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March 29, 1979

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(FSS-79-153)

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SUBJECT: FLECHT-SEASET Program
Informal Monthly Progress Report - February 1979
Contract: NRC-04-77-127, EPRI No: RP959-1

Gentlemen:

Attached is an informal progress letter for the month of February 1979 for FLECHT-SEASET.

Sincerely,

WESTINGHOUSE ELECTRIC CORPORATION
NUCLEAR TECHNOLOGY DIVISION

H. W. Massie, Jr.
FLECHT-SEASET Project Engineer
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jb

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326 085

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FLECHT-SEASET PROGRAM

Contract: NRC-04-77-127
EPRI Project No: RP959-1

INFORMAL MONTHLY PROGRESS REPORT

FEBRUARY 1979

PROJECT MANAGEMENT - H. W. MASSIE, JR.

A major effort was spent on reviewing costs and schedule on the Unblocked Bundle Task (Task 3.2.1), 21 Rod Bundle Task (Task 3.2.2), Steam Generator Separate Effects Task (Task 3.2.6), and overall program schedules. These revised costs and schedules are being incorporated into a cost reestimate for use with Contract Modification No. 3.

No major work was performed on the 21 Rod Bundle this month based on the outcome of the January PMG meeting. Manpower resources were diverted to the 161 Rod Blocked Bundle to minimize restart costs on the 21 Rod Bundle Task.

TEST PLANNING AND ANALYSIS - L. E. HOCHREITER/R. P. VIJUK

Unblocked Bundle Task (Task 3.2.1)

Seven tests have been run to date. Several of these tests are believed to be acceptable runs. These runs await completion of code modifications before confirming validity.

Problems with rod seals have delayed testing intermittently. Heater rod growth was expected to occur from the seal plate downward. Instead the outer rods appear to be binding in the grids and elongating through the upper seal plate. This growth pushes a seal sleeve out of the seal plate and results in vapor leakage. Attempts to hold the rods in the proper position have not succeeded to date. Alternative methods of allowing the rod to grow on additional 1/4-inch out of the top and forcing rod growth out of the bottom are being evaluated with the NRC and EPRI.

Two heater rods (4G and 5G) failed after four cycles. The Kanthal heating element in 4G failed while isolation between element and sheath caused failure of 5G. Review of inspection data for these two rods revealed no information which might lead one to suspect early failures; early failure of a few rods appears to be characteristic of heater rod bundles. Testing will continue with these rods unpowered.

Movies taken in these early tests have been of good quality and are giving sharp images of droplets passing through the bundle subchannels. The camera position was changed to move it closer to the window. These modifications are being evaluated.

A calculation note was issued that calculated the excess stored energy above saturation temperature of the Unblocked Bundle housing windows, at the time when pre-test heating of the windows is complete with the window surface temperature at 500°F. The excess stored energy was calculated to be 1135 BTU's per window assembly which is considered to be negligible compared to the rod initial stored energy.

Testing was performed on a prototype heater rod with 40 mil thermocouples and a reduced diameter kanthal heater coil. Testing was terminated after 80 thermal cycles due to the heater rod failure. The heater was severed around the 6 ft. elevation. The cause of failure is now being investigated. The thermocouple failure rate for this rod was similar to the T/C failure rate of a heater rod with 25 mil thermocouples (prototype 4). Four thermocouples failed prior to the rod failure. Preparations are now in progress to test the next prototype heater rod which has nicrosil-nisil type thermocouples. Testing is expected to start at the beginning of next month.

21-Rod Bundle Flow Blockage Task (Task 3.2.2)

All technical work has been stopped on this task. The cost and schedules were developed for the contract Mod 3 which will include the 21-rod bundle task.

Block Bundle Task (Task 3.2.3)

Work has been initiated on this task with the agreement of the PMG such that the delays in the 21-rod bundle program are kept to a minimum.

A TAP-A two dimensional computer code model of the heater rod and flow blockage sleeve has been set-up in order to determine the effect of a "quenched" blockage sleeve on the thermal response of the heater rod thermocouples immediately downstream of the sleeve. The model is presently being de-bugged in order to verify its accuracy and results are expected in March.

Work is continuing on the facility design requirements for the large blocked bundle. Safeguards Development and Facility Engineering have agreed that the design of the bundle housing and plenums will be the same as the unblocked bundle facility. The requirements for the number of computer channels is being evaluated and will be recommended to the PMG.

The single rod sleeve attachment and instrumentation test was conducted and analysis of the results is underway. The test was successful in that the two blockage sleeves remained securely attached to the heater rod throughout the fifteen prototypical test cycles. However, the blockage sleeve thermocouple failed after 14 cycles and the steam probe thermocouple failed after 10 cycles. In order to provide useful data for all of the matrix tests, the sleeve thermocouple and steam probe would have to survive approximately 20-22 cycles. The design of each will subsequently be changed to incorporate a larger diameter thermocouple - from 20 mil O.D. to 30 mil O.D. It is believed that the larger thermocouple leads will provide the durability to survive the required 20-22 cycles. A report is presently being prepared for issuance to EPRI and NRC recommending the above design change and further testing.

The data from one of the single rod sleeve instrumentation test cycles has been reduced in order to provide comparisons to the proposed blockage sleeve heat transfer model. The DATARH computer code has been utilized to reduce the transient heater rod temperature data to a rod heat flux. This rod heat flux was then compared to the heat flux calculated by a simultantous radiation and conduction heat transfer model of the rod and sleeve. The measured clad and sleeve temperatures were utilized in this calculational model. Although the initial comparison showed significant differences in the rod heat flux as computed by DATARH and the heat flux computed from the proposed model, it is expected that further analysis will provide a better model.

COBRA calculations of 21-rod bundle with single sleeve and four sleeves blockage have been executed to answer EPRI comments on the task plan. Basic geometric parameters and calculations for COBRA inputs have been compiled in a calculation note. It has been found that the discrepancies between W and NUS simulations were due to two reasons:

Filler geometry and location difference - W used preliminary design data for a scoping study. This affected flow rate at the blocked zone.

Flow rate convergence criterion - W used a looser criterion. This affected flow rate at the downstream of blockage.

COBRA calculations showed present grid design gave 6% flow reduction in center channels at grid. This flow redistribution could be minimized by minor modifications of grids to give more flow resistance in peripheral channels. However, it should be noted that even the grid loss coefficients are not known to within 6%. A letter with a recommendation is being prepared for NRC and EPRI review.

Steam Generator Separate Effects Tests (Task 3.2.6)

The shakedown test program was completed and matrix tests began on February 6th. During the matrix tests, several problems were encountered with operating the loop and the data acquisition system.

Data validation consists of establishing the correct test loop initial conditions and maintaining the controlled parameters within acceptable limits during the test run. To date, the primary reason for invalidating tests is the failure of the DAS to function correctly. Also, at least two runs are invalid due to excessive oscillation in the loop pressure and boiler flow. These oscillations occur at time zero immediately after the two phase flow is diverted from the bypass atmospheric dump to the steam generator. These oscillations have been traced to the rapid vaporization of residual liquid in the inlet leg piping and closing the bypass leg solenoid valve before the bundle pressure control valve responds to the opening of the bundle isolation valve. The solutions to each of these sources of flow oscillations were to continuously drain the inlet leg of the test loop during bundle warmup and to impose a time delay between operating the bypass and bundle isolation valves.

The data reduction software programs needed for test validation have been completed. These programs can transform the DAS mag tape to CDC 7600 format (CATALOG program), construct a plot of each data channel vs. time (PLOTS program) and perform an overall mass and energy balance (SGFLOWS). The remaining software will be used to compute local heat flux in the tube bundle (SGTEMPS and SGFLUX programs). Work is continuing to apply these programs to the single phase shakedown tests for verification of the calculational method and then to the matrix test runs.

One set of high speed motion pictures was taken of the flow in the inlet and outlet plenums during run 00200610. Still pictures using a high speed flash unit were also taken in each plenum during runs 00200703 and 00200904. The results of the movies and still pictures show that the drops in the inlet and outlet plenums can be traced on the film.

The test data to date indicates that water does get carried through the steam generator. The exit quality however is still close to unity. There does exist superheating of the primary side vapor, however, it is not exiting the steam generator at the secondary side temperature. The primary side vapor temperature decreases continually from the secondary side temperature at the test initiation to a value which is $\sim$ 100 - 150°F superheat above the primary saturation temperature. Thus the preliminary data indicates less severe steam binding than that postulated in the safety evaluation models.

Systems Effects Task - Twin Bundle (Task 3.2.7)

A detailed instrumentation plan for the Systems Effects rod bundle has been prepared. A total of 50 rods will be instrumented. Of a possible 200 heater rod thermocouples, 148 will be connected to the computer. In addition, 14 steam probes, 14 thimble wall T/C's and 25 ΔP cells will be connected to the computer. A detailed Loop Instrumentation plan was developed for the System Effects test facility. For the Loop Instrumentation plan, it was determined that of the proposed 103 total instrumentation channels, it would be desired to hookup 74 channels to the computer. With the loop instrumentation and selected steam generator instrumentation, the amount of connections made to the computer will not exceed 320 channels.

Work has continued on the Systems Effects Task Plan. Preliminary writeups have been completed in Chapters 1 through 6 and most of Chapter 7. Work is proceeding to finish the draft Task Plan. The twin bundle housing will be designed with windows as previously designed. Modifications to the twin bundle facility are planned to reduce the uncertainties in the mass and energy balances. These modifications include placing collection tanks at the steam generator outlet plenum as is now done in the steam generator task.

It has been found that hot let nozzles in the upper plenum should be designed not to enhance atypical phase separation near the nozzles. An effort to design the nozzle properly has been continued. This includes a development of a scaling principle of the nozzle flow area and studies on the velocity dpeendency of nozzle design. Work to specify the number and shape of upper internals has been initiated.

Work has been started on the Data Reduction and Analysis program for the Twin Bundle System Effects Task. Present existing computer programs (FFLOW, FLEMB, SGFLUX) are being looked at and decision will be made on what modifications are needed for using the existing computer codes in the System Effects Task. Additional computer codes may also be needed.

The steam cooling model developed earlier is being revised. The new version contains a radiation model which accounts for the radiation between clad and steam. The heat transfer was believed to be convection dominating in the old version. The effect of radiation on the peak clad temperature will be determined in this new version.

The basic downcomer annulus design is being pursued in further development. Modifications discussed in a review meeting are now being incorporated in a detailed sketch.

A visit was made to EG&G at the Idaho National Laboratories to investigate the possibility of using optical probes (endoscopes) in place of the present window design on the housing. In addition, discussions were held with EG&G personnel and measurements incorporated about densitometers and drag screens for two-phase flow measurements.

Visits to FLECHT-SEASET

Dr. Kieth Ardon of the CEGB Berkeley Lab in the U.K. spent a day here this month to discuss his work on flow blockage experiments and drift-flux models and to discuss our work in similar areas.

FACILITY ENGINEERING/TEST OPERATIONS - L. R. KATZ/C. E. FUCHS

Unblocked Bundle (Task 3.2.1)

Three matrix tests were made. Two heater rods have been electrically eliminated. The SCR's were recalibrated due to watt transducer expiration of the recommended time-span for the validity period.

Steam Generator Separate Effects (Task 3.2.6)

Matrix testing was initiate on 2-06. Thus far, six runs have been performed. Two runs have thus far been considered invalid due to flow perturbations and validity on the remaining four is still being evaluated. Some problems with the DAS have impeded progress on both running tests and evaluating results. Preliminary data reduction at Forest Hills by the Forest Hills computer was not possible on some runs due to missing data files on the DAS mag tape. Attempts are being made to salvage this data.

Shakedown runs were performed to investigate the large flow and pressure transient[illegible]t the beginning of a test run. These appeared to be due to condensate, trapped in the steam generator hot leg, being slugged into the generator and vaporizing. A continuous drain of this leg during heatup has alleviated the problem.

Twin Bundle Task (Task 3.2.7)

A drawing of the small (broken loop) steam generator, showing the location and routing of the internal instrumentation was started. Windows for the small steam generator were ordered and received.

Prototype Testing

Two prototype tests were conducted, (1) blockage sleeve attachment method, and (2) a prototype test with 40 mil type "K" thermocouples. The blockage sleeve attachment method test lasted 15 cycles out of a possible 22 cycles.

Prototype test with 40 mil thermocouple was completed at 80 cycles when the rod failed. The thermocouple behavior was similar to previous prototype tests.

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