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Summary and Conclusions, Next Steps

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Public meeting on Fuel Fragmentation, Relocation and Dispersal
Friday March 14, 2014

LOCA Experiments, Open Discussion (1/2)

- Discussed which parameters seem to control behavior with respect to the phenomena of fuel fragmentation, relocation and dispersal.
  - Burnup, cladding strain, rod internal pressure, plenum size, fission gas release during operation, effect of grid spacers, effect of fuel/cladding bonding, burst opening size and fuel pellet temperature.
- Discussed which parameters are important for modeling these phenomena
  - Packing fraction of relocated fuel, the possible effect on thermal conductivity, fine resolution of the fuel temperature profile.
- Proposal for terminology to distinguish between fuel fragmentation that occurs during operation, and the fuel fragmentation discussed here that is proposed to occur during a LOCA.

LOCA Experiments, Open Discussion (2/2)

- Many of these parameters are already included in the plans for research programs presented at this meeting. Notably, the following items were discussed that do not seem to be addressed in planned research programs.
  - The effect of these phenomena on thermal conductivity, a detailed quantification of packing fraction as a function of burnup and/or strain, a detailed picture of the rod axial and fuel radial temperature profile during the testing and comparison of this profile to in-reactor predictions, a fine resolution of the impact on cladding temperature of relocated fuel that accounts for the complex synergistic effects of both the potential increased heat load and the potential increased cooling effects of the balloon.
  - Pellet doping, accident tolerant fuel were also mentioned.
  - It appears that none of the planned research programs are designed to measure the consequences of fuel dispersal.
- Discussed testing conditions with respect to their applicability to both PWR and BWR LOCA conditions
  - The results and behavior observed in different testing methods, e.g. external heating and nuclear heating may need to be further evaluated for applicability to reactor conditions.

LOCA Analysis, Open Discussion (1/2)

- Multiple analyses were presented that suggest that under best estimate predictions, fuel dispersal may not occur because the rods vulnerable to fine fragmentation are not predicted to rupture.
  - Thermal-mechanical limits, core loading patterns and exposure plans create an envelope that result in this behavior.
- Discussion of the difference between ECCS analysis for Licensing Basis / Analysis of Record / Design Basis Analysis vs. realistic operation parameters.
  - Presentations and discussions highlight the significant differences.

LOCA Analysis, Open Discussion (2/2)

- Discussion of fragmentation size distribution from high burnup rods (and other empirical observations) being conservatively applied to lower burnup fuel in analytical studies
  - Discussed the lack of empirical observations for low burnup fuel, SCIP-III may provide more information that could be used.
  - Discussed the complexity of a mechanistic model for fuel fragmentation behavior
- Discussed how burnable poisons may influence the analysis.
- Proposal was made to consider an analysis benchmark so that differences in approaches and results can be identified and evaluated.
  - Comments pointed to the need to define guidelines and objectives, for example: Should studies focus on design basis evaluation conditions or realistic conditions and whether the objective is burst population or fuel dispersal quantity?
  - Some expressed concern that this would not be productive.
- Proposal was made to start further analytical efforts on the topic of consequences of fuel dispersal.

Perspectives on Experiments and Analysis, Open Discussion (1/2)

- Discussed the need to understand the consequences of fuel relocation and dispersal.
- Discussed how and when the NRC will communicate proposed regulatory actions.
  - NRC staff clairified that any new regulatory action would follow the normal, rigourous public comment and engagement standards as all new regulatory actions.
  - Some asked for clarification on whether there will be an expectation that this subject is addressed in topical reports.
- Discussed challenges with benchmark calculations for this applications
  - Noted that traditionally there is an experimental data set available to compare results to, however that is not the case in this instance.
  - Noted that the phenomena are very complex and both the thermal-hydraulic and thermo-mechanical models may need to be isolated and examined in detail.
  - Perhaps code comparisons could focus on specific behavior, such the approach to modeling ballooning and burst behavior.
- Proposed that there is a growing need to study specific parameters to better estimate important aspects of these phenomenon with analytical methods.
  - Noted thermal conductivity, packing fraction etc.
- Discussed the value of sensitivity studies related to ECCS performance, fuel parameters, etc.
- Discussed the value of more modeling efforts to complement experiments.

Perspectives on Experiments and Analysis, Open Discussion (2/2)

- Proposed that some may be interested in a detailed review of the NRC's calculations.
  - Noted the importance of a large number of assumptions made during the modeling scheme and open discussions about the choices of these assumptions may be very interesting and useful.
- Discussed the need to match calculation assumptions, and resulting temperature and pressure transient, to the conditions of experiments.
- Discussed the value of a truly coupled, between thermal-hydraulic and fuel thermo-mechanical behavior, approach to model this phenomena.
  - Noted the current approach may over predict burst because the models aren't fully coupled.
  - Noted this is a goal of the NRC's efforts, but this is complex and takes some time.
  - Noted that sub-channel codes may be available already to examine this as a first cut.
- Discussed the need to define a goal for future analytical studies.
  - Proposed one objective is to demonstrate there is no safety issue with respect to fuel dispersal.
  - Proposed another objective is to develop confidence that multiple analysis can show there is no fuel dispersal concern and thereby reduce need to complete significant research on the sensitivities to these phenomena.

NRC Next Steps (1/2)

- Review results of experiments completed in the last year and remain active and engaged in international collaborative research programs focused on the phenomenon discussed today.
- Continue to perform analysis to develop an improved understanding of the sensitivities of these phenomenon with respect to factors including plant design and operation parameters.
- Continue to engage the public on approaches to evaluate the consequences of these phenomenon and regulatory path forward.
- Develop a technical basis and regulatory recommendation that is well informed and comprehensive in scope.

NRC Next Steps (2/2)

- All presentations shown during this meeting will be placed in ADAMS and be available to the public.
- A meeting summary will be prepared and placed in ADAMS and be available to the public.
- You can look for the presentations and meeting summary on the NRC's public meeting page, on the "meeting details" page for this meeting in the next few weeks.
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