UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

September 24, 2009

LICENSEE: Entergy Nuclear Operations, Inc.

FACILITY: Indian Point Nuclear Generating Unit Nos. 2 and 3

SUBJECT: SUMMARY OF SEPTEMBER 16, 2009, CONFERENCE CALL WITH ENTERGY ON THEIR PROPOSED RESPONSE TO A REQUEST FOR ADDITIONAL INFORMATION ON GENERIC LETTER 2004-02 (TAC NOS. MC4689 AND MC4690)

On September 16, 2009, a Category 1 public conference call was held between the Nuclear Regulatory Commission (NRC) staff and representatives of Entergy Nuclear Operations, Inc. (Entergy) and Entergy's contractors, Enercon and Alion. A list of call participants is provided as Enclosure 1. The purpose of the call was to discuss Entergy's proposed response to the NRC staff's request for additional information (RAI) dated November 19, 2008, which is publicly available in the NRC's Agencywide Documents Access and Management System (ADAMS) under accession number ML083230054. The NRC's RAI letter was in response to Entergy's submittal for NRC Generic Letter (GL) 2004-02, "Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized Water Reactors," for Indian Point Nuclear Generating Unit Nos. 2 and 3 (IP2 and IP3). The NRC staff has been conducting calls with all licensees who are responding to RAIs on GL 2004-02 with the intent of providing NRC guidance in order to reduce the need for additional rounds of RAIs.

Entergy presented their proposed responses to the 23 RAIs. Their responses were outlined on the slides provided as Enclosure 2. The NRC staff generally found the method of response acceptable, however, there were some comments from the NRC staff. For RAI 1, the NRC staff questioned the assumption of 40% holdup of small fiberglass on grating, and the size distribution of the small pieces. For RAI 2, the NRC staff has not seen a technical basis for the assumption of 10% fibrous debris erosion in the containment pool. Additional tests are needed to confirm this. RAI 3 was related to erosion rates for the calcium-silicate insulation used in the IP2 and IP3 containment buildings. The NRC staff needs further details on the erosion testing. RAI 5 was on the evaluation of time-dependent debris transport, in order to qualify the smaller containment sump after the recirculation sump had collected most of the debris. The NRC staff needs more details on how much debris could transport to the containment sump, and what is the total debris load that sump is capable of handling. RAI 11 asked about the effect of only achieving partial submergence of the IP2 containment sump strainer, for example during a small-break loss-of-coolant accident (SBLOCA) when the reactor coolant system accumulators may not inject. The NRC staff needs more information about SBLOCAs which may require recirculation with only partial submergence of the sump strainer. RAI 23 was on chemical effects during recirculation. The NRC staff understands that IP2 and IP3 have switched to sodium tetraborate as the chemical buffer, but needs more information on chemical precipitates, especially the temperatures at which the precipitates form.

Please direct any inquiries to me at 301-415-2901, or by email to John.Boska@nrc.gov.

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Plant Licensing Branch I-1
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket Nos. 50-247 and 50-286

Enclosures:
1. List of Participants
2. Entergy Slides

cc w/encls: Distribution via Listserv

List of Participants

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Others
Wes McGowan-Progress Energy
Ross Gould-Clearwater
Dan Greeley-Rockland County

Indian Point Energy Center Generic Letter 2004-02 Responses to RAIs

September 16, 2009

Entergy

Agenda

Introductions

Overview of GL 2004-02 Program (12:30 to 12:40 pm, Entergy)

Overview of items Remaining to be Accomplished (12:40 to 12:45 pm, Entergy)

Discussion of Proposed Responses to NRC RAIs (12:45 – 2:00 pm, Entergy and NRC Staff)

Questions for the NRC (2:00 to 2:30 pm)

Discussion of Proposed Responses to NRC RAIs (2:30 to 4:15, Entergy and NRC staff)

Questions for the NRC (4:15 to 4:30 pm, members of the public)

Adjourn (4:30pm)

Introductions

Introduction of Personnel - Entergy

Ed Weinkam – Sr Mgr, Nuclear Safety & Licensing

Bob Walpole – Manager, Licensing

Roger Waters – Licensing Engineer

Tom McCaffrey – Manager, Design Engineering

Valerie Myers– Supervisor, Design Engineering

Lee Cerra - Senior Mechanical Engineer

Adi Irani – Supervisor, Fuels and Analysis

Introductions

Introduction of Personnel - Contractors

Enercon

Eric Crabtree - Supervisor, Mechanical Engineering

Kip Walker - Mechanical/Chemical Engineer

Alion

Peter Mast – Vice President of Operations

Rob Choromokos – Engineering Manager

Meeting Purpose

Discuss Indian Point’s responses to NRC Request for Request Additional Information (RAIs) for GL 2004-02

Note: The information contained in this presentation is intended for discussion purposes only and, as such, has not been through a formal verification process.

Current Status of Plant Modifications – Unit 2

- **Summary of physical changes completed**
  - IR sump screen area increased from 48 sq ft to 3200 sq ft
  - VC sump screen area increased from 14 sq ft to 1200 sq ft
  - Flow barriers over the incore tunnel
  - Gates at personnel entrances through crane wall
  - Screens on crane wall penetrations
  - Buffer change out (TSP to NaTB)
- **Summary of physical changes to be completed in Spring 2010 refueling outage**
  - Vortex suppressors installed over the IR and VC sump strainers
  - MOV-745A/B Mod to de-energize and add CR position indication

Current Status of Plant Modifications – Unit 3

- **Summary of physical changes completed**
  - IR sump screen area increased from 48 sq ft to 3200 sq ft
  - VC sump screen area increased from 36 sq ft to 1000 sq ft
  - Flow barriers over the incore tunnel
  - Gates at personnel entrances through the crane wall
  - Screens on crane wall penetrations
  - New Internal Recirculation pumps
  - Buffer change out (NaOH to NaTB)
- **Summary of physical changes to be completed by Spring 2011 refueling outage**
  - Vortex suppressors installed over the IR and VC sump strainers

Status of Licensing Activities

- Final Supplemental Response to Generic Letter 2004-02 - To be submitted by November 24, 2009
- License Amendment Request (LAR) for MOV-745A/B valves – Requested NRC approval by February 26, 2010
- Design and Analysis completed by the 8/31/09 deadline
- Unit 2 extension granted for compliance until start up from RFO in March 2010 to allow for installation of Vortex Suppressors and MOV-745A/B valve modifications pending NRC LAR approval
- Unit 3 extension granted for compliance until May 31, 2010. Installation of Vortex Suppressors to be completed no later than RFO in March 2011

Testing

High Temperature Vertical Loop Testing (Chemical Induced Head Loss Precipitation) June 2009

U2/3 Chemical/Debris 3x3 Scaled Array Testing (Using March 2008 Protocol Guidance) Jan 2009

VUEZ 30-Day Containment Condition Testing - Supplemental Case Retest Late 2007/Early 2008

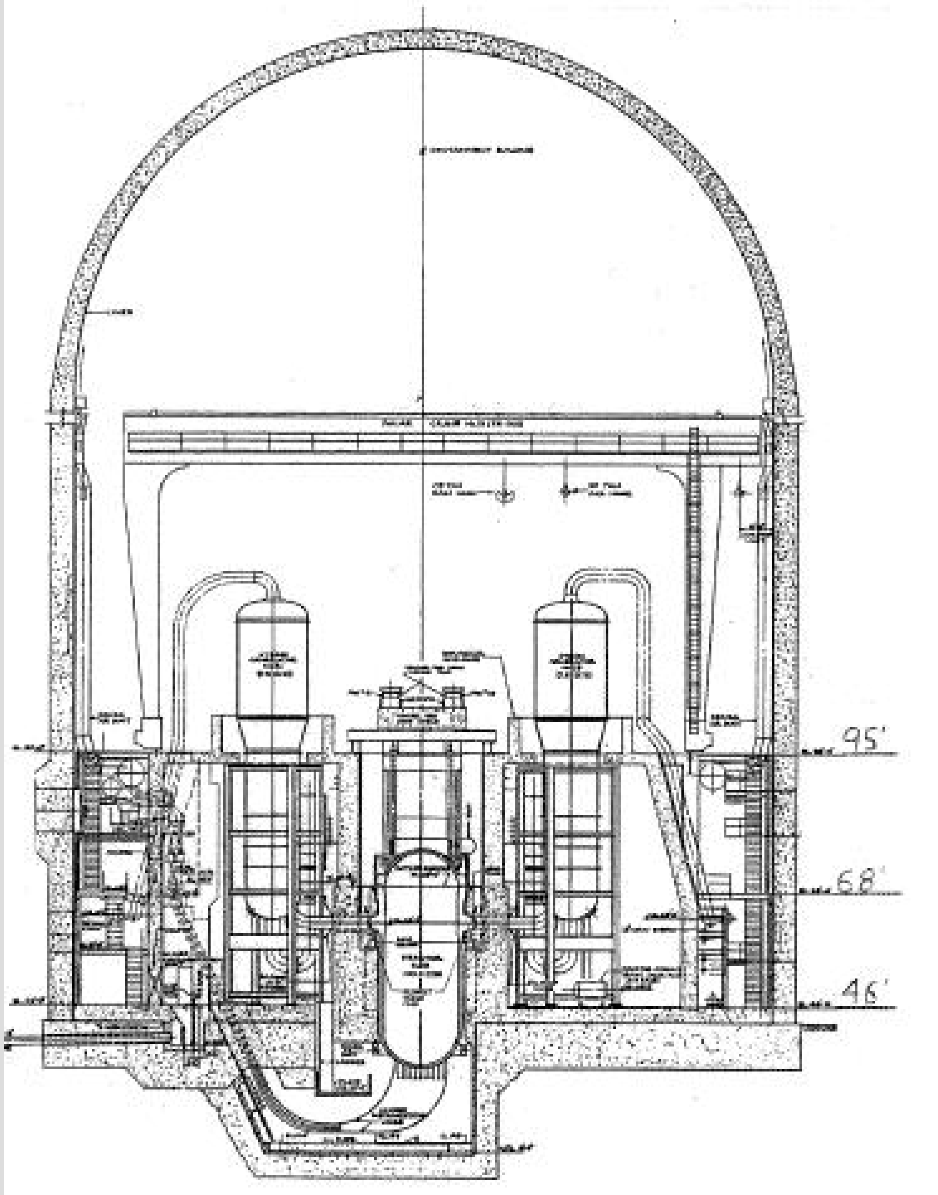
U3 Debris only 3x3 Scaled Array Testing Oct 2007

U2 Debris only 3x3 Scaled Array Testing Feb 2006

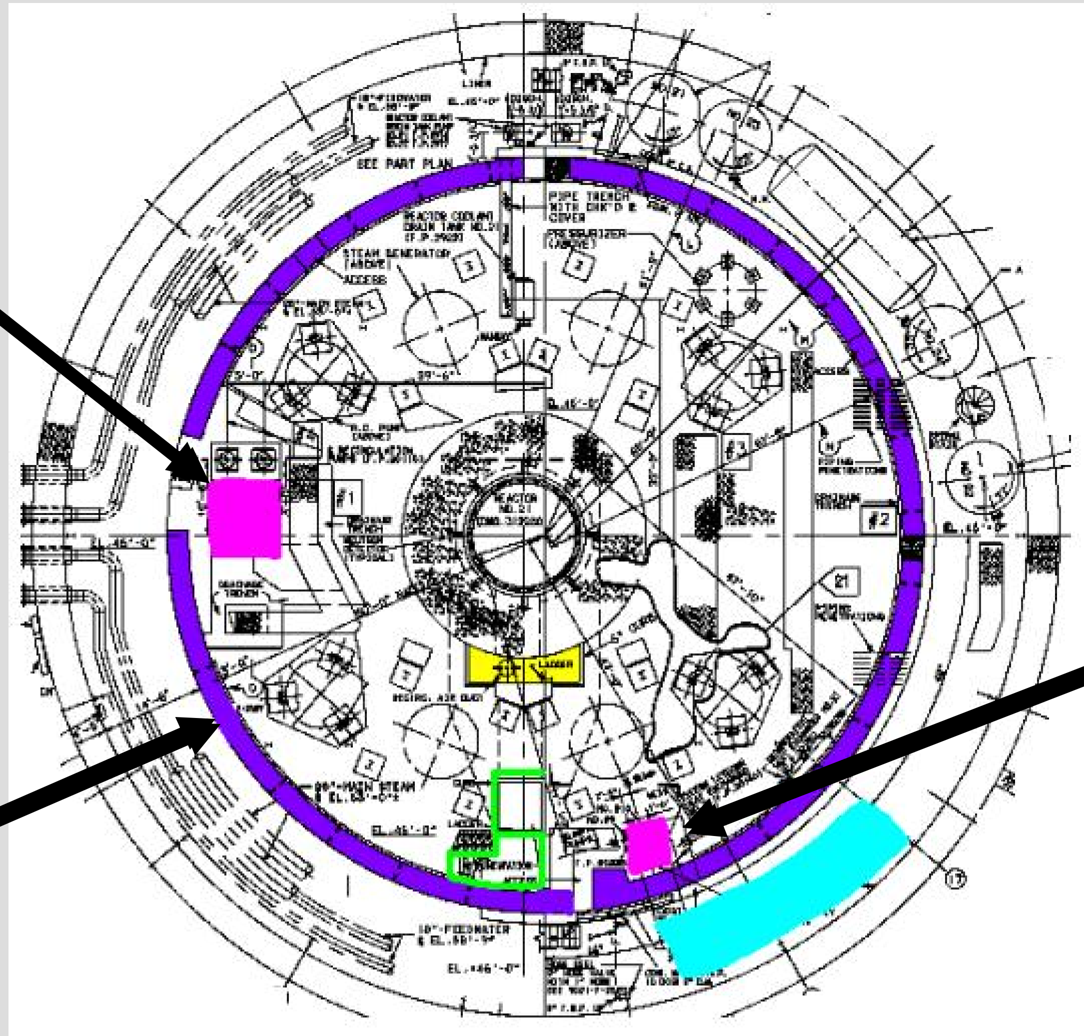
IPEC RAI History

- NRC Audit December 2007
- Submittal of Supplemental Response to Generic Letter 2004-02 in February 2008
- Audit Report received in July 2008
- NRC RAIs received on Supplemental Response included Audit Open Items received on November 19, 2008
- Indian Point Final Supplemental Response due November 24, 2009 will address RAIs

Vapor Containment (VC) Elevations



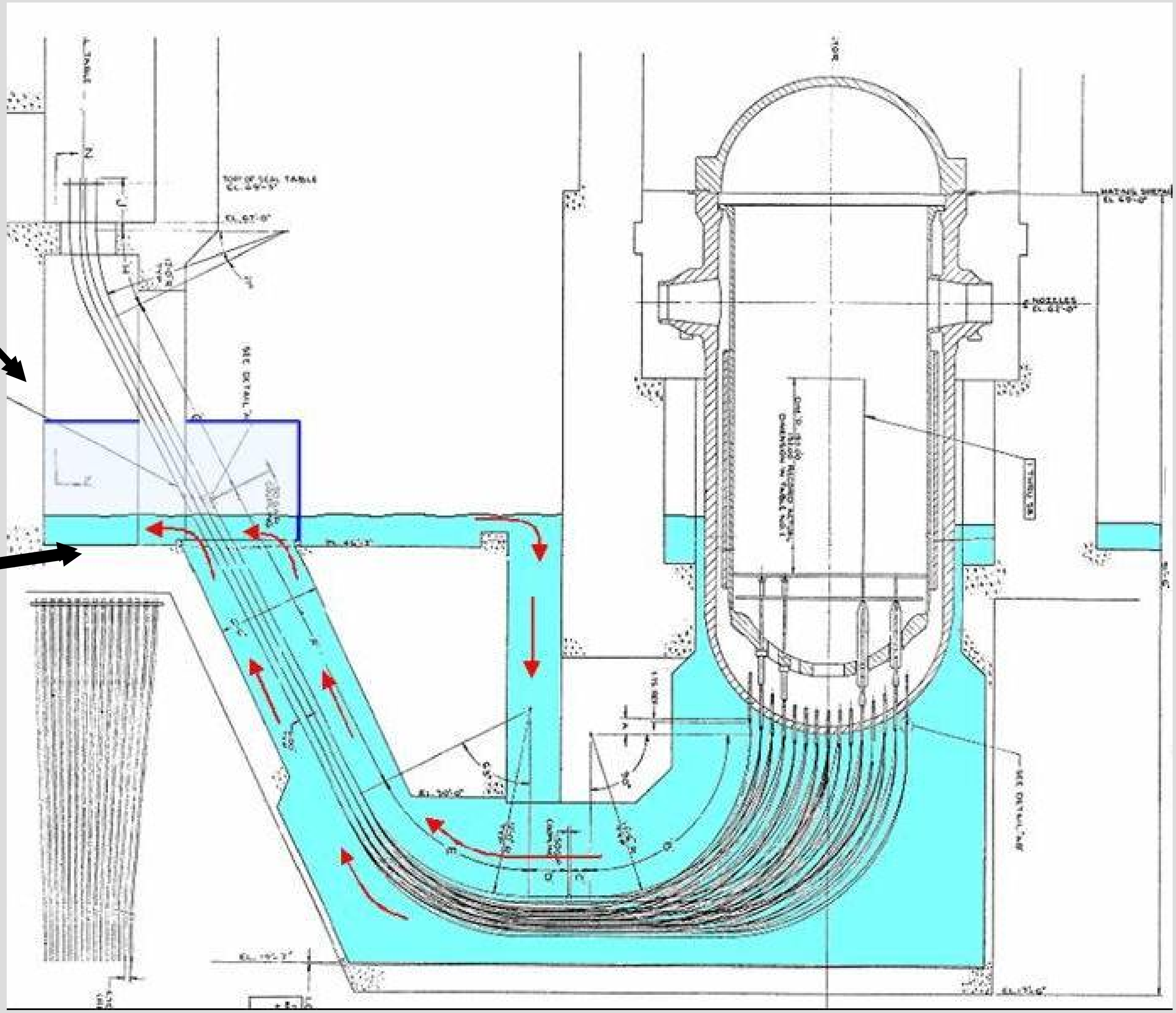
Plan View of lower containment



Flow Channeling

Crane
wall

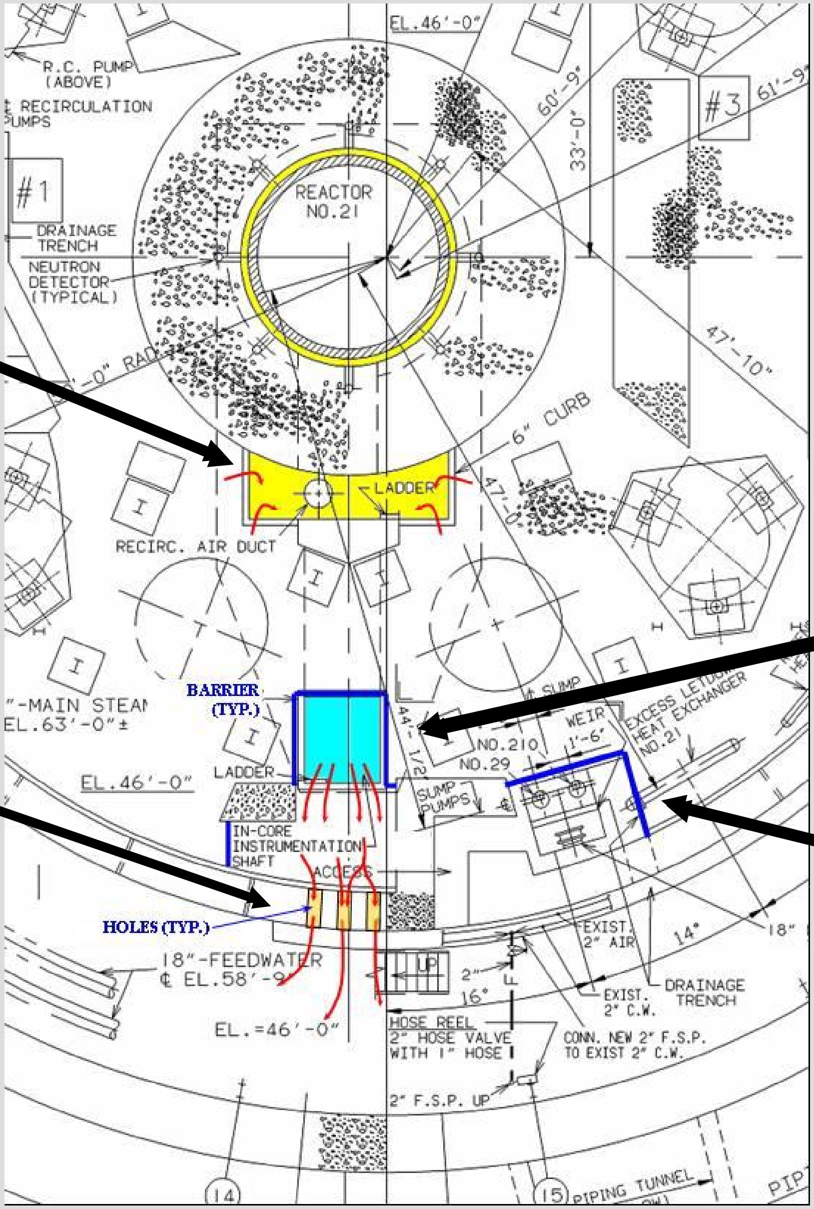
46' Elevation



Flow Channeling

Reactor Cavity Entrance

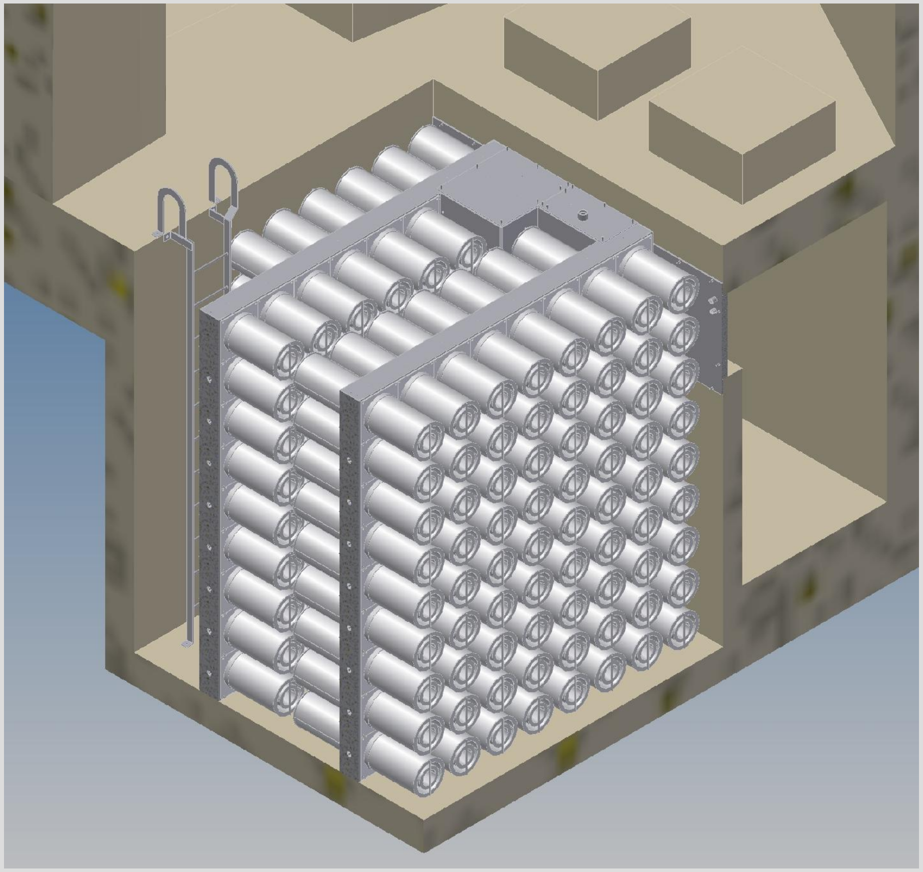
Holes thru crane wall



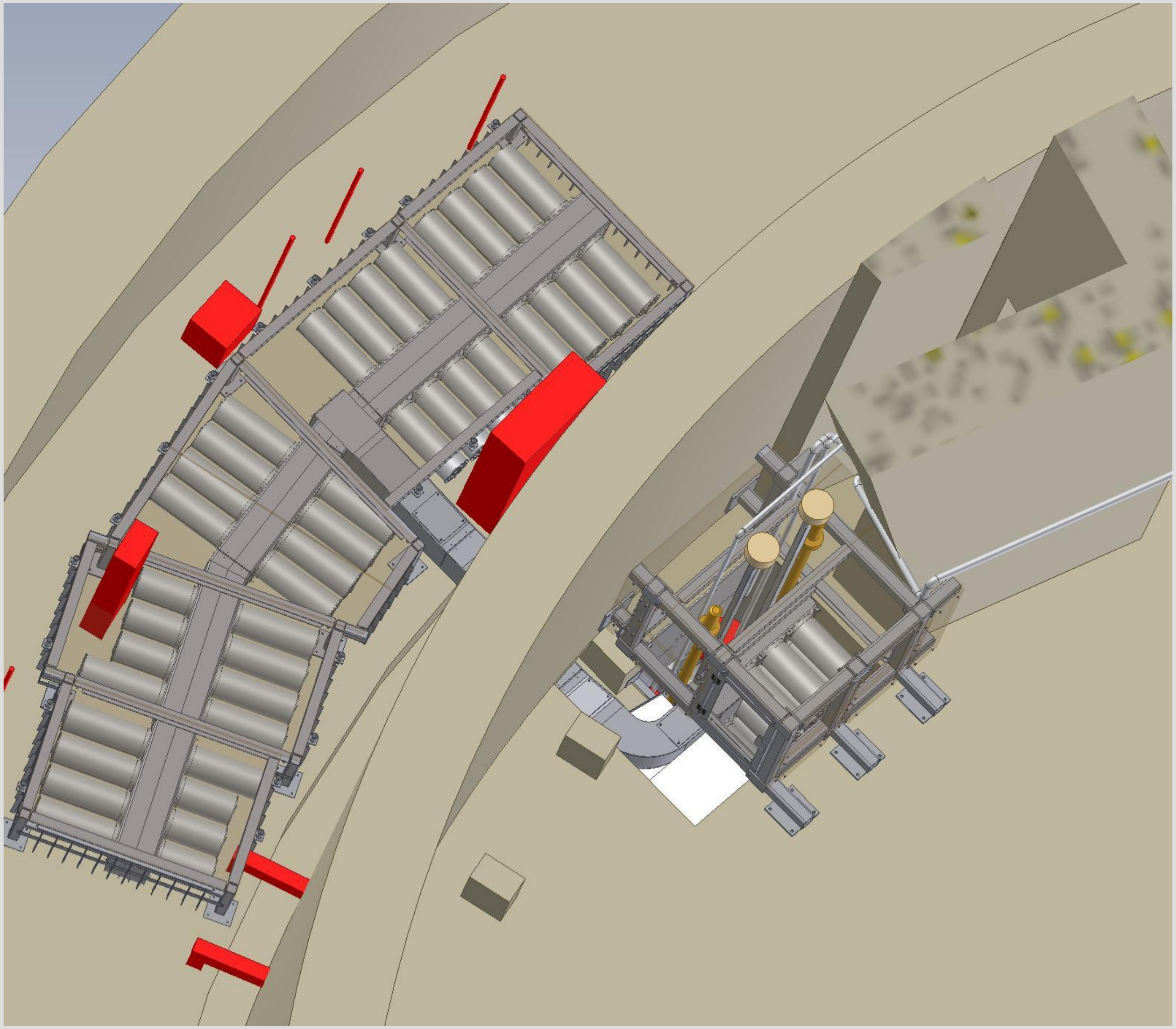
Incore Tunnel

VC sump

Internal Recirculation (IR) Sump



VC Sump – Unit 2



RAI #1 40% Hold Up

RAI #1 – An adequate technical basis was not provided to support the assumption that 40 percent of small pieces of fibrous debris will be captured on gratings in the upper containment. Please provide a justification for this assumption or revise it as determined appropriate (Dec 2007 NRC Audit Open Item)

Background

- IPEC analysis was based on testing as documented NUREG/CR-6369 which was completed for 1 ½ ” fiberglass pieces on 1” x 4” grating, subject to spray with a flow rate of 5 gpm/ft^2 for 30 minutes.
- Testing showed a washdown fraction between 38% and 47% thru a grating
- IPEC grating is approx the same size, with an average spray flow of 0.4 gpm/ft^2 (for 4 hrs) - significantly less flow than that in NUREG/CR-6369 and lower cumulative flow
- IPEC small debris is larger (4”-6”) than that of the tested material
- IPEC used a washdown fraction of 50% for small fiberglass through grating for conservatism.
- The calculation of 40% retention of small fiberglass debris is a result of the methodology used in the Transport Calculation based on the 50% holdup of small fiberglass on grating
- Fiberglass fines were conservatively assumed to have 100% transport – no retention on structures, grating, or inactive cavities.

RAI #1 40% Hold Up

Applicability of Test Results for Long Term Spray Operation

- NUREG/CR-6369 – majority of the washdown occurred within the first 15 minutes
- Therefore its not likely that significantly more debris would be washed down if test is greater than 30 minutes
- Test observed washdown of 38% to 47% which was conservatively rounded to 50% to account for uncertainty.
- Containment spray erosion of fiberglass that is retained on grating is addressed separately and included as an additional transport term in the logic trees.

RAI #1 40% Hold Up

Applicability of Test Results for Debris Washed off of a Concrete Floor through Grating

- Much of the debris would be retained on the upper level because small pieces would only be half submerged in ¼" water level on the upper level and this is conservatively not credited
- Approach velocity at the edge of grated openings is only ~0.3 ft/s; it is likely that a significant fraction of the small fiberglass debris would be captured
- Transport of debris across the deck floor does not impact subsequent capture of this material by gratings

RAI #1 40% Hold Up

Debris Capture as it is Washed through a Second Level of Grating

- Significant portion of small fiberglass debris washed from 95’ grating would likely land on and be caught by the grating bars at 68’ rather than pass right through
- Conservative flow rates used in testing – 5 gpm/ft^2 vs. 0.4 gpm/ft^2 which would cause the actual retention fraction of debris on grating at IPEC to be higher than 50%
- Therefore, even if some of the small pieces fall directly through the second level of grating at 68’ elevation, the washdown fraction through this lower level of grating is considered conservative.

RAI #1 40% Hold Up

Conservatism in Debris Transport Analysis

- IPEC grating retention fractions are considered conservative application of NUREG/CR-6369 due to the differences in flow rate
- Uncertainty in grating retention fractions is easily offset by conservatisms in the Transport Analysis:
  - Assumed no retention of debris on the concrete floors
  - Assumed no retention of debris impinged on walls and structures
- Indian Point compares favorably with BWROG URG methodology (details to be provided in final RAI response)

RAI #1 40% Hold Up

Based on based on comparison of the flow rates from the NUREG/CR-6369, no credit given for debris holdup on concrete walls, low flow rate of washing off 68' and 95' floor, and debris capture thru second level of grating it is concluded that 40% hold up of small pieces of debris is a reasonable.

BWROG washdown testing results compare favorably to Indian Point's calculated results.

RAI #2 10% Erosion Rate

RAI #2 – An adequate technical basis (e.g., test data) was not provide to support the assumption of 10% fibrous debris erosion in the containment pool over a 30-day period. Please provide a justification for this assumption or revise it as determined appropriate (Audit Open Item).

Response

Test data used to support this assumption has been provide to the Staff by Alion in June 2009. Alion is to perform supplemental testing to address the NRC staff's question for the industry. Indian Point will be participating in the proposed re-testing.

RAI #3 Cal-Sil Erosion Testing (30 days)

RAI #3 – The testing performed for IP2 calcium silicate with asbestos, that is also being applied to IP3, was not performed for a sufficiently long period to give high confidence of no erosion of the material, as opposed to a small erosion rate that could lead to a significant fraction of erosion over a 30-day period. Please provide justification for its conclusions about erosion of this material.

Response

- This RAI is directed to the applicability of the results of the dissolution testing reported in ALION-REP-IP2-2833-01 entitled “Indian Point 2 Material Dissolution Report"
- These are the only tests performed with Cal-Sil containing asbestos
- Erosion was not intended to be addressed in this (ALION-REP-IP2-2833-01) report.

Test Background

- The purpose of the test is to quantify the dissolution of Cal-Sil debris pieces
- Some types of Cal-Sil pieces could become soluble in a hot liquid, buffered solution as found in post-LOCA pool
- Dissolution would cause the dissolved material to be placed in solution and behave as a chemical element, not as a particulate
- Dissolution can be evaluated with relatively short tests

RAI #3 Cal-Sil Erosion Testing

IP2 Asbestos Cal-Sil Dissolution Tests

- Actual IP2 Cal-Sil pieces were subjected to borated water baths at different temperatures
- Testing documented macroscopic density and dissolution measurements of IP2 Cal-Sil material
- Two dissolution tests were conducted
  - In deionized water
  - In borated (~2570 ppm), TSP neutralized water

- Test concluded dissolution did not occur for the IP2 specimens (approx 1 in size) in either solution and no chemical reaction precipitates were visually observed in either solution.

RAI #3 Cal-Sil Erosion Testing

Discussion of Erosion Testing

(summary of Hart and Whitaker)

Cal-Sil Background

- Several types of Calcium Silicate pipe and block insulation
  - Type I, which contains asbestos fibers as a reinforcement and is a Post Autoclave process:
  - Type II, which is free of asbestos fibers and is made by a filter press, Pre-autoclave process (sometimes referred to as the Johns-Manville Process); and
  - Type III, which is free of asbestos fibers and is made in a pour and mold process (known as the Pabco Process), also a Post Autoclave process.
- Based on information from the Industrial Insulation Group (IIG), the relative erosion fractions should be: Type I < Type II < Type III

RAI #3 Cal-Sil Erosion Testing

Evaluation

- Flume erosion testing was performed to measure the weight loss of non-asbestos Type II and III Cal-Sil
- The test program established sufficient erosion data, by exposing Cal-Sil samples to a flow comparable to the insipient tumbling velocity. The data was extrapolated linearly to estimate erosion fractions from 100 hours to 30 days for Indian Point.

- Alion's report "Cal-Sil Erosion Fraction for IP2 and IP3" compares test materials and conditions to those in the Containment

Based on knowledge of the time of manufacture and walkdown information, the Cal-Sil at IP2 and IP3 is Type I and/or Type II Cal-Sil which is expected to have lower erosion fractions than that used in the erosion tests.

RAI #3 Cal-Sil Erosion Testing

<u>Conclusion</u>

The erosion fractions used in Indian Point's analysis are conservative based on the fact that testing was performed on Type II and III insulation, while the plants contain more durable Type I and II insulation.

RAI #4 Cal-Sil Erosion Test for IP2 used at IP3

RAI #4 – Please provide a justification for the use of erosion data from the IP2 calcium silicate tests with asbestos for the IP3 calcium silicate material without asbestos.

Response

- No erosion testing was conducted for Cal-Sil with asbestos only dissolution testing was done for Cal-Sil with asbestos
- Comparison of original IP2 and IP3 insulation specs concluded similar asbestos was used in both
- Walkdowns of both Units documented the presence of asbestos Cal-Sil
- Based on the period of construction for both units, it is likely that the same insulation was procured for both
  - IP2 began construction in 1966 and became operational in 1974
  - IP3 began construction in 1969 and became operational in 1976

Conclusion

From this similarity of specifications and the close timeframes of construction it is logical to conclude that the Cal-Sil insulation is the same at both units

RAI #5 Time-dependent Debris Transport

RAI #5 – IP plans to credit time-dependent debris transport for qualification of the VC sump. The licensee should provide adequate technical justification to demonstrate that the time-dependent model is conservative. The areas that require justification in connection with time-dependent debris transport for qualification of the VC sump are blowdown, pool fill, and washdown transport directly to the VC sump, erosion of debris, IR strainer filtering efficiency, potential release of material from the IR strainer when the pump are secured, potential delay of transport to the VC sump strainer due to flotation, and the formation of chemical precipitates.

Methodology Background

- IR Sump is operated for at least 24 hrs following a LOCA, collecting a large portion of the transportable debris.
- Captured debris is then unable to transport to the VC sump
- Debris depletion is based on the number of pool turnovers in the first 24 hrs
- Analysis conservatively uses max pool volumes and min flow rates

7 open items were identified in the NRC audit, which are discussed in subsequent slides

RAI #5 Time-dependent Debris Transport

Item #1 – Washdown Occurring Later in Event

- NUREG/CR-6369 – Majority of the washdown occurs during first 15 minutes
- Min RWST injection time before Recirculation (start of pool turnover) is conservatively determined to be 15.6 minutes
- Most debris is washed down in this first 15 min and reaches the pool prior to start of Recirculation (pool turnover).
- Therefore all fines and majority of small fiberglass from upper containment, would be subject to the full amount of pool turnovers.

RAI #5 Time-dependent Debris Transport

Item #1 – Washdown Occurring Later in Event (con't)

Bounding Assessment of washdown delay

- Containment Spray is limited to a max duration of 4 hrs by procedure
- Hypothetically if depletion due to pool turnover only occurs for 20 hrs, analysis shows that:
    1. The remaining debris in the pool would be ~1% (analysis uses 5%)
    2. The fraction of debris transported to the IR sump would only be slightly decreased
- Small pieces of fiberglass washed down after start of Recirculation would not be significant since the pieces inside the crane wall would not transport through the tunnel and pool velocities are low during VC sump operation

RAI #5 Time-dependent Debris Transport

Item #2 – Fiberglass Erosion Occurring Later in Event

- Testing of submerged fiberglass debris pieces in a recirculation pool shows the majority of erosion occurs in the first 24 hrs
- Highest % of erosion fines are generated early in the event (within approx 4 hrs) and would have time to transport almost completely to the IR sump
- Erosion fines generated at ~ 20 hrs would have a transport fraction of ~ 50% to the IR sump during the 4 hours prior to switch over to the VC sump operation.
- Flow patterns may change during event, although the fraction of debris initially exposed to low flow conditions and later exposed to higher flow is expected to be relatively small.

RAI #5 Time-dependent Debris Transport

Item #3 – IR Sump Strainer Debris Capture Efficiency

- Top-Hat strainer's bypass eliminators significantly reduce the quantity of fiberglass strainer bypass
- Bypass testing showed for an avg approach velocity of 0.0058 ft/s, fiber bypass is 2.85 lbm/1000 ft^2 (or equivalent ~ 9 lbm) or 0.4% of total debris load
- The bypass amount is significantly less than the fiber washdown from upper containment, therefore this is also negligible when compared to the margin between the assumed 5% and calculated ~1% remaining debris in the pool
- Fiberglass debris bed will filter out particulate, increasing strainer capture efficiency

RAI #5 Time-dependent Debris Transport

Item #3 – IR Sump Strainer Debris Capture Efficiency (con't)

- The limiting break has 2,121 lbm of Nukon and fiberglass generated – 15% (~320 lbm) of fiberglass is fines
- After 4 hrs of IR sump operation, ~80% (260 lbm) of debris transports to strainer.
- ~80% (260 lbm) give an ½" equivalent debris bed on the IR strainer which can effectively filter most particulates
- Debris that did bypass the strainer before the debris bed forms has sufficient time to circulate and transport back to the IR sump to then be captured before switchover to the VC sump operation
- Water in test tank was observed to clear up as particulate collected on the strainer with a decrease in measured turbidity which took less than 15 hrs in each of the full load debris tests

RAI #5 Time-dependent Debris Transport

Item #4 – Re-suspension of Accumulated Debris when IR Pumps are Secured

- During Head Loss testing very little debris bed movement was observed after securing pumps
- Check valves in close proximity to the IR pumps prevent reverse flow into strainers
- Debris agglomerates into a thick debris bed as it accumulates on the strainer and would not easily be broken back down into individual constituents (fiber/particles) which could be transported to the VC sump.
- IR strainer is located in a pit in an enclosed sump room
- Pool velocities and turbulence are very low in this area during VC sump operation
- VC and IR sumps are ~ 90 deg apart
- VC sump entrance is adjacent to the flow path from inside crane wall
- Therefore, the majority of flow will not pass by the IR sump to draw any debris out of IR room.

RAI #5 Time-dependent Debris Transport

Item #5 – Reduction in Transport to the IR sump due to Debris Flotation

- Debris Transport Analysis assumed pieces of Mineral wool and Temp-Mat float in the recirculation pool
- NUREG/CR-6808 testing shows fibrous debris absorbs water and sinks more readily in hot water due to reduced viscosity and enhanced absorption
- Small pieces of fibrous debris are expected to fully absorb water and sink more quickly due to a higher surface area to volume ratio.
- Small pieces and many of large pieces of mineral wool and Temp-Mat will sink early in the event given the high initial pool temperatures

RAI #5 Time-dependent Debris Transport

Item #5 – Reduction in Transport to the IR sump due to Debris Flotation (con't)

- Floating debris would transport with the flow of water until they reach either a stagnant pool region or a higher flow velocity area where they can no longer transport horizontally (remain in inner-crane wall)
- Pieces transported to stagnant regions would not experience any significant erosion given the low flow velocities
- Pieces that transport to a high velocity area would likely be eroded by the flowing water similarly as pieces submerged in the pool or be transported to the IR sump
- Floating debris does not transport out of the in-core tunnel, so only small pieces of Mineral wool and Temp-Mat washed down to the annulus might transport
- These small pieces would be sink relatively quickly due to being soaked by Containment Spray, and accumulate on the IR sump strainer during the 24 hrs of IR sump operation

Conclusion – based on the discussion above, floating debris will either sink or transport to a low flow area or the IR sump within 24 hrs

RAI #5 Time-dependent Debris Transport

Item #6 –Transport Directly to the VC Sump During the Blowdown and Pool Fill-up Phases

- Analysis performed for the blowdown phase is based on containment volumes
- Per the Debris Transport Calculation, a negligible quantity of debris transports to the VC sump during blowdown
- The large volume of the Reactor Cavity captures much of the initial break flow
- The VC sump pit is 1/100th of the overall pool volume
- This results in a low transport fraction of the fine debris to the pit during the pool fill-up phase
- VC and IR sump cavities fill simultaneously early in the event when a large percentage of fine debris is in the upper containment
- The majority of the fines during pool fill-up available to transport are located in upper containment therefore only a small fraction of fines in the pool are available to transport to the VC and IR sumps
- Therefore overall transport to the VC sump during pool fill-up is negligible

RAI #5 Time-dependent Debris Transport

Item #7 –Formation of Chemical Precipitates in the IR Sump Strainer Debris Bed

- IR sump strainer is qualified to handle the full debris loads including chemical precipitates

- VC sump is qualified to handle the full chemical load assuming none accumulated on the IR sump.

Note: VC sump is only required to be qualified for a 6” break at the beginning of recirculation and a LBLOCA after 24 hrs

RAI #5 Time-dependent Debris Transport

RAI #5 Conclusion

- Conservative inputs of min flow rate and max pool volume for the transient analysis resulted in a calculated value of 0.7% of debris in the recirculation pool remaining after 24 hrs.

- To account for uncertainties, the transport fraction to the VC sump was conservatively increased:
  - 0.7% to 5.0 % for the majority of debris generated inside the ZOI
  - To 100% for the Cal-Sil and Asbestos fines generated due to erosion
  - To 100% for unqualified coatings outside the ZOI

- The individual contributions of each item within this RAI is small and the cumulative effect is bounded by the use of 5% debris remaining after 24 hrs

RAI #6 Differences in Amount of Debris

RAI #6 – The amounts of LOCA generated debris listed in the debris generation section of the supplemental response differed from the debris generation amounts listed in the transport section. Please provide an explanation for the differences between the values in the tables.

Response

The debris generation amounts listed in the previous Supplemental Response were based on earlier information. A revised Supplemental Response to the NRC will show that the transport fractions were applied to the full amounts of debris generated.

RAI #7 – Use of NUREG-6224

RAI #7 – The Strainer Certification calculation used NUREG-6224 head loss correlation to adjust the test data. The main area of concern is extrapolation of test data to different debris loads or different flow velocities.

Response

- Indian Point completed the re-test of the Test-for-Success Array Head Loss Chemical Effects testing in Spring 2009. Testing incorporated the NRC March 2008 Guidance.
- Debris loads for each plant were bounded by at least one of the tests
- The new Strainer Head Loss and Certification calcs do not use the NUREG-6224 correlation

RAI #8 – Debris Mix in Head Loss Testing

RAI #8 – Please show that testing was conducted using a debris mix that matches its transport calculation or should show its existing method is conservative. The main points of this issue are to ensure that testing is conducted with the amounts of fine (suspendable) fiber predicted to reach the strainer, and to ensure that the fiber is prepared as true fines. In addition, the introduction of the debris should allow prototypical or conservative transport to the strainer (e.g., agglomeration should be avoided). For thin bed testing, only fine fibers should be introduced until the entire fine fiber load has been added incrementally. For example, supplemental response 3f.6 concludes that no thin bed will result. However, the testing that justifies this conclusion should be shown to be appropriately conducted with fine fiber. (Audit Open Item)

<u>Response</u>

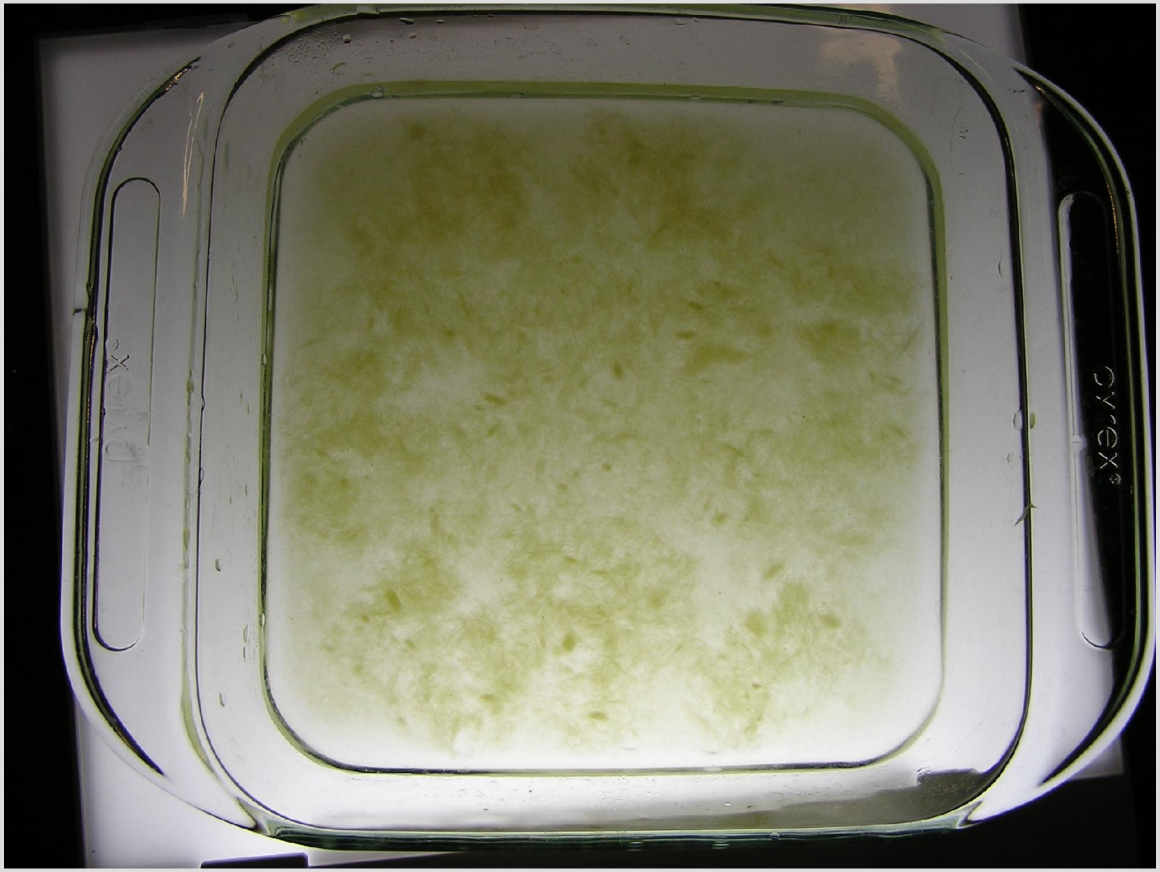
- A 2nd round of prototypical head loss testing was conducted in Spring 2009 (Post IP3 Audit) using the “Test-for-Success” methodology to address the concerns raised in the March 2008 Staff Guidance.

RAI #8 – Debris Mix in Head Loss Testing

Fine fiber prep

- Double shredding fiber blankets and boiling for 10 minutes
- ¼ lb of boiled fiber was added to a bucket with 4 gallons of water and beat with a paint stirrer for 4 minutes
- Mixture was a well dispersed slurry of individual fibers with few clumps, no larger that ¼”
- Next slide is a of prepared fines during the Spring 2009 Head Loss testing in a 9” x 9” glass dish

RAI #8 – Debris Mix in Head Loss Testing



RAI #8 – Debris Mix in Head Loss Testing

The NRC Staff observed and noted the following in a Trip Report:

- *When the debris was added to the flume it was apparent that it was well dispersed in the water and had not agglomerated in the bucket or when added to the flume. The additions resulted in clouds of debris disbursing slowly throughout the tank which was evidence of the fineness of the debris. In particular the fine Nukon behaved as would be expected for fine fiber. It is estimated that 90% of the fine fiber met the definition of Class 1 to 3 fibers with 10% slightly larger. The fine Thermal Wrap fiber was also broken down into relatively small pieces, but appeared to be coarser due to the physical properties of the fiber. The Thermal Wrap fibers were longer, coarser, and straighter than the Nukon, but were well separated.*

- It is concluded the Spring 2009 testing was conducted with sufficiently fine fibers, and complies with the March 2008 Staff Guidance on Head Loss

RAI #8 – Debris Mix in Head Loss Testing

Debris Introduction

- 3x3 array test strainer was in a simulated pit configuration within a larger tank
- Debris was added off to the side of pit and carried into the pit by flow
- Any debris which did not flow into the strainers was subjected to constant turbulence from the pump return line
- Motorized agitator and mechanical stirring prevented settling of debris outside pit
- Per test protocol for thin beds, after particulates were circulated in the tank, fines were then added incrementally
- Due to these methods, agglomeration was avoided, and conservative transport of the debris to the strainer array was ensured.

RAI #8 – Debris Mix in Head Loss Testing

<u>Calculated vs. Test Debris Mix</u>

- The following tests meet the suspendable fibers requirement by utilizing 100% fines and ensuring a prototypical/conservative debris mix:
  - Test A (thin-bed)
  - Test A1 (thin-bed)
  - Test E (thin-bed)
  - Test F (thin-bed)
  - Test G
- Tests B, C & D used a debris mix size distribution of <100% fines based on Debris Generation and Debris Transport Calculations
- Note that all tests were conducted with greater than 80% fines
- Final Supplemental response will contain a comparison of the calculated vs. testing debris mix used

RAI #9 – VC Sump Test Bounding IR Sump Conditions

RAI #9 – Test procedures and test results concentrated on the VC sump and did not provide clear traceability to show that these tests bounded the internal recirculation (IR) conditions. (Audit Open Item)

Response

- Re-testing in Spring 2009 consisted of 8 separate tests
- Every scenario for the IR and VC sump at both units is bounded by at least one full load and one thin-bed test.

RAI #9 – VC Sump Test Bounding IR Sump Conditions

Table 9-1 below if from the IP Strainer Certification Calculation

	Bounding Chemical Effects Test	
Scenario	**Thin-bed**	**Full Load**
IP2 IR (LBLOCA and RC LBLOCA)	Test E	Test B
IP2 VC (6" LOCA and 6" RC LOCA)	Test E	Test A1
IP2 VC (LBLOCA 24hr and RC break)	Test G	Test G
IP3 IR (LBLOCA and RC LBLOCA)	Test E	Test C
IP3 VC (6" LOCA and 6" RC LOCA)	Test E	Test C
IP3 VC (LBLOCA 24hr and RC break)	Test D	Test D

RAI #10 – Vortex Calculations

RAI #10 – The methodology used to qualify the IP2 VC sump strainers for vortex formation/air ingestion was not clear. The supplemental response stated that a vortex evaluation using the submergence Froude number, and consideration of design limits recommended in RG 1.82, was completed. Please provide the methodology, assumptions, and the bases for the assumptions in this evaluation.

Response

- Based on the Spring 2009 testing, Vortex suppressors will be installed over the IR and VC sumps for both units
- Suppressors will be located below the min water level for each sump which precludes the formation of the vortices

RAI #11 – IP2 VC Sump Submergence

RAI #11 – It was not clear that the debris loading for the IP2 VC sump strainer for a small-break LOCA with partial submergence was adequately considered. With partial submergence, less strainer area is available to collect debris and the velocity through the submerged portion of the strainer is higher. The methodology for evaluation of this condition was not provided. The supplemental response states that the VC sump strainer can sustain 1688 gpm flow while only 1350 gpm is required for the small break case.

Response

The IP2 Water Level Calculation was revised to show that the VC sump strainer extension is fully submerged. Therefore, the debris load methodology will include the full strainer area.

RAI #12 – Head Loss Testing Results

RAI #12 – The test results presented in the supplemental response could not be traced by the NRC staff to head loss testing results. Please provide the raw test data and test conditions, and please show how the head loss results were derived from the test data. Please include any assumptions used for this analysis. Please ensure that a clear explanation of how the strainer head loss was determined for each NPSH margin case is provided.

Response

- Head Loss testing was re-performed in Spring 2009 and all test data and analysis was updated since the Supplemental Response of February 28th, 2008. The test results and NPSH margins will be provided in the revised Supplemental Response
- 8 total tank tests in stages to bound 12 analytical cases (RAI #8)

RAI #12 – Head Loss Testing Results

Summary of the Head Loss Calculation Methodology

- Indian Point chemical effects array test results are used as basis for head loss calculation of all scenarios
- Logarithmic curve fit used for extrapolation of data from each chemical addition to 30 days (RAI #15)
- Measured head losses are normalized from test temperatures and flow rates to 70°F and max IR and VC sump flow rates to facilitate matching each analytical case to a bounding test
- Head Loss measurements for each case are corrected from test temp to 70°F and/or 204.7°F and from the test flow rate to scaled plant flow rates
- Strainer head loss = clean screen head loss (CSHL) + debris head loss + RMI head loss

RAI #12 – Head Loss Testing Results

Summary of the NPSH Margin Methodology

Prior to 7 hours post-LOCA

- NPSHa, NPSHr, and min flow performance values are found in the Westinghouse hydraulic performance evaluations
- NPSHa is corrected based on water level (to bound LBLOCAs and SBLOCAs)
- Corrected conventional debris head loss value (@204°F) for each case is compared to the NPSH margin, min flow performance limit, and strainer structural limit

All cases are shown to meet the head loss limits

RAI #12 – Head Loss Testing Results

Summary of the NPSH Margin Methodology (con't)

After 7 hours post-LOCA

- NPSHa, NPSHr, and min flow performance values are found in the Westinghouse hydraulic performance evaluations
- NPSHa is correct based on water level (to bound LBLOCAs and SBLOCAs)
- Corrected conventional debris head loss value plus chemical debris head loss (extrapolated to 30 days) is compared to the NPSH margin and strainer structural limit

All cases are shown to meet the head loss limits

RAI #13 – Time-Delayed Transport to the VC Sump

RAI #13 – The supplemental response did not include information on a test case for time-delayed transport to the VC sump strainer. Note that this strategy has been proposed, and the NRC has received a license amendment request to revise the Update Final Safety Analysis Report to change the assumptions regarding failures of the IR sump. Please provide the results of the analysis that calculate the VC sump strainer head loss considering delayed transport of debris to the sump. Please include the methodology used, any assumptions made, and the bases for the assumptions in the response to this issue.

Response

- Indian Point utilizes a time-delayed qualification for the VC sump strainer for breaks larger than 6 inches
- Assume that the IR sump is in operation for the first 24 hrs of the accident
- Methodology for calculating debris loads for the post 24 hr VC sump initiation scenario is similar to other scenarios
- Debris loads are determined in the Debris Generation Calc
- Debris Fractions that reach the sump are determined in Debris Transport Calc
- Amount of debris that reaches the sump are determined and scaled for the test in the Array Test Debris Amount Calc
- Specific tests were run for each of these cases

RAI #14 – Levels in the Void Fraction Calc

RAI #14 – The basis for the minimum sump level inputs to the void fraction calculation could not be determined. The flood levels in the void fraction calculation did not appear to match the minimum flood levels provided in the supplemental response. Please provide information that justifies the use of the levels that were included in the void fraction calculation.

<u>Response</u>

- Minimum Water Level and Void Fraction calculations have been revised since the Feb 2008 GL response
- Water levels in the Void Fraction calcs either match or are conservative compared to the revised Minimum Water Level calc
- Void Fraction calcs also account for “drawdown” of water above sump pits
- The supplemental response and the RAI response will contain the details of the subject calculations

RAI #15 Test Data Extrapolation

RAI #15 – The licensee's original plan was to use separate chemical effects testing to extrapolate the test results to the emergency core cooling system (ECCS) mission time. It is currently unclear how chemical effects will be addressed by the licensee. Please include information that shows that the test termination criteria and extrapolation of the data to the ECCS mission time were conducted to result in prototypical or conservative results.

<u>Response</u>

- Additional head loss testing was conducted in the Spring 2009 using the "Test-for-Success" methodology, incorporating the staff's March 2008 Guidance
- Chemical precipitates were quantified and prepared in accordance with WCAP-16530
- Pre-prepared chemical precipitates were added to the test tank *after* the formation of particulate and fibrous debris bed
- Test was terminated when the head loss was either:
  - less than 1% change/hr (for headloss values ≥2 ft-water)
  - less than 0.25 inch change/hr (for head loss values less than 2 ft-water)

RAI #15 Test Data Extrapolation

- The following logarithmic curve equation was used to fit the raw test data from each chemical addition

$$\Delta H = a + b \ln t$$

where: ΔH = Head Loss (ft-water)

t = Time (s)

a, b = constants

- A second series is then plotted on the same graph using the equation obtained for the fitted curve
- Constant "a" is adjusted until it is visually confirmed that the raw test data is bounded
- Resulting bounding curve is used to extrapolate for a 30 day mission time

RAI #16 – IR pump test data

RAI #16 – Please provide a justification for the application of data from single-stage testing to the three-stage IP3 internal recirculation pumps (Audit Open Item 3.7-1)

Response

The single stage testing is no longer applied to the three-stage recirculation pumps. Indian Point has applied the more conservative NPSHr curve (i.e. higher required NPSHr values) developed by the pump manufacturer/supplier Flowserve from the test for identical Unit 2 IR pumps

RAI #17 IR Pump NPSH Margin

RAI #17 – Please provide the NPSH margin for a single IP3 IR pump at full recirculation (4124 gpm).

Response

- ECCS System Hydraulic Calculation revision results in a full recirculation flow rate of 4149 gpm for a single IP3 IR pump
- At 4149 gpm, the final margin is 0.01 ft-H_2O
- This margin represents a series of conservatisms which were combined but will not occur simultaneously
  1. Min water levels from SBLOCA cases assumed for NPSH calcs for LBLOCA flows, however that level does increase after start of pump
  2. Max water level was assumed to obtain max flow rates
  3. Full debris load does not arrive at strainer at start of recirc as assumed.
  4. Debris load is assumed to be comprised of the worst combined max debris types from multiple break locations
  5. No accident overpressure is credited

RAI #18 – SBLOCA bounded by LBLOCA

RAI #18 – Please provide information that shows that the small-break LOCA NPSH margins are bounded by the large break cases. Alternatively, please provide the NPSH margins for the small-break LOCA cases.

Response

- The Strainer Certification Calc reduces the NPSHa values given in the Westinghouse System Hydraulic Calc to account for the difference in water level and bound both the LBLOCA and SBLOCA cases. This is very conservative for the SBLOCA because the small break flow rates and related NPSHr, will be much lower.
- The Debris Generation Calc shows that SBLOCA debris loads are less than the LBLOCA
- The Strainer Certification Calc demonstrates that the head loss for a SBLOCA is bounded by prototypical testing for a LBLOCA

RAI #19 – NPSH Margin for Hot-Leg Recirc

RAI #19 – Please provide an NPSH margin evaluation for the hot-leg recirculation case, or show this case to be bounded by other cases that were evaluated.

<u>Response</u>

- The Strainer Head Loss Calc and the Strainer Certification Calc have been revised to include maximum High Head Safety Injection case
- The Hot-Leg recirculation alignment flow rate will always be less than the analyzed HHSI maximum system flow (1350 gpm)
- The hot-leg recirculation case margin is bounded by the case for the High Head Safety Injection (HHSI) alignment.

RAI #20 – 4.28 ZOI for Un-Topcoated IOZ

RAI #20 – The latest NRC review guidance for coatings references WCAP-16568-P "Jet Impingement Testing to Determine the Zone of Influence (ZOI) for DBA-Qualified/Acceptable Coatings", that recommends using a 5D ZOI for un-topcoated in-organic zinc (IOZ) paint. Please provide the rational for using a 4.28 ZOI for un-topcoated IOZ paint. This question was also listed as Open Item 3.8-1 in the audit report

<u>Response</u>

- The coating specifications indicate that in-organic zinc coatings are only applied to structural steel, and that steel could also be coated with an epoxy system.
- The debris loads were calculated for a 100% in-organic zinc system applied to the structural steel with a ZOI of 5D for the break location with the maximum structural steel surface area (6703 ft^2).
- The debris loads were also calculated for a 100% epoxy system applied to the structural steel with a 4D ZOI for the same break location (4256 ft^2).
- A comparison of the results showed that the total amount of coatings generated from the epoxy system was greater.
  - Epoxy: 5.32 ft^3
  - In-organic zinc: 1.68 ft^3
- Therefore, all structural steel was conservatively assumed to be coated with epoxy, and the 4.28D ZOI for in-organic zinc was not used to quantify the final coating loads for Indian Point.

RAI #21 – Downstream Pump Wear Analysis

RAI #21 – Please provide the results of the wear analysis for the Internal Recirculation (IR) pumps, Residual Heat Removal (RHR) pumps and High Head Safety Injection (HHSI) pumps, when completed.

Response

- Pumps were evaluated primarily based on the WCAP-16406 methodology, with some engineering justified changes.
- Data from the Debris Generation calculation was used as an input.
- Two pump reports were prepared by Flowserve, original pump manufacturer
- One report prepared by MPR for all Mechanical seals

RAI #21 – Downstream Pump Wear Analysis

Recirculation Pumps

- IP2 pumps can experience a wear of up to 0.047 inches diametrally at the head bearing (highest Δ P)
- IP3 pumps can experience a wear of up 0.024 inches diametrally at the head bearing (highest Δ P)
- Pumps will be within the maximum clearances of the parametric rotor dynamic analysis for 30-day mission time
- No modifications to the equipment were necessary for the pump to pass
- Flowserve states pumps will operate beyond the 30-day mission time

RAI #21 – Downstream Pump Wear Analysis

Residual Heat Removal and HHSI Pumps

- RHR pump may experience wear of the impellor wear ring of 0.0018 inch
- HHSI Pumps may experience wear of the impellor wear rings of 0.0005 inch and wear on the bushings of 0.0002 inch
- For RHR and HHSI pumps, identified wear is not sufficient to cause a rotordynamic concern, and pumps will be stable for the 30-day mission time

RAI #21 – Downstream Pump Wear Analysis

Pump Seals

- Recirculation pump employs a leakoff packing arrangement
- RHR and HHSI Pump use mechanical type seals
- The various mechanical seals installed in the RHR and HHSI Pumps were evaluated separately by MPR
- The seals will function as required in the debris laden environment for the 30-day mission time

RAI #22 – Fuel Cladding Temperature

RAI #22 – Please confirm that calculated fuel cladding temperature will not exceed 800°F when calculating cladding temperature in accordance with the guidance in WCAP-16793-NP and as qualified by the conditions and limitation of the draft NRC safety evaluation of WCAP-16793-NP.

Response

- Plant specific cladding temperatures were calculated in accordance with the guidance in WCAP-16793-NP and as qualified by the conditions and limitations of the draft NRC safety evaluation of WCAP-16793-NP. The maximum clad temperature for IP2 was 420F and for IP3 was 384F.

RAI #23 – Chemical Effects Testing Approach

RAI #23 – The NRC staff understands that Indian Point has changed their test approach to evaluate chemical effects. Please submit the revised chemical effects test results and analyses to the NRC when they become available.

Response

Indian Point has changed their approach to evaluating chemical effects significantly since the Supplemental Response to NRC Generic Letter 2004-02 was provided in February 2008. The NRC staff has been updated on the direction and status of these efforts via teleconferences. The details and results of the approach will be outlined in the revised Supplemental Response to NRC Generic Letter 2004-02.

- **Questions?**

Please direct any inquiries to me at 301-415-2901, or by email to John.Boska@nrc.gov.

/RA/

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Docket Nos. 50-247 and 50-286

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