Chemical Effects: NRC Head Loss Testing Update

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Purpose

- Communicate preliminary results from additional tests performed at the Argonne National Laboratory.
- Provide the NRC staff perspective on recent chemical effects test results.

Additional Tests at ANL – Motivation

- NRC sponsored some additional confirmatory research to address two technical areas
  - Head loss behavior of chemical precipitate generated using the WCAP-16530-NP guidelines
  - Additional tests in a sodium tetraborate environment to measure aluminum hydroxide solubility and long term head loss behavior

- Testing at ANL: August 2006 to October 2006.

Additional ANL Work Scope

- Exploratory testing of WCAP aluminum oxyhydroxide precipitate
  - WCAP precipitate created in solutions of high concentration
  - Precipitated from acidic solutions by additions of NaOH rather than by more prototypical situation of saturation of an alkaline solution
- Additional studies on head–loss in sodium tetraborate environments
  - Initial ANL loop test in sodium tetraborate (STB) showed no head loss with 50 ppm Al in solutions with pH 8.1-8.3 at 70°F for over 11 days
    - Increase of Al to 100 ppm resulted in rapid increase in head–loss
  - Follow–on loop test to confirm benign behavior of 50 ppm Al in STB solutions and better determine Al levels for onset of high head loss, benchmark small–scale solubility tests
  - Small scale tests to determine solubility of $Al(OH)_3$ in STB environments

WCAP Precipitate – ANL Bench Test Results

- WCAP imposes concentration limits to get fine particle size and slower settling characteristics
  - Exceeding WCAP concentration limits does lead to coarser particle size distribution

- Varying the pH affects the precipitate behavior
  - #1-3 below pH 8 to 9 range, #4 below pH >10

WCAP Precipitate – ANL Head Loss Test

- Initial test with aluminum oxyhydroxide precipitate addition, (corresponding to an equivalent 5 ppm Al in test loop) resulted in immediate high head loss

- This test with along other head loss tests (aluminum hydroxide precipitate tests), suggest the solubility limit is critical; exceeded it by a small amount creates the potential for high head loss

ANL Tests with Sodium Tetraborate

- Aluminum nitrate added at higher temperature (e.g., 120°F), step cooling to 80°F
- Long–term loop test with 50 ppm Al in STB environment showed no increase in head–loss after 19 days at 80°F at pH 8.3
  - Small increases in head–loss observed at 80°F and 120F with 70 ppm
  - With 80 ppm head–loss at 80°F increased to 1.25 psi
    - Would expect high head loss if decrease the pH or increase Al
    - Results consistent with previous test where increase from 50 ppm to 100 ppm resulted in high head loss

- Preliminary data from small–scale solubility bench-top tests seem to be consistent - first visible product at 80ºF (less than 70 ppm) and increasing product with increasing aluminum concentration

NRR Staff Perspective – Recent Test Results

- Vertical head loss loop tests indicate that a relatively small amount of aluminum oxyhydroxide can produce big pressure drops across a debris bed covered screen
- pH has a significant influence on aluminum solubility
- Once the aluminum solubility limit is exceeded, the kinetics of forming a precipitate can take some time
  - Consideration when establishing strainer test termination criteria, especially when precipitates are formed in the test loop

NRR Staff Perspective – Recent ANL Test Results

- Recent long term head loss test in Sodium Tetraborate (STB) consistent with earlier test
  - Head loss did not increase during long term test with equivalent of 50 ppm dissolved aluminum
  - At pH =8.3, head loss response started at a dissolved aluminum concentration equivalent to about 70 ppm

- Higher levels of dissolved calcium can also cause precipitation in STB environments. Plants considering STB as a buffer will need to evaluate potential precipitates from calcium.

NRC Chemical Effects NUREG Schedule

NUREGs to be published 1st week of November

- Integrated Chemical Effects Test Project (6 volumes), NUREG/CR-6914
- GSI-191 PWR Sump Screen Blockage Chemical Effects Tests-Thermodynamic Simulations, NUREG/CR-6912
- Aluminum Chemistry in Prototypical Post-LOCA PWR Containment Environment, NUREG/CR-6915
- Chemical Effects Head-Loss Research in Support of Generic Safety Issue 191, NUREG/CR-6913

NUREG to be published late November

- Chemical Effect Peer Review, NUREG-1861

DISCUSSION

Industry Plans For Addressing
Chemical Effects