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BWR BLOWDOWN/EMERGENCY CORE COOLING SIXTEENTH QUARTERLY PROGRESS REPORT OCTOBER 1 — DECEMBER 31, 1979

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CONTENTS

APPENDICES

ILLUSTRATIONS

TABLES

ABSTRACT

Blowdown/Emergency Core Cooling work completed in the fourth quarter of 1979 (October 1, 1979 through December 31, 1979) is summarized. Planning and necessary facility modifications for the first small break test were completed. Some shakedown tests were completed and the first small break test was successfully executed. Blowdown/ECC injection testing continued with the improved TLTA hardware and power decay simulation.

1. INTRODUCTION

1.1 GENERAL

A major requirement in the design of power reactor systems is the limitation of fuel cladding temperatures below specified values during both normal operation and an unlikely, but postulated, loss-of-coolant-accident (LOCA). To meet this design requirement it is necessary to be able to predict system performance during a LOCA. Since this type of information is not obtainable from tests on actual reactors, scaled system test programs are used to provide basic system performance information. The BWR Blowdown/Emergency Core Cooling (BD/ECC) Program[1] extends the scope of the BWR Blowdown Heat Transfer (BDHT) Program to include ECC system operation. Results from the BD/ECC Program will provide a basis for evaluating BWR system phenomena throughout the entire LOCA transient from break initiation to core reflood.

1.2 PROGRAM OBJECTIVES

The BWR BD/ECC Program charter is to conduct an experimental program, jointly funded by the U.S. Nuclear Regulatory Commission (USNRC), Electric Power Research Institute (EPRI), and General Electric (GE), to obtain information on transient heat transfer following an unlikely, but postulated rupture of a steam line or recirculation line in a boiling water reactor (BWR). This program will:

1. obtain and evaluate basic BD/ECC data from test system configurations which have calculated performance characteristics similar to a BWR with 8x8 fuel bundles during a hypothetical LOCA; and
2. determine the degree to which models for the BWR system and fuel bundles describe the observed phenomena and, as necessary, develop improved models which are generally useful in improved LOCA analysis methods.

Requirements of the BWR BD/ECC Program include use of a test apparatus which will provide LOCA test conditions representative of the environment expected in the postulated BWR LOCA. The scaling and design objectives are to provide a test apparatus for investigating, on a real time basis, the expected BWR fuel thermal-hydraulic response, using an electrically heated, full-sized, full-power test bundle.

1.3 ORGANIZATION OF THE PROGRAM

The BD/ECC Program contract was executed in December 1975. The total BD/ECC Program work scope is shown in Appendix A. A report schedule is contained in Appendix B.

1.4 STATUS OF THE PROGRAM

A number of the completed and reported major milestones are presented below. Appendix B indexes the significant publications pertaining to these milestones.

1. Formulation of program plan[1] and 8x8 BDHT test plan[2] (Task AA).*
2. An evaluation of electric heaters for use in the BD/ECC Program (Task BB).
3. Issuance of report on the transient thermal-hydraulic model, MAYUO4.[3]
4. Distribution of facility description report[4] for the BD/ECC1A phase.
5. Issuance of revised BD/ECC1A test plan.[5]
6. 64-Rod Bundle Test Topical Report completed.[6]

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* See Appendix A for task description.

During the fourth quarter of 1979, the detailed planning for the first small break test was completed and necessary modifications were made to the facility. Some shakedown tests were completed and the first small break test was successfully executed.

Blowdown/ECC injection testing continued with the current two-loop test apparatus (TLTA) configuration. Lower bundle temperatures resulted with the improved TLTA hardware and power decay simulation.

2. PROGRAM PLANNING AND ADMINISTRATION

The fourth quarter activities consisted primarily of planning for the small break tests. At a meeting held in Washington D.C., the status of planning and preparation for a small break scoping test was reviewed. It was decided that the break area would be selected such that the High Pressure Core Spray (HPCS) system flow at rated conditions would slightly exceed the break flow rate. Two small break tests are planned: one with HPCS, the other under degraded ECC conditions with HPCS deactivated. To meet an NRC-REG requirement, pretest predictions for these tests are planned, but will be completed outside the BD/ECC program.

Direct measurements of break flow rate are planned. The very small expected break flow rates make it possible to condense the vapor component using a series of heat exchangers downstream of the break limiting orifice. A calibrated orifice is then used to measure the single phase liquid flow.

Initial conditions and test boundary conditions for the first small break test were discussed at two consecutive planning meetings (EPRI in Palo Alto and GE in San Jose) on December 7, 1979 with each of the three sponsoring organizations and NRC-REG being represented. A complete description of the first small break test is given in Section 3 and Appendix C.

3. EXPERIMENTAL WORK

3.1 BD/ECC1A TESTING

3.1.1 Large Break Tests

Two large break tests were run with the improved TLTA hardware (simulation of bypass to core inlet leakage path) and realistic power decay. The tests were designated as follows:

Test	Description
6423, Run 3	Peak power, low ECC flow, high ECC temperature
6422, Run 3	Average power, average ECC flow and temperature

Data verification, analysis and reporting for these tests have been slowed due to the increased emphasis on the small break tests. Data evaluation activities related to the large break tests will resume following the small break tests.

3.1.2 Small Break Tests

Shakedown and calibration tests were conducted in the TLTA in conjunction with the small break tests. The purpose of these tests was to obtain information on the test vehicle itself so that effects of the following could be evaluated:

System heat loss
System fluid leakage
System pressure/level controllability
Break flow measurement system shakedown/calibration
Initial conditions verification

Heat and mass loss tests were conducted with a static system at approximately the same conditions as those for initiating the planned small break test. No flows were allowed to or from the system except for leakage flow, if any. Power was supplied through the auxiliary heaters in the lower plenum to maintain a steady system pressure. The power required to maintain the system pressure at approximately the same value is an indication of the system heat loss. The liquid inventory or level change implies the leakage loss.

Using auxiliary heaters in the lower plenum, the power input required to maintain a steady pressure and temperature (at nominally 1050 psia and 550°F) was found to be approximately 60 kW. The system was subsequently reinsulated and the test repeated. The subsequent test indicated that the loss was reduced to 50 kW.

System mass losses were found to be very small; no measurable changes in inventory were indicated over a period of about 1/2 hour.

The system pressure/level controllability test results indicated no control problem at the initial conditions and good repeatability of the pressure response.

Shakedown tests were conducted on the break flow measurement system. These tests showed that the heat exchangers were effective in condensing the steam downstream of the break orifice so that the fluid was significantly subcooled before entering the calibrated flow measuring orifice. These tests also indicated that the measurement system response was affected by the acceleration of fluid in the initially stagnant flow in the line. However, pressure drop across the break orifice showed that, while the measuring orifice response is not instantaneous, the break flow was essentially unchanged during the early portion of the transient and could be inferred from the later orifice measurements.

The initial condition verification test showed that the key system parameters, the initial level, system pressure, and fluid conditions, could be achieved to the test specification. The repeatability of the initial conditions was verified by conducting the verification test two additional times.

The first small break test in TLTA was successfully completed in the early evening of December 18, 1979. (A description of the test is provided in Appendix C.) The test lasted approximately 33 minutes. Its identification number is Test 6431 Run 1.

The initial conditions for the test (shown in Table 3-1) were found to be within the specified test conditions except for the bundle inlet flow and the inlet subcooling. The bundle flow and subcooling, though slightly outside their specifications, were judged to be acceptable because the key parameters of interest for this test are the long-term system pressure and inventory responses and not the early bundle heat transfer response. A sensitivity study (conducted outside the scope of this program using the pretest prediction methods) using the actual initial conditions as opposed to the specified conditions showed that the calculated system response was insensitive to the small deviations in the initial conditions.

Table 3-2 contains the measured bundle power and Figure 3-1 depicts the actual head-flow characteristics of the HPCS system.

To provide a basis for further evaluation of the system heat loss and leakage during a transient test, an adiabatic blowdown test was conducted on December 20, 1979, 2 days following the small break test. The primary purpose of this test was to determine the net heat transfer to the fluid. The main sources of mass and energy transfer to the fluid were through the break and net system heat loss. The test was conducted from near 1000 psia with stagnant saturated fluid throughout. There was no power applied to the bundle and the ECC systems were not activated. The break flow was measured as well as the system fluid mass inventory. These data are being evaluated to possibly improve the estimate of net heat transfer to (or from) the fluid inventory.

Table 3-1
COMPARISON OF TEST CONDITIONS

	Specified	Measured
Break size	$0.125^{+0.001}_{-0}$*	$0.125^{+0.001}_{-0}$**
HPCS characteristics		as compared in Figure 3-1
ECC fluid temperature	80 ± 5°F	83 ± 4°F
Bundle power decay		as shown in Table 3-2
Initial Conditions		
Steam dome pressure	1050 ± 20 psia	1041 ± 5 psia
Water level (outside shroud)	283 ± 6-in. el	283 ± 3-in. el
Bundle (core) flow	34 ± 5 lb_m/sec	43 ± 5 lb_m/sec
Bypass flow, total	11% ± 3% of bundle flow	2.6 ± 0.3 lb_m/sec
Steam flow		2.5 ± 0.5 lb_m/sec (t=16.6 sec) 0.0 lb_m/sec (t > 16.6 sec)
Bundle inlet subcooling	23 ± 5°F	16 ± 4°F
Downcomer fluid temperature		
Above JP suction	Tsat	552 ± 4°F
Below JP suction	(Tsat-23°F)±5°F	539 ± 4°F
Timings		
Pump 1 trip	0.0 ± 0.2 sec	0.0 ± 0.1 sec
Pump 2 trip	4.0 ± 1.0 sec	4.0 ± 0.2 sec
Feedwater pump trip	0.0 ± 0.5 sec	0.0 ± 0.5 sec
Break opening	0.0 ± 2 sec	−0.9 ± 0.5 sec
Loop 1 isolation	20 ± 2 sec	19.6 ± 0.5 sec
Steam valve closing	17 ± 1 sec	16.6 ± 0.5 sec
HPCS activation	27 ± 1 sec	26.8 ± 0.5 sec

Notes: *Specified limits
**Measurement uncertainties

Table 3-2
BUNDLE POWER FOR SMALL BREAK TEST, 6431/R1

Time (sec)	Bundle Power* (MW)
0	2.0
1	2.0
2	2.0
3	2.0
4	2.0
5	2.0
6	2.0
7	2.0
8	1.8
9	1.6
10	1.4
12	1.0
14	0.81
16	0.64
18	0.57
20	0.49
25	0.38
30	0.32
35	0.27
40	0.23
45	0.21
50	0.19
60	0.16
70	0.15
80	0.15
90	0.15
100	0.15
150	0.14
200	0.14
250	0.14
300	0.13
350	0.13
400	0.13
600	0.13
800	0.13
1000	0.12
1200	0.12
1400	0.11
1600	0.11
1800	0.11
2100	0.11

* ± 5% uncertainty on nominal value

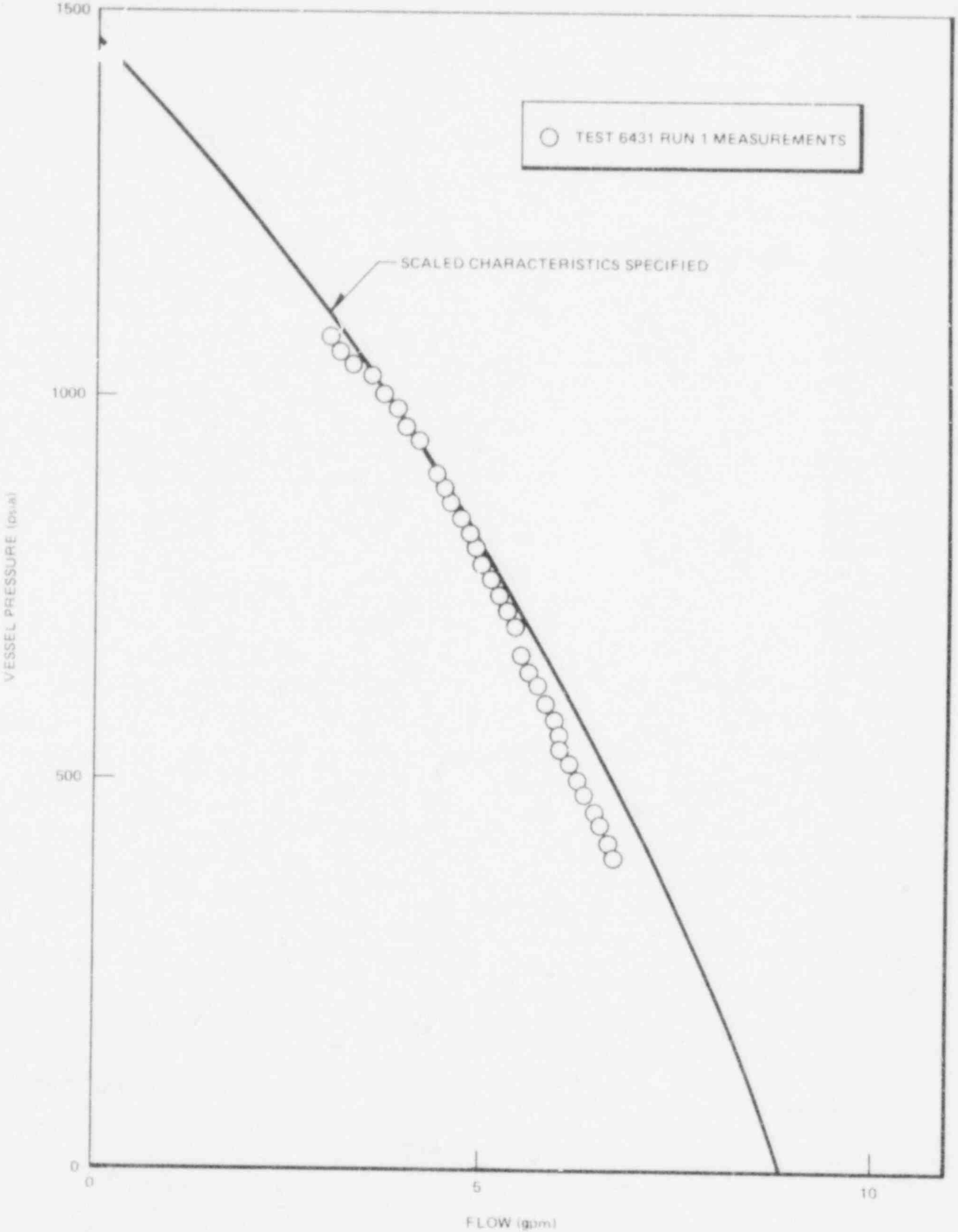

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Figure 3-1. TLTA Small Break Test No. 1 HPCS Flow Characteristics

4. ANALYTICAL EFFORT

4.1 LARGE BREAK RESULTS

Preliminary evaluation of the data from the peak power, low flow/high temperature ECC test (6423) indicates cladding temperatures were significantly lower than those from the previous peak power test (6414). The early system response and bundle heatup response were similar as expected. During the post-lower plenum flashing and bundle uncovery period, the bundle heatup response is significantly slower. The maximum temperature at the peak power plane remained below 1000°F [illegible] this period, compared to 1500°F from the previous test. These lower temperatures are directly attributa[illegible]ajor simulation improvements made in the TLTA-5A facility. These consisted of realistic bundle dec[illegible]ation and addition of the core-to-bypass leakage flow path.

4.2 SMALL BREAK TESTING

Analytical effort related [illegible]eak test was primarily directed at test planning. Detailed data evaluation is expected during the first quarte[illegible]980.

5. TWO-LOOP TEST APPARATUS

5.1 TEST SECTION DESIGN AND FABRICATION

Hardware was installed to simulate the Automatic Depressurization System (ADS) as indicated in Figure 5-1 for small break testing. Simulation is achieved through an orifice and valves installed in series in the TLTA steam line. The ADS is activated long after cessation of normal steam flow, so the TLTA steam line serves a dual purpose. The ADS will be used for the second small break test.

A new break line was added to facilitate the small break test in TLTA. It is connected to the broken loop recirculation line (Figures 5-1 and 5-2) and incorporates a flow-limiting orifice, a flow-measuring orifice, heat exchangers, and instruments.

The line upstream of the flow-limiting orifice is 1/2-in. tubing; downstream is 1 in. The flow-limiting orifice represents the scaled small break in a BWR. It is a 0.124-in. diameter, square-edge hole; the orifice plate is 1/8-in. thick. Downstream of the orifice are two heat exchangers. They are used for condensing the two-phase break flow prior to its entrance to the flow-measuring orifice. Pressure, temperature, and differential pressure instrumentation are located along the line as shown in Figure 5-2. The line discharges into the existing suppression pool.

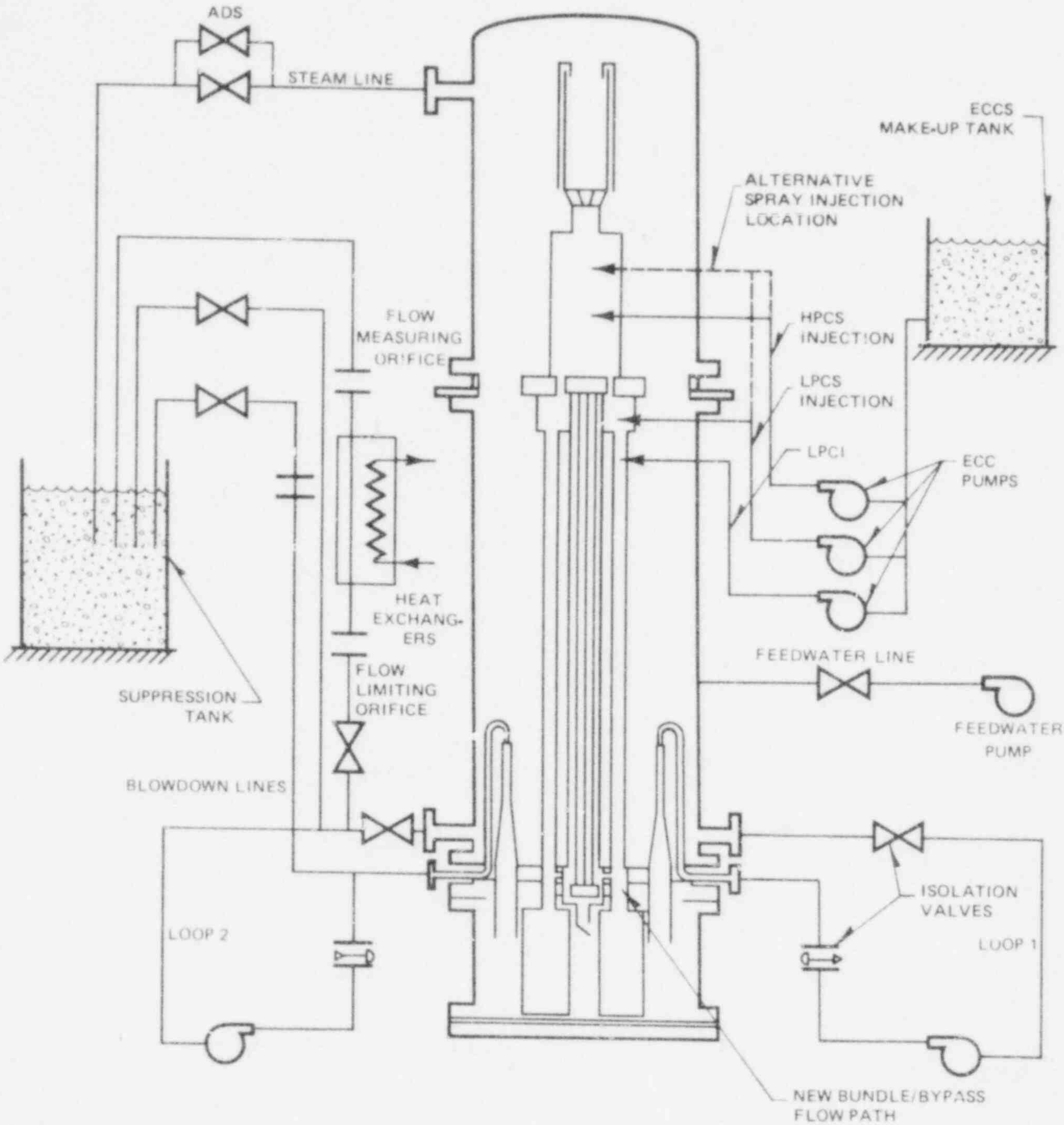

Figure 5-1. Two Loop Test Apparatus Configuration 5B (TLTA-5B) with Emergency Core Cooling Systems

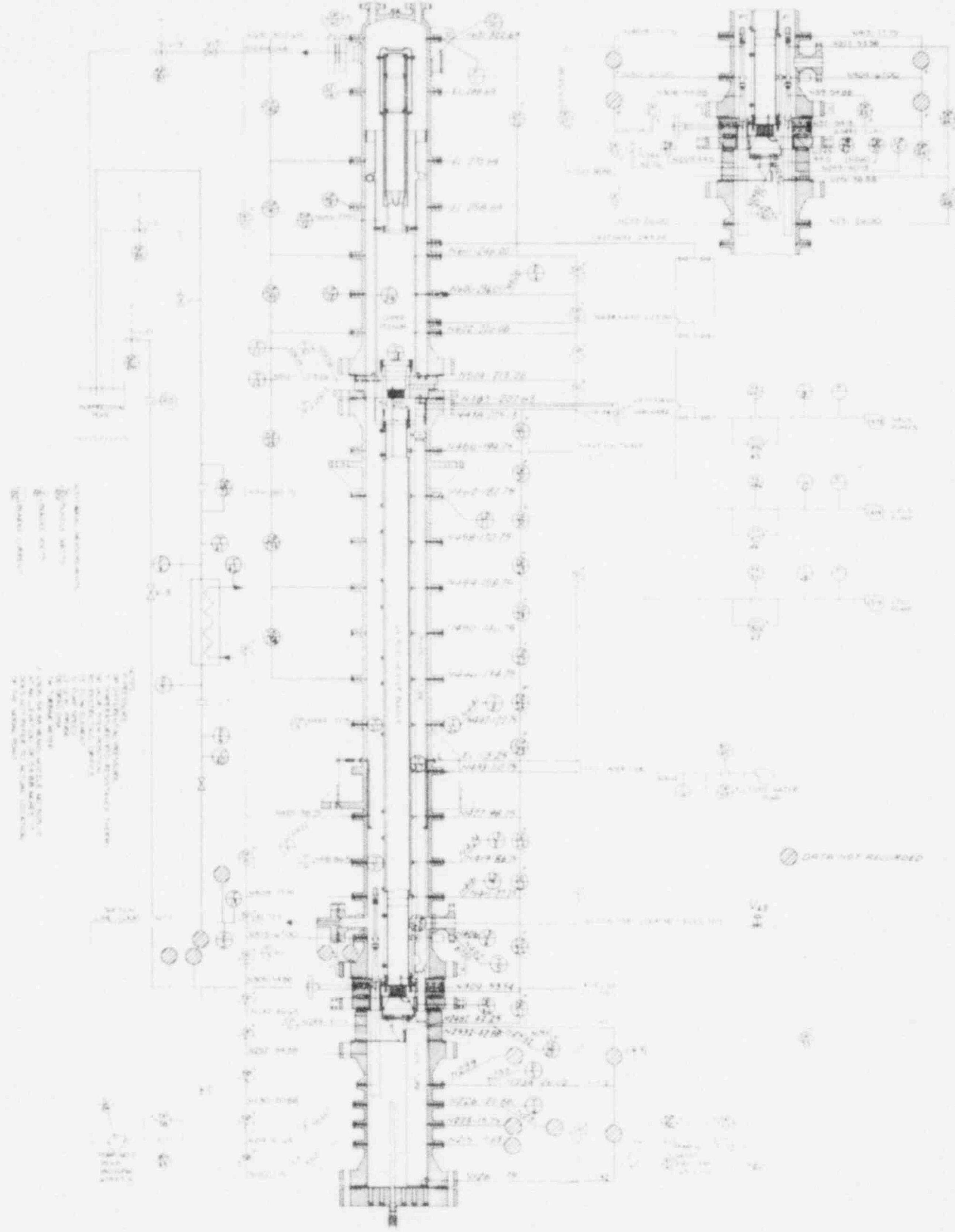

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Figure 5-2. Primary Measurements — Measurement Nodes for TLTA-5B

6. REFERENCES

1. R. J. Muzzy, *Preliminary BWR Blowdown/Emergency Core Cooling Program Plan*, General Electric Company, June 1976 (GEAP-21255).

2. J. P. Walker, *BWR Blowdown/Emergency Core Cooling Program — 64-Rod Bundle Blowdown Heat Transfer Test Plan*, General Electric Company, September 1976 (GEAP-21333).

3. W. C. Punches, *MAYU04 — A Method to Evaluate Transient Thermal Hydraulic Conditions in Rod Bundles*, General Electric Company, March 1977 (GEAP-23517).

4. W. J. Letzring, Editor, *BWR Blowdown/Emergency Core Cooling Program Preliminary Facility Description Report for the BD/ECC1A Test Phase*, General Electric Company, December 1977 (GEAP-23592).

5. J. C. Wood and A. F. Morrison, *BWR Blowdown/Emergency Core Cooling Program — 64-Rod Bundle Core Spray Interaction (BD/ECC1A) Test Plan*, General Electric Company, February 1978 (GEAP-NUREG-21638A).

6. W. S. Hwang and B. S. Schneidman, eds., *BWR Blowdown/Emergency Core Cooling Program — 64-Rod Bundle Blowdown Heat Transfer (8x8 BDHT) Final Report*, General Electric Company, September 1978 (GEAP-NUREG-23977).

APPENDIX A

WORK SCOPE FOR BD/ECC PROGRAM — CONTRACT NO. NRC-04-76-215

PURPOSE

OVERALL PURPOSE

The purposes of the EPRI/NRC/GE Integral Blowdown/Emergency Core Cooling, BD/ECC, test program are to:

1. obtain and evaluate basic BD/ECC data from test system configurations which have calculated performance characteristics similar to a BWR with 8x8 fuel bundles during a hypothetical LOCA; and
2. determine the degree to which models for BWR system and fuel bundles describe the observed phenomena, and as necessary, develop improved models which are generally useful in improved LOCA analysis methods.

SPECIFIC OBJECTIVES

The specific objectives of the integral BD/ECC interaction test program are:

1. **Scaling Analysis:** evaluate and document the scaling basis of the TLTA in the configurations selected for BD/ECC interaction tests as compared to reference BWR designs.
2. **7x7 Counter-Current-Flow-Limited (CCFL) Flooding Characteristics:** conduct CCFL flooding characteristic tests of the present TLTA bundle geometry to establish the need, or lack thereof, to modify the present test apparatus design for the initial BD/ECC interaction experiments.
3. **8x8 Blowdown Heat Transfer Tests:** conduct 8x8 BDHT tests for comparison with 7x7 BDHT data and to serve as a BDHT baseline for BD/ECC interaction experiments.
4. **BD/ECC Interaction Tests:** evaluate system response and heat transfer and evaluate effectiveness of ECC during the blowdown period, and extending well beyond the initial flow coastdown and lower plenum "flashing" periods of the calculated BWR-LOCA in one or more system configurations.
5. **Alternate Power Shape BD/ECC:** determine the effects of axial power shape on the system response and bundle heat transfer behavior during the calculated BWR LOCA.
6. **Non-Jet Pump Plant BD/ECC:** investigate the ECC interaction with the system during blowdown in a representative non-jet pump test system configuration.
7. **Reporting of Data:** report all data (including pertinent error bands) in conventional parametric form suitable for correlation by others.
8. **Model Development:** develop, verify, and document an improved bundle thermal-hydraulic model that can be incorporated into analyses of BWR LOCA's.
9. **Application of Data:** specify how General Electric intends to use the data to qualify the degree of conservativeness of BWR LOCA evaluation models.

SCOPE

Task AA — Program Planning and Administration

1. General Electric will prepare a Preliminary BD/ECC Program Plan that elaborates on the means for meeting the program objectives. The program plan will include, but not be limited to: (a) BWR configurations and LOCA conditions to be tested; (b) test parameters and their ranges; (c) updated conceptual designs and testing strategies; (d) an outline of model development and verification

activities; and (e) the method of relating previous 7x7 rod bundle data to the 8x8 rod bundle data. Sufficient discussion of the above items will be included to substantiate the basis for the preliminary program plan. The program plan will also include an updated schedule, a proposed data verification and reporting plan, and the planned utilization of data by General Electric to assess current BWR LOCA evaluation methods.

The preliminary program plan will be provided for EPRI and NRC review, comment and approval on an agreed upon time schedule. If comments are not supplied to General Electric by NRC or EPRI within the agreed schedule, General Electric may proceed as proposed.

2. Following mutual agreement on the results from Task AA 1, and the appropriate phase of Tasks BB and CC-1, General Electric will prepare a detailed test plan for each major testing phase. Each detailed test plan will include the test objectives, test phase description, test matrices, parameter ranges and reasons for selection, test execution plan, planned utilization of the data, and the planned schedule for completing that phase.

   The preliminary test plans will be provided for EPRI and NRC review, comment, and approval on an agreed upon time schedule. If comments are not supplied to General Electric by EPRI or NRC with the agreed schedule, General Electric may proceed as proposed.

Task BB — Heater Evaluation

1. Perform appropriate analysis relating electrical heater performance to predicted nuclear fuel rod temperature performance during an ECC transient. This analysis will describe the method of programming initial and decaying electrical power to produce representative BWR LOCA thermal response and will describe how differences in thermal properties are accounted for in the electrical simulations.
2. Evaluate the need for tests to demonstrate the validity of the above analyses. The heater evaluation including documentation of the above item will be provided by EPRI and NRC review, comment and approval on an agreed upon time schedule. If comments are not supplied to General Electric by EPRI or NRC within the agreed schedule, General Electric may proceed as proposed.

Task CC — Test Facility Design and Fabrication

1. Scaling and design analyses to define each system configuration will be performed and documented. Particular attention will be given to attaining a real time simulation of calculated BWR system and fuel bundle thermal-hydraulic LOCA response.

   Design trade-off and scaling compromise studies will be performed to establish the final scaling basis to be used for design and operation of each configuration. Appropriate analytical methods including, but not necessarily limited to, those used for BWR performance analyses will be applied to obtain best estimate performance predictions of the BWR reference plants and the test system configurations. These pre-test predictions will include time to boiling transition (BT), lower plenum flashing effects, post-BT heat transfer, and response to ECCS operation. Differences in anticipated dynamic response of the test apparatus as compared to a BWR will be identified by appropriate analysis. Measurement requirements to obtain program objectives, including type, number, location and accuracy of instruments will be specified and an instrumentation plan to meet these requirements will be developed. A preliminary Facility Description including documentation of the above items, presenting the technical basis for the preliminary design, will be provided for EPRI and NRC review, comment and approval on an agreed upon time schedule. If comments are not supplied to General Electric by EPRI or NRC within the agreed schedule, General Electric may proceed as proposed.
2. Upon resolution of comments, if any, the contractor shall provide a revised Facility Description as necessary.

   The final design and procurement of necessary material for each configuration will be completed and the system will be prepared for calibration testing.

Task DD — Test Section Design and Fabrication

Upon completion of Task BB and an evaluation of the BDHT test section counter-current-flow-limiting (CCFL) characteristics, General Electric will complete the design, procurement and assembly of the 8x8 rod test sections for BD/ECC testing. The test section designs will be documented in the appropriate Facility Description reports.

Task EE — System Startup Tests

Upon assembly of each configuration, conduct performance and flow calibration tests. Perform hydrostatic, hydrodynamic and transient startup tests for each configuration to establish system operational characteristics including adequacy of heater and instrumentation response. Conduct steady-state and/or transient separate effects tests necessary to provide the basis for interpretation of BD/ECC experimental results.

Task FF — BD/ECC Interaction Tests

For each configuration, perform tests as detailed Tasks AA 2 and CC-2.

Task GG — Data Evaluation and Model Development

1. Analyze and document the as-built system performance characteristics based on system startup tests. Evaluate the test apparatus design for meeting program objectives on the basis of system startup performance tests. Determine what, if any, minor modification and/or adjustments should be made on the test facility and update the predictions of system response as appropriate.

2. Upon completion of a specified test series, reduce, evaluate, and report the experimental data. Provide the experimental basis for confirming or modifying the assumptions and models used in LOCA evaluations such as the onset of boiling transition (BT), the subsequent heat transfer rates, effects of lower plenum flashing on core thermal response, and the effects of ECC on core and system response. Document the data obtained, the storage format and how it can be accessed by others.

3. As appropriate, develop and document improved analytical models, which can be incorporated into best estimate analyses of BWR LOCA's. This will include, but not be limited to, the development of a self-standing transient thermal-hydraulic model for the prediction of local thermodynamic parameters in rod bundles during LOCA's. These local parameters are necessary for the phenomenological understanding and correlation of local heat transfer coefficients. Values for local heat transfer coefficients are desired which may be expressed as a function of local conditions such as temperature differences, flowrates, pressure and quality.

4. Indicate how the data obtained can be used to assess current BWR LOCA evaluation models including a quantitive determination of safety margins.

APPENDIX B

BD/ECC PROGRAM REPORTS

B.1 LIST OF REPORTS PREPARED AS PART OF THE BWR BD/ECC PROGRAM DOCUMENTATION

Report No./Type	Title/Author(s)	Principal Contents
GEAP-21207 Informal	BWR 8x8 Fuel Rod Simulation Using Electrical Heaters. J. P. Dougherty, R. J. Muzzy. March 1976.	Analysis of electrical heaters to simulate nuclear fuel rods
GEAP-21304-1 Quarterly	BWR Blowdown/Emergency Core Cooling First Quarterly Progress Report. January 1 — March 31, 1976	
GEAP-21255 Topical Report	Preliminary BWR Blowdown/Emergency Core Cooling Program Plan. R. J. Muzzy. June 1976	Design consideration leading to various test configurations. Test parameters and ranges. Test strategy.
GEAP-21304-2 Quarterly	BWR Blowdown/Emergency Core Cooling Second Quarterly Progress Report. April 1 — June 30, 1976	
GEAP-21333 Topical Report	64-Rod Bundle BDHT Test Plan. J. P. Walker. September 1976.	Test matrix and test strategy for 8x8 plan
GEAP-21304-3 Quarterly	BWR Blowdown/Emergency Core Cooling Third Quarterly Progress Report. July 1 — September 30, 1976	
GEAP-21304-4 Quarterly	BWR Blowdown/Emergency Core Cooling Fourth Quarterly Progress Report. October 1 — December 31, 1976	
GEAP-21304-5 Quarterly	BWR Blowdown/Emergency Core Cooling Fifth Quarterly Progress Report. January 1 — March 31, 1977	
GEAP-21304-6 Quarterly	BWR Blowdown/Emergency Core Cooling Sixth Quarterly Progress Report. April 1 — June 30, 1977	
GEAP-21304-7 Quarterly	BWR Blowdown/Emergency Core Cooling Seventh Quarterly Progress Report. July 1 — September 30, 1977	

B.1 LIST OF REPORTS PREPARED AS PART OF THE BWR BD/ECC PROGRAM DOCUMENTATION (Continued)

Report No./Type	Title/Author(s)	Principal Contents
NEDG-NUREG-23732	TLTA Components CCFL Tests D. D. Jones, December 1977	Results of CCFL testing of TLTA-1 and- 3 core inlets and TLTA jet pump. Results of single phase liquid pressure drops across TLTA-3 core inlet and single phase reverse flow steam pressure drops across TLTA jet pumps.
GEAP-23592	BWR Blowdown/Emergency Core Cooling Program Preliminary Facility Description Report for the BD/ECC-1A Test Phase. W. J. Letzring, editor, December 1977.	Detailed description of TLTA configuration for BD/ECC-1A.
GEAP-NUREG-21304-8	BD/ECC 8th Quarterly Progress Report October 1 — December 31, 1977	
GEAP-NUREG 21304-9	BD/ECC 9th Quarterly Progress Report January 1 — March 30, 1978	
GEAP-NUREG-21638A	BWR Blowdown/Emergency Core Cooling Program 64-Rod Bundle Core Spray Interaction (BD/ECC1A) Test Plan, J. C. Wood and A. F. Morrison, February 1978	Test matrix and test strategy for BD/ECC1A phase
GEAP-21304-10 Quarterly	BWR Blowdown/Emergency Core Cooling Tenth Quarterly Progress Report April 1 — June 30, 1978	
GEAP-21364-11 Quarterly	BWR Blowdown/Emergency Core Cooling Eleventh Quarterly Progress Report July 1 — September 30, 1978	
GEAP-NUREG-23977	64-Rod Bundle Blowdown Heat Transfer (8x8) Final Report September, 1978	Topical report covering blowdown heat transfer without ECC injection
GEAP-NUREG-21304-12	BWR Blowdown/Emergency Core Cooling Twelfth Quarterly Progress Report October 1 — December 31, 1978	
GEAP-NUREG-21304-13	BWR Blowdown/Emergency Core Cooling Thirteenth Quarterly Progress Report January 1 — March 31, 1979	

B.1 LIST OF REPORTS PREPARED AS PART OF THE BWR BD/ECC PROGRAM DOCUMENTATION (Continued)

Report No./Type	Title/Author(s)	Principal Contents
GEAP-NUREG-21304-14	BWR Blowdown/Emergency Core Cooling Fourteenth Quarterly Progress Report April 1 — June 30, 1979	
GEAP-NUREG-21304-15	BWR Blowdown/Emergency Core Cooling Fifteenth Quarterly Progress Report July 1 — September 30, 1979	

B.2 LIST OF REPORTS PLANNED AS PART OF BWR BD/ECC PROGRAM DOCUMENTATION

Title	Principal Contents	Scheduled Date
BD/ECC1B Test Plan	Preliminary plan and test strategy for BD/ECC1B testing	
BD/ECC1B Facility Description	Detailed description of TLTA configuration for BD/ECC1B	
BD/ECC1A Final Report	Results from BD/ECC1A testing	
Final BD/ECC Report	Summary and Conclusions from BD/ECC program	

* Major revision of program is currently under consideration by the program sponsors.

APPENDIX C

TLTA SMALL BREAK TEST NO. 1 DESCRIPTION

L. S. LEE

TLTA SMALL BREAK TEST NO. 1 BASIS

The current TLTA configuration is designated TLTA-5B, which is similar to TLTA-5A except for the break line addition described in Section 5. The scaling basis for the facility (as detailed in GEAP-23592) is the BWR/6-218. The bases for this small break test in TLTA are as follows:

BWR/6-218
0.05 ± 0.02 sq ft recirculation line break*
Loss of feedwater and trip of recirculation pumps
ADS not activated
Full complement of ECCS (low pressure systems not expected to inject)
Decay heat as per ANS-5 (1978)
ECC water at 70°F
Reactor scram on high drywell pressure
HPCS activated on high drywell pressure

SMALL BREAK TEST OPERATION

Operational changes for conducting the small break test are necessitated by the scaling compromises of the facility. In addition, the TLTA pressure control system cannot now function repeatably under the testing requirements for this small break.

The TLTA includes or scales to some degree the major components and regions within the reactor pressure vessel of a BWR. Scaling compromises of the facility in general are documented in the Facility Description Report (GEAP-23592). Several other compromises that are specifically germane to conducting small break tests in the TLTA have been identified.**

The small break test operation was developed and reviewed with the program sponsors, NRC and EPRI, in a meeting at GE, San Jose on December 7, 1979. It is different from the TLTA normal operation described in GEAP-23592 for large break. The significant differences are the power decay and the steam flow.

Figure C-1 depicts these differences. In normal TLTA test operation the bundle power (dotted line in Figure C-1a) is raised from the value at Stage 2 operation (GEAP-23592) to the desired initial bundle power level at Stage 3 before power decay begins (at time zero).

As the power is raised, the steam flow increases to maintain system pressure (Figure C-1b). Because the TLTA has limited feedwater temperature range, the feedwater flow is held constant during Stage 3 operation and there is a net loss in system inventory. When the desired inventory, or level in the downcomer, is attained, the blowdown transient is initiated. For the small break, the water level must be maintained higher initially in the downcomer. It was determined from shakedown tests that it was not possible to independently control system pressure, steam flow, power and level to achieve the desired initial test conditions. Therefore, the alternative test operation was developed.

* Note: A small break of a BWR for no loss of high pressure ECC system, is defined as a break that does not produce a low level trip or activation of the ADS system. This break size is near the upper bound of the small break spectrum.

** Letter, G. W. Burnette (GE) to W. D. Beckner (NRC), *Status of TLTA Small Break Scoping Test*, August 14, 1979.

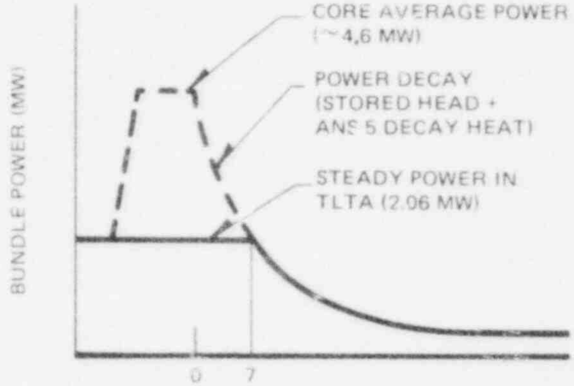

Figure C-1a. *Bundle Power for TLTA Small Break Test*

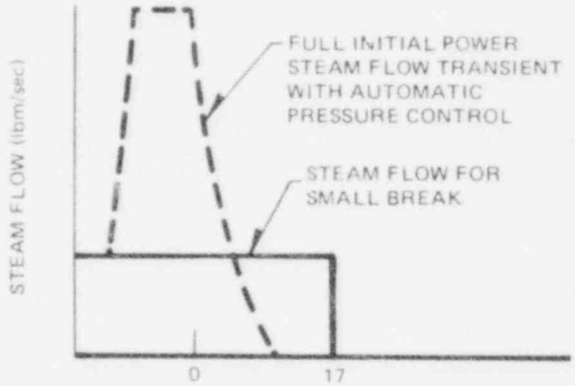

Figure C-1b. *Steam Flow and Hence Valve Stroke for TLTA Small Break*

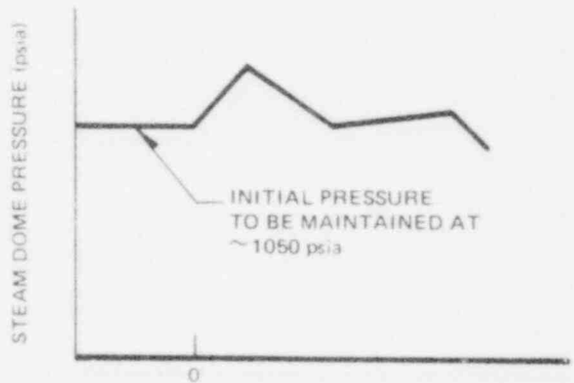

Figure C-1c. *Expected Steam Dome Pressure History in TLTA Small Break*

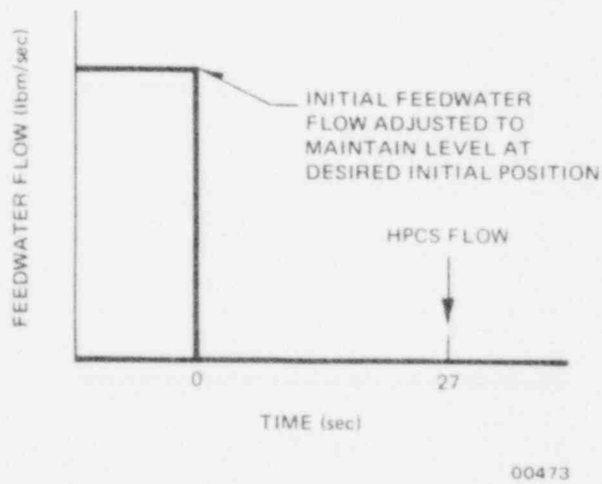

Figure C-1d. *Feedwater Flow Transient for TLTA Small Break*

For the small break test, the bundle power is maintained at the steady state, Stage 2 level (2MW) and is not increased to Stage 3 (see Figure C-1a). The power is held constant for approximately 7 seconds after which time it is decayed in accordance with the stored heat and ANS-5 decay heat for a central average power bundle. The steam flow is also held constant during this period. As the steam generation diminishes with the power decay, the pressure control valve would normally close in its attempt to maintain the system pressure and reduce the steam outflow. However, shakedown tests showed that the pressure control response was not repeatable. So, in order to assure repeatable response for the small break test evaluations, the valve is maintained at the same opening position until 17 seconds, at which time it is rapidly closed. This closure timing is selected to be approximately midway through the start of power decay (7 seconds) and activation of the HPCS flow (27 seconds).

The feedwater flow in the small break test is tripped at time zero, as shown in Figure C-1d. Other flows and set values are given in Table 3-1.

The system pressure is expected to be affected in the manner shown in Figure C-1c. It will initially rise as a result of loss of feedwater, and fall as the power decays. It will rise again when the steam valve is closed and fall again following HPCS injection.

TEST CONDITIONS

The initial and operating conditions for the small break test are described in Section 3 of the basic document, and also Figure C-1. The test termination time is specified as when the liquid level in the downcomer region is rising but before the level reaches its initial value or approximately 2000 seconds, whichever occurs first.

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Blowdown/Emergency Core Cooling work completed in the fourth quarter of 1979 (October 1, 1979 through December 31, 1979) is summarized. Planning and necessary facility modifications for the first small break test were completed. Some shakedown tests were completed and the first small break test was successfully executed. Blowdown/ECC injection testing continued with the improved TLTA hardware and power decay simulation.

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