# Emergency Core Cooling Systems and RCIC

GE BWR/4 Advanced Technology Course

R-504B – 6.1

# Learning Objectives

1. Identify the Emergency Core Cooling Systems (ECCSs) used for each BWR product line.
2. In each BWR product line, recognize how ECCSs operate in conjunction such that for the full range of LOCA sizes, no single failure will cause core damage.

# Learning Objectives

3. Identify how the various types of ECCSs provide core cooling, including what constitutes the ultimate heat sink for long term decay heat removal.
4. Recognize the purpose and operation of an isolation condenser.
5. Identify how the various BWR product lines remove decay heat and control RPV pressure and level following vessel isolation events

# BWR/2

- ADS
- Core Spray (4 main pumps and 4 booster pumps)
- FWCI (Not ECCS)
  - Motor-driven feedwater pumps
  - Dedicated power supply
- Isolation Condenser
  - High pressure
  - Passive
  - Does not raise inventory

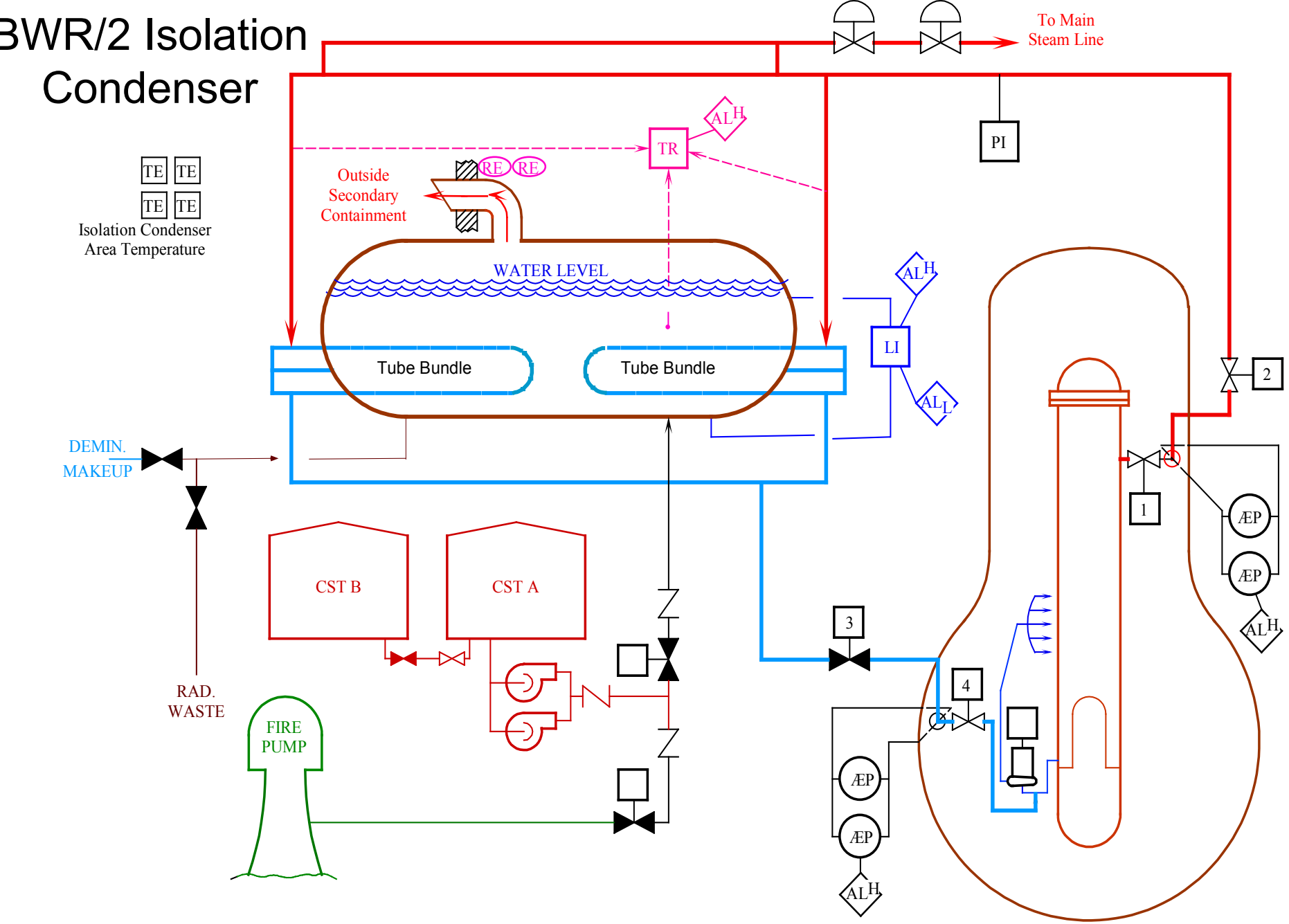

BWR/2 Isolation Condenser
To Main Steam Line
PI
TR
ALH
RE
RE
Outside Secondary Containment
TE
TE
TE
TE
Isolation Condenser Area Temperature
WATER LEVEL
Tube Bundle
Tube Bundle
LI
ALH
ALL
DEMIN. MAKEUP
CST B
CST A
RAD. WASTE
FIRE PUMP
1
2
3
4
ÆP
ÆP
ÆP
ÆP
ALH
ALH

Figure 6.1-11

High Drywell Pressure or
Low-Low water level

# BWR/2 Core Spray

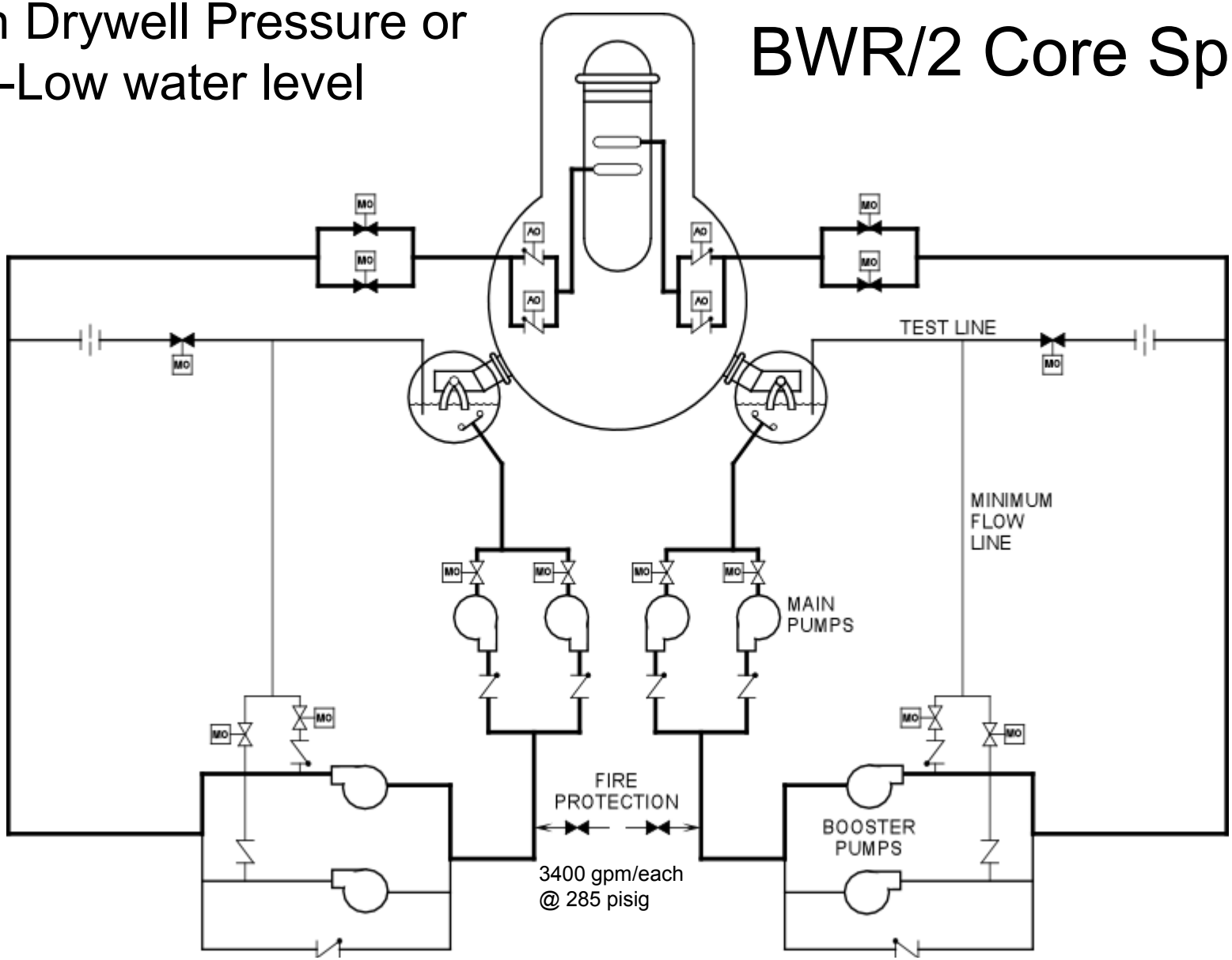



Figure 6.1-1

# BWR/3

- HPCI
  - HPCI – Steam turbine driven pump (AC Independent)
- ADS
- LPCI (RHR)
- Core Spray (2 pumps)
- Isolation Condenser (Dresden 2 and 3 only) or RCIC (Monticello, Pilgrim and Quad Cities 1 and 2)
  - May have one, not both

# BWR/4

- HPCI
  - Steam turbine driven pump (AC Independent)
- ADS
- LPCI
- Core Spray (2 or 4 pumps)
- RCIC (not ECCS)

# Typical of BWR 3/4 ECCS

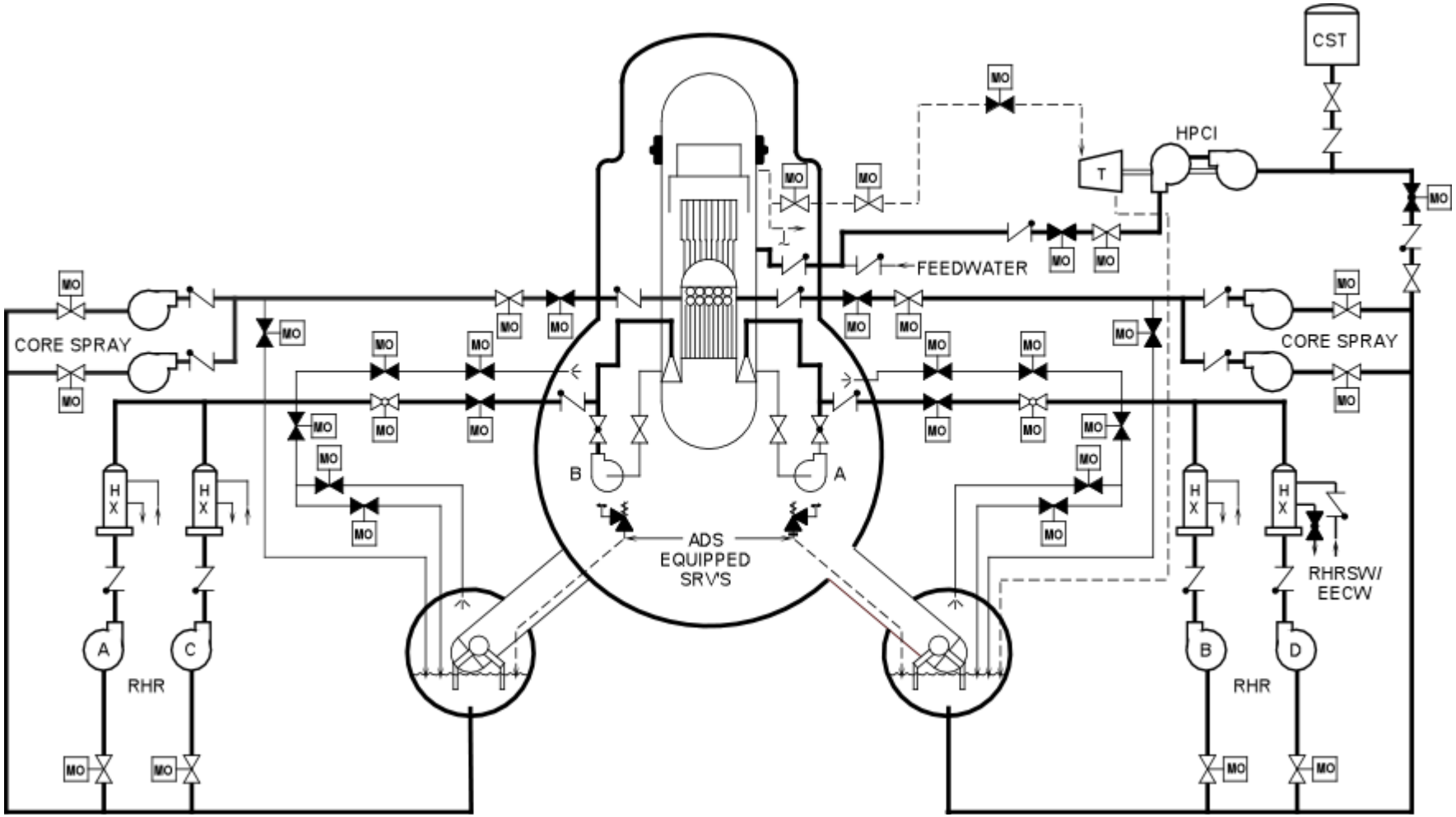



Figure 6.1-2

**Typical BWR/3 & BWR/4 HPCI**

- **Maintains adequate core cooling on small break LOCAs.**
- **Assist Low Pressure ECCSs on Intermediate LOCAs.**
- **Backs up RCIC.**

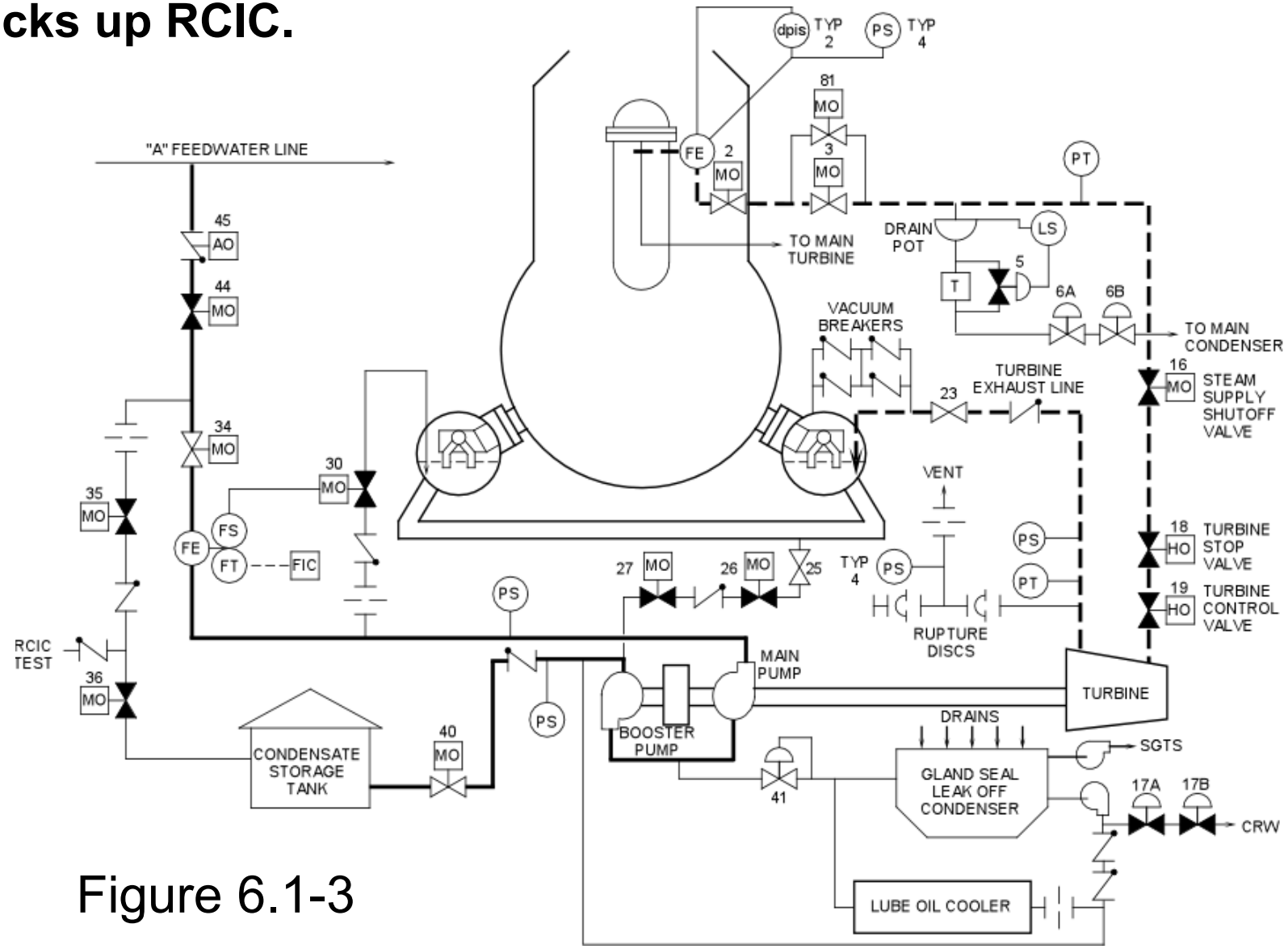



Figure 6.1-3

High Drywell Pressure or
Low-Low water level

# BWR/3 and BWR/4 Core Spray

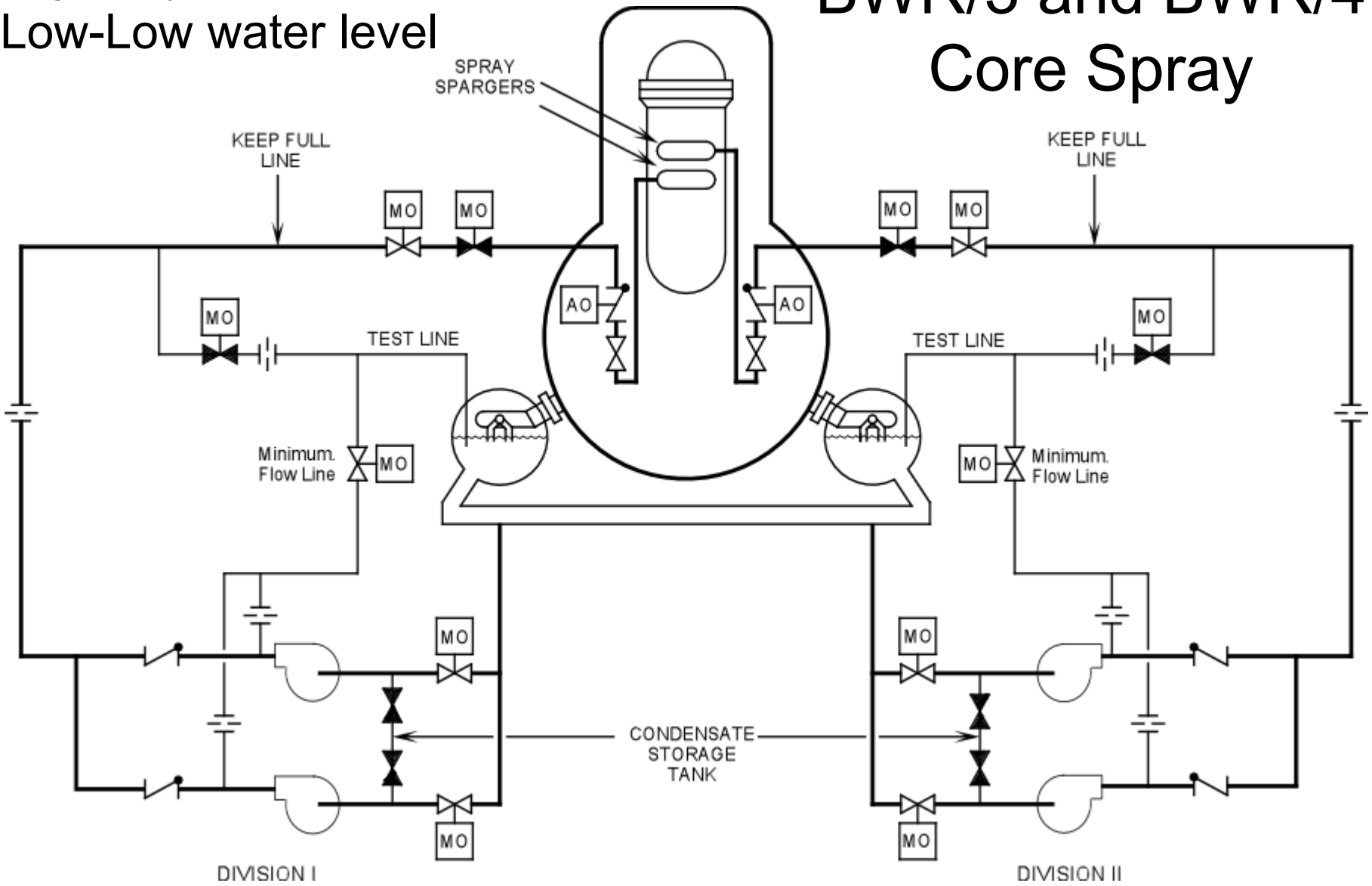



Figure 6.1-4

# BWR/3 and some BWR/4 LPCI

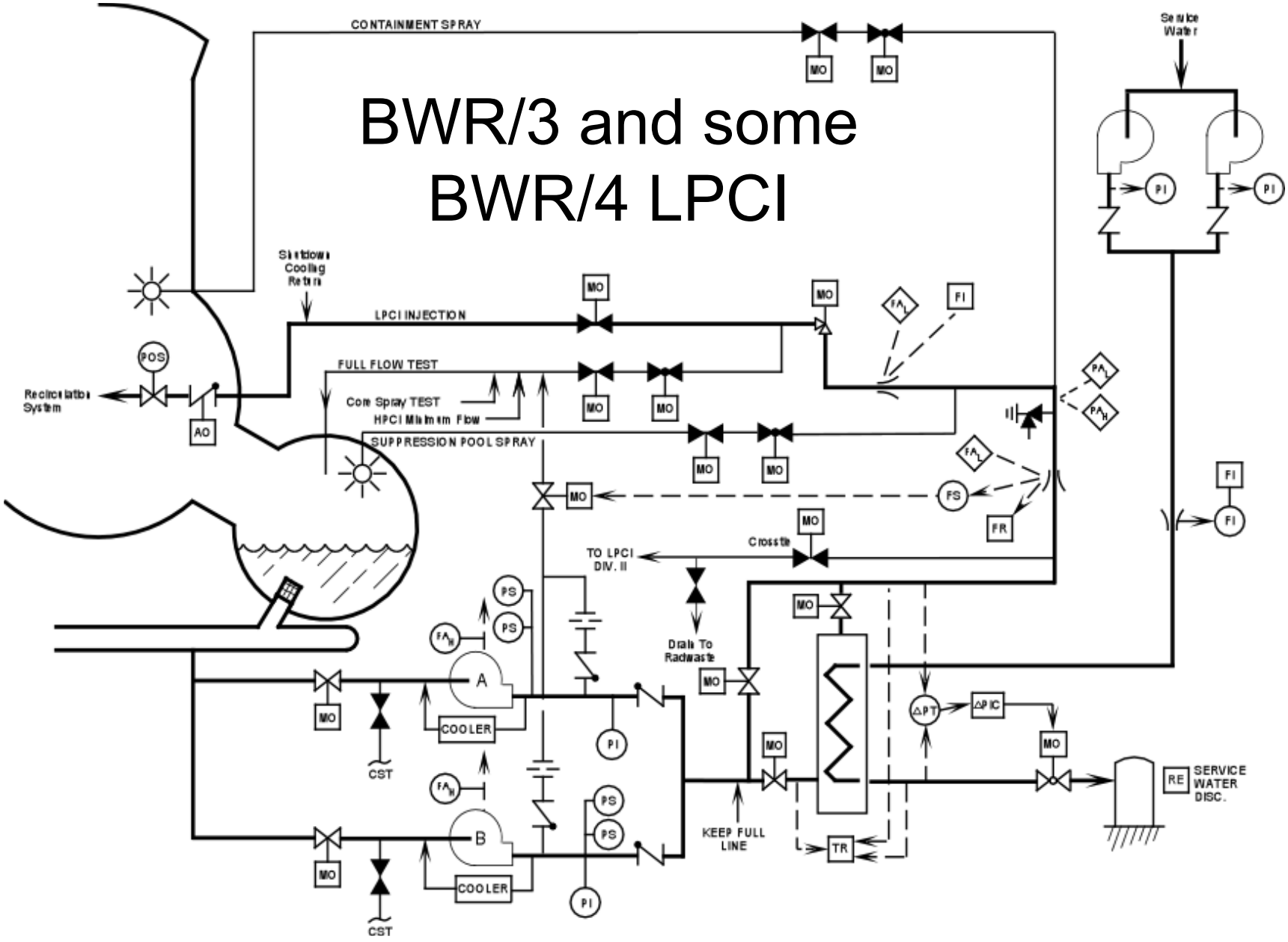



Figure 6.1-5

# Typical BWR/4 LPCI

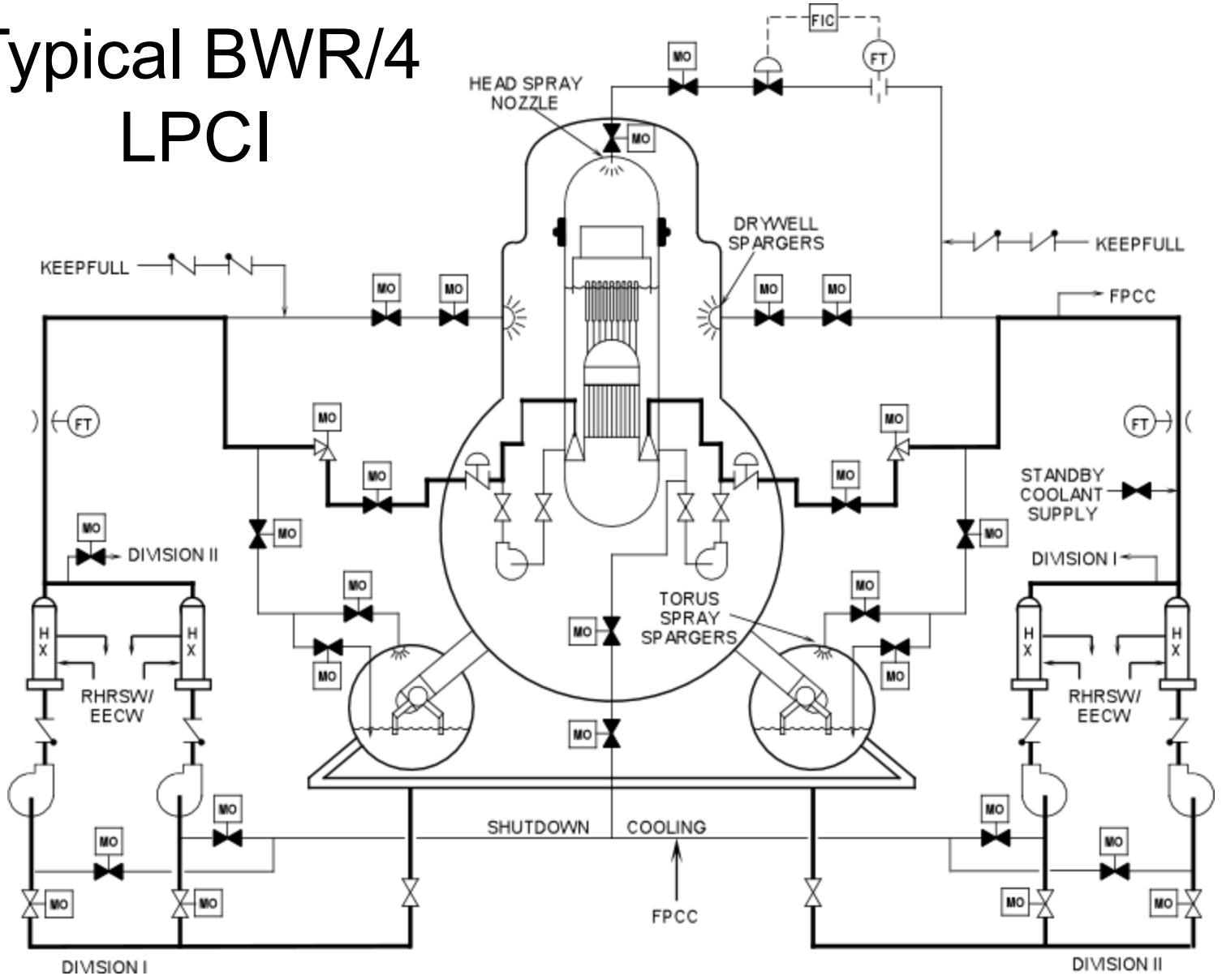
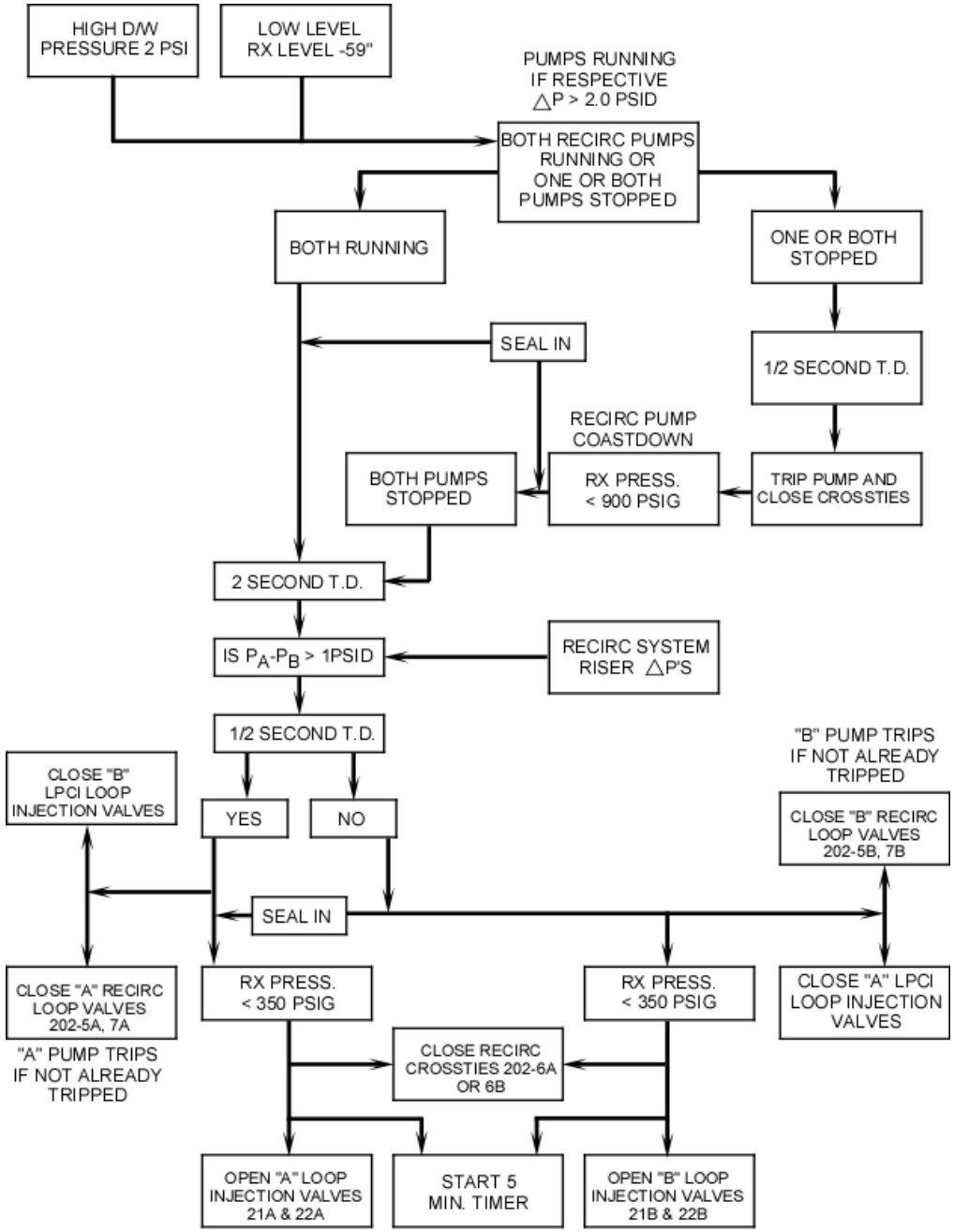



Figure 6.1-7




## Loop Select Logic

- Isolates ruptured Recirculation loop
- Closes the associated LPCI injection valve
- Most BWR/3s
- Some BWR/4s

Figure 6.1-6

# BWR/5 & BWR/6

- HPCS
  - Motor driven with dedicated diesel
  - Injects inside shroud
- ADS
- LPCI
  - Three loops
  - Loop C dedicated to LPCI only (no RHR)
- Low Pressure Core Spray
  - Single loop

# BWR/5 & BWR/6

Advantages over BWR/3 & BWR/4:

- three separate / independent LPCI injection lines
- HPCS & LPCS - both high and low pressure injection directly inside the core shroud

Typical of BWR/5 & BWR/6 (Mark III containment shown)

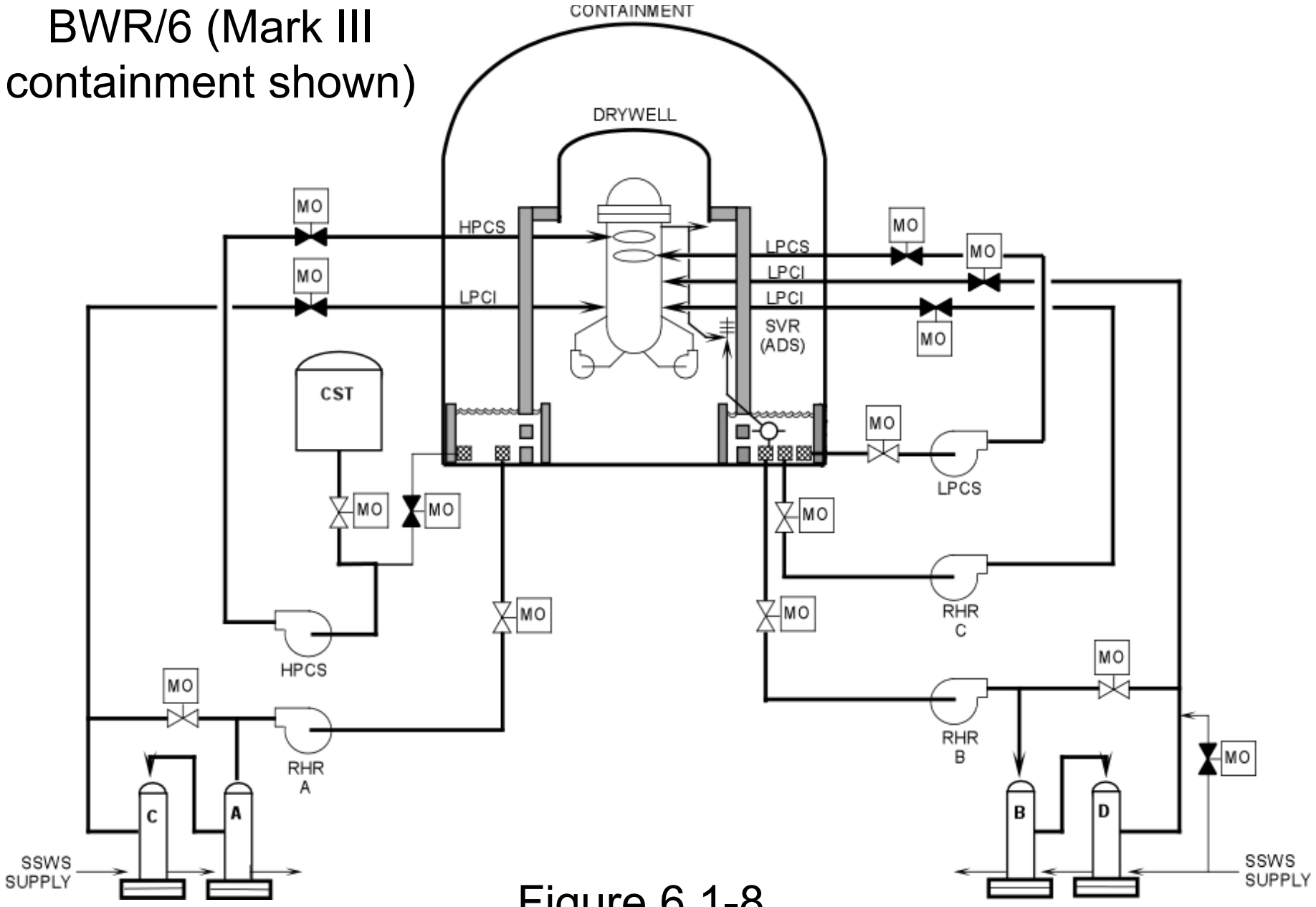
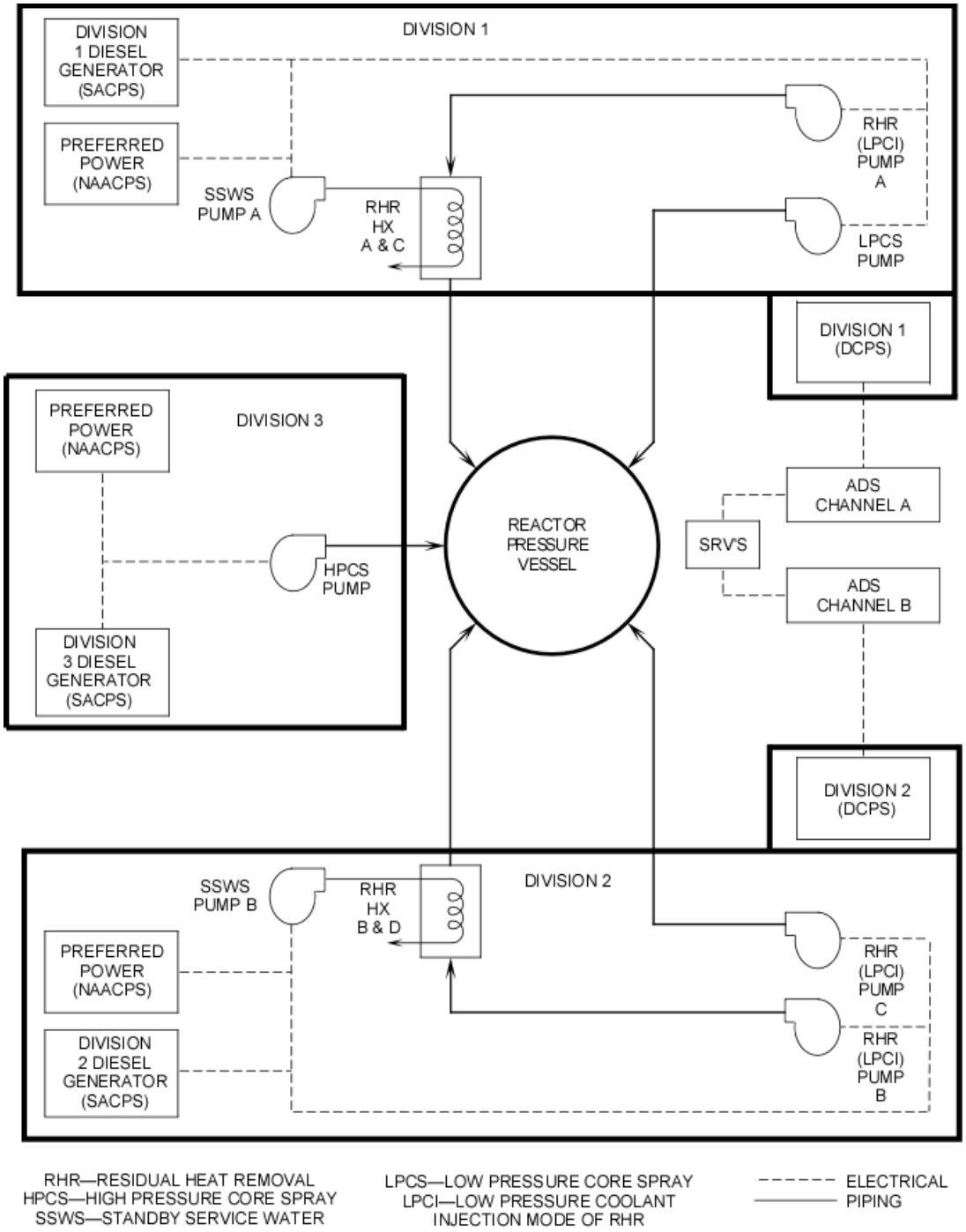
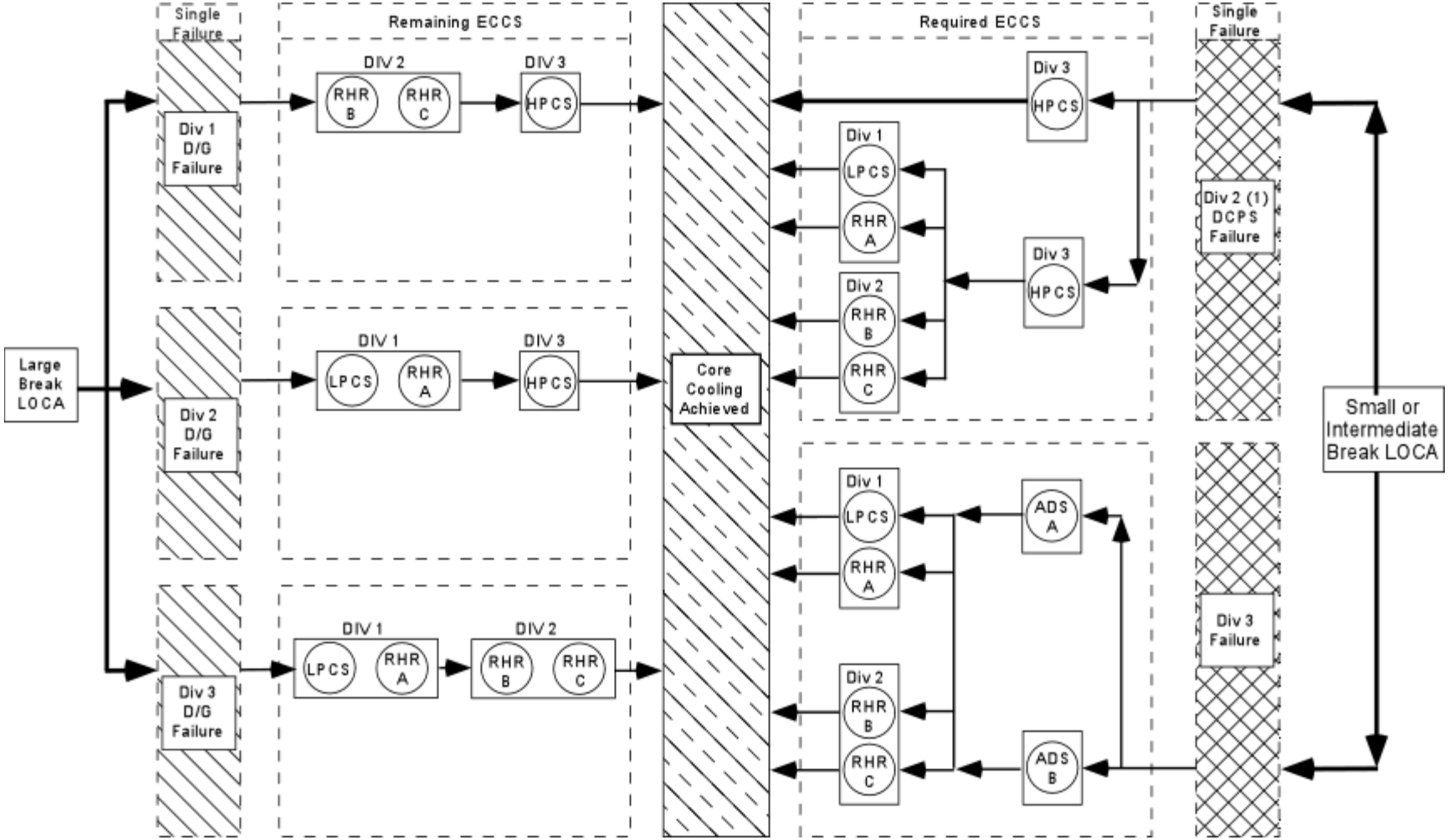



Figure 6.1-8




# BWR/5 & BWR/6 ECCS Divisions

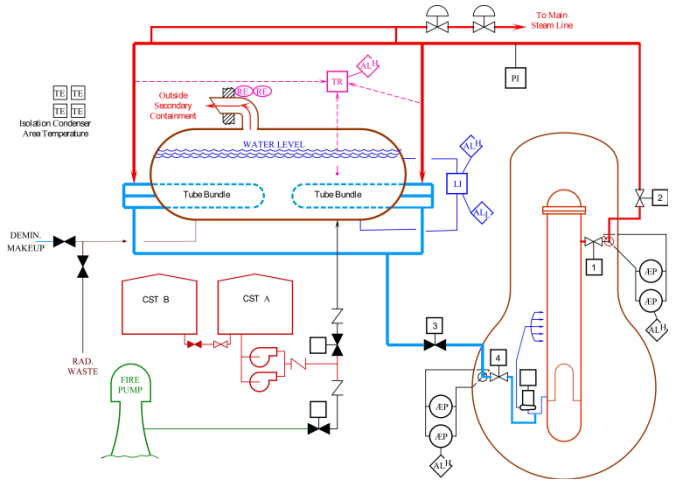
Figure 6.1-9



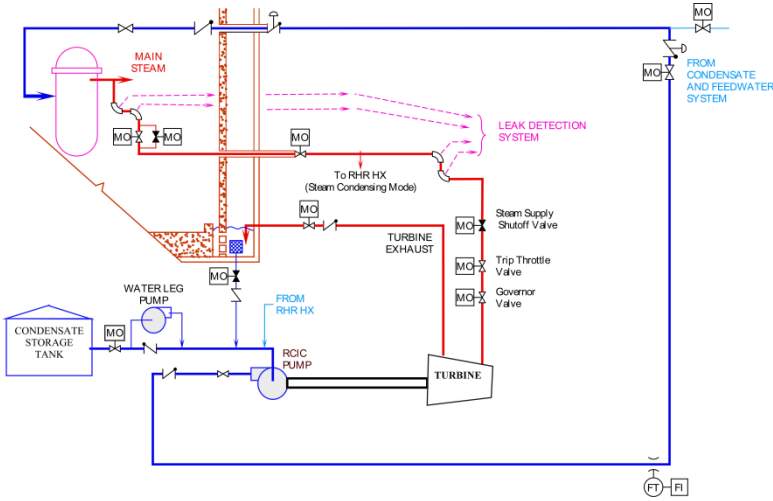

Integrated ECCS Response to LOCA with one failed Division

Figure 6.1-10

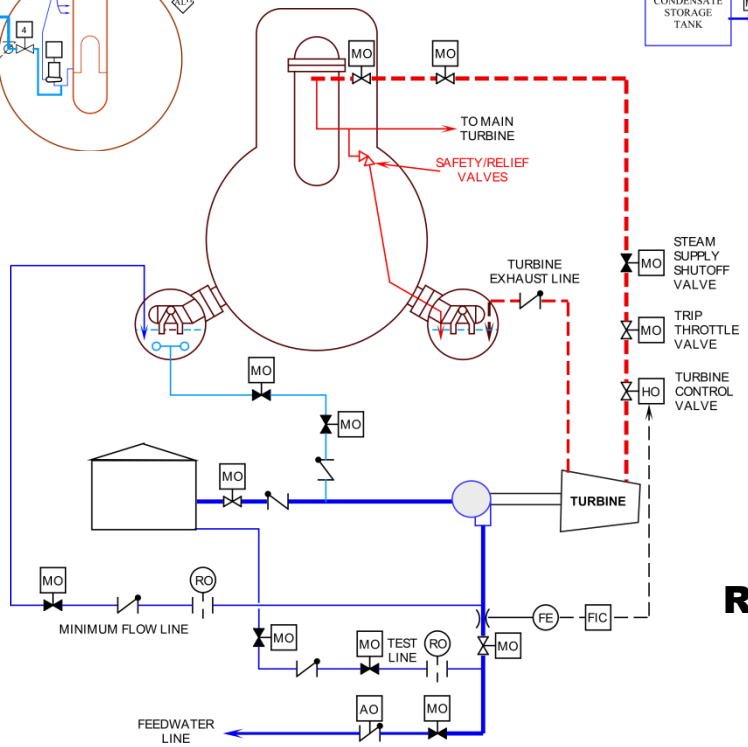
# Isolated Reactor Pressure & Inventory Control




**BWR/2/3 IC**




**RCIC BWR/6**




**RCIC BWR/3/4/5**

# Isolation Condenser System (BWR/2 & some BWR/3)

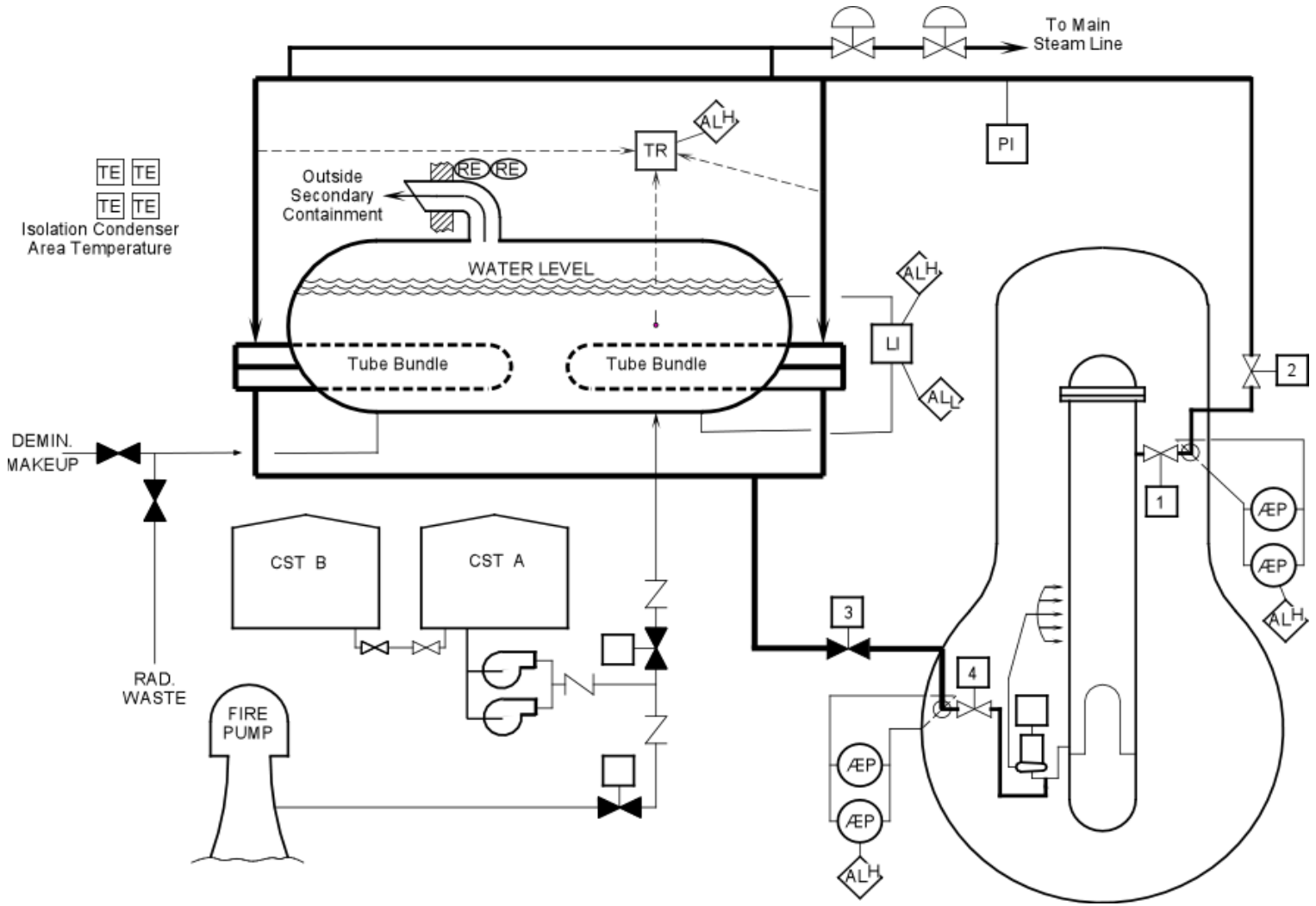



Figure 6.1-11

# RCIC

(Some BWR/3s, BWR/4 & BWR 5, Mark I containment shown)

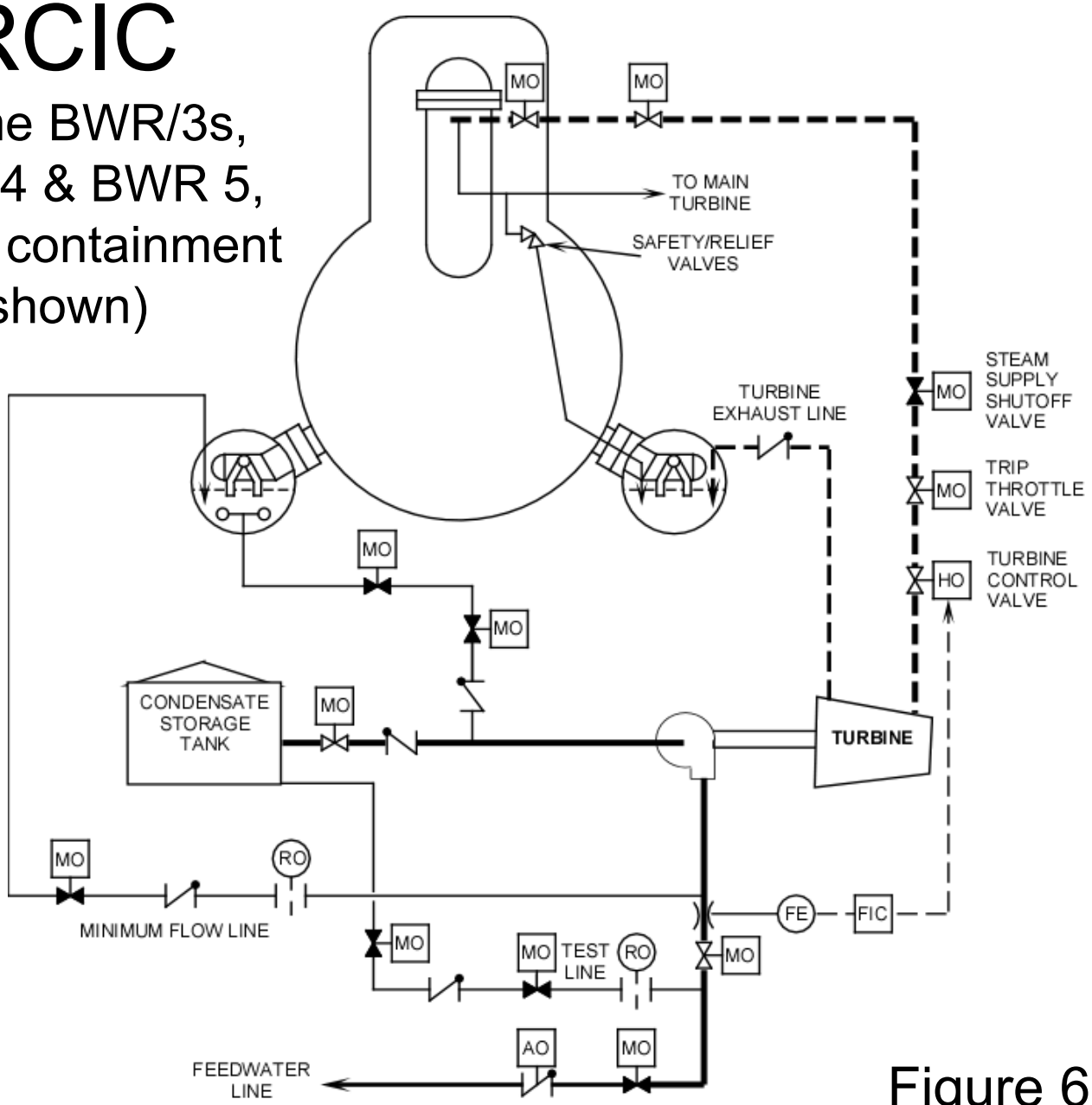



Figure 6.1-12

# BWR/6 RCIC

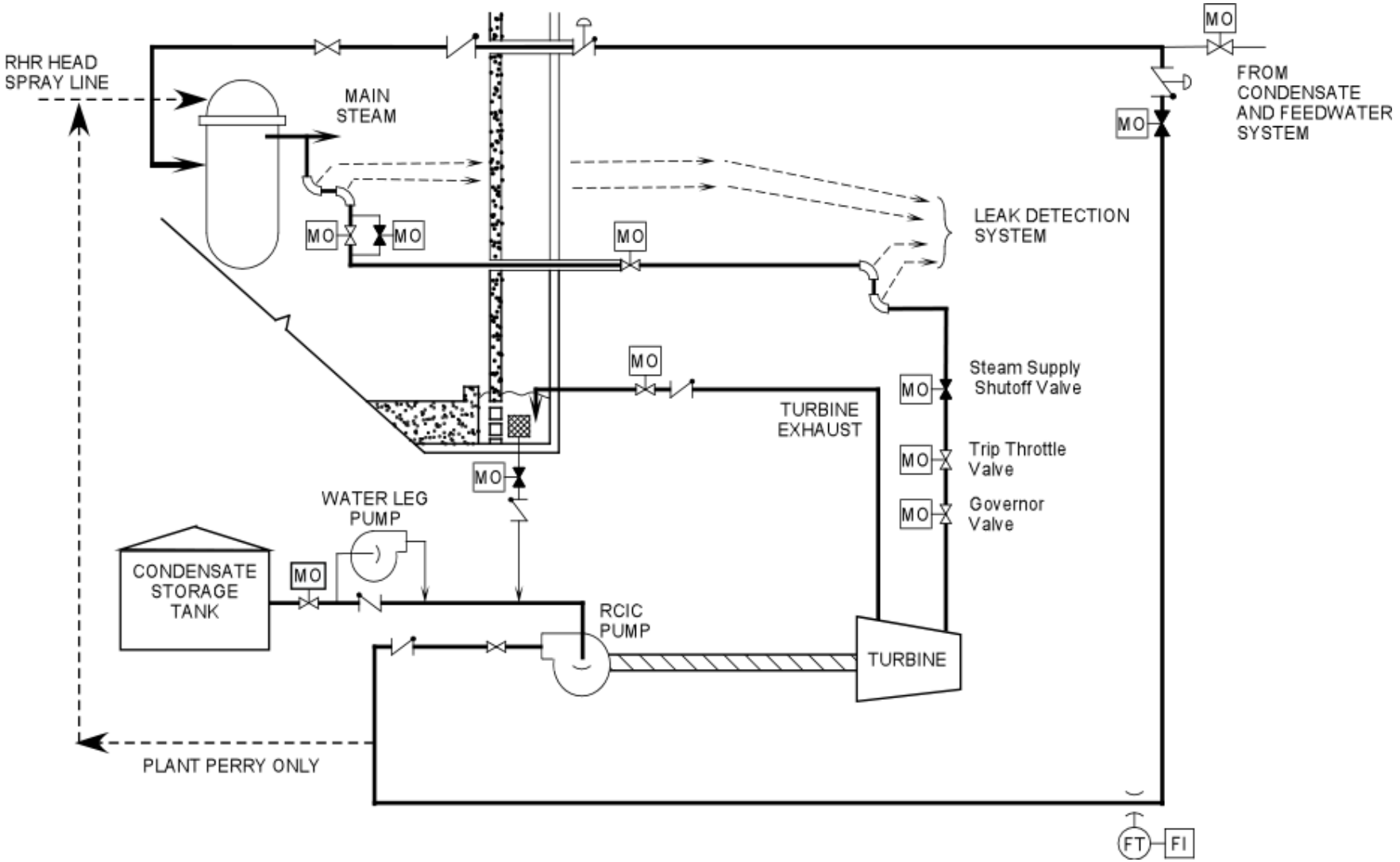



Figure 6.1-13

| Function | BWR/2 | BWR/3 | BWR/4 | BWR/5 | BWR/6 |
|---|---|---|---|---|---|
| Containment Spray and Cooling | Containment Spray System | MODE of LPCI or RHR System | MODE of RHR system | MODE of RHR system | MODE of RHR system |
| ECCS High Pressure Pumping | Feedwater Pumps | HPCI | HPCI | HPCS | HPCS |
| ECCS High Pressure Pumping Delivery Point | Vessel annulus via feedwater sparger | Vessel annulus via feedwater sparger | Vessel annulus via feedwater sparger | Directly above core outlet (one spray ring) | Directly above core outlet (one spray ring) |
| ECCS High Pressure Pump Type | Normal RFPs with and without emergency power | Normal RFPs or Turbine Driven HPCI | Turbine Driven | Motor Driven | Motor Driven |
| ECCS Blowdown | ADS | ADS | ADS | ADS | ADS |
| ECCS Low Pressure Spray | Two core spray (independent) loops | Two core spray (independent) loops | Two core spray (independent) loops | One LPCS loop | One LPCS loop |
| ECCS Low Pressure Flooding | NONE | LPCI sys, 2 loops; or LPCI MODE of RHR | LPCI MODE of RHR 2 independent loops (2 plants have 4 loops) | LPCI MODE of RHR 3 independent loops | LPCI MODE of RHR 3 independent loops |
| ECCS Low Pressure Flooding Deliver point | | Recirculation pump discharge pipe | Recirculation pump discharge pipe or inside shroud (core region) | Inside core shroud, core region | Inside core shroud, core region |
| Standby Coolant Supply | UHS to condenser and then feedwater to vessel | From UHS to Feedwater or RHR | From UHS to RHR | From UHS to RHR | From UHS to RHR |

Table 6.1-1

# Suction Strainers

- NRC raises the blockage issue in 1979
- Barseback Unit 2 Event 1992
  - Spurious relief valve actuation
  - Suction strainers became clogged with dislodged insulation from relief valve operation
- Perry Events 1993
  - Debris in suppression pool
  - “Dropped” cooling unit filters, paint chips & sludge

# Suction Strainers

- Quad Cities Unit 1 Events 1994
  - Shredded plastic bag on RHR valve
  - Wire brush wheel and metal strap on RHR pump vane
- River Bend 1994
  - Plastic bag on RHR strainer

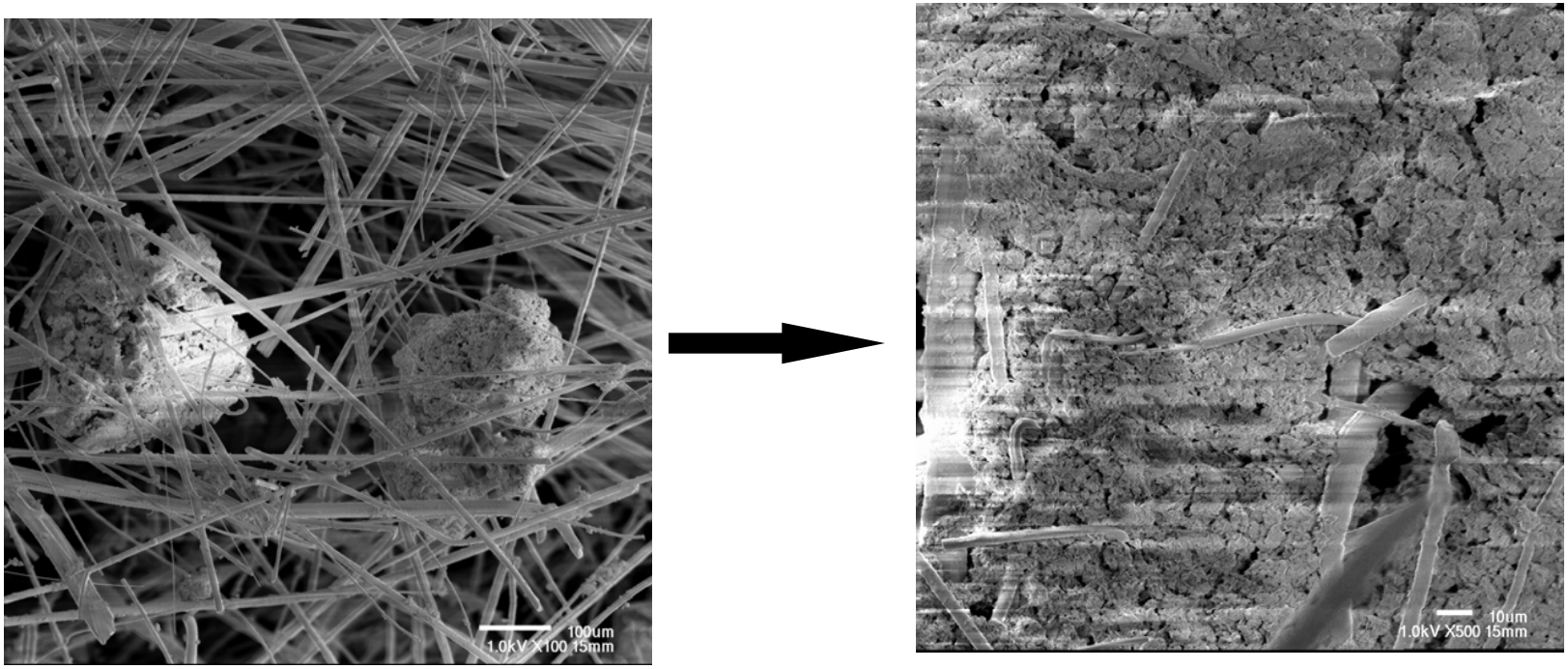
# Suction Strainers

- Limerick Unit 1 Event 1995
  - SRV lift
  - Low suppression pool cooling flow
  - Strainer clogged with fibrous material and sludge
  - 1400 pounds of debris removed from U1 suppression pool & about the same amount removed from U2 suppression pool

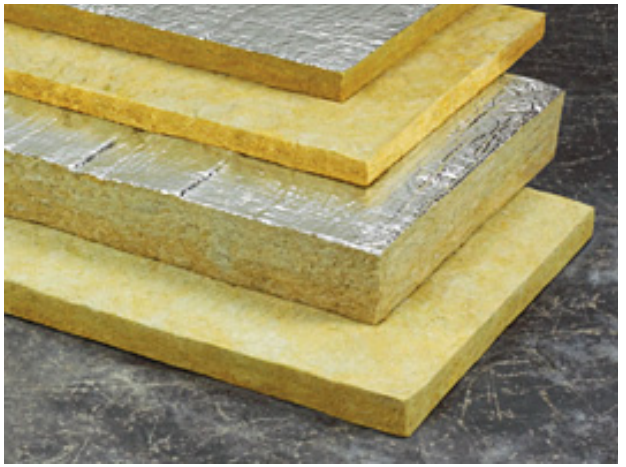
# The old problematic style strainer

# Worst Case

- Fibers begin to capture particulates
- Rapid loss of NPSH



# Mineral Wool



Generic term for various insulation materials such as fiber glass.

# Strainer Remedies

NRC Bulletin 96-03

- Install large capacity passive strainers
- Install self-cleaning strainers
- Install backflush system that relies on operator action
- Propose another approach.

# Strainer Remedies

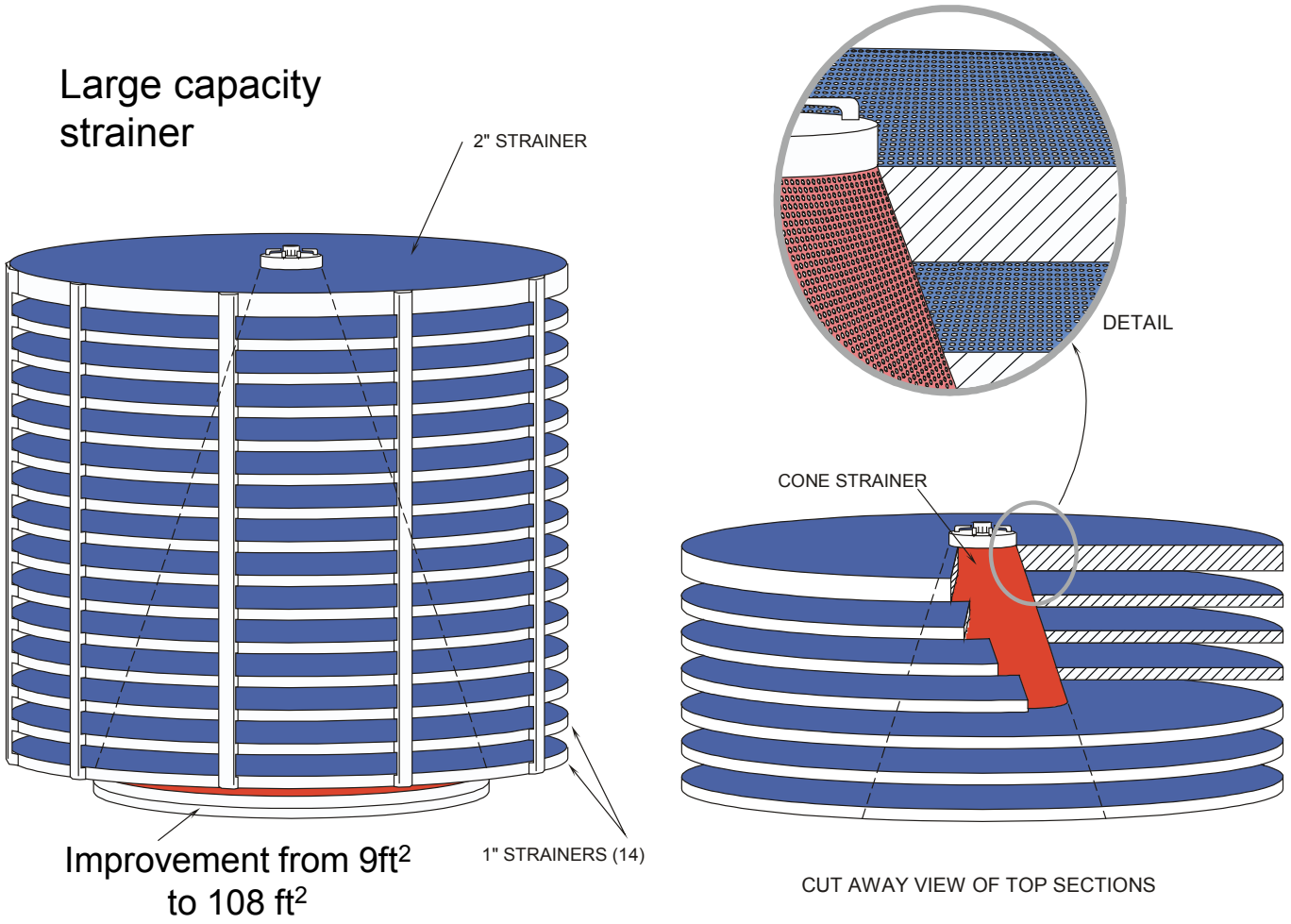
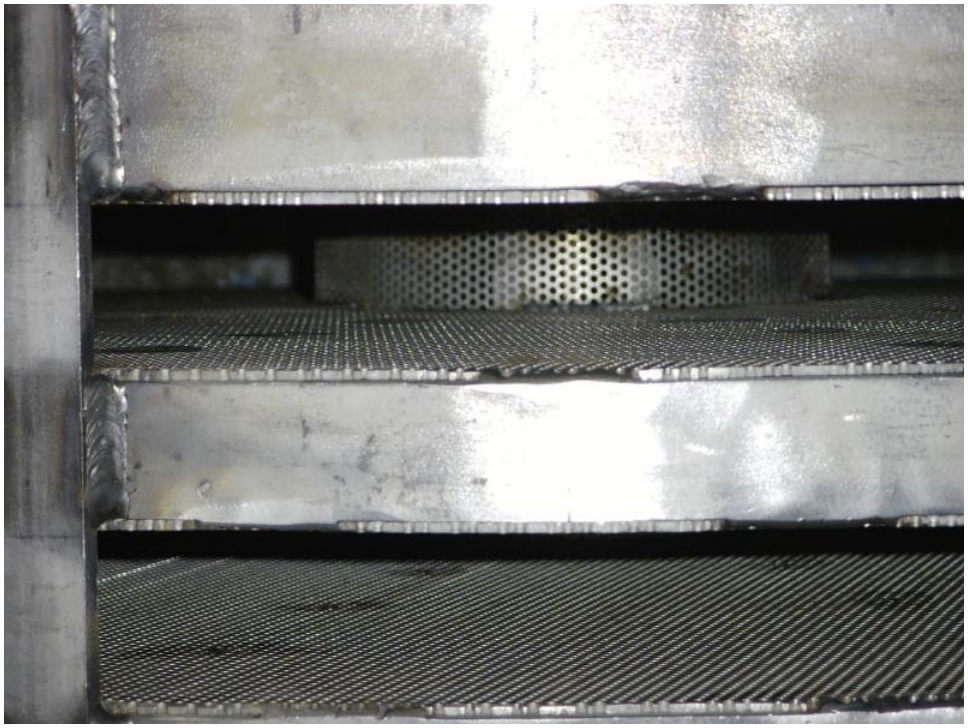



Figure 6.1-14

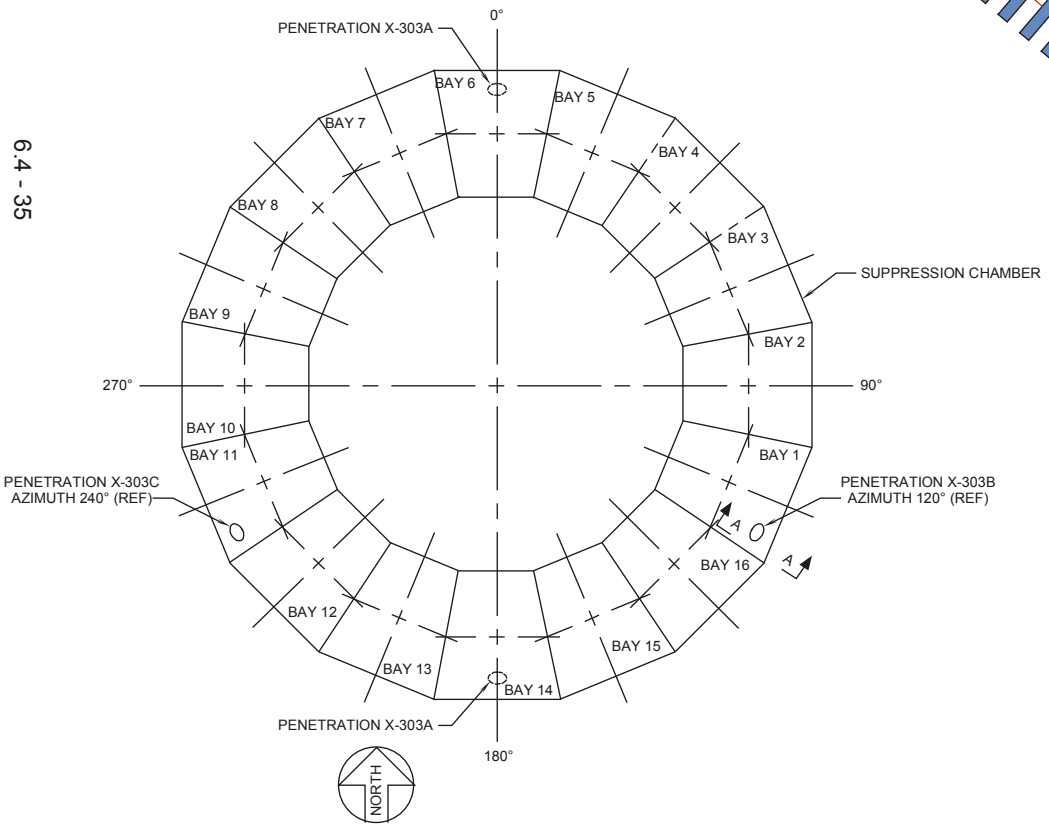
# Strainer Remedies

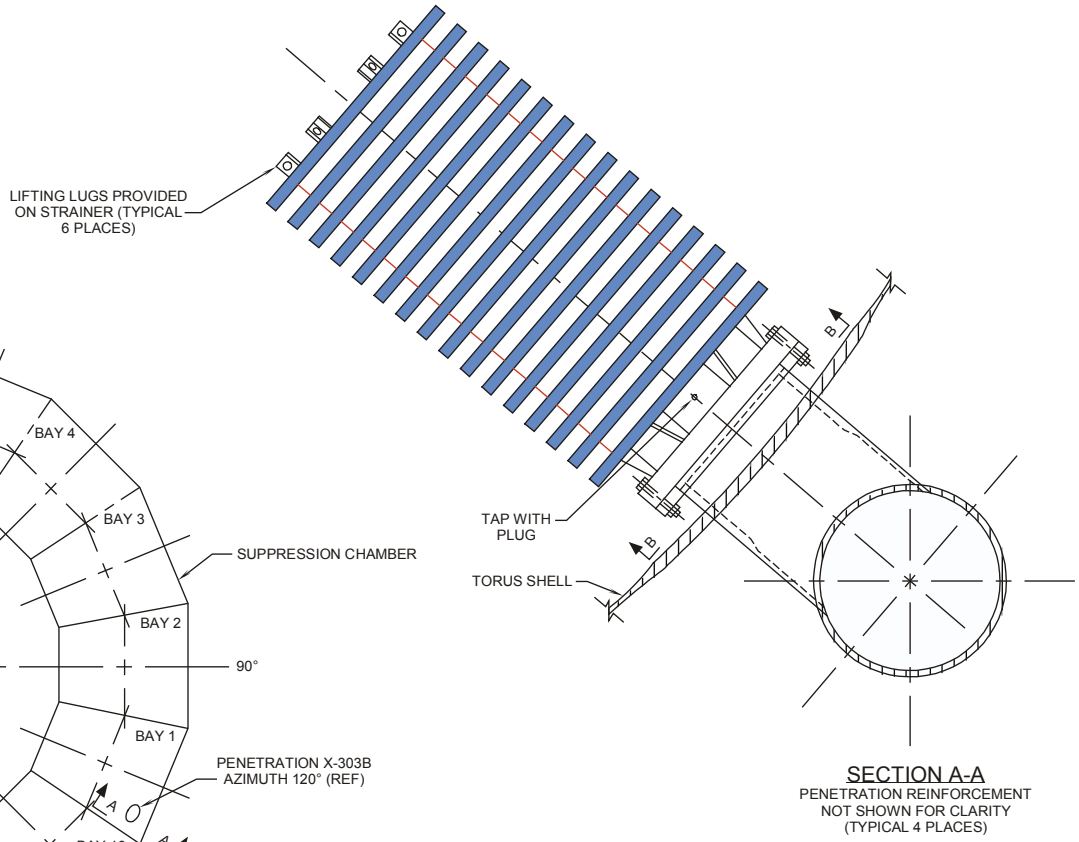


Hatch Strainers

# Strainer Remedies

## Dresden

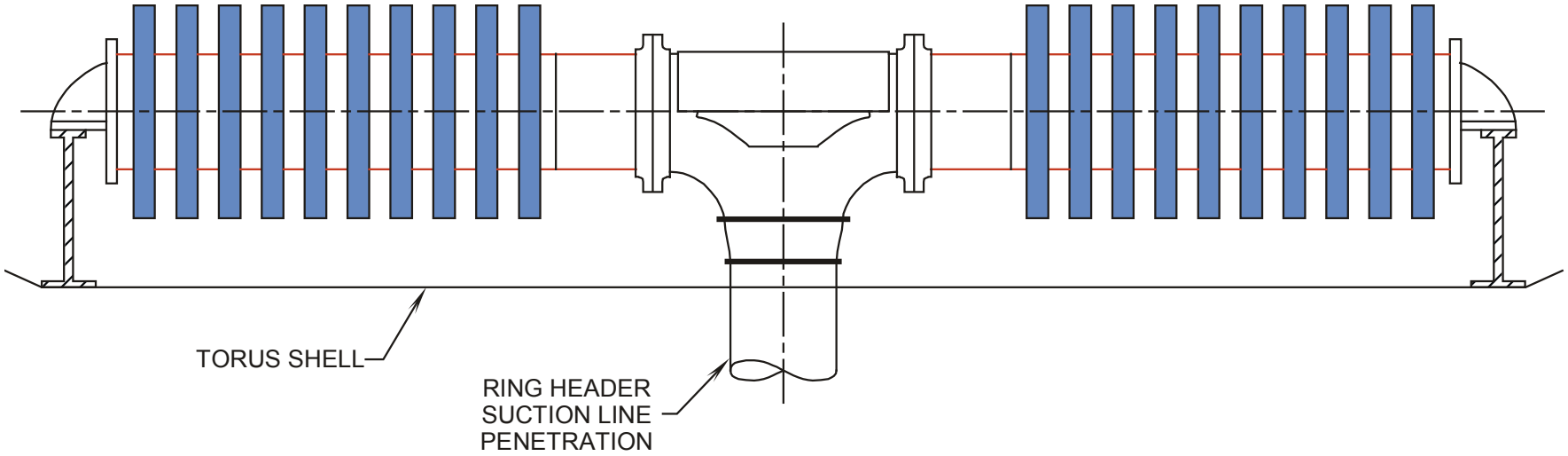



118Ft$^2$

# Brunswick Strainer

# Strainer Remedies



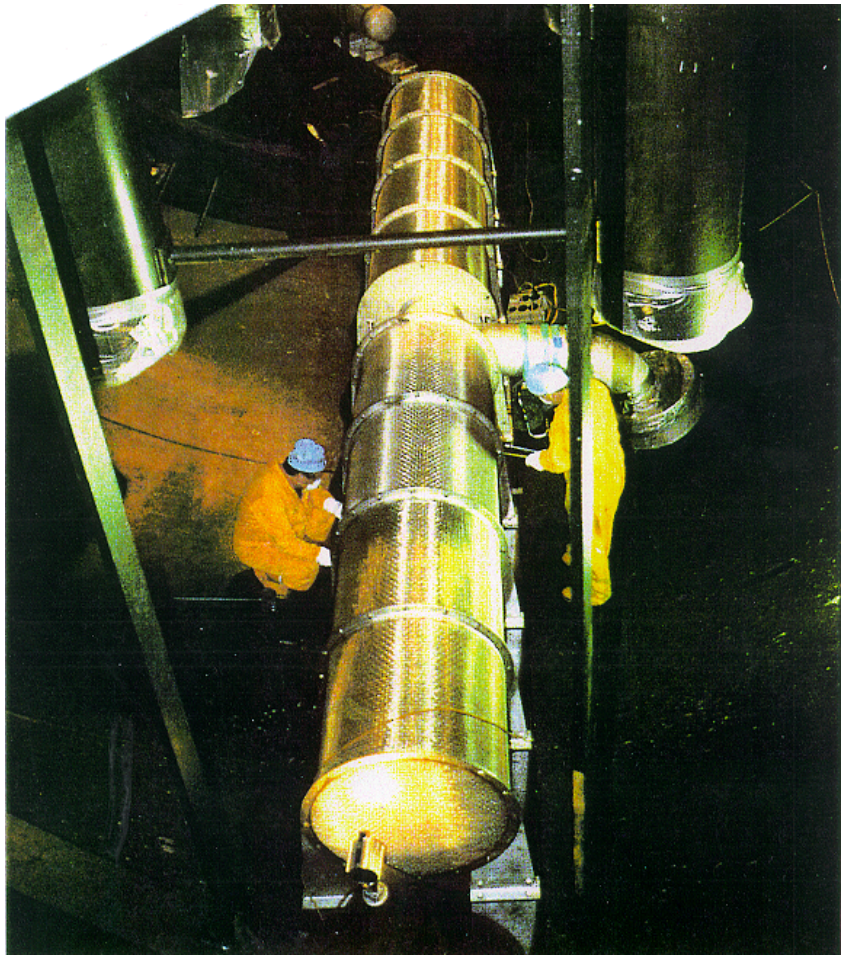

Monticello

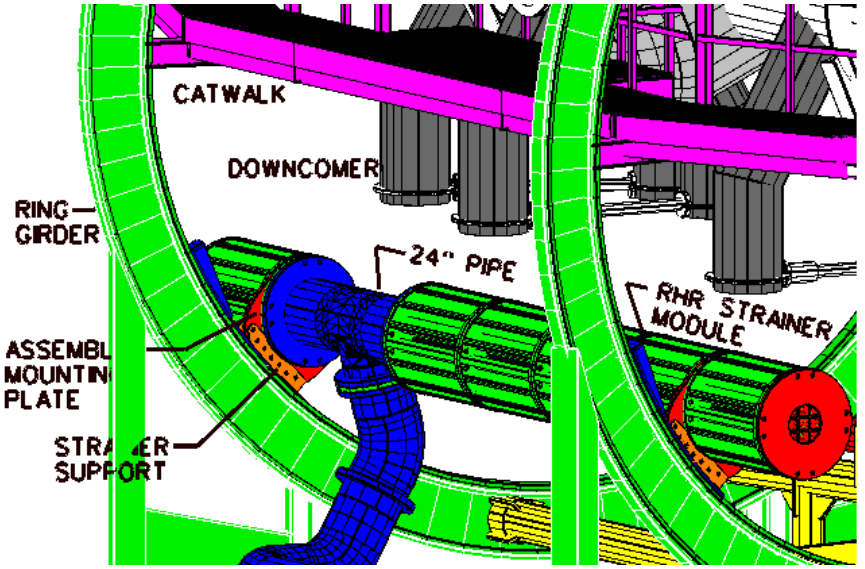
100Ft$^2$

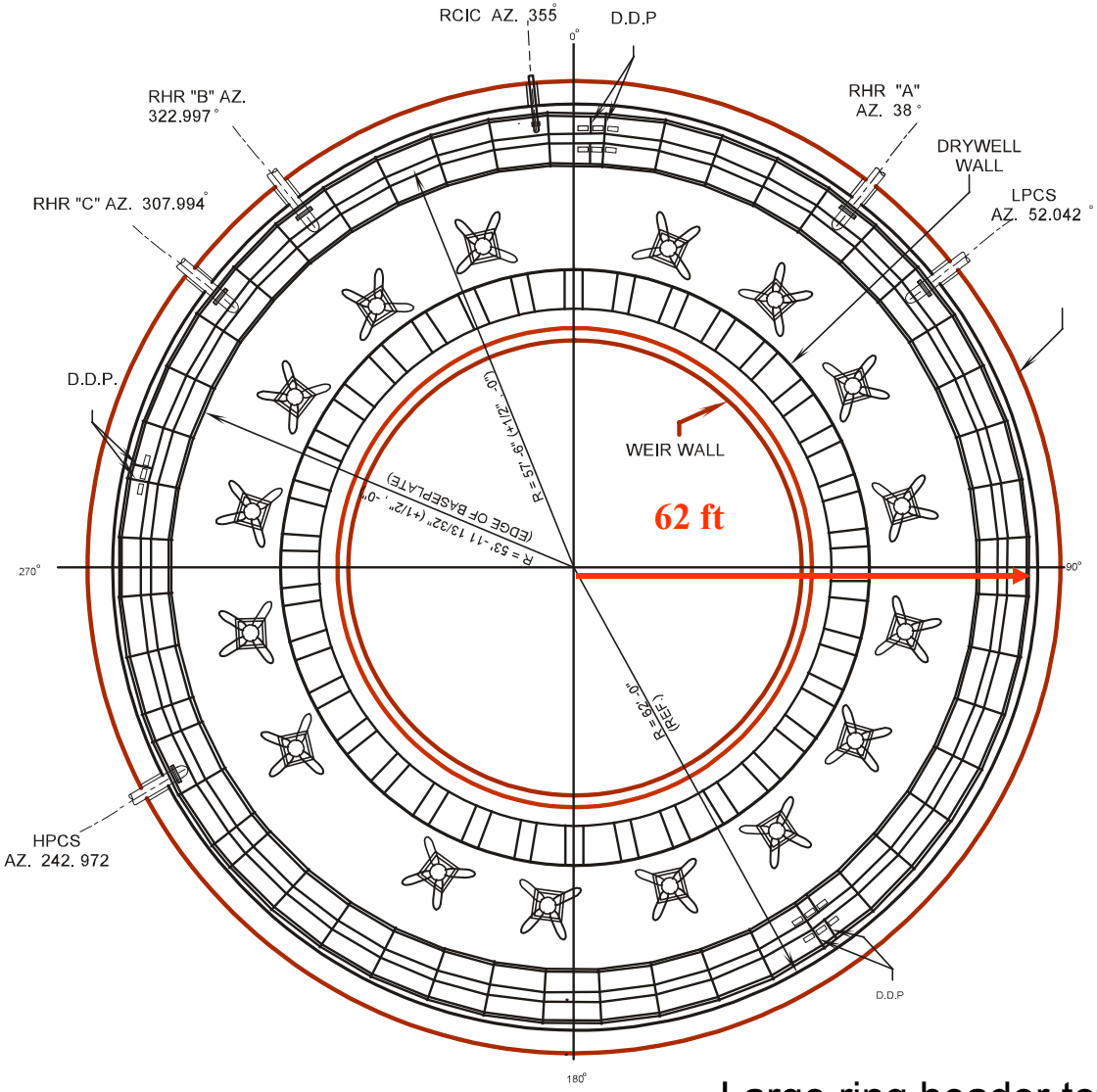
Figure 6.1-15

# Strainer Remedies

# Peach Bottom Strainer








**Circumference 389 ft**

# Mark III

Large ring header totally circumscribes the suppression chamber with perforation on bottom of the ring.

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