



ECCS Strainer Blockage: Current Status

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Presented to:
IAEA Workshop on ECCS Strainer Blockage
October 15, 2008
Wuhan, China



Presentation Outline

- Progress of NRC staff reviews of PWR licensees' responses to Generic Letter 2004-02
- Example technical issues that are still being resolved for some plants
- Timeline for completing remaining actions to resolve Generic Safety Issue 191
- Summary of industry corrective actions in response to Generic Letter 2004-02



Generic Letter 2004-02

- [Generic Letter \(GL\) 2004-02](#) requested that U.S. pressurized-water reactors (PWRs)
 - Perform a plant-specific analysis of the emergency core cooling and containment spray systems in recirculation mode when mechanistically considering post-LOCA debris
 - Based on the results of the analysis, implement any corrective actions necessary to ensure compliance with regulatory requirements
 - NRC did not identify specific plant modifications to be made
- GL 2004-02 requested completion of corrective actions by December 31, 2007



Generic Letter 2004-02 – September 2005 Response

- The NRC staff requested that PWR licensees provide a description of their corrective actions in response to GL 2004-02 by September 1, 2005
- PWR licensees' responses showed that
 - Progress had been made in installing larger emergency core cooling system (ECCS) strainers
 - However, analyses demonstrating adequacy of corrective actions were substantially incomplete
- As a result, significant requests for additional information (RAIs) were issued to PWR licensees in February 2006



Generic Letter 2004-02 – Supplemental Responses

- NRC subsequently decided that instead of responding to staff RAIs, licensees could submit a deferred supplemental response to GL 2004-02
 - Approach allowed PWR licensees to focus on completing testing, analysis, and plant modifications
 - Schedule for submitting deferred supplemental responses to GL 2004-02 was subsequently set to be February 2008
- NRC staff provided a Content Guide to PWR licensees detailing the information to include in supplemental responses to GL 2004-02

<http://www.nrc.gov/reactors/operating/ops-experience/pwr-sump-performance/regs-guidance.html#six>



Generic Letter 2004-02 – Staff Review of Responses (1)

- NRC staff performed a two-stage review of February 2008 supplemental responses
 - Initial “quicklook” review of supplemental responses completed to screen out any potential immediate operability concerns
 - Subsequent detailed review of supplemental responses in the following technical areas:
 - Break selection
 - Debris generation
 - Debris characteristics
 - Latent debris
 - Debris transport
 - Head loss and vortexing
 - Net positive suction head
 - Coatings
 - Debris source term
 - Screen modifications
 - Structural analysis
 - Upstream effects
 - Downstream effects
 - Chemical effects



Generic Letter 2004-02 – Staff Review of Responses (2)

- Initial “quicklook” review results
 - No immediate operability questions identified for most plants
 - All operability questions acceptably resolved by affected licensees
- Status of detailed reviews
 - Reviews are in progress and about 75% complete
 - Plan to complete detailed reviews of February 2008 supplemental responses in November



Generic Letter 2004-02 – Detailed Review Process

- Detailed reviews of technical areas typically result in draft requests for additional information (RAIs)
- The draft RAIs are then reviewed by a panel of three senior technical staff that recommends whether or not to issue RAIs
 - Panel makes a “holistic” determination on whether RAIs are necessary
 - Uncertainties or non-conservatisms in one technical area are weighed against conservatisms in another area
- NRC management makes final decision on issuance of RAIs



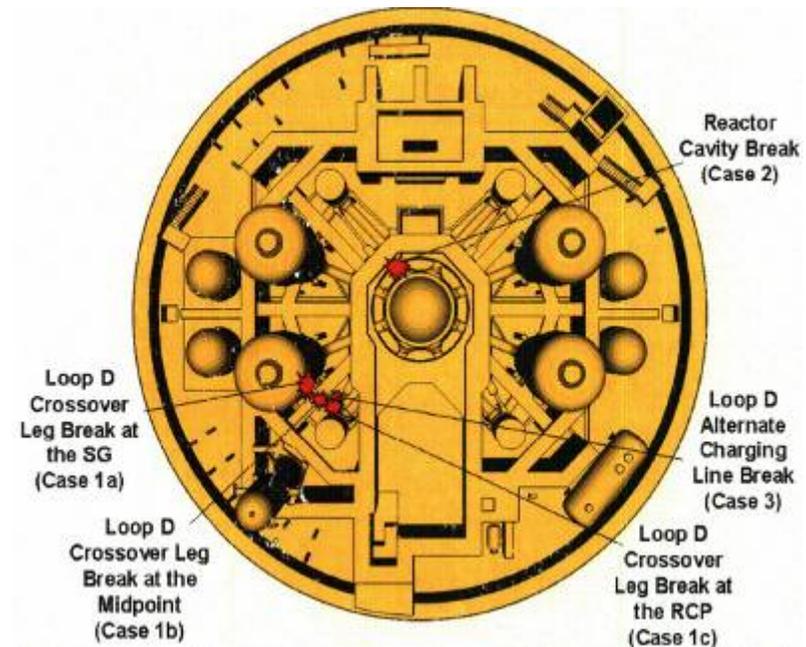
Generic Letter 2004-02 – Results of Detailed Reviews

- NRC staff has informed several licensees without significant fibrous or other problematic debris that the staff has few or no RAIs
- Most other plants have received or will receive more extensive RAIs
- Some licensees did not submit complete supplemental responses in February 2008
 - An additional round of supplemental response reviews will be necessary for these cases



Example Topics of NRC Staff RAIs (1)

- Break Selection
 - Consideration of a sufficient number of break locations following zone of influence (ZOI) reductions or other analytical or actual plant changes
 - Consideration of reactor vessel nozzle break





Example Topics of NRC Staff RAIs (2)

- Debris Generation
 - Scaling of tests used to determine the ZOI around a pipe rupture in which debris will be destroyed
 - Applicability of debris generation testing to insulation of a similar type

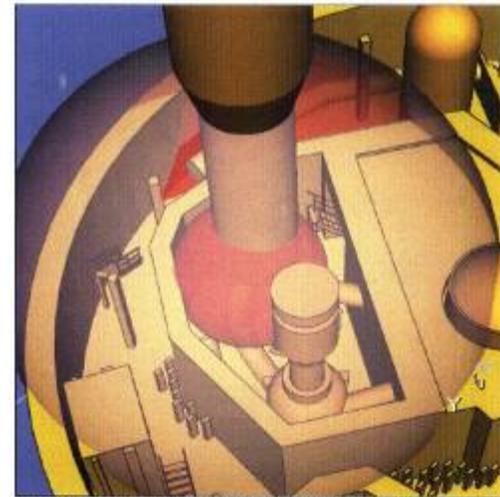


Figure 3.b.2.3 – Case 1 Temp-Mat™ ZOI (3.7D and 11.7D)



Example Topics of NRC Staff RAIs (3)

- Debris Characteristics
 - Use of default debris size distribution applicable to a large ZOI for a smaller ZOI for which the volume-averaged destruction pressure from the break is greater
 - Consideration of fine fibrous debris as a separate analytical category from small pieces
- Latent Debris
 - Methodology for estimating latent debris masses and surface areas



Example Topics of NRC Staff RAIs (4)

- Debris Transport
 - Settling of fine debris in the containment pool
 - Testing for debris erosion
 - Testing and analysis for debris interceptors
 - Determination of flow conditions and debris addition locations for head loss testing that credits debris settling
 - Debris retention in upper containment

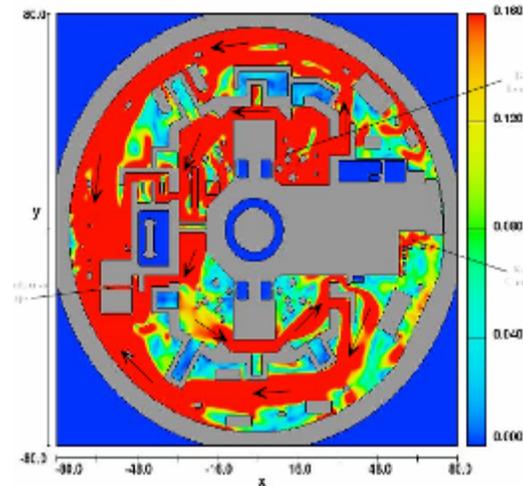


Figure 1: Baseline Case Containment Pool Velocity [ft/s]

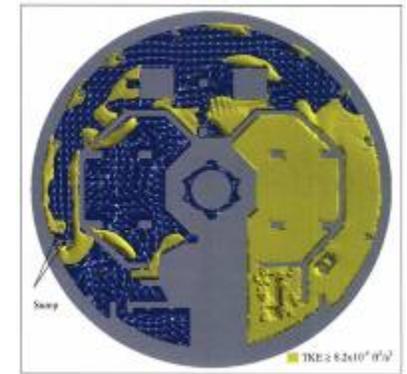
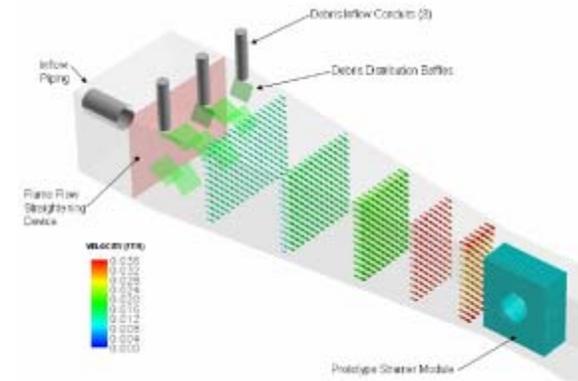


Figure 2: TKE required to suspend individual fiber (No-spray case, Break in A SG bay)

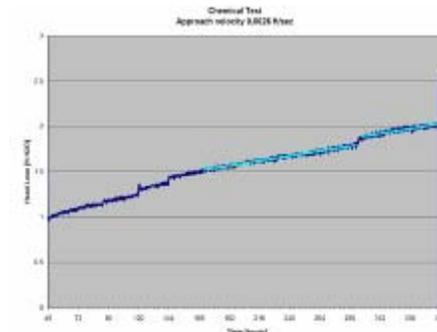


Note: One Half of Test Flume Geometry Shown



Example Topics of NRC Staff RAIs (5)

- Head Loss
 - Adequate fragmentation of fine fibrous debris
 - Preparation of debris slurries without excessive agglomeration
 - Debris addition sequence and location
 - Debris settling during testing
 - Effect of stirring on debris bed formation
 - Air ingestion and vortexing
 - Scaling and extrapolation of head loss results





Example Topics of NRC Staff RAIs (6)

- Net Positive Suction Head (NPSH)
 - Documentation and basis for assumptions concerning flow rates and minimum water level calculation
 - Consideration of limiting system configuration and single failure
- Chemical Effects
 - Settling of chemical precipitate during head loss testing
 - In-situ generation of chemical precipitates
 - Determination of bare strainer area
 - Results of bench-scale testing used to justify assumptions made for strainer qualification testing





Example Topics of NRC Staff RAIs (7)

- Coatings
 - Applicability of testing to demonstrate unqualified/degraded coating failure as chips rather than particulate
- Upstream Effects
 - Potential for blockage of refueling cavity drains

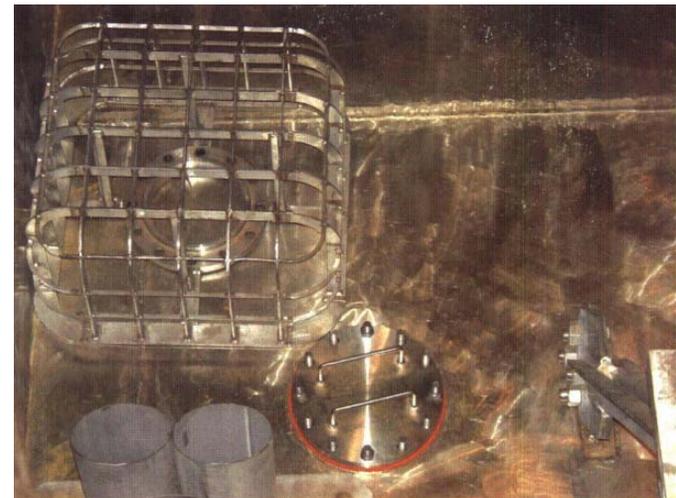
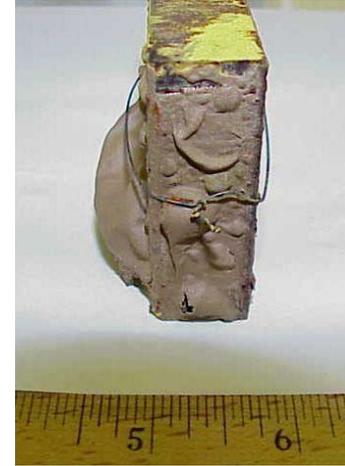


Figure 3I-1. Refueling Pool Trash Rack Cage



Example Topics of NRC Staff RAIs (8)

- Downstream Effects

- Assumed particulate filtration fraction at strainer
- Standard RAI for in-vessel analysis being incomplete pending resolution of issues on the WCAP-16793 topical report



- Structural Analysis

- Structural adequacy of strainers, trash racks, and debris interceptors



RAI Responses

- Potentially acceptable licensee responses to NRC staff RAIs:
 - Demonstration that existing approach in an area is technically adequate
 - Holistic demonstration of sufficient overall conservatism in analysis to account for uncertainties or non-conservatism in a given area
 - Change from existing approach in an area to an approach acceptable to the staff



Future Head Loss Testing Strategy

- Essentially all PWR licensees have performed one or more rounds of head loss testing for GSI-191
- To resolve NRC staff RAIs, additional head loss testing may be necessary for some licensees due to
 - Questions on prototypicality of existing testing
 - Questions which affect debris load that was tested
- If future head loss testing is necessary, staff expects that licensees will “test to success” by identifying and testing several contingency plans until a successful result is achieved, for example:
 - Analytical changes to reduce calculated debris loading
 - Physically removing debris sources from containment
 - Installing debris interceptors or other plant modifications
 - Plant to be modified at upcoming outage to be consistent with successful test condition



Generic Letter 2004-02 – Closeout Process

- NRC staff plans to issue a GL 2004-02 closeout letter to each PWR licensee when
 - All supplemental responses from the licensee have been received and reviewed by the staff
 - All RAIs from the NRC staff have been addressed by the licensee
 - Regional inspections of corrective actions are complete
- If a plant has not completed all modifications but has a satisfactory strainer evaluation in place and an acceptable plan for completing remaining modifications, staff plans to close the GL 2004-02 review for that plant
- NRC staff will track all corrective actions to completion at all plants



Generic Letter 2004-02 – Resolution Timeline

- GL 2004-02 originally requested that PWR licensees complete corrective actions by December 31, 2007
- Most licensees requested extensions beyond December 2007 to complete certain corrective actions
 - Integrated head loss testing, including chemical effects
 - Downstream effects analyses
 - Plant modifications
- Approximately 24 of 69 U.S. PWR units have active extension requests at the present time



Generic Letter 2004-02 – Resolution Timeline

- The staff is currently projecting the resolution of GSI-191 technical issues by December 2009 based on the facts that
 - Some outstanding technical issues which remain may prove complex
 - Additional time may be necessary for some plants to complete a final round of head loss testing
- Some PWR licensees may request extensions into 2010 or 2011 to complete final plant modifications
 - Provided these licensees have a satisfactory strainer evaluation in place and an acceptable plan to complete remaining modifications, the GL 2004-02 review will be closed out prior to completion of final modifications



Overview of Licensees' Corrective Actions

- All licensees have installed significantly larger ECCS sump strainers in response to GL 2004-02
- Licensees have also performed, or will perform, other modifications, for example:
 - Insulation modifications to reduce problematic debris
 - Sump buffer replacement to reduce precipitate formation
 - Installation of debris interceptors upstream of strainers
 - Installation of trash racks over refueling canal drains
 - Increasing minimum required refueling water tank level
 - Modification of gates in bioshield wall to prevent debris blockage and water hold up



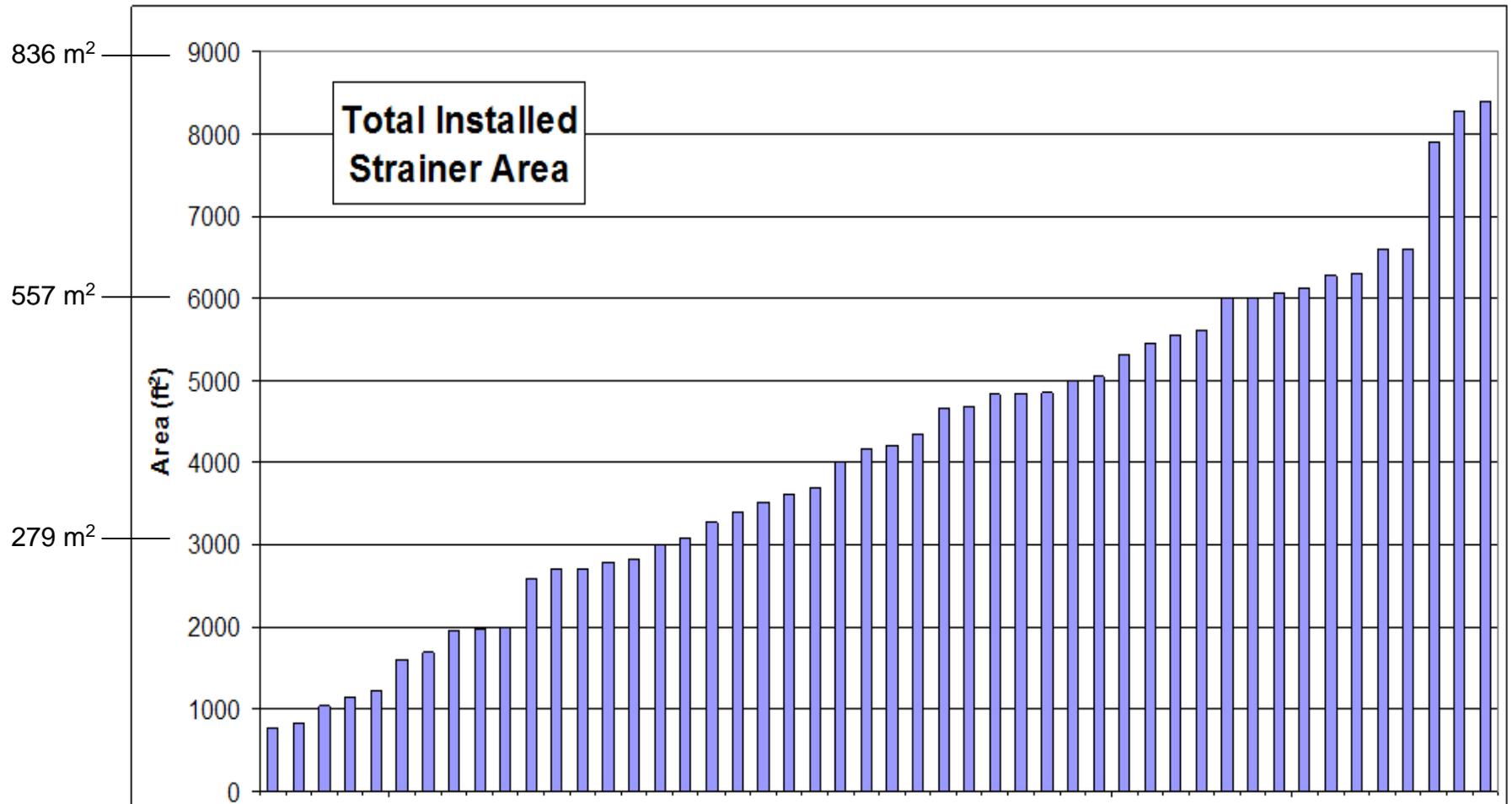
U.S. PWR Replacement Strainer Data

- NRC staff has tabulated data from the February 2008 supplemental responses to GL 2004-02 concerning several aspects of the replacement strainer design
- Caution:
 - Data is preliminary and has not been verified to be completely accurate
 - Some information may change if PWR licensees perform additional plant modifications
- However, data is of sufficient quality to provide an idea of the typical range of values for U.S. PWR replacement strainers



U.S. PWRs

Total Installed Strainer Area

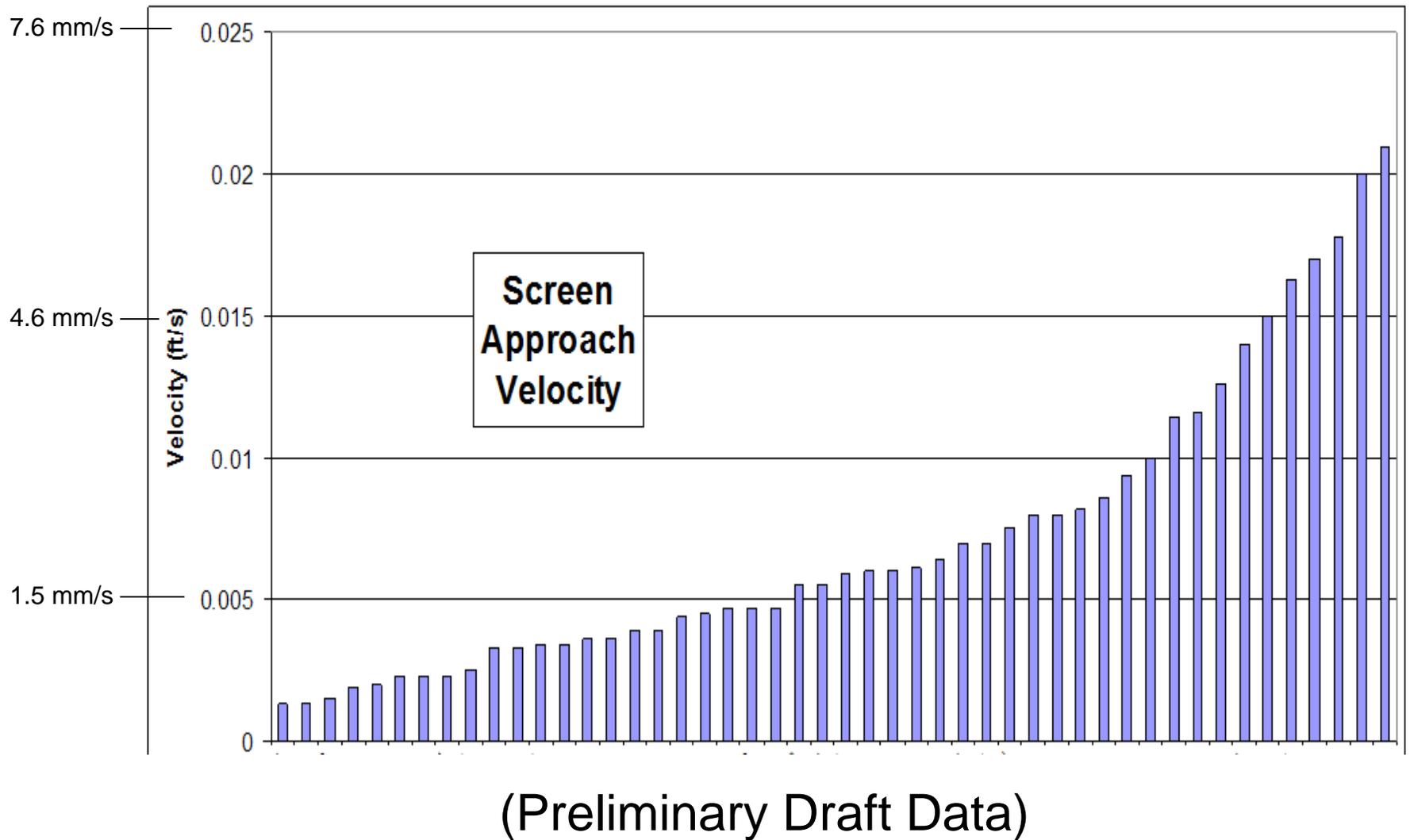


(Preliminary Draft Data)



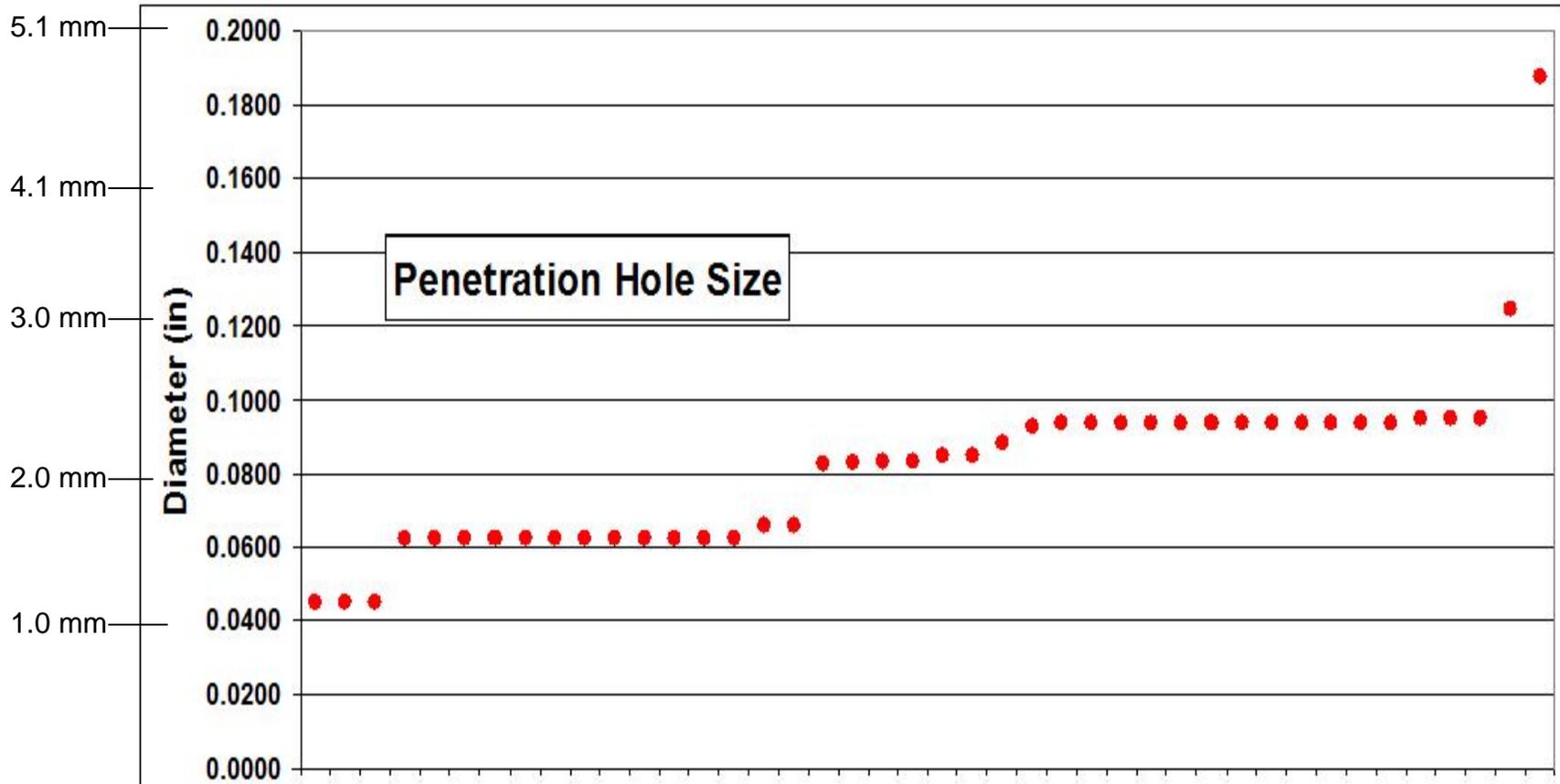
U.S. PWRs

Strainer Average Approach Velocity





U.S. PWRs Strainer Perforation Diameter





U.S. PWRs

Potential Fiber Bed Thickness

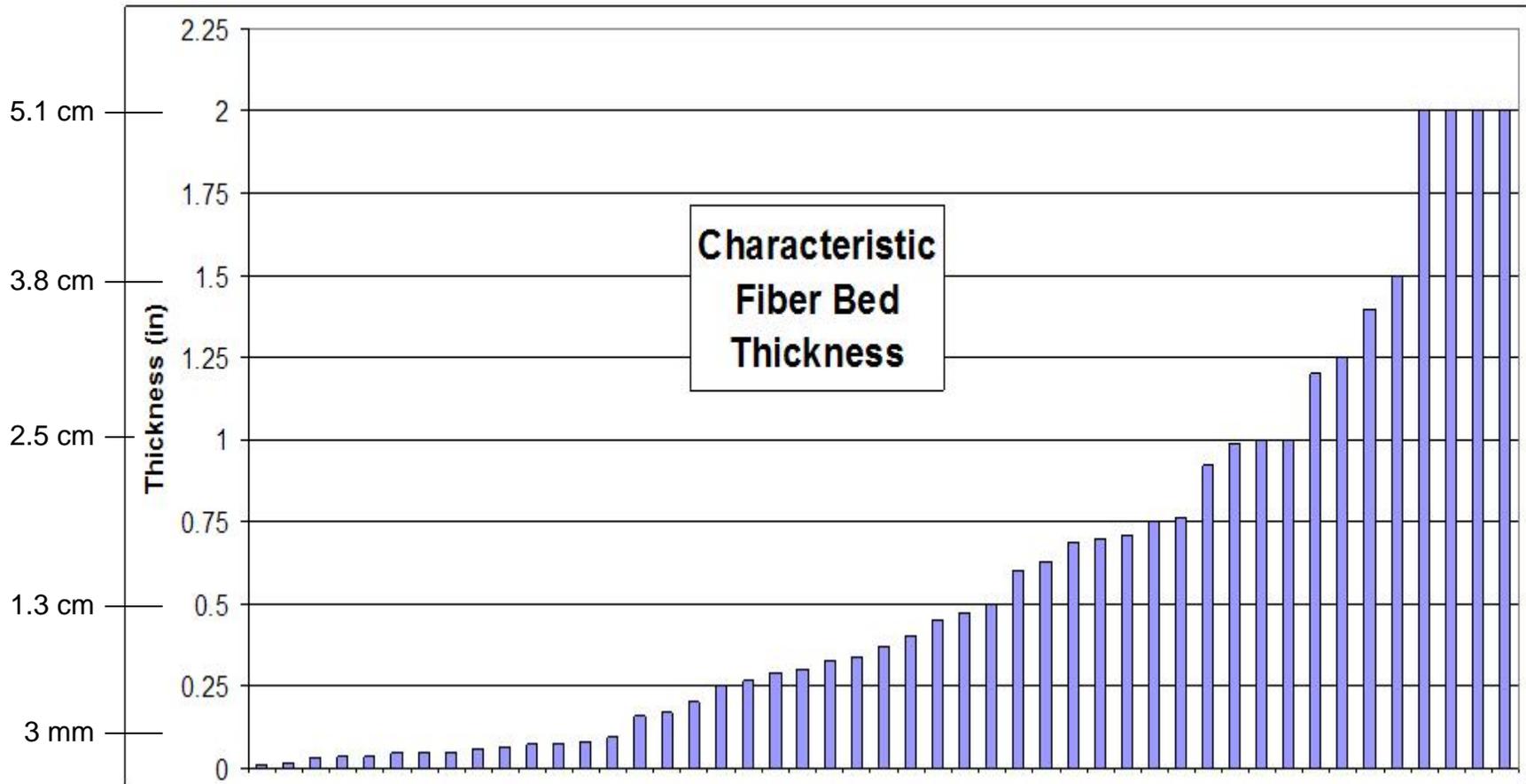
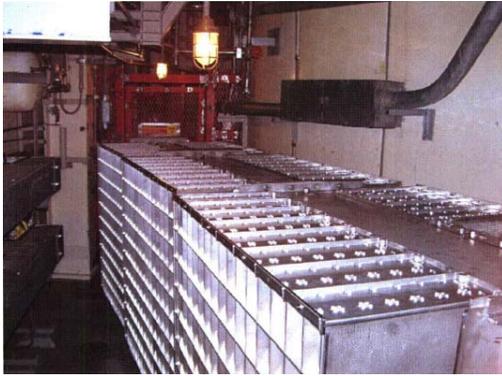


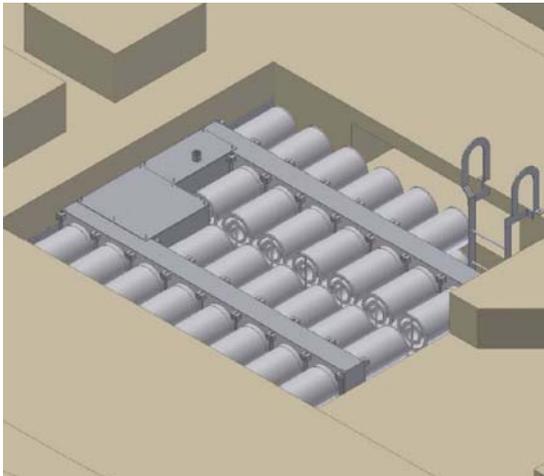
Photo Gallery



Strainer at D.C. Cook



Debris Interceptor at D.C. Cook



Strainer at Indian Point



Strainer at Oconee



Debris Interceptor at Crystal River



Conclusions

- All U.S. PWRs have installed significantly larger ECCS sump strainers and made other plant improvements in response to GL 2004-02
 - Vulnerability to post-LOCA debris effects is substantially reduced
- Outstanding technical issues remain for most plants
 - Additional head loss testing may be necessary for some plants to demonstrate adequate strainer performance
- Staff currently projects closure of GL 2004-02 reviews by December 2009
 - Some plant modifications may continue into 2010 or 2011 and will be tracked by NRC staff



Access to NRC Documents

- Documents generated by NRC are typically publicly available
- Many public documents associated with GSI-191 may be found on the NRC's PWR Sump Performance Website:

<http://www.nrc.gov/reactors/operating/ops-experience/pwr-sump-performance.html>

- Public documents not posted on sump website are available online through our ADAMS document management system:

<http://www.nrc.gov/reading-rm/adams/web-based.html>



Abbreviations

- ECCS – emergency core cooling system
- GL – generic letter
- GSI-191 – Generic Safety Issue 191
- NPSH – net positive suction head
- NRC – U.S. Nuclear Regulatory Commission
- PWR – pressurized-water reactor
- RAI – request for additional information
- ZOI – zone of influence (for a pipe rupture)