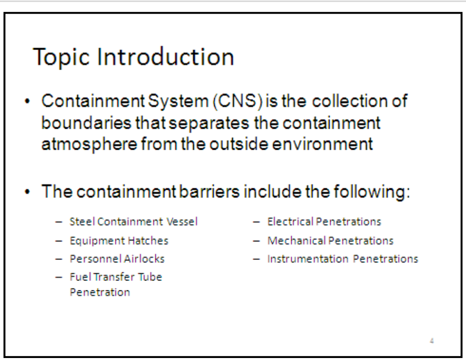
Containment System (CNS)

Unless otherwise stated in the objective, the trainee shall be able to perform the following from memory.

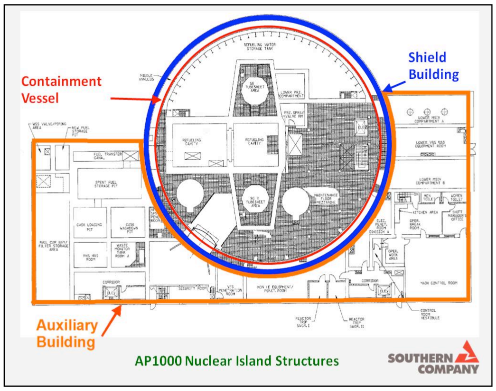
Terminal Objective

Explain the CNS design basis, major components and flow paths.

Enabling Objective		
1.	SUMMARIZE the purpose of the CNS.	
2.	EXPLAIN the safety-related functions and design basis of the CNS.	
3.	DESCRIBE the functions of major components of the CNS.	
4.	LIST the containment isolation signals.	

Content/Skills	Instructor Notes
1.0 INTRODUCTION	Introduction to the Class • Introduce yourself to the trainees. • Classroom Safety (Fire, Emergencies, etc) • Course length • Evaluation method • Take attendance.
 	Slide: 1
2.0 OBJECTIVES	
1. SUMMARIZE the purpose of the CNS 2. EXPLAIN the safety-related functions and design basis of the CNS 3. DESCRIBE the functions of major CNS components 4. LIST the containment isolation signals.	Slide: 4
3.0 TOPIC INTRODUCTION	
 CNS is made up of the boundaries that separate the containment atmosphere from the outside environment. The containment barrier includes the following: 1. Containment Vessel 2. Mechanical Penetrations 3. Electrical Penetrations 4. Instrumentation Penetrations 5. Fuel Transfer Tube Penetration 6. Equipment Hatches 7. Personnel Airlocks Containment isolation valves (CIVs), the piping between the CIVs, and any test connections are part of the CNS isolation boundary (mechanical penetrations).	Slide: 5 Objective: 1

Content/Skills	Instructor Notes



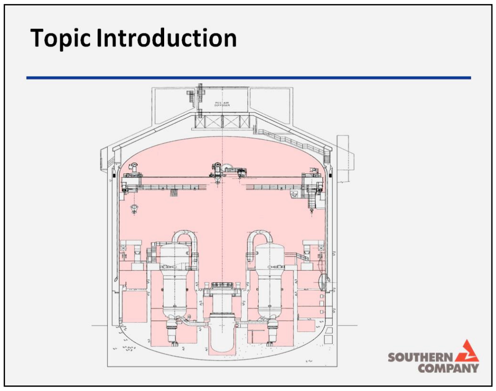
The containment vessel is located on the nuclear island of the AP1000 site.

The nuclear island consists of the following buildings:

1. Auxiliary building
2. Shield building (containment vessel located within the shield building)

Slide: 6

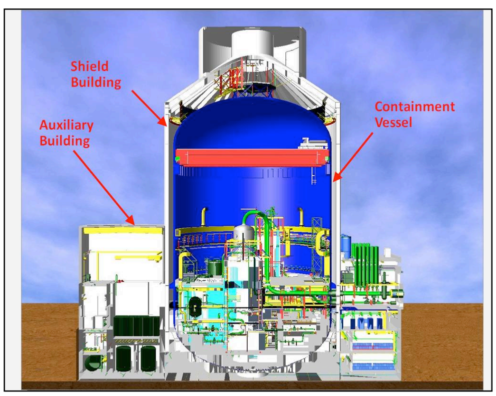
Objective: 3



The containment vessel is located on the nuclear island within the shield building.

Slide: 7

Objective: 3



Slide: 8

Objective: 3

4.0 SAFETY-RELATED FUNCTIONS AND DESIGN BASES

- There are five safety related functions:
  - Containment Vessel Integrity
  - Containment Isolation
  - Heat Removal
  - Containment Closure
  - Containment Bypass Reduction

Slide: 9

Objective: 2

Note:

These are discussed in detail on subsequent slides

Containment Integrity:

Three barriers that prevent fission product release:

1. Fuel cladding

Slide: 10

Objective: 2

Content/Skills	Instructor Notes
2. Reactor Coolant System (RCS) boundary 3. Containment System The containment is designed to withstand the maximum internal and external pressures/temperatures resulting from Design Basis Accidents (DBA): 1. LOCA 2. Steam line breaks 3. Feedwater line breaks The containment system shall be designed to withstand the effects of the following conditions: 1. Initiation of PCS at a 40°F water temperature with the containment vessel at design pressures and temperatures. 2. Differential thermal stresses due to uneven distribution of the water film on the containment. 3. External pressure conditions resulting from design basis events including a loss of all ac power, inadvertent PCS actuation, or extreme weather transients. Containment Isolation: The containment isolation system provisions must assure that fluid lines which penetrate the containment boundary are isolated in the event of an accident to minimize the release of radioactivity to the environment. The containment isolation function must meet the following standards: 1. The containment isolation valves (CIVs) must be leak tight if exposed to the containment atmosphere. 2. CIVs must be capable of closing against the conditions which may exist during DBA events. 3. Containment isolation shall be actuated on signals indicating accident conditions. 4. The MCR shall have provisions for remote manual containment isolation. 5. All penetrations except those which remain open to provide accident mitigation functions shall be isolated by signals from the protection and safety monitoring system (PMS) and the diverse actuation system (DAS). 6. Component redundancy shall be provided.	
Heat Removal: Containment heat removal is the primary function of the passive containment cooling system (PCS), which has a safety-related interface with the containment system. The containment vessel is used as the primary means of heat removal during PCS operation. The CNS interface with PCS shall meet the following functional requirements: 1. The supports for the PCS air baffle shall have minimal effect on air flow. 2. Zinc coating on inside and outside of the containment vessel used for efficient heat removal. 3. PCS Distribution basket is located directly above center line (dome) of the containment shell. 4. Condensation inside containment returns to the IRWST (gutter system). PCS interface is designed for: 1. LOCA 2. Steam Line Break	Slide: 11 Objective: 2

Content/Skills	Instructor Notes

3. Feedwater Line Break
4. In-containment Refueling Water Storage Tank (IRWST) steaming during operation of passive residual heat removal (PRHR)
5. Automatic Depressurization System (ADS) actuation

Containment Closure:

Containment closure capability is required during shutdown operations when there is fuel inside containment to maintain the cooling water inventory within the containment. Due to the large volume of the IRWST and the reduced sensible heat during shutdown, the loss of some of the water inventory can be accepted. Therefore, containment does not need to be leak tight during shutdown modes.

Shutdown Containment closure means that all potential escape paths are closed or capable of being closed. Provides containment closure capability during shutdown with fuel inside containment.

The containment leakage bypassing the containment pressure boundary is known as “containment bypass leakage”.

The CNS functional design and isolation systems provide containment pressure boundary isolation during normal and accident modes of operation. This isolation assures that there are limited potential escape paths from the containment atmosphere following an accident.

Vintage plants use a secondary containment system to contain/process any leakage out of containment. The AP1000 design doesn’t have a secondary containment system. The structural members enclose containment, minimizing non-structural leakage pathways. Ventilation and filtration pathways have filters for limiting radioactive releases.

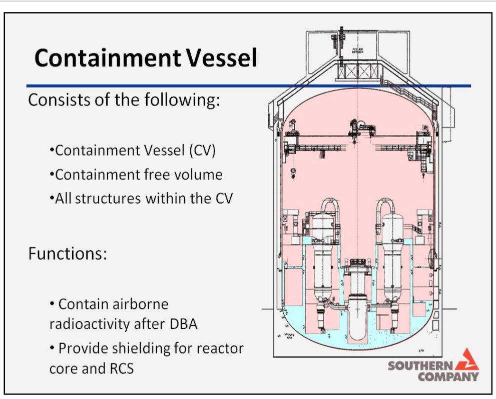
Slide: 12

Objective: 2

Note:

The AP1000 units do NOT have a secondary containment structure. CNS is assumed to remain intact due to the passive design

5.0 CONTAINMENT VESSEL



The containment vessel is a free-standing, cylindrical steel vessel with ellipsoidal (rounded) upper and lower heads.

The steel containment shell serves as the support and mounting structure for the PCS air flow baffle and is capable of accepting the total baffle weight.

The containment shell also serves as the mounting structure for the PCS water distribution weir system. The channeling walls are welded directly to the containment dome. The distribution boxes and distribution troughs are supported by brackets welded to the containment shell at the distribution box and at the free end of each trough.

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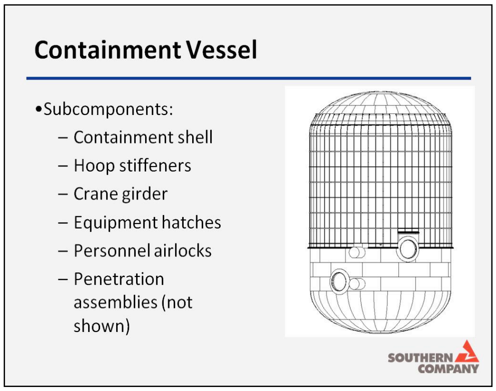
Objective: 3

Animation:

Highlights the different areas listed

Content/Skills	Instructor Notes



The containment bottom head is embedded in concrete up to elevation 100’-0” on the outside, and up to the maintenance floor at elevation 107’-2” on the inside.

The containment vessel is an independent, free-standing structure above elevation 100’-0”.

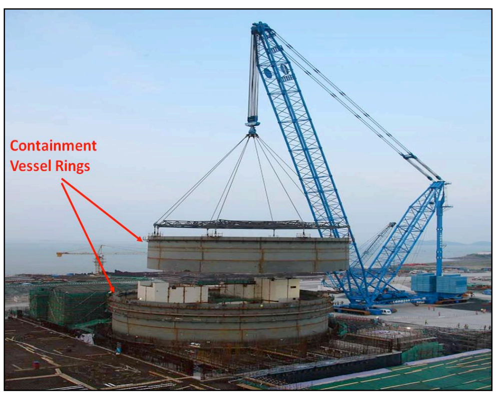
Slide: 14

Objective: 3

This picture was taken in 2010 at the Sanmen AP1000 site in China. The CV bottom head is being lowered into place on the Nuclear Island.

Slide: 15

Objective: 3



This picture was taken in 2010 at the Sanmen AP1000 site in China. The Crane is lowering the 2nd CV ring into place.

Slide: 16

Objective: 3

<u>Containment Vessel</u>:

The containment vessel is a passive component that is an integral part of the PCS. The containment vessel provides the safety-related interface with the ultimate heat sink (surrounding atmosphere).
Specific design details:

1. 130’ cylindrical diameter
2. Height of 215’ 4”
3. Elliptical head at top and bottom
4. Internal Design Pressure: **59 psig**
5. Design Temperature: **300ºF**
6. External Design Pressure: **2.9 psid**
7. Normal internal temperature: 50-120ºF
8. Normal internal pressure: -0.2 to +1.0 psig
9. Shell wall thickness of 1-3/4”, plus additional thickness in areas embedded in concrete
10. Zn coating on inside and outside surfaces (improved heat transfer)

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Objective: 3

Content/Skills	Instructor Notes

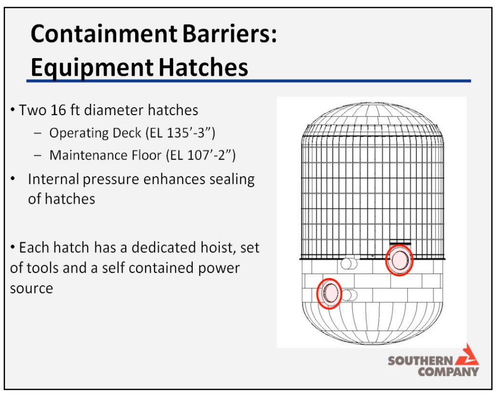
6.0 CONTAINMENT BARRIERS

- Containment Vessel
- Equipment Hatches
- Personnel Airlocks
- Fuel Transfer Tube Penetration
- Electrical Penetrations
- Mechanical Penetrations
- Instrumentation Penetrations

Slide: 18

Objective:3

7.0 CONTAINMENT BARRIERS: EQUIPMENT HATCHES



Equipment Hatches:

The containment equipment hatches are part of the containment pressure boundary and provide a means for moving large equipment and components into and out of containment. The hatches are located on the operating deck (elev. 135'-3" - permits access to the staging area) and the maintenance floor (elev. 107'-2" – permits grade-level access from outside).

Containment internal pressure acts on the convex face of the dished head to enhance sealing. Each equipment hatch is provided with an electrically powered hoist for movement to/from the storage location when opening and closing the hatches. A dedicated set of hardware and tools is provided for movement of the hatches if AC power is lost to the hoist.

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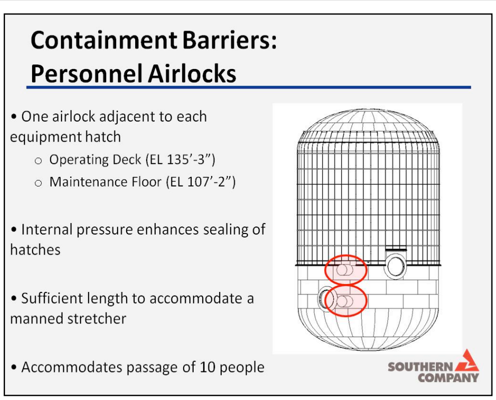
Objective: 3

8.0 CONTAINMENT BARRIERS: PERSONNEL AIRLOCKS



Personnel Airlocks:

There are two (2) personnel airlocks, one located adjacent to each equipment hatch on the operating deck (elev. 135?-3?) and the maintenance floor (elev. 107?-2?). Airlocks are of sufficient length to provide clear distance for a manned stretcher and sized to accommodate 10 people at one time. They have approximately a 10-foot external diameter.

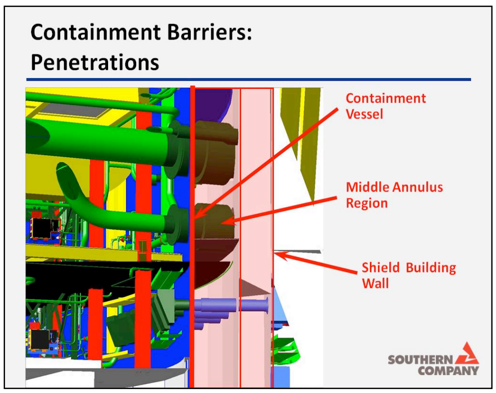
Each airlock contains a door set (inner and outer doors) that are mechanically

Slide: 20

Objective: 3

Content/Skills	Instructor Notes
interlocked to prevent simultaneous opening of both doors in the airlock. The interlock can be bypassed by using special tools and procedures if needed. The equalizing valves for the two doors of the airlock are also interlocked so that only one set of equalizing valves can be opened at a time, and only when the opposite door is closed. An interior lighting system located inside the airlocks is capable of operating from an emergency eight-hour battery pack power supply.	

9.0 CONTAINMENT BARRIERS: PENETRATIONS



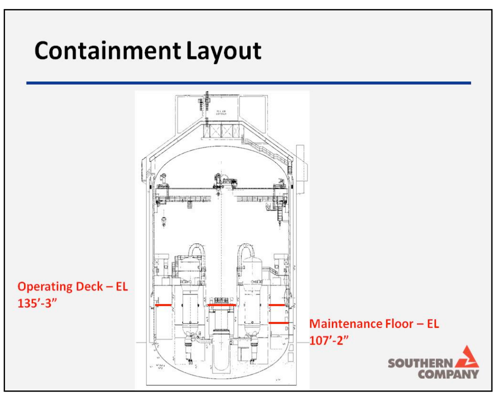
Containment Penetrations:

Mechanical Penetrations
Fuel transfer tube penetration
Electrical penetrations
Instrumentation penetrations

Slide: 21

Objective: 3

10.0 CONTAINMENT LAYOUT



The Containment Vessel has two floor elevations, elev. 107'-2" (maintenance floor) and elev. 135'-3" (operating deck).

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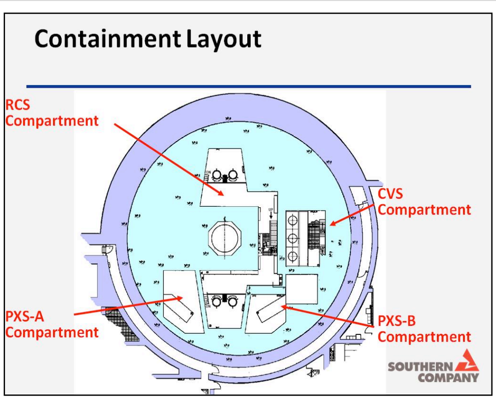
Objective: 3



The RCS compartment consists of the reactor vessel cavity, two (2) main coolant loops, two (2) steam generators, four (4) RCPs, and the Pressurizer.

Passive Core Cooling System (PXS)-A compartment contains PXS accumulator 'A' and CMT 'A'

PXS-B compartment contains PXS accumulator 'B' and CMT 'B'

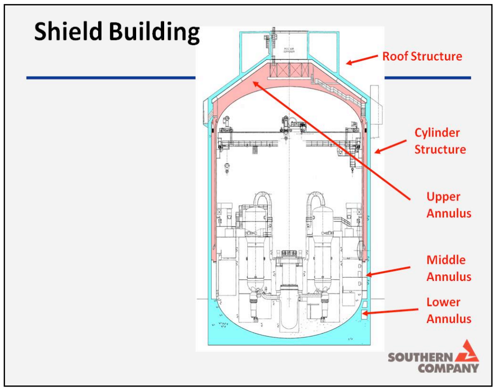
Slide: 23

Objective: 3

Chemical and Volume Control System (CVS) compartment contains:
1. CVS demineralizers

Content/Skills	Instructor Notes
2. Filters 3. Heat exchangers	

11.0 SHIELD BUILDING



Shield Building:

Provides radiation shielding and acts as a missile barrier to the containment (airplane impact).

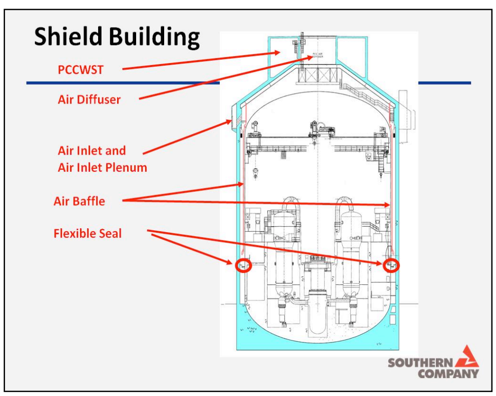
Significant features of the shield building and the annulus area are:

1. Shield building structure
2. Shield building roof structure
3. Lower annulus area
4. Middle annulus area
5. Upper annulus area
6. Passive containment cooling system air inlet
7. Passive containment cooling system air inlet plenum
8. Passive containment cooling system water storage tank
9. Passive containment cooling system air diffuser
10. Passive containment cooling system air baffle

Instructor Notes: Slide: 24; Objective: 3

Note:

The Shield Building is not part of CNS; covered due to its relationship to CNS



Instructor Notes: Slide: 25; Objective: 3

12.0 CONTAINMENT ISOLATION

Containment Isolation System:

An actuation signal for a containment isolation valve may be generated:

1. Automatically or manually within the PMS at a system level
2. Automatically or manually within the diverse actuation system (DAS) at a system level for “select valves”
3. Manually at an individual valve level (PLS)

The manual PMS isolation signals can be initiated from either the MCR or the RSW via PLS.

DAS provides NONSAFETY-RELATED backup to isolate critical containment penetrations.

Instructor Notes: Slide: 26; Objective: 4

Content/Skills	Instructor Notes
<u>PMS Containment Isolation Signals</u>: 1. “S” signal* 2. Manual PCS Actuation (1/2 switches on the PDSP or RSR – 1/1 switch) 3. Manually (1/2 switches on the PDSP or RSR - 1/1 switch) *The automatic PMS containment isolation signal will be initiated by a Safeguards Actuation (“S” signal) on any of the following signals (2/4 logic): 1. High-2 containment pressure: 6.2 psig 2. Low-2 steam line pressure: 560.3 psig (2/4 on 1/2 steam lines) 3. Low Tcold: 505°F (2/4 on 1/2 loops) 4. Low-3 PPZR: 1815 psig	Slide: 27 Objective: 4
13.0 REVIEW QUESTIONS	
• Which of the following will result in an automatic containment isolation signal (“T” signal)? a. High Containment Temperature b. Low-2 Main Steam line pressure c. Manual isolation from the PDSP and SDSP d. High-1 containment pressure	ANSWER: B
• Which of the following is **NOT** part of the CNS boundary? a. Containment shell b. Electrical penetrations c. Steam Generator Shell d. Personnel airlocks	ANSWER: C