# Reactor Water Cleanup System (RWCU)

304B Chapter 2.8

# Objectives

1. Identify the purposes of the reactor water cleanup system.
2. Recognize the purpose, function and operation of the following reactor water cleanup system major components:

a. RWCU inlet piping
b. RWCU pumps
c. regenerative heat exchangers
d. non-regenerative heat exchangers
e. filter demineralizer units
f. RWCU outlet piping
g. system bypass valve (MOV-035)
h. filter demineralizer bypass valve (MOV-036)
i. orifice bypass valve (MOV-037)
j. Blowdown control valve (HCV-04)

# Objectives

3. Describe the following flow paths of the reactor water cleanup system:
   a. normal operation
   b. blowdown operation
   c. filter demineralizer operations

# Objectives (continued)

4. Identify the purpose or function of the following reactor water cleanup system setpoints:

a. Low low reactor vessel water level (Level 2 at -38”)
b. RWCU heat exchanger/pump area high temperature (155°F)
c. RWCU system high differential flow (44 gallons for 45 seconds)
d. Main steam tunnel penetration area high temperature (175°F)
e. Non-regenerative heat exchanger outlet high temperature (140°F)
f. Standby liquid control system initiation

# Objectives (continued)

5. Describe how the reactor water cleanup system interfaces with the following systems:
   a. recirculation system
   b. reactor vessel system
   c. condensate and feedwater system
   d. reactor building closed loop cooling water system
   e. nuclear steam supply shutoff system
   f. control rod drive system
   g. standby liquid control system
   h. liquid and solid radwaste systems

# Purposes

**RWCU**:

- Maintains reactor water quality by filtration and ion exchange
- Provides a method of removing water from the reactor vessel during startups and shutdowns
- Prevents excessive loss of water inventory from the reactor vessel
- Limits the release of radioactive material from containment

# Overview

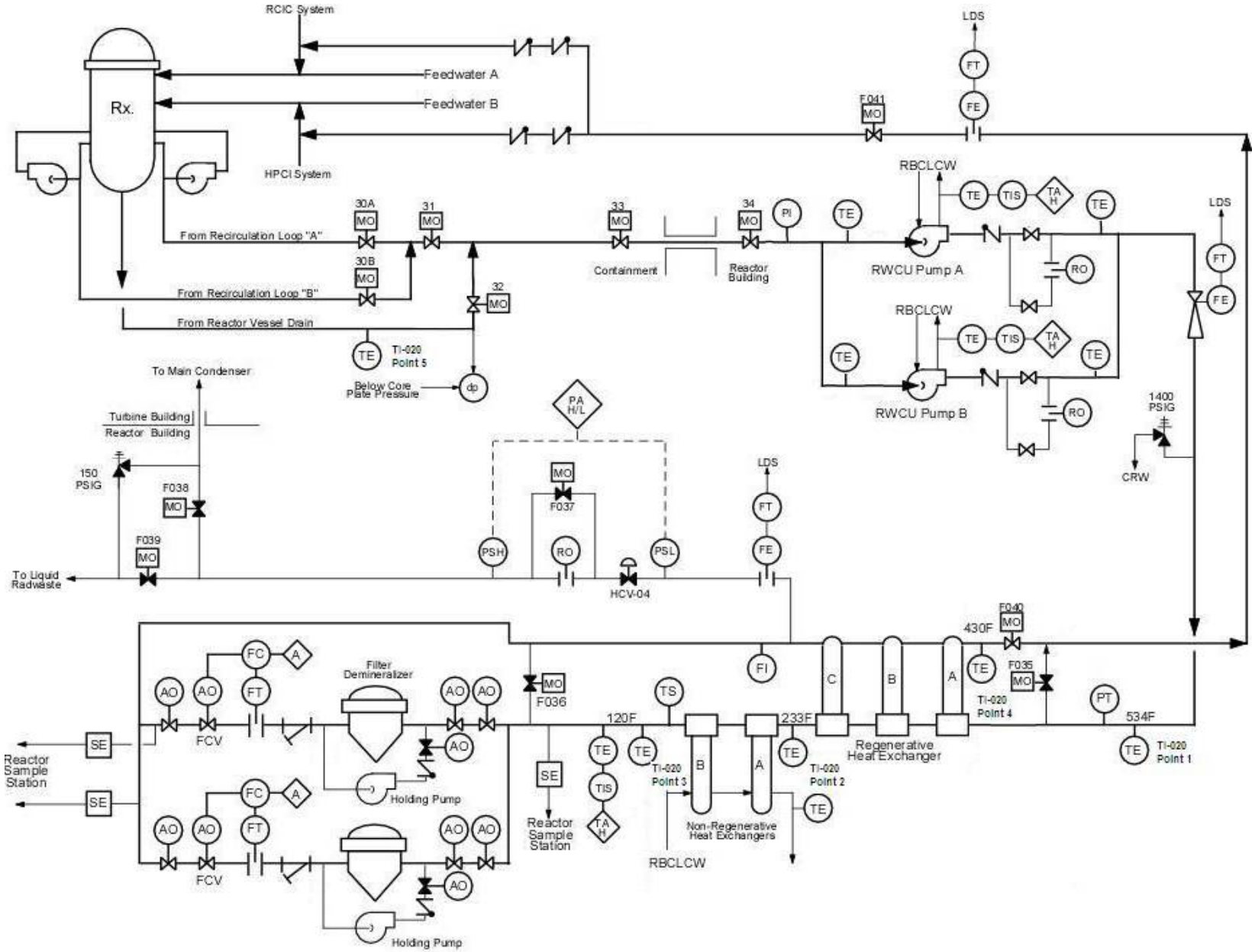


Figure 2.8-1 Reactor Water Cleanup System

Objective 3

# Inlet Piping

- RWCU system takes water from the suction side of each recirculation pump and from the bottom head drain.
- Suction from bottom head drain protects against thermal stratification of water within the reactor vessel and buildup of insoluble material in bottom head.
- Two motor operated valves automatically close to isolate the portions of the RWCU system outside containment.

# RWCU Pumps

- Two 100% capacity pumps with rated flow of 207 gpm each
- One pump normally running with second pump in standby
- RBCLCW system provides bearing and seal cooling
- CRD system provides seal water

Objectives 2 & 5

# Regenerative Heat Exchangers

- Three regenerative heat exchangers in series cool RWCU water from 534°F to 233°F
- RWCU water returning to the reactor vessel flows through the shell side of the regenerative heat exchangers, warming from 120°F to 430°F.
- About 80% of the heat loss is recovered, minimizing thermal stresses on the return piping and nozzles.

Objective 2

# Non-Regenerative Heat Exchangers

- Two non-regenerative heat exchangers in series cool RWCU water from 233°F to 120°F
- RBCLCW flows through the shell side of the non-regenerative heat exchangers

Objectives 2 & 5

# Filter Demineralizers

- Two filter demineralizer (F/D) units operate in parallel use powdered resin to remove insolubles by filtration and solubles by ion exchange.
- When pressure across a F/D reaches 20 psid, outlet conductivity reaches 0.1 micro-mho, or outlet to inlet conductivity reaches 1.0, the F/D unit is removed from service for backwashing and precoating.

# Filter Demineralizers (continued)

- If flow through a F/D unit drops below 60 gpm, air operated valves automatically realign and the applicable holding pump automatically starts to recycle water through the F/D unit to prevent the resin from fall off the filter tubes.

# Outlet Piping

- RWCU water leaves the F/D units, passes through the regenerative heat exchangers and re-enters the reactor vessel via the RCIC piping connected to feedwater line ‘A’ and the HPCI piping connected to feedwater line ‘B.’
- Two check valves on each return line function as containment isolation valves.

Objectives 2 & 5

# System Bypass Valve

- A motor operated valve (MOV-035) is located on a cross-tie line between the header connecting the RWCU pumps to the regenerative heat exchangers and the header returning system flow to the vessel.
- Opening the system bypass valve promotes mixing within the reactor vessel, protecting against thermal stratification.

# F/D Bypass Valve

- A motor operated valve (MOV-036) is located on a cross-tie line between the inlet and outlet headers for the filter demineralizer (F/D) units.
- Opening the F/D bypass valve allows the RWCU to be used for reactor vessel level and pressure control during low power and shut down conditions.

# Orifice Bypass Valve

- A motor operated valve (MOV-037) is located on a bypass line around the restricting orifice in the blowdown line.
- Opening the orifice bypass valve facilitates blowdown operation at low reactor pressure (<60 psig) when differential pressure does not provide sufficient blowdown flow.

# Blowdown Control Valve

- A motor operated valve (HCU-04) is located in the blowdown line.
- Opening the blowdown control valve allows some or all of the RWCU system return flow to the reactor vessel to be diverted to the main condenser or the liquid radwaste system.
- HCU-04 automatically closes on high downstream pressure or low upstream pressure

# Normal Operation

90 gpm from each recirculation loop and 20 gpm from the bottom head drain are moved by one RWCU pump through the regenerative and non-regenerative heat exchangers, through both F/D units, back through the regenerative heat exchangers, and through the RCIC/HPCI connections on both feedwater lines into the reactor vessel.

Objectives 3 & 5

# Blowdown Operation

- Some or all of the RWCU system return flow can be diverted via a blowdown line located between the F/D units and the regenerative heat exchangers.
- Blowdown flow can be sent to either the main condenser (MOV-038) or to the liquid radwaste system (MOV-039).
- Blowdown flow rate is manually controlled (HCV-04).

Objectives 3 & 5

# Blowdown Operation (continued)

- Low steaming rates during startups and shut downs may not match water added via the CRD and other systems.
- CRD alone, at ~47 gpm, can increase vessel level about 1 inch every 4 minutes.
- Blowdown flow rate may be limited by F/D unit inlet temperature or reactor pressure.

# F/D Operation

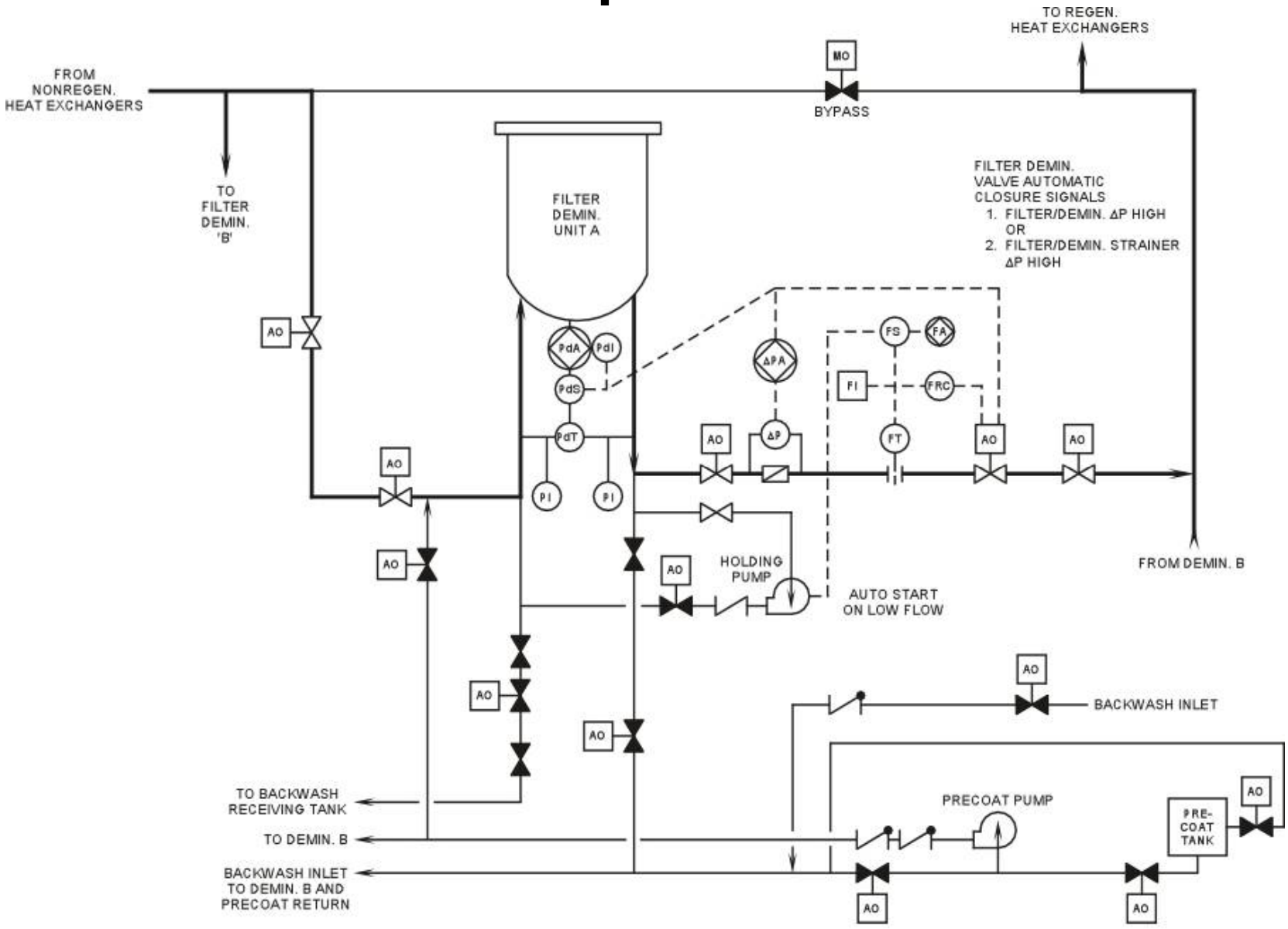


Figure 2.8-2 RWCU Filter/Demineralizer

Objective 3

# F/D Operation (continued)

- Backwash: F/D unit is removed from service. Air is used to dislodge the resin from the stainless steel filter tubes. Condensate enters the F/D unit via the outlet line. The drain line connected to the inlet line is opened to slurry the resins to the backwash receiving tank in radwaste.
- Precoat:  Resin slurry from the precoat tank is moved by the precoat pump into the F/D unit where it evenly coats the filter tubes.

# System Isolations

| | Inboard Containment Isolation MOV-033 | Outboard Containment Isolation MOV-034 |
|---|---|---|
| Level 2 | ✓ | ✓ |
| RWCU Diff. Flow | ✓ | ✓ |
| MS Tunnel Hi Temp | ✓ | ✓ |
| RWCU Area Hi Temp | ✓ | ✓ |
| SLC Initiation | | ✓ |
| Non-Regen Outlet Hi Temp | | ✓ |

# Component Trips & Interlocks

- RWCU pumps automatically trip if:
  - Pump cooling water outlet temperature >195°F
  - Inboard isolation valve MOV-033 not fully open
  - Outboard isolation valve MOV-034 not fully open
  - Pump flow < 70 gpm
- RWCU pumps are de-energized by load shed logic following an accident signal

# Component Trips & Interlocks

- RWCU holding pumps automatically start if:
  - RWCU system flow < 60 gpm
  - Strainer differential pressure > 10 psid
  - F/D unit differential pressure > 30 psid

# Component Trips & Interlocks

- Blowdown flow controller HCV-004 automatically closes if:
  - Downstream pressure > 140 psig
  - Upstream pressure < 5 psig

# System Interfaces

- Reactor recirculation
  - RWCU takes water from suction side of recirculation pumps
- Reactor vessel
  - RWCU takes water from the bottom head drain
- Reactor building closed loop cooling water
  - RBCLCW cools the RWCU pump bearings and seals and the non-regenerative heat exchangers

# System Interfaces

- Condensate and feedwater
  - RWCU return flow enters feedwater lines A and B via RCIC and HPCI piping
  - Main condenser can receive RWCU blowdown flow
- Control rod drive
  - CRD provides RWCU pump seal flow
- Liquid and solid radwaste
  - Liquid radwaste can receive RWCU blowdown flow
  - Liquid and solid radwaste receives RWCU F/D backwashes

# System Interfaces

- Nuclear steam supply shutoff
  - NSSSS provides automatic closure signals to RWCU MOV-033 and MOV-034
- Standby liquid control
  - SLC initiation provides automatic closure signal to RWCU MOV-034

# Review

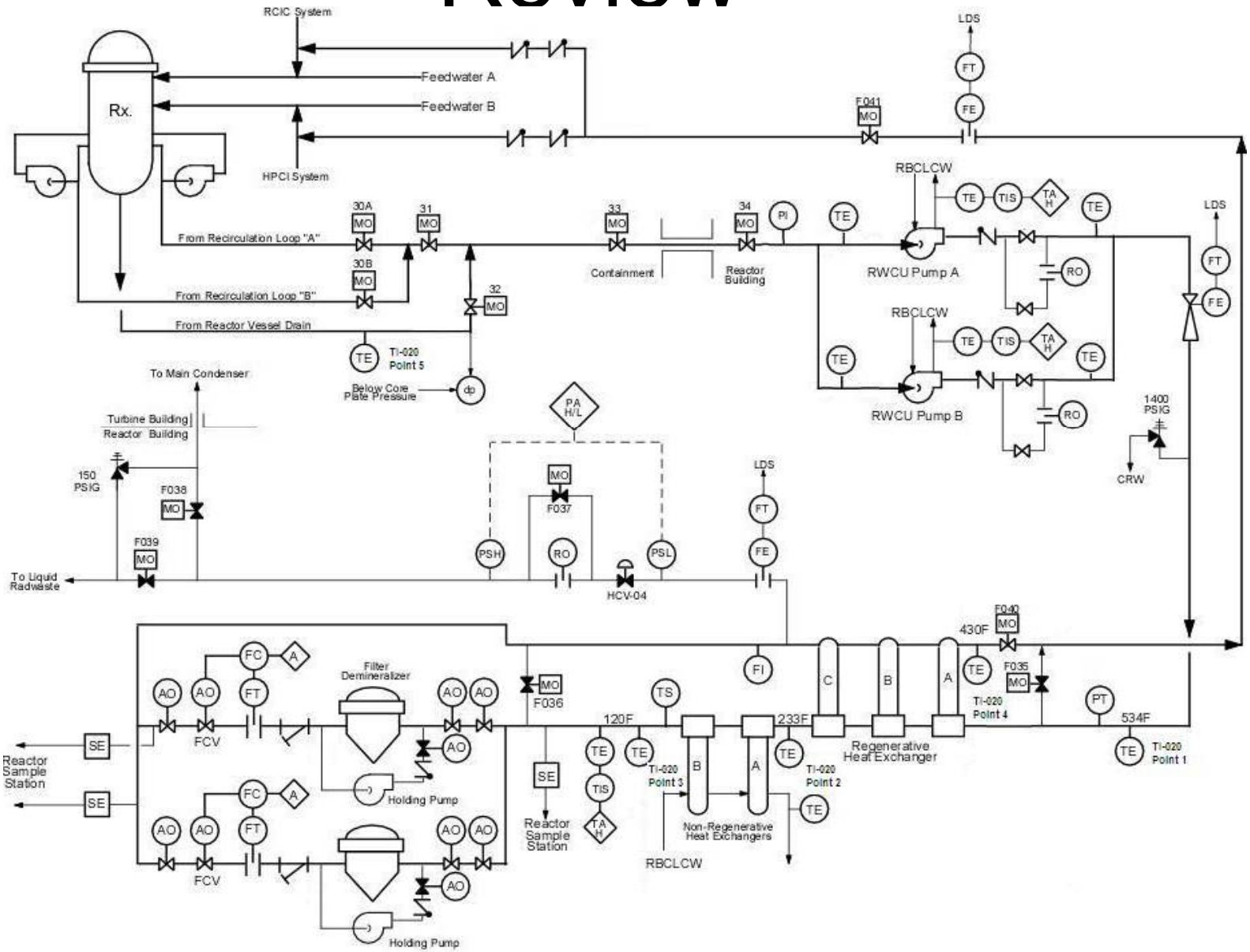


Figure 2.8-1 Reactor Water Cleanup System

# Review (continued)

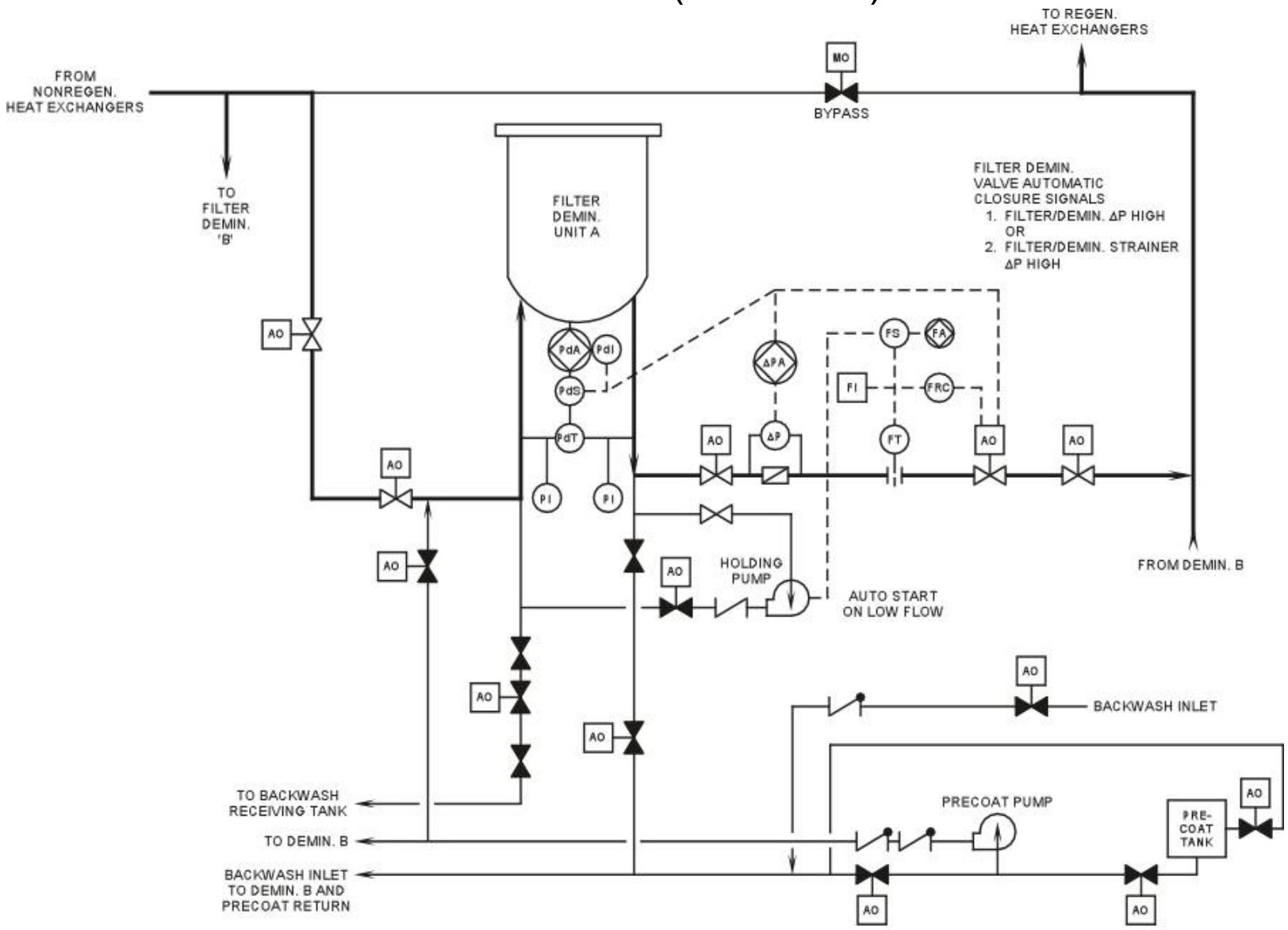


Figure 2.8-2 RWCU Filter/Demineralizer

# Objectives

1. Identify the system's purposes.
2. Recognize the purpose, function and operation of major system components:
   a) inlet piping
   b) pumps
   c) regenerative heat exchangers
   d) non-regenerative heat exchangers
   e) filter demineralizers
   f) outlet piping
   g) system bypass valve
   h) filter demineralizer bypass valve
   i) orifice bypass valve
   j) blowdown control valve

# Objectives

3. Describe the system flow paths during:
   a) normal operation
   b) blowdown mode
   c) filter demineralizer backwashing and pre-coating

# Objectives (continued)

4. Identify the purpose or function of system setpoints:
   a) low low reactor water level
   b) RWCU heat exchanger/pump area high temperature
   c) RWCU space high differential flow
   d) main steam tunnel penetration area high temperature
   e) non-regenerative heat exchanger outlet high temperature
   f) standby liquid control system initiation
   g) RWCU pump low flow
   h) RWCU system low flow
   i) Blowdown line high/low pressures

# Objectives (continued)

5. Describe the system's interfaces with the following systems:
   a) recirculation
   b) reactor vessel
   c) condensate and feedwater
   d) reactor building closed loop cooling water
   e) nuclear steam supply shutoff
   f) control rod drive
   g) standby liquid control
   h) liquid and solid radwaste

Are there any questions?