



Debris Accumulation & CalSil Head Loss Testing

-- Findings & Preliminary Conclusions --

Mark T. Leonard
Arup K. Maji
Ashok K. Ghosh

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Decision Applications Division



Test Program: Objectives

- **Characterize spatial distribution of debris accumulation on a vertical screen.**
 - What conditions generate debris beds of uniform thickness and composition?
- **Evaluate applicability of NUREG/CR-6224 head loss correlation to PWR sump screen conditions.**
 - Is the correlation suitable for a vertical screen configuration and hydraulic conditions at a PWR recirculation sump.
- **Generate data to characterize head loss across debris beds containing fragments of CalSil insulation.**
 - Can the NUREG/CR-6224 correlation be adapted to predict head loss for debris beds containing CalSil?



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Experimental Facilities

- **Debris accumulation testing**
 - Debris bed formation simulated in the large flume at UNM
- **Head Loss Measurements**
 - Work-horse test facility was the closed-loop head loss measurement facility at UNM
 - Selected (confirmatory) measurements made in large flume
 - Emphasis on effects of CalSil



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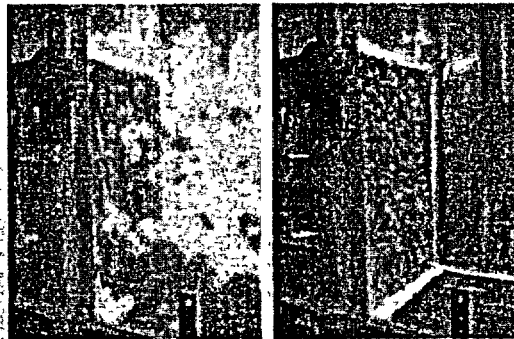
Debris Accumulation

- **Testing designed to address fully-submerged screens.**
- **Debris accumulation profiles observed for several types of debris at 0.5 & 0.9 ft/sec.**

- Fiberglass fragments
- Crushed CalSil
- Crumpled S/S RMI foils
- Fiber/CalSil Mixtures

• **Results:**

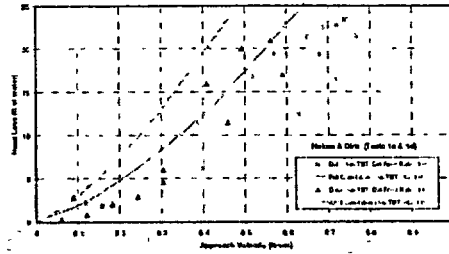
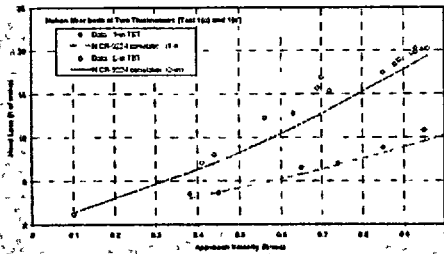
- Fiberglass: Uniform bed
- CalSil & RMI foils: Debris distribution skewed toward bottom of screen
- Fiberglass & CalSil: Near-uniform - both types covered entire screen



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Head Loss - Correlation Benchmark



- Initial testing involved fiberglass fragments (with and without dirt) to generate benchmark data for comparison to NUREG/CR-6224 correlation.
- Correlation provided accurate prediction of data; Test facility measurements consistent with prior testing.

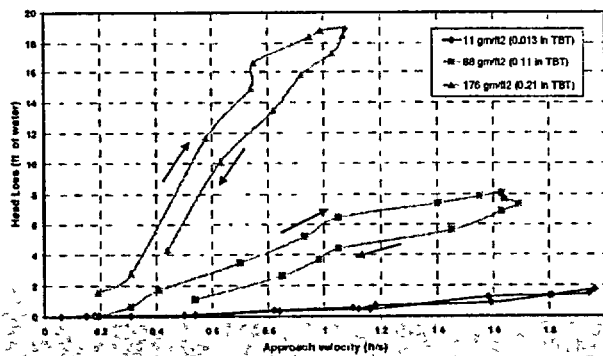


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CalSil Measurements

- Head loss caused by CalSil is considerably higher than debris beds of previously tested materials of comparable thickness.
- Coherent beds observed with measurable head loss at thickness less than 1/8-in.
- NUREG/CR-6224 correlation fits data if appropriate physical properties of debris are used.



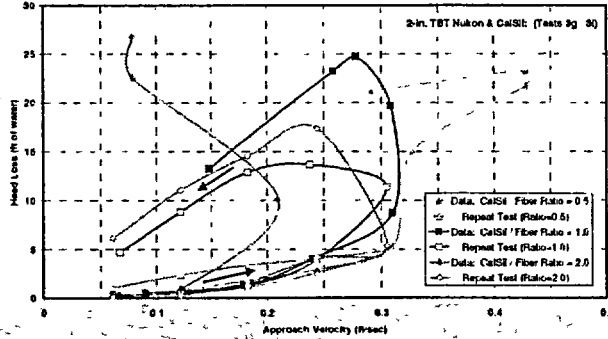
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Fiber/CalSil Mixtures

- Relationship between head loss and approach velocity initially follows trends of particulate-laden fiber bed.
- Severe bed compaction above ~0.3 ft/sec causes dramatic and irreversible increase in head loss.
- NUREG/CR-6224 correlation fits data well at low velocities, but requires significant adjustment after bed compaction.

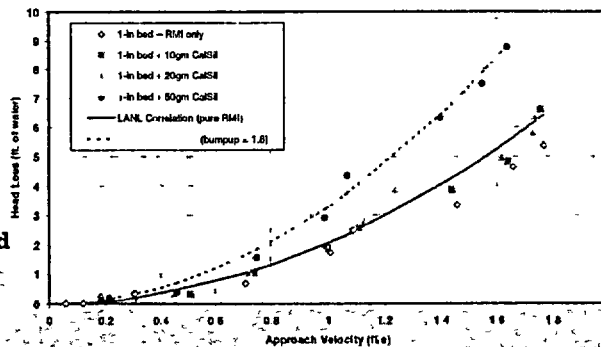


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RMI /CalSil Mixtures

- CalSil deposited throughout base debris bed of crumpled RMI foils.
- Distribution more uniform in 1-in bed than in 8-in bed.
- Head loss noticeably higher with CalSil in quantities greater than ~20 gm/ft² of screen area.
- LANL correlation for RMI debris bed head loss can be adjusted with 'bump-up' factors to fit data



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Preliminary Conclusions (1)

- **Debris accumulation profile depends on type of debris transported to vertical screen.**
 - Fiberglass and mixtures of fiber/Calsil debris form uniform, or near-uniform debris beds on a submerged vertical screen.
 - Calsil alone can accumulate on a 1/8-in mesh screen without an underlying base debris bed, distribution is bottom-skewed.
 - Crumpled S/S RMI foils collect near the bottom of the screen and gradually 'climb' on each other, forming a bottom-skewed accumulation profile.
- **Head loss measurements for well-characterized debris consistent with those measured in previous studies.**
 - NUREG/CR-6224 correlation accurately predicted head loss fibrous debris bed data generated in UNM facility.



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Preliminary Conclusions (2)

- **Effects of Calsil on head loss across a fibrous debris bed are complicated.**
 - At low (< 0.3 ft/sec), stable approach velocities, the exacerbating effects of Calsil are similar to those of common particulate.
 - At higher approach velocities, severe bed compaction causes a sharp increase in head loss.
 - Bed compaction and its effect on head loss is non-recoverable if velocity is subsequently decreased.
- **General framework of NUREG/CR-6224 correlation can be used to predict head loss for Fiber/Calsil mixtures.**
 - Treating Calsil as 'particulate' generates reasonable predictions for low approach velocities (< 0.3 ft/sec)
 - Special form of correlation (high particulate-to-fiber ratio) with bump-up factors is probably needed to capture effects of bed compaction at higher velocity.



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Preliminary Conclusions (3)

- **CalSil increases head loss across RMI debris beds.**
 - Effect of CalSil in low quantities is small (increase within data scatter for RMI alone for quantities below approx 30 gm/ft^2 of screen area)
 - However, head loss nearly doubles with $\sim 75 \text{ gm/ft}^2$.
 - LANL correlation for RMI debris bed behavior can be adjusted to fit data for RMI/CalSil mixtures.



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