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UNITED STATES NUCLEAR REGULATORY COMMISSION
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GSI-191 Resolution Status Meeting
February 7, 2007

In-Vessel Downstream Effects

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Purpose of Presentation

- Respond to PWROG letter on Long-Term Cooling
- Emphasize some items that need to be addressed in the upcoming Topical Report on In-Vessel Downstream Effects

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Owners Group Position on Long-Term Cooling

Cladding Embrittlement:

- PWROG position: Maximum allowable cladding temperature 800ºF for 30 days with no significant impact on mechanical properties, corrosion, or hydrogen pickup
- References "Long-term autoclave testing"

PWROG needs to provide test results for NRC staff to review

Should demonstrate test results are applicable to all commercial cladding materials

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Topical Report Methodology

Methodology should account for differences in PWR RCS and ECCS designs

Examples:

- CE plants with smaller recirculation flows (core boiling long after hot leg injection initiation may impact concentration of debris in core, plate-out, etc…)
- Use of pressurizer spray nozzles for hot-leg injection evaluated for the potential to be clogged with debris
- Upper Plenum Injection plants with no cold leg recirculation flow may have no means of flushing the core following a large hot leg LOCA

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Topical Report Methodology

Need to account for additional debris trapped/hot spots due to swelled and ruptured cladding

- Debris may collect in the restricted channels caused by clad swelling, and at the rough edges at rupture locations
- FLECHT tests have shown that swelled and ruptured cladding will affect the cladding temperature profile. FLECHT tests did not include post-LOCA debris

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Topical Report Methodology

Should account for long-term boiling effects on debris and chemical concentrations in the core

- Similar to post-LOCA boric acid precipitation evaluation
- Account for change in water volume available to mix with constituents concentrated by the core
- Partial blockage of the core creates alternate circulation patterns within the reactor vessel and will affect the concentration analysis
- Will the solubility limits be exceeded for any of the material dissolved in the coolant that is being concentrated by boiling in the core?

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Topical Report Methodology

Should evaluate how spacer grids might trap debris and chemicals and potentially affect heat transfer from the fuel rods

- Analyses show that a partially filled spacer grid produces only a moderate cladding temperature increase even if only axial conduction down the cladding is considered
- Similar analyses show that a blocked spacer grid with only axial conduction will result in unacceptable temperatures
- Need to provide a basis for the extent that the spacer grids can trap debris, and for the ability for the debris to block flow
- Evaluation needs to include potential for issues identified in previous slides may negatively impact this concern

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Topical Report Methodology

Consideration for plating out of debris and/or chemicals on the fuel rods during long-term boiling

- Long-term boiling in the core following a large LOCA may last for several weeks for some designs depending on the ECCS flow and core inlet temperature
- Should determine the concentration of materials in the core, and the potential for plate out on the fuel rods from this material (boiler scale)
- When the composition and thickness of the boiler scale has been determined, the effect on fuel rod heat transfer can be evaluated

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Topical Report Methodology

Need to address whether high concentrations of debris and chemicals in the core from long-term boiling can affect long-term cooling

- For a large cold leg break, the density difference between the core and the downcomer determines the hydrostatic driving head and subsequent flowrate into the core
- Debris blockage of the core inlet will reduce the flow of water into the core
- As the boiling rate decreases, the high concentration of debris and chemicals in the core will increase the coolant density in the core and reduce the flow into the core region
- Voiding within the core will decrease the coolant density relative to the downcomer and increase the flow of water into the core (recognized counter-active effect)