Enclosure 4

APP-GW-GLY-089 Revision 0
MCR Dose, Hydrogen Venting, PMS Flux Doubling, and MCR Heat Up Open Session ACRS Presentation
Non-Proprietary

(19 pages including cover page)

Main Control Room Dose

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Post-Accident Main Control Room Dose

Background:

- The ***AP1000*** main control room (MCR) operator dose requirements are met by the safety-related main control room emergency habitability system (VES)
- DCD Chapters 6 and 15 present operator dose analyses and results for a range of design-basis accidents

Problem Statement:

- The certified design did not include direct dose contributions from the VES filter unit: direct filter dose increase the operator dose when considered
- The Main Steam line break analysis did not model the most limiting release scenario: secondary side coolant release timing assumptions were non-bounding
- Discrepancies were identified in the underlying shielding calculations for post-accident operator dose: AP1000 shielding design non-conservatively differed from the analysis model

Issue Resolution:

- A combination of design and analysis changes were needed to demonstrate operator doses satisfy General Design Criterion (GDC) 19

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Summary of Proposed Changes

- Changes encompass modifications to the physical plant design, I&C, technical specifications, and analysis changes
- Changes include:
  - The addition of a VES Filter shield plate below the filter unit and inclusion of calculated shine components in the operator dose calculations
  - Update and refinement of MCR HVAC intake radioactivity concentration setpoints and logic
  - Decrease in Technical Specification value for secondary side dose equivalent iodine (reduction to 10% of standard value)
  - Refinement of MCR direct dose radiation transport calculations to accurately reflect the AP1000 shielding design
  - Rod Ejection Accident methodology changed to reflect current SRP Section 4.2, R3 methodology
  - Changes reflecting refinements in AP1000 detailed design and associated safety analyses

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Analysis Margin (Main Control Room Dose)

- The MCR Operator Dose analysis uses conservative assumptions and inputs
  - A core melt source term (RG 1.183) is applied
  - Direct Dose analyses considers maximum dose rate locations inside the MCR rather than average and neglects plant SSCs, including rebar and structural steel
  - Standard plant χ/Q values are applied and bound site-specific values (increasing airborne dose)
- Margins are maintained
  - The revised safety-related MCR Dose analysis provides more margin than the certified design

    4.33 rem vs. 4.41 rem
  - Defense in depth analysis demonstrates that MCR operator dose is <5 rem even if only the non-safety VBS is operating

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Hydrogen Venting Inside Containment

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Reason for the Change

Background:

- For severe accident mitigation, AP1000 containment hydrogen control system (VLS) is designed to promote hydrogen burning soon after the lower flammability limit is reached.
- The design of the PXS and CVS compartments (Rooms 11206/11207 and 11209) allows for venting of hydrogen into Room 11300 above.

Concern:

- AP1000 design changes to containment layout were implemented without revision to supporting analyses for hydrogen diffusion flame
- In one particular severe accident scenario (frequency = 6E-9/yr), a hydrogen diffusion flame may create a locally high temperature near containment pressure boundary, hatch and penetrations
  - Analysis required to verify a containment survivability
  - ITAAC revision is required to reflect containment layout design changes

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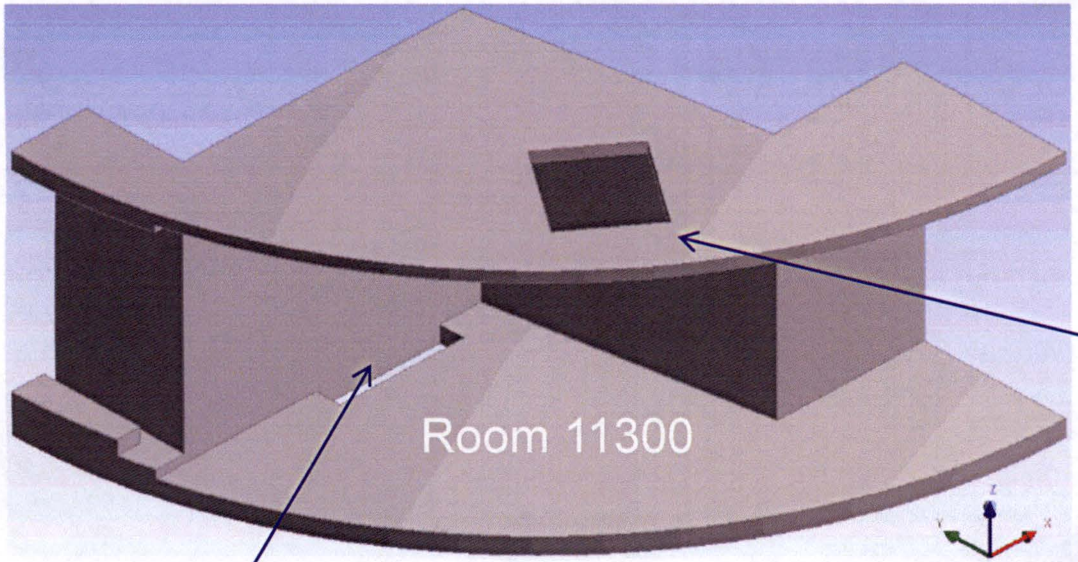
PXS-A Compartment (Room 11206) Vents

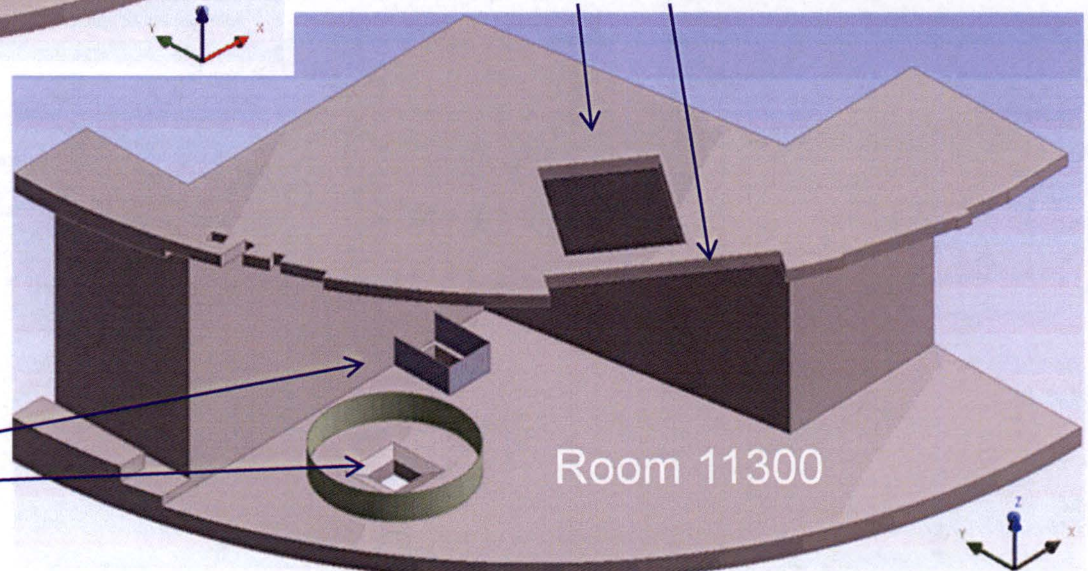


<- Original layout

Vents in Ceiling of 11300 to Upper Compartment

Vent from 11206

Final layout ->



Vents from 11206

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Summary of Analysis Required to Support Change

- Hydrogen source term to PXS compartment
  - Double-ended direct vessel injection line break with matrix of ADS valve success configurations to define worst H_2 source term
  - MAAP4.0.7 analyses
- CFD Analysis of the H_2 plume burning and containment shell heatup
  - Identified that layout changes potentially introduced new phenomena that created a worse condition than previously analyzed
- "Simple" H_2 burning plume and containment pressure boundary heat transfer analysis of shell, equipment hatch cover/seals to calculate maximum temperatures and temperature distributions on containment pressure boundary
- Structural evaluation of the containment survivability demonstrated containment integrity for all components
  - Eigenvalue buckling analysis
  - ASME Service Level C stress evaluation

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Conclusions

	Peak Surface Temperatures °F (°C)			
		<---- Temp Distribution for Structural Analysis --→		
Component	Maximum Hot Spot	Hot Spot Allowables	Zone 1 Convection and Radiation	Zone 2 Radiation Only
Cnmt Shell	585 (307)	650* (343)	470 (243)	436 (224)
Insert Plate / Hatch Barrel	439 (226)	488** (253)	366 (186)	344 (173)
Hatch Cover	741 (394)	800 (427)	591 (310)	543 (284)

* Allowable max temp limit from ASME code for SA 738 Grade B

** Allowable max temp limit for hatch barrel corresponding to accept criteria for EPDM rubber

- Structural analysis performed for 2 temperature distributions on the containment demonstrates success of the pressure boundary integrity

Reasonable assurance of containment vessel survivability during a hydrogen diffusion flame event is demonstrated

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Description of licensing change

- Revised ITAAC (Tier 1 Table 2.3.9-3)
  - Updated the minimum distances requirement between openings and the containment shell to reflect the actual geometry, including tolerances

- Supporting Subsections 6.2.4.5.1 and Section 19.41.7 also updated.

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Flux Doubling Algorithm Compliance with IEEE 603

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Reason for the Change

- Flux doubling algorithm protects against inadvertent criticality due to boron dilution during shutdown conditions
  - Isolates dilute water sources to the reactor coolant system
- Non-compliance was identified to one subpart of IEEE 603 for the logic associated the algorithm
- The design did not comply with a portion of IEEE 603 Sub-clause 6.6 criteria:
  - Whenever the applicable permissive conditions are not met, a safety system shall automatically prevent the activation of an operating bypass or initiate the appropriate safety function(s).

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Operator could block flux doubling logic without an appropriate permissive

Description of change

- A new permissive, P-8, based on minimum required reactor coolant temperature for criticality (MTC), was added to satisfy the IEEE 603 Sub-clause 6.6 criteria:
  - P-8 setpoint is at TAVG of 551°F
- Operators can still initiate operating bypass ("Block" in Westinghouse terminology) for flux doubling algorithm at any time:
  - Above P-8 setpoint, operators can control both control rods & boron concentration change for reactivity adjustment
  - Below P-8 setpoint, safety system overrides isolation valves from the demineralized water system closed
    - Prevents boron dilution event

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Operational Impacts

- Operators must verify P-8 permissive status prior to blocking Flux Doubling when preparing for the approach to criticality during reactor startup
  - Operating procedures direct operators when to block Flux Doubling after P-8 is verified to be satisfied
  - Permissive status indications are available on both safety displays and normal operator workstations
  - Operators train extensively on reactor startup procedures and the approach to criticality
- Ability to block flux doubling logic below P-8 setpoint needed to prevent unnecessary Boron Dilution Block actuations during control rod testing during shutdown conditions
  - Isolation valves to the demineralized water system will be overridden closed and prevent a dilution event

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Main Control Room Heat Up

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Reason for the Change

Background:

- The ***AP1000*** main control room (MCR) air temperature must remain at or below the defined limits during operation of the main control room emergency habitability system (VES)

Problem Statement:

- Throughout the design evolution of the MCR, the size and quantity of equipment have increased, raising the total MCR heat load. These increases result in a MCR temperature response exceeding the current licensing basis limit and equipment qualification conditions
- A new more limiting transient where non-safety power is provided to non-safety equipment but VBS is NOT available was identified

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Description of change

Two stage automatic load shed

- This automatic operation is proposed to maintain the required MCR environmental conditions
  - Only select non-safety loads are de-energized, with no impact to the minimum inventory of displays / controls provided by the primary dedicated safety panel
  - No impact to the plant controls and indication of plant parameters at operator workstations
  - Load shed circuitry is safety related

Additional Surveillance Requirements

- Limit initial conditions for adjacent rooms in the updated MCR Heat Up analysis
- Limit moisture content for air in the VES storage tanks

Human Factors Considerations

- Analysis supports unlimited operator stay time at a WBGT Index of 90°F
  - Acceptance criterion is from NUREG-0700
  - Same limit is met for post-72 hour ancillary fan operation

Summary of Analysis Required to Support Change

- Updated GOTHIC Model
  - MCR Model was refined to show greater resolution
  - Heat loads distributed to reflect as-designed layout
- Surveillance requirements verify assumptions are bounded
- Extended Post-72 hour model based on described VBS operation

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