April 6, 2009

MEMORANDUM TO: Donnie Harrison, Acting Chief
Safety Issues Resolution Branch
Division of Safety Systems

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SUBJECT: TRIP REPORT ON STAFF OBSERVATIONS OF GENERIC SAFETY ISSUE (GSI)-191-RELATED AREVA FUEL BLOCKAGE TESTING AT CONTINUUM DYNAMICS INC.

On December 17 and 18 of 2008, NRC staff observed GSI-191-related downstream effects fuel blockage testing conducted on AREVA fuel assemblies by Continuum Dynamics Inc. in Ewing NJ. Enclosed is the trip report, prepared by staff members, describing their observations.

Enclosure:
As noted

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Trip Report
Flow Blockage Testing of AREVA 17 x 17 Fuel Assembly at
Continuum Dynamics Inc. Located in Ewing New Jersey
December 17 and 18, 2008

**Background**

As a follow up to the NRC's review of topical report WCAP-16793-NP "*Evaluation of Long-Term Cooling Considering Particulate, Fibrous and Chemical Debris in the Recirculating Fluid",* and to support a revision to the WCAP, the Pressurized Water Reactor Owners Group (PWROG) is performing testing to evaluate in-vessel effects of debris and chemical precipitates that pass through the sump strainer following a loss-of-coolant-accident (LOCA). These tests are being conducted by Westinghouse and AREVA on their respective fuel designs using various insulation fiber, particulate, and chemical precipitate debris loads to examine the pressure drop across a single fuel assembly. The tests also examine the effect of the various fuel inlet nozzle designs on debris capture and the possibility for flow blockage. The Combustion Engineering fuel designs are being addressed by Westinghouse. The ultimate goal of the tests is to bound the maximum anticipated debris bypass loads reported by the participating plants.

In an effort to streamline the staff's review of the anticipated revised WCAP-16793-NP, NRC GSI-191 technical reviewers Paul Klein (NRR/DCI/CSGB), Ervin Geiger (NRR/DSS/SSIB), and Steve Smith (NRR/DSS/SSIB) witnessed one fuel assembly mock-up test being performed by AREVA at Continuum Dynamics Inc. (CDI). The following is a description of the test and staff's observations.

**Discussion**

Prior to beginning the test, AREVA presented the preliminary results of several completed tests which demonstrated that for the tested debris load/inlet nozzle configurations, the pressure drop across the fuel assembly did not exceed the acceptance criterion. Considering this information, NRC staff was offered a choice of which of the remaining debris load tests it wished to observe. Based on staff input, the AREVA representative decided to test the AREVA FUELGUARD® inlet nozzle configuration using particulate, calcium silicate insulation debris, fiberglass insulation, and chemical precipitate.

The observed test is intended to simulate the conditions expected during an assumed worst-case RCS hot-leg break. The flow rate and debris load used in the test is scaled down from that expected for typical 3-and 4-loop Westinghouse plants and 2-loop B&W plants. The debris characteristics are based on the types of bypassed debris reported by the PWR licensees and the tested quantities are based on the amounts that are expected to provide acceptable results, with the objective of bounding most, if not all, plants.

The test loop, test rig, and fuel assembly are shown in Figures 1, 2 and 3, respectively. The test article (fuel assembly) consists of a single 17x17 AREVA fuel assembly incorporating the AREVA FUELGUARD® inlet nozzle. The mock-up fuel assembly is full scale in all dimensions except height and number of spacer grids. The height of the mock-up fuel is 52 inches, (approximately one-third the length of an actual fuel assembly) and the number of spacer grid is reduced to 4 spacer grids from the 7 to 11 grids in a typical fuel assembly.

The flow rate through the assembly was maintained constant at approximately 45 gpm. (about 0.2 ft/sec). Initially, 29 lbm of particulate in the form of silicon carbide and 3 lbm of calcium silicate insulation was added to the loop and allowed to circulate in the loop for several turnovers. Next, 150 grams of fiber were added in 10 gram increments, allowing for the pressure drop to stabilize between additions. Next, a total of 10 lbm of WCAP-16530-NP AlOOH chemical precipitate, mixed with approximately 120 gallons of water, was added in two equal batches. Each addition was made allowing for several test-fluid turnovers between batches. Finally, an additional 3 lbm of calcium silicate particulate was added to simulate material produced over time by an erosion process.

The calcium silicate insulation for the fuel assembly tests was prepared by a sieving process which results in a test product with some differences in fiber content and particle size relative to strainer testing.

The temperature of the recirculated water was maintained at room temperature (approximately 70 °F).

**NRC Staff Observations**

Before beginning the actual test, staff reviewed the test protocol documents, observed the test setup, and examined the debris (fiber, particulate, and chemical precipitate). Staff observed the initiation of the test, the gathering and recording of data, and the addition of debris. Overall, the NRC staff agreed that the preparation of the debris and method of introduction into the test loop was acceptable. Also, the staff agreed that the partial length mock fuel assembly is sufficiently representative of an actual fuel assembly and that it allowed for a more realistic debris distribution throughout the fuel assembly as compared to the much shorter/single spacer grid test assembly used in previous tests observed by NRC staff.

As expected, NRC staff observed very little pressure drop resulting from the particulate debris initially added to the test loop. The test fluid pH rose from the initial near-neutral tap water pH to greater than 9.5 after the calcium silicate addition. Since elevated pH can affect the WCAP-16530 precipitate, (Argonne Technical Letter report, NRC ADAMS Accession Number ML090480294) CDI personnel added two 50 ml batches of muriatic acid (20% HCl solution), reducing the test fluid pH to approximately 8.1. The test fluid pH was approximately 8.4 at the time of chemical precipitate addition. With each addition of fiber, the pressure drop across the fuel assembly was observed to slowly increase. However, the pressure drop across the fuel assembly did not approach the acceptance limit of 13 psi. Also, chemical precipitate addition did not result in a large increase in pressure drop across the mock-up fuel assembly.

An unexpected observation was that the addition of calcium silicate resulted in a reduction in head loss as compared to tests conducted without particulate type insulations. The observation was unexpected because the introduction of calcium silicate during strainer head loss testing has generally resulted in a significant increase in head loss. According to the AREVA representative, the staff's observation of calcium silicate effects in this test is consistent with other similar PWROG fuel blockage tests performed at a Westinghouse facility. At the time of this test, the PWROG did not offer a hypothesis for the differences in head loss effects between the strainer testing and the fuel assembly testing.

Post-test observation of the disassembled test article indicated that fiber and particulate were relatively uniformly distributed among the spacer and mixing grids and that the FUELGUARD® inlet nozzle did not collect any visible fiber or particulate debris. Also, there was little accumulation of debris on the core support plate or in the bottom of the test chamber. Debris accumulation distributed over multiple grid layers and the lack of a compressed “thin bed” at any one location seem consistent with the head loss values observed by the staff during the test.

**Documentation**

The test procedures and test results were classified “proprietary” by AREVA. Therefore, the staff has not attached a copy of the test procedure to this trip report. AREVA stated that the protocol and results will be submitted for NRC review as proprietary documents in support of the revised WCAP-16793-NP.

**Conclusions**

The observed mock-up fuel assembly test with scaled flow rate, scaled debris load, scaled 1/3 height mock-up fuel assembly, and simulated gap between fuel assemblies is considered representative for the specific type of AREVA fuel assembly and debris load being tested. In previous meetings, the PWROG stated that WCAP-16793-NP will provide guidance for the maximum amount of debris loading conditions that will result in acceptable pressure drop across the reactor core. The guidance will be based on the results of the tests of the various fuel designs using the various combinations of debris loads. The NRC staff plans to review the complete set of test data as part of the review of a revision to WCAP-16793-NP.

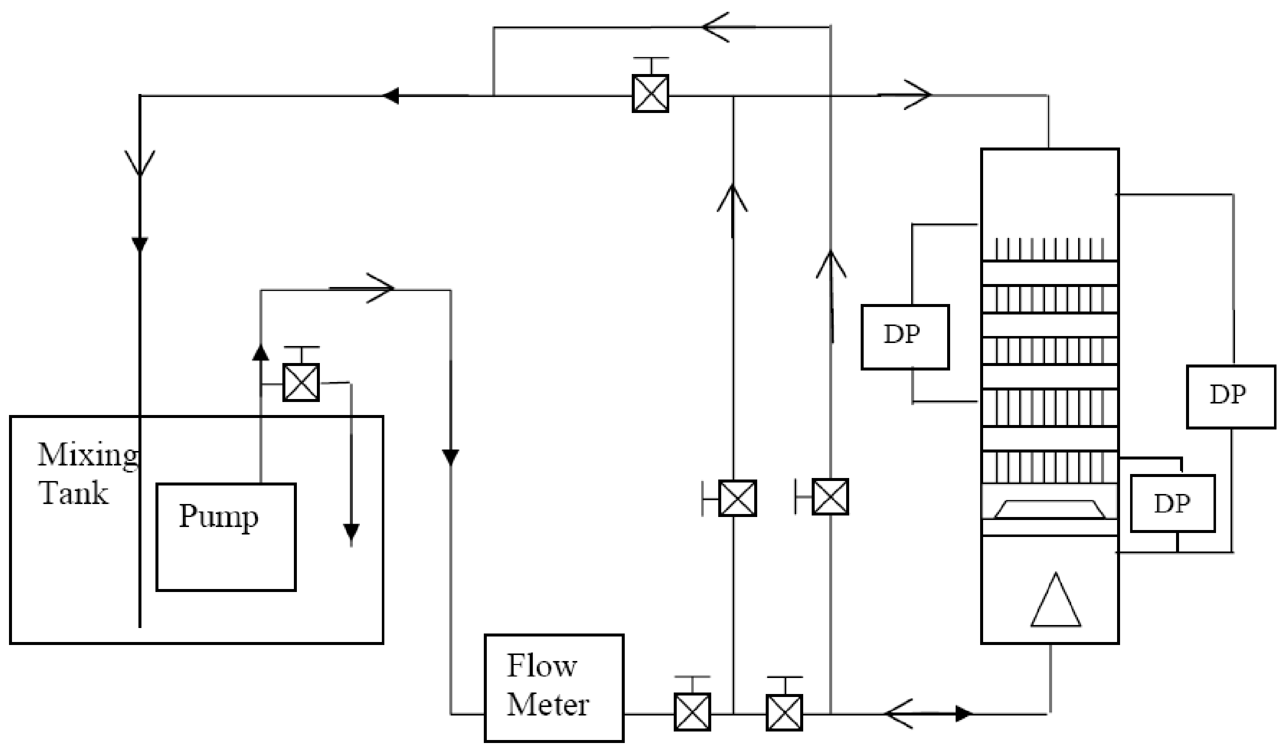


Figure 1 AREVA/CDI Test Loop Schematic
(Note: Larger arrows depict location of piping unions installed for ease of disassembly. Small arrows indicate direction of normal flow).

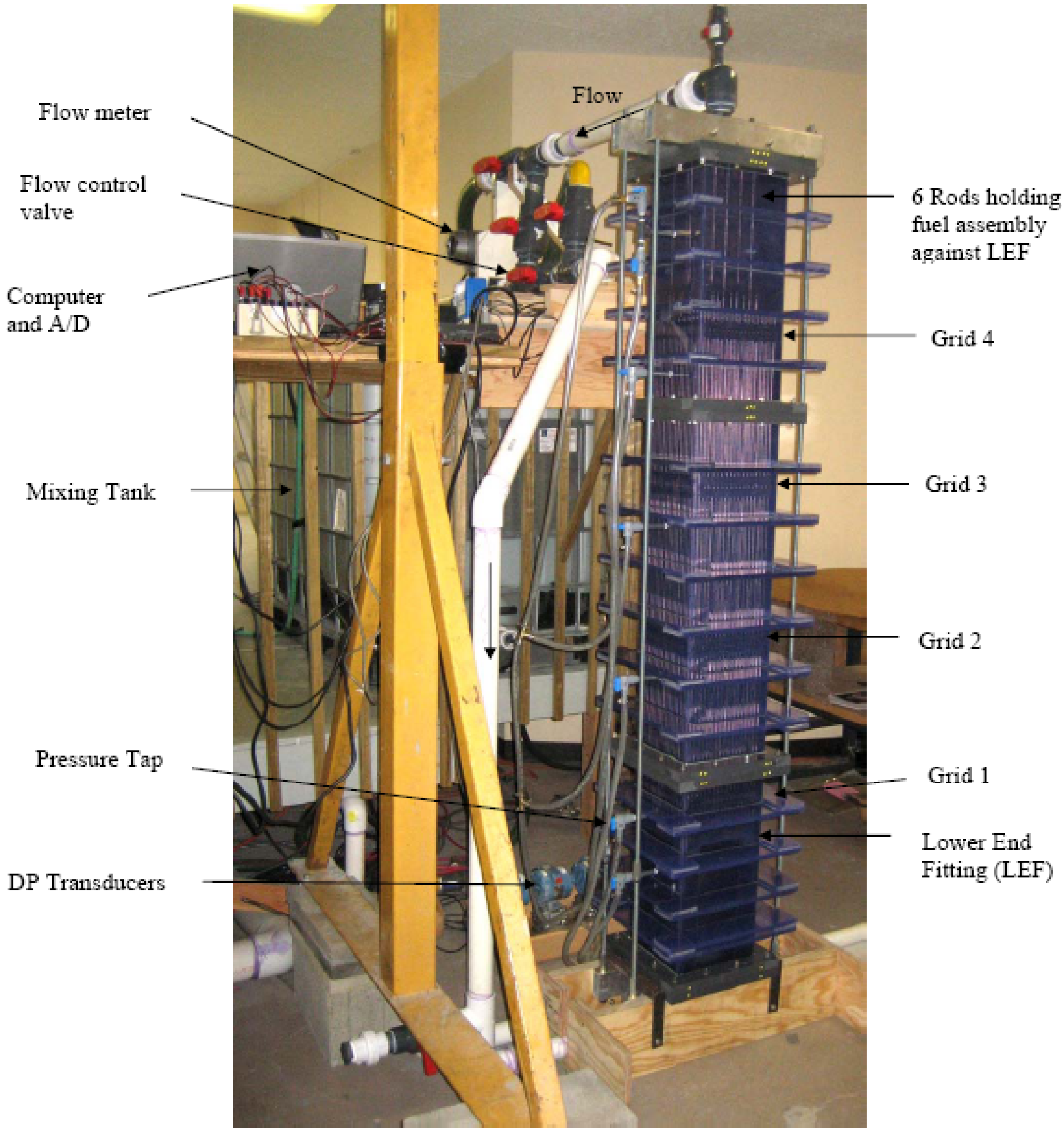


Figure 2  AREVA/CDI Test Rig

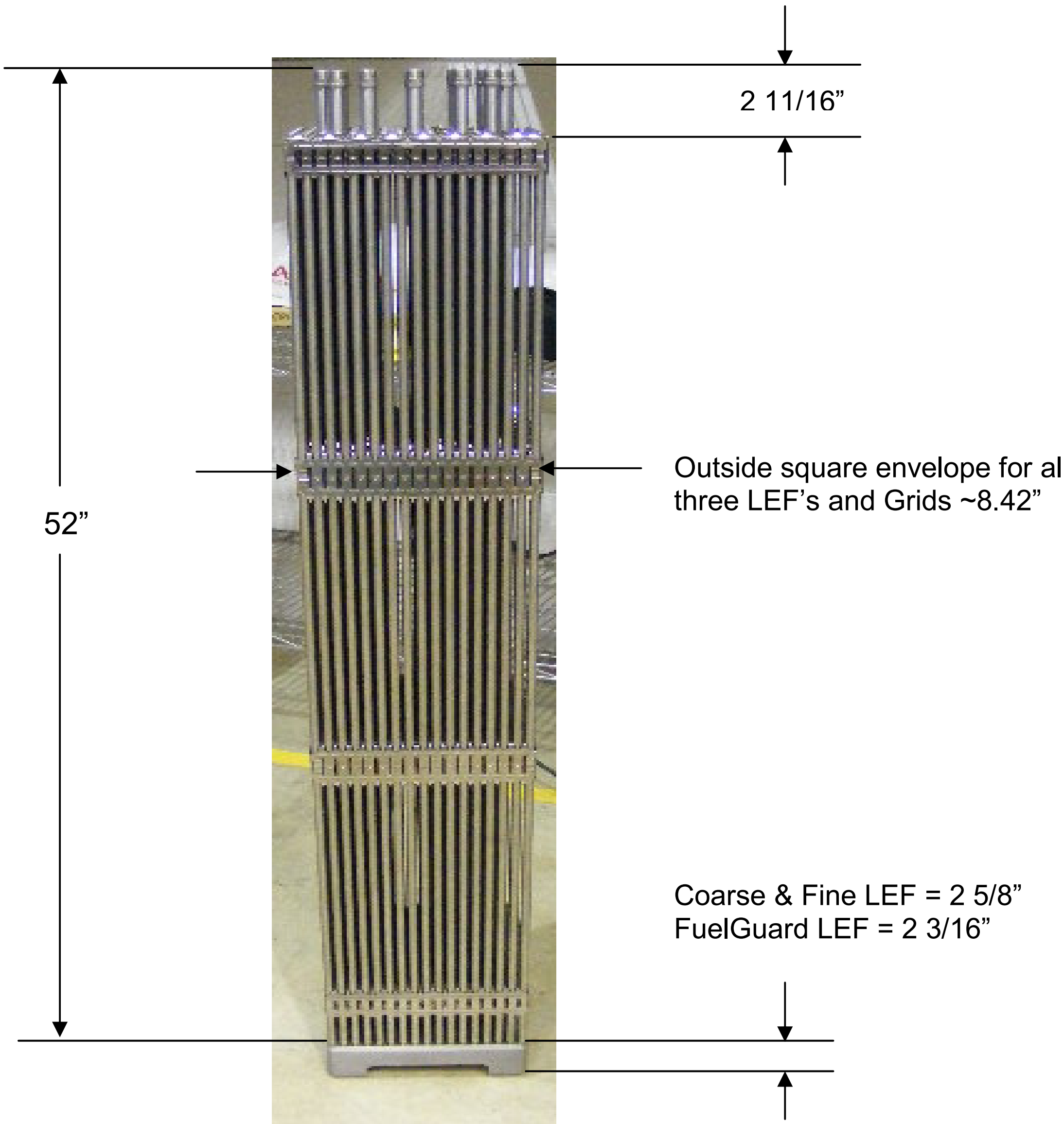


Figure 3  Mock-up Fuel Assembly