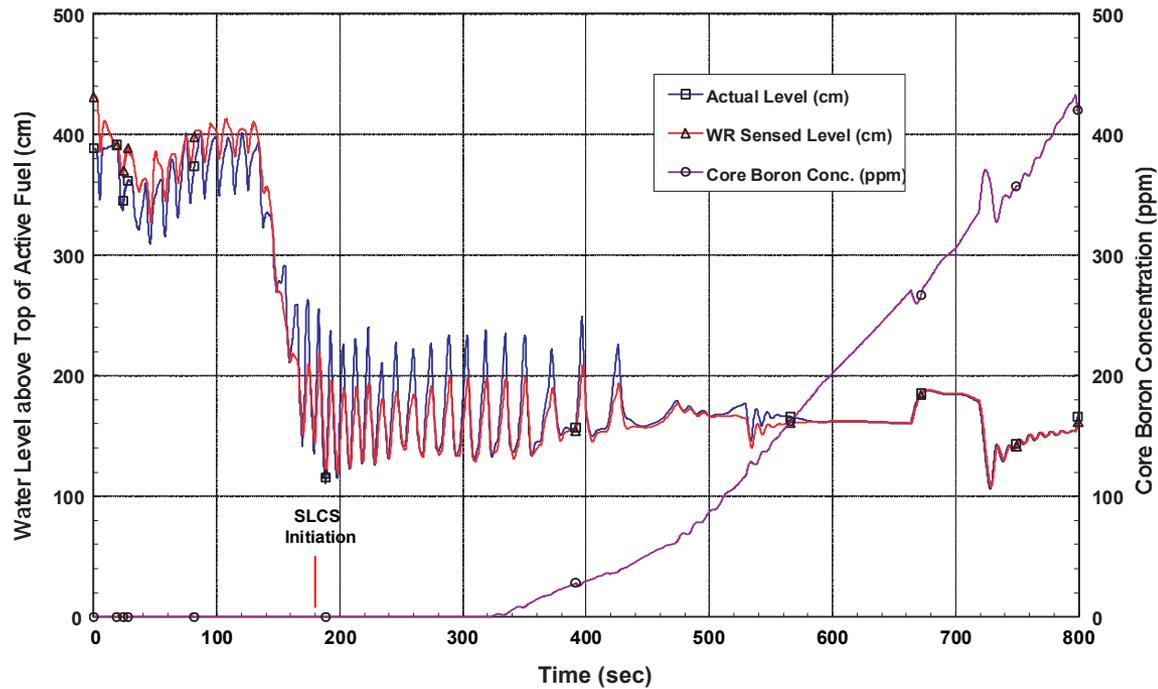
# ATWS Mitigation – MSIV Closure



# ATWS Mitigation – MSIV Closure



# ATWS Mitigation – MSIV Closure



# Flammability Control System (FCS)

- The Certified Design included two active Hydrogen ( $H_2$ ) Recombiners
- The Design will be revised to take advantage of the new requirements of 10 CFR 50.44
  - The active active Hydrogen ( $H_2$ ) Recombiners will be eliminated from the design