Agenda for GEH-NRC
Public and Closed Meetings on Containment Issues
March 5, 2008

0800 to 1200 March 5th - Open Session

- Overview of ESBWR Containment
  (H. Upton) - 30 min
  - General Arrangement
  - Diaphragm Floor Design
  - Inventory of Diaphragm Floor Penetrations
  - Vacuum Breaker and Vacuum Breaker Isolation Valve Summary
  - Design Considerations to Prevent Drywell-to-Wetwell Bypass Leakage
- Non Proprietary Discussion of Vacuum Breaker and Vacuum Breaker Isolation Valve Design
  (H. Upton) - 30 min
- Non Proprietary Discussion on Vacuum Breaker Test Program and Results
  (H. Upton) - 30 min
- Drywell-to-Wetwell Bypass Leakage Test Procedure and Acceptance Criteria
  (H. Upton/B. Shirk) - 30 min
  - Vacuum Breaker and Vacuum Breaker Isolation Valve Local Leak Rate Testing and Frequency
- GDC 38 - Passive Containment Cooling System Vent Fans and Containment Response
  (W. Marquino) - 30 min
- Post LOCA Safe Shutdown >7 Days
  (W. Marquino) - 30 min
  - Containment Margins Presentation (C. Cheung/M. Withrow)
  - Containment Sensitivity Study to Bypass Leakage (C. Cheung)
  - Containment Bypass Leakage Capability RAI 6.2-145 (W. Marquino)

Lunch

1300 to 1700 March 5th - Closed Session

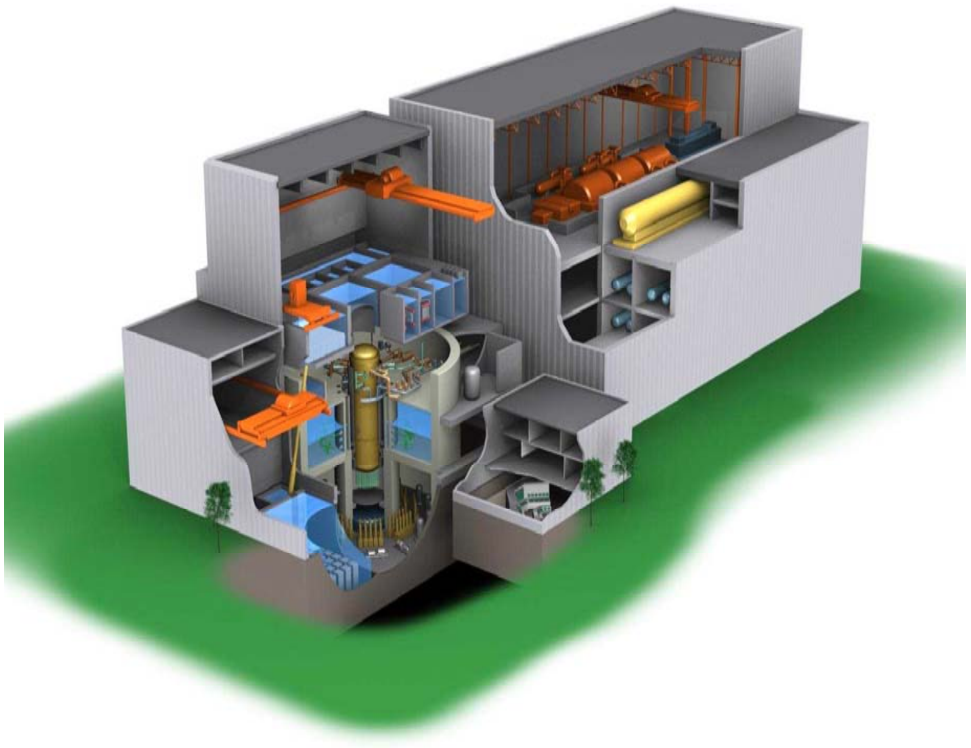
- Reactor Building Mixing and Leakage Update
  (W. Marquino) - 30 min
- Detailed Proprietary Results of the Vacuum Breaker Test Program
  (H. Upton) - 60 min
- Discussion of Draft Vacuum Breaker and Vacuum Breaker Isolation Valve, Drywell-to-Wetwell Bypass Leakage Testing, and Local Leak Rate Testing RAI Responses
  (H. Upton/B. Shirk) - 90 min
- Continued Proprietary Discussion of Unresolved DCD Section 6.2 and 6.3 RAIs
  (W. Marquino) - 60 min

Overview of ESBWR Containment

Presented to NRC Staff

Hugh Upton

March 5, 2008



GE Hitachi Nuclear Energy

ESBWR Containment Overview

- Pressure suppression containment
- Reinforced, lined concrete cylindrical structure
- Encloses RPV, related systems & components
- Internal steel liner provides leak-tight containment boundary
- Divided into DW and WW region separated by diaphragm floor with interconnecting vent system

Containment Key Design Requirements

Upper Drywell and Lower Drywell

- Design Pressure (P_d): 310 kPa(g) (45 psig)
- Design Temp: 171°C (340°F)

Wetwell

- Design Pressure: 310 kPa(g) (45 psig)
- Design Temp: 121°C (250°F)

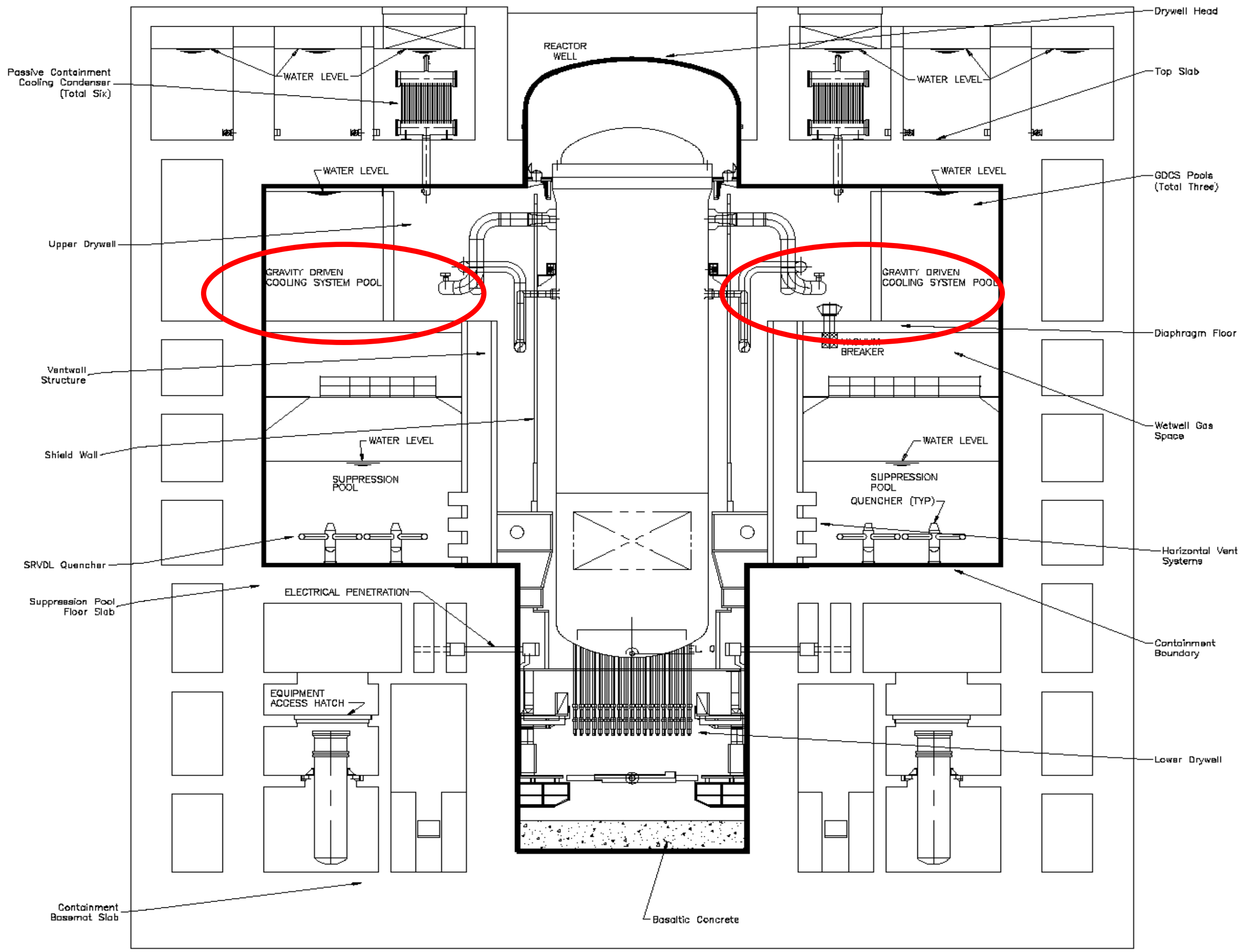
Containment Ultimate Strength

Summary of Pressure Fragility for Drywell Head

Failure Mode and Thermal Condition	PDF Lognormal Distribution		Failure Pressure, MPaG (Load Factor on P_d)	
	μ	β	Median Value	95% Value
Leakage Due to Bolt Yielding				
260 °C Steady State	1.621	0.1535	1.587 (5.12)	1.219 (3.93)
Ambient Steady State	1.846	0.1428	1.983 (6.40)	1.552 (5.01)
538 °C Transient	1.760	0.1645	1.826 (5.89)	1.374 (4.43)

- DW Head Bolts Yield at 1.219 MPa(g) (177 psig) & containment integrity lost
- Greater than drywell press if 100% fuel clad-coolant reaction assumed

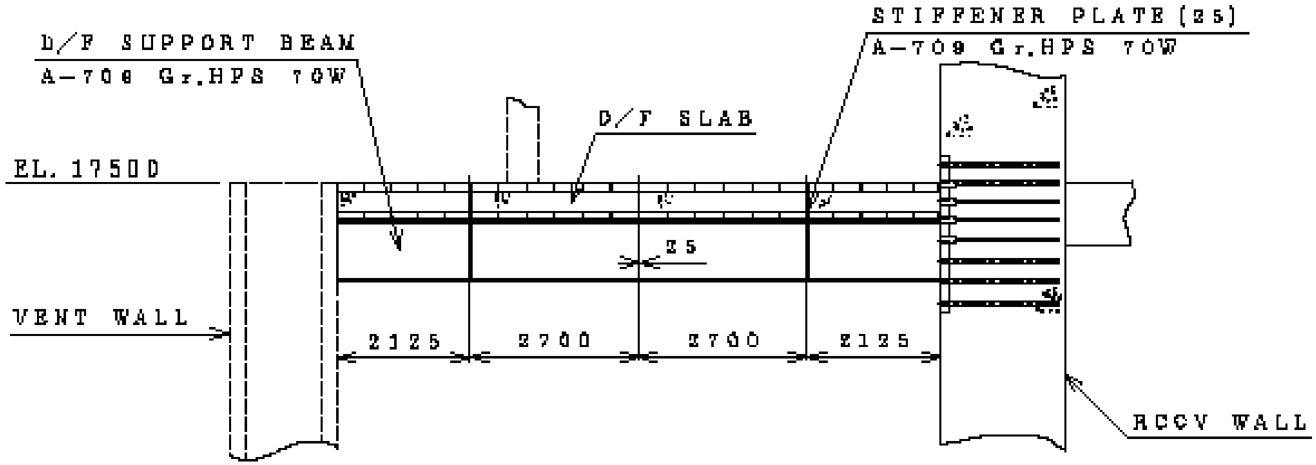
Containment System



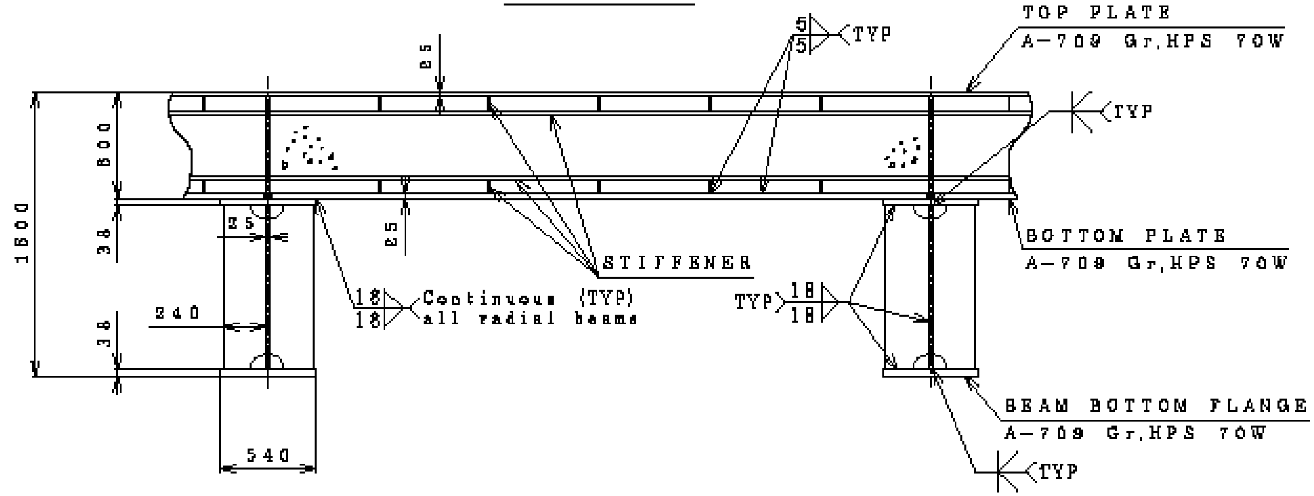
Diaphragm Floor Design

- Composite structure consisting of plate steel DW liner with full penetration welds, concrete slab and WW stainless steel liner
- Design minimizes the penetrations across the diaphragm floor
- All welds are subject to Pre-service inspection and ISI
- Bypass leakage across Diaphragm floor penetration welds and plate welds is not credible
- Diaphragm floor is designed for annulus pressurization loads during a LOCA and leak tightness of diaphragm floor is maintained

Diaphragm Floor Design Details



Diaphragm Floor (1:100)



Diaphragm Floor Section (1:30)

Diaphragm Floor Penetrations

- Only ESBWR diaphragm floor penetrations are:
  - 3 VB penetrations
  - 6 PCCS vent line penetrations
  - 4 ICS vent line penetrations
- Table below compares ESBWR Diaphragm floor penetrations with previous BWR containment designs:

	Penetration Description	Number Penetrations	Size cm (inches)]	Total Number
ABWR	Vacuum Breaker	8	50.8 (20)	
	SRV Discharge Lines	18	66.0 (26) OD	
				26
Mark II	DW to WW Downcomers	84	61 (24) OD	
	SRV Discharge Line Downcomer	18	71.1 (28) OD	
				102
ESBWR	Vacuum Breaker	3	60.9 (24)	
	PCCS Vent Lines	6	25.4 (10)	
	ICS Vent Lines	4	2.54 (1)	
				13

Diaphragm Floor Penetrations Cont'd

- SRV discharge lines are routed through the containment vent walls and seal welded at the vent wall penetrations
- PCCS and ICS vent line penetrations are subject to periodic ISI to confirm weld integrity
- Only credible source of ESBWR DW to WW bypass leakage is from the 3 VB penetrations
- Each VB is designed with an isolation valve and independent logic to isolate leaking VB

Vacuum Breaker (VB)

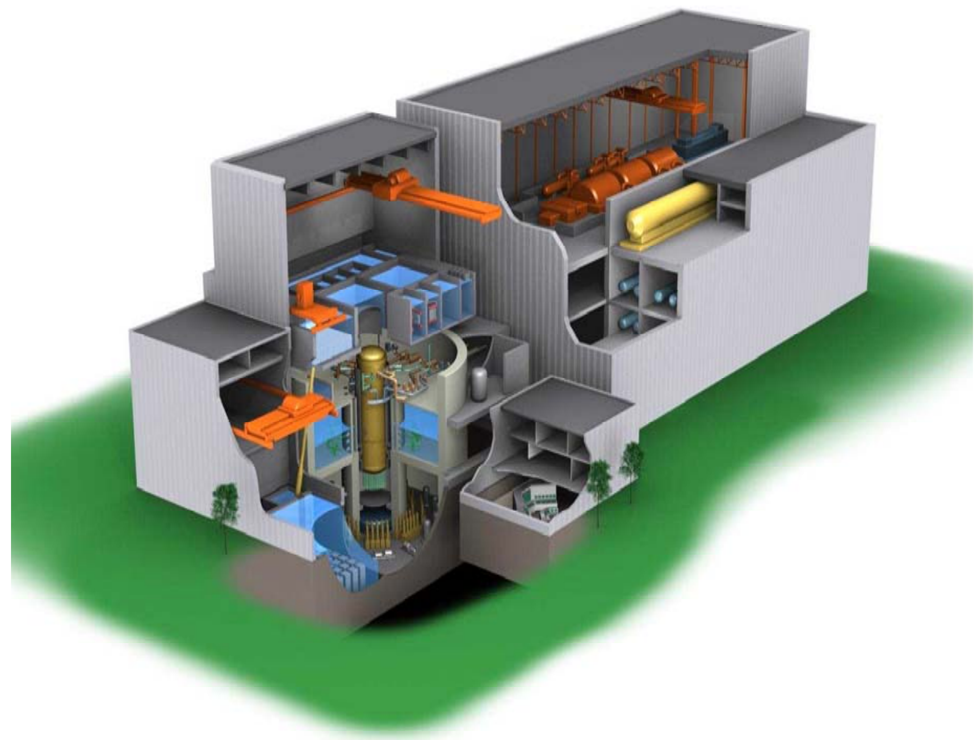
- A unique leak tight VB with a non-metallic seat and hard seat was designed for the SBWR, the ESBWR uses an identical VB
- VB prototype testing was completed in July 1994 and details issued to the NRC as part of response to RAI 900.62 issued by letter MFN-155-94 dated 12/15/94 under Docket STN 52-004
- Next Presentations address the Vacuum Breaker and Vacuum Breaker Isolation Valve

Vacuum Breakers (VB) and VB Isolation Valve

Presented to NRC Staff

Hugh Upton

March 5, 2008



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Vacuum Breaker

- Developed under the SBWR Program in the early 1990's
- Unique bypass leakage requirements for passive plants lead to the development of a new VB design
- The VB is designed to meet the following requirements:
  - High reliability - > 1E-4 failures per demand
  - Leak Tightness – A/sqrt(k) < 0.02 cm^2/VB at end of 60 year life DBA
  - Passive Operation
  - Resistant to LOCA debris
  - Operational Stability
  - Design for Inservice Testing
  - Direct Valve Seat Position Monitoring
  - Missile and Jet Protection

Vacuum Breaker (cont'd)

The details of VB valve design to meet criteria:

- Poppet type valve for simplicity and high reliability
  - one moving part and two bearing surfaces
- Closing force provided by gravity and DW to WW differential pressure
- Opening force provided by DW to WW differential pressure
- Full force of gravity applied over entire stroke
  - Provides more positive seating then a swing check
- Sealing surface engagement is uniform over entire perimeter of seat
  - Provides more positive seating then a swing check
- Bearing are vertical – do not support the weight of the disc
  - minimizes drag that retards disk motion.

Vacuum Breaker (cont'd)

The details of VB valve design to meet criteria:

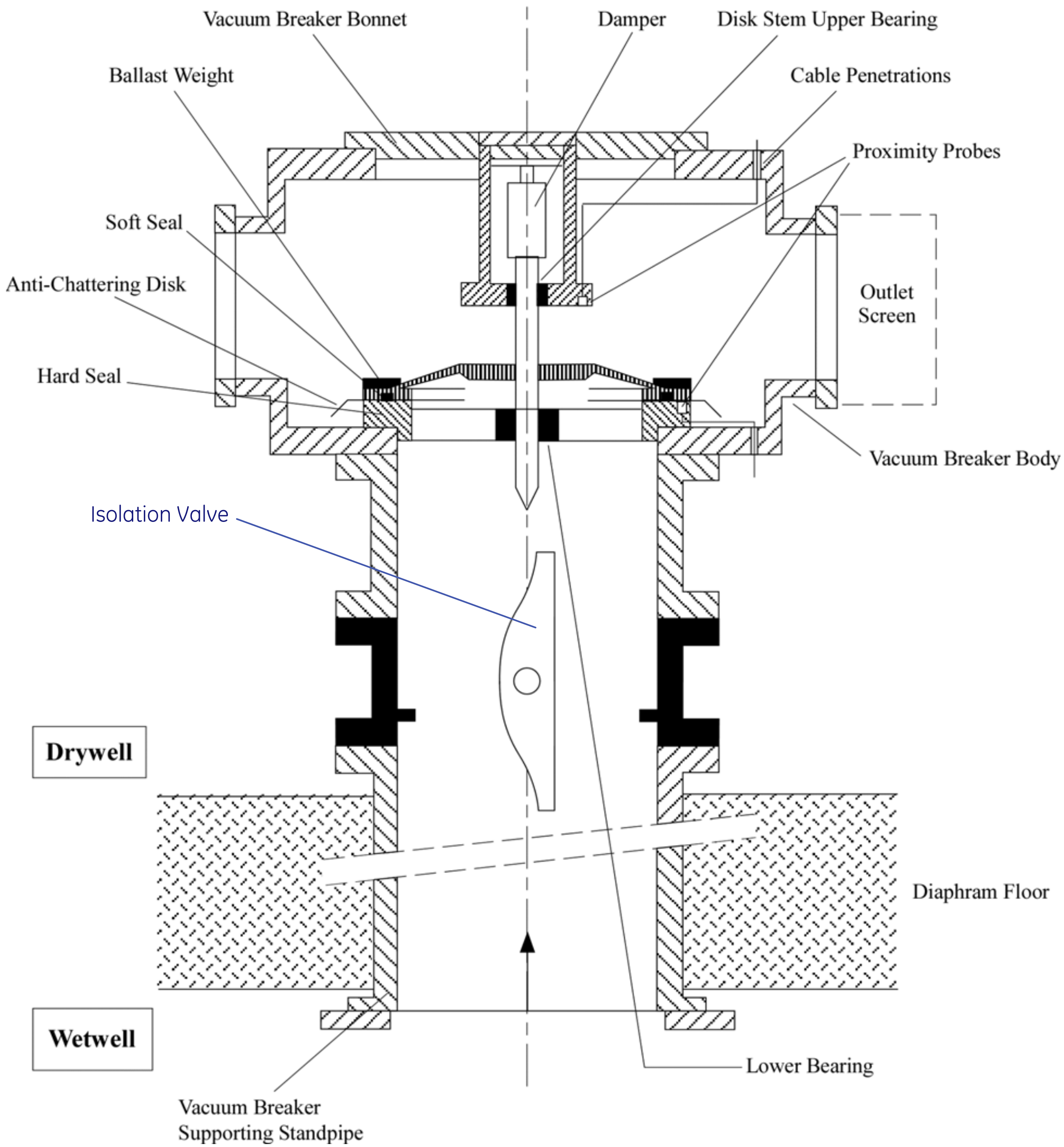
- Double barrier seal design – non-metallic seat and backup hard seat
  - Provides protection from debris lodging on either seat and still maintains leak tightness – provides seat single failure protection
  - Either seal provides leak tightness requirements – VB test program demonstrates leak tightness < 0.02 cm^2
- Anti-Chatter design
- Equipped with inlet and outlet debris screens with 0.9 mm perforations
  - Prevents entrance of LOCA debris particles that can create leakage
- Disk Position Sensors – Provides confirmation that the VB disk is seated securely
  - 4 proximity probes are located around the disc perimeter, with MCR indication and alarm and 1 proximity probe gives full open indication

Vacuum Breaker (cont'd)

VB Operating Characteristics

Number of Vacuum Breakers	Three (3)
Vacuum Breaker Opening Differential Pressure (Wetwell Pressure minus Drywell Pressure)	3.07 kPa [0.445 psi]
Vacuum Breaker Closing Differential Pressure (Wetwell Pressure minus Drywell Pressure)	2.21 kPa [0.320 psi]

Vacuum Breaker and Isolation Valve

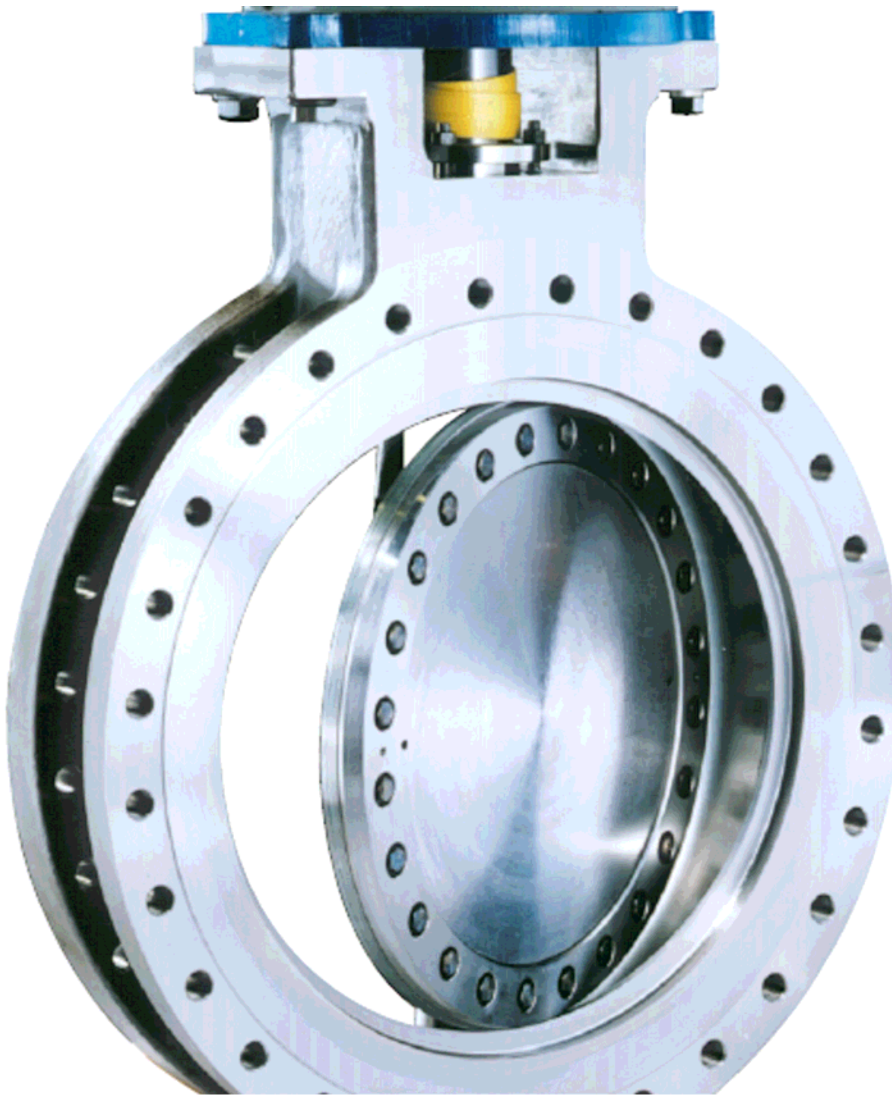


Vacuum Breaker Isolation Valve

Design Requirements

- 24 inch diameter
- Normally open
- Manually or automatically close to isolate a leaking vacuum breaker
- Fail as-is on loss of air or power
- Must meet Class VI leakage requirements
- Expected to be stroked less than 200 times over 60-year plant life for surveillance testing
- Located between diaphragm floor and vacuum breakers
- Installed in vertical pipe with valve stem horizontal

Weir Tricentric Butterfly Valve

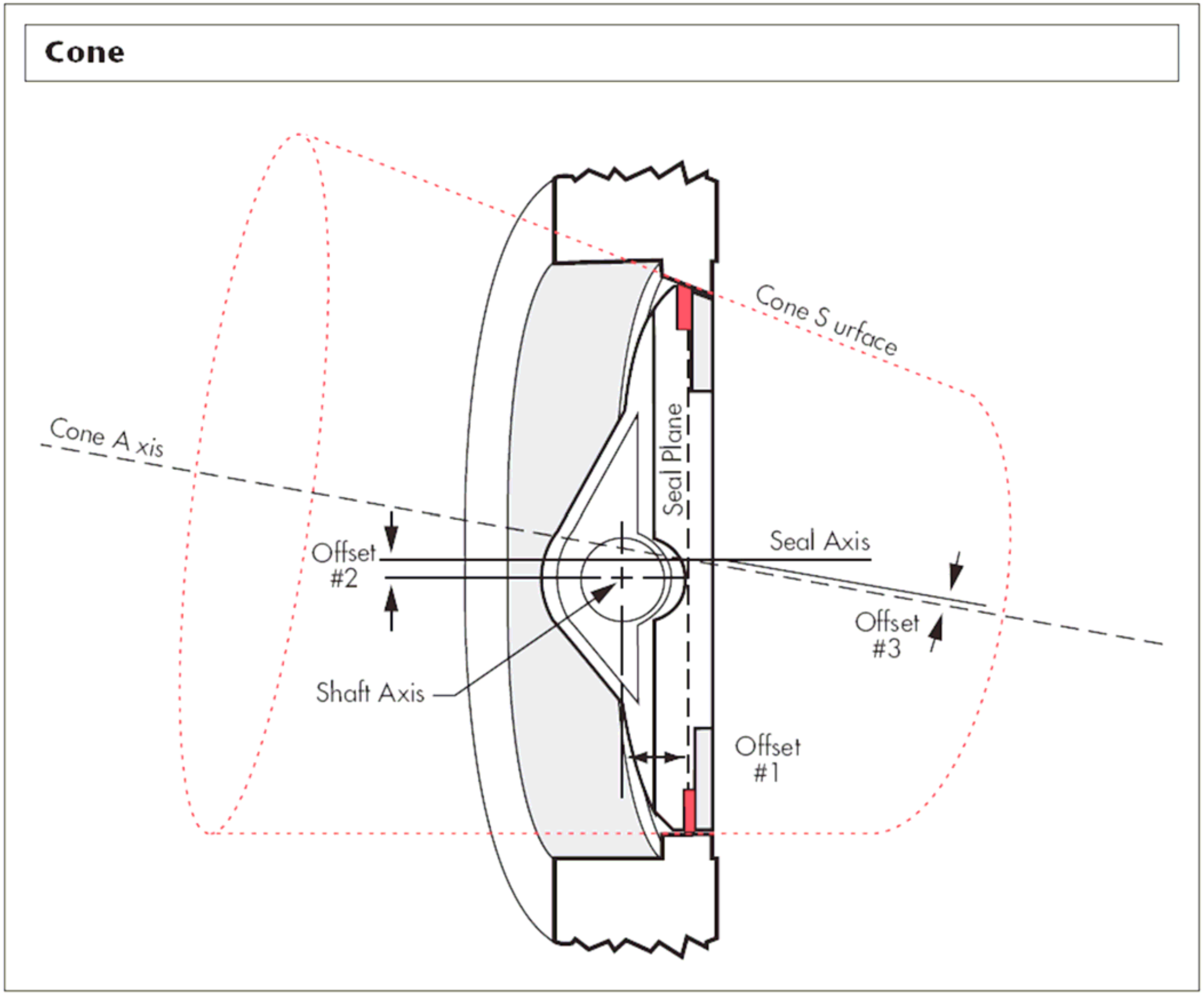


Vacuum Breaker Isolation Valve

Design Features

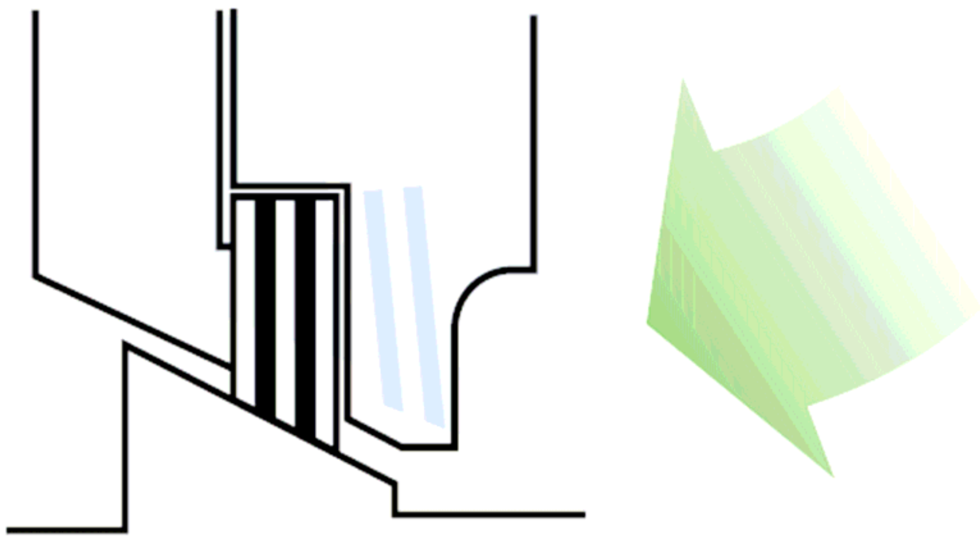
- Metal-to-metal seating (hard seated)
  - Concentric metal rings with graphite spacers
- Zero leakage (Class VI) – bi-directional
  - “Bubble-tight” after 50,000 cycles
- Zero maintenance on the seat
- Tricentric design minimizes seat wear by eliminating disk-to-body interference

Triple Offset Design



Seat Design

Seat Contact



Seat contact does not occur until the disc is seated closed.

On opening the seal lifts cleanly off the seat at all points allowing long life and quality sealing for many cycles.

Vacuum Breaker Isolation Valve

Actuator Design

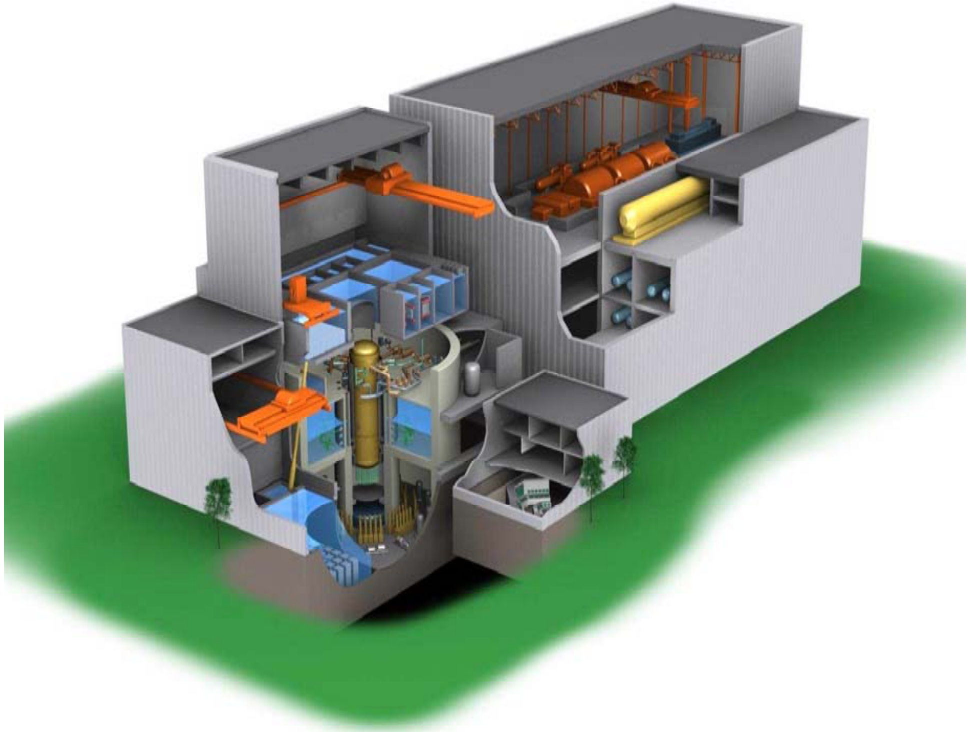
- Quarter-turn piston actuator
  - Scotch yoke or rack-and-pinion
- Nitrogen-driven
  - Double-acting with no return spring (for fail as-is performance)
- Accumulator provided
  - Sized to stroke each valve 5 times on loss of supply nitrogen

Summary of Vacuum Breaker Test Program and Results

Presented to NRC Staff

Hugh Upton

March 5, 2008



Vacuum Breaker (VB) Test Program

- Under the SBWR Program a prototype VB was manufactured and extensively tested and qualified per IEEE 323
- The Vacuum Breaker Test Program was completed in October of 1994
- NRC staff representatives witnessed seismic testing, the conclusion of the 3000 cycle reliability test, post test inspection and leakage testing in the presence of debris. Letter MFN-021-96 documented the staff's conclusion:

  "**The tests were performed by competent and experienced people….the test program appeared to be thorough. This together with the review of the test results, leads the staff to believe that the test results are valid and acceptable for use in licensing.**"

- Letter MFN-06-127 transmitted SBWR VB Test Program Report to the NRC staff and placed it on the ESBWR Docket

Vacuum Breaker Test Program (cont'd)

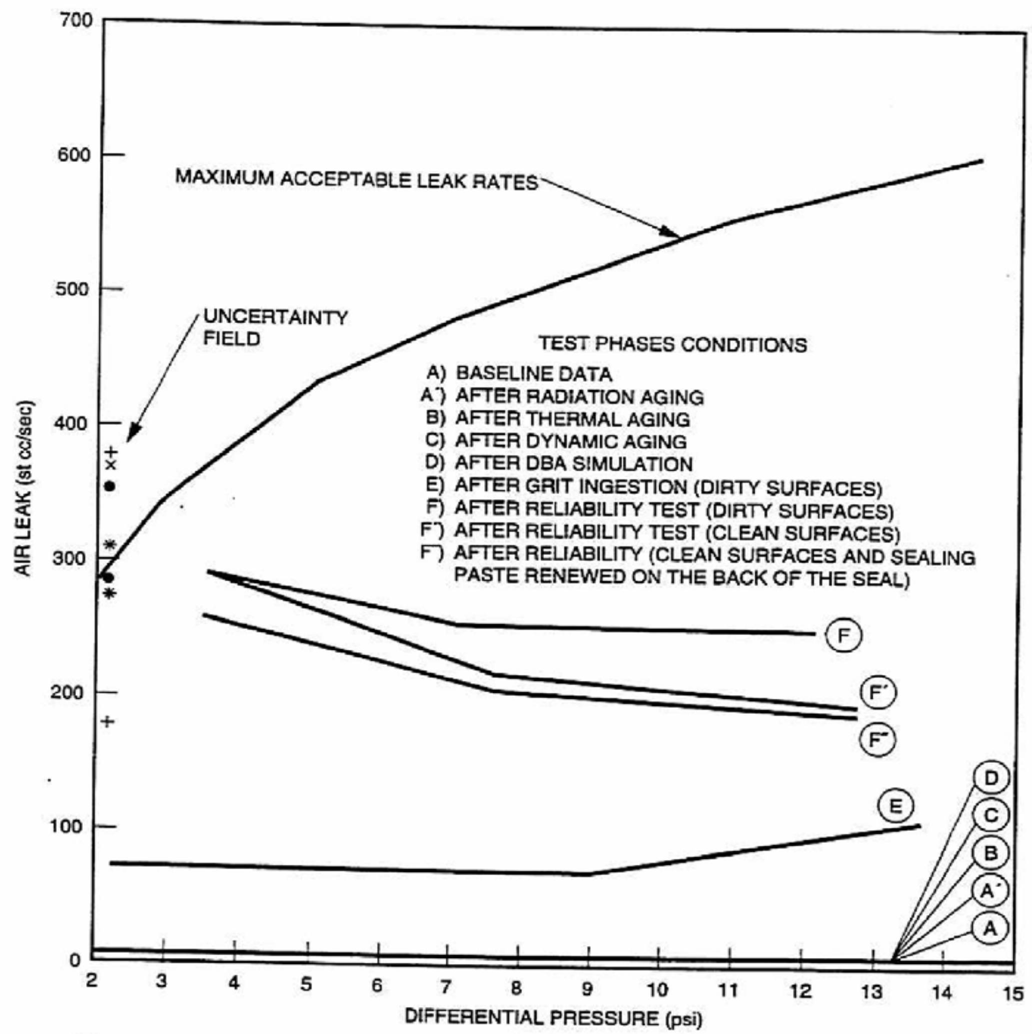
- What follows is a summary of the VB Test Program:
  - **Leak Tightness Test** – VB as built condition: soft seat tested bubble tight, hard tested with a leakage area equal to 0.00002 cm^2
  - **Performance Test** – Tested in full flow test facility – confirmed lift pressure, flow rate and chatter performance
  - **Design Basis Accident Leak Tightness** – VB was radiation aged, thermally aged and dynamically aged (including seismic) to simulate 60 years of operation. VB was leak tested with steam for 80 hours at Temp and Press enveloping DBA conditions. Periodic spray of cold water simulated thermal shock expected from DW spray. VB had zero steam leakage over duration of test. VB disc was lifted several times during the test with no change in leak tightness. Following the test VB leakage remained zero – bubble tight

Vacuum Breaker Test Program (cont'd)

- VB Test Program Summary (continued):
  - **Reliability Testing** – Confirm VB could open and close without failure to demonstrate a failure rate of <3E-4/demand. Prior to beginning the test 4 pounds of sand blasting grit were passed through the valve to simulate grit collected during the 60 years of service. Valve was coated with oil to ensure that grit adhered to bearing surfaces. VB was then cycled 3000 times in the test facility without measurable change in lift and reset pressure and flow rate. Following the Reliability test the valve was leak rate tested. As tested VB had leakage area << 0.02 cm^2.

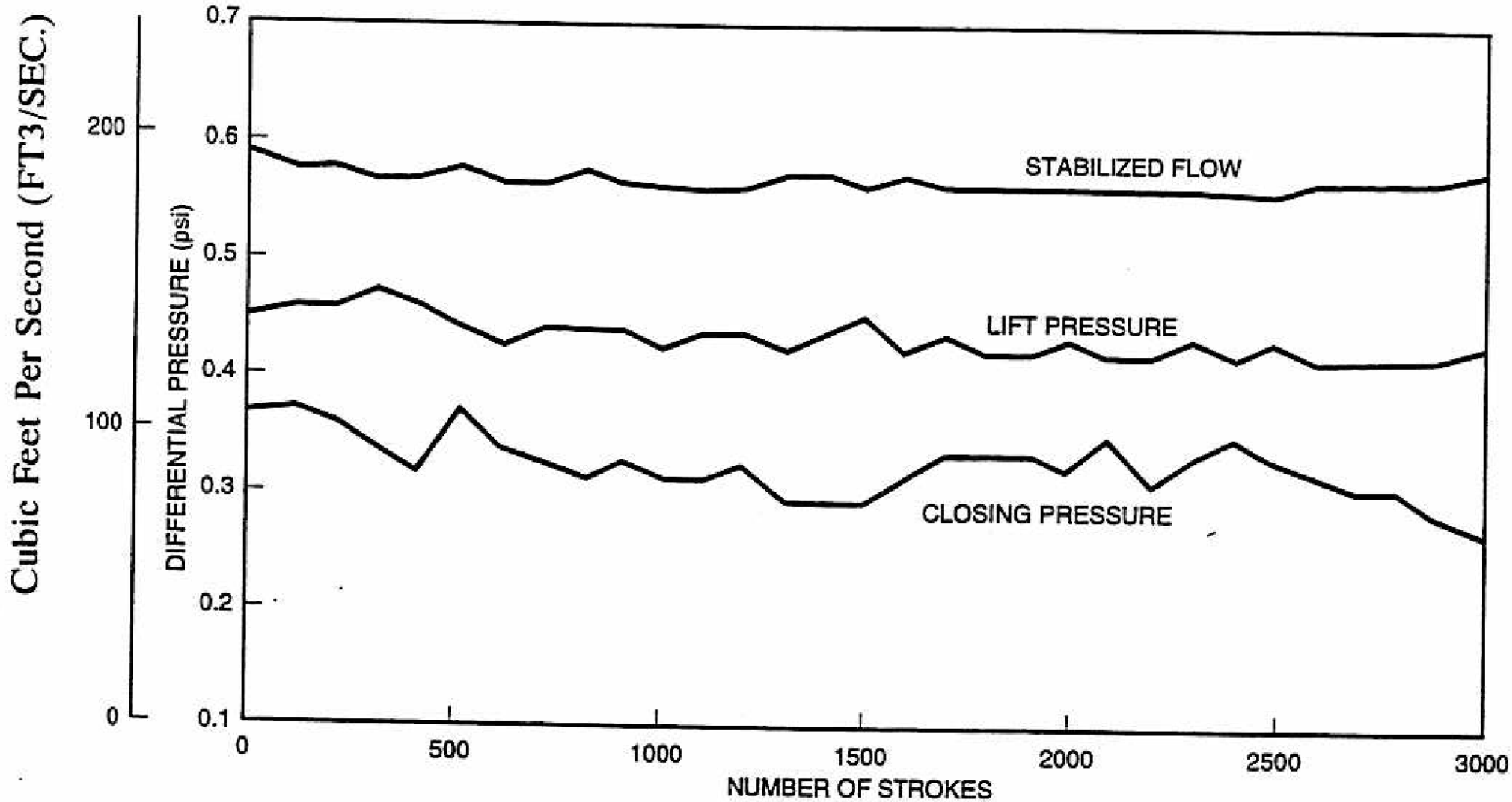
Vacuum Breaker Test Program (cont'd)

VB Systematic Checks Primary Soft Seal Leak Test Results



Vacuum Breaker Test Program (cont'd)

VB Reliability Test Summary Results

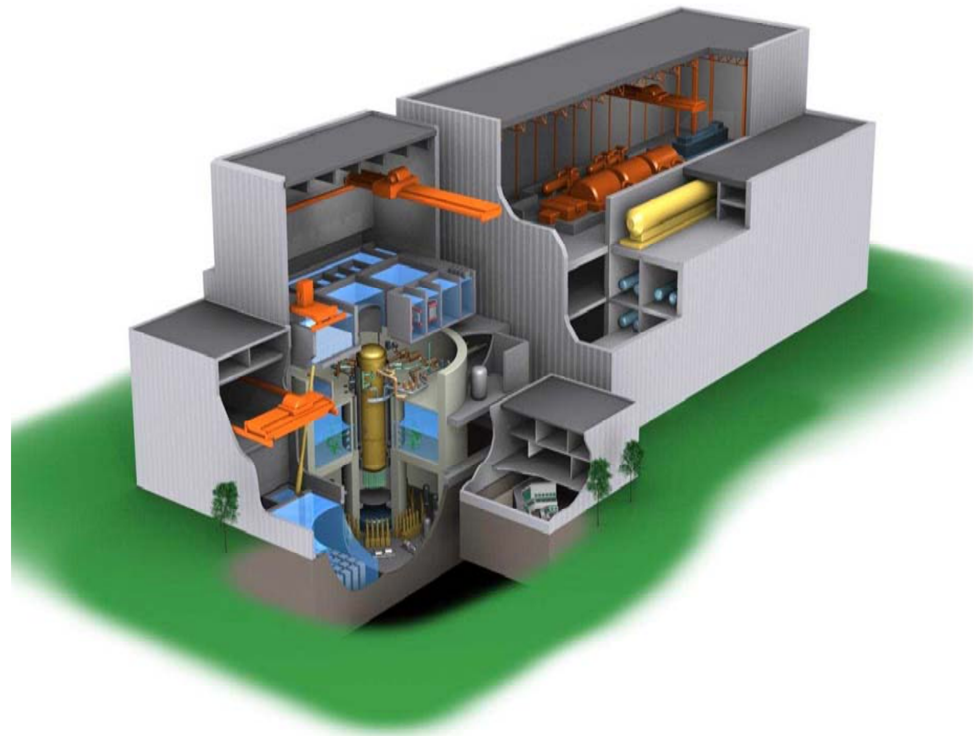


Vacuum Breaker Test Program (cont'd)

Test Program confirmed VB was rugged, reliable and met leak tightness requirements after being exposed to conditions more severe than design basis service

DW to WW Bypass Leakage Test and Acceptance Criteria

Presented to NRC Staff



Hugh Upton

March 5, 2008

GE Hitachi Nuclear Energy

DW to WW Bypass Leakage Test

- NUREG 0800 Section 6.2.1.1.C "Pressure Suppression type BWRs Containments – App A" requires Pre-op and periodic bypass leakage tests:
  - SRP indicates test required to detect leakage in:
    - DW to WW Vent Piping
    - Penetration Downcomers
    - Vacuum Breakers
    - Floor Seals
    - Vent Seals, and
    - Diaphragm
- Only possible bypass leakage paths in ESBWR are:
    - penetration downcomers,
    - vacuum breakers, and
    - diaphragm floor

DW to WW Bypass Leakage Test

- ESBWR bypass leakage test based on determining the effective bypass leakage area using volumetric flow and flow velocity.

$$A/\sqrt{k} = 144Q/v$$

- GEH Proposed Test Frequency is coincident with ILRT similar to the following BWRs with Mark II containments:
  - Columbia Generating Station,
  - Nine Mile Point Unit 2,
  - Susquehanna Units 1 and 2 and
  - Limerick Units 1 and 2
- These BWRs use bypass leakage test based on determining the effective bypass leakage area using volumetric flow and flow velocity.

DW to WW Bypass Leakage Test

- GEH Proposes to conduct Bypass Testing at the ILRT Frequency every 10 years:
  - Test will use calibrated instruments already in place for the ILRT
  - This gives the ability to measure the DW and WW pressure, humidity, and dry bulb temperatures during the test
  - The mass transfer from the DW to the WW across the diaphragm floor will be calculated
  - Results for the effective bypass leakage area will be reported at the 95% confidence level
- GEH Proposes to do local leak rate testing on the VB and VB Isolation Valves every refueling outage (similar to BWR's with Mark II containments)

DW to WW Bypass Leakage Test

Test Acceptance Criteria

- SRP recommends an acceptance criteria for bypass leakage test of 10 % of containment capability.
- 10% of containment capability was established by GE during licensing of the initial pressure suppression containments in the early seventies.
  - 10 % criteria was intended to leave sufficient margin for possible bypass leakage increases between outages due to lack of field data
- Actual experience has shown little or no increase in bypass leakage between outages.
- 90% margin to containment capability is overly conservative.

DW to WW Bypass Leakage Test

Test Acceptance Criteria

- GEH proposes to use 50% of containment capability as the test acceptance criteria for DW to WW Bypass Leakage Test.
  - This leaves 50% margin for possible bypass leakage increases between tests.
- An ESBWR test acceptance criteria of 50% of containment capability provides:
  - Adequate margin to account for possible bypass leakage increases between tests while still ensuring that the containment design pressure will not be exceeded in a DBA,
  - Ensures the test acceptance criteria is measurable within current technology at a 95% confidence level and
  - Does not impose undue regulatory burden on plant owners.

DW to WW Bypass Leakage Test Criteria Justification

GEH considers 50% of containment bypass leakage capability adequate for ESBWR for the following reasons:

- The diaphragm floor in the ESBWR containment is a unique, leak tight composite structure.
- Bypass leakage through this structure is not credible.
- The diaphragm floor is designed to minimize the number of penetrations across it.
- All penetration welds are subject to pre-service inspection and ISI to ensure leak tight weld integrity.

DW to WW Bypass Leakage Test Criteria Justification

- Only credible bypass leakage path is thru the Vacuum Breakers
  - ESBWR Vacuum Breakers are Class VI bubble tight valves.
  - Valves with elastomeric seats (like the VB) exhibit excellent leak tightness with age.
  - The SBWR vacuum breaker test program confirmed the leak tightness of the VB under all aging mechanisms.
  - Vacuum breaker, VB isolation valve will be subject to LLRT every refueling outage.
  - Each VB has an isolation valve that can isolate leaking VB which provides additional assurance containment capability is not threatened.

DW to WW Bypass Leakage Test Procedure

Bypass Leakage Test Procedure follows recommendations in "Testing Criteria for Bypass Leakage Testing of DW to WW Interface for ESBWR Nuclear Power Plants" by ILRT, Inc.

The procedure is summarized as follows:

- Isolate penetrations across diaphragm floor
  - Rotate PCCS vent Line spectacle flange closed
  - Close the Isolation Condenser System vent line block valves
- Following completion of ILRT, containment is depressurized to $\geq$ 2.0 psig.
- Communication path between DW and WW used during ILRT is isolated.
- Maintain WW water level constant during test.
- Depressurize WW airspace to 0 psig and then isolate

DW to WW Bypass Leakage Test Procedure

Procedure Summary continued:

- Maintain $\geq$ 2.0 psig in DW as WW is depressurized. If needed, re-starting the ILRT air compressor to maintain $\geq$ 2.0 psig – isolate when WW airspace is at 0 psig.
- Record DW and WW pressure to ensure it is within the required range
- Record WW water level to ensure it remains constant
- Let DW and WW conditions stabilize for 1 hr
- Record DW and WW pressure, temperature and relative humidity for 2 hours using ILRT test instruments
- Analyze data to determine $A/\sqrt{k} = 144Q/v$

Local Leak Rate Test (LLRT) of VBs and Isolation Valves

- 24 month frequency when DW to WW bypass leakage test not performed
- Will provide assurance bypass leakage does not substantially increase between refueling outages.
- Acceptance criteria – SR 3.6.1.1.4 and SR 3.6.1.1.5
  - Test Pressure $\geq$ 2.0 psid
  - Individual VB bypass leakage criteria $\leq$ 15% of $A/\sqrt{K}$ value for containment bypass leakage capability (bypass capability)
  - Total bypass leakage criteria $\leq$ 35% of $A/\sqrt{K}$ value for bypass capability
  - Total Leakage rate is determined by summing the maximum pathway leakage for each VB and VB isolation valve pair.
  - Provides a 65% margin to the bypass capability

LLRT of VBs and Isolation Valves

- LLRT acceptance criteria provides large, conservative margin to accommodate potential leakage through passive structural components.
- Mark II containment bypass test data indicates that leakage through passive structural components is much less than 65% of acceptance criteria.
- Combined VB leakage acceptance criteria ensures bypass leakage limit is met for outages not scheduled to perform a bypass leakage test.
- Individual VB and VB Isolation valve acceptance criteria is 15% of the bypass capability.

LLRT of VBs and Isolation Valves - Procedure

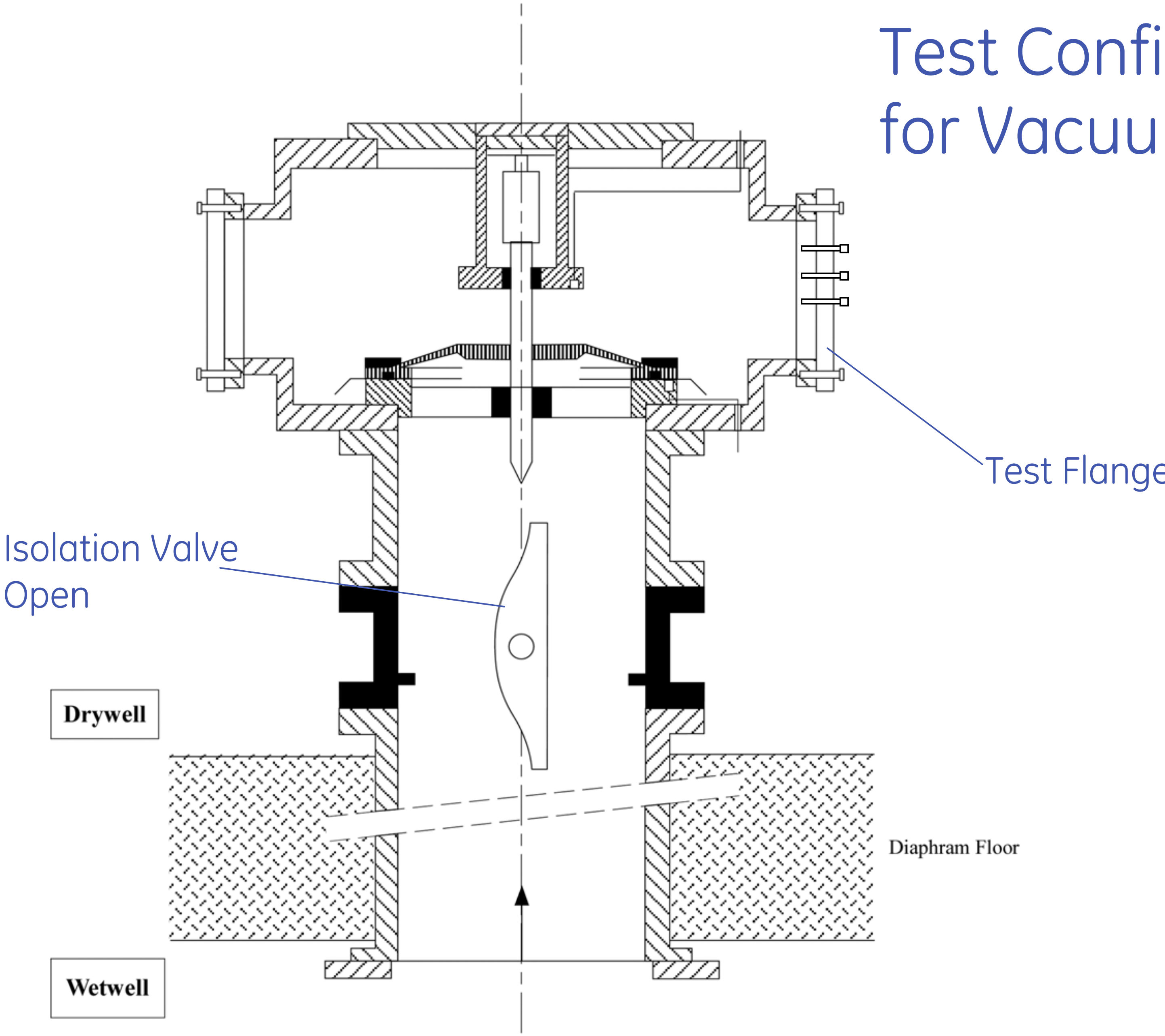
- ESBWR designed with VB Maintenance platform:
  - Provides access to the VB's and VB discharge ports
  - Installed Jib crane provided to allow easy removal of the VB discharge ports
- Special VB LLRT test flanges will be developed during detailed design
- LLRT takes ~ 15 minutes per valve (once test equipment is installed)
- Utility existing, highly accurate Appendix J leak rate equipment used
- VB LLRT Uses air or nitrogen flow make-up method as described in ANSI/ANS 56.8-1994

LLRT of VBs and Isolation Valves - Procedure

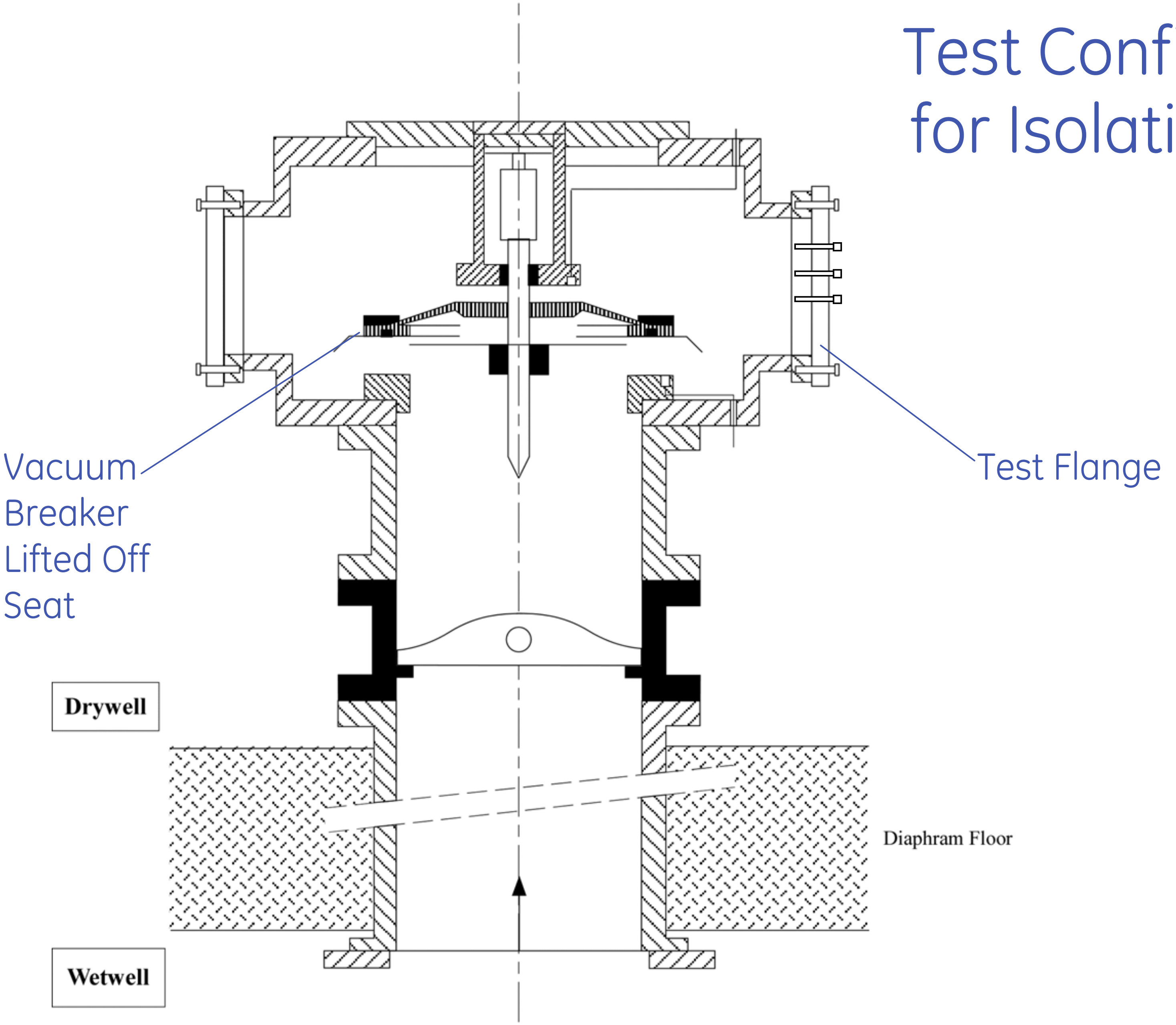
Procedure Summary:

- Replace outlet screens with 3 blind flanges and 1 test flange.
- Connect leakage test equipment to flange - tubing $\geq$ 3/8 inch diameter.
- Open vacuum breaker isolation valve if not already open.
- Pressurize and maintain at least 2.0 psig but not over 2.4 psig to prevent forcing VB seat to seal
  - Flow to maintain test pressure used as the leakage rate of the vacuum breaker.
  - No minimum test duration is required,
  - Test data shall be obtained during stable conditions.
- Record leakage rate for vacuum breaker in sccm/min from the readout of the LLRT test equipment.
- Depressurize and lift vacuum breaker and close isolation valve.
- Repeat the test for the VB Isolation valve

Test Configuration for Vacuum Breaker



Test Configuration for Isolation Valve

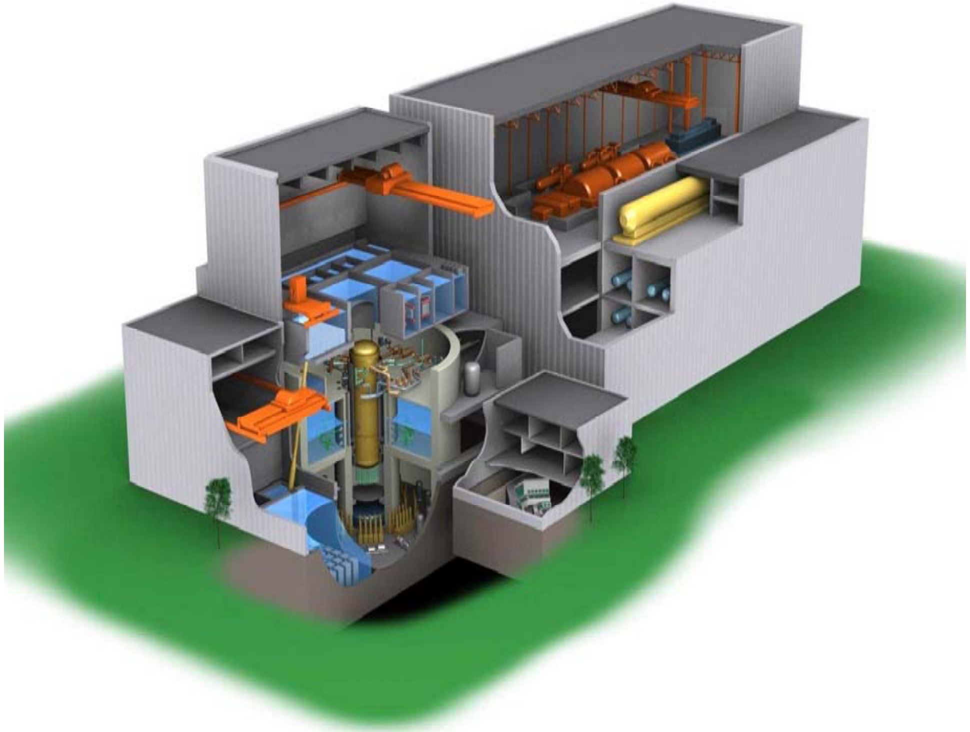


GDC 38 and
Post LOCA Safe Shutdown

Presented to NRC Staff

Wayne Marquino

March 5, 2008



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GDC 38 - PCC Vent Fans

- RAI 6.2-139 and discussions with the Containment Systems indicated a concern with ability to rapidly reduce containment pressure.
- GEH has added fans connected to the PCC vent lines.
- Fans reduce the non-condensable gas concentration in the PCC and allow it to condense steam generated by decay heat, at a lower pressure.

Preliminary/Unverified RAI 6.2-139

PCC fan schematic

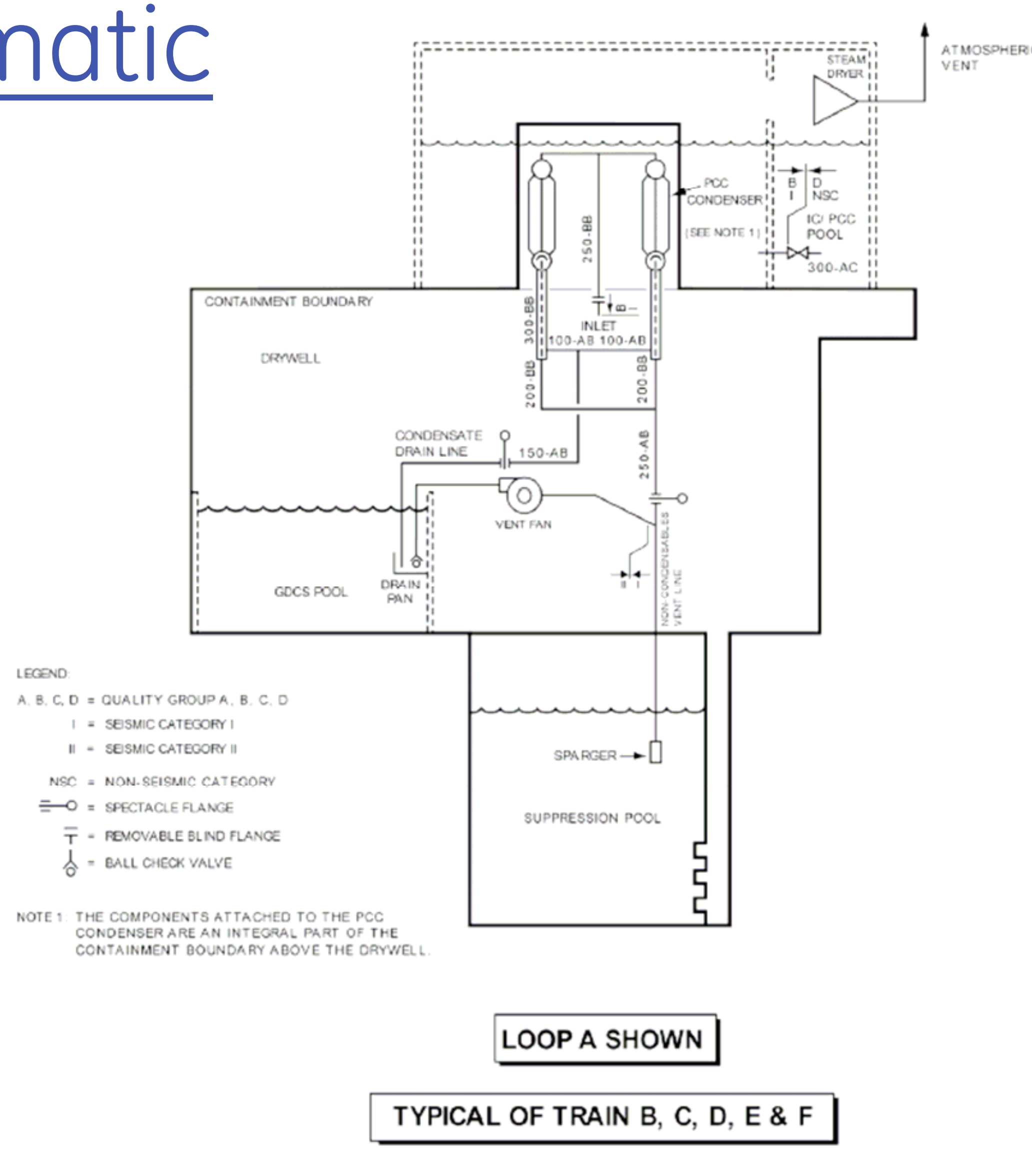
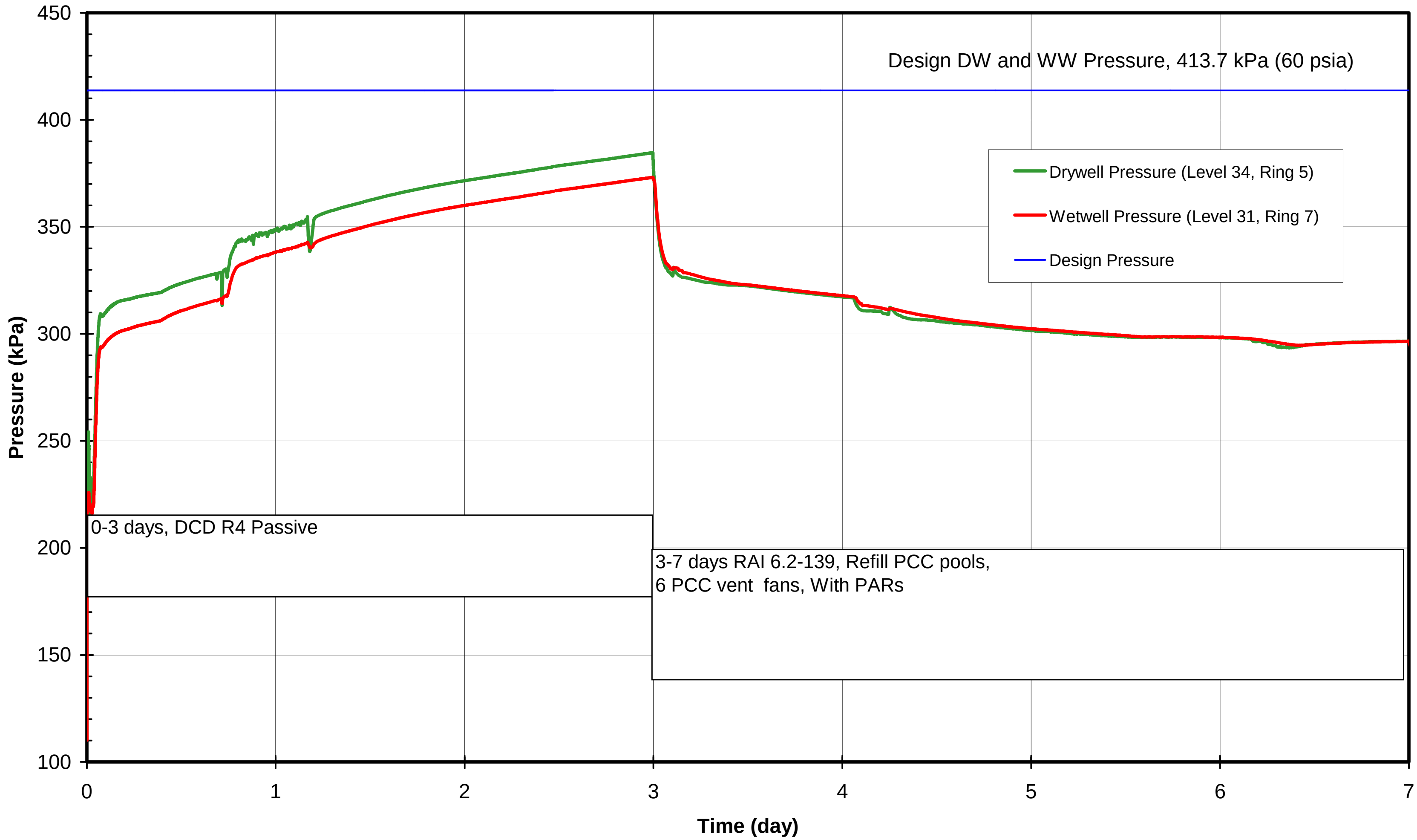


Figure 6.2-16

PCC Vent Fan Performance used in TRACG analysis:

- Flow rate of 0.343 m^3/sec (727cfm)
- Head of $(\Delta P/\ \rho)\ = 586\ m^2/s^2$ ($6307.652\ ft^2/s^2$) at a fluid density of 2.2 Kg/m^3 (0.137 lb/ft^3)
- Submerged discharge assures PCC vent flow to suppression pool is from lower header, not from DW
- Check valve limits backflow from GDCS pool during LOCA blowdown

RAI 6.2-139 Preliminary/Unverified



Post LOCA 7 day Cooldown

- During discussions NRC Staff asked if active systems would be used post LOCA
- GEH Analyzed DW spray but it can impact PCC heat removal
- GEH looked at which active systems could be used to cooldown, without impacting radiation dose, while minimizing plant cost

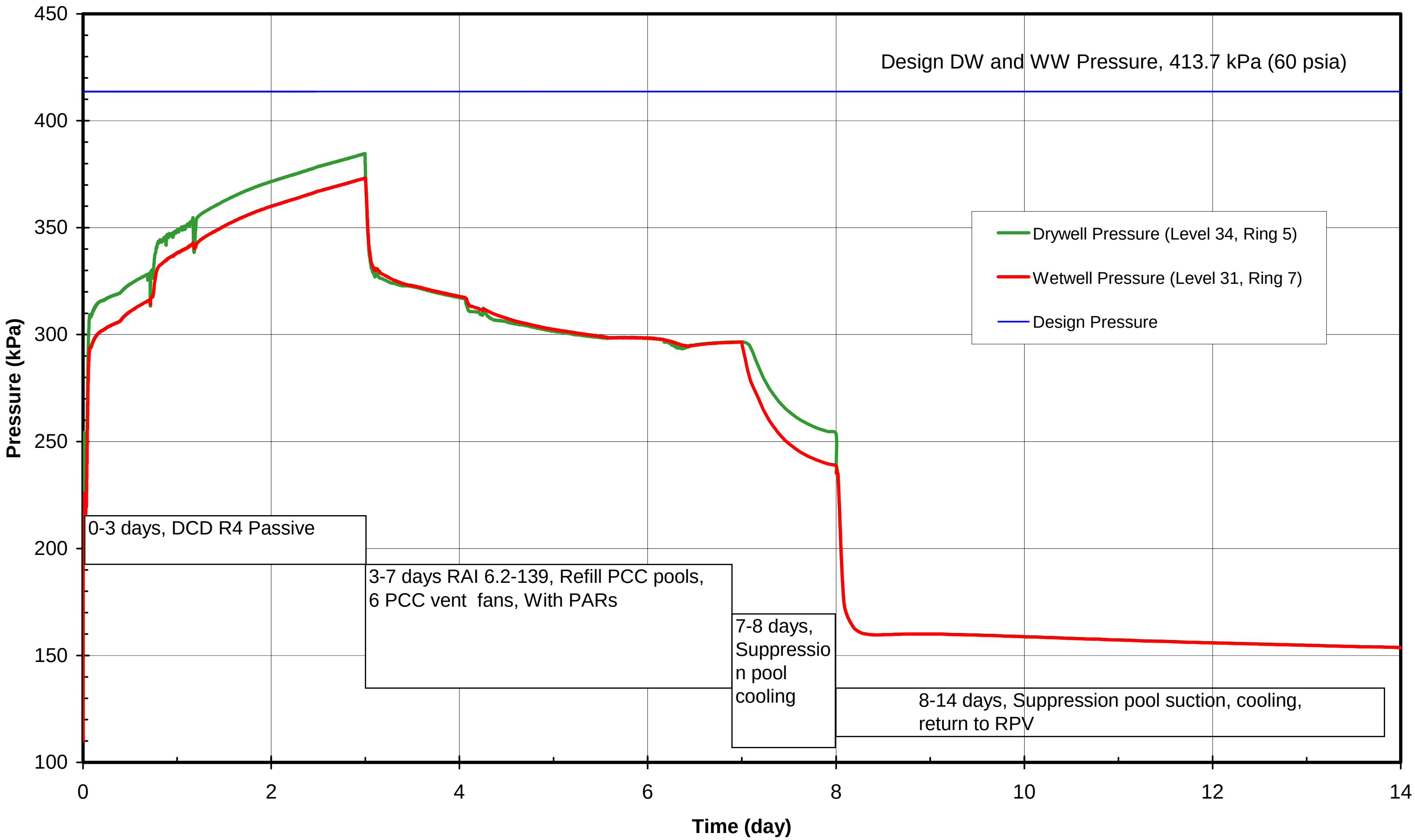
Cooling Containment 7 Days Post-LOCA

- Mechanism for bringing the plant to cold shutdown while maintaining the control room and off site dose rates within limits
- Crosstie of the FAPCS to the RWCU/SDC system to allow post LOCA Containment Cooling
- Crediting the Reactor building HVAC systems for cleanup of leakage of contaminated fluid
- Maintaining release within the on&off site dose limits

Description of Change:

1) Connection from FAPCS suppression pool suction to RWCU Non-Regenerative Heat Exchanger (both trains) via spectacle flange
2) Connection from discharge of the RWCU/SDC to the FAPCS for Suppression pool cooling, DW Spray, and GDCS injection
3) Design Reactor Building HVAC to limit off site dose when contaminated fluids are circulated in the RB (retain passive mode bounding dose)

Post LOCA Cooldown (Preliminary/Unverified)



Summary Post-LOCA Cooldown

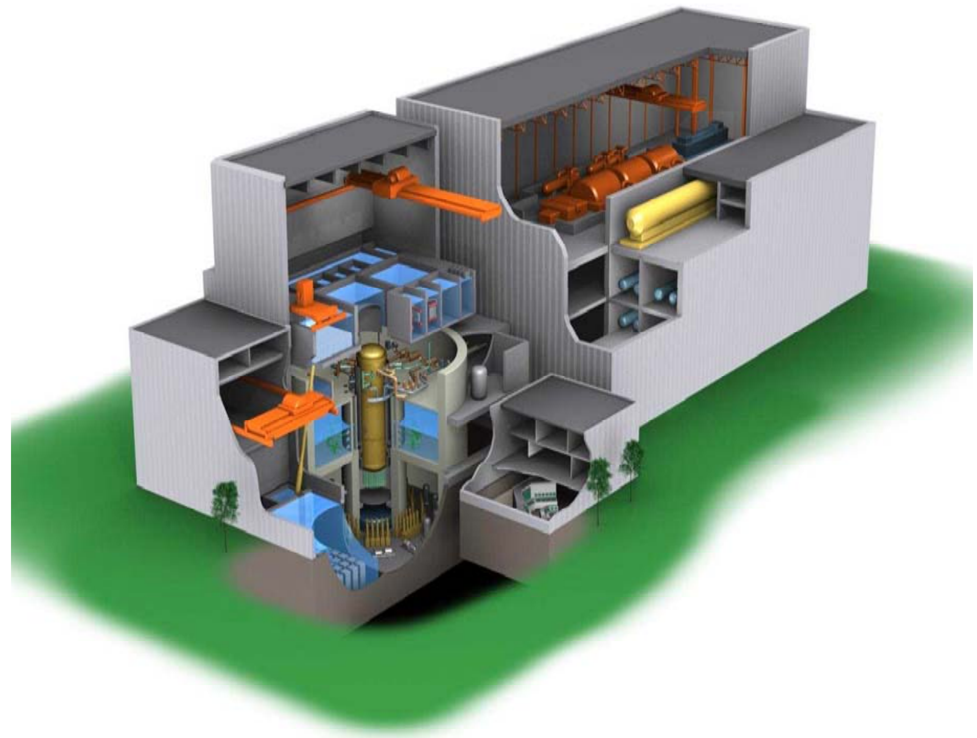
- After a LOCA, ESBWR can apply active systems
- Because the passive ECCS systems prevent fuel damage (section 6.3) the FAPCS system can be applied to cooldown
- In the event of significant fuel damage, a cross tie to the RWCU/SDC heat exchanger is available
- HVAC design will provide for active cleanup prior to use of this system if fuel damage exists
- Exact operations will be determined using the HFE process including procedure development

DW to WW Bypass Leakage Acceptance Criteria

Presented to NRC Staff

Chester Cheung

March 5, 2008



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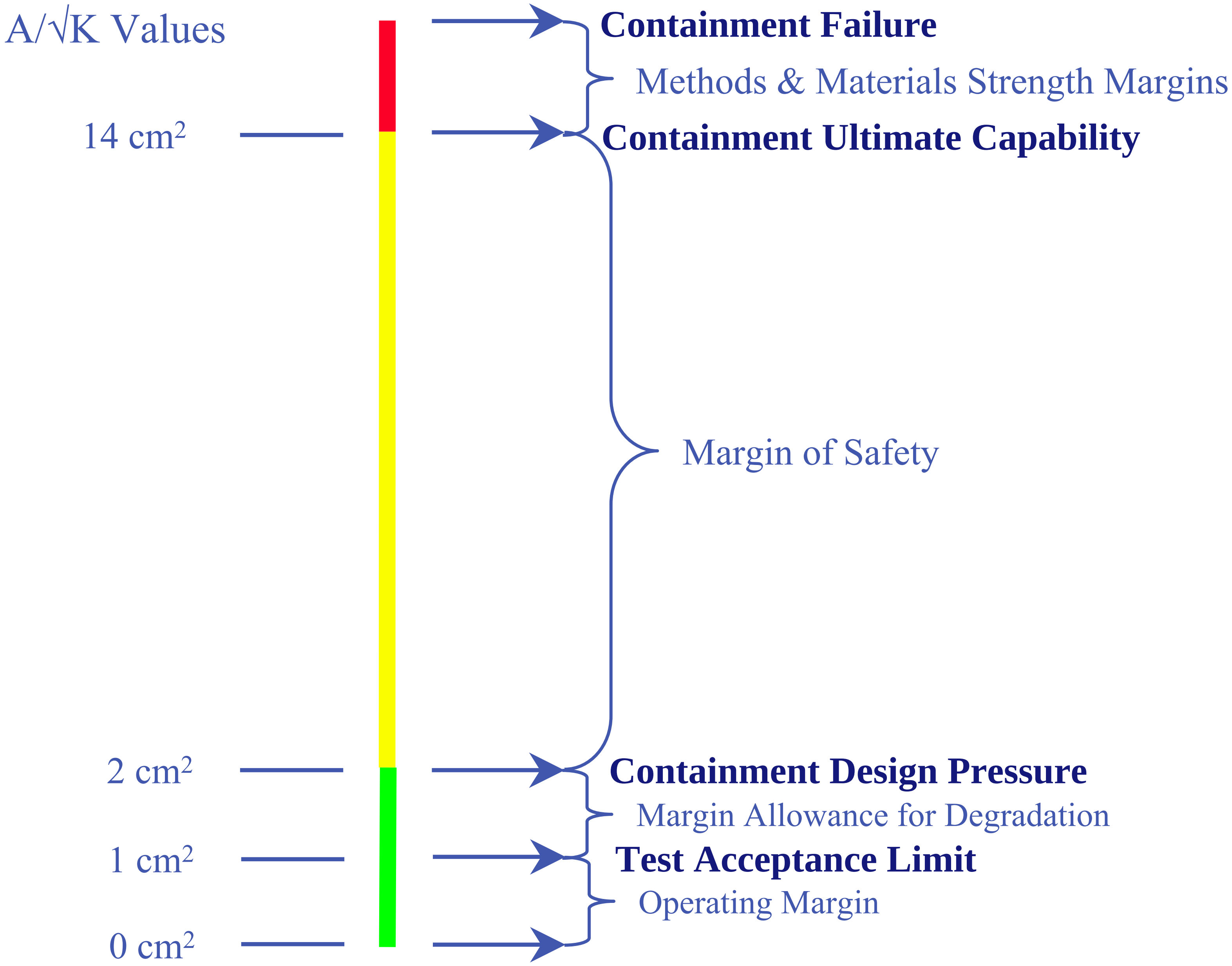
Presentation Content

- Bypass Leakage Margin illustration
- Review of ESBWR containment pressure calculation with respect to conservatism
- Summary

ESBWR DW/WW Bypass Leakage Margin



ESBWR Containment Pressure Calculations

- Test acceptance limit
  - ESBWR: 50% of allowable leakage (1.0 cm^2), supported by substantial margin from analyses using more realistic conditions
- Peak Pressure timing
  - ESBWR: Maximum DW pressure occurs at end of 72 hrs calculation

ESBWR Containment Pressure Calculation with Respect to Conservatism

- Conservative modeling
  - NO mixing in WW gas space and Suppression pool, for the duration of 72 hrs calculation
  - Not all containment heat sinks are modeled
- Bounding plant conditions (DCD Table 6.2-6) and model parameters (DCD Table 6.2-8) used in the calculations
- Realistic leakage area through diaphragm floor << 1.0 cm^2

ESBWR Containment Pressure Calculation with Respect to Conservatism (cont'd)

Table 6.2-6

Plant Initial Conditions Considered in the Containment DBA Cases

No.	Plant Parameter	Nominal Value	Bounding Value
1	RPV Power	100%	102%
2	WW relative humidity	100%	100%
3	PCC pool level	4.8 m	4.8 m
4	PCC pool temperature	43.3°C (110°F)	43.3°C (110°F)
5	DW Pressure	101.3 kPa (14.7 psia)	110.3 kPa (16.0 psia)
6	DW Temperature	46.1°C (115°F)	46.1°C (115°F)
7	WW Pressure	101.3 kPa (14.7 psia)	110.3 kPa (16.0 psia)
8	WW Temperature	43.3°C (110°F)	43.3°C (110°F)
9	Suppression pool Temp.	43.3°C (110°F)	43.3°C (110°F)
10	GDCS pool temperature	46.1°C (115°F)	46.1°C (115°F)
11	Suppression pool level	5.45 m	5.50 m
12	GDCS pool level	6.60 m	6.60 m
13	DW relative humidity	20%	20%
14	RPV pressure	7.17 MPa (1040 psia)	7.274 MPa (1055 psia)
15	RPV Water Level	NWL	NWL+0.3m

ESBWR Containment Pressure Calculation with Respect to Conservatism (cont'd)

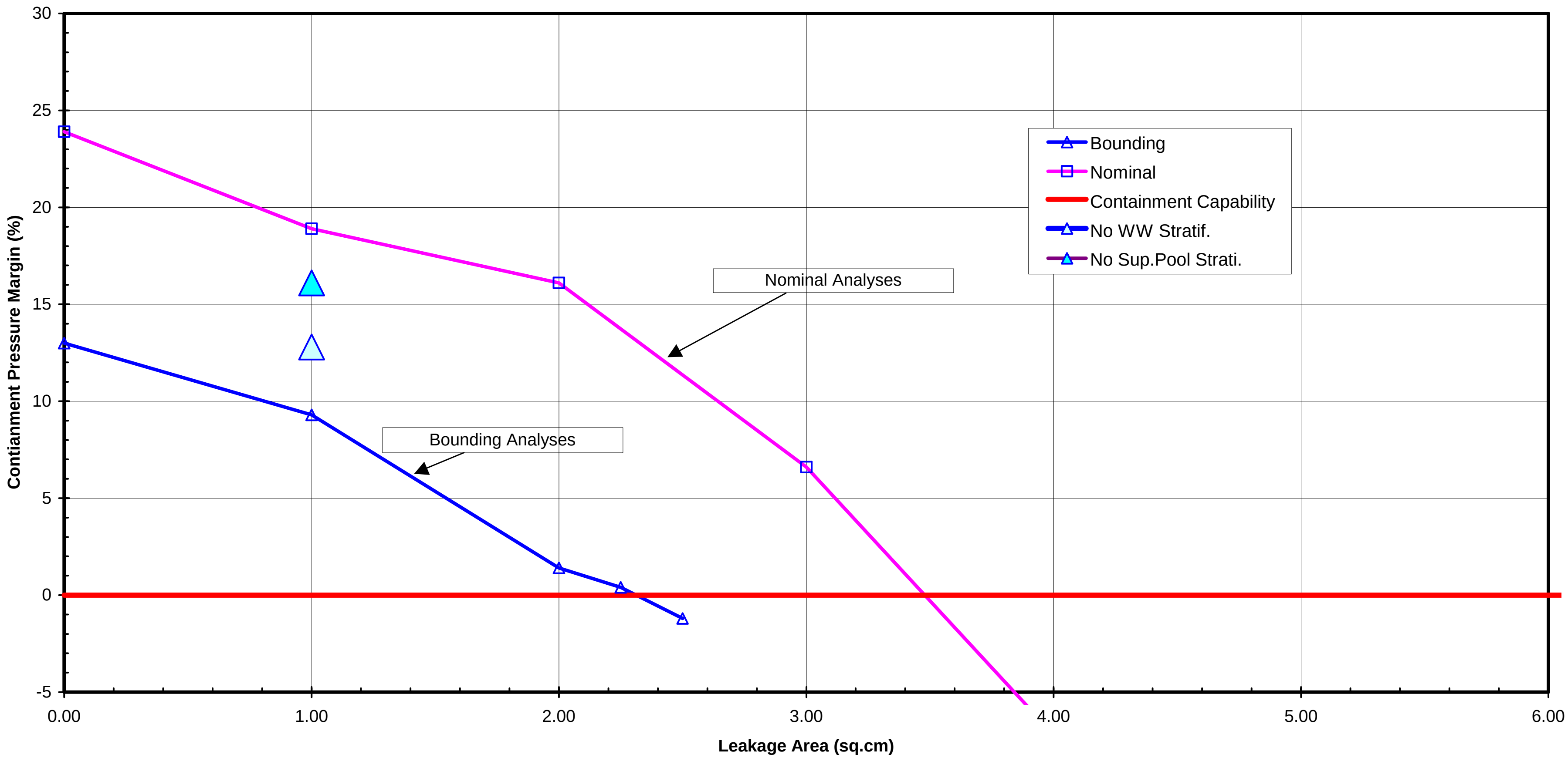
Table 6.2-8
Model Parameters for Containment Bounding Calculation

No.	Model Parameter	Base value	Distribution	Uncertainty (1 sigma)	Bounding case	Bounding value used
1	Crit Flow* (PIRT84)	1.0	Normal	9.5%	- 2 sigma	0.81
2	Decay Heat Mult.	1.0	Normal	~0.05	+ 2 sigma	D.H. + 2 sigma
3	Surf. HT** (PIRT07)	100	Uniform	1 to 200	Lower bound	1
4	PCC inlet Loss (k/A^2)	$1065 m^{-4}$	Normal	$260.0 m^{-4}$	+ 2 sigma	$1585 m^{-4}$
5	PCC HT (PIRT78)	1.0	Normal	7.9% (bias – 6.0%)	- 2 sigma	0.902
6	VB Loss (k/A^2)	$169.0 m^{-4}$	Normal	$21.18 m^{-4}$	+ 2 sigma	$211.4 m^{-4}$

* In Reference 6.2-1, the limiting case is the Main Steam Line Break and the value for PIRT84 is –2 sigma (or 0.81).

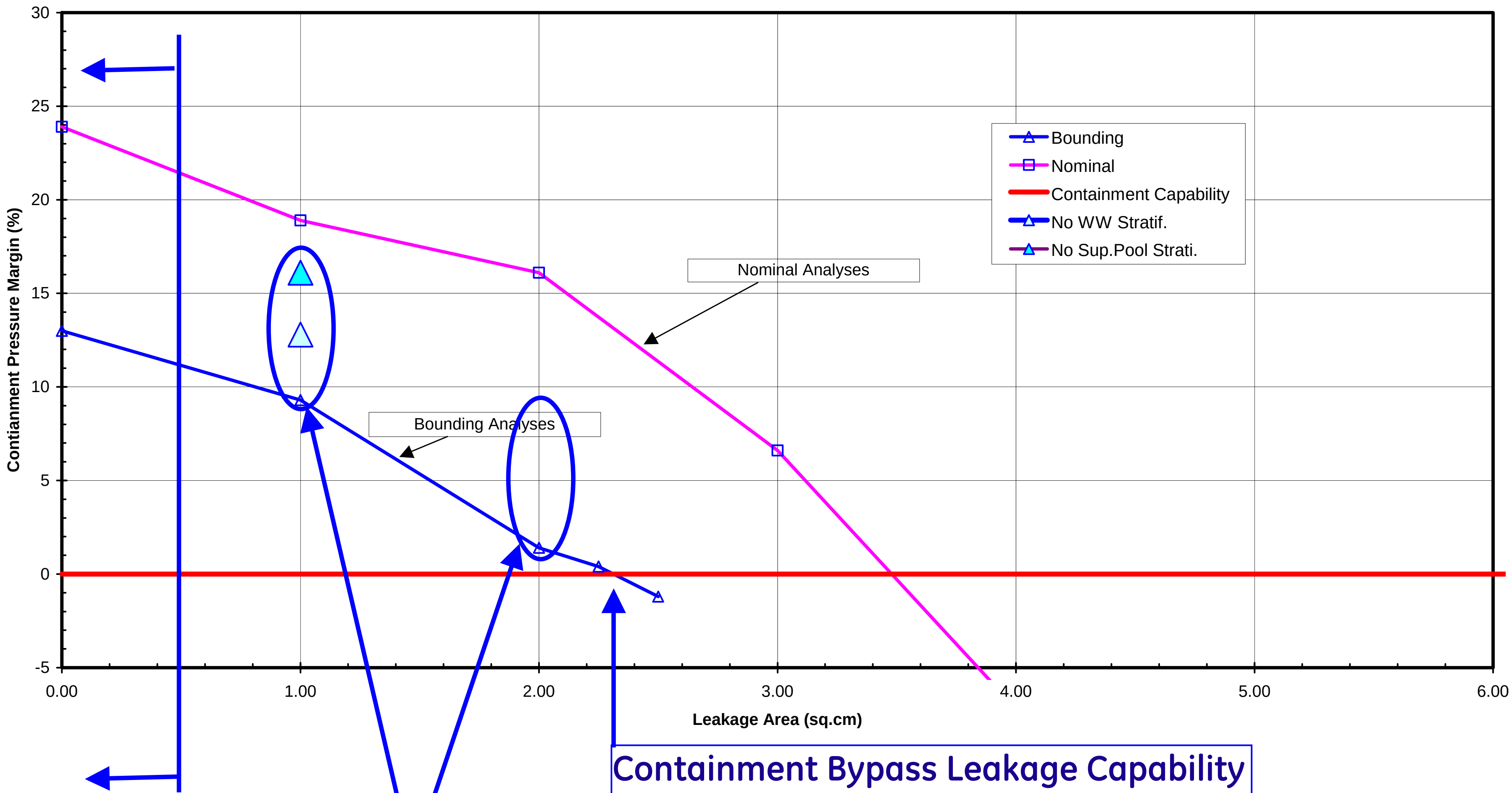
** Free surface to vapor heat transfer in wetwell.

ESBWR DW Pressure Margins versus Leakage Area



DRAFT RESULTS

ESBWR DW Pressure Margins versus Leakage Area



Containment Bypass Leakage Capability (No Mixing)

Realistic leakage through diaphragm floor << 0.5 cm^2

Realistic Modeling with mixing

DRAFT RESULTS

Summary

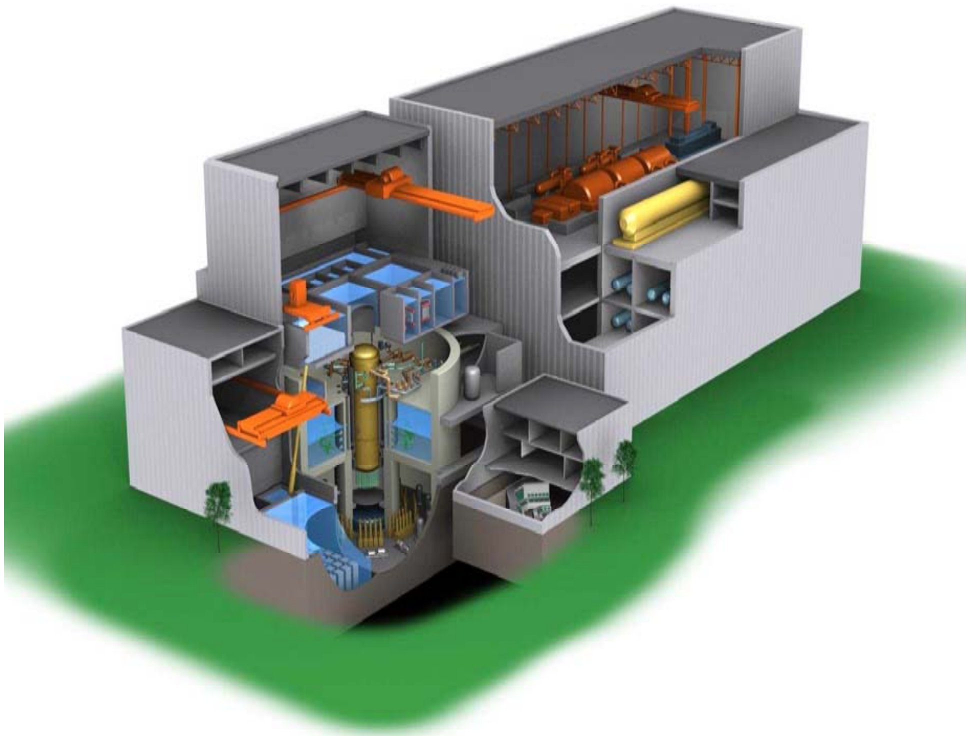
- ESBWR uses very conservative models: NO mixing in gas spaces and suppression pool, and limited heat sinks, in addition to bounding analysis conditions to establish the allowable leakage limit at 2 cm^2
- Test acceptance limit at 1 cm^2, or 50% of the containment bypass leakage capacity, is supported by substantial margin from analyses using more realistic conditions.

Containment Bypass Leakage Capability

Presented to NRC Staff

Wayne Marquino

March 5, 2008

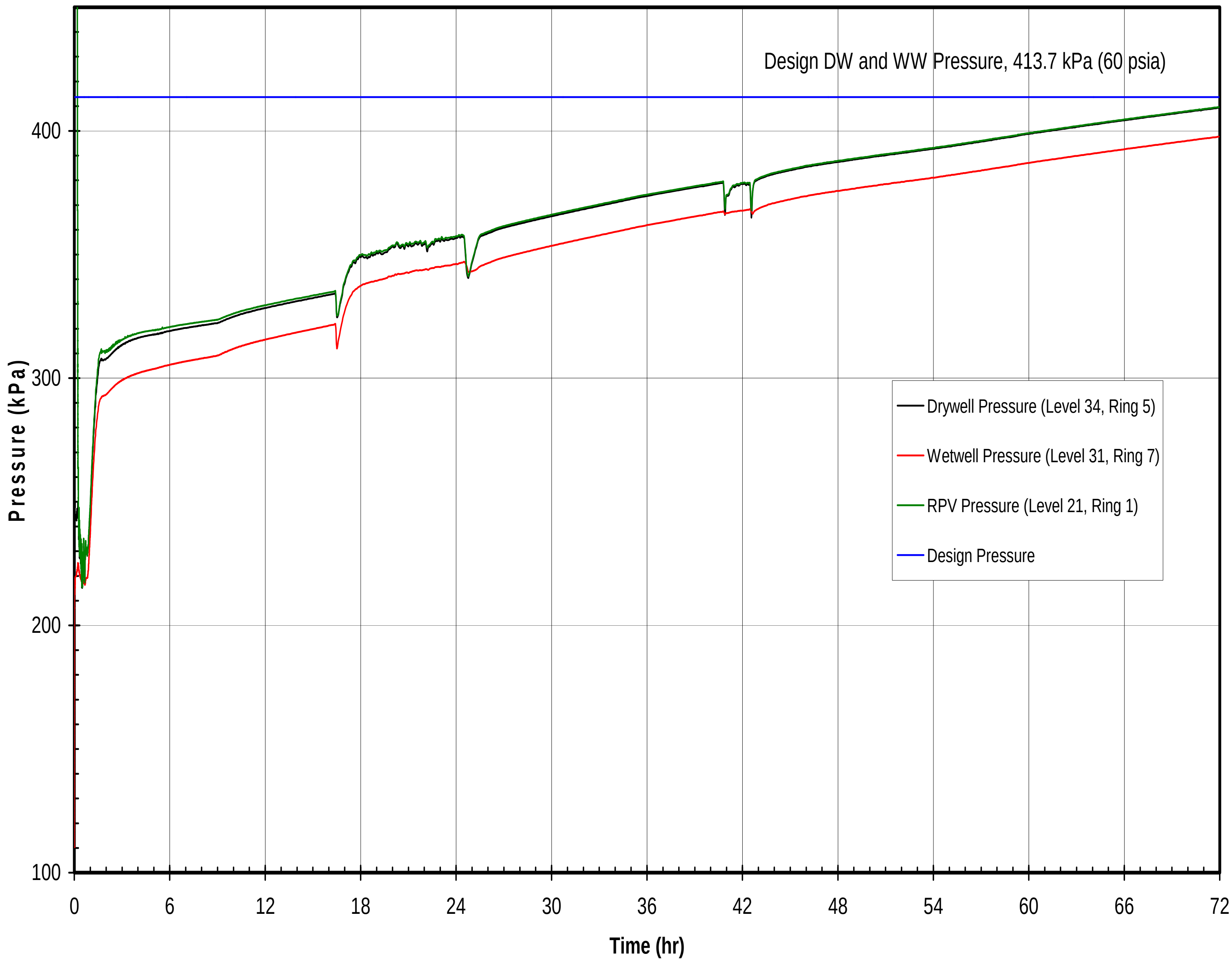


GE Hitachi Nuclear Energy

NRC RAI 6.2-145 S01

A. It is not clear to the staff whether the design leakage is 1 cm^2 (1.08E-03 ft^2), (A/%K) or 2 cm^2 (2.16E-03 ft^2), (A/%K). Please confirm that the results provided in DCD Tier 2, Rev 3, table 6.2-5 are based on 1 cm^2 (1.08E-03 ft^2), (A/%K) bypass leakage area. If so, please provide the containment peak pressure results using 2 cm^2 (2.16E-03 ft^2), (A/%K) as the assumed bypass leakage, and provide the margin to the containment design pressure.

Containment Bypass Leakage Capability



Justification for Containment Bypass Leakage Capability

- SRP includes determination of the bypass leakage capability for use in the surveillance test
- Use of bounding plant parameters and modeling conservatism is implicit in the calculation, therefore no additional margin required
- Containment robust, includes safety margins above the design pressure
- 50% margin provided for degradation between test intervals
- Testing performed at 95% confidence level

RAI 6.2-145 S01 GEH Response Plan

Consistent with the SRP, GE will provide LOCA analysis results in Section 6.2.1.1.3.5 which show the containment bypass leakage capability, for purposes of determining the Surveillance Requirement.

GEH Response will revise DCD LOCA Results in 6.2

- Nominal/Best Estimate 1 cm^2 (in Rev 4)
- Bounding 1 cm^2 (in Rev 4)
- Bounding Containment bypass leakage, capability – addition for Rev 5

ESBWR Containment Bypass Leakage

GEH will provide additional detail in the DCD Rev 5 for the containment bypass leakage capability cases as follows:

- For the MSL break, in addition to the statement on 2 cm2 area, the figures, sequence of events table and description of results which are provided in Section 6.2.1.1.3.5 for 1 cm2 bounding assumptions will be added to 6.2.1.1.5.1
- For the FW break, GEH will evaluate a 2 cm2 leakage case, the figures, sequence of events table and description of results which are provided in Section 6.2.1.1.3.5 for 1 cm2 bounding assumptions will be added to 6.2.1.1.5.1

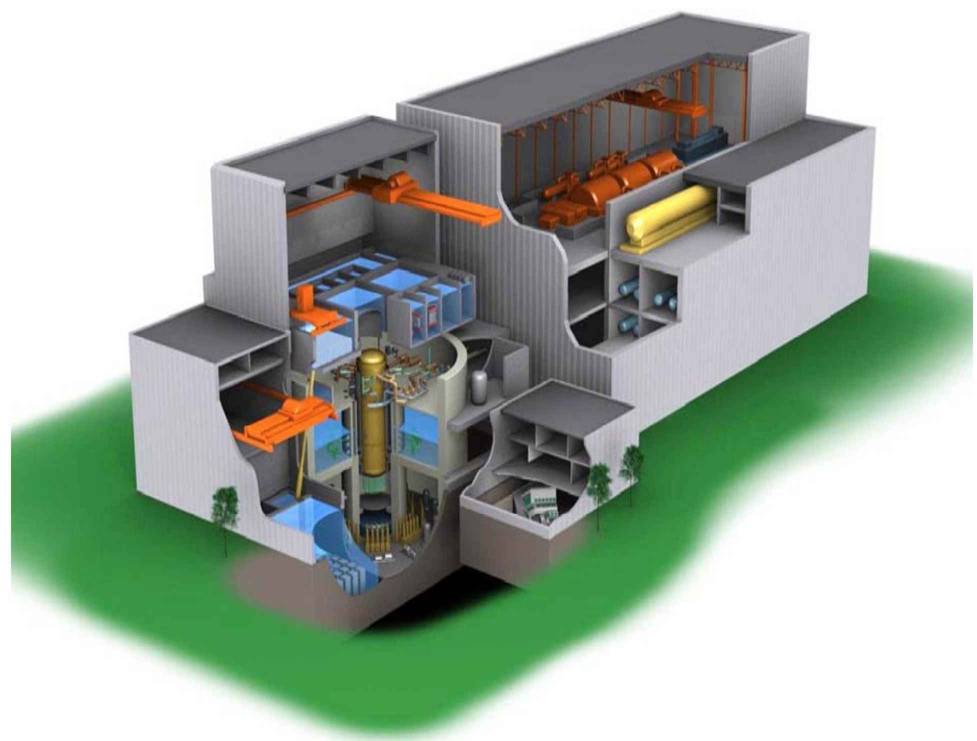
Summary

All results currently provided, remain in DCD.

- Only Section 6.2.1.1.5.1 will be affected by this change
- Additional MSLB bounding results for the Containment Bypass Leakage Capability will be added, and an additional scenario (FW break) will be added.

Reactor Building Holdup

Presented to NRC Staff



Wayne Marquino

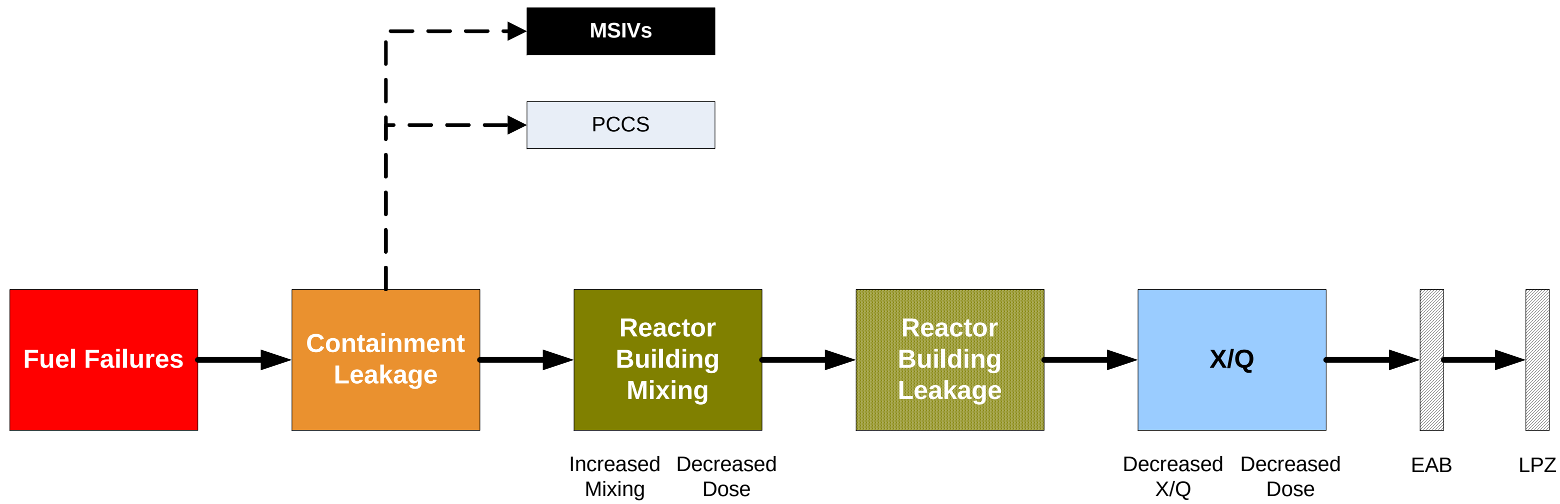
March 5, 2008

GE Hitachi Nuclear Energy

ESBWR design meets 10CFR52.47(a)(2)(iv) fission product release limits without a secondary containment

ESBWR Reactor Building is designed as a passive fission product holdup volume and credited in the LOCA dose analysis

- Robust Seismic Category 1 concrete structure
- Encloses Primary Containment
- Compartmentalized
- Airlocks/double doors
- Doors & hatches have monitoring and alarms
- Operability and Testing are prescribed in Technical Specifications



Assumption	Significant core melt	0.4% weight/day	40% assumed	50%/day assumed	Non-mechanistic Concurrent Conditions: High wind velocity – high building leakage Low wind velocity – stable atmosphere & low dispersion
Reality	No LOCA induced fuel failures	0.3% weight/day (LLRT @ 75% La) (ILRT @ 60% La) Containment depressurizes below design pressure	Verified by analysis	Verified by analysis, preop test and surveillance	Wind ↑ ➔ RB leakage ↑ Dose ↑ X/Q ↓ Dose ↓

X/Q Review

	Regulatory Limit 10CFR50.47(a)(2)(iv)	ESBWR as designed	ESBWR Candidate Site 1 estimated	ESBWR Candidate Site 2 estimated
LPZ (30 days)	≤ 25 Rem	20.37 Rem	1.54 Rem	7.7 Rem
EAB (2 hrs)	≤ 25 Rem	15.59 Rem	1.76 Rem	4.63 Rem
Control Room (30 days)	≤ 5 Rem	4.96 Rem	3.21 Rem	2.37 Rem

ESBWR design meets 10CFR52.47(a)(2)(iv) fission product release limits without a secondary containment

Analytical conservatisms:

- Accident source term
- Containment Leak Rate
- Impossible worst case combination of RB leakage and X/Q value
- (High Wind RB leakage/Low Wind X/Q)

Support for analytical margin

- No LOCA-induced fuel failures
- Containment Leak Rate
  - Supported by Containment Leak Rate testing
- Reactor Building leakage
  - Supported by analysis to confirm design margin assumptions
  - Supported by SR 3.6.3.1.1 & 2 (doors & hatches)
  - Supported by SR 3.6.3.1.4 exfiltration testing
- Reactor Building mixing
  - Gothic Reactor Building analysis to confirm analysis value
- X/Q default values used for DCD

ESBWR Dose limits are met without a secondary containment

Secondary Containment is not required by regulations