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Test for Success

Prototype Tank Testing Protocol

November 6, 2008

ALION
SCIENCE AND TECHNOLOGY

NRC Expectations

- Details on debris preparation, sizing, and introduction
- Any unique testing variations to address plant design differences
- Discussion on testing to search for thin bed
- Scaling
- Minimum submergence
- Stabilization criteria
- Generally, discussion on how closely testing will follow or deviate from March 08 guidance

Outline of Presentation

- Head Loss Testing Objective
- Key Concerns Regarding Testing
- Head Loss Testing Protocol
  - Description of Testing
  - Scaling/Selection of prototype
  - Test Matrix
  - Debris Characteristics/Size Distribution
  - Debris Preparation
  - Debris Introduction
  - Submergence
  - Stabilization Criteria

Head Loss Test Objective

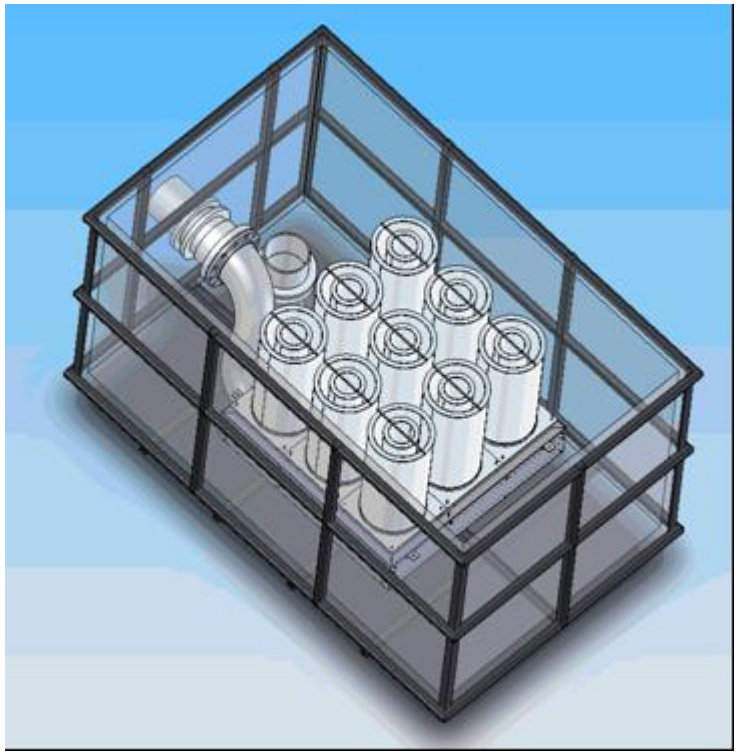
1. To acquire data that is used to demonstrate acceptable pressure drop across the installed strainer subjected to post-LOCA debris:
   - Non-chemical debris: fiber, particulates
   - Chemical precipitates
2. To acquire sufficient information to establish a clear path forward should plant physical changes (e.g. problematic insulation removal) and/or operational changes (e.g. flow reduction) need to be implemented to ensure acceptable NPSH
3. To address regulatory concerns regarding head loss testing methods identified in RAIs and incorporate the latest guidance provided by the NRC in the March 08 Supplemental Guidance document

Key Concerns on Head Loss Testing

- Identification of Maximum Head Loss
  - Search for the Thin Bed
  - Maximum Loading
- Scaling & Selection of Prototype Module
- Debris Characteristics
- Debris Size Distribution & Preparation Methods
- Debris Introduction
- Minimum Submergence
- Stabilization Criteria

Description of Testing

- Top Hat array testing in tank with WCAP precipitates
- Tap water at room temperature
- Range of debris loadings (Thin Bed through Max Loading)
- WCAP surrogate recipe for chemical precipitates
- Protocol updated to account for NRC RAIs and March 08 guidance



Sample Test Tank Setup

Scaling and Selection of Prototype Module

- Top Hat array used in all tank testing
- Boundary conditions simulated
- Water levels are consistent with containment water level
- Tank turbulence pre-test to ensure no settling of debris (i.e. no “Near Field” effects)
- Tank turbulence will not impact debris bed formation (i.e. no debris bed damage by return flow or excessive turbulence)
- Debris and flow scaling
  - Chemical and non-chemical debris scaled as the ratio of test strainer surface area to plant strainer surface area
  - Test flow set so that the average test strainer surface approach velocity is the same as the average approach velocity of the plant strainer (i.e. no scaling of velocity)

Test Matrix

Thin Bed Test:

- Prototype array in test tank
- Test Sequence:
  a) All particulate material introduced first into test tank
  b) 1/8” equivalent bed thickness fibers batched into tank up to ½” equivalent bed thickness
  c) WCAP precipitates batched into tank after stabilized head loss is achieved for the thin-bed

Full Load Test:

- Prototype array in test tank
- Test Sequence
  a) Multiple batches of homogenous mixture of Fiber+Particulate
  b) WCAP precipitates batched into tank after stabilized head loss is achieved following the addition of the final debris batch

Debris Characteristics

- Fibers debris size distribution (Low Density Fiber Glass (LDFG) and Mineral Wool) is obtained from the debris generation calculation. Examples include:
  - NEI 04-07: 60% fines, 40% large pieces
  - Alion Four Size Distribution for LDFG (next slide)
  - Plant specific size distributions
- Latent fibers are considered as “Fines”

Debris Characteristics (Cont.)

Table 4.1 – LDFG debris size distribution within each zone

Size	18.6 psi ZOI (7.0 L/D)	10.0 – 18.6 psi ZOI (11.9 – 7.0 L/D)	6.0 – 10.0 psi ZOI (17.0 – 11.9 L/D)
Fines (Individual Fibers)	20%	13%	8%
Small Pieces (< 6" on a Side)	80%	54%	7%
Large Pieces (> 6" on a side)	0%	16%	41%
Intact (covered) Blankets	0%	17%	44%

Debris Size Distribution - Testing

Fibers:

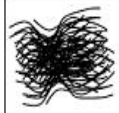
"Fines"

- Definition: Classes 1 – 3
- Produced by double shredding and broken down by either motorized paint stirrer or hydrolyze (water jet)

"Smalls Pieces"

- Definition: Classes 4 - 7
- Produced by single pass through a leaf shredder

Table 3-2 Size Classification Scheme for Fibrous Debris[3-2]

No.		Description
1		Very small pieces of fiberglass material; "microscopic" fines that appear to be cylinders of varying L/D.
2		Single, flexible strands of fiberglass; essentially acts as a suspending strand.
3		Multiple attached or interwoven strands that exhibit considerable flexibility and that, because of random orientations induced by turbulent drag, can exhibit low settling velocities.
4		Fiber clusters that have more rigidity than Class 3 debris and that react to drag forces as a semi-rigid body.
5		Clumps of fibrous debris that have been noted to sink when saturated with water. Generated by different methods by various researchers but easily created by manual shredding of fiber matting.
6		Larger clumps of fibers lying between Classes 5 and 7.
7		Fragments of fiber that retain some aspects of the original rectangular construction of the fiber matting. Typically precut pieces of a large blanket to simulate moderate-size segments of original blanket.

Debris Preparation

Class 1, 2, and 3 Fibers

Class 1 through 5 Fibers

Debris Size Distribution

Particulate Size Distribution

- The particulate debris size distribution are based on the size distribution defined in the Debris Generation calculation
- The coating debris surrogate is silicon carbide with a nominal diameter of 10 microns
- Latent dirt/dust debris in accordance with SER Appendix VII recipe

Debris Preparation Protocol

Fiber:

- All shredded fiber is boiled for 5 minutes
- Fiber is then placed in a bucket with plenty of water to create a thin slurry – ¼ lbs fiber/2 gallons of water
- Fiber and water stirred with a paint stirrer for 4 minutes
- Fiber slurry sampled to visually verify that the fiber in slurry meets the required size distribution

Debris Preparation Protocol

Particulate:

- Particulates are placed in a bucket with plenty of water to create a thin slurry
- Particulate with water is stirred with a paint stirrer to ensure homogeneous dispersal – no “clumps”

Debris Preparation Protocol

Fiber + Particulate:

- Fiber is prepared as per fiber only protocol
- Particulate is prepared as per the particulate only protocol
- Particulate slurry introduced into the fiber + water container and stirred with a paint stirrer for 1 minute
- Fiber + Particulate slurry visually examined to ensure no clumping of debris

Debris Preparation Protocol

Chemical Precipitates:

- Chemical precipitates are prepared in a separate mixing vessel following the “cook book” prescribed method of WCAP-16530
- Chemical precipitates tested to ensure the appropriate settling velocity has been achieved
- Chemical precipitates added to the tank once the last non-chemical head loss stabilization criteria has been achieved

Debris Introduction Methodology

- Walls surrounding the strainer module prevent turbulence from the return flow and internal mixing from negatively affecting debris deposition
- Debris is introduced to the tank outside the array box
- Turbulence is induced in volumes outside array box to suspend debris and allow debris to drift on to array box so as to form a flow induced debris bed
- Tank internal mixing is verified in pre-operational testing
- Debris accumulates based on approach flow to strainer

Thin-Bed Debris Loading

Maximum Load Debris Bed

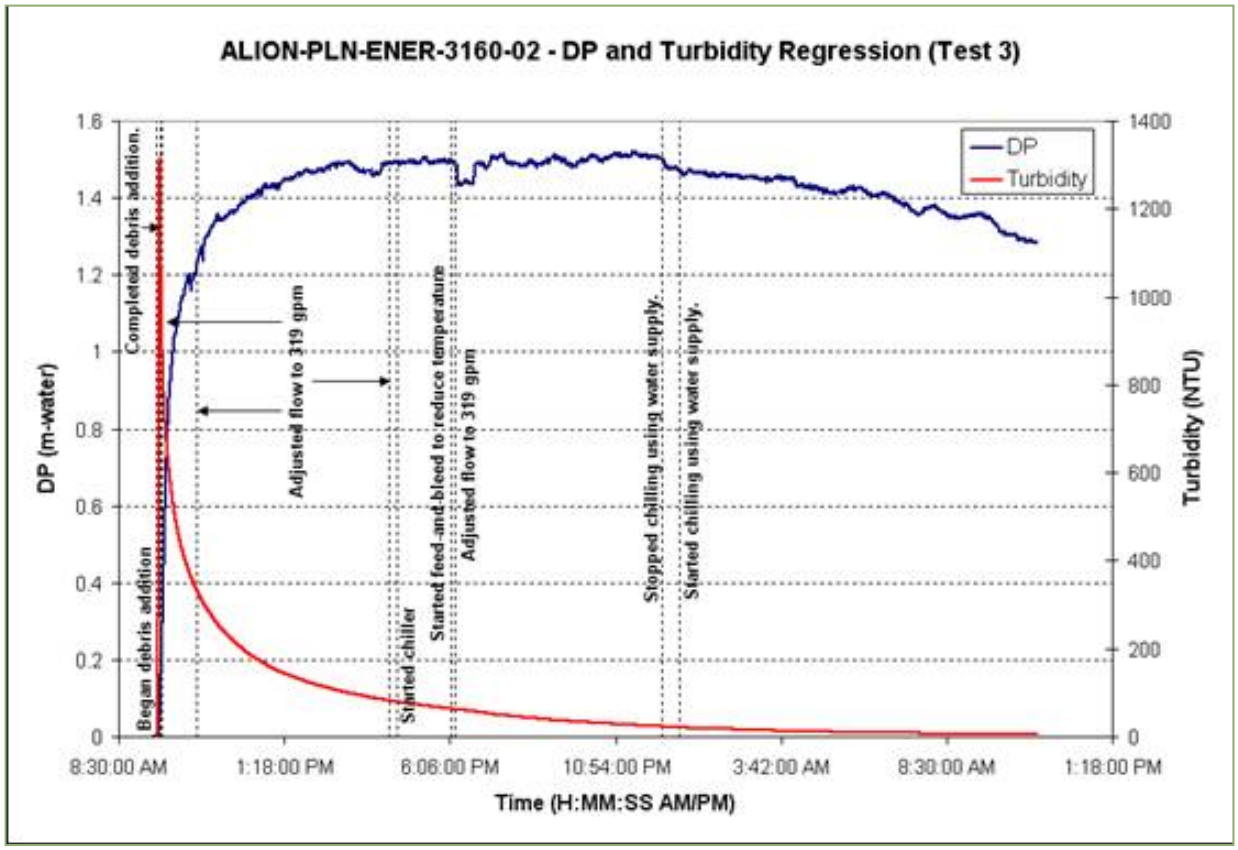
Submergence

- Water level in the tank or submergence of the strainer assembly is critical to evaluating the potential for vortex formation
- Due to dilution of debris to prevent agglomeration during debris addition it is difficult to maintain the water level at prescribed levels
- Water level is reduced to required submergence after stabilization to check for vortex formation

Stabilization Criteria

- For particulate only addition (Thin Bed Test):
  - Wait for 5 pool turnovers to ensure that all particulates are evenly distributed throughout the tank
- For Thin Bed Test and Full Load Test (non-Chemical):
  - Head loss increase < 1% / hr
  - High Filtration Efficiency Beds: Tank clarity/turbidity
- For chemical debris:
  - Head loss increase < 1% / hr
- Flow sweeps are also performed after the last head loss measurement is stabilized for temperature correction analysis

Sample Head Loss Trace



Summary

- Conservative Head Loss testing protocol
  - Based on the recommendations of the NRC March 08 Guidance
  - Test debris characteristics matches or is more conservative than the debris characteristics adopted in the Debris Generation calculation
- Head Loss testing protocol addresses the two limiting conditions:
  - Thin Bed
  - Full Load
- WCAP chemical precipitates added after the head loss has stabilized following the addition of the last non-chemical debris batch