U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

CONTAINMENT AND CONTAINMENT SYSTEMS

AP1000 Technology Sections 5.1, 5.2

HRTD
Human Resources Training & Development

Section 5.1: Containment Structure

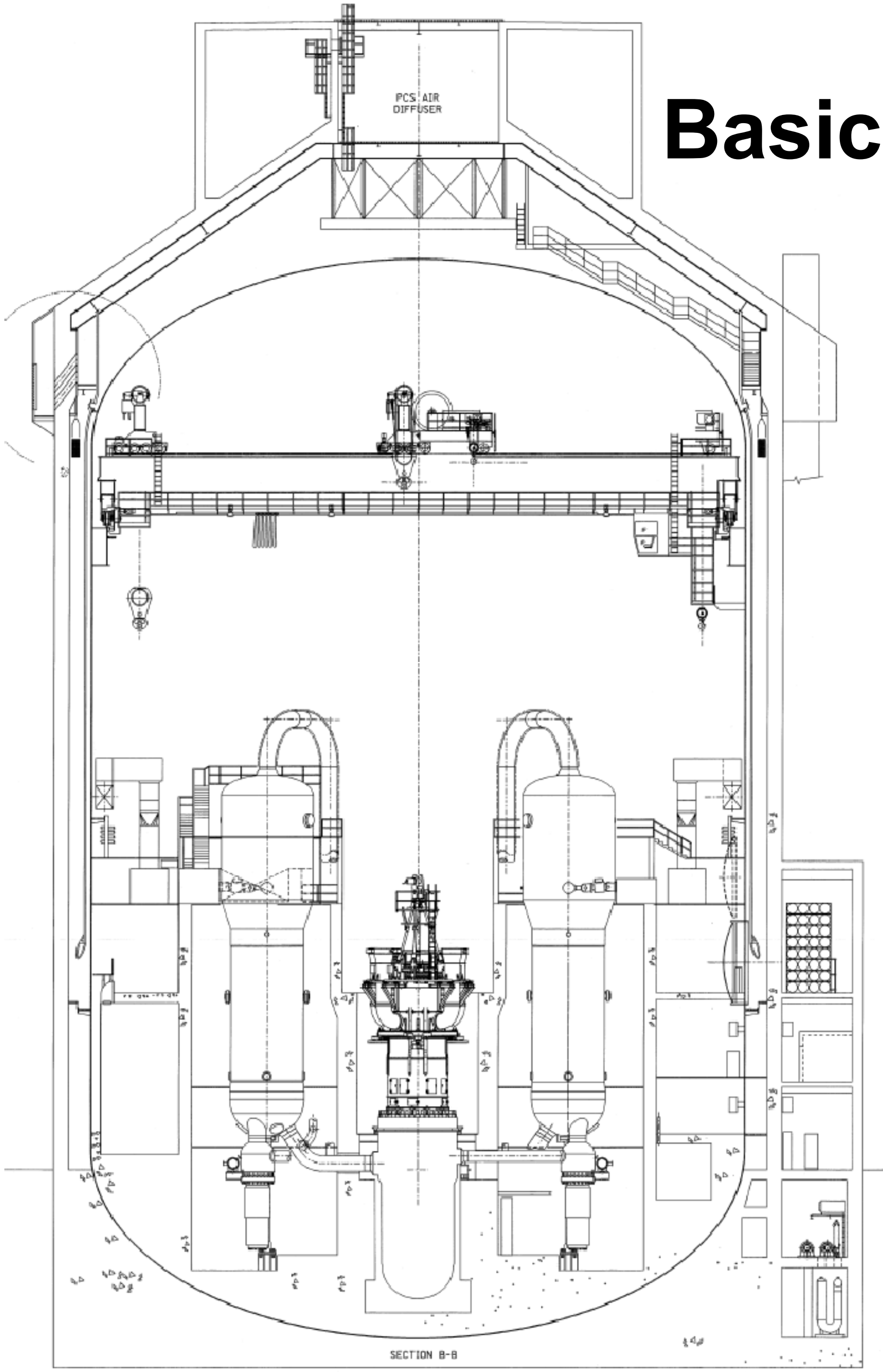
Objectives

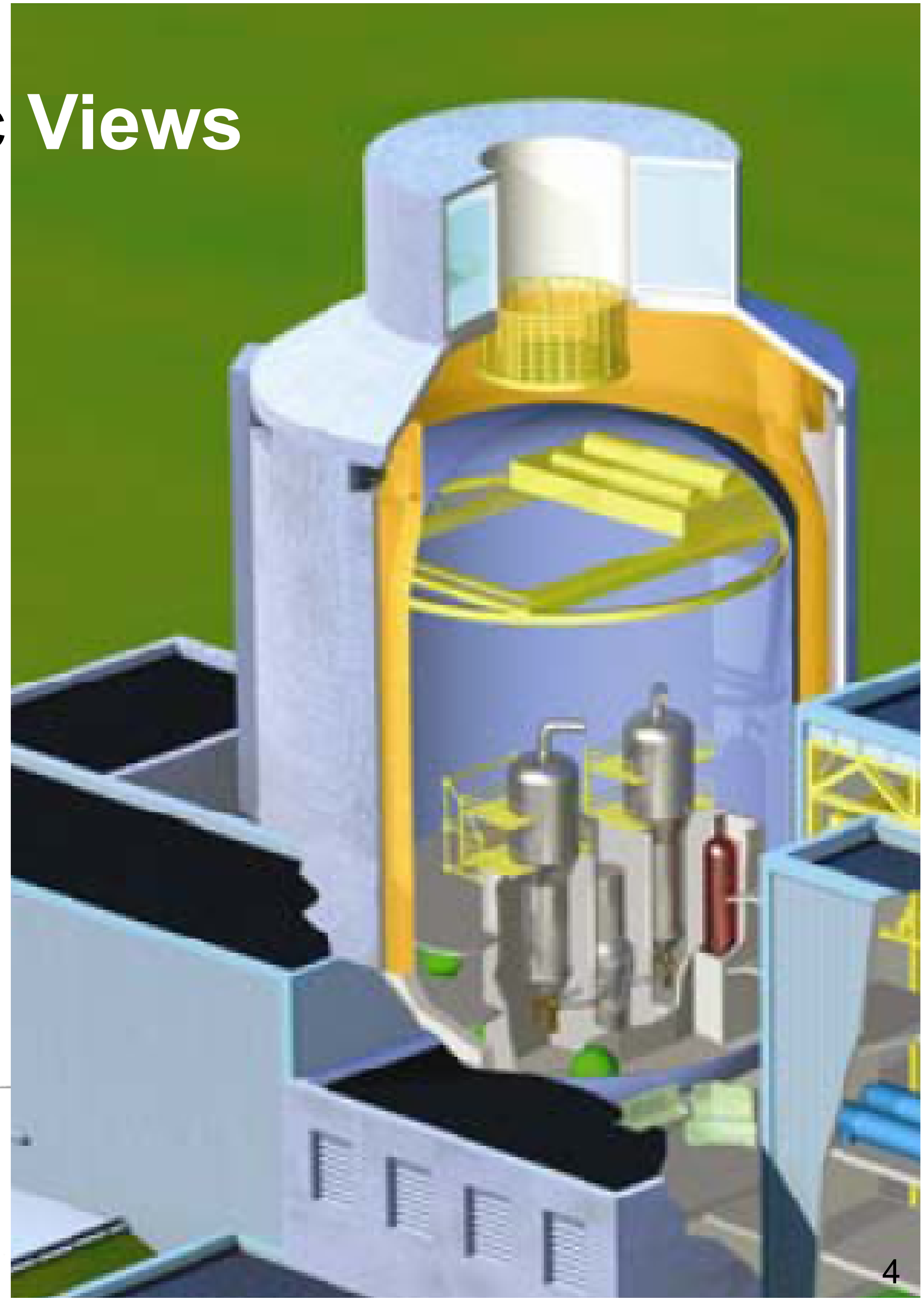
1. **State the purposes of the containment building.**

2. **State the purposes of the shield building.**

3. **Briefly describe the physical arrangement of the containment & shield buildings.**

Basic Views





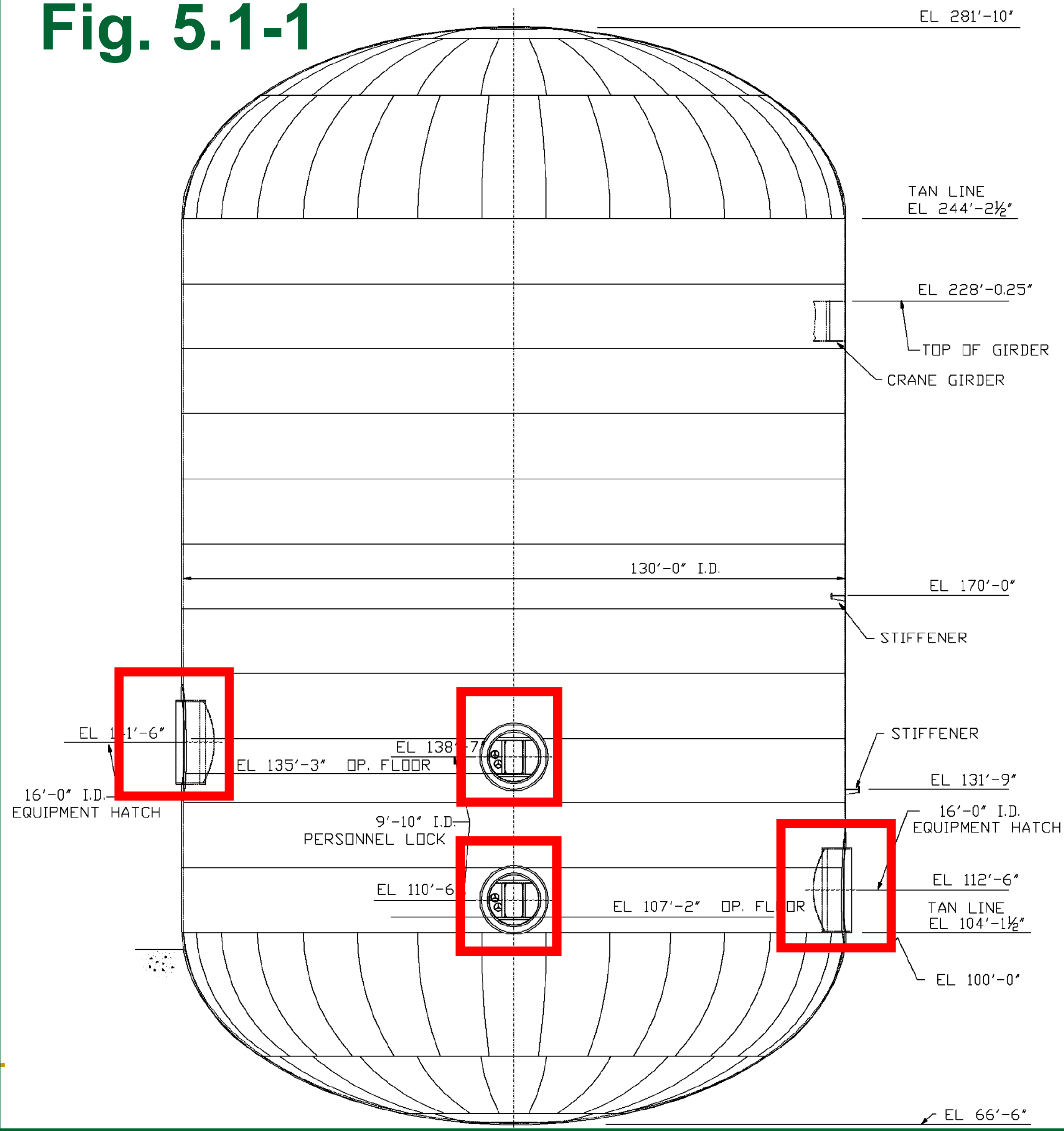
Containment Building (Containment Vessel) Purposes

- **Houses & supports RCS and related systems & some ESF systems.**
- **Provides shielding for core & RCS during normal ops.**
- **Contains the release of airborne radioactivity during a design-basis accident.**
- **Is an integral part of the passive containment cooling system (PCS), which prevents exceeding containment design pressure following a design-basis accident.**

Containment Vessel

- Seismic Cat. I freestanding vessel
- Cylindrical w/ elliptical heads
- Diam: 130 ft
- Ht: 215 ft
- Wall thick-ness: 1.75 in.*
- Design press: 59 psig
- 2 equipment hatches, 2 airlocks

Fig. 5.1-1



Containment Vessel – Orientations of Major Penetrations

- **Equipment hatch at operating deck**
- **Equipment hatch at maintenance floor**
- **Airlocks at both levels**

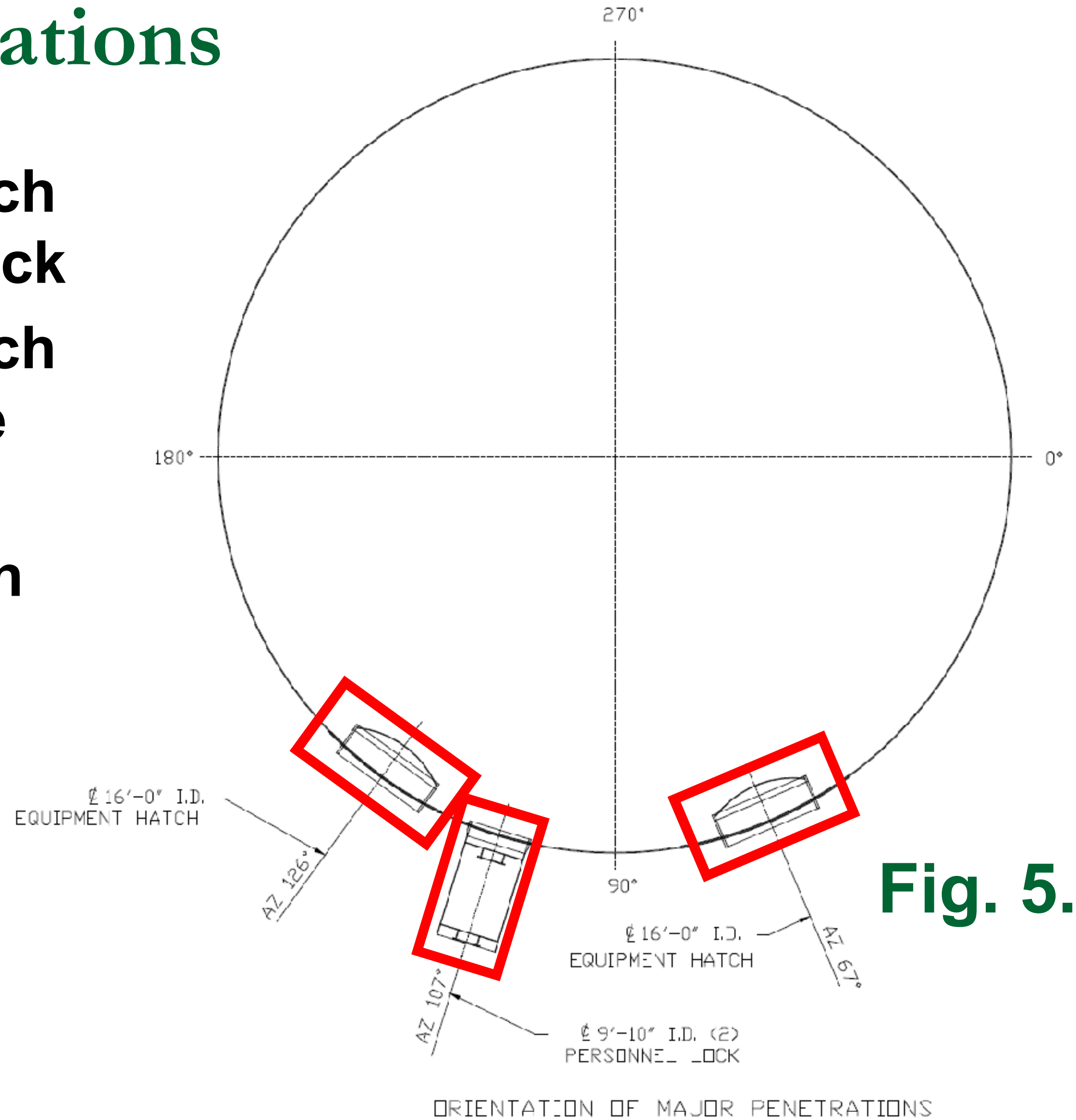
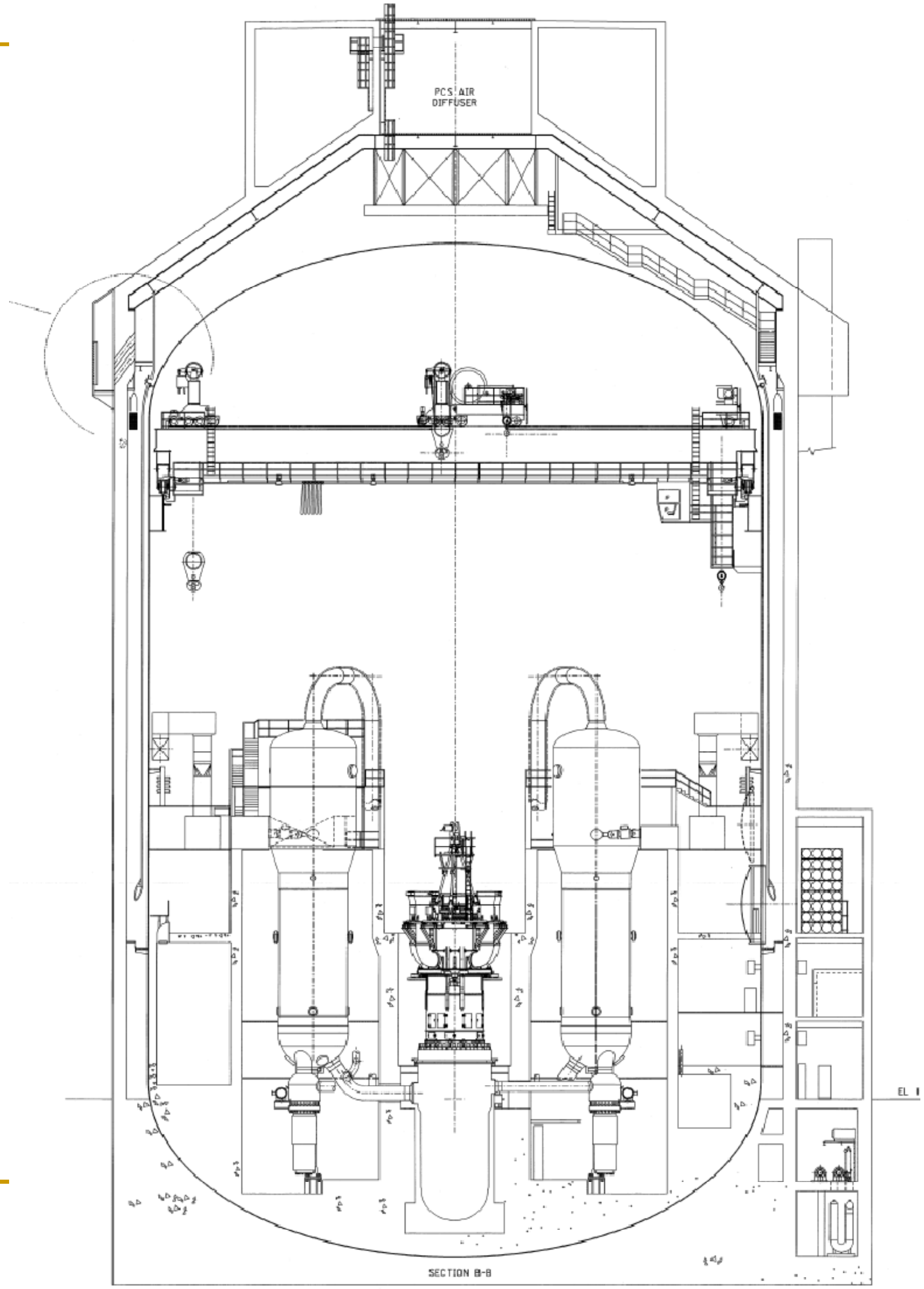


Fig. 5.1-1

Containment Vessel (cont'd)

- Bottom head is embedded in concrete on inside & outside
- Watertight seals on top of concrete
- Inorganic zinc coating except for embedded portions
- Epoxy top coat on portions of vessel inside surfaces



Shield Building Purposes

- Provides shielding for the containment vessel & radioactive systems & components inside the vessel.

- Protects the containment vessel from external events (tornadoes, missiles).

- Is an integral part of the PCS.

Shield Building

- Seismic Category I complex concrete/steel structure
- Air intakes for PCS at top of cylinder
- Annular space w/ baffle to direct air flow as part of PCS operation
- Watertight seal between upper & middle annuli
- Conical roof supports PCS water storage tank
- Air diffuser (chimney) in center of roof for PCS air discharge

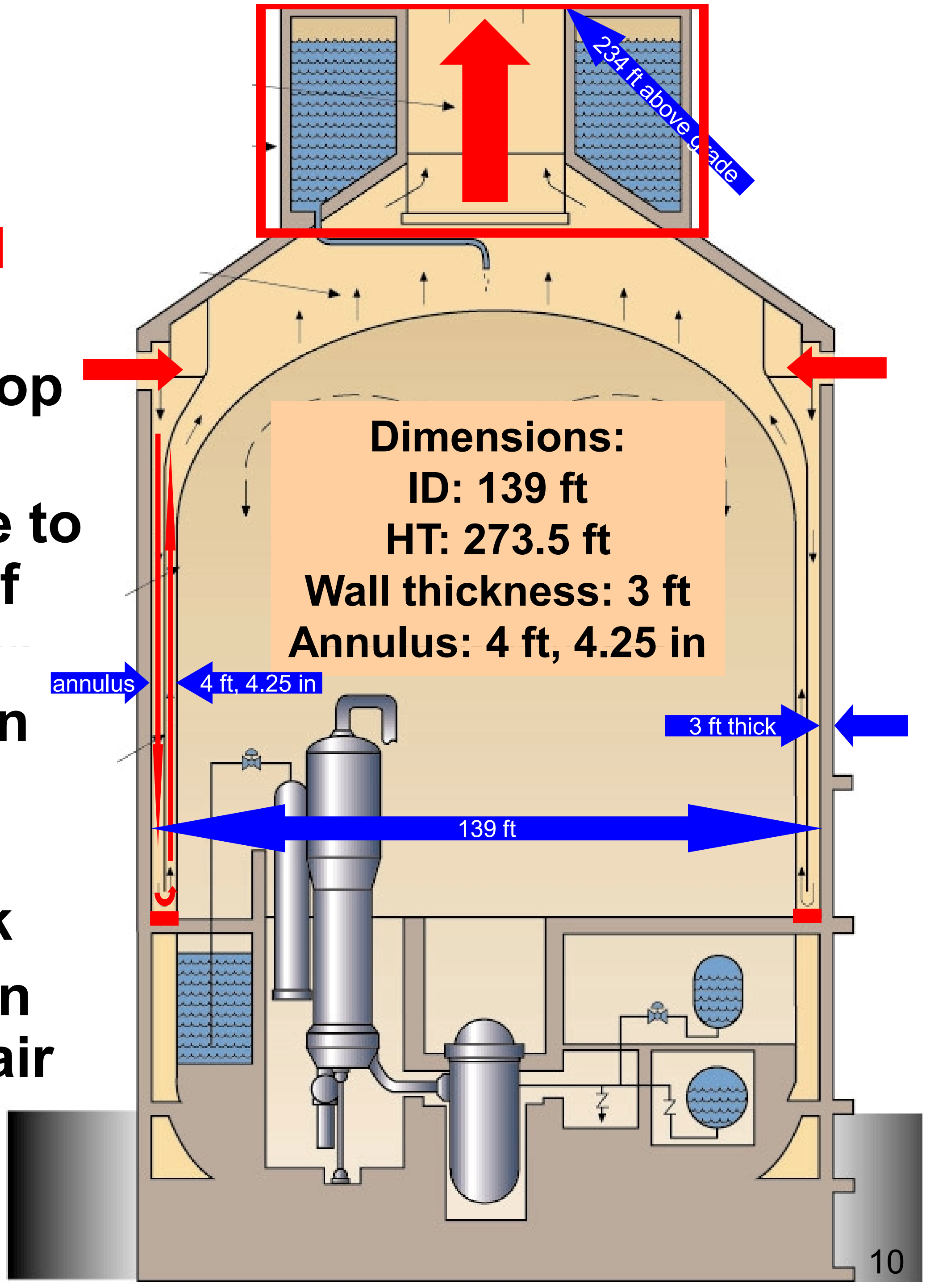
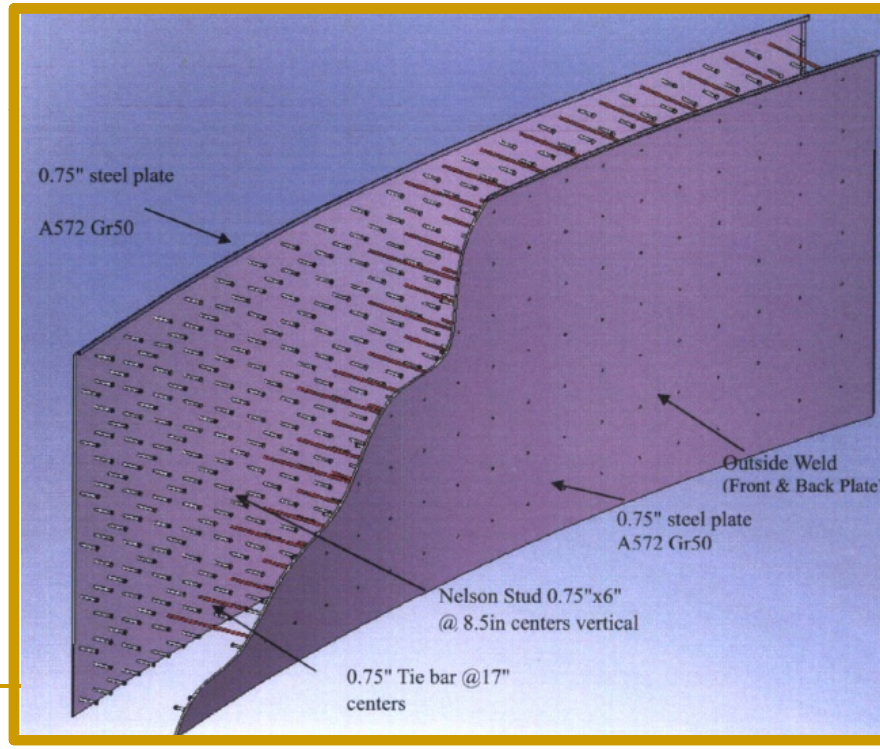


Fig. 5.1-2

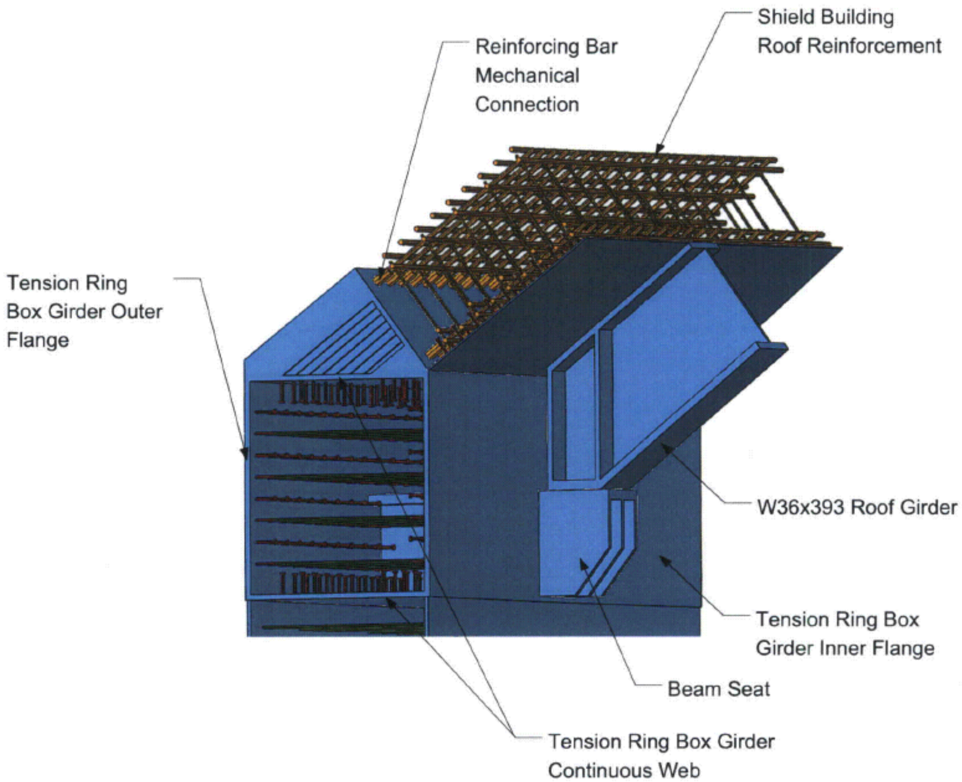
Shield Building Design Details

- Cylindrical wall not protected by aux. bldg. is steel/concrete composite structure (SC). Rest is reinforced concrete (RC).
- SC: Concrete w/ 0.75-in. steel plates on inside & outside, w/ tie bars & sheer studs
- Complex mechanical connectors now necessary at RC/SC transitions



Shield Building Design Details (cont'd)

- Tension ring (concrete-filled box girder) & air inlets redesigned for enhanced structural performance
- Air inlet region: 4.5-ft thick, 1-in. plates w/ tie bars
- 236 air inlet openings: 18-in. pipes, sloped 38° from vertical, welded to inner & outer faceplates



ES-5 Shield Building Tension Ring

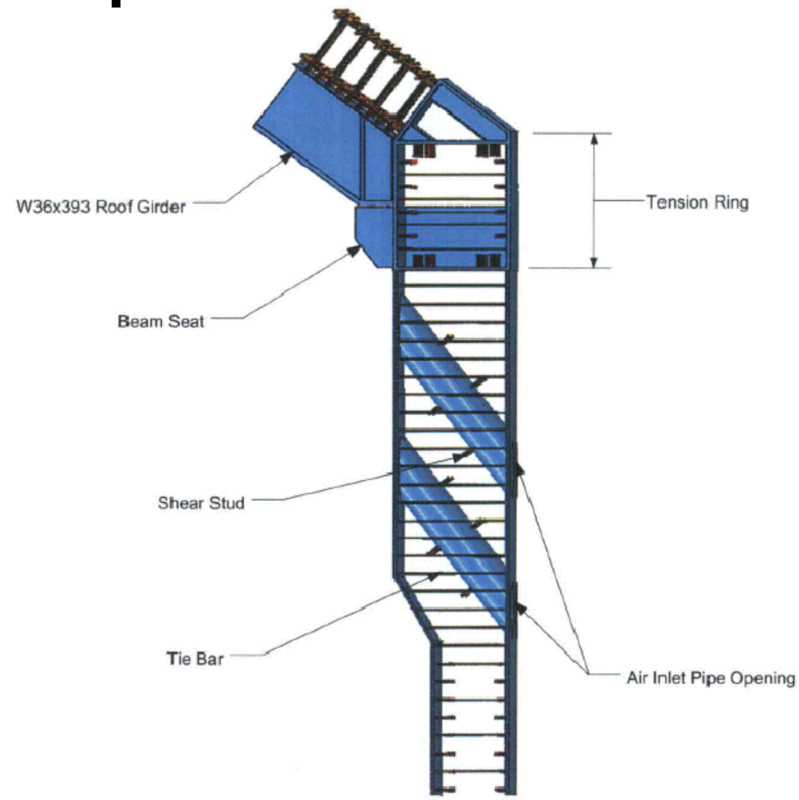


Figure ES-4 Elevation View of Tension Ring and Air Inlets

Section 5.2: Passive Containment Cooling System (PCS)

Objectives

1. **State the purpose of the passive containment cooling system.**

2. **Describe how the system cools the containment atmosphere.**

Section 5.2: Objectives (cont'd)

3. Describe how the following components & features contribute to the containment cooling function:

   a. PCS water storage tank
   b. PCS water storage tank isolation valves
   c. Water distribution bucket
   d. Water distribution weir system
   e. Containment air baffle
   f. PCS ancillary water storage tank

Purpose

- **To reduce containment temperature & pressure following a LOCA or MSLB by removing thermal energy from the containment atmosphere.**
  - **Operation of the PCS prevents exceeding the containment design pressure.**
  - **Reducing the containment pressure lessens the driving force for leakage of fission products to the environment.**

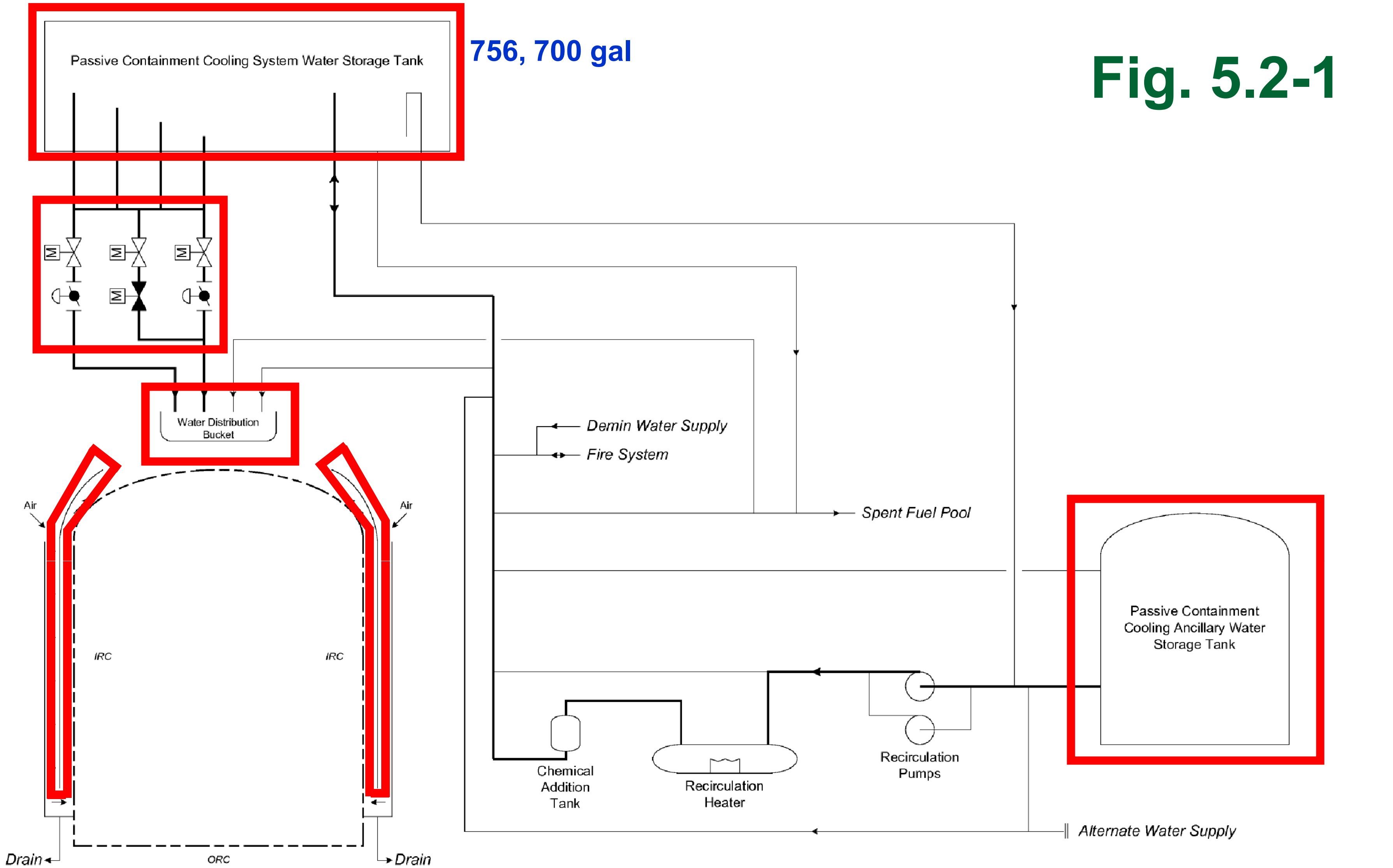


Fig. 5.2-1

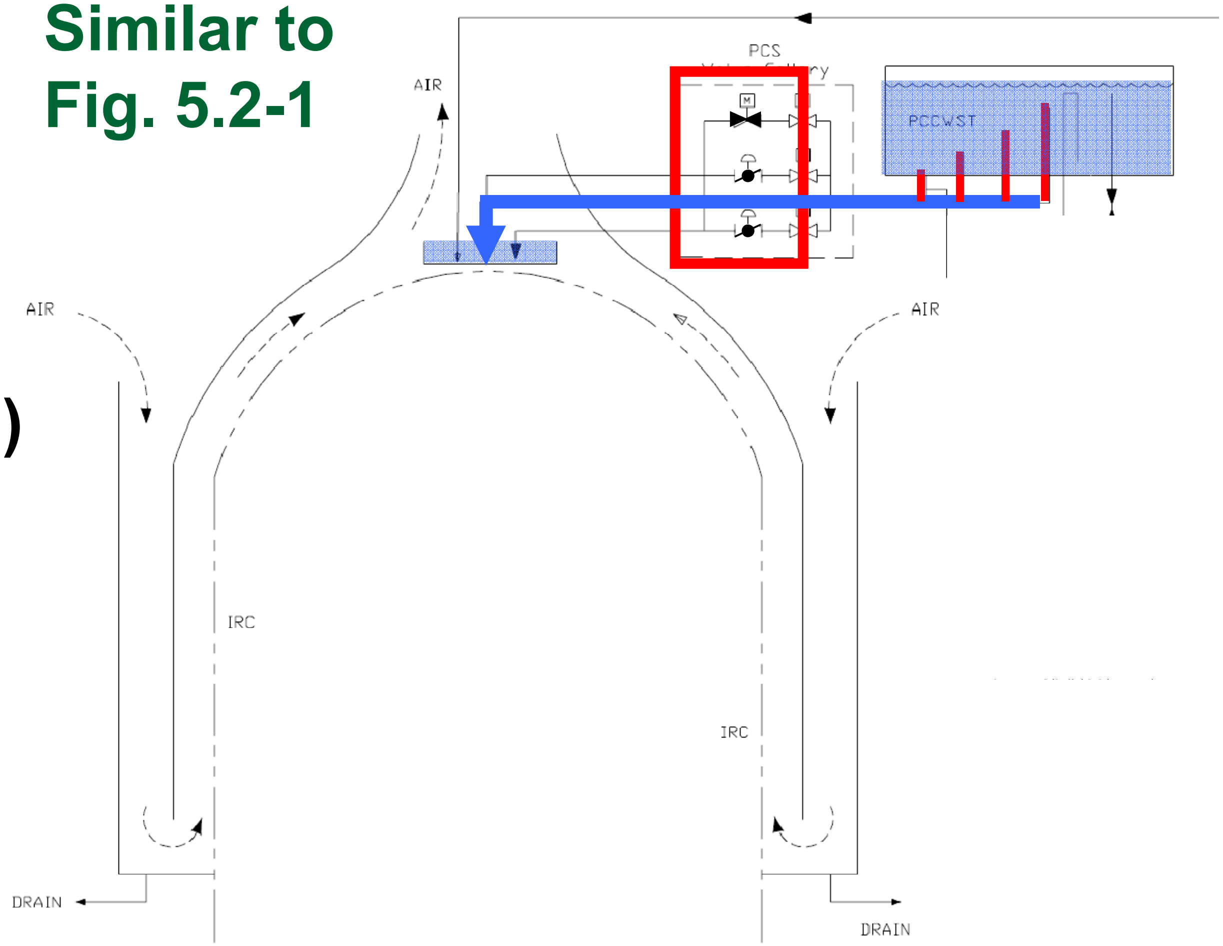
Key Components:
PCCWST
PCCWST isolation valves
Water distribution bucket

Water distribution weir system (not shown)
Containment air baffle
PCCA(ncillary)WST

System Operation

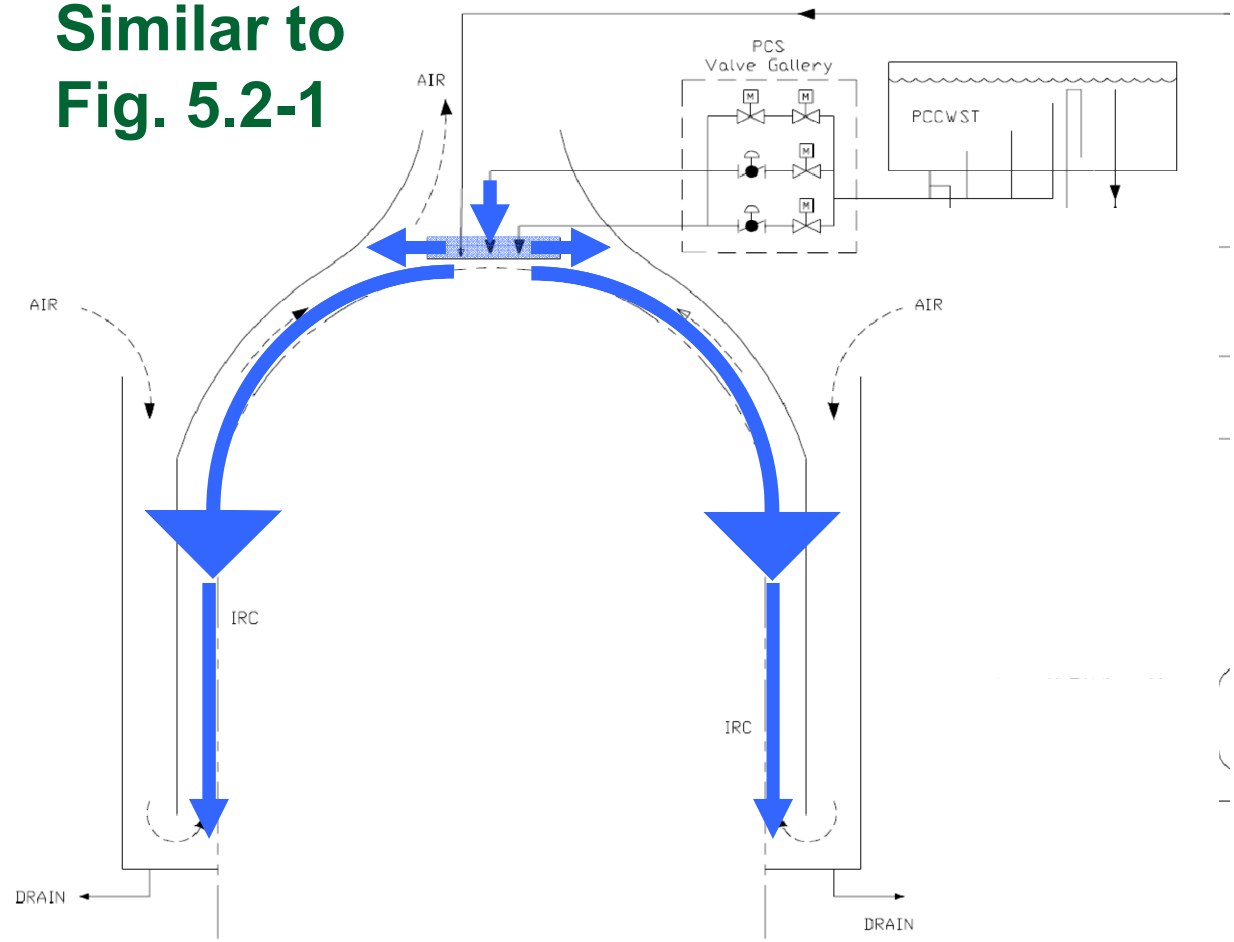
Similar to Fig. 5.2-1

- Containment Hi-2 pressure (6.2 psig) opens PCCWST discharge iso. valves.
- Water gravity drains from PCCWST.
- Heights of dis-charge standpipes govern flow rates.



System Operation

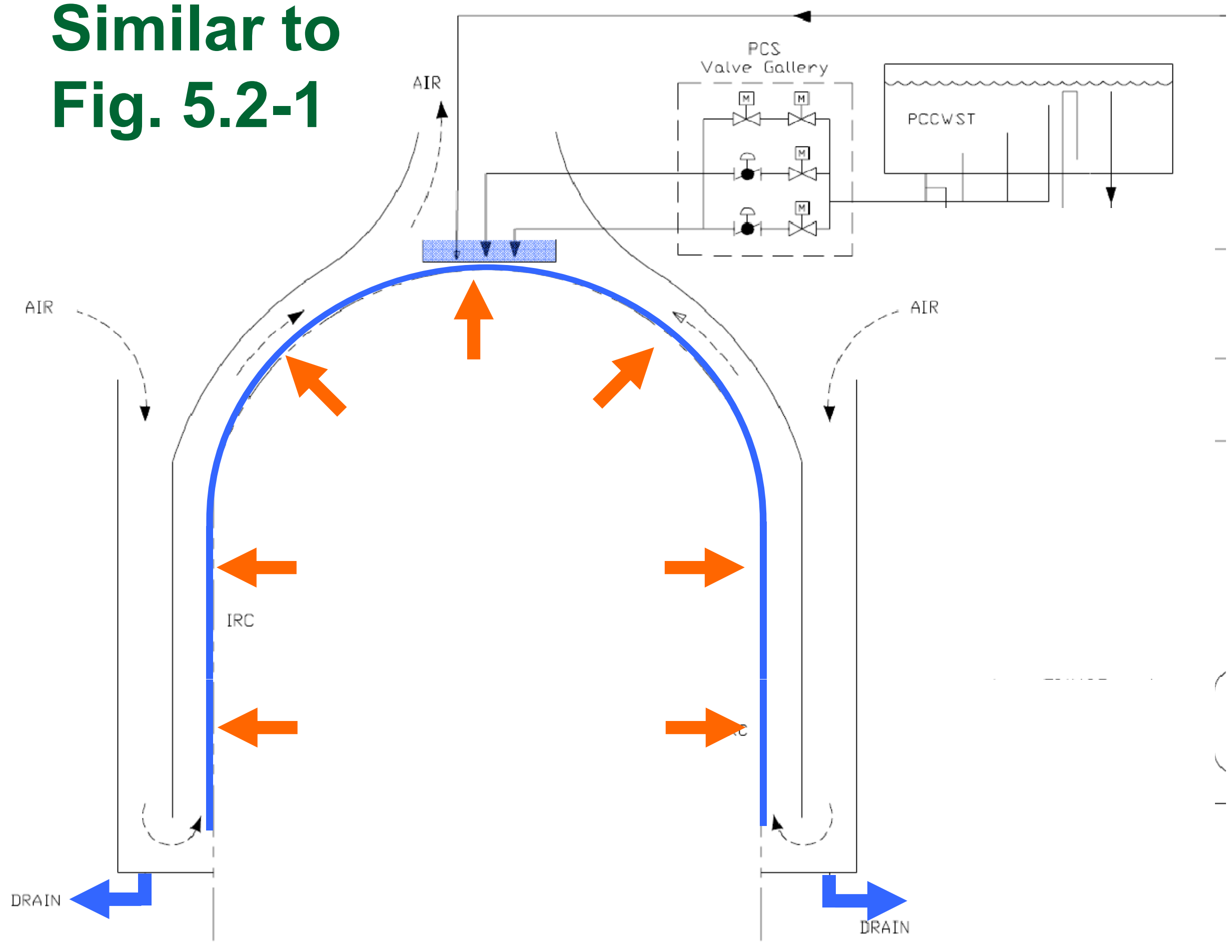
Similar to Fig. 5.2-1



- **Water from PCCWST is delivered to water distribution bucket.**
- **Slots in bucket allow water to spill out onto containment vessel head.**
- **Weir system delivers water evenly to containment dome & vertical sides.**

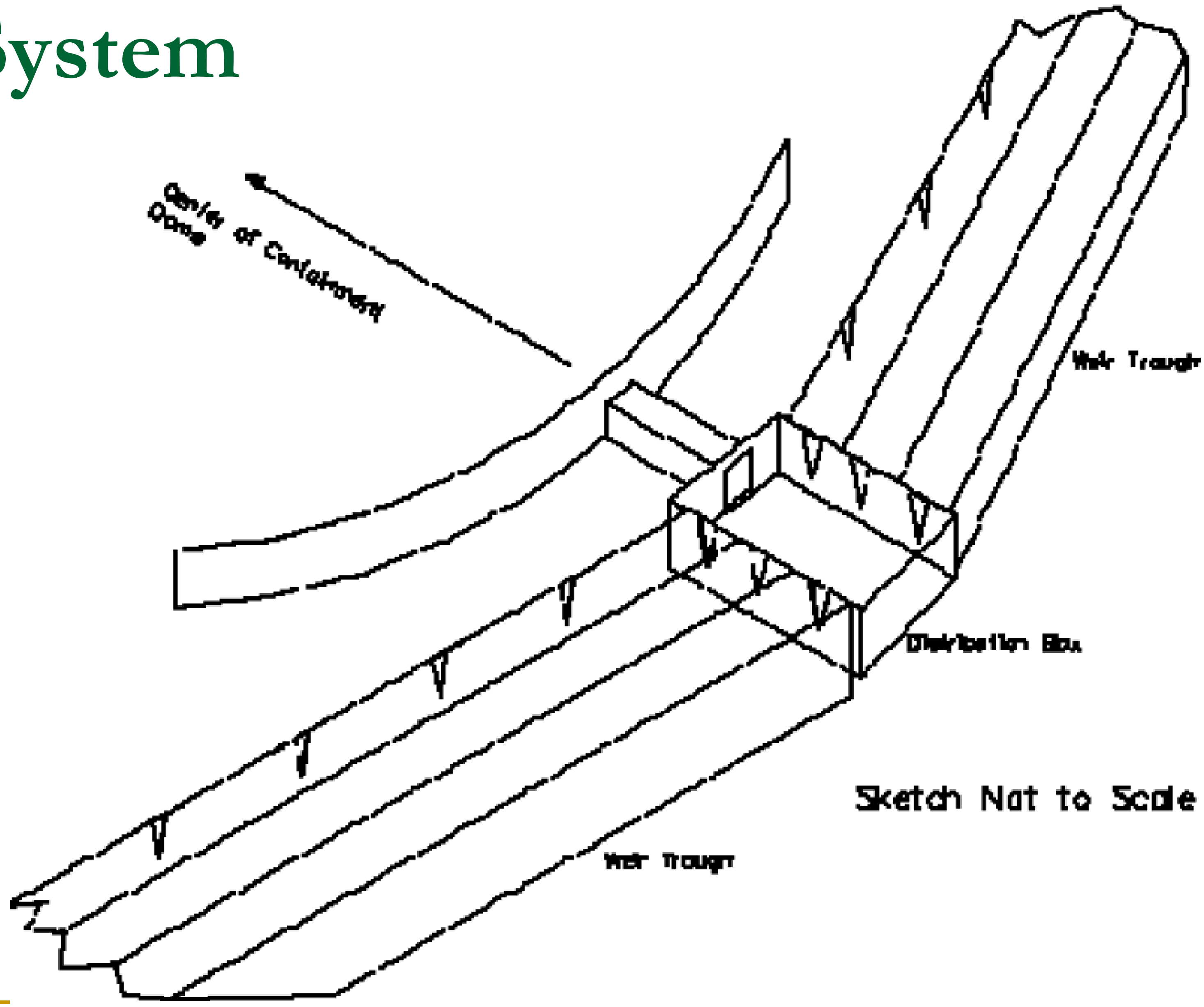
System Operation

Similar to Fig. 5.2-1



- Water from PCCWST is delivered to water distribution bucket.
- Slots in bucket allow water to spill out onto containment vessel head.
- Weir system delivers water evenly to containment dome & vertical sides.
- Heat from containment shell is transferred to water film.
- Water which does not evaporate drains from shield building upper annulus.

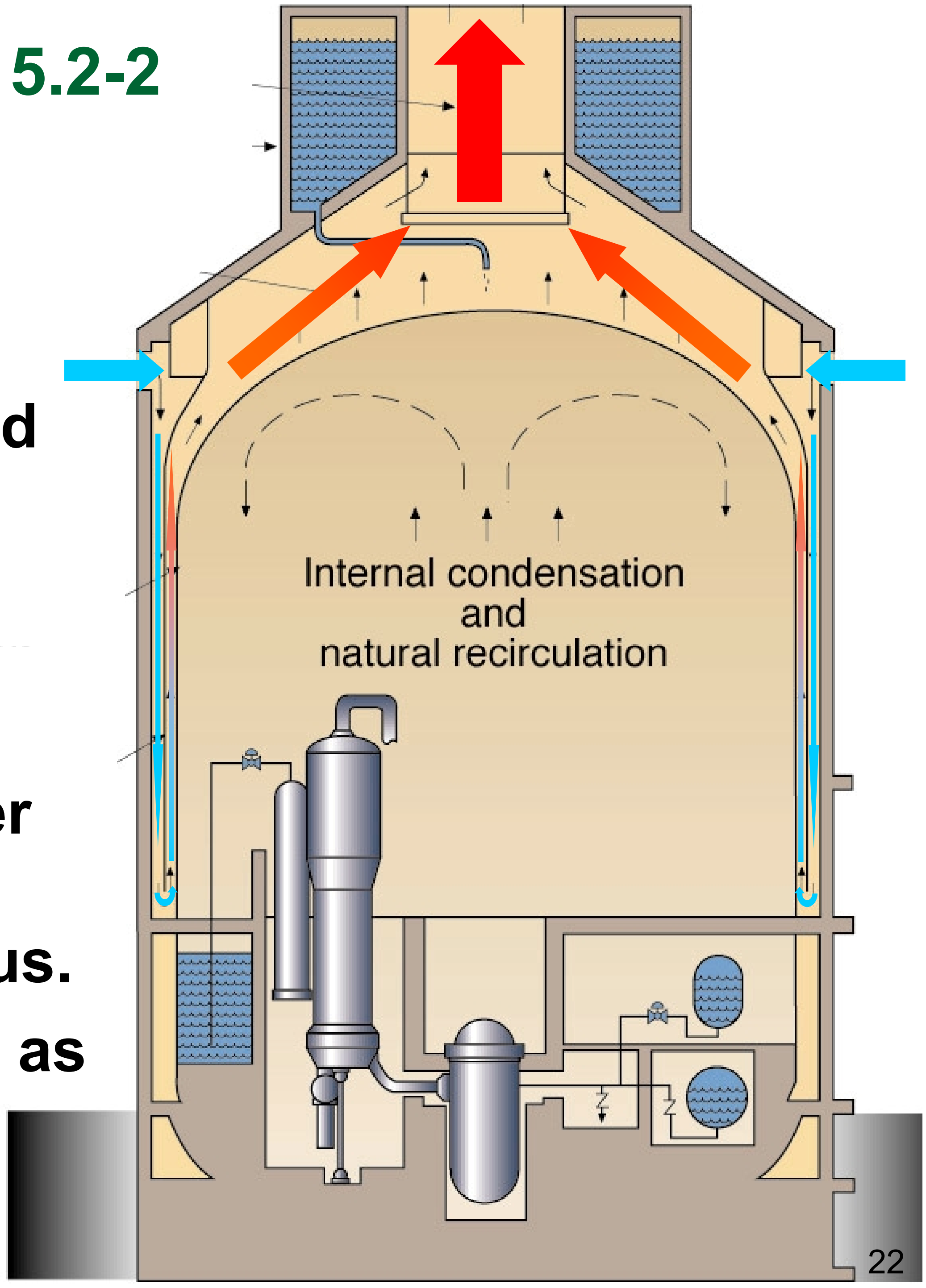
Weir System


Center of Containment
Dome
Weir Trough
Distribution Box
Sketch Not to Scale
Weir Trough

System Operation

- Water film transfers heat to air flow in shield building annulus via convection & evaporation.
- With transfer of heat & water vapor, air in inner annulus is less dense than air in outer annulus.
- Air naturally circulates as shown.

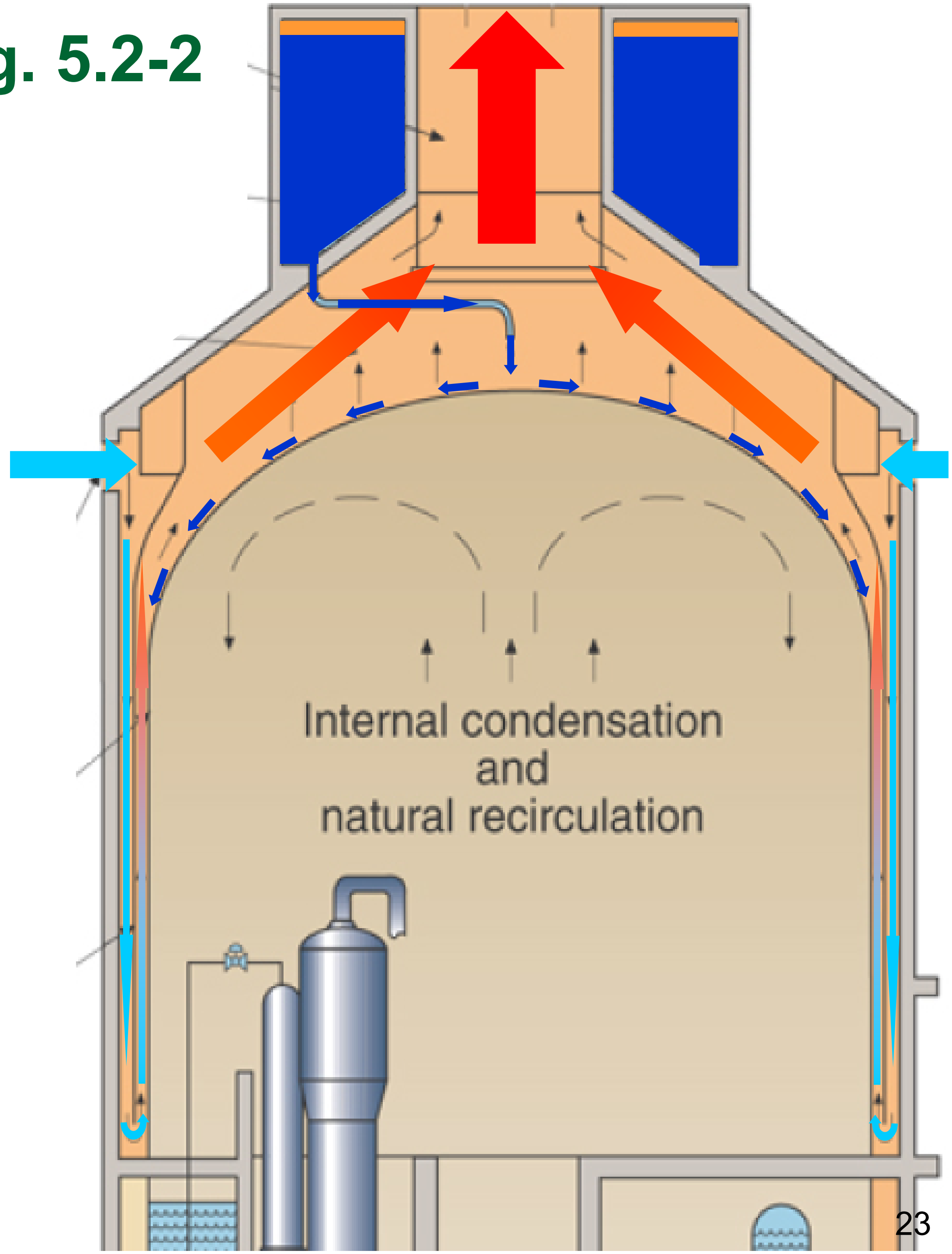
Fig. 5.2-2



System Operation

- **To summarize, as water drains from PCCWST onto exterior of containment vessel, the resulting water film transfers heat to natural-circulation air flow in shield building.**

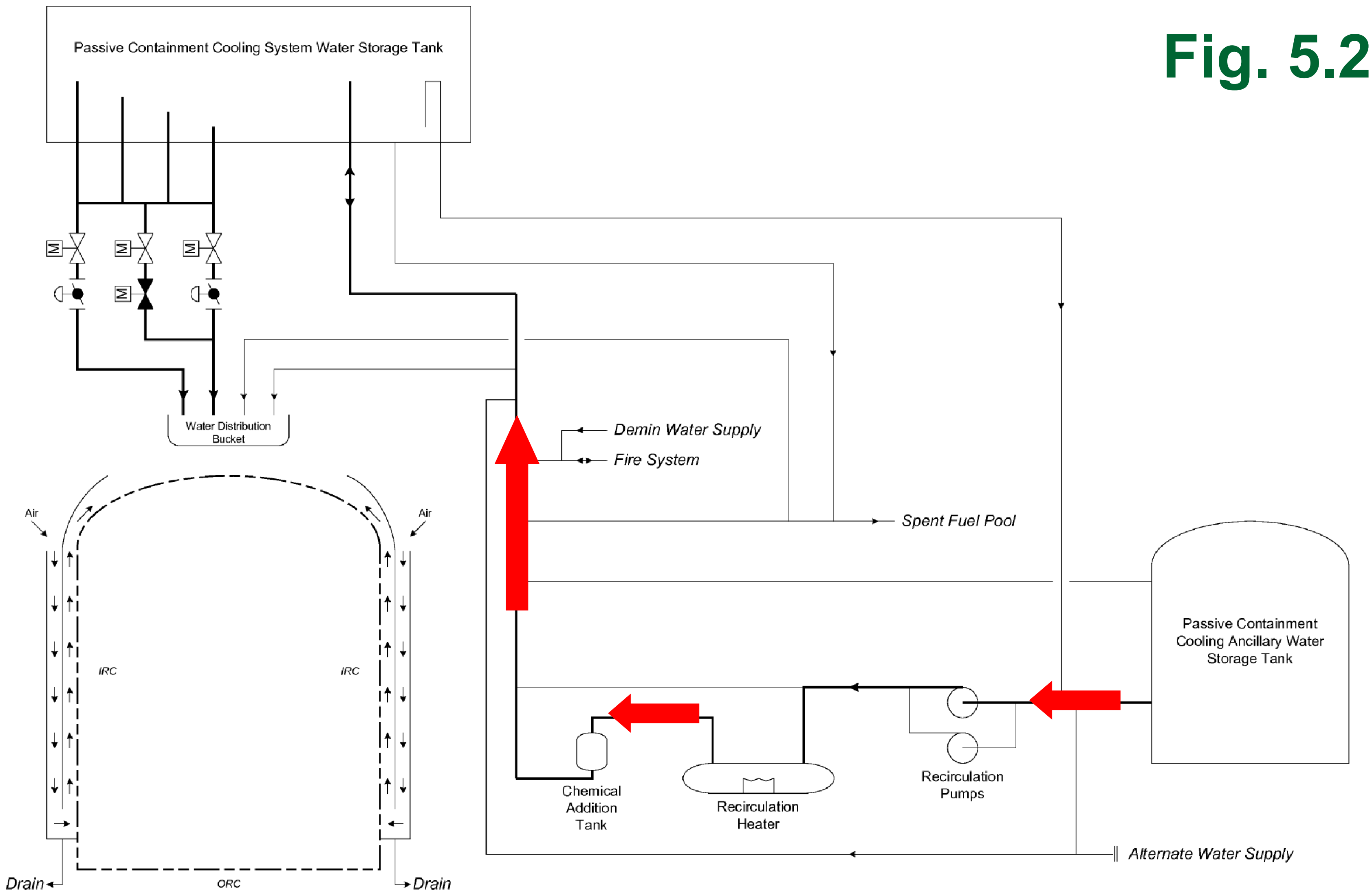
Fig. 5.2-2



Heat Transfer

- Convective heat transfer from containment atmosphere to, & condensation of steam on, internal containment vessel surfaces
- Conduction through the vessel
- Convection from containment outer surfaces to water film
- Convective heat transfer from water film to, & evaporation of water film into, shield building annulus air flow
- Heated air and entrained water vapor exhausted out shield building chimney

Fig. 5.2-1



- **Volume in PCCWST is good for 72 hr without operator action.**
- **After that, operators can align system to replenish PCCWST from PCCAWST. PCCAWST volume is good for another 4 days of PCS operation.**

Containment Performance

- **Design pressure: 59 psig**
- **Containment structure design & PCS operation ensure pressure not exceeded for worst possible LOCA or steam break.**
- **Worst-case single failure is failure of 1 PCS flow control valve.**
- **Containment subcompartments can withstand transient ΔPs.**
- **Results: Table 5.1-1 (next slide)**

Containment Performance (cont'd)

Table 5.1-1 SUMMARY OF CALCULATED PRESSURES AND TEMPERATURES			
Break	**Peak Pressure (psig)**	**Available[1] Margin (psi)**	**Peak Temperature (°F)**
Double-ended hot leg guillotine	50.0	9.0	415.3
Double-ended cold leg guillotine	57.8	1.2	295.1
Full main steam line DER, 30% power, MSIV failure	57.0	2.0	374.1
Full main steam line DER, 101% power, MSIV failure	53.5	5.5	375.5

Note:

1. Design Pressure is 59 psig

Review: Which is NOT a purpose of the containment vessel?

a. It houses & supports the RCS and related systems & some ESF systems.
b. It provides shielding for the core & RCS during normal ops.
c. It withstands the impact of an airplane crash.
d. It contains the release of airborne radioactivity during a design-basis accident.

Review: Which is NOT a purpose of the containment vessel?

a. It houses & supports RCS and related systems & some ESF systems.
b. It provides shielding for core & RCS during normal ops.
c. It withstands the impact of an airplane crash.
d. It contains the release of airborne radioactivity during a design-basis accident.

Review: The shield building does NOT…

a. **Support the passive containment cooling water storage tank.**
b. **Channel air flow during passive containment cooling system operation.**
c. **Provide a barrier to radioactive release.**
d. **Protect the containment vessel against impact from an external missile.**

Review: The shield building does NOT…

a. Support the passive containment cooling water storage tank.
b. Channel air flow during passive containment cooling system operation.
c. Provide a barrier to radioactive release.
d. Protect the containment vessel against impact from an external missile.

Review: Passive containment cooling involves…

a. **Wetting the exterior of the containment vessel.**
b. **Spraying the containment atmosphere with water droplets.**
c. **Adding sodium hydroxide to the containment atmosphere for iodine scavenging.**
d. **Directing containment air through heat exchangers for heat removal.**

Review: Passive containment cooling involves…

a. Wetting the exterior of the containment vessel.
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d. Directing containment air through heat exchangers for heat removal.

Review: Shield building air flow during containment cooling is principally generated by…

a. **Fan operation.**
b. **A forced draft cooling tower.**
c. **Effectively channeling the site's prevailing winds.**
d. **The geometry of the containment structures and heat transfer from the containment vessel.**

Review: Shield building air flow during containment cooling is principally generated by…

a. **Fan operation.**
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c. **Effectively channeling the site's prevailing winds.**
d. **The geometry of the containment structures and heat transfer from the containment vessel.**

Review: The discharge flow rate from the passive containment cooling water storage tank is controlled by…

a. **Automatic flow control valves.**
b. **Sequentially opening discharge isolation valves.**
c. **Discharge standpipes of varying heights.**
d. **Remote-manual throttling of flow control valves.**

Review: The discharge flow rate from the passive containment cooling water storage tank is controlled by…

a. **Automatic flow control valves.**
b. **Sequentially opening discharge isolation valves.**
c. **Discharge standpipes of varying heights.**
d. **Remote-manual throttling of flow control valves.**