United States Nuclear Regulatory Commission

Protecting People and the Environment

DIFFERENCES IN TREATMENT OF CONTAINMENT STRAINER/SUMP CLOGGING TECHNICAL ISSUES FOR BOILING WATER AND PRESSURIZED WATER REACTORS

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Perceived Safety Significance Of The Strainer Blockage Issue For BWRs

- Actual debris blockage events had occurred at a number of BWRs
- BWR strainers had significantly deformed in service from differential pressure caused by debris blockage
- BWRs pass flow through the strainers immediately following a loss-of-coolant accident (LOCA), whereas PWRs do not
- The mass flow into the suppression pool creates turbulent conditions favorable for debris transport by keeping debris in suspension
- BWR drywells are not compartmentalized as are PWR containments and hence are potentially more vulnerable to transport of insulation and coating debris to the strainers
- Design of the suppression system is intended to direct flow to the pools, which will tend to carry the debris along with the flow

Tabulation of Selected Issues

Technical Issue	Examined for BWRs	Potentially More Significant for BWR or PWR
Downstream effects- components	No	Similar - some components (e.g. fixed throttle valves) more problematic for PWRs
Downstream effects- fuel	Limited	BWR
Debris bed head loss predictions	Yes	BWR
Chemical effects	No	PWR
Assessment of coatings	Yes	Similar
Latent debris	Limited	BWR
ZOI (zone of influence) adjustment for air jet testing	No	Similar- but single-phase breaks more likely at BWRs
ZOI for protective coatings	Yes	Similar
Debris transport - erosion	Yes	Similar - Plant-specific
Debris characteristics - calcium silicate Insulation	Limited	Similar for blockage
Near field effect	No	Similar
Spherical ZOI approach	No	Spherical ZOI approach can ignore fragile material in containment

Downstream Effects – Components

- Recent evaluations of downstream effects question the technical adequacy of previous evaluations (1980 time frame)
  - Erosion of piping and valves
  - Abrasion of pump internals
  - Blockage of tight clearance flow areas (e.g., throttle valves)
- This issue was added to the resolution of GSI-191
- Impact of the more recent evaluations of the issue for BWRs should be evaluated

Downstream Effects – Fuel

- Debris intrusion in the reactor vessel not reviewed during Utility Resolution Guidance reviews
- Particular concern because BWRs use channeled fuel assemblies which inhibit crossflow
- Staff believes that the issue of incore debris blockage for BWRs is potentially significant and should be evaluated

Debris Bed Head Loss

- Most significant areas with more conservative head loss positions for PWRs than BWRs
  - (1) treatment of “microporous” and Calcium silicate insulations that may result in high head losses
  - (2) the application of the NUREG/CR-6224 correlation in the strainer design process
  - (3) the treatment of thin fibrous/particulate debris beds (thin beds)
- BWR strainers likely designed based on the use of the NUREG/CR-6224 correlation and/or some questionable assumptions with regard to the treatment of microporous insulations and/or thin beds

Chemical Effects

Issue never examined for BWRs

- High head loss of chemical precipitates
- Likely high aluminum quantities
- Limited data available on precipitate generation for BWR environments
- No significant additives for most BWRs
- Differences in pH
  - Neutral pH could mean less formation
  - Dissolution of Debris can raise pH
    - Nukon, TempMat, and calcium silicate in deionized water raised the pH to 9.6

Assessment of Coatings

- Form of debris potentially non conservative
  - Left to plant-specific judgments
- The staff is evaluating changes to coatings assessment programs for PWRs
- Zone of Influence (ZOI) for Protective Coatings
  - Not clear whether the BWR treatment is non-conservative, though the default PWR position is intentionally conservative
  - Plant-specific analyses required for PWRs
  - Much larger default ZOI

Assessment of Latent Debris

- No guidance related to the form of latent debris in BWRs
- Staff understands that BWRs generally just increased the particulate debris source term to address the issue of latent debris
- Treatment may be non-conservative because latent debris may be different form
- Plant-specific issue for PWRs
  - Necessitated improvements in cleanliness/foreign material exclusion controls
- Generic treatment for BWRs with potential lower quantities

ZOI Adjustment for Air Jet Testing

- Question - Is air testing valid for two-phase blowdowns?
- PWRs required to triple the affected volume
  - Same data, normalized for pressure, used for determination of destruction volumes
  - Consistent regulatory treatment of same physical issue desirable
- Some BWRs considered entire drywell for debris source term
  - ZOIs already conservative
  - BWRs more likely to have single-phase breaks

Debris Transport and Erosion

- Differences in debris size distributions used between PWRs and BWRs may not have a substantial technical basis
- Evaluation beneficial to identify and resolve significant differences that exist in the guidance for PWRs and BWRs on debris transport issues that are similarly applicable
  - Supports development of future regulatory guidance
- Erosion differences should be reconciled
- Possibly based on differences in design

Debris Characteristics

- Blockage potential of calcium silicate insulation and other problematic materials such as microporous insulation may not have been treated conservatively
- Recent testing for PWRs has identified potential for significant head loss increases

Near Field Effect/Scaling

- Settling during testing takes credit for lack of transport which has already been assessed
- Non-prototypical conditions in test facilities may lead to settling that may not occur in plants
- Generally PWRs used the BWR vendors and initial methods similar to the BWR solutions
- BWRs have high turbulence that can keep debris in water column
- Scaling issues can result in under-prediction of head loss
  - e.g., boreholes, module arrangements

Spherical ZOI Assumption

- Common to PWR and BWR approaches
- Evaluate the validity of the spherical ZOI approach as an exclusion area for problematic debris?
  - Fragile debris can be excluded from consideration and yet be vulnerable
  - Potentially non-conservative effects for existing plant designs