GSI-191 Resolution Paths

September 21, 2011

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FRN Response

- FRN Response Included 3 Attachments
  - Attachment 1 – Regulatory Framework
    - A summary of the three regulatory frameworks that can be utilized to implement the identified comments and proposals identified in Attachment 2
      - Traditional 50.46
      - NEI 04-07 Section 6 (Transition Break Size)
      - Regulatory Guide 1.174 Resolution Framework
  - Attachment 2 – Recommendations for Incorporating Risk Insights into GSI-191 Resolution
    - Focus of today's meeting
  - Attachment 3 – GSI-191 Operability Evaluations
    - Topic for discussion at a future meeting

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FRN Response

- **Attachment 1 – Traditional 50.46**
  - **From GSI-191 Perspective**
    - **Approach that has been generally used to date**
      - **Highly mechanistic**
  - **Potential Improvements Available**
    - **Consider intent of 50.46**

Pursuant to 10 CFR 50.46, an evaluation model must include sufficient supporting justification to show that the <u>analytical technique realistically describes</u> the behavior of the reactor system during a loss-of-coolant accident (LOCA). Uncertainties need only be accounted for, so that, when the calculated ECCS cooling performance is compared to the acceptance criteria, <u>there is a</u> <u>high level of probability that the criteria would not be exceeded</u>.

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FRN Response

- Attachment 1 – NEI 04-07 (Alternate Evaluation Model)
  - Region I Breaks
    - Guillotine break of the largest line connected to RCS or break in RCS equivalent in area to DEGB of a 14-inch Schedule 160 pipe
    - Uses conservative analysis methodologies
  - Region II Breaks
    - Break size up to and including a DEGB of the largest RCS pipe
    - Region II analysis performed using more realistic analysis methods and assumptions
      - Lack of clear definition of "realistic" which prevented many licensees from adopting this approach

FRN Response

- Attachment 1 – RG 1.174 Resolution Framework
  - South Texas Project Approach
  - Risk-Informed Change to Plant's Licensing Basis
  - Provides for Consideration of Defense-In-Depth
  - Subject of Separate Meetings with NRC
    - There is substantial interest by other licensees
    - Topic of discussion in today's meeting as time permits

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FRN Response

- Attachment 2 to the FRN Response included multiple suggestions on methods to provide risk insight for the resolution of GSI-191
- The suggestions were identified and associated with an applicable attribute for resolution of GSI-191
  - Break Selection
  - Break Characteristics
  - Break Configuration
  - Debris Generation
  - Debris Transport
  - Strainer Debris Accumulation and Head Loss
  - Chemical Effects
  - In-Vessel Effects
  - Strainer Bypass
  - Water Management
- Selected items are the focus of today's meeting

Break Location and Break Opening Size For Debris Generation

- Breaks in piping attached to RCS would be determined per requirements of BTP 3-4
  - Terminal ends and locations of high stress as defined by BTP 3-4
  - Meets requirements of 10 CFR 50.46(a)(1)(i)
    - Supports an evaluation model that includes sufficient supporting justification
    - Analytical technique that realistically describes the behavior of the RCS
    - Provides high level of probability that criteria set forth in paragraph (b) of 10 CFR 50.46 would not be exceeded

Break Location and Break Opening Size For Debris Generation

- **Breaks in Qualified Piping Conservatively Sized per Fracture Mechanics Methods**
  - Size exceeds the size established for leakage detection systems
    - Calculated area of break for leakage detection (10 gpm leak) ranges from 0.030 in^2 to 0.083 in^2 (NSSS vendor specific)
    - Assumed area of break for debris generation ranges from 40 in^2 to 83 in^2 (3 orders of magnitude increase)
  - Meets requirements of 10 CFR 50.46(a)(1)(i)
    - Supports an evaluation model that includes sufficient supporting justification
    - Analytical technique that realistically describes the behavior of the RCS
    - Provides high level of probability that criteria set forth in paragraph (b) of 10 CFR 50.46 would not be exceeded

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Break Characteristics for Debris Generation

- Breaks in Qualified Piping Do Not Occur Instantaneously
  - Would limit the quantity of debris generated to assumed initial opening of qualified piping (fracture mechanics approach)
  - Subsequent further opening of break assumed to result in minimal additional debris generation
- 10 CFR 50.46 does not require the assumption of an instantaneous break
  - 10 CFR 50 Appendix K requires assumption of an instantaneous break
- Technical basis that supports GDC-4 exemption remains valid

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Debris Generation

- **Treat All Breaks that Generate Debris as a Beyond Design Basis Event**
  - Discussed in Commission Voting Records for SRM-SECY-10-0113
  - Potential that latent debris and some of the materials that would fail in the post-LOCA environment would have to be considered to be within design basis
  - Would use mitigative strategies developed for response to IEB 2003-01 and possibly those developed for B.5.b
    - Strainer backwash, flow reductions, alternate water supplies
  - Use of more realistic methodologies for performance of analysis and testing

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Debris Generation

- Increased Credit for Improved Insulation Jacketing and Banding
  - Double jacketing with seams offset approximately 180° has been shown through testing to prevent generation of debris from underlying insulation
  - Sure-Hold™ Bands have been shown to provide improved resistance to failure for single jacketed materials
  - Increased banding (decreased space between bands) has been shown to provide increased resistance to failure

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Debris Generation

- Use of More Realistic Debris Size Distribution for Fibrous Debris
  - Significant confusion exists as to the definition of small fines as referred to in NEI 04-07
  - Assumption that 60% small fines means individual fibers is extremely conservative
    - A PWR jet will wet the fibrous debris generated resulting in a greater agglomeration of fibers
  - OPG test data determined that 48% was either collected as pieces of debris less than 1 in. or passed through the cage and was not collected NUREG/CR-6762
    - Not an indicator that this value was all individual fines
  - Generation of shards is expected to be negligible

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Debris Transport

- Realistic Allowance for Debris Transport to Inactive Volumes
  - Current 15% limit not realistic for some plant geometries
- More Realistic Models for Break Flow and Other Flows Entering the Pool
  - Depending on break orientation, water entering the pool could be in the form of sheets or significantly smaller streams
  - For drainage, breakup could occur from grating or contact with other physical features
  - This would reduce the momentum generated turbulence in the pool allowing greater settling
- Increased credit for debris interceptors/debris traps

Debris Transport

- Increased Allowance for Non-Transport in Quiescent Regions of the Pool
  – Reduces the total of all debris types that could transport to the strainer
- Credit for Expected Reductions in Strainer Flow Through Course of the Event
  – As the event proceeds, flow requirements are substantially reduced
  – Once relatively stable RCS conditions are established, flows will be reduced and pumps stopped through existing procedure network

Debris Composition / Strainer Head Loss

- Realistic Condition is that Homogeneous Debris Mixture will Exist in the Containment Sump Pool
  - All testing (strainer, bypass, fuel) should be performed with homogeneous mixture
  - Credit for RMI in the debris mix should also be allowed
- Maximum Strainer Debris Load should not be Assumed to Exist at Initiation of Recirculation
  - There is a time dependency associated with arrival of debris at the strainer
  - This would result in development of the maximum strainer head loss significantly later in the event when NPSH margin is greater

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Chemical Effects Considerations

- **Maintaining pH Greater Than or Equal to 7 may not be necessary to Ensure Radioactive Iodine Capture**
  - Testing by French suggests that this may be a viable option
  - Would significantly reduce Al corrosion resulting in substantially less chemical precipitate
  - For TSP plants, would also result in less precipitate
  - Concern with stress corrosion cracking of austenitic stainless steel is a restart consideration, not a design basis requirement
  - This will support use of water management

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Chemical Effects Considerations

- Control of Sump Pool Temperature Through Use of Non-Safety Related (NSR) Equipment and Non-RG 1.97 Instrumentation
  - Shutdown cooling systems utilize both safety related (SR) and NSR components
  - Components in systems have demonstrated high reliability through significant number of reactor years of operation for normal plant cooldowns and heatups
  - Would allow for maintaining sump pool temperature above precipitation limits for chemical species
- Obtain Concurrence for an Integrated Chemical Effects Testing Protocol
  - Integrated chemical effects testing performed to date has identified formation of precipitates that are different than the extent and type of approved surrogates
- Establish more realistic precipitate formation temperature

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Strainer Bypass

- Realistic Protocol for Performing Strainer Bypass Testing Needs To Be Established
  - Open dialogue on strainer bypass testing
  - Testing should:
    - Use realistic debris preparation
    - Be performed with a homogeneous debris mixture
    - Consider the time dependent changes in strainer flow rate
    - Consider debris availability at the strainer as the result of erosion
  - This would provide the necessary input for assessing the potential for fuel blockage

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Water Management

- **Benefits of Water Management Approach Include:**
  - Increased time from initiation of event to switchover to recirculation
    - Allows greater time for settling of debris in the pool
    - Extends the time for reduction in core decay heat load
  - Reduced flow rate through strainer following switchover
    - Increased settling of debris in the containment sump pool
    - Reduction in strainer head loss
    - Reduced transport of debris through the strainer potentially impacting core cooling
  - For more probable small LOCAs, greater time available to establish normal decay heat pathways

Water Management

- Benefits of Water Management Approach Include: (cont'd)
  - Extends the time available for taking other mitigative actions
    - Alignment of alternate injection pathway water sources
    - Refill of RWST
    - Other actions established from response to IEB 2003-01
- Water Management Efforts to Date
  - One large dry containment and one ice condenser containment have implemented water management
    - The large dry containment eliminated containment spray actuation for LOCA events
    - The ice condenser containment eliminated automatic containment spray actuation, but does start one containment spray pump after switchover to recirculation based on containment pressure

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Water Management

- **Why More Plants Did Not Adopt Water Management**
  - The time and expense associated with adopting this approach
  - There was a substantial push to close GSI-191
  - Due to the extremely conservative mechanistic methodologies that were required for addressing GSI-191, little benefit was seen
  - For many plants, due to the required core damage following a LOCA, whether an AST plant or not, containment spray is always required to reduce the source term
    - Assumed core damage and the time for release is not expected
    - Instrumentation is available to alert plant operators if unexpected core damage does occur allowing for start of containment spray

Water Management

- Regulatory Implications
  - 10 CFR 50.67 does not specify the degree of core damage or the time at which it is assumed to occur
    - Only that total dose and dose rate limits be met
  - TID-14844 originally used for siting evaluations for reactor sites
    - Subsequently used for other design basis applications such as EQ (10 CFR 50.49) and some requirements related to TMI
  - RG 1.183 specifies the quantity and timing of release of radioactive materials into containment from a hypothesized accident
- Use of large and early release from the core requiring containment spray is counter to maintaining injection flow to the core for a longer period of time which provides greater core cooling and reduces the probability for substantial core damage occurring

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Summary

- Several proposals to inform the resolution path for GSI-191 have been provided
- There are actions that need to be taken by both the Industry and NRC to enable use of the proposals presented today
- Future interactions are necessary to establish the criteria by which these proposals can be implemented
- The response to the FRN provided additional items that were not discussed today but could be discussed in a future meeting

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