NRC Workshop on RIA Coolability Issues

Westinghouse Electric Company
Working Group 2
October 16, 2007

Westinghouse Electric Company LLC
4350 Northern Pike
Monroeville, PA 15146

© 2007 Westinghouse Electric Company LLC
All Rights Reserved

Westinghouse

Impact of Expelled Fuel Particles on Coolability

- Post RIA coolability due to expelled fuel is bounded by Post LOCA coolability as long as pressure pulse from expelled material is acceptable
  - Fraction of core with cladding breach and ballooning greater in LOCA than in RIA
  - Material expelled small compared to material expelled in LOCA especially when combined with material introduced through sump
- For LOCA these are being addressed for PWRs in WCAP-16793-NP, Evaluation of Long-Term Cooling Considering Particulate and Chemical Debris in the Recirculating Fluid

Westinghouse

Impact of Ballooning on Coolability

- Concern is for at power RIA
  - Shape of power peak would place balloons coplanar possibly resulting in flow blockage
- At Power RIA event compared to LOCA
  - Time of event very short compared to LOCA
    - Channel closure will be limited since cladding will either burst (very localized) at low strain and high temperature or strain will stop due to short duration of event compared to LOCA

Fuel Melt Coolability Criteria

- Peak radial average fuel enthalpy < 230 cal/g
- Peak fuel temperature < Incipient fuel melting conditions (including degradation of both melting point and fuel conductivity with burnup)

HZP RIA and Fuel Melt

- HZP rod ejection has concave pellet temperature distribution (high temperatures on surface)

- Burnup is higher on surface of pellets => lower melting point
- Molten fuel, when expelled into coolant, can cause rapid energy transfer leading to pressure pulse
- Therefore, NRC coolability criteria precludes surface fuel melt

HFP RIA and Fuel Melt

- HFP rod ejection has convex pellet temperature distribution (high temperature at center)

- FSARs for Westinghouse NSSS plants show small amount of centerline fuel melt
  - Rods in DNB (failure criteria)
  - Conservative fuel temperature calculation
  - Fuel enthalpies above 160 cal/g (well below 230)
- PCM data shows that no expulsion of molten fuel occurs with up to 80% centerline melting of the pellet (the same data demonstrated coolable geometry was maintained)

Coolability Criteria Proposed Revision

- Peak radial average fuel enthalpy must remain below 230 cal/g
- Peak fuel temperature must remain below incipient fuel melting conditions in outer 75% volume of fuel pellet