Westinghouse Response to DCD 6.4 RAIs

VES and MCR

Design & Analysis

March 16, 2009

Presentation Overview

- **VES & VBS Design to Support Control Room Habitability**
- **Main Control Room (MCR) Design Features to Support Low Out-leakage**
- **AP1000 Control Room Dose Analysis**
- **Main Control Ingress & Egress**
- **VES & MCR Testing**

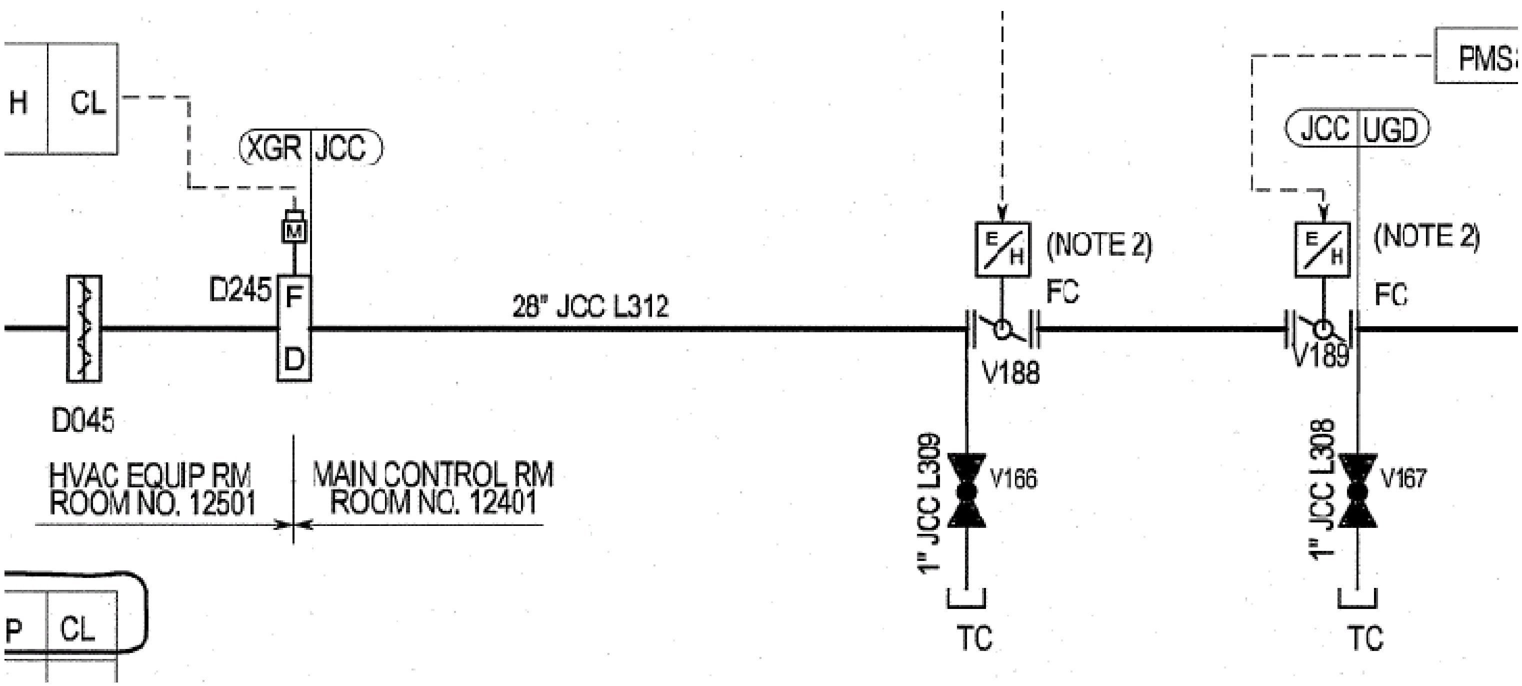
Presentation Objectives

- **Understand AP1000 design features to support a low leakage positive pressure MCR**
  - RAI-SRP6.4-SPCV-03
- **Understand MCR dose analysis & assumptions**
  - RAI-SRP6.4-SPCV-06
- **Discuss current commitments for VES & MCR testing & potential testing alternative**
  - RAI-SRP6.4-SPCV-04

VBS Design Basis

- **VBS Design Functions (DCD 9.4)**
  - Safety
    - Monitors the MCR supply air for radioactive particulate and iodine concentrations
    - Isolates the HVAC penetrations in the MCR envelope
  - Defense-in-depth
    - Maintains MCR at a positive pressure with respect to its adjacent areas during normal operation
  - HVAC Penetrations through the MCR envelope are piping

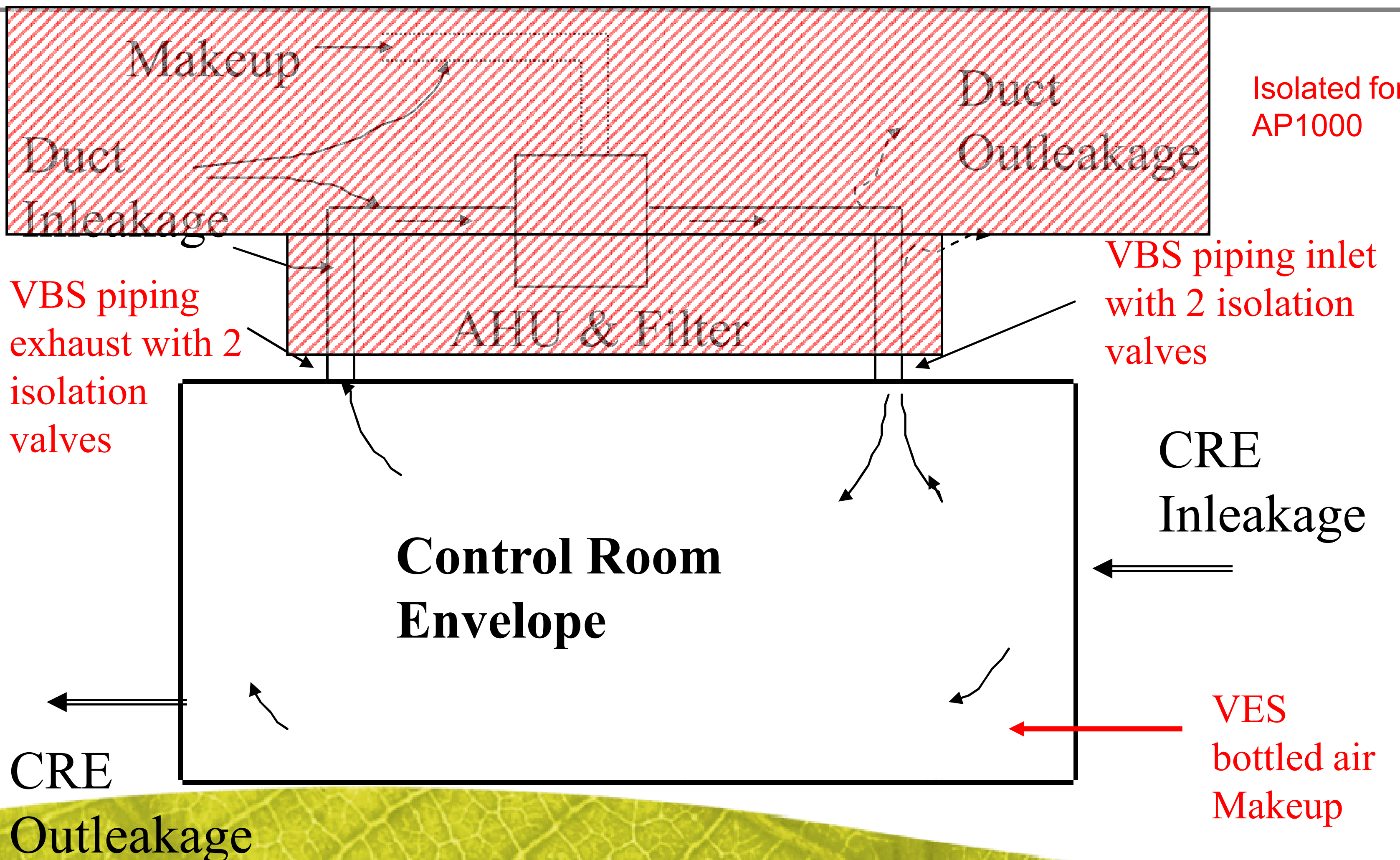
VBS Design Basis



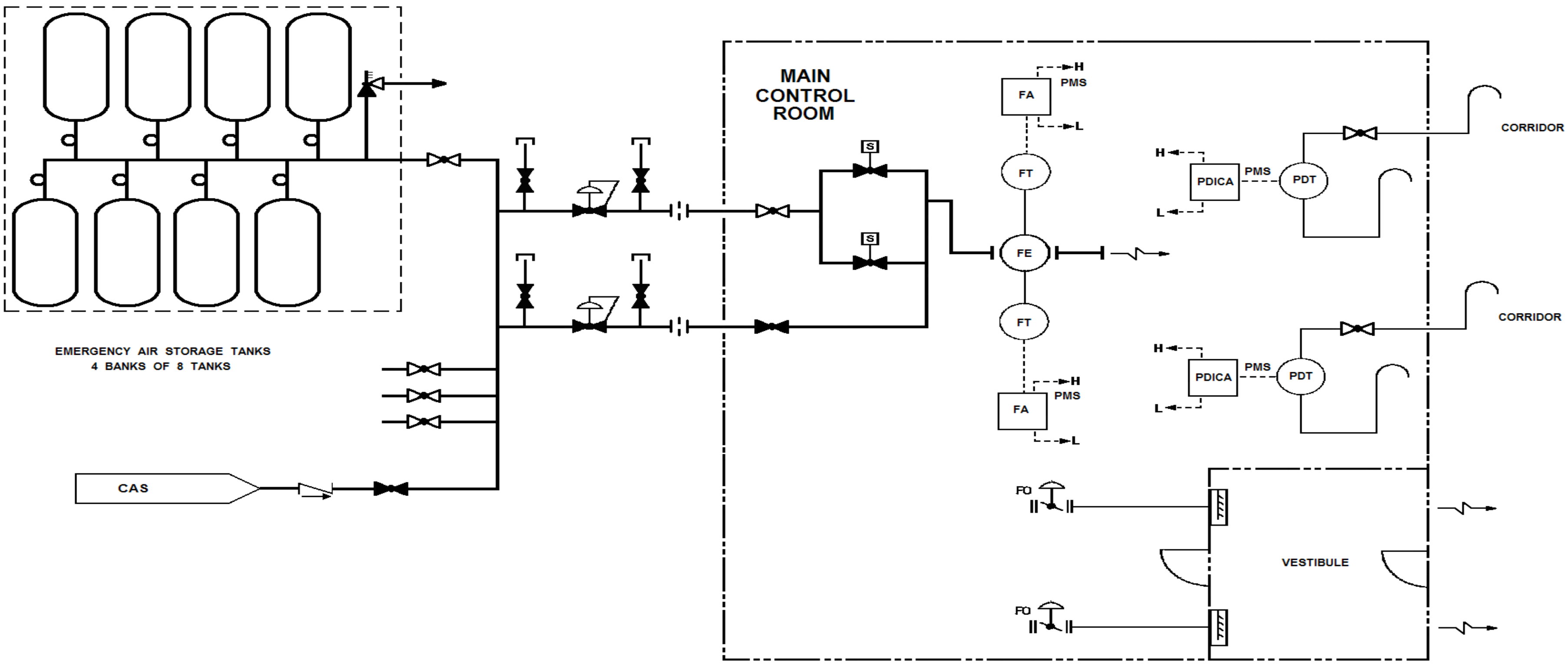
VES Design Basis

- **VES Design Functions (DCD 6.4)**
  - Safety
    - Maximum MCR occupancy of 11 persons
    - Breathable air to MCR occupants
      - Maintain CO_2 concentration to less than 0.5%
    - MCR pressurization above ambient
      - Maintain constant pressure of at least 1/8” WG
      - Gravity dampers in VES exhaust line control pressure
    - Limit MCR occupant exposure to less than the 5.0 rem TEDE limit

Typical CRHS vs. AP1000 VES



AP1000 VES Simplified Sketch



VES / VBS operation

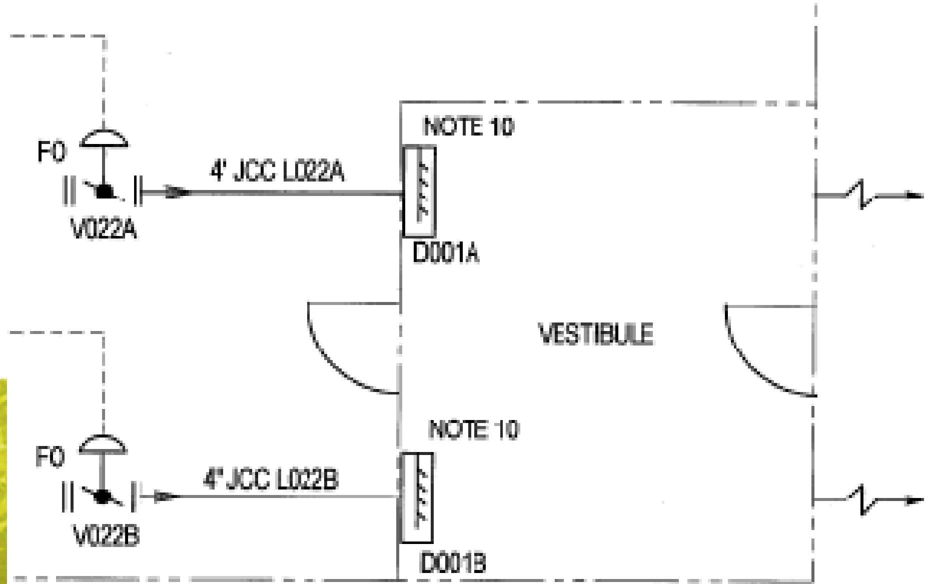
- VES actuation / VBS isolation signals
  - Low pressurizer pressure *(Added in DCD Rev. 17)*
  - High-High particulate or iodine radioactivity in the VBS supply duct
  - Loss of ac power for more than 10 minutes
  - Manual actuation
- 65 ±5 scfm VES flowrate into MCR
- Air in MCR is purged through the vestibule and into the adjacent corridor *(Changed in DCD Rev. 16)*
- VBS will continue to supply air to adjacent areas in a supplemental filtration mode if it is operable
  - This includes the Control Support Area (CSA)
- VBS & VES are designed to maintain MCR at a positive DP relative to its adjacent areas

AP1000 VES MCR DP

- VES contains 2 safety-related DP transmitters that alarm on low & high DP (PT-001A/B)
- PT-001A/B monitor DP between MCR & Corridor 12411
  - Alarm is provided to alert operator of a low DP
  - Operator would be instructed to inspect VES discharge dampers

Certified Design to Rev. 17 System Related Changes

- Rev. 16 changes
  - VES discharge line is directed through the vestibule
  - Reduces activity concentration of air entering MCR during ingress/egress
- Rev. 17 changes
  - Added VES actuation signal on low pressurizer-pressure
  - Following a LOCA, isolates MCR prior to fuel damage



AP1000 Main Control Room Envelope

Vestibule →

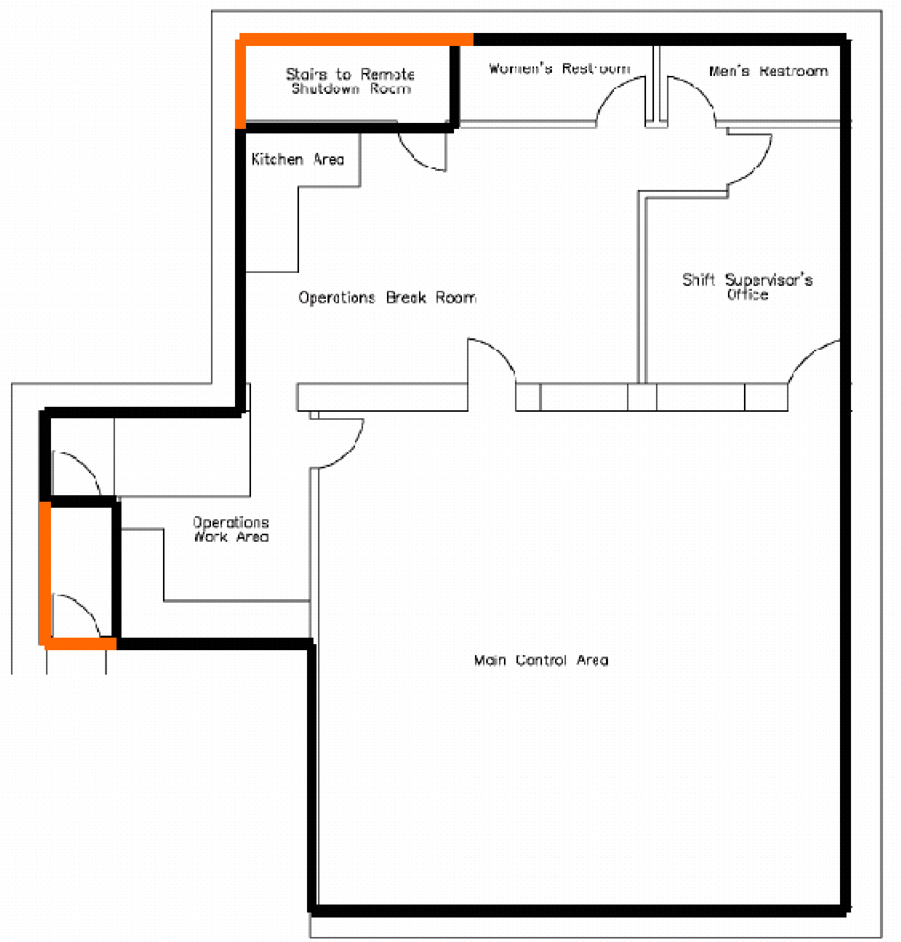


Figure 6.4-1
Main Control Room Envelope

Main Control Room Comparison

- Operating plant MCR
  - 150,000 - 200,000 cubic feet
  - Design basis unfiltered leak rate from ductwork, fans, filters ~0 to > 100 cfm
  - 10 cfm inleakage for ingress/egress
  - Active emergency HVAC system brings in filtered air
    - Traditional suction duct in-leakage source due to low duct pressure
    - Pass-through HVAC ducts contribute to in-leakage
- AP1000 MCR with VES Operation
  - 35,700 cubic feet
  - 0 cfm inleakage from all components/walls/floors/ceiling in MCR envelope
  - 5 cfm design basis unfiltered leak rate is appropriate due to vestibule design
  - Passive bottled air system does not contribute to in-leakage

AP1000 MCR Leakage Paths

- Penetrations in MCR envelope
  - 2 door penetrations
  - 5 I&C and electrical penetration locations (4 safety for Division A to D / 1 for nonsafety)
  - 3 VBS penetrations
    - Penetrations are <u>piping not ducts</u> (DCD Figure 9.4.1-1 Sheet 5 of 7)
    - Penetrations contain dual isolation valves
  - 2 VES 1” piping supply lines (DCD Figure 6.4-2 Sheet 2 of 2)
  - 2 VES 4” piping exhaust lines (DCD Figure 6.4-2 Sheet 2 of 2)
  - 1 PWS 2” piping penetration
  - 2 WWS and 2 SDS 4” piping penetrations
- Number of penetrations in the MCR envelope is significantly reduced compared to operating plants

AP1000 MCR Leakage Paths

- GL 2003-01 identifies 2 main sources likely to introduce contaminants into MCR
  - CRHS fan suction ductwork located outside control room envelope
  - Pressurized ducts that transverse control room envelope
- AP1000 MCR design eliminates both potential high leakage paths
  - During VES operation, VBS fans are isolated from the MCR by dual safety related isolation valves
  - AP1000 MCR contains no duct penetrations, ALL PIPING

AP1000 MCR Leakage Paths

- GL 2003-01, Regulatory Guide 1.197, and NEI 99-03 provide additional leakage paths to be considered
- Leakage values consistent with methodology & industry guidance included in SRP 6.4

Leak Path	AP1000 Impact
MCR ceiling, floor, walls, & doors	Considered
Electrical conduit	Considered
Piping penetrations	Considered
Duct located inside / outside MCR	Not applicable once VBS isolates
Isolation dampers inside / outside MCR	Not applicable once VBS isolates

AP1000 MCR Leaktightness (DCD 6.4.2.4)

- Majority of MCR is designed with reinforced 2'-0" concrete walls
- Interior & exterior walls of MCR are coated with low permeability paint/epoxy sealant
- Penetrations sealant material is gypsum cement or equivalent
- Outer surface of penetration sleeves are sealed with epoxy crack sealer
- Piping and electrical penetrations are sealed with qualified pressure resistant material
- Two door air-lock vestibule design

Low Leakage Positive Pressure MCR Summary

- MCR is maintained at positive pressure relative to adjacent areas during normal and abnormal operations
- Penetrations into MCR have been reduced and no HVAC duct penetrates MCR envelope
- MCR utilizes low-leakage construction techniques

Main Control Room Dose Analysis

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NRC Guidance on Control Room Infiltration Due to Ingress and Egress

- SRP Section 6.4: "Normally 5 L/s (10 cfm) infiltration is assumed for conservatism. This flow could be reduced or eliminated if the applicant provides assurance that backflow (primarily as a result of ingress and egress) will not occur. This may mean installing two-door vestibules or equivalent."

- Paper by Murphy & Campe (1974): "The Regulatory staff normally assumes a 10 cfm infiltration rate, notwithstanding pressurization. This is to account for the possibility of backflow of contamination into the control room when doors are opened or closed. This flow would be reduced or eliminated if the design rules out the possibility of backflow by installing devices such as two-door vestibules."

Physical Model Equivalent to Control Room Inleakage of 10 cfm

- Assuming that 10 cfm inleakage is valid, the average infiltration rate can be converted to an air volume transfer per door opening
  - 2 per hour = 300 ft^3 per ingress or egress
  - 6 per hour = 100 ft^3 per ingress or egress
  - 12 per hour = 50 ft^3 per ingress or egress
- Greater than 12 door openings per hour, while possible, is not reasonable
- Less than 50 ft^3 per ingress or egress might be appropriate but would be difficult to support

DCD Revision 15 (Certified Design)

- Dose analyses assume inleakage of 5.0 cfm to the MCR ($300\ ft^3$ per hour)
  - All inleakage is assumed to be from MCR ingress/egress
  - This is half the standard value associated with a design having no vestibule
  - Assumes activity concentration in the vestibule is same as that for air at the Annex Building entrance (no credit for dilution or depletion within the building)

Impact of Site Specific Dispersion Factors

- In 2007, calculations for prospective sites showed that the MCR dispersion factors used in the DCD LOCA dose analysis did not bound all sites
- DCD non-bounding dispersion factor values were increased by factor of 1.5 to 1.9 for VES in operation
- Changes in design and analysis modeling were made to obtain an acceptable dose in the MCR for the LOCA

DCD Revision 16

- Analysis change was made to take credit for aerosol impaction to remove aerosols in the containment leak path
  - Not specific to MCR dose model
  - Reduced doses both offsite and in MCR
- Design change was implemented to direct the MCR purge out through the vestibule
  - Minimum VES air supply flow to the MCR is 60 cfm
  - The inflow is balanced by outflow to maintain MCR pressure
  - 5 cfm is conservatively assumed to escape through leaks
  - 55 cfm passes through the vestibule so vestibule air concentrations quickly match MCR concentrations

DCD Revision 16 (continued)

- No credit was taken for purge through vestibule to reduce activity concentration prior to ingress from corridor
- The 5.0 cfm inleakage was conservatively assumed to be based on:
  - 1 ingress and 1 egress per hour
  - 150 ft^3 entering the MCR for each ingress or egress
- After entering the vestibule, credit was taken for the purge flow to clear activity from the vestibule
  - During the first 24 hours, an 11 minute delay was required before entering the MCR to allow the purge to reduce the air concentration
  - After 24 hours, no delay was required for personnel entering the MCR

DCD Revision 16 (continued)

- Each ingress operation was assumed to be followed by an egress operation 15 minutes later and credit was taken for the purge to further reduce the air concentration in the vestibule
- During first 24 hours, inleakage is 5 cfm at 10.6% of outside air concentration
  - Equivalent to approximately 0.5 cfm at the Annex Building entrance concentration
- After 24 hours, inleakage is 5 cfm at 53% of outside air concentration
  - Equivalent to approximately 2.7 cfm at the Annex Building entrance concentration

DCD Revision 17

- As a result of NRC concerns, the analysis was revised to remove credit for two of the Revision 16 analysis changes:
  - Aerosol impaction removal in the containment leak path
  - The 11-minute delay to move from vestibule to MCR

DCD Revision 17 (continued)

- MCR inleakage model was revised to take credit for the impact of purge flow on vestibule concentration prior to ingress from corridor
  - Initial vestibule concentration assumed to be same as in MCR
  - An air exchange of 150 ft^3 is assumed to occur when entering the vestibule from the corridor (same as modeled for passing from the vestibule into the MCR)

DCD Revision 17 (continued)

- As in the DCD Rev. 16 analysis:
  - Air concentration in corridor outside vestibule is assumed to be same as at Annex Building entrance
  - One ingress and one egress are assumed per hour with 150 ft^3 of air entering the MCR for each
  - After an ingress there is assumed to be a 15 minute delay before an egress operation takes place

DCD Revision 17 (continued)

- Average inleakage remains at 5 cfm but with 22% of the concentration at the Annex Building entrance
  - Equivalent to an inleakage rate of 1.1 cfm at the Annex Building entrance concentration
- For the dose analysis, concentration of inleakage was conservatively increased to 30% of the concentration at the Annex Building entrance
  - Equivalent to an inleakage rate of 1.5 cfm at the Annex Building entrance concentration

An Alternative

- Current LOCA analysis assumes that activity release is at ground level
  - If an elevated release is assumed (top of the diffuser), 5 cfm unfiltered inleakage with no dilution credit is estimated to result in a dose of <5 rem TEDE.
  - Additional review of subject site data is required to assure that the selected dispersion factors are bounding but are not excessively conservative

Industry Practice Regarding Control Room Access

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General Controls for MCR Access

- Access limited for security reasons
- Access limited for business reasons
- Permission generally required
  - other than shift complement
- Further restricted during critical activities

MCR Habitability – Access Evaluation

- Situation:
  - High levels of radioactivity released or possible
- Response:
  - Evacuation of non-essential personnel
  - Onsite essential personnel to TSC
- Result:
  - Minimal attempts to access

Main Control Room Habitability Testing

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MCR Habitability Testing

- Westinghouse is currently committed to perform the ASTM E741 tracer gas test to measure our design basis inleakage values (DCD 6.4.5.4)
- Tracer gas testing will be performed as part of initial preoperational testing and periodically thereafter (DCD Table 3.9-17)
- Tech Spec 3.7.6.10 includes testing to verify that one VES air delivery path maintains at least 1/8 inch WG positive pressure relative to adjacent areas

MCR Habitability Testing

- Westinghouse is evaluating appropriateness of tracer gas test for AP1000 design and ITAACs
- Westinghouse is considering additional Tech Spec surveillance testing once appropriate acceptance criteria is established
- Westinghouse is committed to performing testing to validate vestibule design & analysis assumptions

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