ROD BUNDLE HEAT TRANSFER TEST RESULTS; Spacer Grid Effects and Potential Impacts on LOCA Evaluation Models

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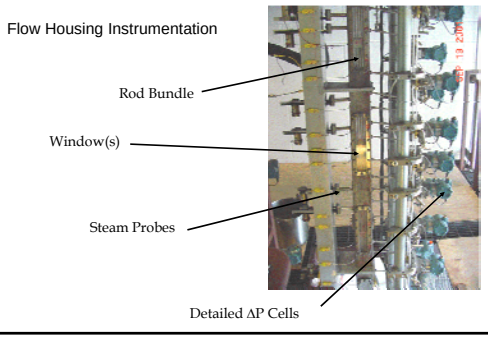
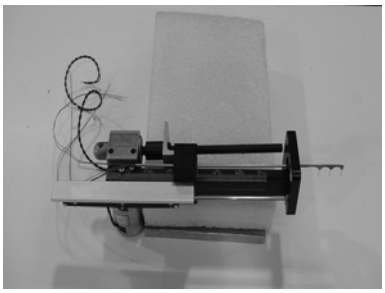
Spacer Grid Effects

- The effect of spacer grids on reflood heat transfer has been observed in several test series (FLECHT-SEASET, FLECHT, FEBA). Important effects are:
  - Convective enhancement (downstream of grid)
  - Droplet breakup
  - Grid rewet
- The NRC has sponsored tests at the Penn State Rod Bundle Heat Transfer Test Facility (RBHT) to investigate reflood heat transfer and other LOCA processes.
  - Reflood Heat Transfer
  - Steam Cooling
  - Droplet Injection
- The NRC has recently begun to evaluate the data and incorporate findings into analysis codes.

RBHT Test Facility



RBHT Steam Probe Rake



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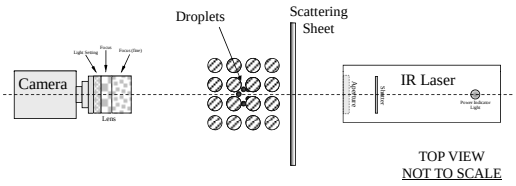
Digital Imaging System



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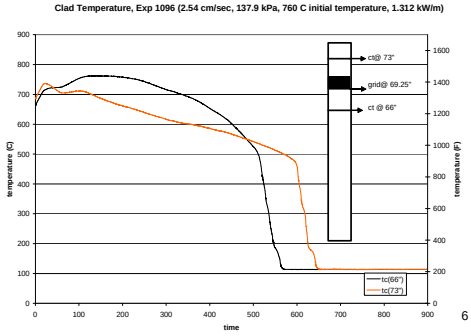
Convective Enhancement



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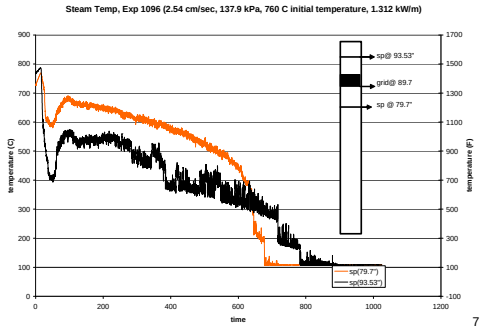
Droplet Breakup



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Spacer Grid Effects

- Local convective enhancement downstream of spacer grids is due to disruption of the boundary layer. The "entrance length effect" increases the heat transfer coefficient as the boundary layer reforms.
- Droplet breakup increases the interfacial area of the droplet field. Rapid evaporation decreases the steam temperature, which increases the rod to fluid heat flux.

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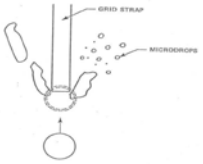
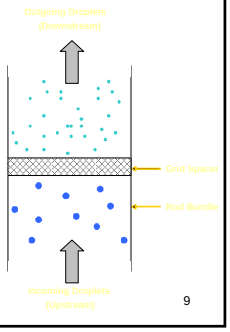
Droplet Breakup – Dry Grids

- The conventional "theory" has been that the primary mechanism for droplet breakup (and resulting downstream increase in evaporation) is due to drops interacting with a dry grid. Sharp obstructions shear the incoming droplet into two or more smaller droplets.





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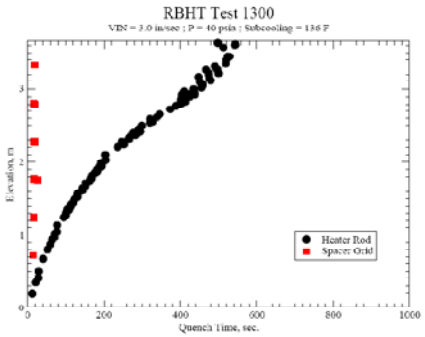
RBHT Test 1300 Results



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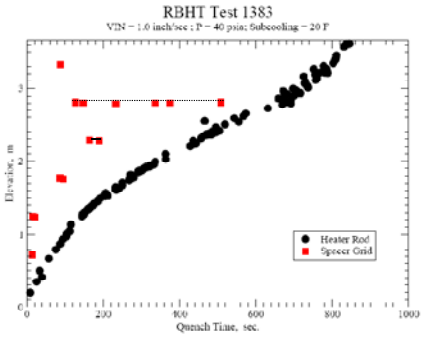
RBHT Test 1383 Results



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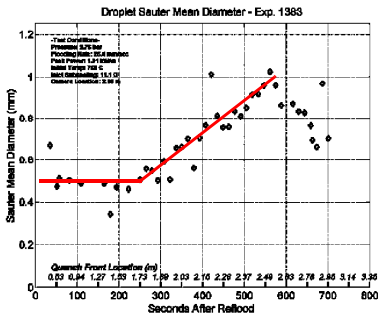
Droplet Size vs. Time



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Droplet Formation Processes

Dry Grid

- May not persist except far from QF, or if VIN is small.
- Drop formation by breakup at sharp interfaces.
- Drop sizes found to be small.

Wet Grid

- For VIN > 1.0 in/s, most grids show quick rewet.
- Drop formation may be due to entrainment from film on grid.
- Drop sizes increase as quench front approaches grid.

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Summary & Conclusions

- RBHT data from recently completed test series is now being evaluated and used in code assessment.
- RBHT Reflood test data show grid rewet to occur everywhere in the bundle when VIN > 3 in/sec and on two or more grids ahead of the quench front for low flooding rates.
- Drop sizes downstream of a wet grid are larger than those produced by a dry spacer grid, indicating that the mechanism for drop formation changes.
- Consequence for Evaluation Models:
  - **Wet grids can act as a source for droplets high in a bundle.**
  - **Drop formation mechanism in codes to be concerned may not be that at the quench front, but from rewet grids just downstream of high power and PCT locations.**

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