GNF Perspectives on Testing Debris Effects on GNF BWR Fuel

June 2009

Why A Fuel Effects Perspective ?

- HISTORY: BWR work conducted in the 1992-2001 time frame by the BWR industry to address clogging of suction strainers completed prior to the more recent PWR work
- NEW INFORMATION: While addressing PWR recirculation issues, further knowledge has been developed in various disciplines that could be applicable to BWR strainer design.
- NRC OBSERVATIONS: Several areas were treated more conservatively during the course of the PWR work and several areas were not examined for BWRs during the earlier work.
- NRC CONCLUSIONS: The staff concluded that several subject areas not addressed by the BWR licensees during the 1990s warranted additional consideration to determine the applicability to BWR designs.

ONE STAFF CONCLUSION IS TO CONSIDER THE DOWNSTREAM EFFECTS OF DEBRIS PASSING THE ECCS SUCTION STRAINER

Excerpts from Letter to Richard Anderson, BWROG Executive Chairman, from John A. Grobe, Associate Director for Engineering and Safety Systems Office of Nuclear Reactor Regulation , dated April 10, 2008. Subject POTENTIAL ISSUES RELATED TO EMERGENCY CORE COOLING SYSTEMS (ECCS) STRAINER PERFORMANCE AT BOILING WATER REACTORS

GNF Experience

- GNF has considered a small concentration of fibrous material in water injected by the ECCS system
  - First set of tests were performed in 1997
    - Atlas single phase facility
    - Focus on Debris Filter LTP
  - Second set of tests were performed in 2007
    - low flow test loop in Wilmington
    - Focus on Defender LTP

Testing Has Focused on LTP Clogging

Test Considerations

- Source Material (Slurry)
- Test Loop
- Conduct of Test
- Deciding What to Test
- Schedule

Source Material

- Source Material (Making the Slurry)
  - In addition to the type of material, the total amount, concentration, and delivery rate of debris needs to be well defined
  - Maintaining and measuring the concentration is often difficult and subject to undetectable variations
    - Mixing apparatus and a means to ensure limited deposition of the debris in the loop is required
  - Deposition of material is as random as the source material within the slurry
    - This is an uncontrolled variable that will result in some level of repeatability problems
  - Pretreatment of fibrous material has an impact on the results
    - Consistent repeatable methods must be utilized
    - Thermal aging and material disintegration simulation techniques as well as mechanical processing of material should be considered

Differences from Test to Test Source Material Expected

Test Loop Design Matters

- Detailed Description of the test loop needs to be considered.
  - Large loops can hide much more material in loop internal components
  - Small loops help ensure slurry is delivered to the test element (fuel assembly) in prescribed concentrations – hide out of debris can be controlled (but not eliminated)
- Flow measurement and control , turbidity, differential pressure, pipe size, and pump type, need to consider the potential for clogging and hide out of debris (Minimize and Verify)

Test Assembly Components
Not Debris "Hide Out" in the Loop

Conduct of The Test

- Safety under 10CFR50 Appendix B program
  - Calibration & Documentation
  - Training & Qualification
- Some Contributors to Variation (Clog Test)
  - Consider mixing operations and modes of mixing
    - Fixed time for mixing (if any mixing) or settling
    - Fixed time to injection of slurry (e.g. rate of injection)
  - Consider how slurry is introduced
    - Bottom Drain
    - Elevated Drain
- Development of TP&P and Operating Procedures
  - By our procedures the test requestor (Designated individual of BWROG) will review and sign off on final TP&P
  - Changes concurred in by the designated BWROG requestor

ENSURES QUALITY & REDUCES VARIATION IN RESULTS

GNF Assemblies In Operation Today

- GNF Fuel In Service Today

10x10	9x9
GE12	GE11
GE14, GE14N	STEP3 (Japan Only)
GNF2, GNF2N	

*MOX 8x8 Fuel Assemblies (Japan Only)

Deciding What To Test ?

Global Nuclear Fuel
A Joint Venture of GE, Toshiba, & Hitachi

Selection Process (GNF Fuel)

- Majority of fuel in operation today is GE14
  - For all but the BWR2s GE14 is now supplied
  - Last GE12 for US operations fabricated long ago – Only supplied to LV in recent years and LV has just transitioned to GE14 – The GE12 product line has been retired
- Transitioning to GNF2
  - Over half the fabrication in 2010 is GNF2
  - BWR2s transition to GNF2 with initial reloads planned for 2010 and 2011 – This will retire the GE11 product line
- Ignoring long term operation of 9x9 fuel in Japan, as well as Nordic version of 10x10 products, for a US NRC focus GNF's primary interest is in 10x10 fuel with respect to this testing
  - GNF2
  - GE14
- GNF may evaluate the components of each design with respect to projected areas of obstructed and unobstructed regions along the direction of flow.
  - The greatest changes in the ratio of these areas will be used to estimate the components and geometries for the test
  - Since only two designs are considered for evaluation the method of selecting a component or region with respect to its tendency to clog faster may be evaluated by direct testing
  - If the method proves accurate, the method could be applied to other fuel vendor designs with the intent of minimizing testing

Testing Targets

1. Initial Reflooding [can debris in the rising level significantly delay two phase mixture reflooding ?]
   Committee expectation: Testing should assess blockage during level reflooding (level rate to be determined)

2. Core Spray [can debris in spray significantly reduce coolant passing through the bundle?]
   Committee expectation: Testing should assess blockage during core spray (to approximately 10 gpm per bundle)

3. Natural Circulation for covered core [degree that debris in coolant clogs the inlet?]
   Committee expectation: Testing should assess blockage during low flow natural circulation (flow rate to be determined)

4. Bypass Region path [can debris in spray and injection inside shroud clog the LTP holes to any significant degree to prevent flow to lower plenum and bundle inlet?].
   Committee expectation: Testing should assess blockage during LPTH back flow (flow rate to be determined)

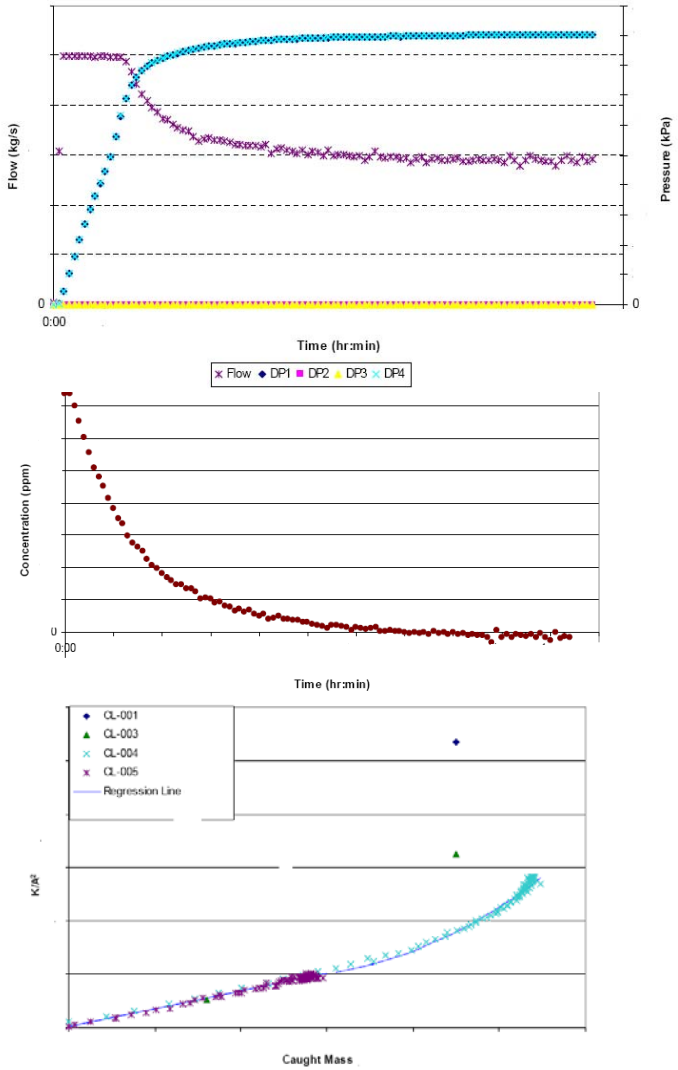
GNF Interpretation of Targets

- Low flow, forward, and reverse testing at ambient temperature of a slurry of prepared debris and water in a fuel assembly and fuel cell
  - Conceptual Test Setup
    - Plexiglas vessel consisting of a mock cell with one test location for insertion of a BWR assembly of sufficient length to mock up specific assembly features (e.g. Spacers, LTP, UTP, PLRs, etc ..)
    - Flow control of slurry from 0-20 gpm (variable)
    - Data Acquisition (~20 Channels)
    - Video data acquisition
    - Debris Preparation Facilities (Steam, Lab Furnaces)
    - Tank, mixer, pumps, and instrumentation suitable for slurry and hardened to clogging by the debris
    - Fuel assembly, cross sectional full scale, utilizes actual fuel assembly components, scaled height of assembly (saves money)

Schedule Analysis

- The 2007 clogging test of Defender was requested by a customer in 2006
  - Loop design, fabrication, and commissioning occurred over an 8 month period (This is a scaled loop ~ 6 ft in BWR fuel assembly length)
    - Accelerated schedules are possible (Increases Costs)
  - Testing and analysis of results occurred over an additional 4 month period
- Full Scale –vs.- Part Length (Longer Schedule)
  - Full scale testing is possible
    - Considerable increase in cost
      - Cost Driven by Facility Construction
    - Considerable Increase in schedule
      - For GNF we would need to build a facility, may add 6 months to a year provided sufficient real estate could be found within an existing High Bay facility.
      - Add one year if a High Bay building needs to be constructed

Expected Results



Self Consistent Results

A decrease in the concentration of debris in the slurry consistent in time with an increased differential pressure within the assembly and reduced flow within the loop

Pictures\Video – Visual Verification

Mass Correlation

Good test behavior as demonstrated over a series of test where the loss coefficient can be estimated as a function of accumulated debris within the assembly

Questions