INTERIM REPORT

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Prepared for
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

INTERIM REPORT

GENERAL ELECTRIC

NUCLEAR ENERGY

BUSINESS GROUP

GENERAL ELECTRIC COMPANY, 175 CURTNER AVE., SAN JOSE, CALIFORNIA 95125

November 5, 1979

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Division of Contracts
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SUBJECT: BWR BLOWDOWN/ECC PROGRAM
CONTRACT NO. NRC-04-76-215
INFORMAL MONTHLY PROGRESS REPORT FOR OCTOBER 1979

Gentlemen:

The following summarizes the subject matter covered in the attached report:

Planning for the small break scoping test continues and a shakedown test confirms an expected scaling compromise behavior. Blowdown/ECC injection testing continues with the current TLTA configuration. Lower bundle temperatures are confirmed with the improved TLTA hardware and power decay simulation. Work continues on determining heat transfer coefficients from the measurements.

Distribution of this report is being made in accordance with the "Monthly Distribution List" provided with W. D. Beckner's letter of September 6, 1979.

Very truly yours,

G W Burnett

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cc: RG Bock

GWB/cat

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B W R B D / E C C P R O G R A M

F O R T Y - E I G H T H M O N T H L Y R E P O R T

O C T O B E R 1 9 7 9

Prepared for:

Division of Reactor Safety Research
U.S. Nuclear Regulatory Commission
Washington, DC 20555
NRC FIN No. B3014

and

Electric Power Research Institute
3412 Hillview Avenue
Palo Alto, CA 94304
EPRI Project No. RP-495-1

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By

General Electric Company

Under

Contract No. NRC-04-76-215

B W R B D / E C C P R O G R A M

F O R T Y - E I G H T H M O N T H L Y R E P O R T

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SUMMARY

Planning for the small break scoping test continues and a shakedown test confirms an expected scaling compromise behavior. Blowdown/ECC injection testing continues with the current TLTA configuration. Lower bundle temperatures are confirmed with the improved TLTA hardware and power decay simulation. Work continues on determining heat transfer coefficients from the measurements.

TASK AA - PROGRAM PLANNING AND ADMINISTRATION

Analysis effort continued in support of small break scoping test planning. Because of the existing compromises in the TLTA, there is no single scaling criterion that can be applied to reproduce the response expected in a BWR during a small break. Various alternatives and combinations of scaling criteria are being evaluated. It appears that most of the controlling phenomena can be evaluated in the TLTA although the magnitude of the responses and timing of key events may not be prototypical. A meeting will be held in Washington, D.C., during the first part of November to review this planning effort.

TASK FF - TLTA TESTING

Several TLTA tests were conducted during the month as follows:

	TEST	DESCRIPTION
1)	6423, Run 2	- Peak power, low ECC flow, high ECC temperature.
2)	6422, Run 3	- Average power, average ECC flow and temperature.
3)	1017	- Pressure Isolation/Leak Test

A problem was encountered during Test 6423 which resulted in not having the vessel pressure recorded. Since this test is an upper bound and will likely receive considerable scrutiny, the test will be repeated to obtain a complete set of measurements. Two runs were made for Test 6422. The first run contained a bundle power malfunction; the second, completed near the end of the month, appears to be a good run. Test 1017 was a shakedown test to determine if the system could hold constant pressure. Bundle power decay was initiated at time zero, coincident with tripping power to the recirculation pumps. The pressure control valve didn't seat completely which lead to a slight depressurization of the system. An order for a new operator and plug has been made. While the test was unsuccessful in holding system pressure, the test did confirm the presence of a manometer type bundle uncovery at the end of flow coastdown when the transient was initiated from the "normal" (very low relative elevation) water level of the TLTA.

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TASK GG - ANALYSIS

Data from the peak power, low flow/high temperature ECC test (6423) are being evaluated for acceptability as well as for interpretation. Preliminary evaluation reveals that the cladding temperatures from this test are significantly lower than the previous peak power test (6414). The early system response and bundle heatup response are similar as expected. During the post-lower plenum flashing and bundle uncovery period, the bundle heatup response is significantly slower due to the improved power decay simulation. The maximum temperature at peak power plane is <1000°F in this period compared to 1500°F from the previous test (Figure 1).

The lower temperatures observed in the recent peak power test (6423) are attributable to the major improvements in the TLTA simulation. One of the improvements is the improved bundle decay heat simulation; another is one more representative bypass to core leakage flow path.

Heat transfer coefficients are being obtained from selected heater rod thermocouples in the BD/ECC-1A series 1 tests. The purpose is to evaluate the heat transfer effects for tests with and without ECC injection. The thermocouples were selected from those measurements giving the maximum temperature at the higher temperature elevations. The tests from which the thermocouples have been selected are: Average power, no ECC (6007/Run 26); average power, average ECC (6406/Run 1); peak power, low flow/high temperature ECC (6414/Run 3).

The current test series has a bundle with better instrumentated heater rods. Results from these new tests are also being evaluated to determine the heatup response throughout the bundle as well as in the vicinity of the grid spacers. A copy of the program summary and status report, "BWR Blowdown/Emergency Core Cooling Integral Program", presented at the 7th Water Reactor Safety Research Information Meeting is enclosed.

G W Burnett
G. W. Burnette, Manager
External Programs

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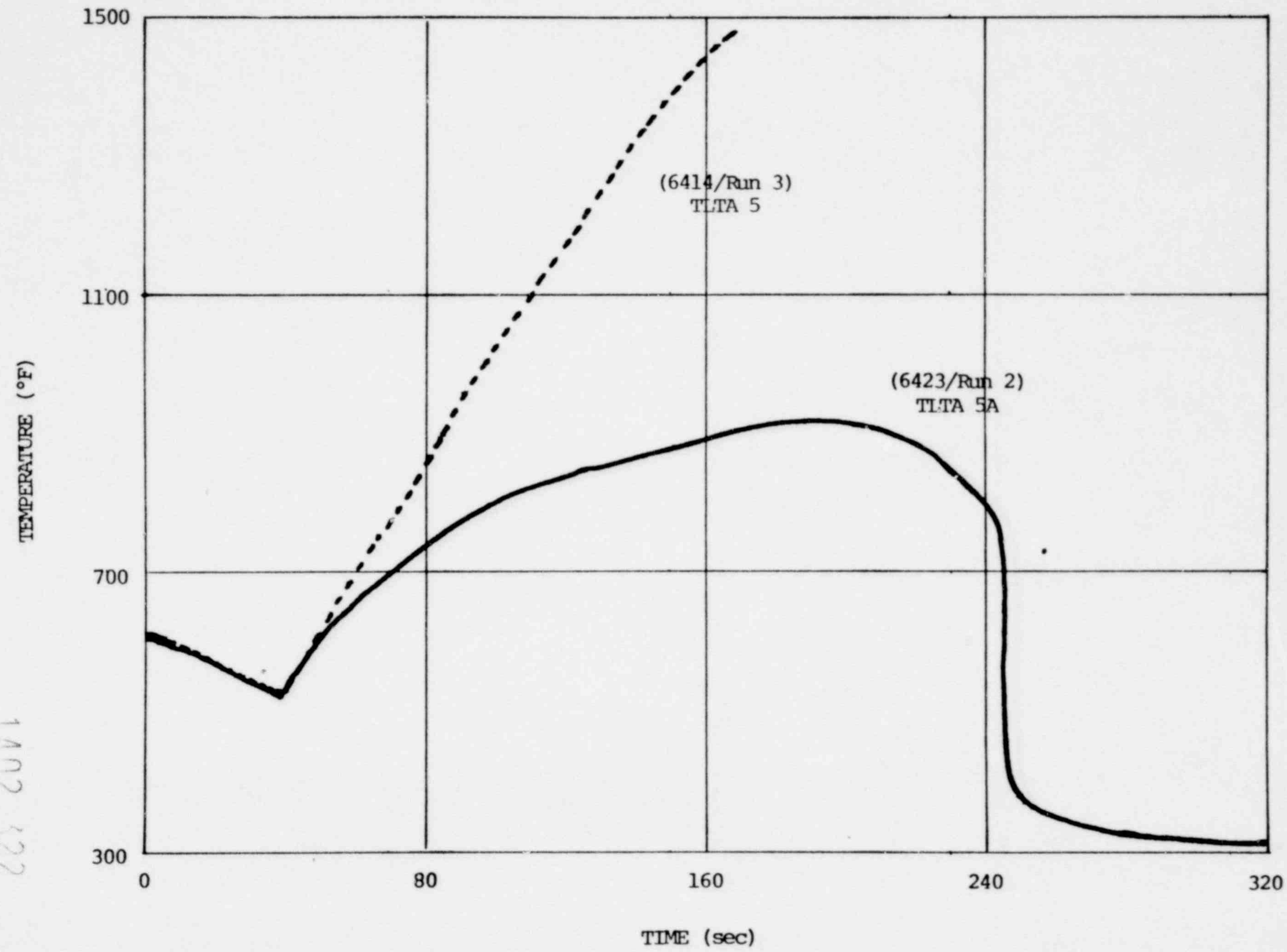
FIGURE 1 - COMPARISON OF MAXIMUM CLADDING TEMPERATURE AT PEAK POWER PLANE FOR PEAK POWER, LOW FLOW/HIGH TEMPERATURE ECC TESTS



BWR BLOWDOWN/EMERGENCY CORE COOLING INTEGRAL PROGRAM

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L. S. Lee

R. P. Jordan

September, 1979

General Electric Company

Nuclear Energy Engineering Division

San Jose, California, USA

For Presentation at 7th Water Reactor Safety Research Information Meeting

November 5 - 9, 1979

National Bureau of Standards

BACKGROUND

Emergency core cooling (ECC) systems are designed to maintain fuel cladding temperatures below specified limits, even under the hypothetical loss of coolant accident (LOCA) in which a rupture of one of the main pipes connected to the reactor pressure vessel is postulated. The BWR Blowdown/Emergency Core Coolant (BD/ECC) Program is an experimentally based program to investigate the integral effects of ECC injection during a hypothetical LOCA. This program is sponsored by the Nuclear Regulatory Commission (NRC), the Electric Power Research Institute (EPRI), and the General Electric Company (GE).

The principal objective of the BD/ECC Program is to obtain and evaluate basic BD/ECC data from test system configurations which have performance characteristics similar to a BWR during a hypothetical LOCA. Another principal objective is to determine the degree to which current LOCA models describe the observed phenomena and, as necessary, develop improved physical interpretation of the governing phenomena.

The Two-Loop Test Apparatus (TLTA) [Figure 1] is used to provide the thermal-hydraulic characteristics of a BWR under the postulated LOCA situation. Electrically heated rods are used to simulate a fuel bundle from full initial power to decay heat power level, and coolant injection systems are designed to supply the scaled ECC flow rates.

The BD/ECC program can be considered as an extention of the BWR Blowdown Heat Transfer (BDHT) Program which was completed in late 1975. The program is divided into several test phases which are designed to investigate different portions or variations of the BWR LOCA response. The TLTA has been modified to meet the primary objective of each testing phase with the overall objective of maintaining a real-time, thermal-hydraulic system response. The various test phases are identified and summarized in Table 1.

STATUS

The 7x7 BDHT and 8x8 BDHT test phases and the first series of BD/ECC-1A tests have been completed. The 7x7 and 8x8 BDHT tests investigated mainly the blowdown portion of the LOCA transient and as such, the ECC system was not activated. These results serve as a baseline from which the effectiveness of the ECC system can be evaluated. The tests with the ECC injections were performed in the BD/ECC-1A phase.

RESULTS

(a) The Reference Test With ECC

The phenomena that dominate the system response are characterized by the snap shots at selected instances in time as shown in Figures 2 and 3. The two-phase mixture level throughout the system (Figure 4) serves to illustrate the overall conditions during the transient.

(b) Comparisons of Tests With and Without ECC

Detailed comparisons of the test results with and without ECC are given in Figures 5 through 10. The system depressurizes at a slower rate in the test with ECC, particularly beyond about 60 seconds (Figure 5). As expected, the ECC injections cause mass accumulations in various regions (Figure 6) during the transient, which are also reflected in the two-phase level comparison (Figure 7). As shown in Figure 8, the effects of the ECC injections are to produce significantly lower rod temperatures at each bundle elevation. These comparsions also show a delay in bulk bundle heat-up and significant rod rewet through the transient. Beyond 60 seconds significant differences are seen in the fluid density in the break vicinity, break flow rate and quality between the tests with and without ECC (Figures 9 and 10). These break flow differences cause the observed differences in the system depressurization rate (Figure 5). Figure 11 shows a comparison of the measured bundle pressure drop for the peak power (6.49 mw) and average power (5.05 mw) bundle tests. This comparison indicates that there are no significant differences in the bundle hydraulic response for different bundle power levels. This indicates that bundle responses for both the average and peak power cases are representative. As shown in Figure 12, the peak cladding temperature (PCT) is higher as expected for the peak power test. Figure 12 also shows the PCT for the low power test.

Comparisons of the measured and predicted system blowdown and peak clad temperature responses are shown for the reference tests in Figure 13. The predicted response was obtained from the current BWR evaluation models (EM) applied to the TLTA. The comparisons show the expected faster calculated depressurization response and indicate a large margin in the calculated peak cladding temperature.

CONCLUSIONS

- BWR ECC system is very effective - the peak cladding temperature is significantly lower in the test with ECC.
- The slower system blowdown seen in the test with ECC is due mainly to the break flow differences.
- The system responses are found to be similar in the peak and average power tests.
- There is a large margin in predicted peak cladding temperature.

TABLE 1

BWR-BLOWDOWN HEAT TRANSFER/ECCS INTEGRAL TEST PROGRAM

PHASE	TLTA	OBJECTIVE	STATUS
7x7 BDHT	1	o Baseline BWR Data	Completed 1975
8x8 BDHT	2	o Bundle Variation	Completed 1976
	3	o BWR/4 - 6	Completed 1977
	4	o Baseline Data with No ECC	Completed 1977
BD/ECC-1A	5	o Early ECC Interaction o Blowdown → Refill	Completed 1978
	5a	o Improved Simulation o Small Break	In progress - early 1980
BD/ECC-1B		o Blowdown → Reflood o Complete Integral o Non-LOCA Options	o Several Design Alternatives Identified
BD/ECC-2		o Separate Effects ECC Tests at High Temperature o Alternate Power Profile	May Be Eliminated
Non Jet Pump		o BD/ECC Phenomena in Non Jet Pump Configuration	May Be Eliminated

FIGURE 1

TWO LOOP TEST APPARATUS (TLTA-5) WITH EMERGENCY CORE COOLING SYSTEMS

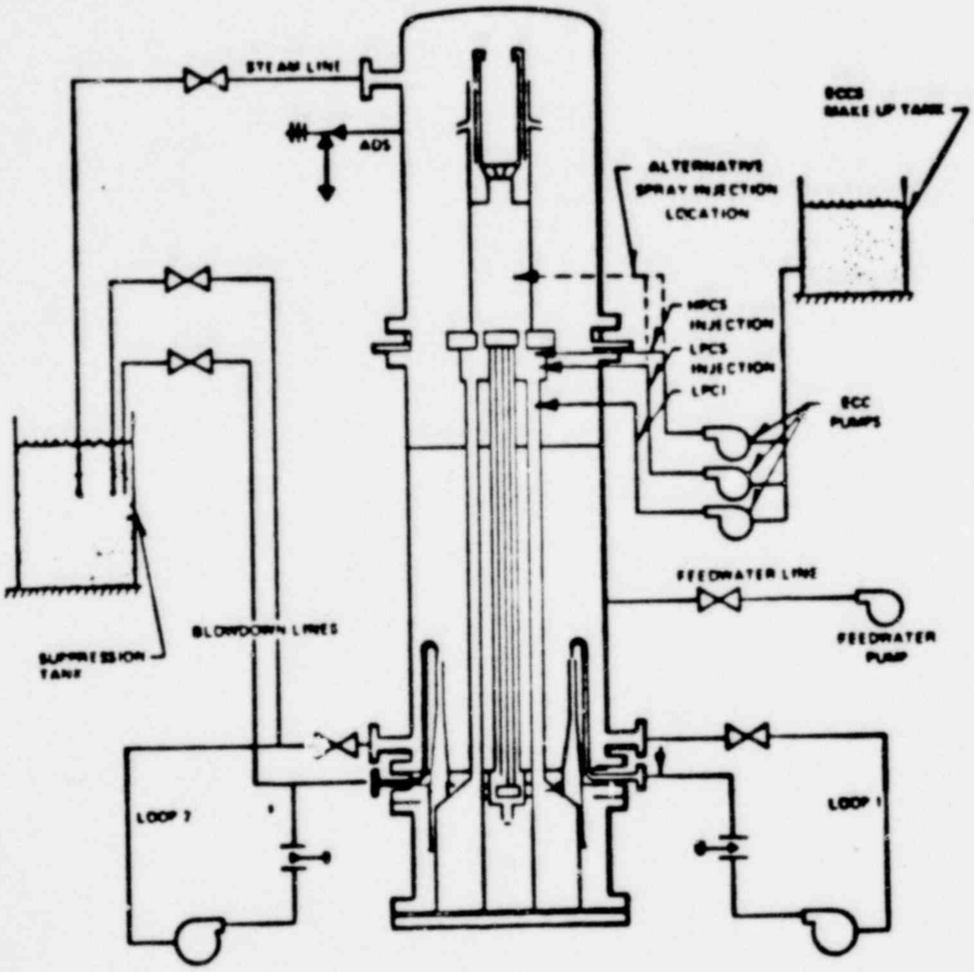
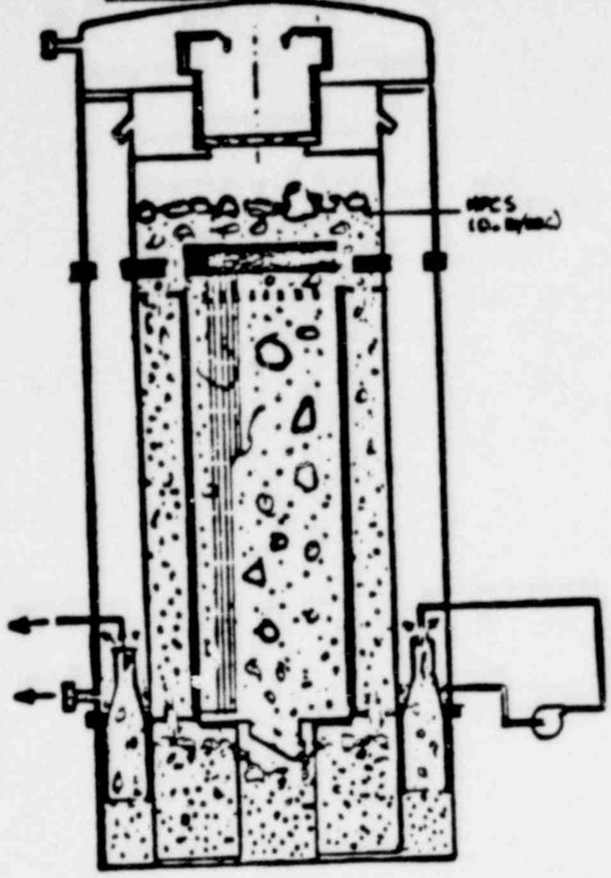
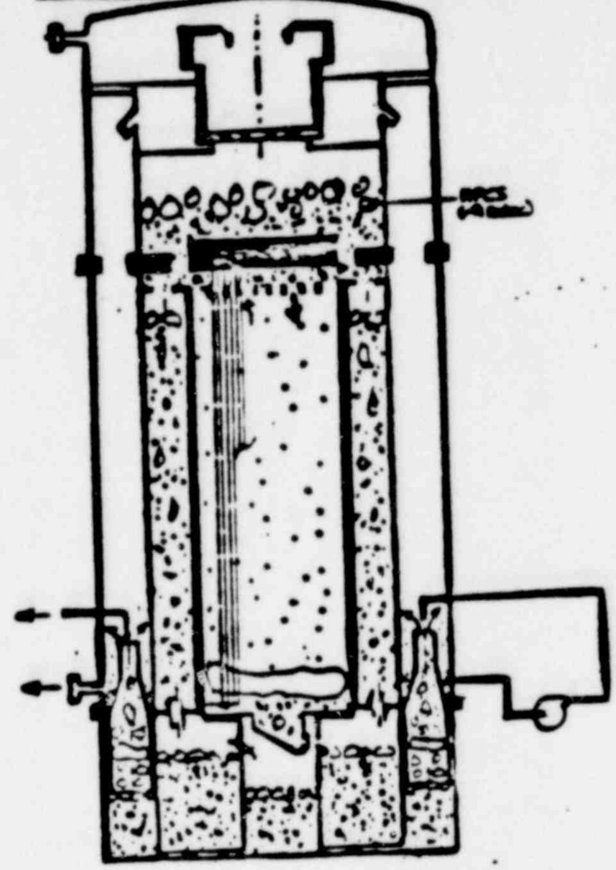


FIGURE 2

SNAP SHOTS AT SELECTED INSTANCES FOR THE REFERENCE TEST (AVERAGE POWER, AVERAGE ECC)

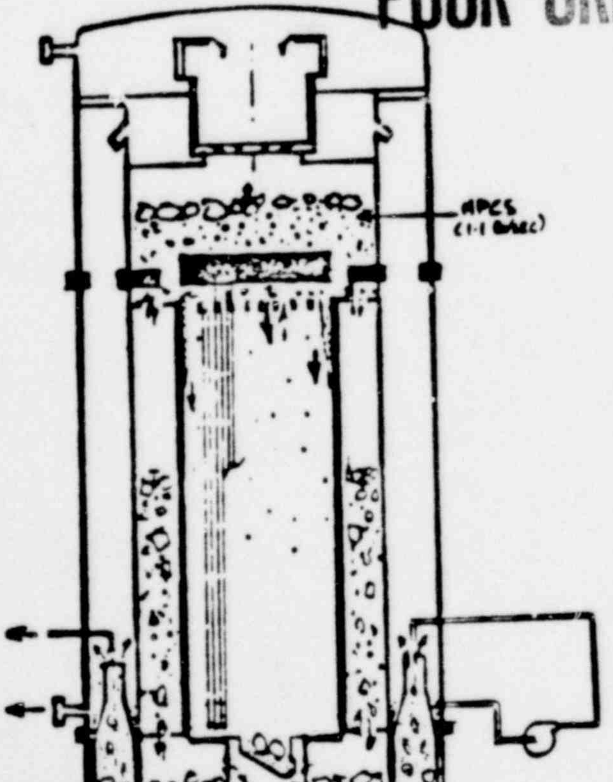


A. HPCS Injection (27 sec.)

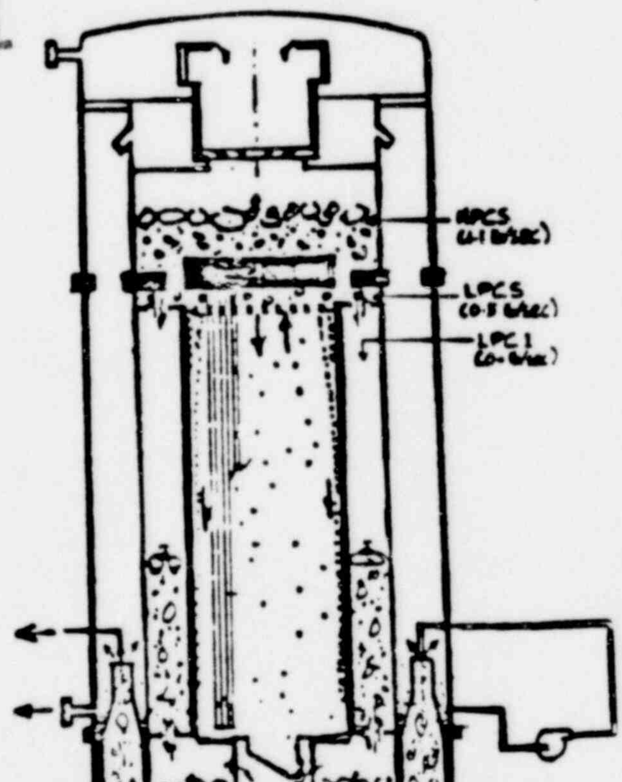


B. Jet Pump Exit Uncovery (~40 sec.)

POOR ORIGINAL



C. Difference Discernible (~64 sec.)



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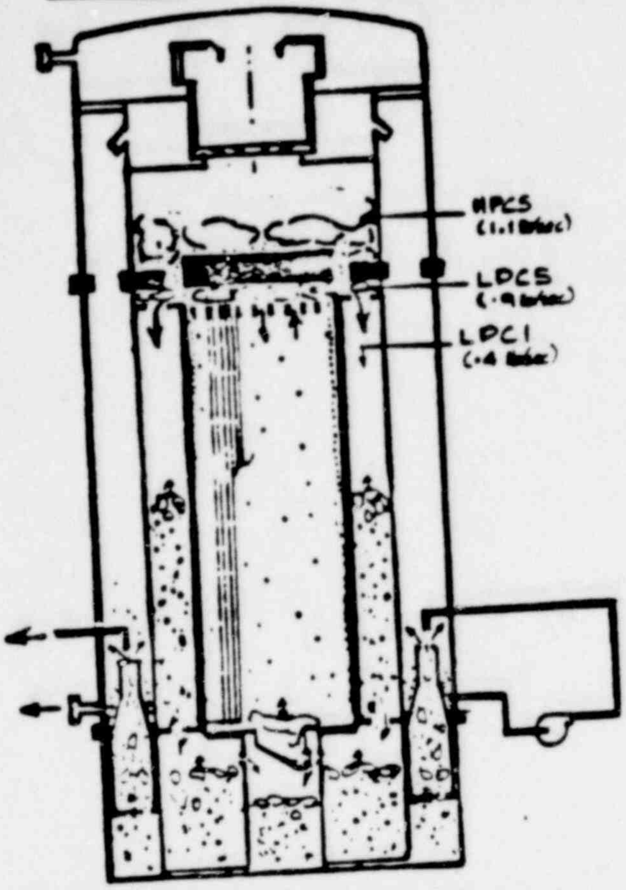
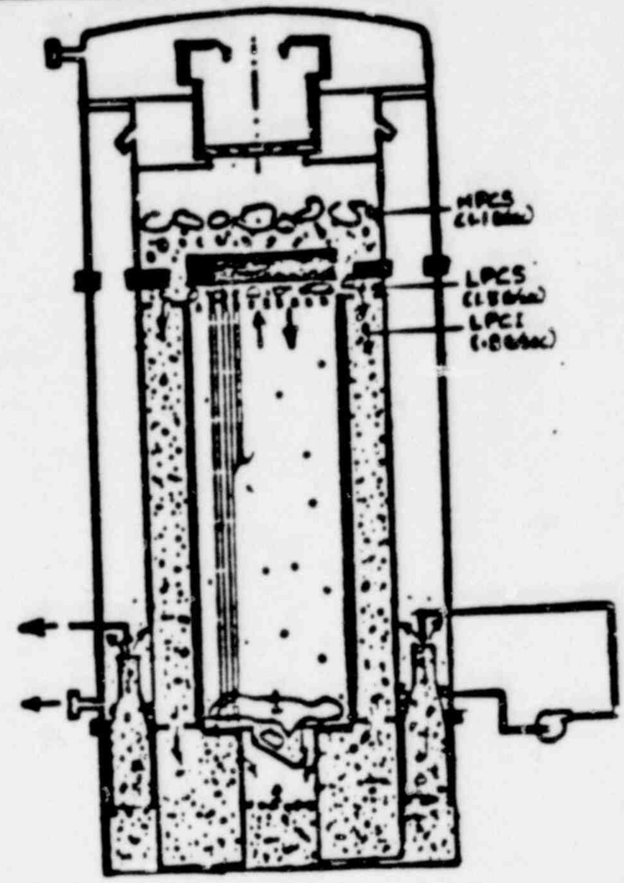
D. LPCS and LPCI Injections (~90 sec.)

F I G U R E 3

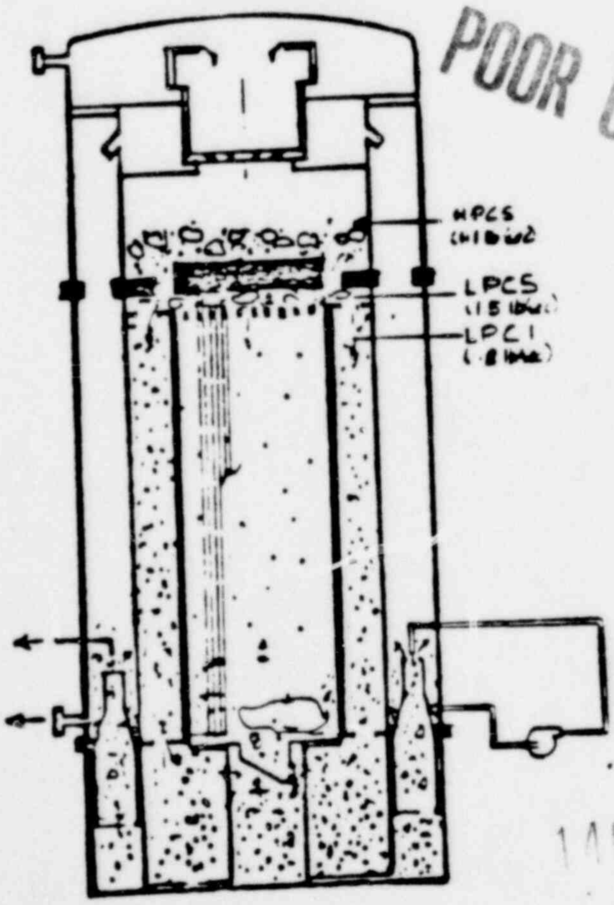
SNAP SHOTS AT SELECTED INSTANCES FOR THE REFERENCE TEST (AVERAGE POWER, AVERAGE ECC) Cont.



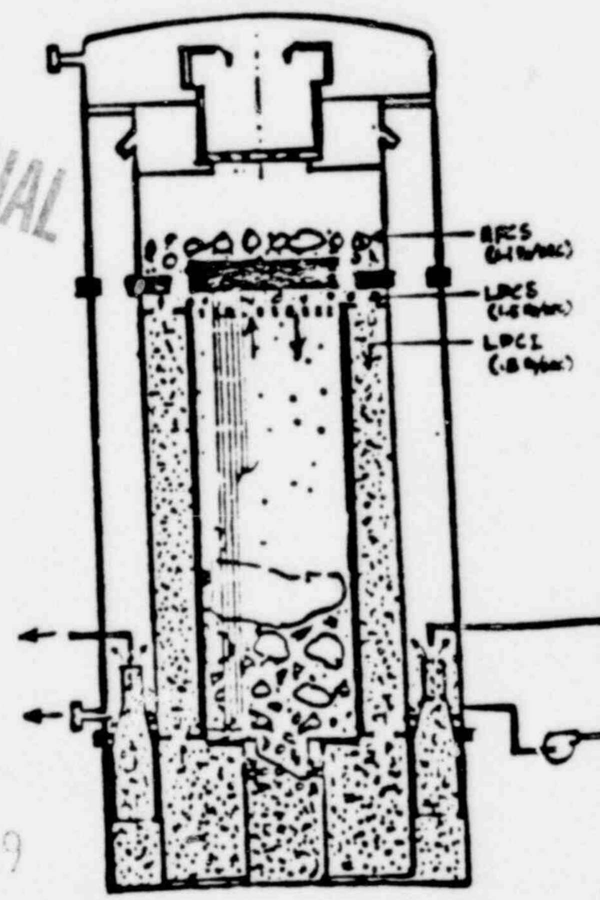
E. Bypass CCFL Breakdown (~105 sec.)



F. Jet Pump Refilled with Liquid (~150 sec.)



G. System Refilling (~160 sec.)



H. TLTA Refilled (~200 - 300 sec.)

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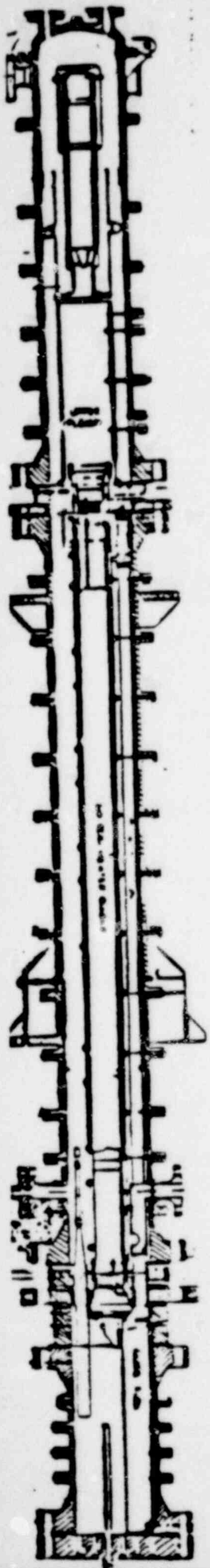
FIGURE 4

TWO-PHASE MIXTURE LEVEL RESPONSES ILLUSTRATING
BUNDLE REFILL FOR THE REFERENCE TEST
(AVERAGE POWER, AVERAGE ECC)



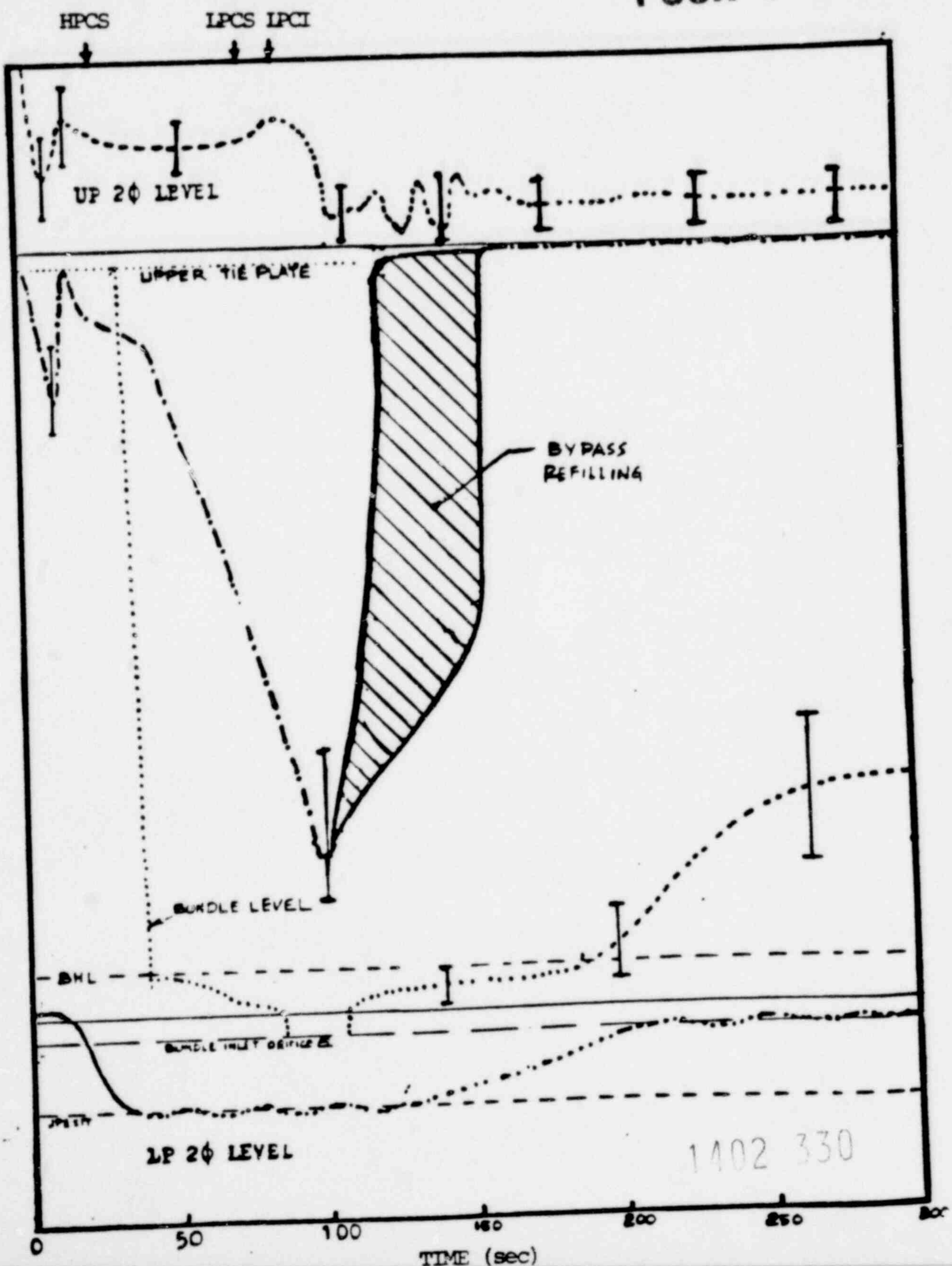


FIGURE 5

COMPARISON OF SYSTEM PRESSURE RESPONSES BETWEEN TESTS WITH/WITHOUT ECC

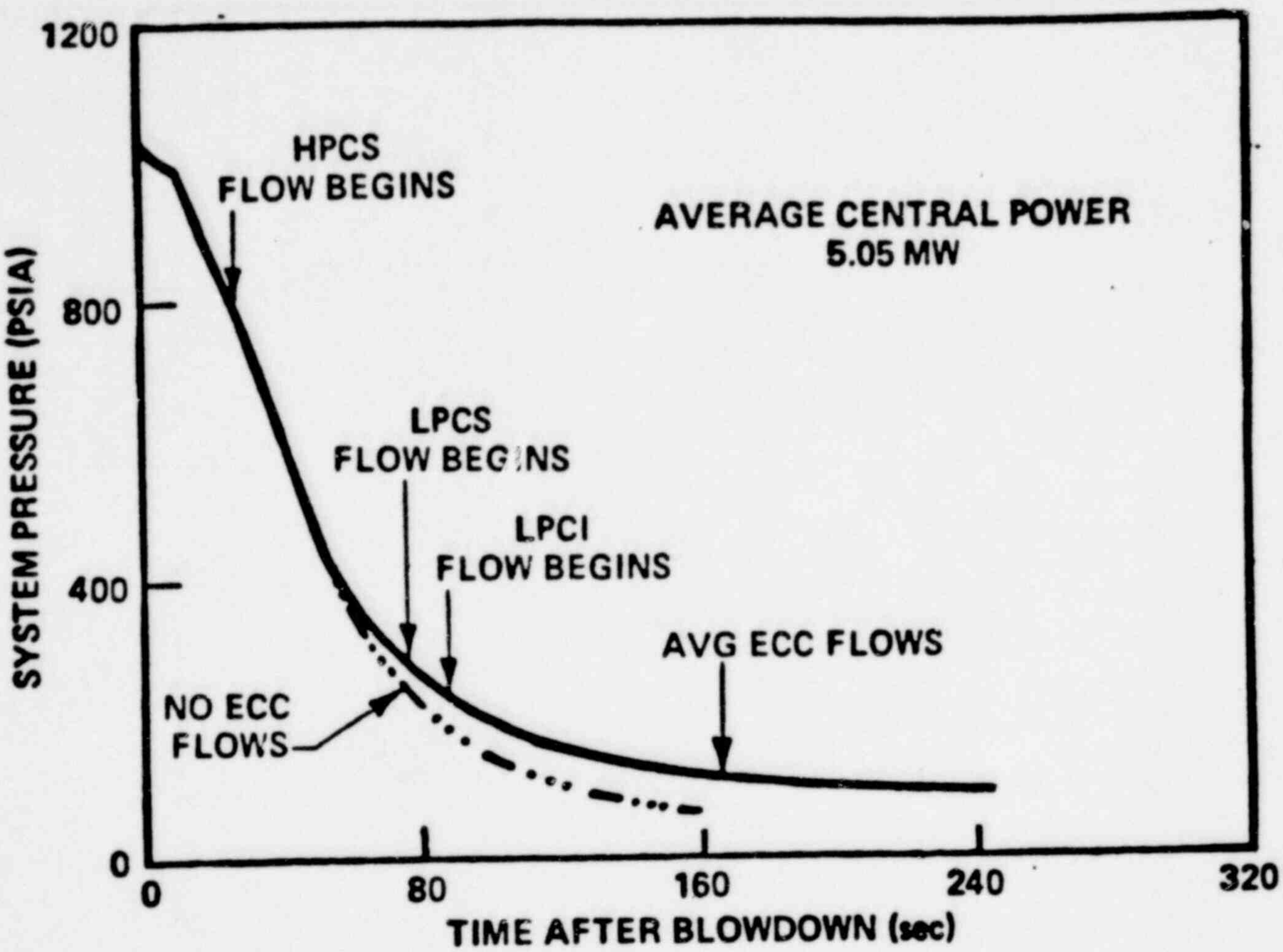


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FIGURE 6

COMPARISON OF MASS INVENTORIES BETWEEN TESTS WITH/WITHOUT ECC

(AVERAGE POWER)

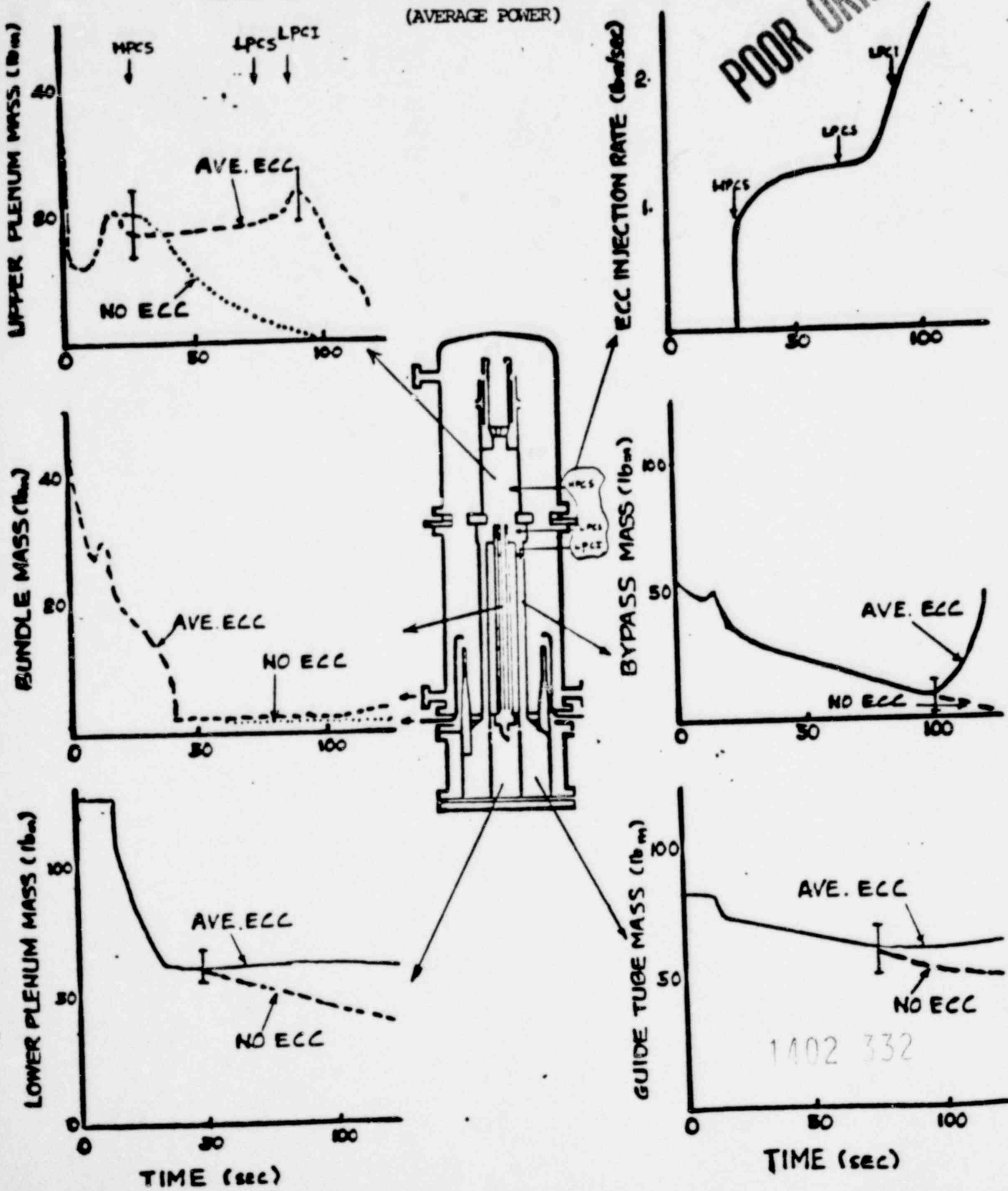

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FIGURE 7

COMPARISON OF MIXTURE LEVEL RESPONSES BETWEEN TESTS WITH/WITHOUT ECC (AVERAGE POWER)

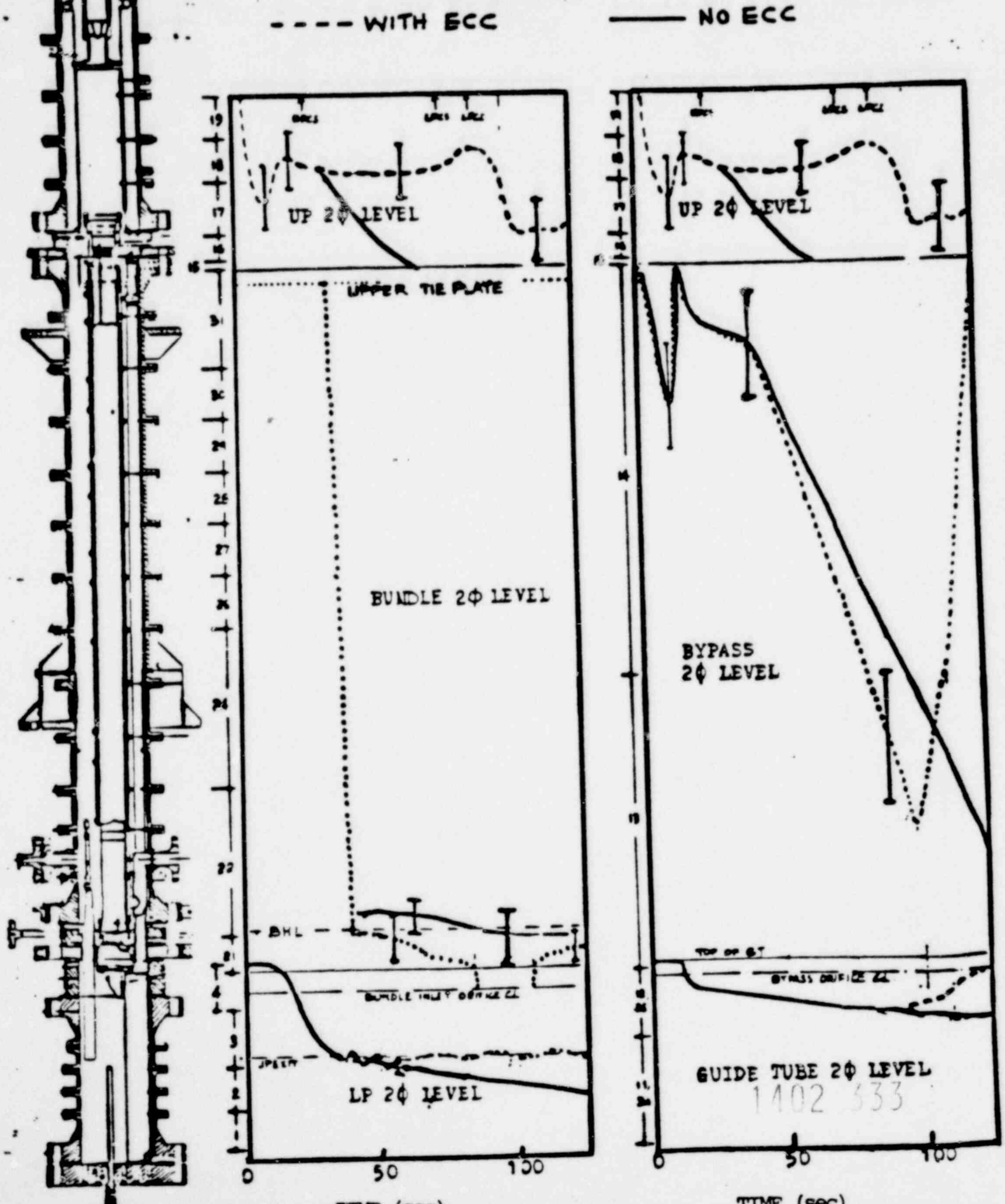

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FIGURE 8

COMPARISON OF TEMPERATURE RESPONSES IN BUNDLE BETWEEN TESTS WITH/WITHOUT ECC (AVERAGE POWER)

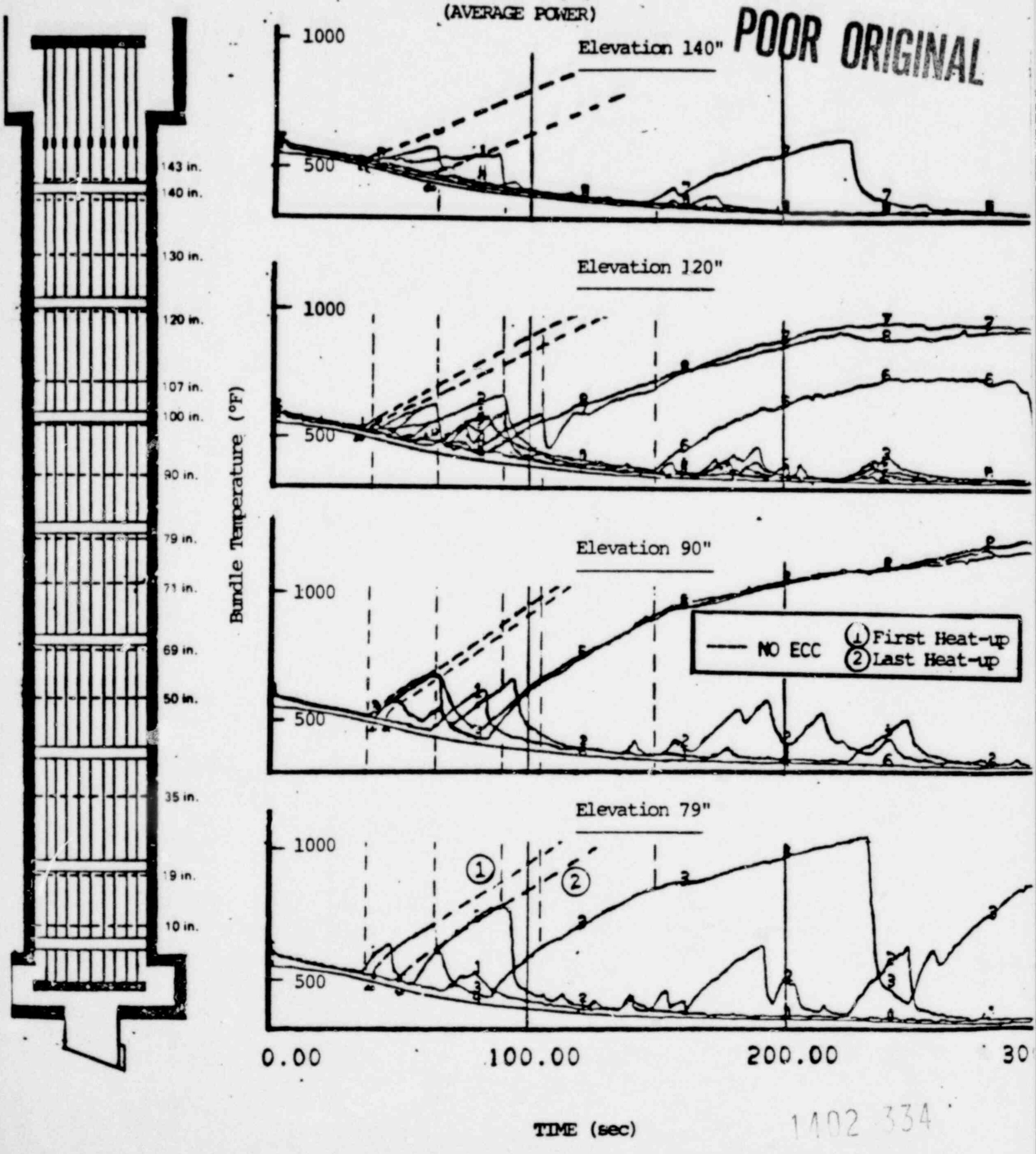

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FIGURE 9

BREAK FLOW DENSITY COMPARISON (AVERAGE POWER)

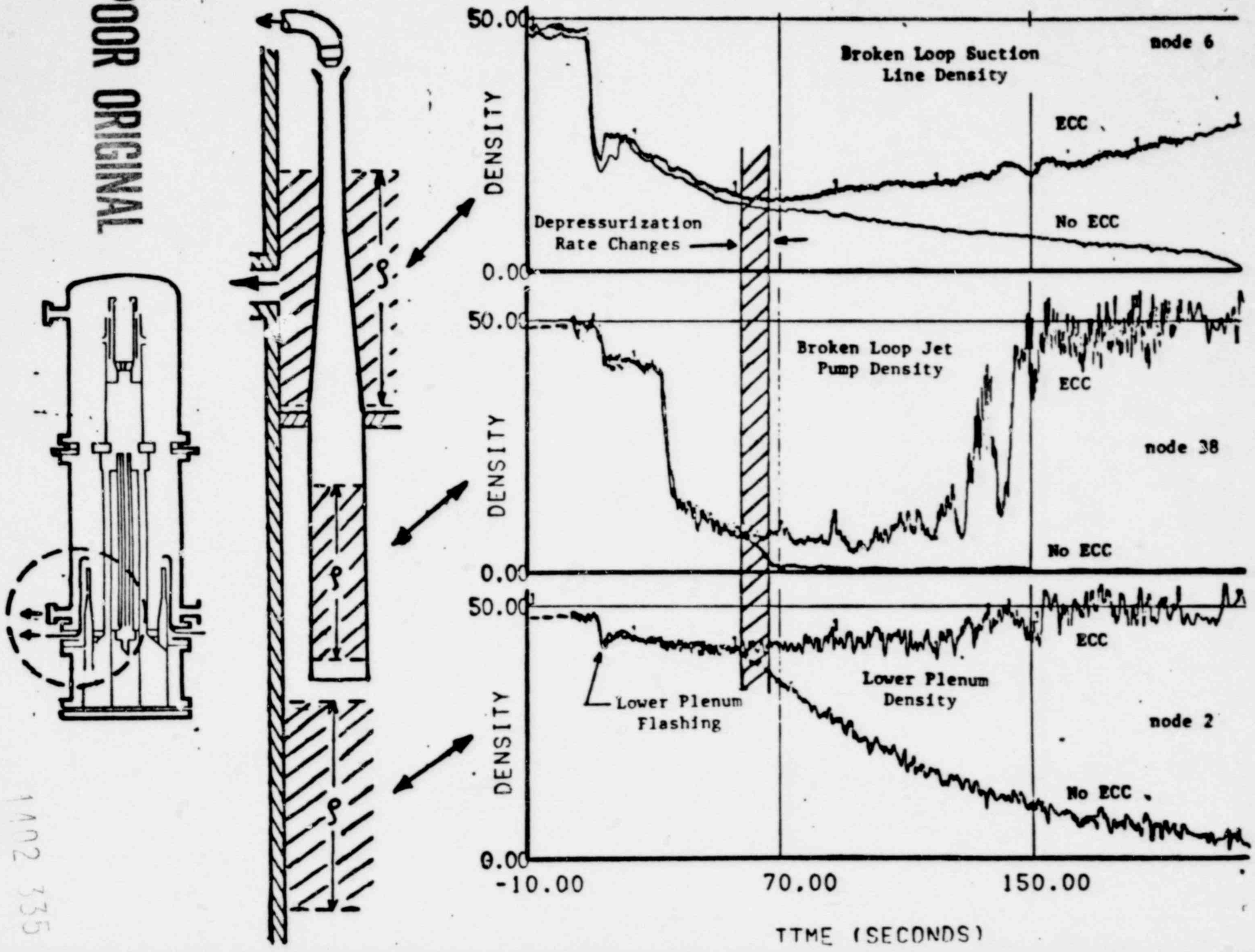

FIGURE 10

COMPARISONS OF BREAK FLOW RATE AND QUALITY

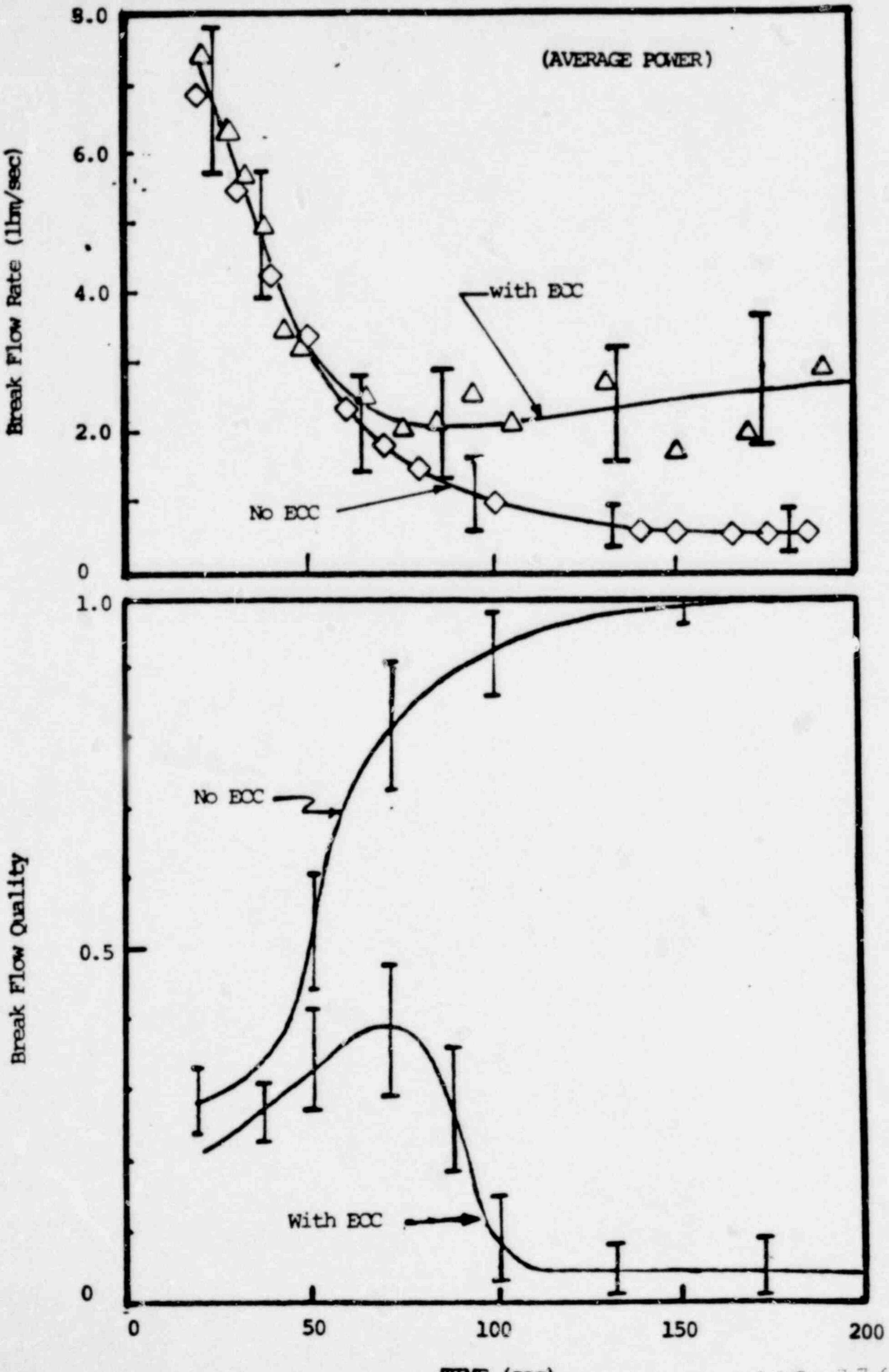

FIGURE 11

COMPARISON OF BUNDLE INLET/OUTLET PRESSURE DROPS

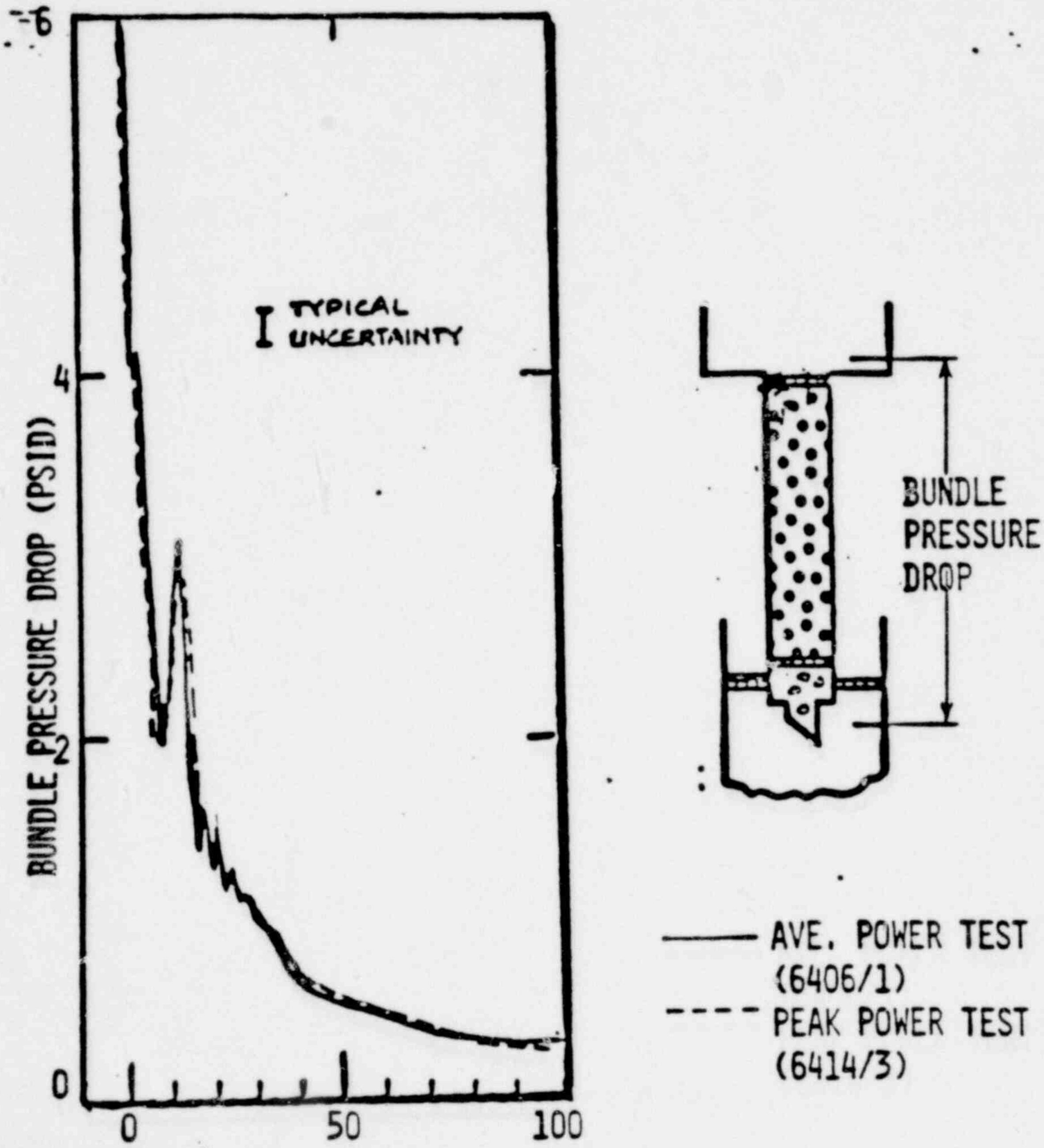

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FIGURE 12

COMPARISON OF CLADDING TEMPERATURES AT PEAK-POWER ELEVATION

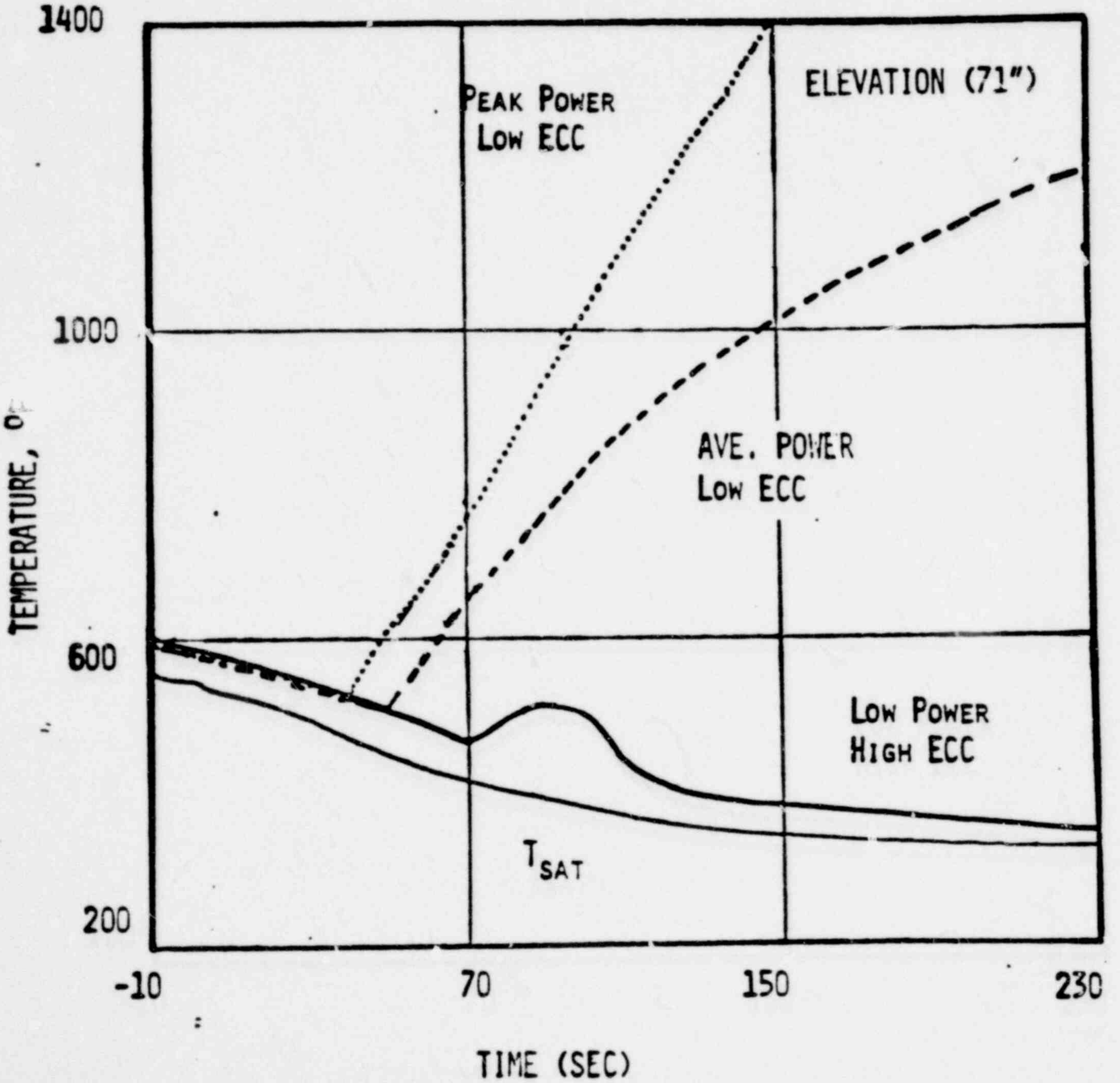

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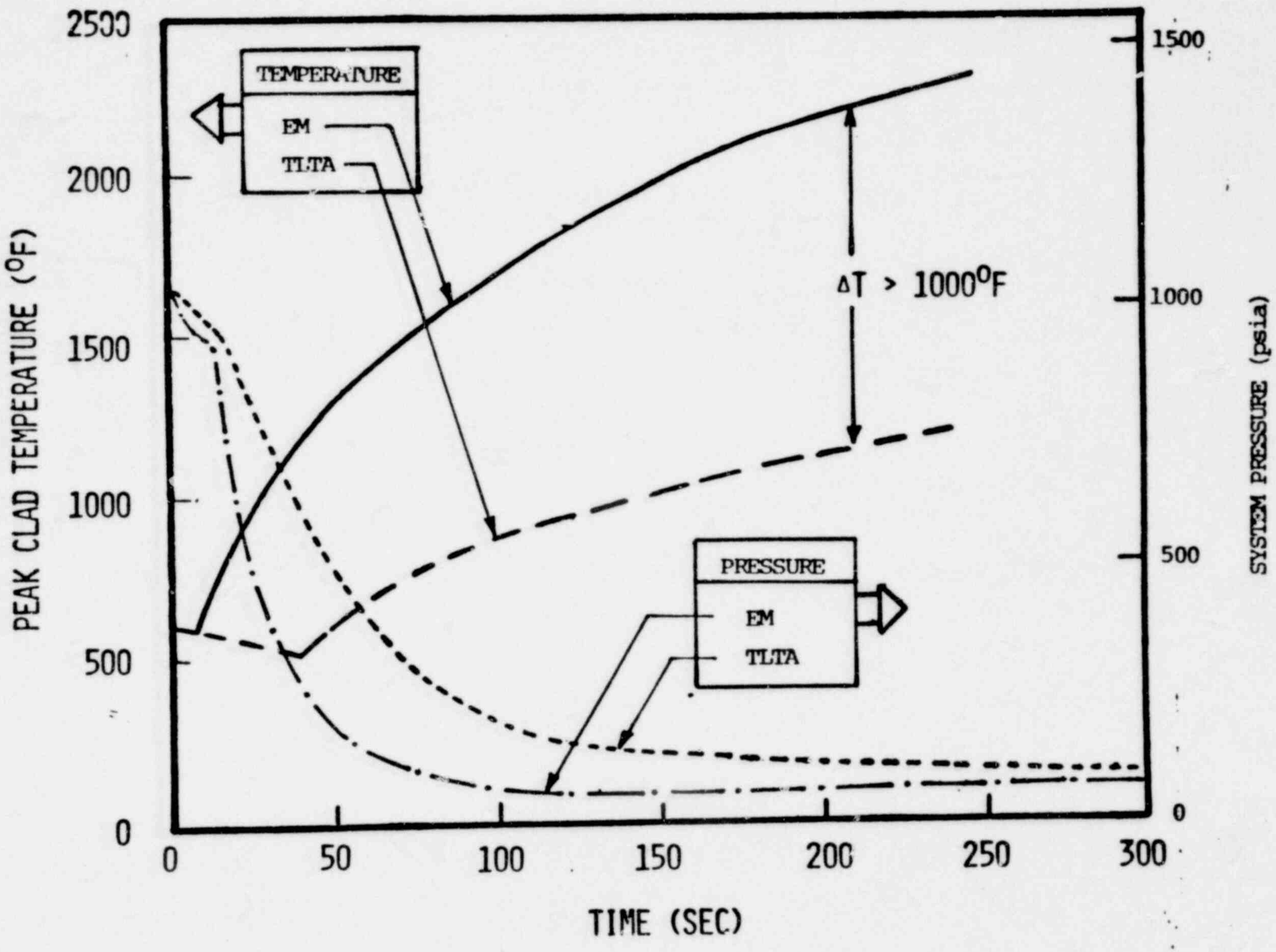
FIGURE 13

TLTA/EM COMPARISONS
(AVERAGE POWER)



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