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NRC Staff Technical Issues And Questions for Generic Safety Issue 191

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Presented to:
Public Meeting
June 19, 2007

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Purpose of Presentation

- Discuss significant common strainer hydraulic design and testing issues for licensees to address
- Discuss draft list of remaining technical questions or concerns regarding GSI-191 obtained through informal elicitation of NRC team evaluating the issue

  (Note: Results of chemical effects peer review to be addressed in a separate presentation)

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Outline

Set 1. Issues to be addressed by licensees as applicable to their plant configurations

- Hydraulic input and design criteria
- Scaling
- Testing protocols
- Near-field settlement
- Other design considerations

Set 2. Questions raised by NRC staff but for which no industry actions expected at this time

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Set 1. Issues to be addressed by licensees as applicable to their specific sump configurations

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Hydraulic Input And Design Criteria

Issue #1: Single failure assumption regarding ECCS or CSS pump operation

- For some plants, LPCI or other pumps are shut off after RAS
- 10CFR50. App. A. Criterion 35 requires a single failure assumption to evaluate ECCS active components
- The single failure assumption of one LPCI pump failure to stop has been correctly adopted by many PWR licensees

Note: This is a repeat audit finding. It has been discussed during the past two public meetings

Staff Position

- ECCS/CSS pump failure to stop needs to be considered when defining maximum sump flow rate if plant design basis includes stopping one or more pumps

Hydraulic Input And Design Criteria

Issue #2: Small Strainer Submergence and Possibility of Flashing

Note : This issue was included in February 2006 GL2004-02 RAIs

- During the early phase of the recirculation, the pool temperature is at or close to saturation temperature
- If the strainer head loss is greater than the minimum submergence, flashing and de-aeration may occur inside the strainer. The flashing and de-aeration may cause higher debris bed head loss, steam binding and pump failure
- NRC SE states that bulk flow void fraction downstream of the strainer surface should be less than 3%

Staff Position

Licensees should evaluate flashing and de-aeration by determining bulk flow void fraction downstream of the screen

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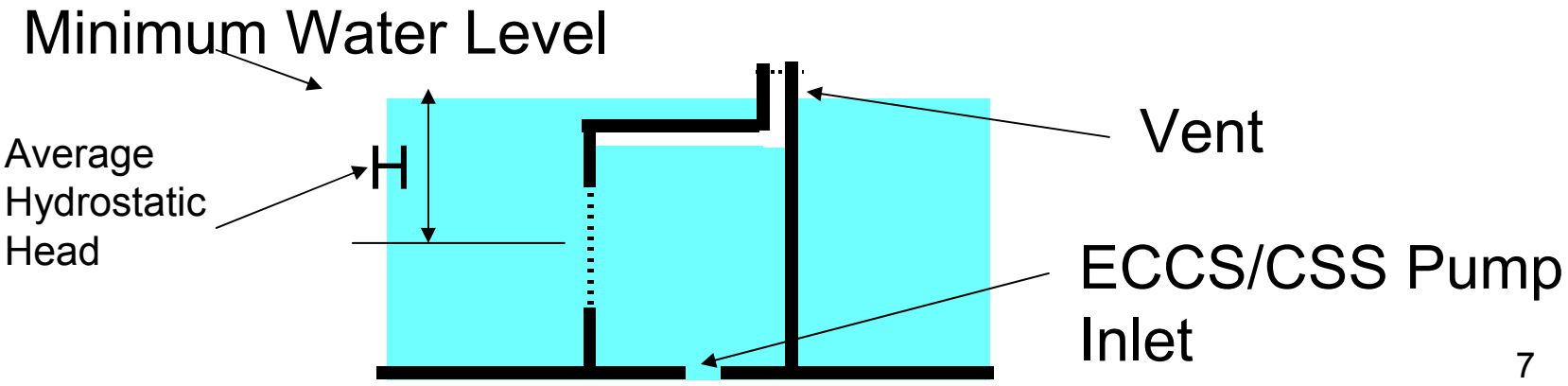
Hydraulic Input And Design Criteria

Issue # 3 Vented Sump

- Sump strainers that are vented to an elevation above the containment minimum water level may be susceptible to flow starvation failure if the total head loss is greater than the average screen static head

Note: This issue was included in February 2006 GL2004-02 RAIs

Staff Position: The total head loss must be less than the submerged screen average hydraulic static head. The average hydraulic head should be determined considering specific strainer type, actual flow and debris distribution



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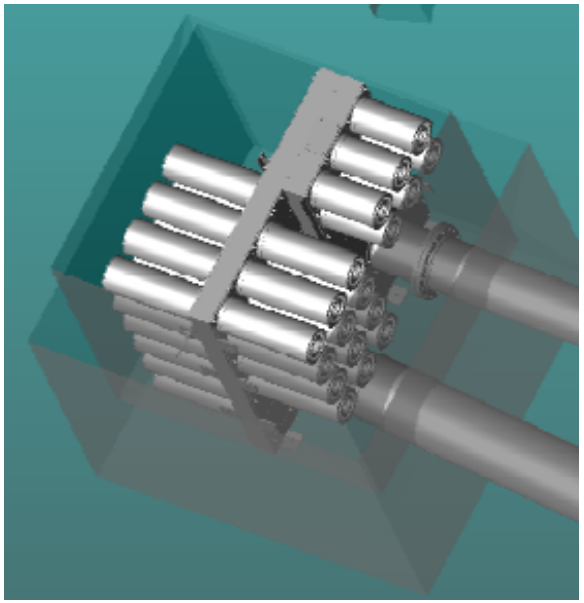
Scaling

Issue # 4 Circumscribed Flow Condition in a Debris-Filled Pit Geometry

• Phenomenon:

For plant strainers located in a pit which may be completely or partially filled with debris, a significant head loss could occur from the flow of fluid downward through the debris in the pit. If debris bridging occurs at the top row of the strainer array, high fluid velocity is expected through the debris bed at the entrance of the pit



Side View

Strainer Module
Mounted Horizontally

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Scaling

Issue # 4. Circumscribed Flow Condition in a Debris-Filled Pit Geometry

Staff Concerns:

1. Full-scale module testing performed to date has not adequately modeled higher velocity through the top layer of the debris at the entrance of the pit without modeling the entire stack of the strainer module

2. Neglecting the velocity of the downward flow through accumulated debris in the pit could significantly underestimate the plant debris bed head loss

3. Non-uniform distribution of the debris and the flow may increase the internal clean strainer head loss and the debris bed head loss due to different compression

4. Similar concern may arise for closely spaced floor-mounted strainers

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Scaling

Issue # 4 Circumscribed Flow Condition in a Debris-Filled Pit Geometry

Staff Positions:

- Scaling principle based on test versus actual strainer area ratio does not apply to the circumscribed flow condition in a debris-filled pit geometry
- Scaling principle based on test versus actual strainer area ratio may not be conservative for partially-filled pit geometry and close-spaced floor mounted strainer arrays
- Licensees need to evaluate the flow and debris distribution condition to determine whether retesting is necessary based on a proper scaling analysis specifically for these two debris distribution scenarios

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Testing Protocol

Issue #5 Coating Debris Form For Head Loss Test With Chemical Effects

- **SE Positions**
  - 1/8th inch fiber bed discussed as “thin-bed” threshold without consideration of chemical effects
  - Coatings debris to be treated as particulate unless no thin bed substantiated, else use chip form
  - Permitted to use plant specific test data to justify debris characterization, i.e., use other than 100% chips or 100% particulate
  - If chemical effects observed then integrated evaluation of head loss expected
- **Staff View**
  - A 1/8th inch bed criterion to decide whether to test coating chips or particulate is potentially non-conservative
  - Some tests with chemical precipitates have filtered particulate with fiber beds thinner than 1/8th inch
  - Additional information since SE position developed warrants consideration of revised treatment of coatings form

Testing Protocol

Issue #5 Coating Debris Form For Head Loss Test With Chemical Effects

- Testing concerns
  - Testing with chips only may not reveal potential for filtering bed with a low fiber-chemical precipitate combination
  - Testing with particulate only for plants calculated to be greater than a 1/8th inch bed may not represent conservative condition if non-uniform bed formation results in bare strainer area and coating chips could cover the bare strainer area
  - Conservatism of testing with chips vs. particulate form not always known before testing conducted

Testing Protocol

Issue #5 Coating Debris Form For Head Loss Test With Chemical Effects

- NRC Staff Expectations
  - Licensees should test with coating debris in a form that is conservative with respect to head loss
  - Because coating chips are not likely to transport to the strainer surface, staff believes that in most cases testing with particulates is conservative
  - Licensees should justify why the approach taken is conservative considering plant specifics, analysis, and coatings test data

Testing Protocol

Issue #6 Termination Criteria

Staff Concern:

- Head loss test results have sometimes indicated significant head loss increase after relatively long testing times (e.g., overnight)
- Chemical precipitate may have different hydraulic behavior from normal fiber and particulate debris during head loss testing
- Issues identified during audits

Staff Position:

- Licensees need to apply and justify proper termination criteria to predict the peak head loss when dealing with chemical effects

Testing Protocol

Issue #7 Debris Sequencing When Crediting Near-Field Settlement

Staff Concerns:

Introducing debris less transportable than fine fiber and particulate (RMI, tags and label, large chunk of fiber) first may be non-conservative in that excessive filtration of fine fibers and particulate may be achieved

Staff Positions:

- For licensees taking credit for near field settlement, the sequencing should be determined to avoid non-prototypical settlement and non-conservative head loss measurement

  Considering the possible non-conservative filtration of fine fiber and particulate due to the presence of less transportable debris, one possible debris introduction sequence could be that the most transportable debris is introduced first and the least transportable introduced last

Near-field Settlement

Issue #8 Near Strainer Velocity And Turbulence Modeling

- Near-strainer debris settlement due to debris agglomeration is realistic. However, proper scaling and testing need to be performed to take credit for strainer surface debris loading reduction due to near-field settling

Staff Concern

- Neither the localized fluid **velocity** nor the **turbulence** near the strainer have been adequately/conservatively modeled

Staff Positions

- Before conducting the test, licensees should perform adequate evaluation of the local fluid velocity and turbulence level considering strainer near-by structures, obstructions, flow channels, actual containment layout and possible break flow, if it is close to the strainer

- Based on the evaluation, the combined near-field transport and head loss test needs to be performed with a prototypical or conservative velocity and turbulence distribution

Other Design Issues

Issue #9 Use of Back Flush Option

- Back flush mechanism has been proposed by some licensees to mitigate the chemical effects and address the head loss testing uncertainties

Staff Position

- Although the staff has indicated it is receptive to this concept as a defense in depth measure, licensees planning to credit back flush need to demonstrate that it works

- Staff has discussed considerations regarding back flush at previous meetings (ML070720317)

Other Design Issues

Issue #10 Chemical Model Refinements

The PWROG has evaluated refinements, such as aluminum corrosion inhibition and solubility, to the WCAP-16530 base chemical model

Staff Concern

. Solubility is complex; depends on other plant materials and plant-specific environment (pH, temperature)

. Silicate inhibition credit – ensure analyzed breaks generate, transport, and dissolve sufficient material to achieve threshold levels for inhibition. Leaching of silica from fiberglass can be inhibited by aluminum in solution (ICET 1)

Staff Position

. Licensees should perform a conservative chemical effects evaluation

. If silicate inhibition is being credited to reduce chemical effects, additional analysis may be needed to determine the limiting break location with respect to head loss

Other Design Issues

Issue #11 Coating Zone of Influence (ZOI)

- Staff position is that licensees may use 10 D ZOI for coatings debris generation or may justify difficult criteria
- Staff reviewing technical reports attempting to justify use of less than 10D ZOI

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Set 2. Questions raised by NRC staff for which no specific industry action needed at this time

Note: Most questions raised by NRC staff during informal elicitation either included in Set 1 or already expressed to industry via public meetings

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Questions Raised by Staff

1. Possible sequential clogging caused by uneven flow through various parts of a large strainer could result in higher head loss than expected from testing at average flow. In addition, higher flow rate close to suction line may challenge the vortex evaluation based on average flow

   Resolution:

   No further action planned unless substantiated

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Questions Raised by Staff

2. If pump flow through a strainer covered by a full debris bed, debris on the strainer closest to the ECCS suction could be blown off a burst of air released from the system. When the pump is restarted, the uncovered part of the strainer is subject to vortex due to the very high flow through it

   Resolution:

   No further action planned unless substantiated

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Summary

11 issues associated with strainer hydraulic design and testing should be addressed by licensees in their GL submittals as applicable to their configuration

2 additional questions raised by the staff

no further work planned

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Acronym

ECCS	Emergency Core Cooling System
CSS	Containment Spray System
RAS	Recirculation Activation Signal
NRC	Nuclear Regulatory Commission
GL	Generic Letter
LPCI	Low Pressure Coolant Injection
PWROG	Pressurized Water Reactor Owner's Group