GSI-191/SUMP MEETING BETWEEN NRC AND WESTINGHOUSE ELECTRIC COMPANY ON THE AP1000 DESIGN CERTIFICATION AMENDMENT

September 2, 2009

Purpose of the Meeting

- Provide detailed information regarding current NRC RAI's on Chapter 6 "Engineered Safety Features" related to GSI 191 issues
- Improve Westinghouse submittal of information to resolve NRC concerns on containment sump design
- Promote continuous communication and feedback towards resolution of these RAI's and related issues
- Achieve a clear understanding of information needed to resolve long standing questions
- Agree on actions and schedule going forward

AP1000 Long-Term Cooling Debris Issues Resolution

September 2, 2009

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Meeting Objective

- Major progress has been made over last year + in raising and addressing issues with respect to AP1000 meeting GSI-191
- Some questions remain
- Westinghouse will propose today specific resolutions to these open RAIs
  - Actual RAI responses can be displayed if desired
  - Integrated DCD and ITAAC markups presented at end of day
- Objective is to get feedback from NRC on
  - Where proposed resolution seems acceptable
  - Where proposed resolution requires additional information
- Discuss schedule of RAI / Report submittals

AP1000 Progress on GSI-191 Resolution

- AP1000 Has Many Characteristics / Features That Addresses GSI-191
  - Greatly reduced recirculation flow rates
    - Use of passive systems and no spray system
  - Greatly reduced containment water velocities
    - Reduced flow rates and deep flood levels
  - No fibrous debris generated by LOCA
    - Use of MRI
    - Fire barriers and HVAC filters located outside ZOI

AP1000 Progress on GSI-191 Resolution

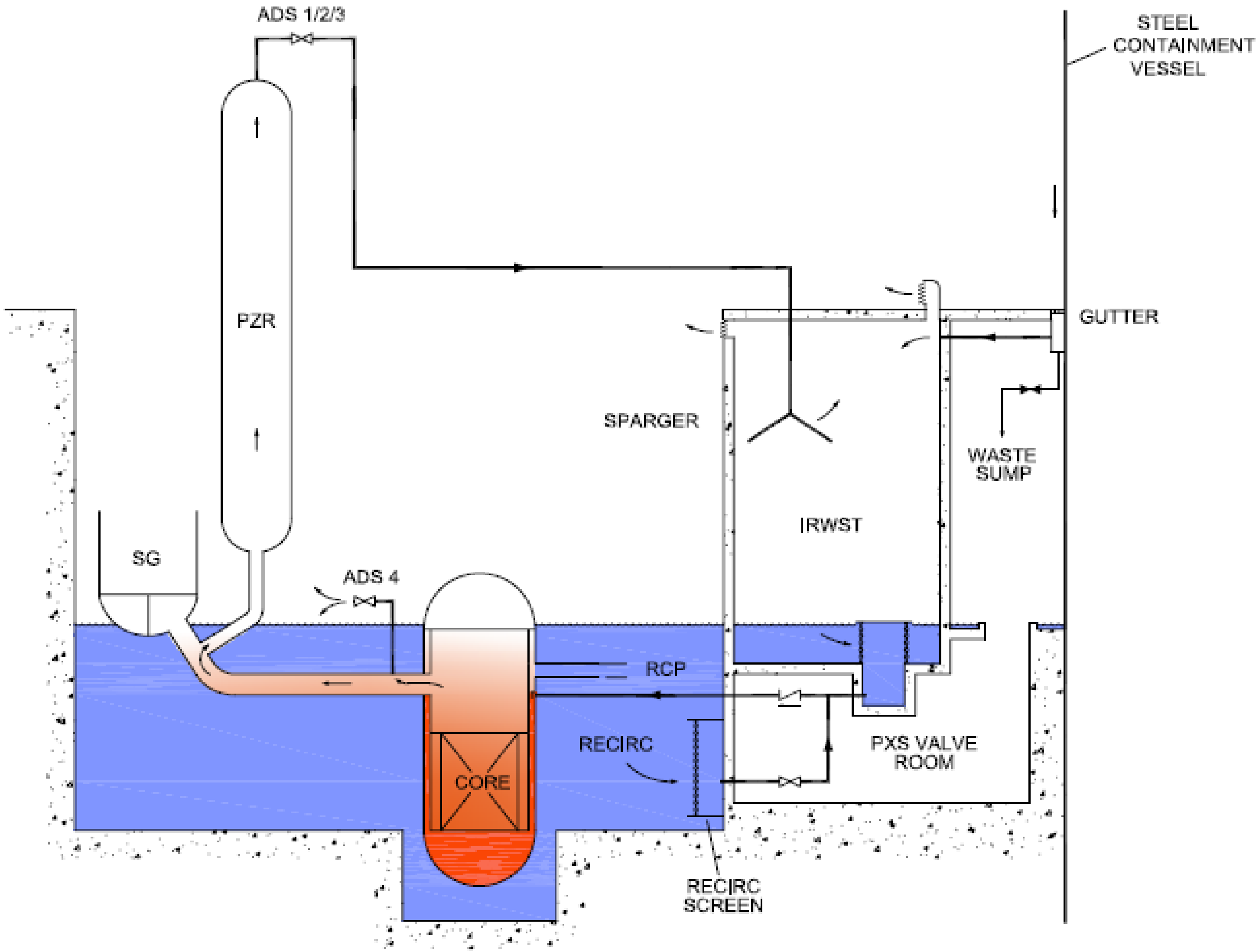
- AP1000 Has Many Characteristics / Features That Addresses GSI-191
  - Coatings
    - Walls, structures use high density coatings
      - DBA qualified; application not safety; doesn't transport
    - Engineered equipment use high density coatings
      - Application not safety; do not transport
  - Chemical Precipitates
    - With TSP chemistry, aluminum is primary concern
    - Aluminum has been greatly reduced
      - 400+ lb of aluminum in excore detectors has been enclosed in SS
      - Design limit of 60 lb established / tracked

AP1000 Progress on GSI-191 Resolution

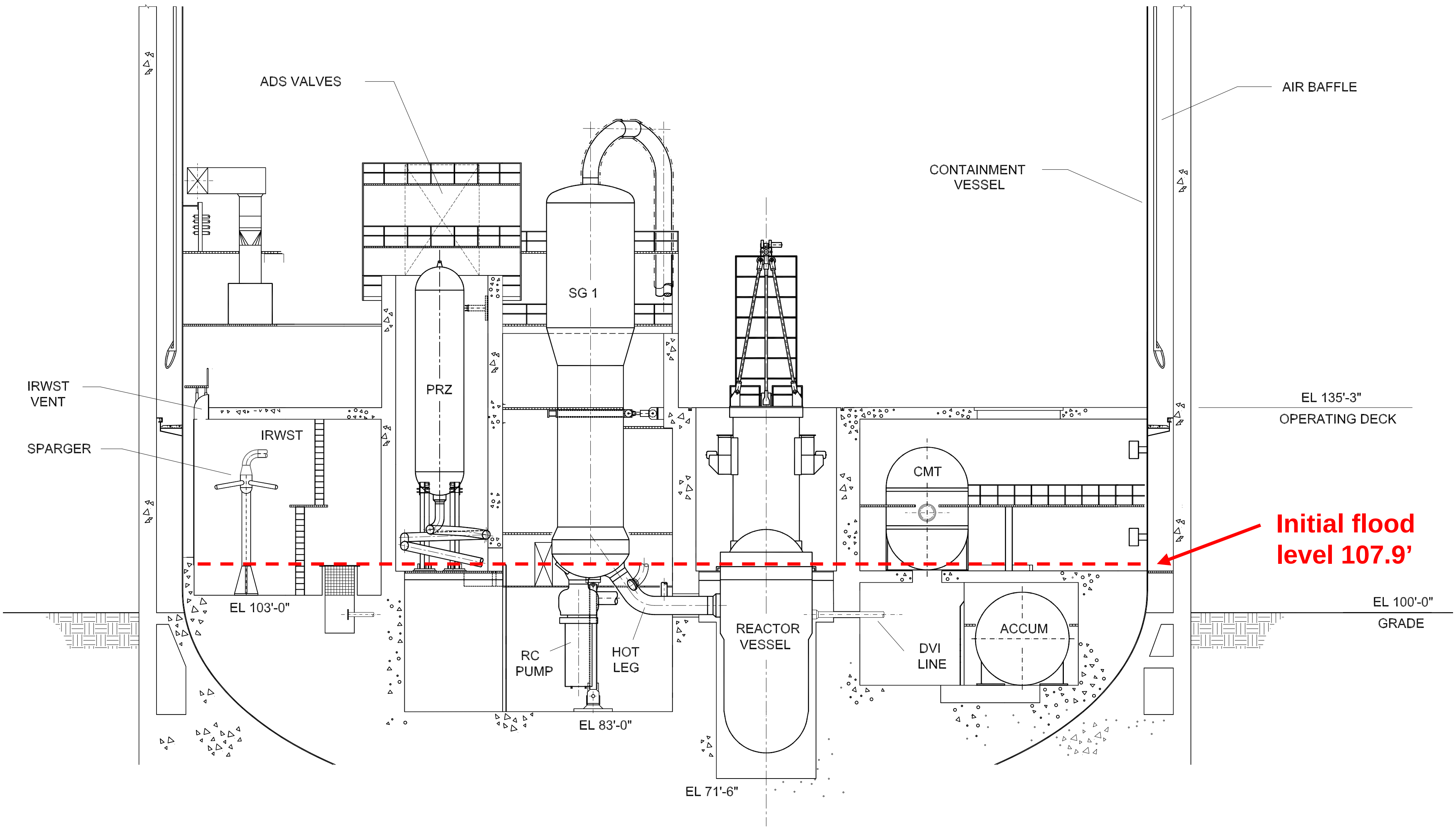
- AP1000 Has Many Characteristics / Features That Addresses GSI-191
  - Signs, Tags, Caulking – required to be high density
    - Do not transport
  - Screen designs
    - Large surface areas (total CR = 5000 ft2, IRWST = 1000 ft2)
    - Advanced “pocket” design reduces head loss
    - Protective plates located above containment recirc (CR) screens
      - Prevents failed coatings from transporting to CR screens

Modifications / Additions Proposed In Today’s Meeting Are Not Listed Above

LOCA Long Term Cooling Showing Initial Recirc Flood Up Level



PSI Equipment Layout



Order of Discussion of RAIs

SRSB	16	a	Percent bypass	DEDVI vs DECLB
SRSB	16	b	Percent bypass	why use DEDVI for sensitivity
SRSB	16	c	Percent bypass	fiber pass through
CIB1	24	a	ZOI coatings	ZOI used vs coating type
CIB1	24	b	ZOI coatings	ZOI coating amounts
CIB1	24	c	ZOI coatings	use of Keeler & Long tests for AP1000
CIB1	24	d	ZOI coatings	ZOI summary
SRSB	23		FA test report	why reduce flow for test #16
SPCV	21	a	Screen test report	reduced max flows
SPCV	21	b	Screen test report	RNS operability w debris
SRSB	24		FA test report	diff vs fiber; need more tests?
SRSB	21		FA test report	why only report 13 of 16 tests
SRSB	22		FA test report	explain differences vs AlOOH add
SPCV	24	a	ITAAC issues	insulation suitable equivalent
SPCV	24	b	ITAAC issues	DCD test report for insulation
SPCV	24	c	ITAAC issues	caulking suitable equivalent
SPCV	19	a	Screen design analysis	
SPCV	19	b	Screen design analysis	
SPCV	19	c	Screen design analysis	ITAAC
SPCV	21	c	Screen test report	fiber clumping
SPCV	21	d	Screen test report	test termination
SPCV	21	e	Screen test report	water depth vs vortexing
SPCV	21	f	Screen test report	flashing in IRWST screen
SPCV	21	g	Screen test report	diff is flow/temp vs analysis
SPCV	23	a	Upstream effects	other break locations > screens
SPCV	23	b	Upstream effects	wall-to-wall IRWST level
SPCV	22	a	ZOI definition	ZOI vs insulation type
SPCV	22	b	ZOI definition	ZOI for Min-K & Koolphen-K
SRSB	17		Sensitivity analysis	include flow skirt
SRSB	18		Sensitivity analysis	why only initial & not wall-to-wall
SRSB	19		Sensitivity analysis	DVI elevation?
SRSB	20		Bump up factor	Fiber included?

SPCV-16, Percent Bypass

a) Use DECLB as design basis
   - 90% bypass (instead of 75% bypass)
   - Reduce fiber limit in containment from 8 lb to 6.6 lb
     - Same amount of fiber transported to core
     - No need to repeat AP1000 tests
     - Several months ago AP1000 DCD was 6 lb

b) Use DEDVI for sensitivity studies
   - Base on limiting core / screen head losses
     - Consistent with more debris from DECLB
   - With more limiting DEDVI T&H conditions
     - Earlier start recirc (higher decay heat)
     - Lower containment water level

SPCV-16, Percent Bypass

c) Fiber passing through AP1000 screen is insignificant

- 90% fiber transports directly to core (6.6 * 90% = 5.94 lb)
- Only 10% fiber transport to screen (6.6 * 10% = 0.66 lb)
- Only 1% passes through the screen (0.66 * 1% = 0.007 lb)
    - Pass through based on testing performed by Los Alamos
        - LA-UR-04-5416, “Screen Penetration Test Report”
    - Testing shows for AP1000 conditions (velocities, screen hole size, and fiber length) the pass through is 1%

CIB1-24; ZOI Coating Amounts

a) ZOIs used for AP1000 assessments
- 4 IDs Epoxy
- 5 IDs Inorganic Zinc

b) Amount of ZOI coatings
- Establish design limit – include in DCD
- Don’t know all coating amounts at this time
  - OEM coatings (valves, etc) not known until purchased
- Base on sphere surface area of largest pipe
  - Survey of operating plants ZOIs indicates typical ZOI is only 50% of sphere area
  - AP1000 will use 100% to be conservative
  - Largest pipe of interest is the CL (22” ID)

CIB1-24; ZOI Coating Amounts

- HL pipe is not limiting for AP1000
  - Core - Fiber entering the HL is not challenging because at worst it sits on top of fuel assembly, doesn't plug up inlet nozzle and collect particles and chemical precipitates
  - CR screen – HL case will be limiting but head loss will still be much less than IRWST
    - » Quantitative comparison of screen loading provided in RAI response
  - IRWST screen – HL case will be less limiting than DVI
    - » 2 screen will be in operation
    - » No chemicals can get into IRWST in HL case
    - » Chemicals can get into IRWST in DVI case resulting in greater DP

CIB1-24; ZOI Coating Amounts

- Sphere area based on CL pipe (epoxy)
  - 4 * 22" = 88"
  - Area = 4 * 3.14 * (88/2)^2 = 169 ft2
- Epoxy amount = 10.6 lb (calculated)
- IOZ amount = 5.3 lb (assumed)
  - Use of IOZ will be severely restricted inside containment
    - » Inside surface of containment vessel (outside ZOI)
    - » Hot surfaces on OEM components
    - » Any IOZ used inside containment will be safety to prevent failure / transport outside ZOI
- Total ZOI coatings = 10.6+5.3=15.9 roundup to 20 lb
- Reduce latent debris by same 150 – 20 = 130 lb
  - Still bounds many plants GSI-191 submittals
  - Consistent with current AP1000 tests, no need to retest

CIB1-24; ZOI Coating Amounts

c) Use safety epoxy failure sizes for AP1000
- Epoxy material used on walls, ceiling, structures is qualified
- Epoxy used on OEM is same coating material as DBA qualified except without safety paper work
- Application and inspection will be controlled by procedures although not safety
  - Will be covered by QA although not Appendix B

d) Summary of coating ZOI approach
- ZOI coating limit defined as 20 lb fine particles that transport
  - Latent debris amount reduced to keep total same, no retest
- Outside ZOI no coating transport to screens
  - Non-safety IOZ eliminated
  - Failure size of epoxy based on Keller & Long report

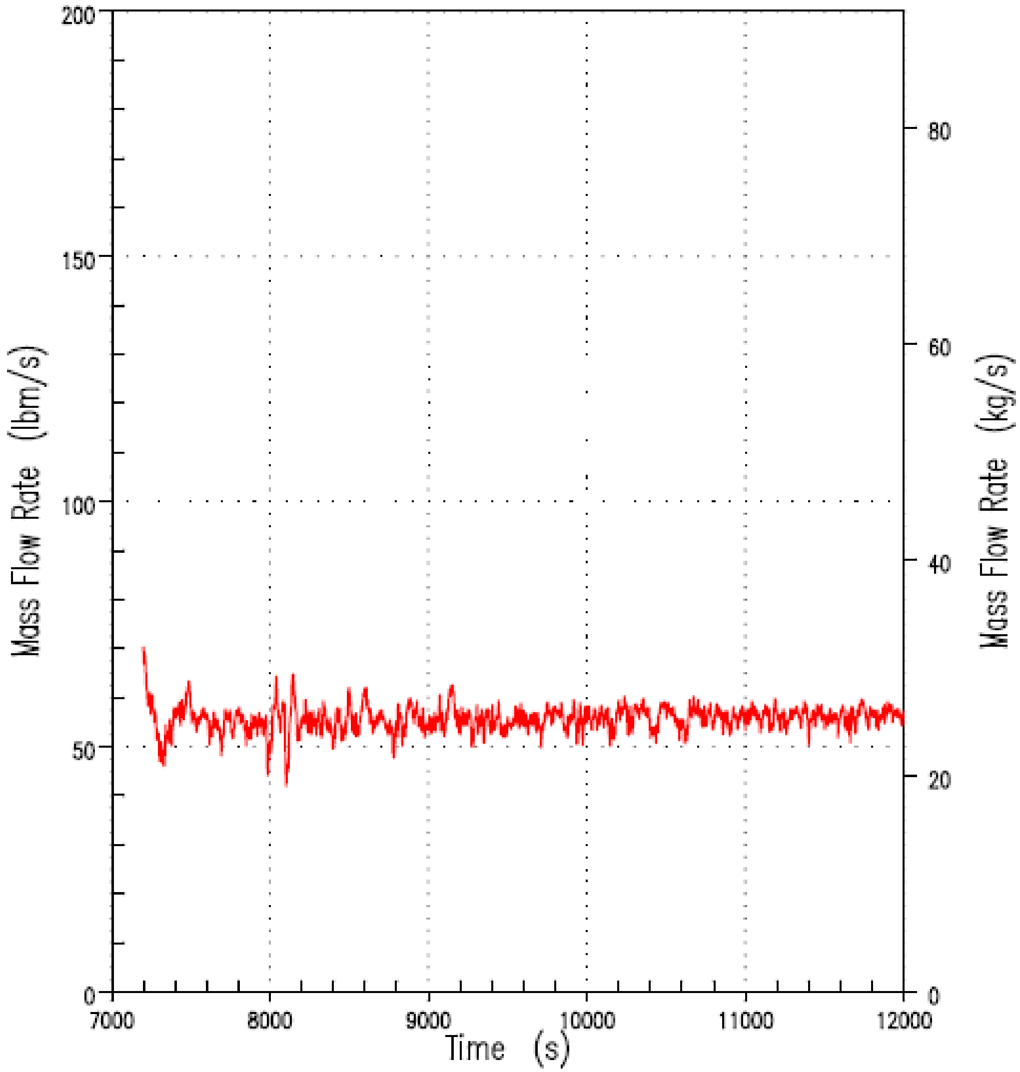
SRSB-23; FA Test Report, Reduced Flow

- Why reduce flow for test #16
  - AP1000 has run 3 LTC sensitivity analysis with increasing amounts of assumed head loss across core and screens
    - As head losses were increased the flow rates through the core decreased
      - To be expected since plant operates in natural circulation
      - Different that active plants where flow remains constant as long as pumps have enough NPSH
    - Most FA tests were run with a higher flow rate that was based on clean core / screens with high head loss limit
    - Need to verify head loss at reduced flow used in sensitivity analysis
      - Running test at reduced flow avoids need to extrapolate the test flow / head loss to the sensitivity analysis flow / head loss
      - Eliminates uncertainty

SRSB-23; FA Test Report, Reduced Flow

- Why use nominal flow instead of peak flow
  - During LTC post LOCA operation the core flow fluctuates
    - With LTC case #3 limiting debris DPs, min/max vary +/- 9%
    - When flow varies, head loss in analysis varies
      - Analysis assumes DP varies with flow squared
      - Using Nominal flow reduces max extrapolate from 18% to 9%
    - Flow fluctuation is relatively small, extrapolation is small
    - Since the flow is lower than nominal half the time, errors in extrapolation tend to cancel out
  - Margins on core cooling are large during LTC
    - There is 1.5’ collapsed water level in HL
    - Provides large core water inventory above top of core
- DCD will be revised to reduce flow rates and allowable DPs

LTC Sensitivity Analysis Case #3
Intact DVI Line Injection Flow



SPCV-21; Screen Test Report

a) Reduced max flow rates
- See response to SRSB-23

b) RNS operation support
- The RNS is not a safety system
- It is a DID system that is credited in PRA for some LOCAs
  - Not credited for DVI or large LOCAs
  - Debris transport is more limiting during these LOCAs
    - More screen bypass into core
    - Backflow into IRWST (brings chemicals into IRWST)
    - Only one IRWST operates
- Safety case debris loadings are very conservative
  - RNS operation need not use same level of conservatism
- RNS operation is expected to not be limited by debris
  - Operating procedures will advise operators to throttle back flow if there are indications of cavitation

SRSB-24; FA Test Report, Fiber Amounts

- Tests vs Fiber Types / Amounts
  - Tests #5 vs #3 results seem inconsistent
    - Test #5 used unbaked (clumpy) NUKON which makes its results questionable
  - Test #6 vs #8 results seem inconsistent
    - The reason #8 had a lower head loss with the same amount of fiber was that it used a lower rate of chemical addition
  - Test #8 - #11 tested different fiber types
    - Test #11 had highest head loss, #8 had slightly less
    - Fiber type from #8 was used as design basis because
      - DP was only 19% more in test #11
      - Fiber makeup in test #11
        - » Significant amounts of cloth fiber and hair not expected
        - » Difficult to make and was expected to result in variable results (hand separated cloth fibers and human hair)

SRSB-24; FA Test Report, Fiber Amounts

- Tests vs Fiber Types / Amounts
  - Tests #13 vs #6 and #8 results seem inconsistent
    - #13 has more fiber than either #6 & #8
      - Showed that more fiber increases DP
    - Chemical addition was slowest in #13, but greater amount of fiber was more important
- Additional Testing To Confirm Acceptability
  - Additional tests are not needed because test #16 used the limiting AP1000 conditions and showed margin to DP limit
    - Lower flows / DP limit from LTC sensitivity case #3
    - Debris loads (particle, fiber and chemical)
    - Margin was large, 28%

SRSB-21; Why Report 13 of 16 FA Tests

- Three FA tests were not considered valid and therefore data was not reported
  - Test #7
    - Test loop was modified to add a pump bypass line
    - Malfunctioned resulting in too little flow through the test fixture
  - Test #12
    - The chemicals were mixed in the test loop instead of outside the loop (not per WCAP-16530-NP-A)
    - The magnetic loop flow meter reading fluctuated due to conductivity changes introduced by the chemical addition method – this caused the loop flow to deviate from required flow

SRSB-21; Why Report 13 of 16 FA Tests

- Test #15
  - After this test was run, it was determined that the flow rate and DP limit should have been lower (ie based on LTC sensitivity case #3) as was used in test #16

SRSB-22; FA Test Differences for AlOOH

- Current understanding of AlOOH additions
  - Early FA tests were run with a few large AlOOH additions (test #6)
    - Resulted in large initial DP peak and subsequent reduction in DP when additional chemicals were added
    - Reduction in DP with additional chemical additions seems to be caused by development of break through channels or bore holes when the DP became high enough
  - Next tests were run with smaller initial batches (test #8)
    - Reduced initial peak, still see reduction later
  - Final tests were run with continuous initial chemical addition (tests #13, #14, #16)
    - Greatly reduced / eliminated peak, later reduction smaller
    - Min addition rates > twice plant production

SPCV-24; ITAAC Ques Insulation / Caulking

a) ITAAC for MRI suitable equivalent needs to be more than inspection
   - Resolution – agreed, will add need for test report that exists and concludes that other insulation is equivalent

b) DCD needs to define testing to support suitable equivalent to MRI
   - Resolution – agreed, will add words to require
     - Other insulation be tested to conditions that bounds AP1000 conditions and insulation is not damaged
       – if damaged it is shown that it doesn't transport (using test or analysis)
     - NRC has reviewed and approved the test report

SPCV-24; ITAAC Ques Insulation/Caulking

c) ITAAC for Caulking, Tags, Signs

- Resolution - use similar approach as for MRI suitable equivalent
  - Inspect if signs, tags or caulking have density > 100 lb/ft3
  - If located above flood level and density < 100 lb/ft3
    - OK if located inside cabinet or enclosure
    - Otherwise need report that
      - Shows will not transport under AP1000 conditions
      - Has been reviewed and approved by NRC

SPCV-19; Screen Design Analysis

a) and b) relate to Westinghouse's Revision 1 response

- This response did not address the basic NRC concern
- Item c) below responds to the NRC concern

c) Screen structural analysis

- Resolution – Add ITAAC addressing structural design
  - Currently have ITAAC confirming screen meets seismic requirements (see ITAAC Table 2.2.3-4, item 5.a)
  - Will expand this ITAAC to also include post accident operating loads (head loss and debris weight)
    - Limits for structural design will include margins on top of thermal hydraulic limits
    - For Example for IRWST

Case	Max Forward		Max Reverse	
Number screens	1		1	
Weight total debris	250	lb	0	lb
Flow rate / direction	2500	gpm (forward)	6000	gpm (reverse)
Max DP	5	psi	1	psi

SPCV-21; Screen Test Fiber Preparation

c) Screen test fiber preparation:

- **Fiber Preparation**:
  - NUKON has baked to remove binder
  - NUKON was then shredded
  - NUKON was then put in container of loop water prior to loop addition and stirred
    - Ensured NUKON was wet and clumps broken up
- Test #7 indicated fiber preparation was successful
  - Significant DP measured – indicates fiber bed formed across screen surface area
  - Pictures of debris after test indicates debris bed formed
  - Fiber clumps were sufficiently broken up to allow fiber bed to form

SPCV-21; Screen Test Fiber Preparation

SPCV-21; Screen Test Fiber Preparation

SPCV-21; Screen Test Termination

d) **Screen test termination**:

- The screen test termination criteria was based on the rate of change of pressure drop across the screen.
  - When rate of change of the pressure drop across the screen decreases to an absolute value less than 0.05 inches of water equivalent per hour the test is terminated.

SPCV-21;

e) Water levels in test vs fixture:

- The height of the screen in the screen face is 48”.
- The height from the bottom of the flume to the top of the screen face is 49.8”.
- Shown on figure on next slide.

- Test water level was 52.5” or 2.7” above top face of screen
- In plant
  - Minimum initial water level is 107.9” or 58.8” above the tank bottom.
  - Top face of the screen is 56” above the tank bottom
  - Minimum water level is 2.8” above the screen.

Screen Test Fixture Height

48 in.
(Not Including Flange)

49.8 in.
(from inside Flume floor
to top of the filter opening)

SPCV-21; Flashing Across IRWST Screen

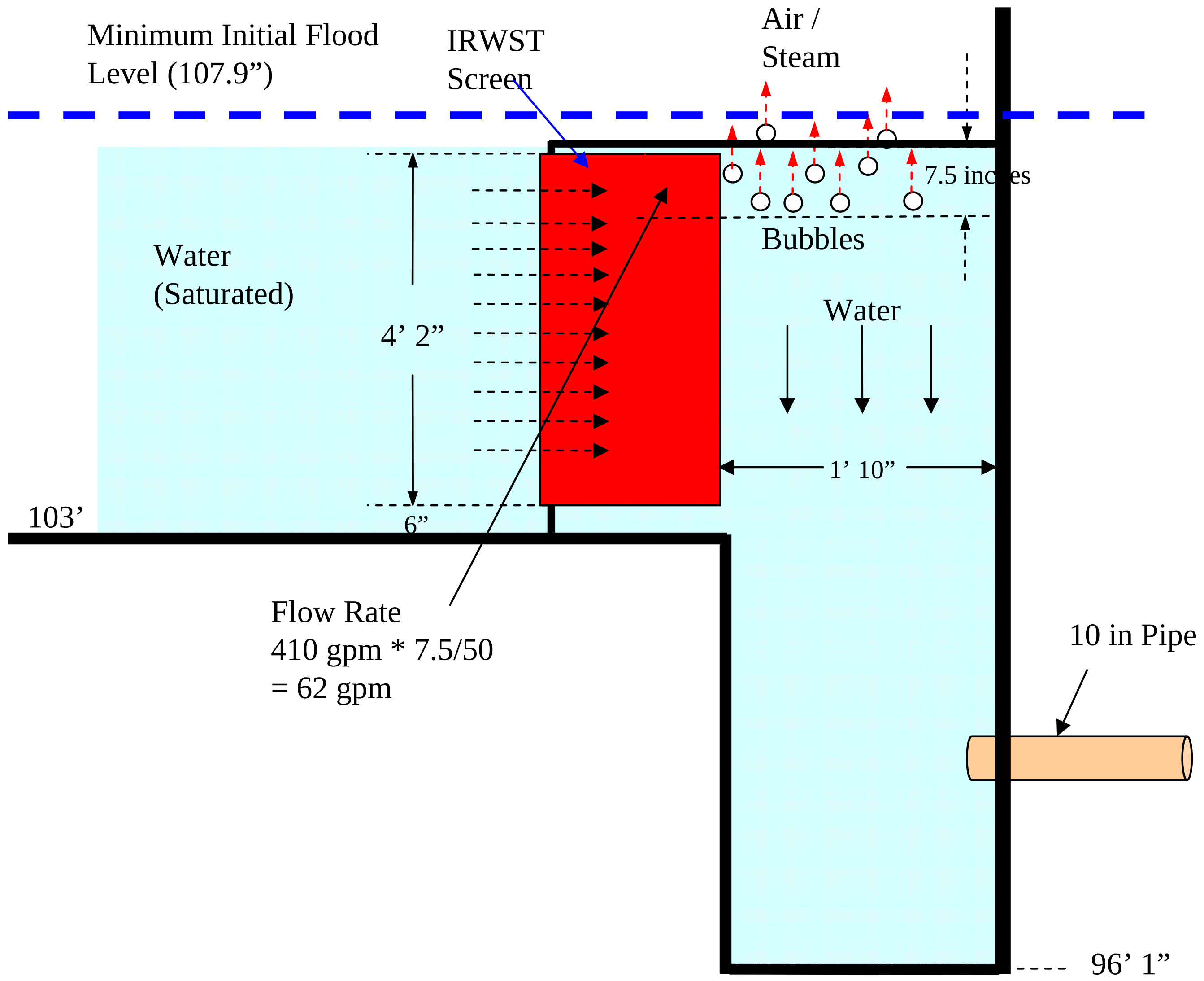
f) Flashing across IRWST screen

- For small LOCAs, there will be extended operation of the PRHR HX prior to the actuation of ADS
  - Will heat up IRWST to saturation
  - In long-term IRWST will become sub-cooled
    - Passive containment steam condensate is sub-cooled 30-40F
- Two limiting saturated water levels are considered
  - One limiting level is just above top of sceen such that water seals screen from IRWST gas space
    - Flashing could occur across screen
  - Another limiting case is a slightly lower level when water no longer seals off IRWST gas space
    - Flashing will no longer occur
  - Min initial recirc level will be at 107.9’, about 2.8” above top screen

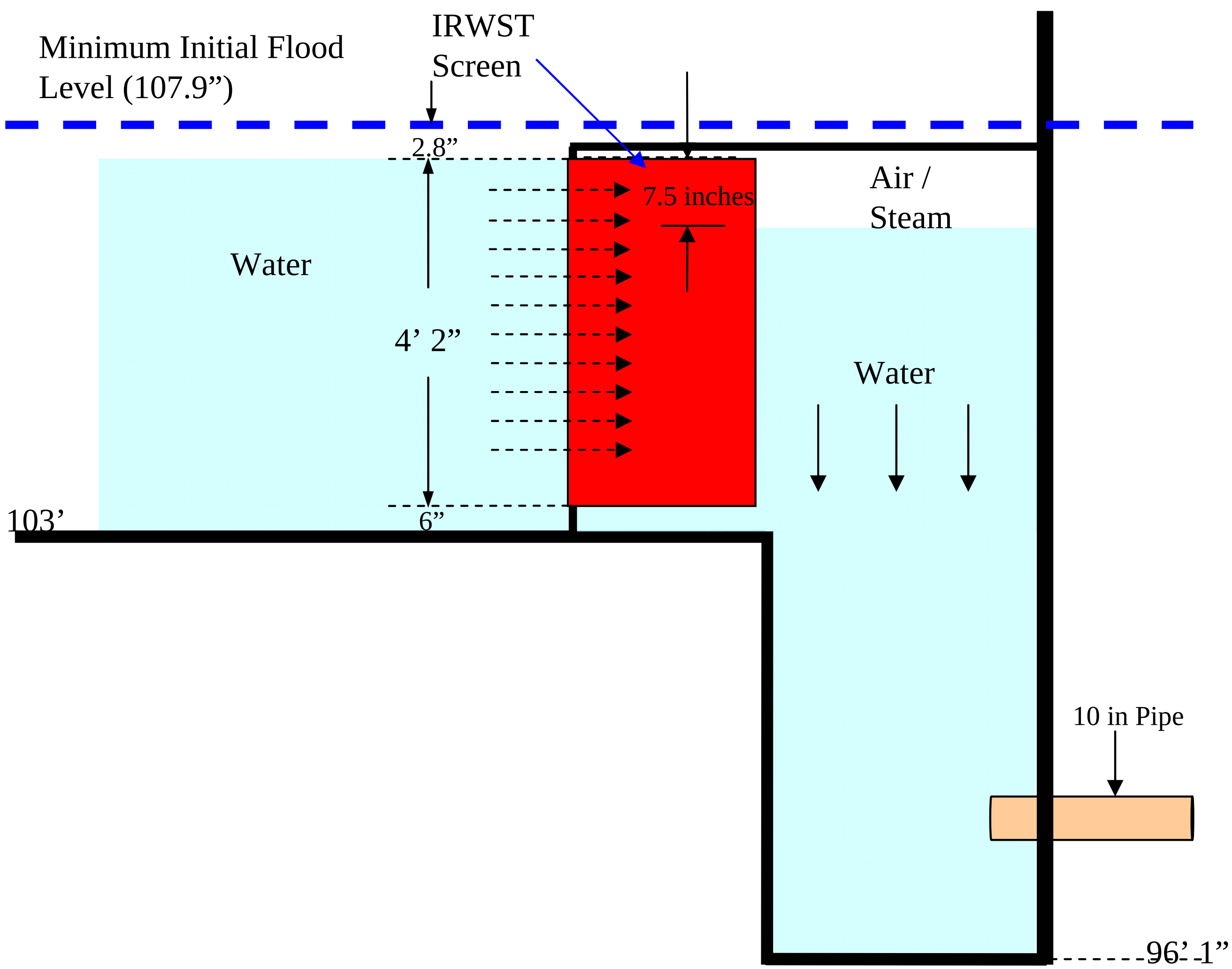
SPCV-21; Flashing Across IRWST Screen

- Flashing across IRWST screen
  - The steam bubble rise velocity and the water down flow velocities are calculated and compared
  - Steam bubble rise is calc based on
    - Lowest level where bubbles can occur is 7.5” below the top of the screen based on max head loss across screen.
    - The water level is at the top of the IRWST screen.
    - Steam bubble diameter is 1/16” (hole ID through screen)
  - Calc steam bubble rise velocity (> 15cm/s) is much higher than the water down flow velocity (0.3 cm/s) such that the bubbles will not be entrained into the PXS injection flow

SPCV-21; Flashing Across IRWST Screen



SPCV-21; Flashing Across IRWST Screen



SPCV-21; c) – g)

g) Differences between LTC analysis and screen test:

- The flow rates calculated in the LTC analysis were converted from lbm/sec to gpm based on the associated temperature and pressure.
- The head loss limit was then taken from the LTC analysis for the most limiting head loss at the selected flow rate.
- This head loss limit was then used as the acceptance criteria for the screen testing.

SPCV-23 – Blockage / Wall-to-Wall Floodup Case

a. Other LOCA Break Locations

1. CMT inlet lines outside loop compartments
2. DVI injection lines inside the PXS equipment rooms
3. Pzr lines connected to the top of the Pressurizer

All flow paths for these break locations can flow through stair wells to the loop compartments. Details provided in RAI response. Curbs are provided around openings through 107’ 2” floor

Several cross-connects are provided between the refueling canal and containment

1. 6” drain line with series check valves
2. 20” overflow line
3. Locked open valve between refueling canal and containment

SPCV-23 – Blockage / Wall-to-Wall Floodup Case

b. SPCV-21 (f) provides information on the potential for flashing across the IRWST screens.

- For the wall-to-wall flood-up case, the IRWST level will drop below the top of the screen.
  - Occurs after about 2 weeks into the transient
  - With 70% less decay heat.
  - Has less steaming and needs significantly less flow through the core
  - Has a collapsed liquid level which is several feet above the core.

- Surface area of the IRWST is significantly less than the containment.
  - If the IRWST water level increases to half the IRWST screen height, the containment level will only drop about 1 foot.

SPCV-22 – ZOI / Insulation

a. The following table shows the applicable ZOI values and what will be added to the AP1000 DCD:

Insulation Types	ZOI Values
Jacketed Nukon (fiberglass)	2.4
Unjacketed Nukon	17
K-wool	5.4
Min - K	28.6

To simplify the AP1000 DCD the ZOIs will be listed as 29 for Min-K and 20 for other insulation types

b. Koolphen-K is not used in AP1000.

Min-K has limited use. When inside the ZOI, the min-K is encapsulated by steel plates with a weld along the length of the seams

SRSB-17; LTC Sensitivity Analysis
Was RV Flow Skirt Modeled?

Was the flow skirt modeled in the Long Term Cooling Sensitivities

- Response
  - The flow skirt is modeled in the WCOBRA/TRAC runs in the LTC sensitivity analysis (APP-PXS-GLR-001)

SRSB-18; LTC Sensitivity Analysis
Why Was Wall-To-Wall Not Included

- Why the wall-to-wall flood up case was not included in the LTC sensitivities in APP-PXS-GLR-001
- Response
  - Wall-to-wall floodup case is not limiting from a long term cooling perspective.
    - Collapsed water level in core is x ft higher in WTW case
  - The water flow rate needed for delivery to the core is much less because of the reduction in decay heat for this case.

SRSB-19; LTC Sensitivity Analysis
Is DVI Elevation Consistent

- Is there inconsistency in the DVI line elevation?
  - A prior RAI response indicated that the DVI line elevation was 97 ft not the correct value of 99 ft 7 inches.
- Response
  - The correct DVI line nozzle elevation is 99 ft 7 inches
    - This elevation is what is used in the WCOBRA/TRAC model.
    - The 97 ft elevation is the point at which the IRWST injection pipe from the IRWST/containment sump enters the TRAC component.

SRSB-20 - LOCADM

- LOCADM “bump-up” factor includes the equivalent of 22.5 lbm fiber which more than bounds the 6.6 lbm fiber in containment.

Show ITAAC / DCD Changes (APP-GW

Review of Action Items

Conclusions and Schedule Going Forward