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September 26, 1978

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SUBJECT: FLECHT-SEASET Program
Informal Monthly Progress Report - August 1978
Contract: NRC-04-77-127, EPRI No: RP959-1

Gentlemen:

Attached is an informal progress letter for the month of August 1978 for FLECHT-SEASET.

Sincerely,

WESTINGHOUSE ELECTRIC CORPORATION

H. W. Massie, Jr.
FLECHT-SEASET Project Engineer
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HWM/bms

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FLECHT-SEASET PROGRAM

Contract: NRC-04-77-127

EPRI Project No: RP959-1

INFORMAL MONTHLY PROGRESS REPORT
AUGUST 1978

PROGRAM ADMINISTRATION - H. W. MASSIE, JR.

An August 30-31, 1978 PMG Meeting was held to discuss the NRC problem of lack of additional funding for the revised FLECHT-SEASET Program (includes new flow blockage program). Various funding alternatives were discussed and reviewed. No obvious alternative existed that would reduce the costs of the revised program back to the original contract level. This issue is unresolved for future discussions. Also, the PMG reviewed and approved the basis for the cost estimates of the flow blockage program, specifically the 21 Rod Bundle Task. All major procurement items for the Unblocked Bundle Task and the Steam Generator Separate Effects Task have been delivered.

TEST PLANNING AND ANALYSIS - L. E. HOCHREITER

(1) Unblocked Bundle (Task 3.2.1)

Design of the bundle and determination of heater rod placement has begun for the unblocked bundle. Some problems have surfaced with knowing exactly what the angular placement of the rod thermocouples (T/C's) are. Additional thermal search measurements for axial and azimuthal location of heater rod thermocouples were conducted on 6 representative heater rods. The results indicated differences between the Westinghouse thermal search results and the heater rod vendor measurements. The Westinghouse results indicated that thermocouple locations were as much as 1-1/2 and 2-1/8 inches from nominal axial locations and as much as +45 degrees and -133 degrees from radial locations. These results are being further evaluated before actual rod placement in the bundle is initiated. This is not believed to be a problem since subchannel heat transfer variation is small for the unblocked bundle. An improved thermal search technique is being developed for the 21-Rod Bundle.

The local power steps for each heater rod is being calculated from the vendor supplied X-ray data. Some anomalies have been observed and are being checked before the rods are placed in the bundle.

Data reduction programs are being upgraded to reflect the need for metric and English plots in FLECHT reports. A new method has been developed to maintain an updated list of heater rod thermocouple channel connections as a hedge against high thermocouple failure rates. Also, a way of improving the mass storage calculations above the quench front for the Code FFLOWS is being investigated.

NASA Lewis at Cleveland, University of California at Berkeley and Wichita State University were contacted to discuss techniques for taking still photos of water droplets in a highly dispersed flow regime during reflood. In general, all of them successfully used a microflash in conjunction with a Nikon or Canon 35 MM camera for this purpose. These techniques will be incorporated in the photography procedures.

The task plan has been reviewed for publication.

(2) 21-Rod Bundle est (Task (3.2.2)

Work has continued on the steam probe design which includes the associated temperature correction and flow velocity calculations. The optimum design from a minimum flow blockage/quenching standpoint and maximum measuring capability is a 20 mil thermocouple enclosed in a 3/32" O.D. hollow tube with flow holes spaced approximately 0.25" apart. This design will not be tested in the Lehigh University facility due to the penetrations limitations. However, this probe will be placed in the unblocked bundle test facility for comparison to the aspirating steam probe.

Testing the steam probe in the University of California at Berkeley Single Tube Test Facility is also being investigated by EPRI.

Work has been completed on the bundle instrumentation plan for the first three 21-rod bundles. The axial, radial and azimuthal distribution of heater rod thermocouples; and the axial and radial distribution of steam probes; and the radial and azimuthal distribution of blockage sleeve thermocouples have been specified. These specifications will be used as input to a mock-up of the bundle mid-section which will be built to investigate methods of bundle assembly and instrumentation routing.

The hydraulic design of the downcomer/cross-over/leg lower plenum hardware has been completed. A 1-1/2" diameter bi-directional turbine meter will be specially built to obtain the desired flow measuring capability and associated pressure losses.

The hydraulic characteristics of the concentric flow blockage shape was analyzed using both COBRA, paper and references in the literature. The problem is deciding how long the low strain tails of the blockage burst should be to have a meaningful representation of the blockage hydraulic effects. Longer simulations would require longer sleeves thereby covering up heater rod T/C's. A quick review of the literature on separated flow effects and the concentric blockage shape indicates that the separation effects of the blockage can be preserved with a short sleeve simulation. Heat transfer studies indicate that the separation and reattachment points significantly effect the local heat transfer and thus should be preserved. The COBRA calculations for four rods blocked indicated that with longer sleeves, more flow would be diverted out of the blocked channel lower in the bundle as compared to the more desirable short sleeves. However, if this flow is integrated up to the blockage plane, the flow difference is only approximately 10% for the longest possible sleeve. A letter was written to the PMG and their consultants to again recommend the short concentric sleeve.

675334

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

(1) Unblocked Bundle (Task 3.2.1)

The low mass housing was received and inspected. The upper and lower plenums and housing extensions were attached to the housing and the assembled unit was installed in the support stand. The support stand will be installed vertically for bundle loading.

The grids, fillers and upper seal plate were installed in the bundle strongback and the fillers were welded to the grids and this completed structure was attached to the upper seal plate. The unit is now ready for bundle assembly which is waiting a decision on rod location (heater rod preparation and QC are complete).

(2) 21-Rod Bundle Test (Task 3.2.2)

Considerable effort was spent developing steam probe fabrication and thermocouple lead routing techniques. Several prototype steam probes were fabricated. The steam probes consist of a 20 mil thermocouple centered in a 3/32 inch diameter tube. The thermocouple is centered using an inner sheath. The steam probe assembly is completed by crimping the outer tube down onto the inner sheath and thermocouple. A roll crimping tool was fabricated for this purpose.

A mockup of the bundle mid-section is to be built to investigate methods of assembly including installation of steam probes and blockage sleeves and routing and attachment of thermocouple leads. The mockup will be based upon the bundle instrumentation requirements.

A request for quote and equipment specification have been issued for the low mass housing. In addition, long lead items were ordered. Purchase orders have been issued for the loop turbine meters. A special turbine meter has been ordered for use in the reflood line.

(3) Steam Generator Separate Effects (Task 3.2.6)

Bench testing of the hemispherical lower plenum was completed. Distribution of air and water flow into each of the "steam" tubes was measured under various flow conditions. The simulated FLECHT lower plenum has been installed in the bench test loop and air-water tests have been initiated. All air-water tests will be complete by 9/15/78.

Boiler house construction is complete with the exception of electrical hookup of the air intake louver and exhaust fan, installation of door knobs, completion of the dike and fence around the oil supply tanks.

Installation of the piping was completed and facility shakedown was started. Boiler startup and checkout has been completed and the steam generator steam probe manifold flow checks have been performed. Delays in shakedown testing are anticipated due to problems in the software-data acquisition system (DAS) interface.

The electrical construction of the facility has been completed except for installation of the DAS. The DAS installation will follow repair by the vendor. Presently, the data tape contains repeated information from a previous record file. Computer software cannot be finalized until this problem is eliminated from the data tape.

(3) Steam Generator Separate Effects Tests (Task 3.2.6)

The two phase air/water testing was initiated on August 7. Data reduction of the first series of air/water tests indicated an uncertainty in the inlet air and water mass flow rates. Modifications were performed on the facility by installing a main line air flow orifice and a rotameter in the water line. All preceeding air/water tests were repeated and their results indicated improved mass balances. On August 25, the facility was modified by installing the FLECHT plenum and the first air/water test resulted in good mass balances.

The air/water inlet plenum data includes the air and water mass flow rates in each tube and the total inlet plenum air and water mass flow rates. Test results from the hemispherical inlet plenum and one test with the FLECHT steam generator shaped inlet plenum show the following:

1) Air flow rate distribution across the tube sheet is independent of the total mass flow rate.

2) The air/water tests with Q_{air} >250 CFM and Q_{liq} <1.44 GPM have the same air flow rate distribution as the single phase tests.

3) From the replicate runs, the standard deviation of the air flow rate is 2% and the water flow rate is 14% in a given tube.

4) In one run (Q_{air} ~130 CFM, Q_{liq} = 2.9 GPM) the air and liquid flowrate distributions are significantly different than runs with higher air flow and lower water flow indicating a flow regime change in the inlet plenum.

5) The FLECHT plenum test resulted in a flat air flow distribution and a largely rectangular liquid distribution with the highest liquid concentrations in tubes adjacent to the baffle and the lowest concentration in the column of tubes furthest away from the baffle. The liquid concentration varies by a factor of three over this range. This measured flow distribution supports the choice of instrumented tubes made for the steam/water tests.

The mass and energy balance program (SG FLOWS) is complete. The temperature interpolation program (SG TEM) is ~70% complete and the program which calculates the steam generator tube bundle heat flux is ~50% complete. These programs will be needed to reduce the shakedown test data from the tube wall T/C calibration test and the spray nozzle thermodynamic characteristics test.

The task plan for the steam generator separate effects tests was formally issued.

(4) FLECHT-SEASET Presentations

A presentation was made to the ACRS Working Group One on the FLECHT-SEASET program. The ACRS writes a report to Congress each year on the NRC safety related R&D program. The FLECHT-SEASET program is one of the programs in the ACRS yearly review.

675336