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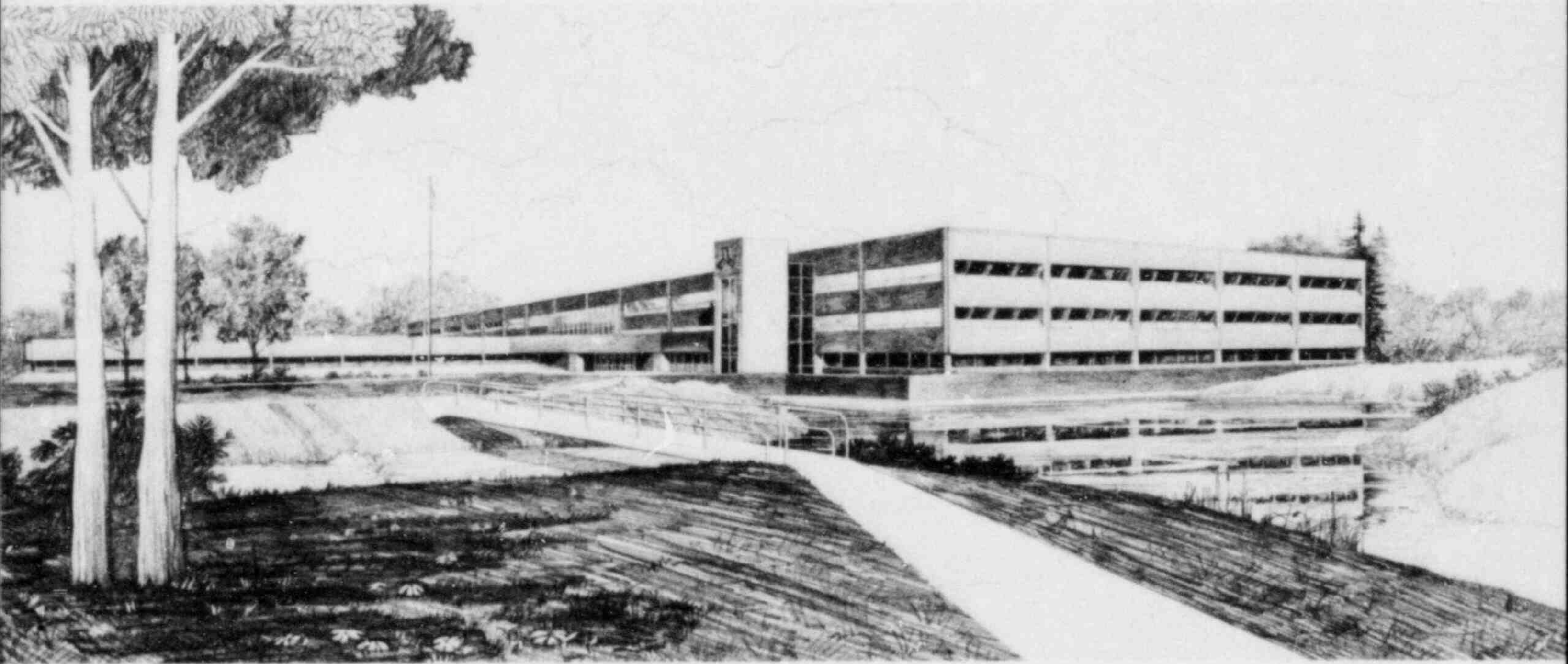
LARGE BREAK PARAMETRIC STUDIES FOR PRETEST PLANNING OF LOFT EXPERIMENT L2-5

K. S. Fullmer

U.S. Department of Energy
Idaho Operations Office • Idaho National Engineering Laboratory



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K. S. Fullmer

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G.D. McPherson, Chief, LOFT Research Branch
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EG&G Idaho, Inc.
Idaho Falls, Idaho 83415

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INTERIM REPORT

SUMMARY

A computer study was performed to characterize the thermal-hydraulic response of the LOFT core during a double-ended cold leg (DECL) break experiment. This was in support of planning for LOFT Experiment L2-5. The objective of the analysis was to determine if operating conditions exist, typical of a full-scale pressurized water reactor (PWR), which would not produce a rewet of the fuel rods during a large break blowdown.

The study used the RELAP4 thermal-hydraulic code to compare the effects on core response of varying: (1) initial core power, (2) pump operation after the break, and (3) break size. The results of these simulations predict a range of operational conditions which would not produce a core rewet during a large break blowdown. It was decided after reviewing the results of the study to conduct LOFT Experiment L2-5 from an initial core power of 37 MW (75% power) and disconnect the pump flywheels from the impellers at the initiation of the break.

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LARGE BREAK PARAMETRIC STUDIES FOR PRETEST PLANNING OF LOFT EXPERIMENT L2-5

INTRODUCTION

This report documents a series of RELAP4 analyses in support of planning for LOFT Experiments L2-5. The primary purpose for the analyses was to determine if there was a range of operating conditions which would result in a large break blowdown without the core rewet which occurred in the LOFT L2-3 experiment.[1] Experiment L2-3 showed that during the large double-ended cold leg (DECL) break blowdown a surge of low quality coolant was forced up through the core as the pump flow temporarily exceeded the flow out the broken loop cold leg. The slug of low quality coolant from the cold leg produced an unexpected rewet of the core. One of the objectives of Experiment L2-5 is to determine if conditions exist which will result in a large break blowdown without core rewet. It was decided to run a series of thermal hydraulic calculations varying power, break size, and pump coastdown behavior to determine if operating conditions existed which would indicate the potential for a large break blowdown without the rewet experienced in the L2-3 experiment.[2]

PROCEDURE

The RELAP4 thermal hydraulic code was used for this analysis because of the past experience in using it to analyze large breaks. The model used in this analysis was based on the model used in the experiment prediction for the LOFT L2-3 LOCE.[3] The L2-3 model was modified from a three-volume, one-channel core to a twelve-volume, two-channel model. The input data was also modified to be compatible with the MOD7 version of RELAP4, to allow the use of the self-initialization capability, present in the MOD7 version.

A sketch of the model nodalization is shown in Figure 1. A detail of the 12-volume, 2-channel core is shown in Figure 2. The model contains 64 volumes, 80 junctions, and 35 heat slabs. A detailed description

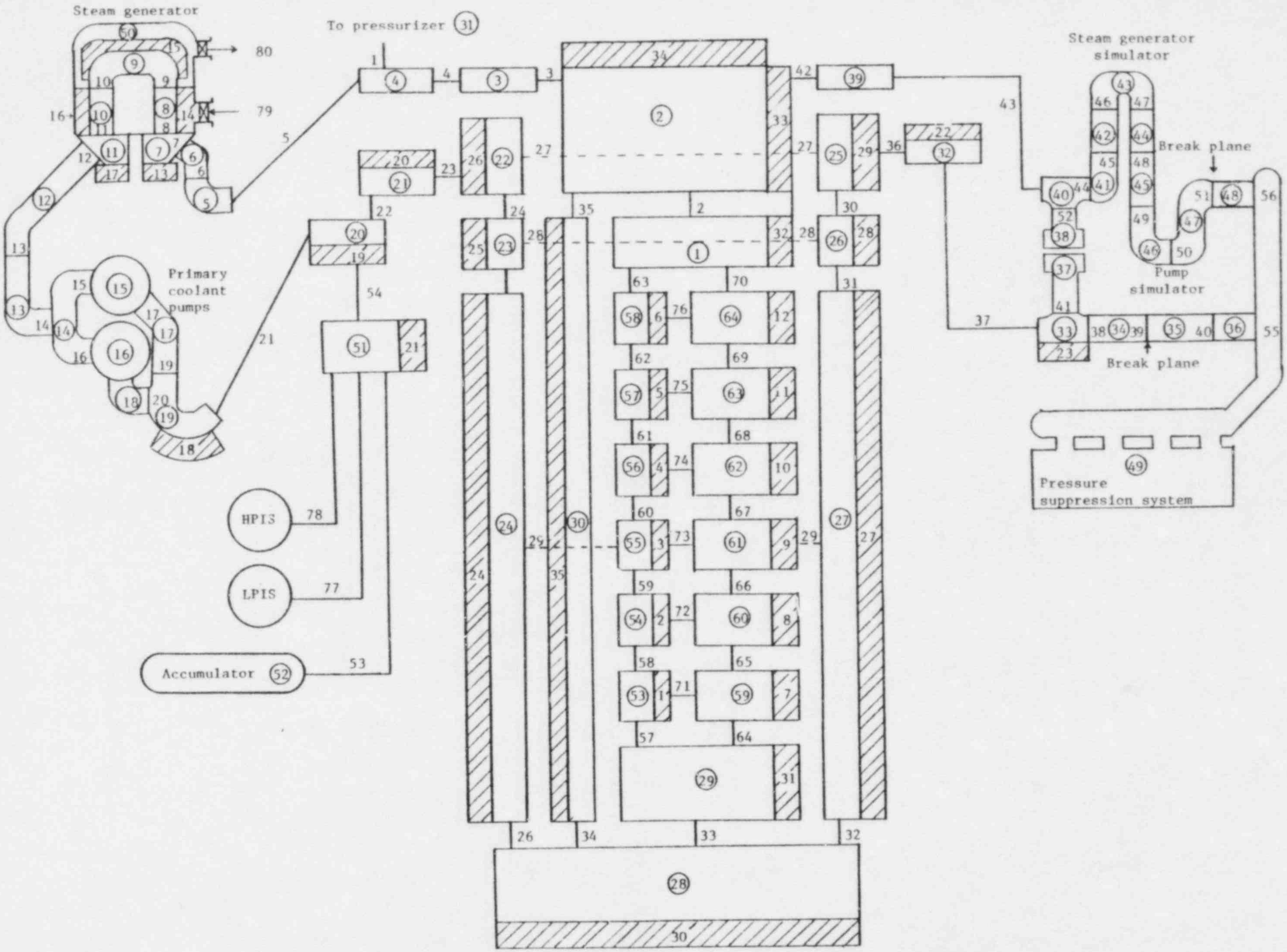
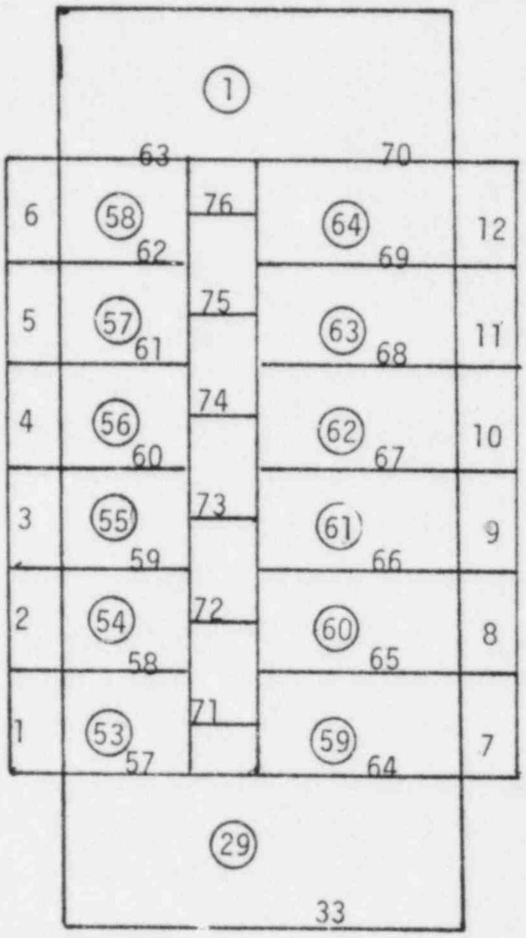


Figure 1. RELAP4 nodalization for LOFT system



Volumes 53 - 58 represent center bundle

Slabs 1 - 6 represent center bundle

Junctions 57 - 63 represent center bundle

Figure 2. Core area with separate center bundle

of the L2-3 base deck is given in Reference 3. A description of the changes made to the base deck for this model and a checkout run compared with the L2-3 test data is given in Reference 4.

Most of the cases analyzed in this study used the Biasi-Zuber critical heat flux (CHF) correlation which was used in the L2-3 post-test analysis. The Biasi CHF correlation modified the RELAP4 heat transfer surface which provides heat flux as a function of flow conditions by increasing the minimum film boiling temperature. This was done based on a comparison of the results using the Hsu-Beckner CHF correlation contained in RELAP4/MOD6 and results using the Biasi CHF correlation. The core flows for L2-3 and the cases analyzed in this study were on the order of 300 kg/m^2-sec which was in the range of the Biasi data, but outside the range of the Hsu-Beckner data. Using the Biasi CHF correlation RELAP4 predicted a rewet of the core with the L2-3 operational conditions, while using the Hsu-Beckner CHF correlation did not. A further description of this study is given in Reference 5.

The study was limited to variations of three system parameters: (1) core power, (2) pump operation, and (3) break size. Runs were made with core power at 37 MW and 50 MW. The initial steady-state operating conditions for these two cases are shown in Table 1. Since the model accounts for the pump impeller and flywheel inertia separately, runs were made with full flywheel inertia and also assuming the pump was disconnected from the flywheel at the opening of the break. In addition runs were made with various fractional parts of the flywheel inertia and also assuming one or both of the pump rotors were locked at the initiation of the break. Runs were also made with various break size combinations.

TABLE 1. INITIAL OPERATING CONDITIONS

Core Power	37 MW	50 MW
Hot Leg Temperature	605.0 F	605.0 F
Cold Leg Temperature	540.5 F	540.5 F
Core Temperature Rise	64.5 F	64.5 F
Mass Flowrate		
Loop	409.7 lb/sec	555.6 lb/sec
Core	389.3 lb/sec	527.8 lb/sec
Bypass	20.4 lb/sec	27.8 lb/sec

For the cases where break sizes are greater than the nominal 100%, the areas and diameters of the broken loop junctions and volumes were increased so that the break plane was the limiting flow area. In these cases (Runs 201, 202, 203, 204, 205, and 206) the hydraulic response would be effected by these changes. Comparison of results with other runs should reflect this.

RESULTS

Initial runs were made with a core power of 50 MW. High cladding temperatures in the 50 MW cases indicated that fuel rod damage would result in the LOFT experiments from this power level. FRAP analyses supported this and it was decided that the experiments would be run at a 75% power level. Subsequent runs were confined to a core power of 37 MW.[6] A description of the runs made and a summary of the response of fuel rod cladding temperatures to the various transients is given in Table 2. The primary consideration was whether a rewet of the core was predicted in the initial 20.0 seconds of the blowdown.

As shown, both the pump operation and the break size influence the RELAP4 prediction of the core rewet. For the "pumps on" case (operating conditions of the L2-3 experiment) a rewet was experienced through the entire core. When the pumps were turned off at the opening of the break, a full or partial rewet was predicted in some cases and not in others. The

TABLE 2. DESCRIPTION OF RELAP4 RUNS

Run Number	Description Break Size (%CL/%HL)	Description Pump Operation	Core Response
37 MW Core Power			
016	100CL/100HL	Pumps on	Full core rewet
017	100CL/100HL	Pumps off, full inertia	Partial rewet
018	100CL/100HL	Pumps off, flywheel disc.	No rewet
019	100CL/100HL	Pumps off, 1/2 inertia	No rewet
021	100CL/100HL	Pumps off, locked rotors	No rewet
022	100CL/100HL	Pumps off, 1 rotor locked	No rewet
023	110CL/110HL	Pumps off, full inertia	Partial rewet
024	110CL/110HL	Pumps off, 1/2 inertia	No rewet
025	110CL/110HL	Pumps off, flywheel disc.	No rewet
026	110CL/110HL	Pumps off, locked rotors	No rewet
027	100CL/100HL	Pumps off, 1/4 inertia	No rewet
028	100CL/100HL	Pumps off, 3/4 inertia	No rewet
029	120CL/120HL	Pumps off, full inertia	No rewet
030	120CL/120HL	Pumps off, 1/2 inertia	No rewet

TABLE 2. (continued)

Run Number	Description		Core Response
	Break Size (%CL/%HL)	Pump Operation	
37 MW Core Power (continued)			
031	120CL/120HL	Pumps off, flywheel disc.	No rewet
032	120CL/120HL	Pumps off, rotors locke	No rewet
033	90CL/90HL	Pumps off, full inertia	Full core rewet
034	90CL/90HL	Pumps off, 1/2 inertia	Partial rewet
035	90CL/90HL	Pumps off, flywheel disc.	No rewet
036	90CL/90HL	Pumps off, rotors locked	No rewet
037	100CL/100HL	Pumps off, 2X inertia	Partial rewet
038*	100CL/100HL	Pumps off, 1/2 inertia	No rewet
039	100CL/100HL	Pumps off, 1 locked rotor	No rewet
040	110CL/110HL	Pumps off, 3/4 inertia	No rewet
041	110CL/110HL	Pumps off, 2X inertia	Partial rewet
042	100CL/100HL	Pumps off 4X inertia	Full core rewet
043	100CL/100HL	Pumps off 1.5X inertia	Partial rewet
044	100CL/100HL	Pumps off .88X inertia	Partial rewet

TABLE 2. (continued)

Run Number	Description Break Size (%CL/%HL)	 Pump Operation	Core Response
37 MW Core Power (continued)			
045	100CL/100HL	Pumps off .62X inertia	No rewet
046	100CL/100HL	Pumps off 2/3 of 0 inertia RPM	No rewet
047	100CL/100HL	Pumps off 1/3 of 0 inertia RPM	No rewet
201	50CL/150HL	Pumps off, full inertia	Full core rewet
202	150CL/50HL	Pumps off, full inertia	No rewet
203	150CL/25HL	Pumps off, full inertia	No rewet
204	150CL/5HL	Pumps off, full inertia	Partial rewet
205*	150CL/5HL	Pumps off, full inertia	Full core rewet
206*	100CL/100HL	Pumps off, locked rotors	Partial rewet
50 MW Core Power			
120	100CL/100HL	Pumps off, full inertia	Full rewet
121	100CL/100HL	Pumps off, flywheel disc.	No rewet
122	100CL/75HL	Pumps off, flywheel disc.	No rewet
123	100CL/100HL	Pumps off, 1 rotor locked	No rewet

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* Used MOD7 CHF correlation.

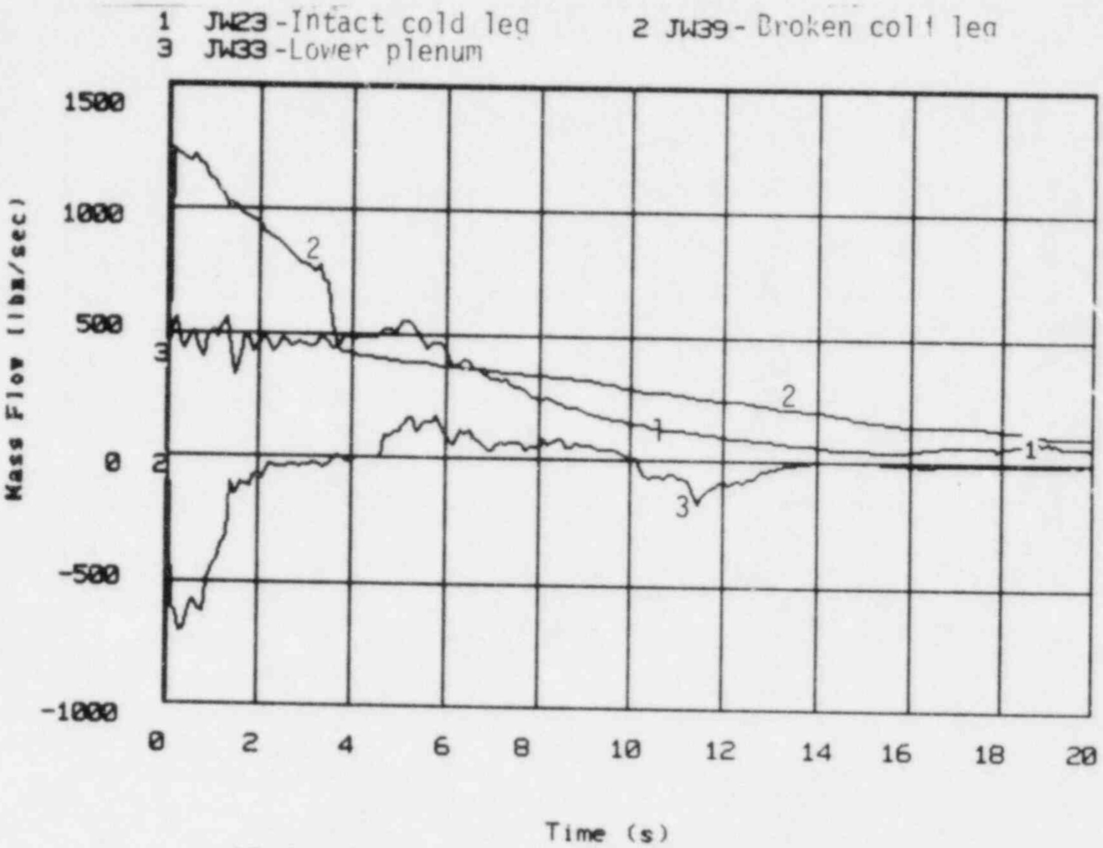
TABLE 2. (continued)

Run Number	Description Break Size (%CL/%HL)	 Pump Operation	Core Response
50 MW Core Power (continued)			
124	100CL/50HL	Pumps off, flywheel disc.	No rewet
125	100CL/25HL	Pumps off, flywheel disc.	No rewet

difference in the results can be understood by examining the cause of the quench during the blowdown for the pumps-on (L2-3) case. Figure 3 is a plot of the intact and broken loop cold leg flowrates and the lower plenum flowrates. The flow through the break is initially much higher than is coming into the core through the intact cold leg, but at approximately 3.5 seconds there is a sharp reduction in mass flow out the cold leg break as the fluid becomes two-phase. As shown, the intact loop flow remains approximately constant to 6.0 seconds and is higher than the broken loop from 3.5 to 6.0 seconds. This results in low quality fluid being forced up through the core which is shown by the positive flow established through the lower plenum (Figure 3) and the plot of core density (Figure 4). The positive flow of low quality fluid results in a quench of the core as reflected in the hot channel cladding (slab) temperatures (Figure 5).

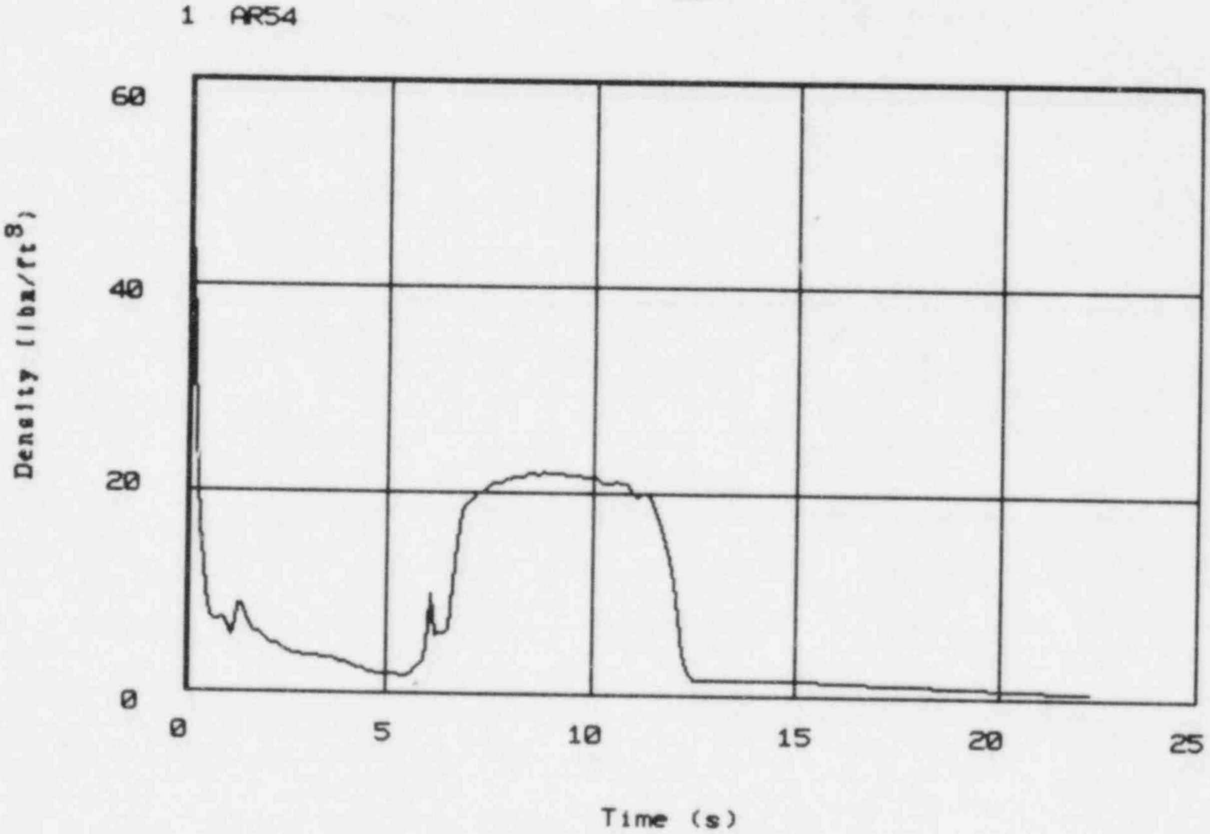
A similar hydraulic response exists in the pumps off case (RUN017), however the intact loop flow falls off more quickly with the pumps coasting down and the flow up through the core is not as strong as shown in the comparison plot of Figure 6. The coolant flow surge through the core is also a lower density coolant for the pumps off case (Figure 7). As a result, the rewet is not as pronounced for the pumps-off case as in the pumps-on case. This is shown in the comparison of the hot spot cladding temperature (Figure 8) and in the hot-channel cladding temperature distribution (Figure 9). There is not sufficient low-quality mass flow to quench the top of the core with the pumps off. With the pumps on the entire core was quenched (Figure 5).

Comparisons were made of the results varying only pump operations. Several different pump rpm vs. time responses were produced by varying the effective pump flywheel inertia as shown in Figure 10. A quicker pump coastdown results in less coolant being pumped into the core (Figure 11). Figure 12 shows this condition results in a lower density coolant within the core. The lower flow, lower density produced by quick pump coastdowns results in no quench of the core (Figure 13). Several other cases were run to better characterize the core response to pump operation. The integral



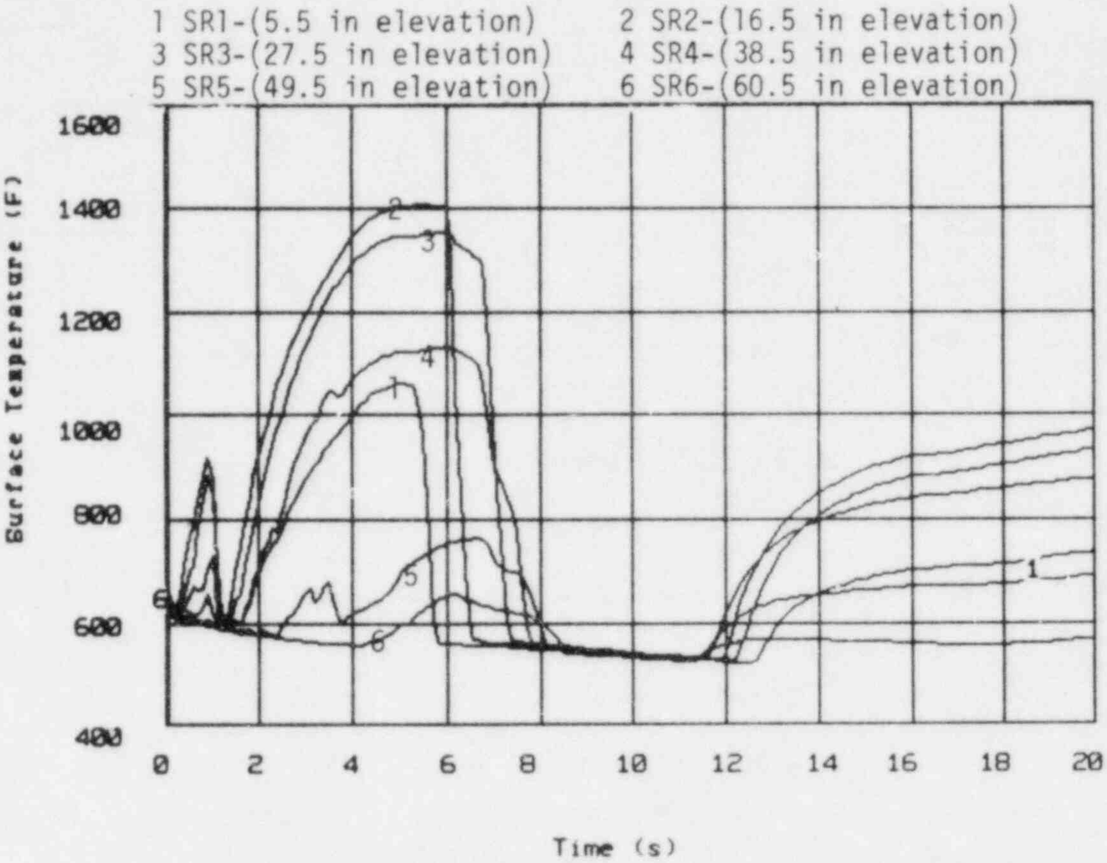
37 MW, PUMPS ON, FULL INERTIA (CWAF016, CY=1)

Figure 3. Cold leg and lower plenum mass flowrates



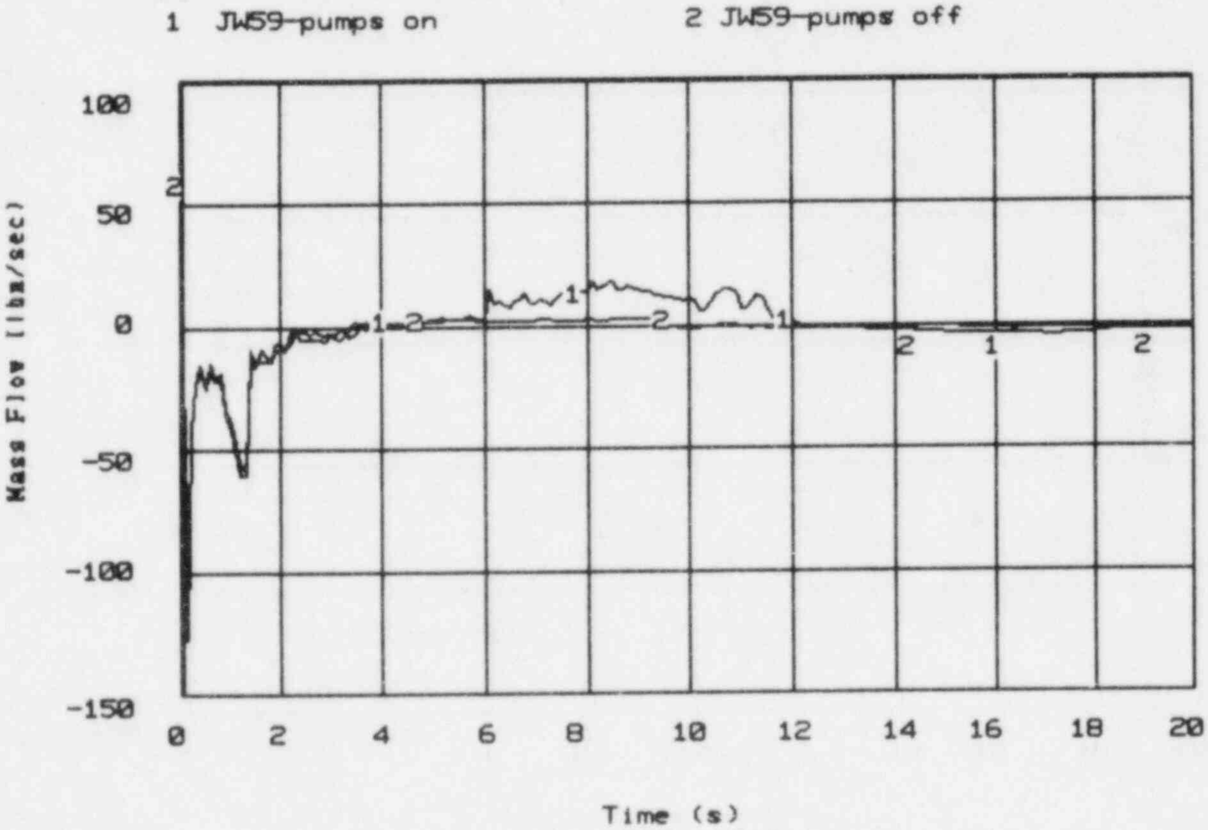
37 MW, PUMPS ON, FULL INERTIA (CWAF016, CY=1)

Figure 4. Hot channel, hot spot average density



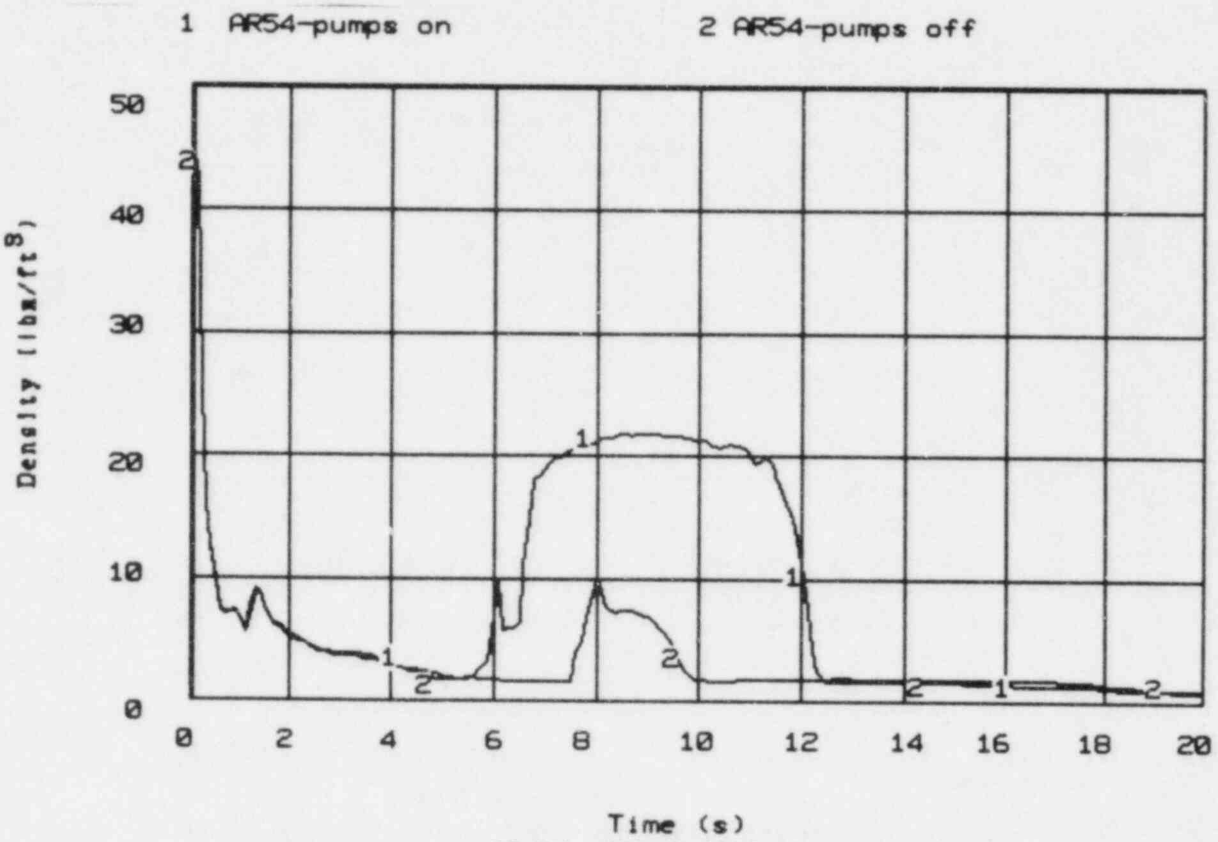
37 MW, PUMPS ON, FULL INERTIA (CWAF016, CY=1)

Figures 5. Hot channel cladding temperatures

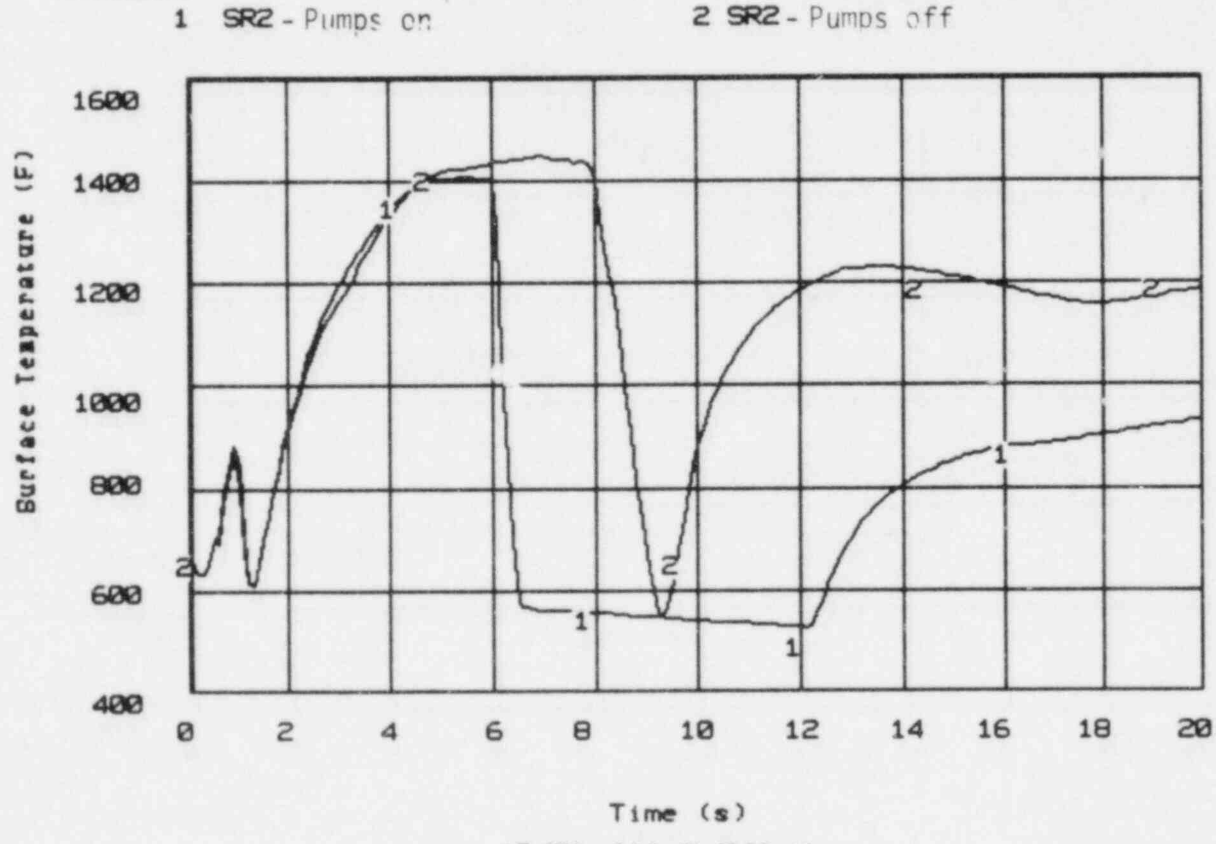


37 MW, 100 CL/100 HL

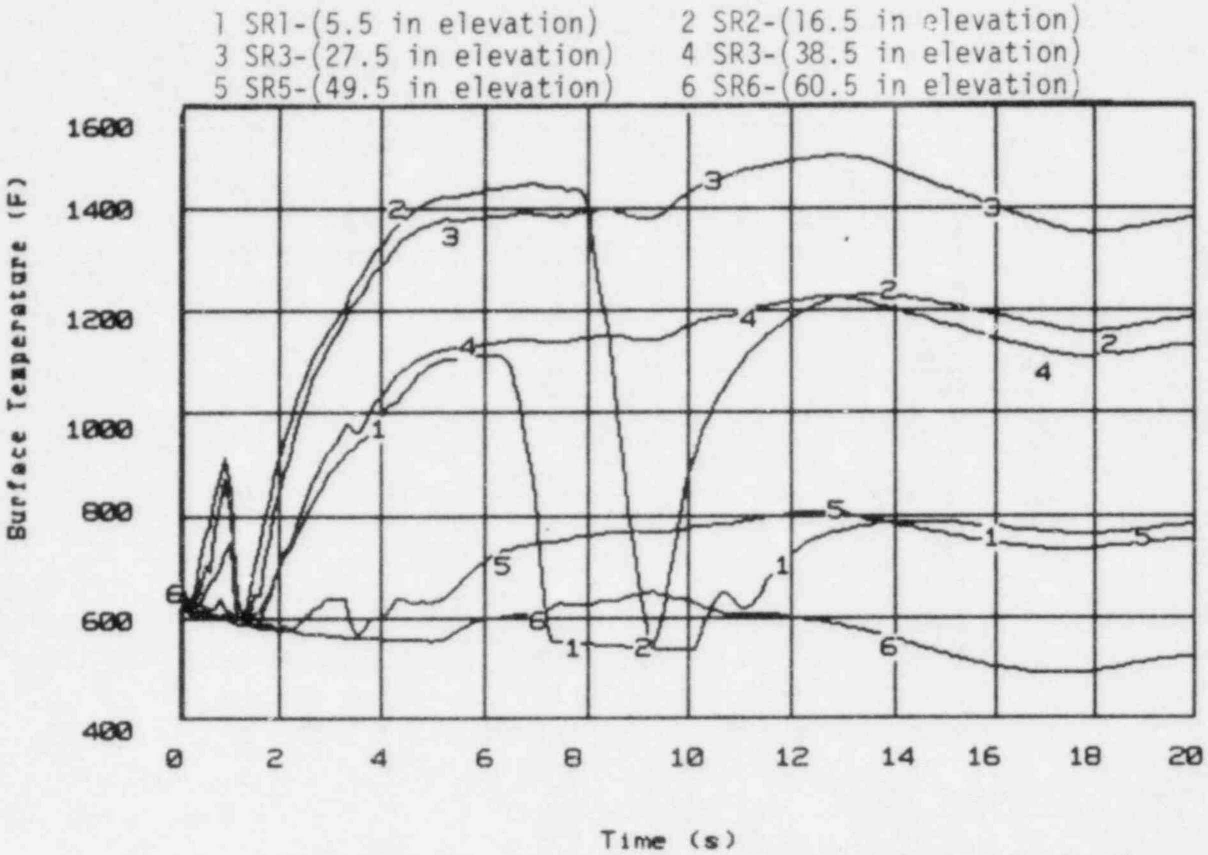
Figure 6. Hot channel, hot spot flowrate



37 MW, 100 CL/100 HL
Figure 7. Hot channel, hot spot average density

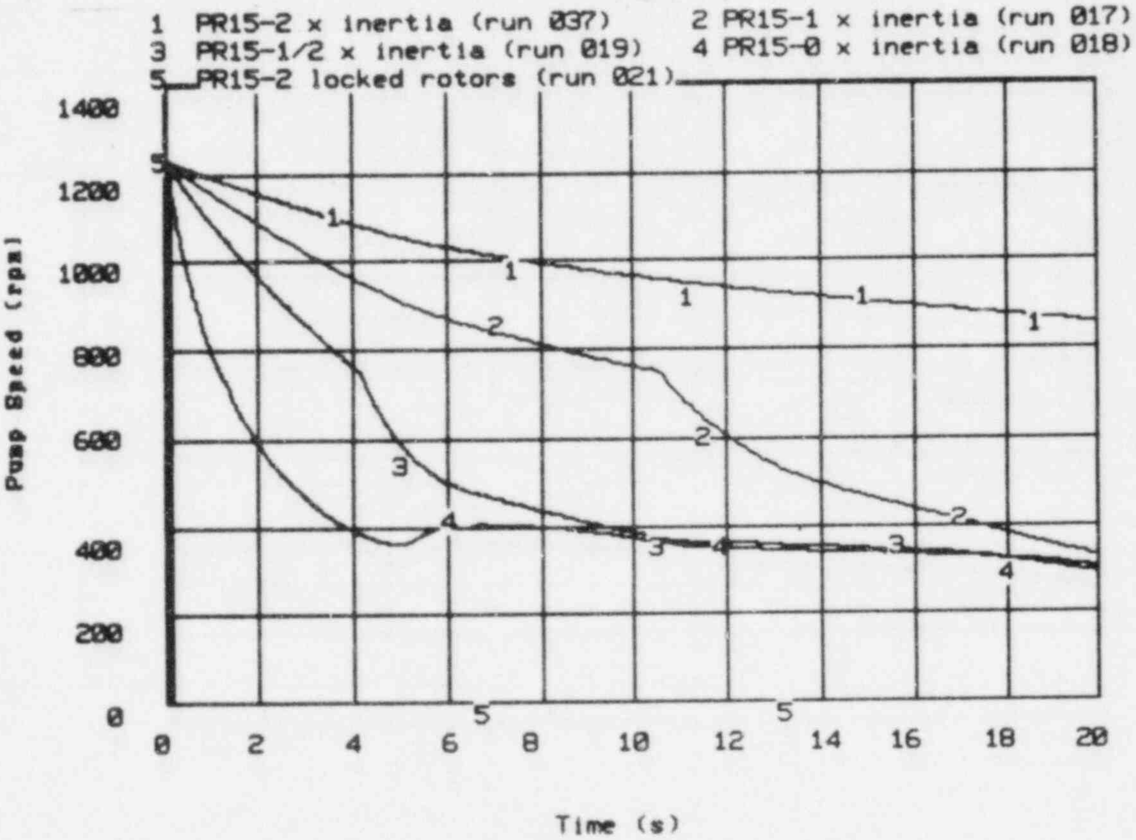


37 MW, 100 CL/100 HL
Figure 8. Hot channel, hot spot cladding temperature



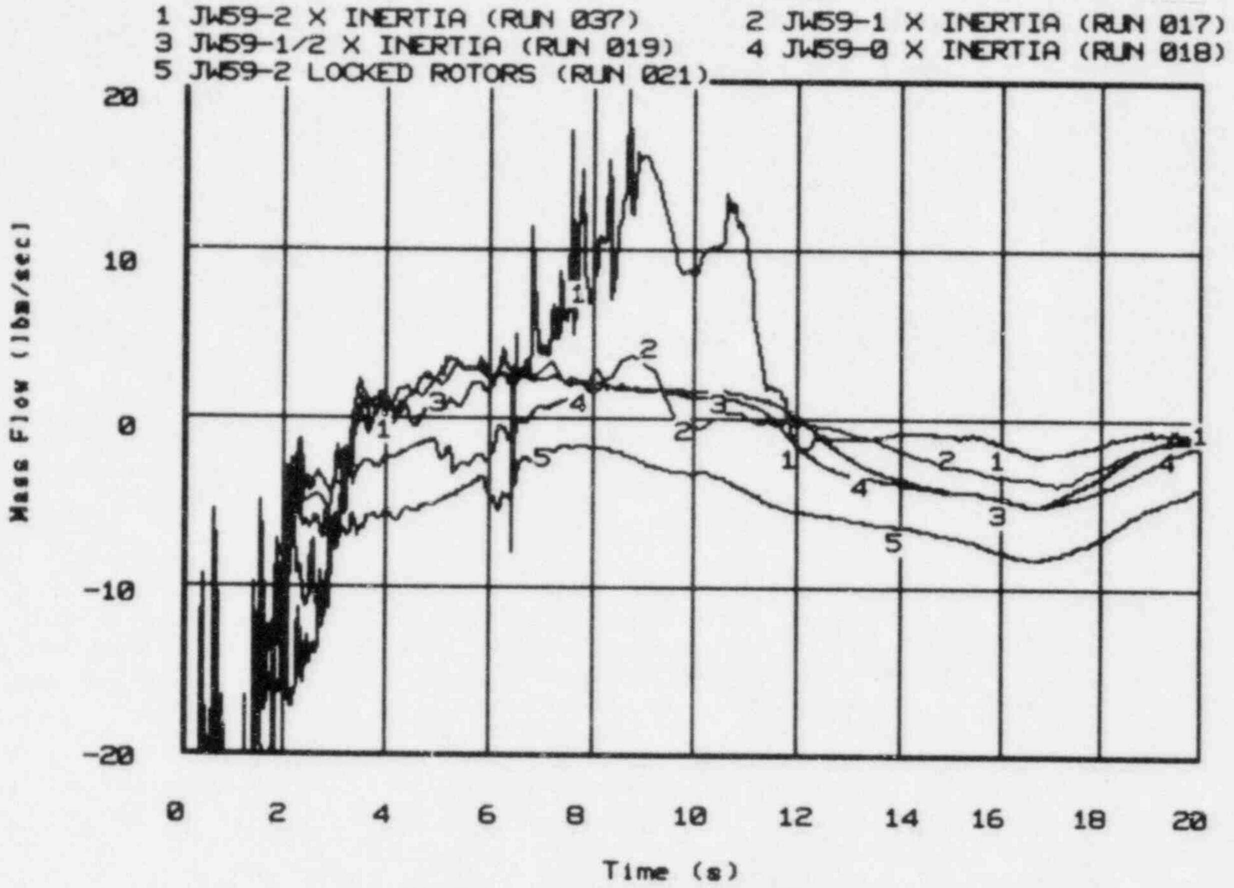
37 MW, 100 CL/100 HL, PUMPS OFF, FULL INERTIA (CWAF017, CY=1)

Figure 9. Hot channel cladding temperatures



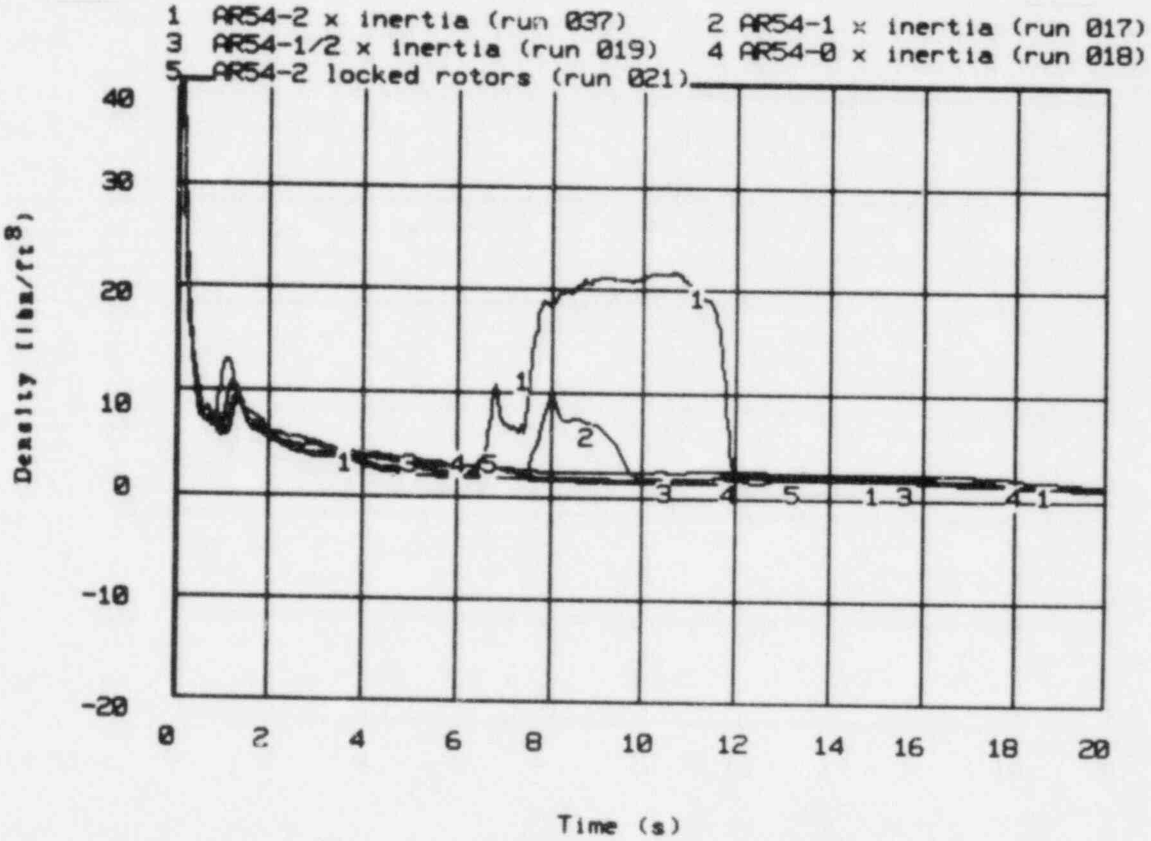
37 MW, 100 CL/100 HL, PUMPS OFF

Figure 10. Influence of pump flywheel inertia on pump coastdown



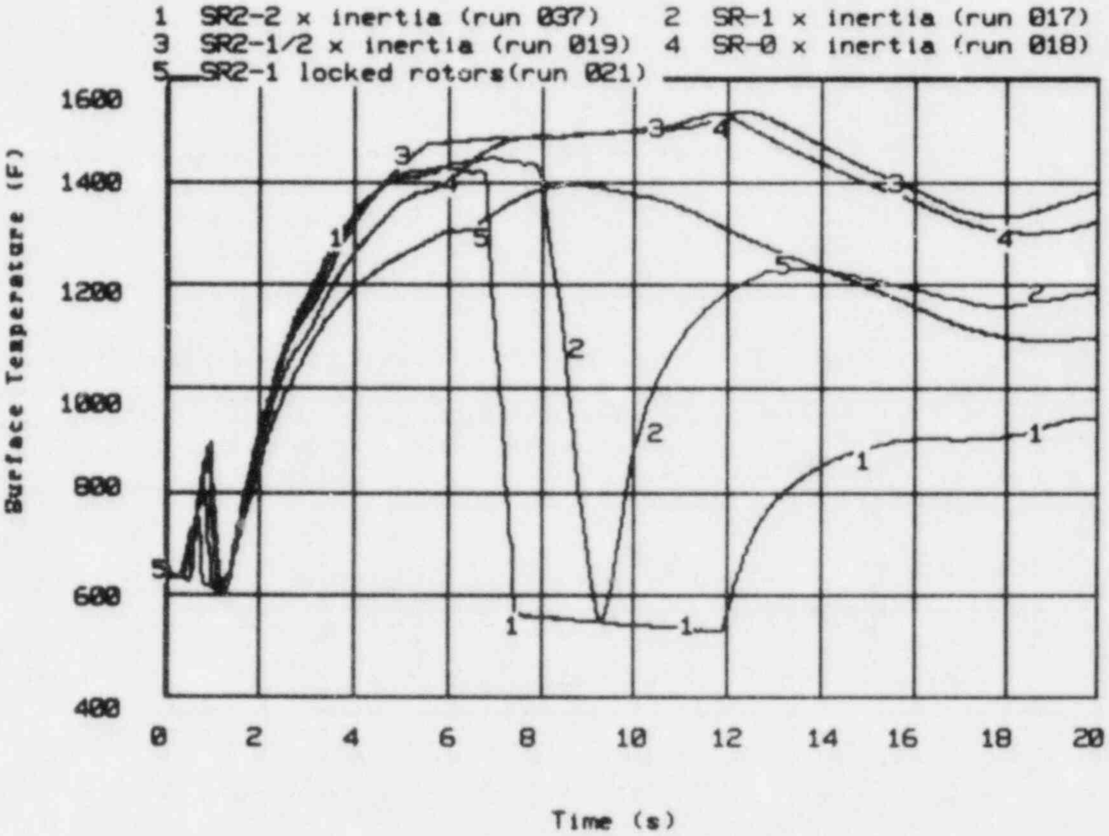
37 MW, 100 CL/100 HL, PUMPS OFF

Figure 11. Hot channel, hot spot mass flow rate - variable pump inertia



37 MW, 100 CL/100 HL, PUMPS OFF

Figure 12. Hot channel, hot spot average density



37 MW, 100 CL/100 HL, PUMPS OFF, HOT SPOT CLADDING TEMPERATURE

Figure 13. Hot spot cladding temperature - variable pump inertia

of pump RPM (0 to 10 seconds) was used as a measure of the pumping effect and the hot spot peak cladding temperature and minimum cladding temperature which occurred after the peak were plotted against this parameter (Figure 14). The plot indicates that with the primary coolant pumps turned off at the initiation of the break, the core does not rewet with anything less than the full pump flywheel inertia.

The results of the analysis discussed above indicate that when sufficient flow from the cold leg is forced up through the core, a rewet occurs (bottom-up quench). To determine if a negative core flow could produce a core rewet (top down quench), runs were made varying the ratio between the hot and cold leg break areas to force more flow from the hot leg down through the core. The results, shown in the plot of hot spot cladding temperature (Figure 15) and hot channel core flow (Figure 16), indicate that cooling occurs with negative core flow, but the core does not rewet. The reason is shown in the comparison of densities in Figure 17. Even though the core flow is higher for Runs 202 (150%CL/50%HL), 203 (150%CL/25%HL), and 204 (150%CL/5%HL); the core does not rewet because the coolant density is very low.

In an effort to relate core response to the hydraulic transient, a plot was made with the integral of the mathematical product of hot channel mass flow and hot channel density as the independent variable (ordinate) and cladding temperature as the dependent variable. The integral was taken from 2.0 seconds to 20.0 seconds. The first 2.0 seconds of the transient were not included in the integration as there was considerable variation in mass flux during this time which would effect the value of the integral, however there is little difference in the cladding temperature until the core voids. Between 1.0 and 2.0 seconds the core voids, the rods dry out, and cladding temperatures quickly rise. The results of this comparison are shown in Figure 18. This shows the peak cladding temperature and the minimum cladding temperature after the peak for the 100%CL/100%HL break which varied the pump operation from the "pumps on" condition to "locked rotors" and several points in between, by adjusting the pump flywheel

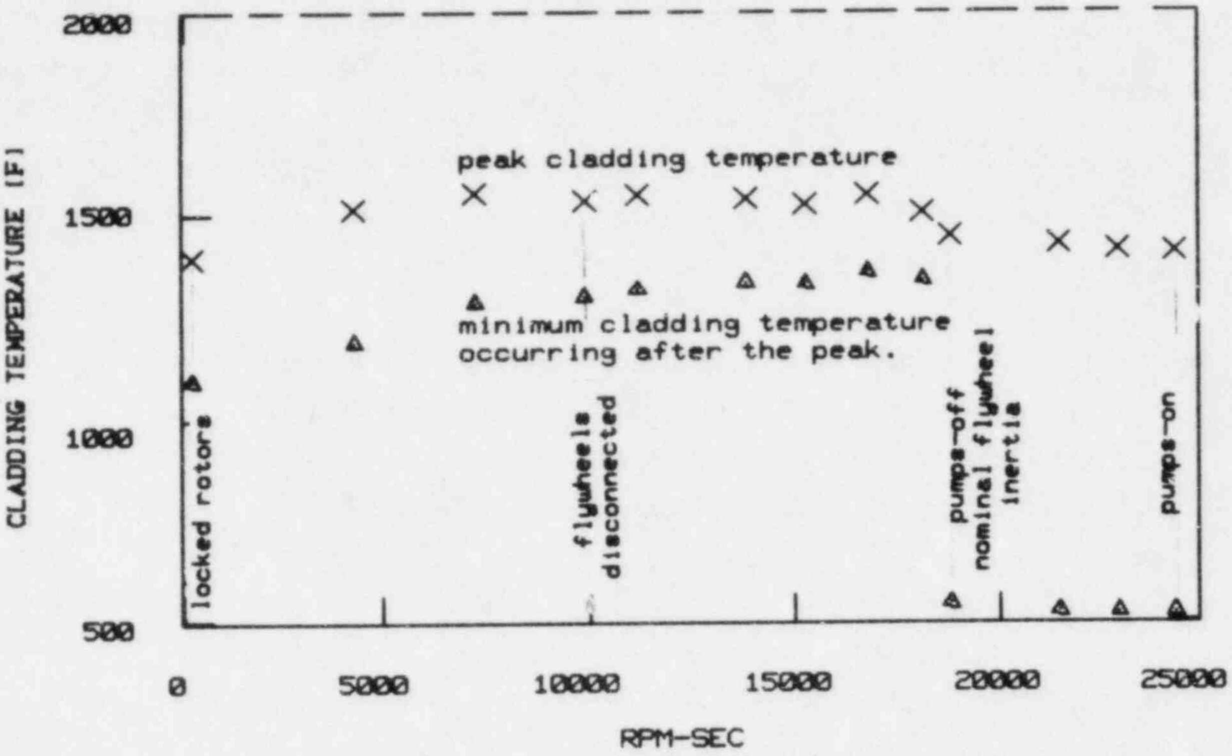
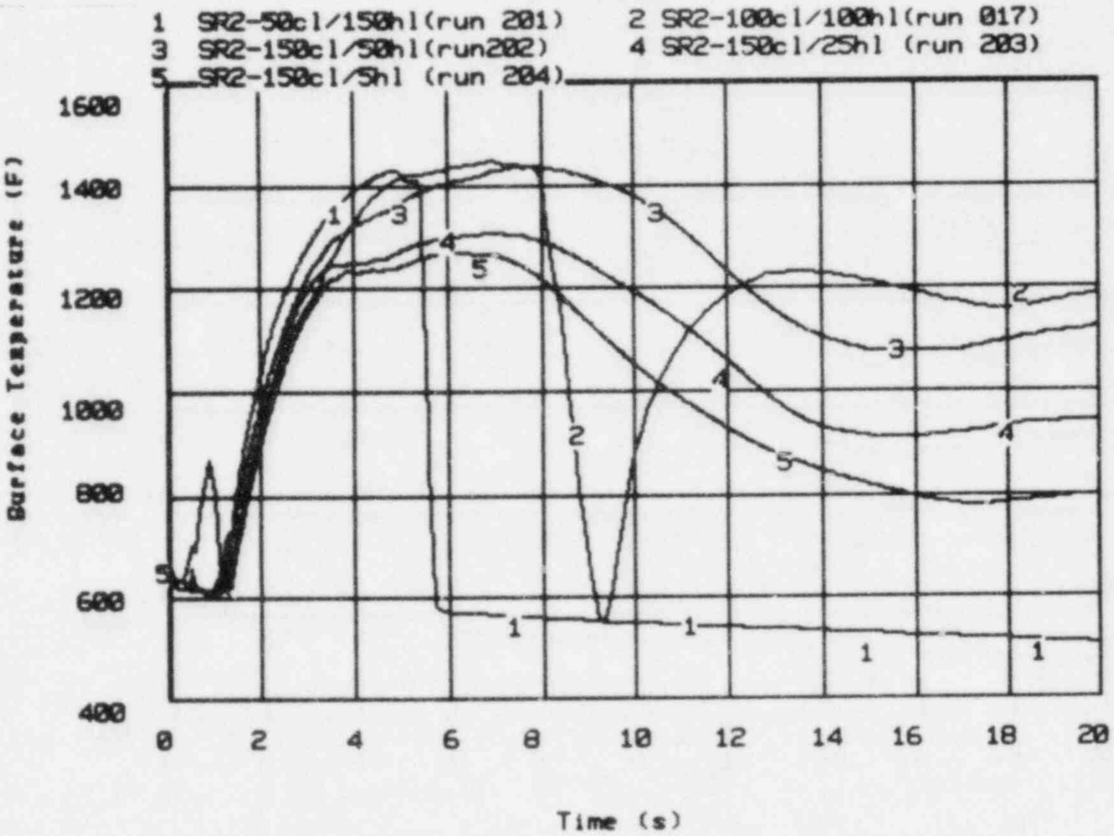
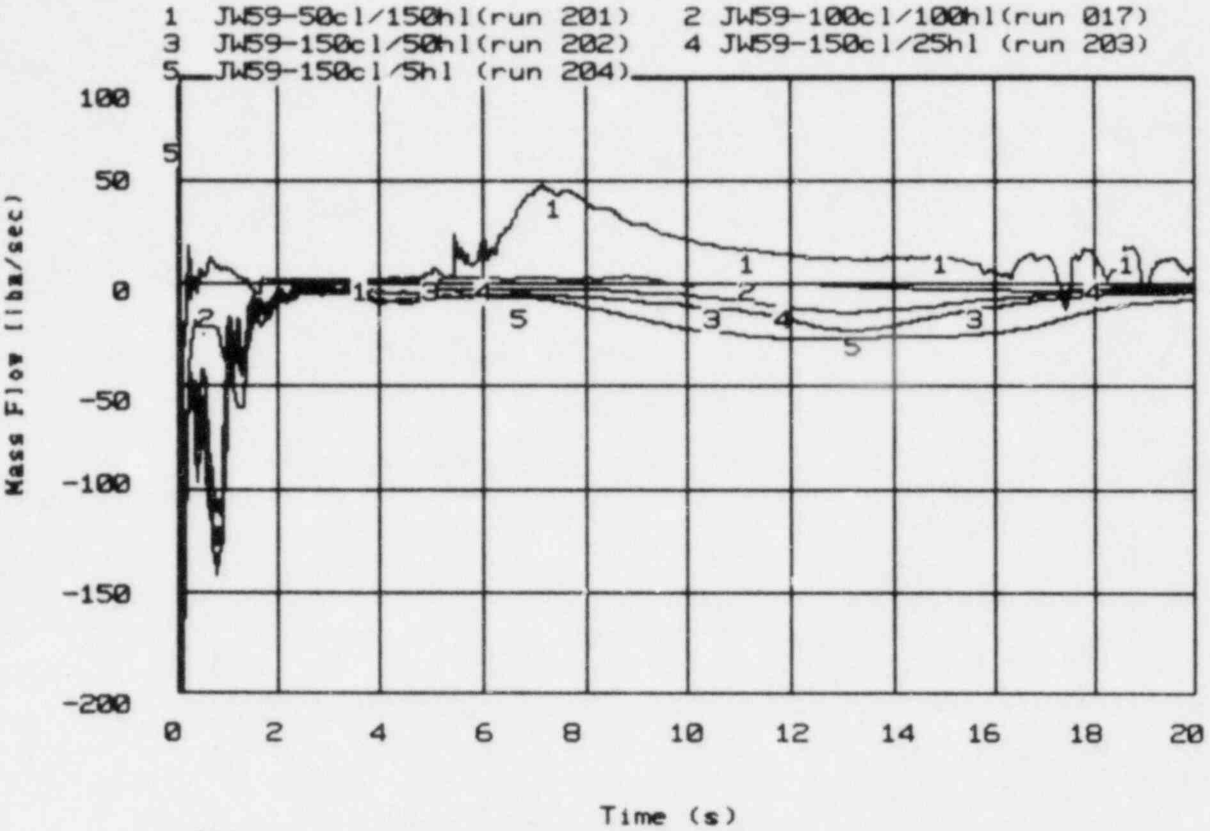


Figure 14. Influence of pump coastdown on cladding temperature



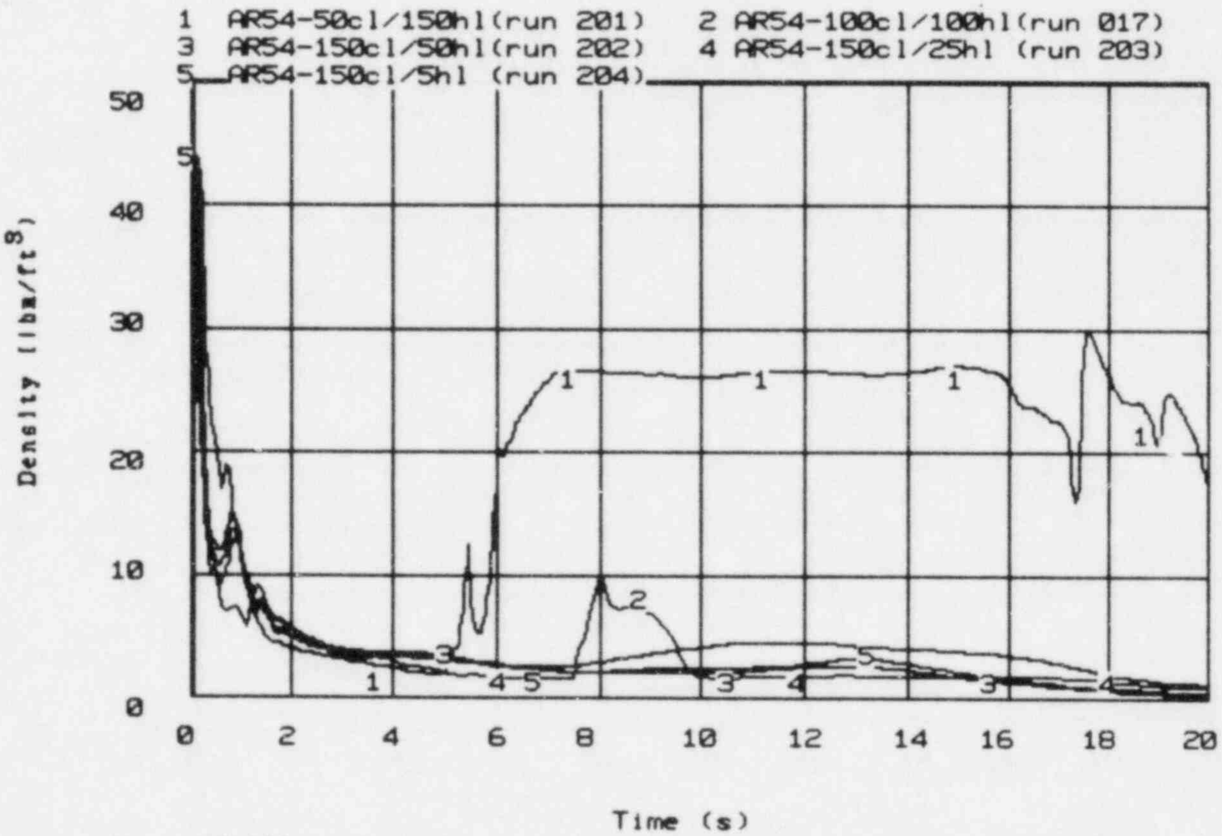
VARIABLE BREAK SIZE, 37 MW, PUMPS OFF, FULL PUMP INERTIA

Figure 15. Hot channel peak cladding temperature



VARIABLE BREAK SIZE, 37 MW, PUMPS OFF, FULL PUMP INERTIA

Figure 16. Hot channel core flow - variable break size



VARIABLE BREAK SIZE, 37 MW, PUMPS OFF, FULL PUMP INERTIA

Figure 17. Hot channel average density - variable break size

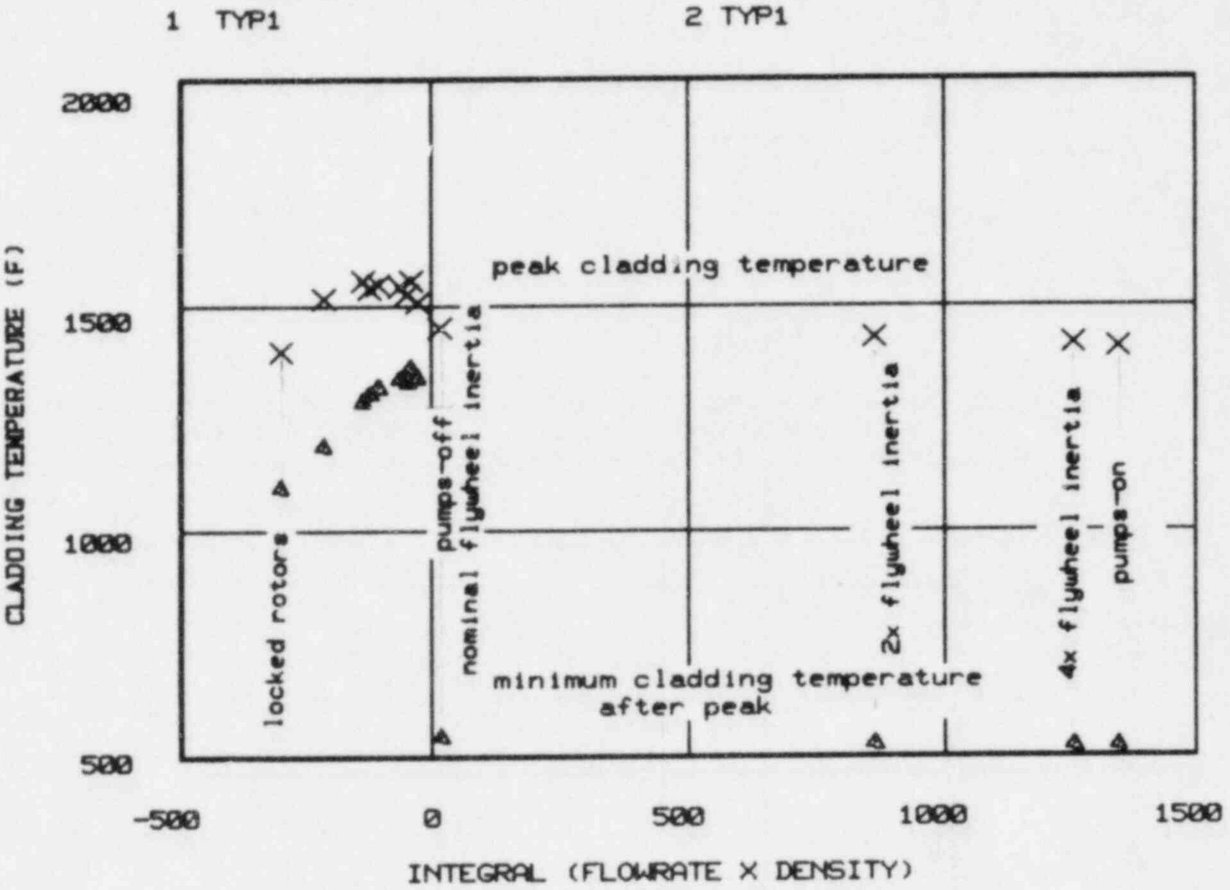


Figure 18. Cladding temperature response to core flow

inertia. The results indicate that a very small positive value for the integral of the core flow/density product, results in at least a partial quench of the core. Negative values result in cooling, but not fuel rod quench. Figure 19 adds the runs which varied the break areas. This adds lower negative and higher positive values to the ordinate, but the results follow the same trend.

The values used in Figure 18 and 19 are tabulated in Table 3. It should be noted that the absolute value of the product of core flow and density was not taken. A zero value for the integral therefore does not represent no flow through the core, but indicates that the net flow was zero.

Review of the other cases as they were run indicated the same core flow conditions were required in order to result in rewet; low quality flow from the cold leg forced up through the core after the initial dryout. This was accomplished in cases where the pump had sufficient inertia to force coolant up through the core during pump coast-down. Reducing the break size in the hot and cold legs increased the rewet. Increasing break size decreased the rewet for the same pump conditions. This is indicated by comparing the result of runs varying break size with the same pump operation as shown in Table 4. The results are also indicated graphically in Figure 20 which shows the hot channel cladding temperatures.

All of the runs discussed previously used the Biasi CHF correlation. Three runs were made comparing the Biasi with the MOD7 CHF correlation. The first comparison, Run 019 and Run 038, are 100%CL/100%HL, pumps-off, and 1/2 of the nominal pump flywheel inertia. The hot channel cladding temperatures are shown in Figure 21 (Biasi CHF) and Figure 22 (MOD7 CHF) and indicate that the Biasi correlation predicts slightly lower peak cladding temperatures than the MOD7 correlation. The MOD7 correlation predicts a rewet of the top of the core where the Biasi CHF correlation does not. The comparison of hot channel core flow and average density (Figure 23 and Figure 24, respectively) are close and indicate relatively low negative flow through the core of low density coolant.

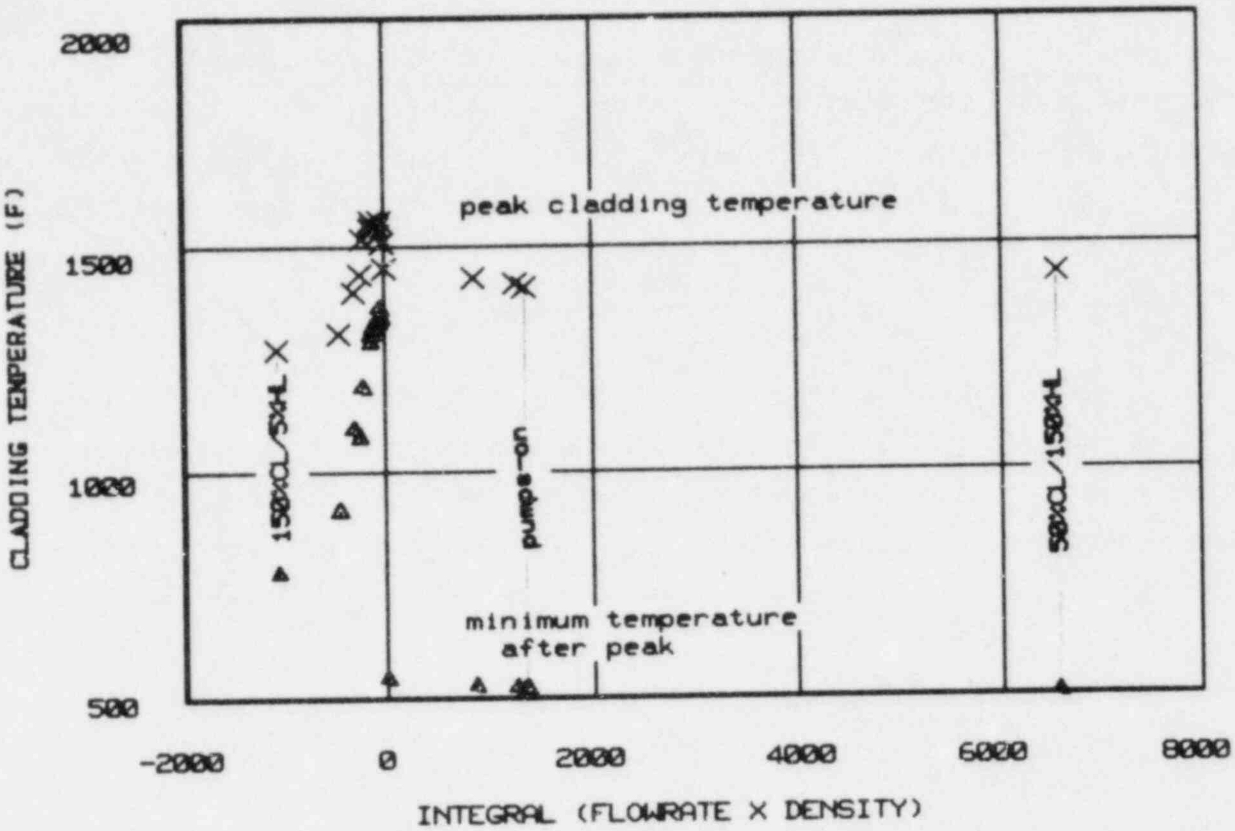
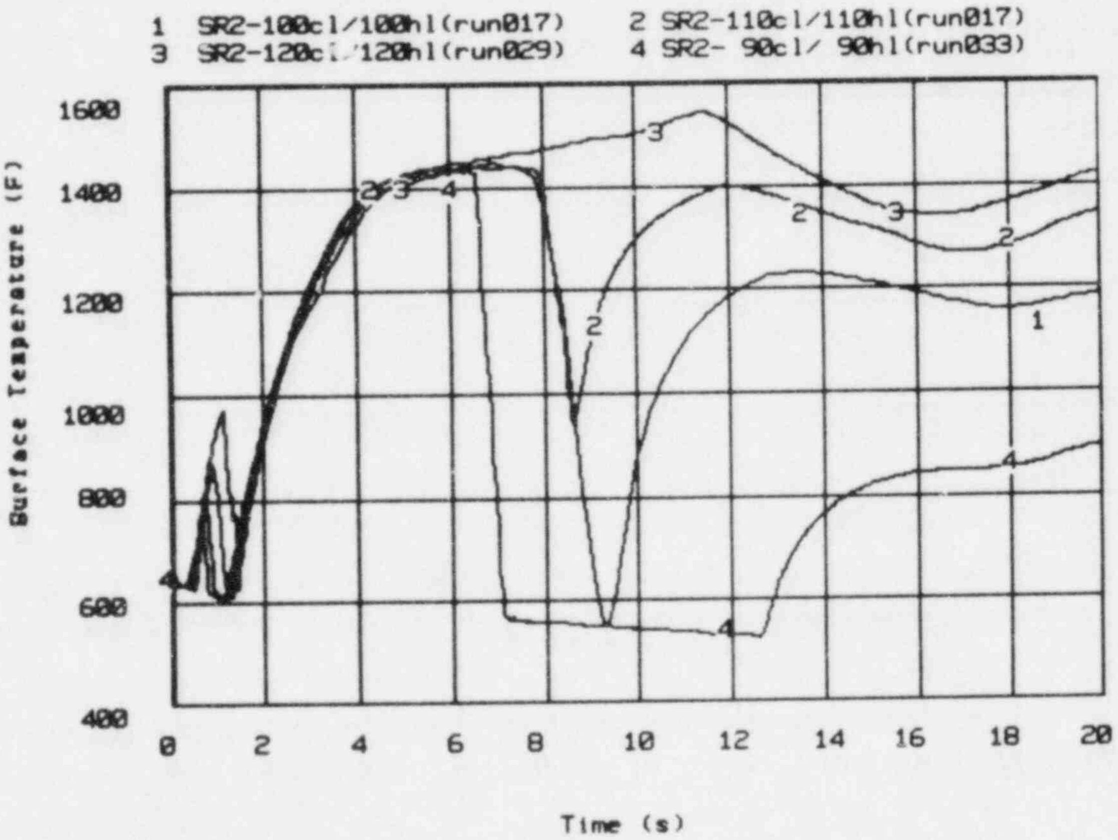


Figure 19. Cladding temperature response to core flow - density product

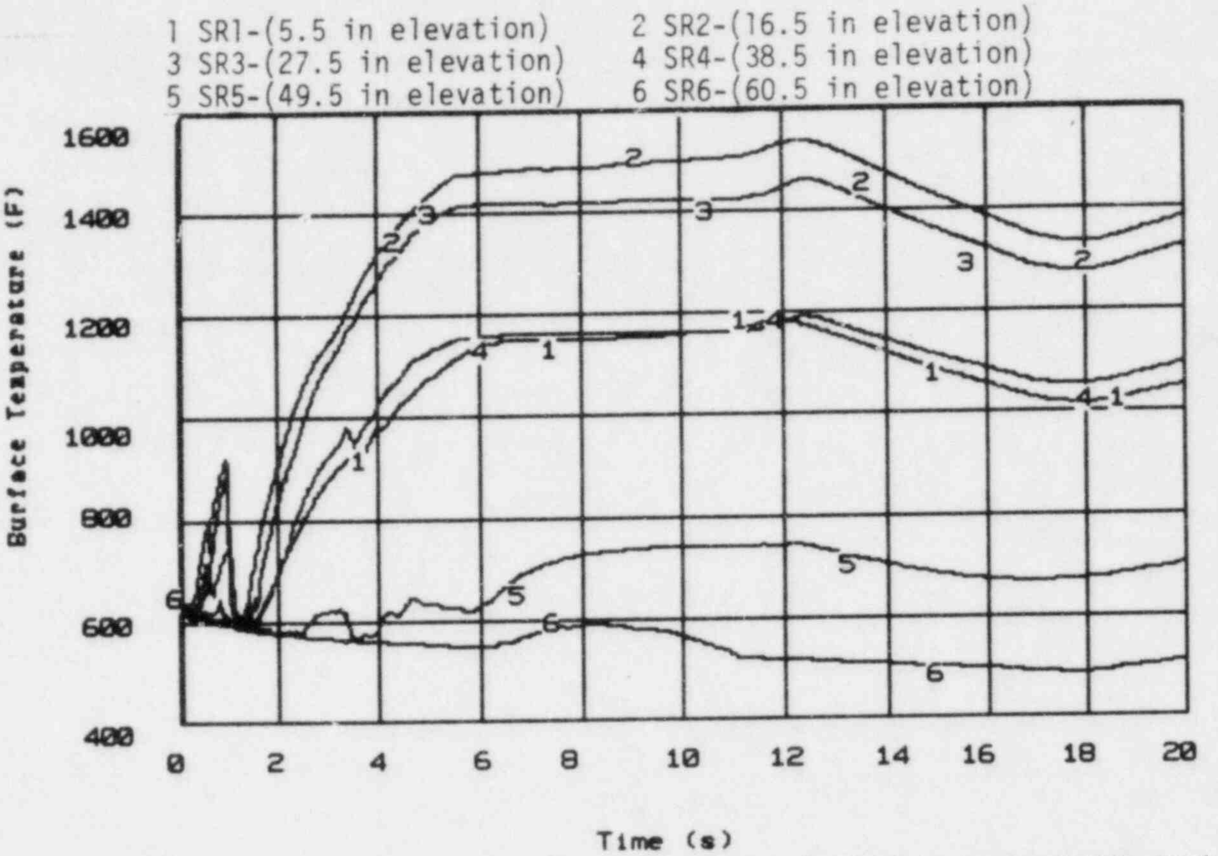


VARIABLE BREAK AREA, HOT CHANNEL CLADDING TEMPERATURE

Figure 20. Influence of break size on core flow

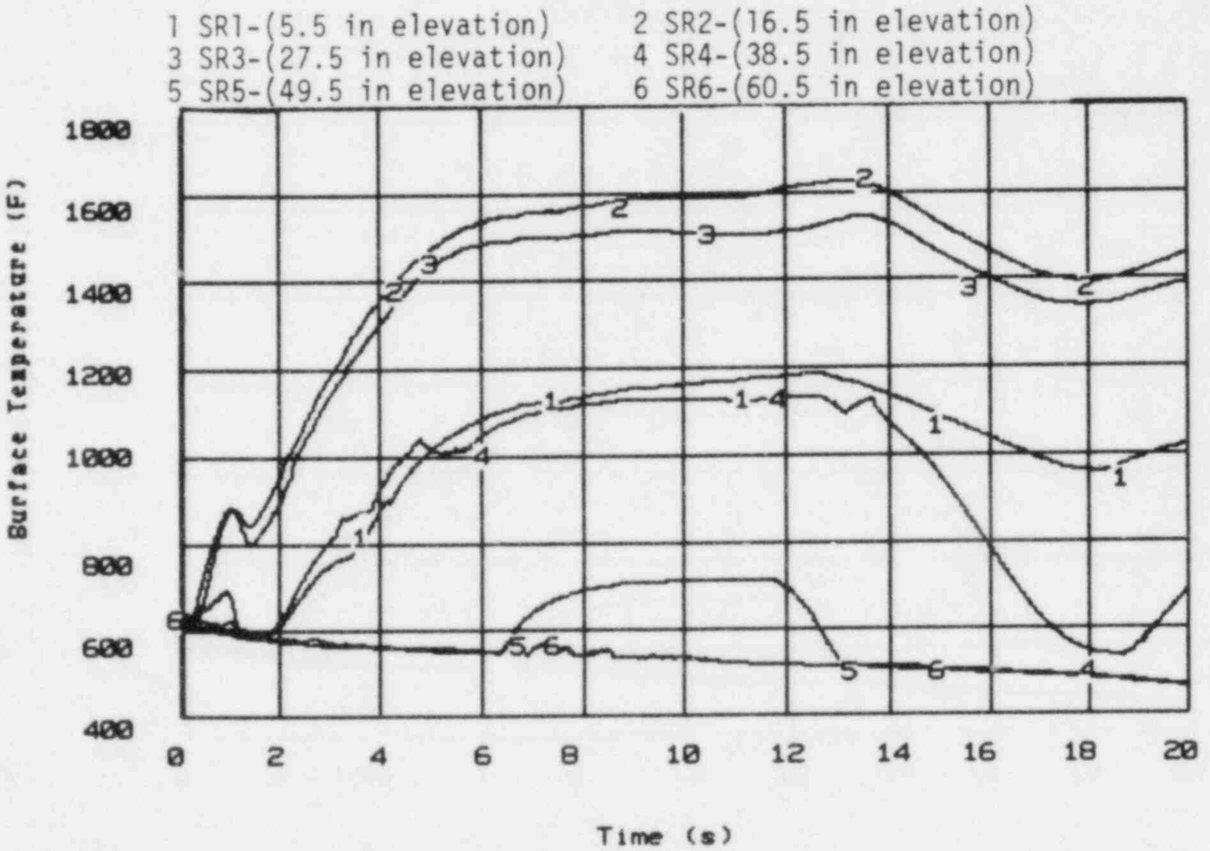
TABLE 3. INFLUENCE OF CORE FLOW ON CLADDING TEMPERATURE RESPONSE

Run Number	Break Size (%CL/%HL)	Pump Operation	Integral (Flow Rate X Density)	Peak Cladding Temperature (°F)	Minimum Cladding Temperature After Peak (°F)
016	100/100	Pumps-on	1344	1408	525
042	100/100	Pumps off 4 x inertia	1256	1415	525
037	100/100	Pumps off 2 x inertia	861	1426	526
017	100/100	Pumps off 1 x inertia	18	1448	546
044	100/100	Pumps off .88 x inertia	-29	1507	1338
028	100/100	Pumps off .75 x inertia	-42	1553	1361
045	100/100	Pumps off .62 x inertia	-48	1525	1330
019	100/100	Pumps off .50 inertia	-60	1541	1334
027	100/100	Pumps off .25 x inertia	-103	1548	1318
018	100/100	Pumps off flywheel disc.	-122	1535	1301
046	100/100	Pumps off 2/3 of 0 inertia RPM	-134	1554	1285
047	100/100	Pumps off 1/3 of 0 inertia RPM	-213	1516	1188
021	100/100	Pumps off rotors locked	-296	1397	1094
201	50/100	Pumps off full inertia	6556	1432	505
202	150/ 50	Pumps off full inertia	-240	1437	1076
203	150/ 25	Pumps off full inertia	-446	1308	914
204	150/ 5	Pumps off full inertia	-1055	1269	779



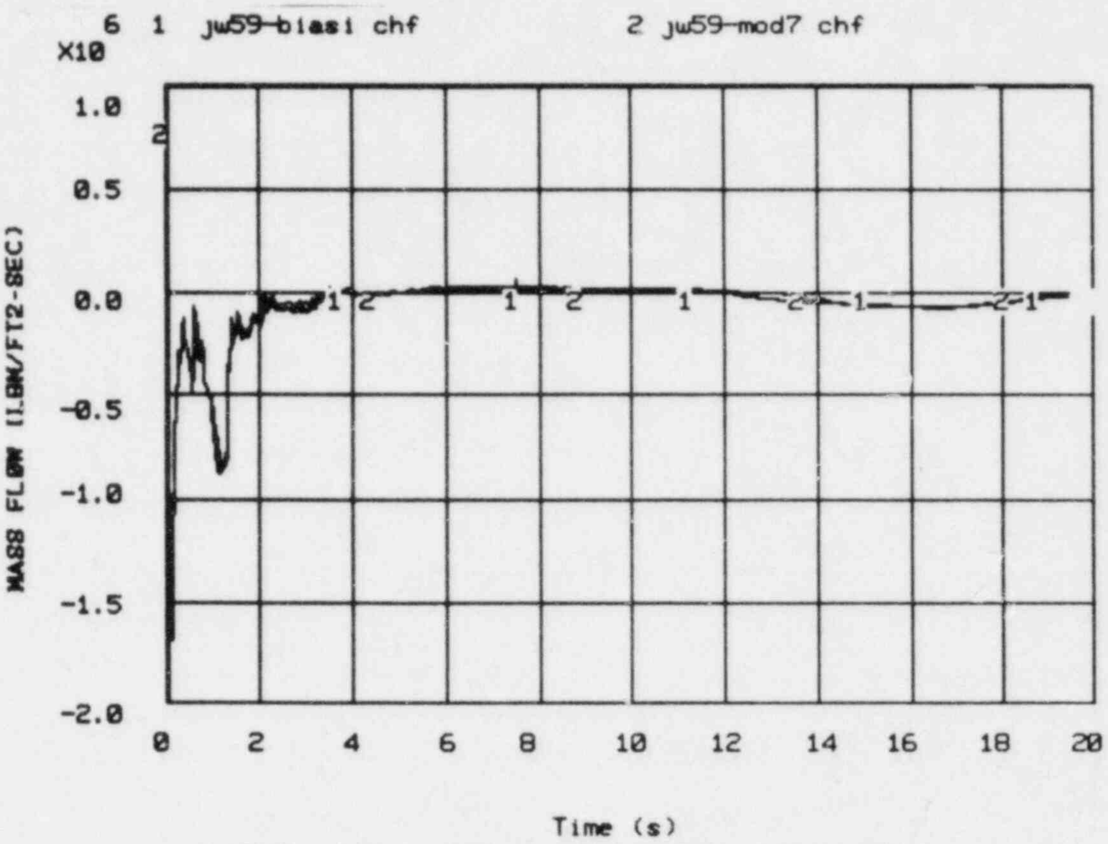
37 MW, 100 CL/100 HL, PUMPS OFF, 1/2 INERTIA (CWAF019, CY=1, BIASI CHF)

Figure 21. Cladding temperature



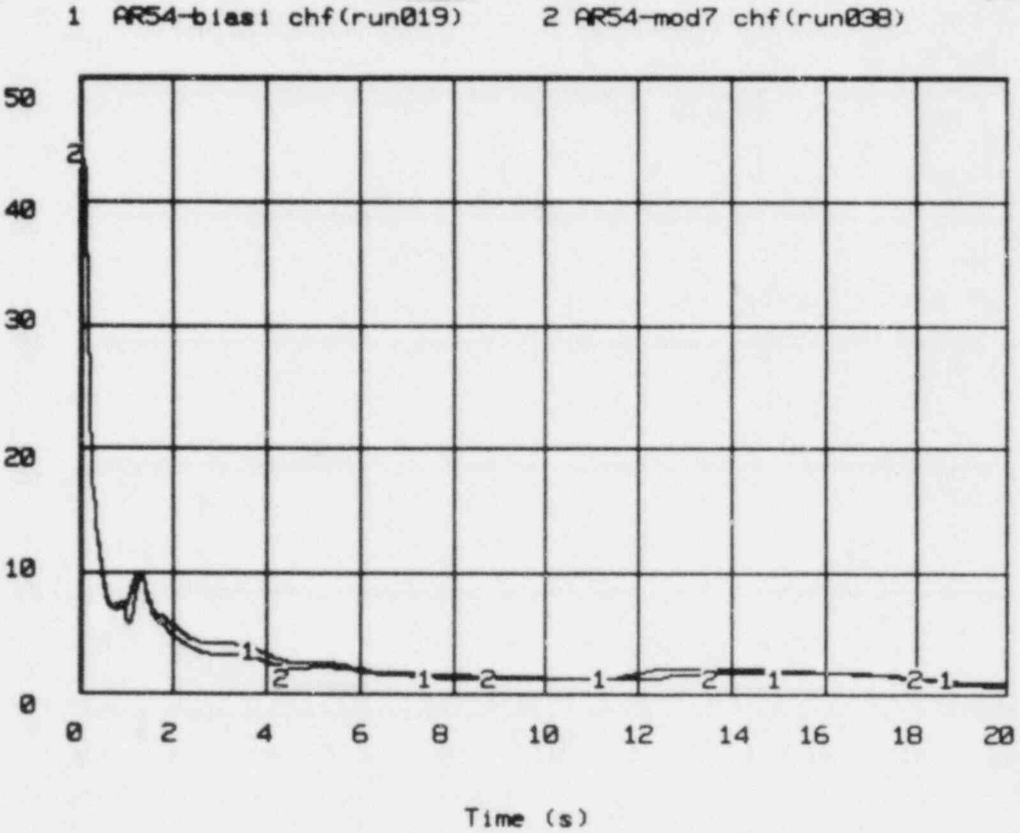
37 MW, 100 CL/100 HL, PUMPS OFF, 1/2 INERTIA (CWAF038, CY=1, MOD7 CHF)

Figure 22. Cladding temperature



37 MW, 100 CL/100 HL, PUMPS OFF, 1/2 INERTIA

Figure 23. Hot channel mass flow



37 MW, 100 CL/100 HL, PUMPS OFF, 1/2 INERTIA

Figure 24. Hot channel average density

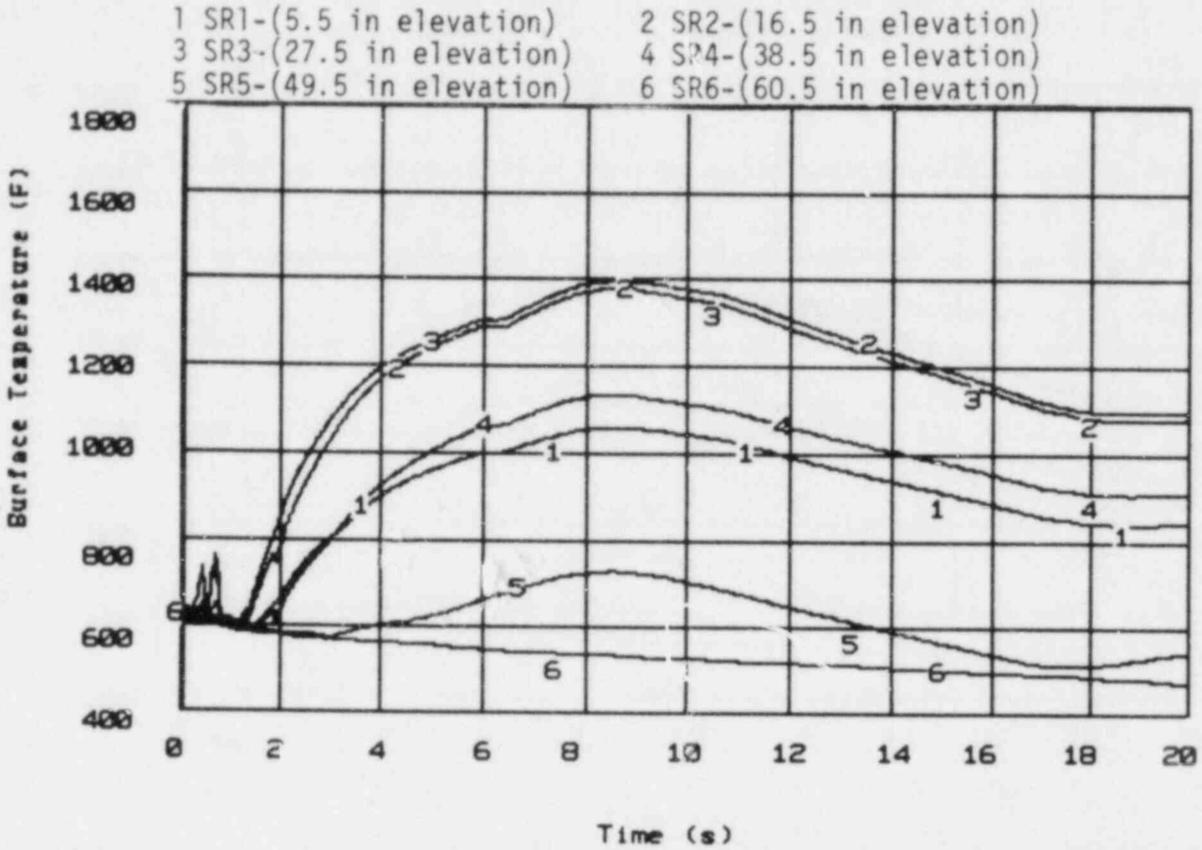
TABLE 4. COMPARISON OF CORE RESPONSE VARYING BREAK SIZE

Run Number	Break Size %CL/%HL	Pump Operation	Response of Core
017	100/100	off/full inertia	Rewet (slabs 1 & 2)
023	110/110	off/full inertia	Rewet (decrease from 017)
029	120/120	off/full inertia	No Rewet
033	90/90	off/full inertia	Full Rewet

The second comparison (Run 021 and Run 206-100%CL/100%HL, pumps-off, and locked pump rotors) shows a greater difference in hot channel cladding temperatures (Figure 25 and Figure 26). This is with a higher negative core flow resulting from the locked rotor pump condition as shown in Figure 27 and slightly higher density (Figure 28).

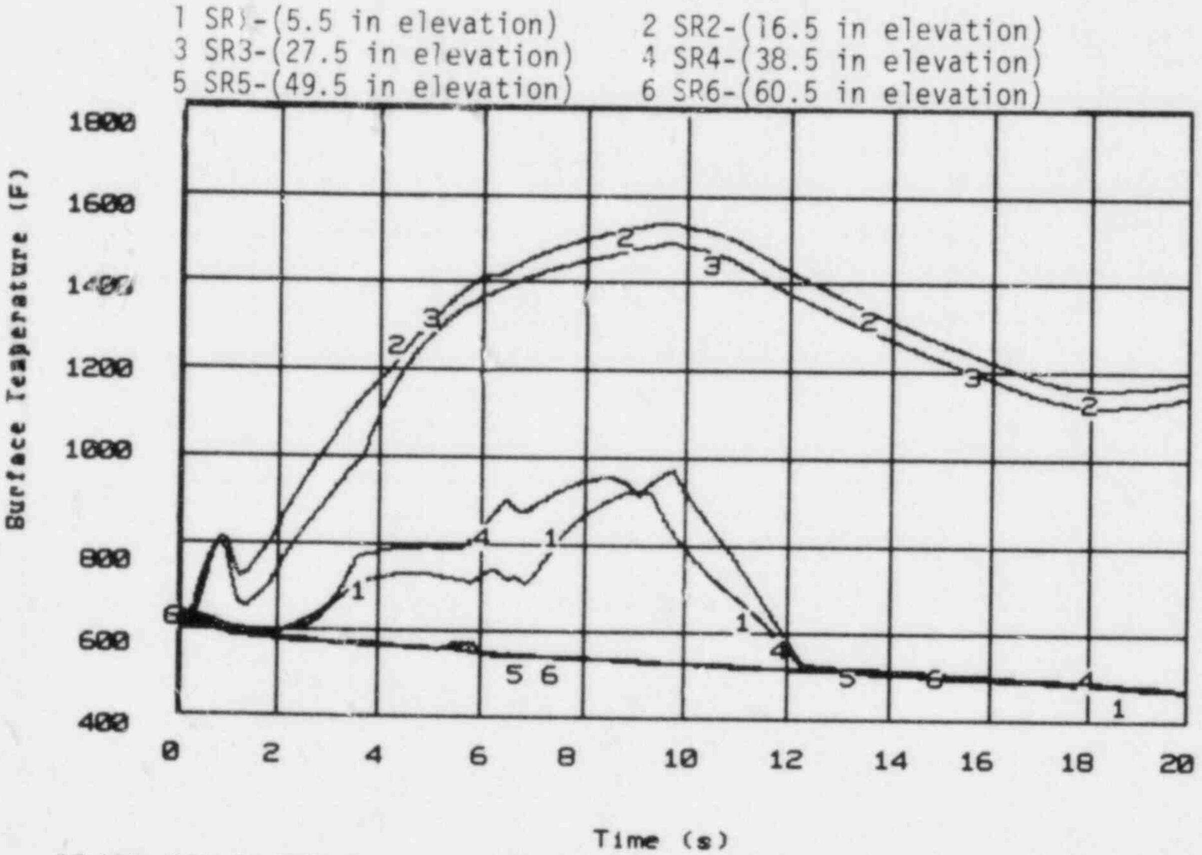
The third comparison (Run 204 and Run 205-150%CL/5%HL, pumps off, and full pump inertia) of cladding temperature response (Figure 29 and Figure 30, respectively) shows the MOD7 correlation predicting a rewet of the entire core. The Biasi correlation shows cooling only at the bottom of the core. As expected with the large reduction in the hot leg break size relative to the cold leg, the mass flow (Figure 31) is much higher, down through the core from the hot leg. The density (Figure 32) is higher than either of the previous cases.

In analyses using RELAP5 to model Zion, two cases were examined in which relatively low density, low mass flux down through the core, resulted in a quench of the core (top-bottom quench).[7] The two cases in Reference 7 which produced a top-bottom quench were the "two intact-loop pump shafts broken and remaining pumps unpowered" and "all pump shafts locked." The "all pump shafts locked" case was compared to the "locked rotors" case (Run 021) of this study. The mass fluxes down through the core were comparable, however Run 021 did not show a rewet using the Biasi



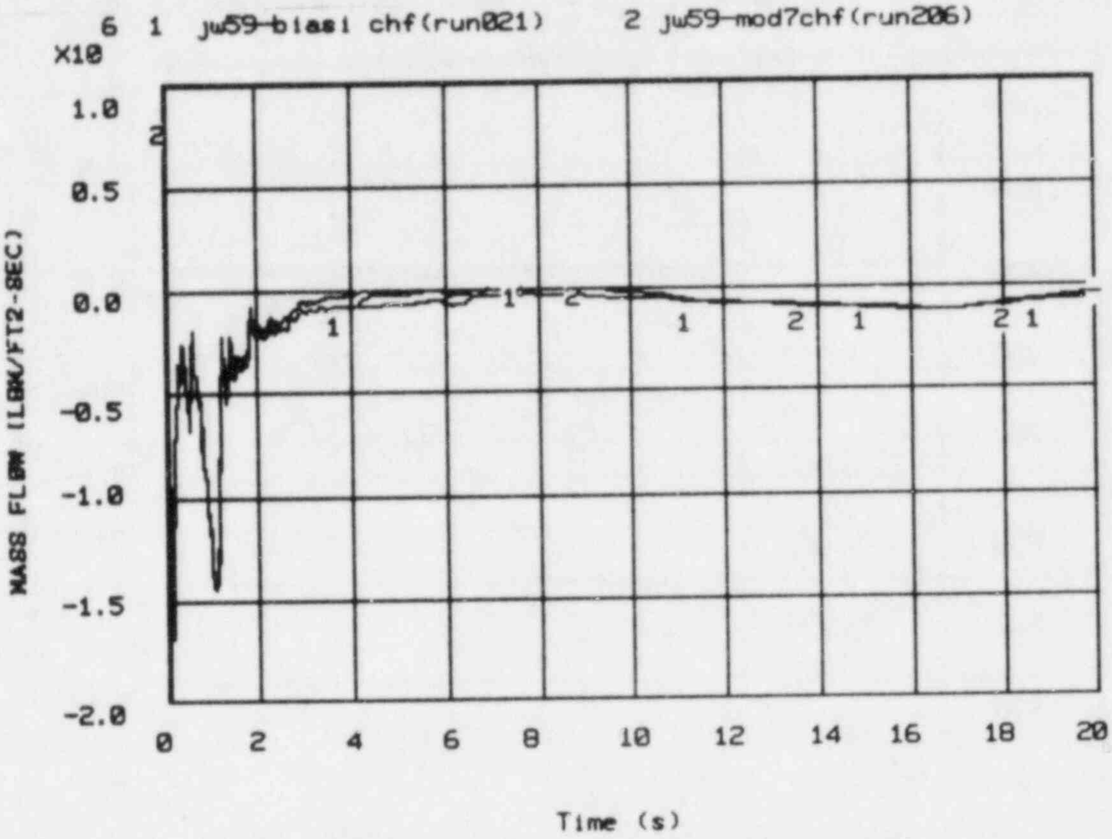
37 MW, 100 CL/100 HL, PUMPS OFF, LOCKED ROTORS (CWAF021, CY=1, BIASI CHF)

Figure 25. Cladding temperatures



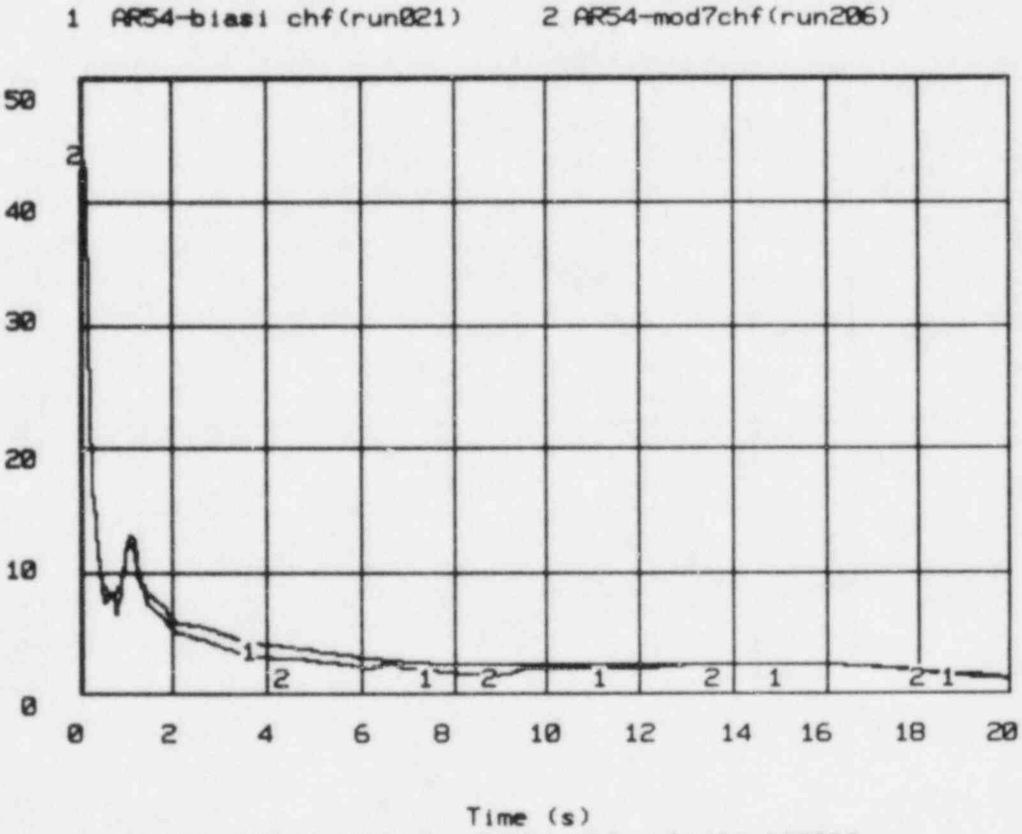
37 MW, 100 CL/100 HL, PUMPS OFF, LOCKED ROTORS (CWAF206, CY=1, MOD7 CHF)

Figure 26. Cladding temperatures



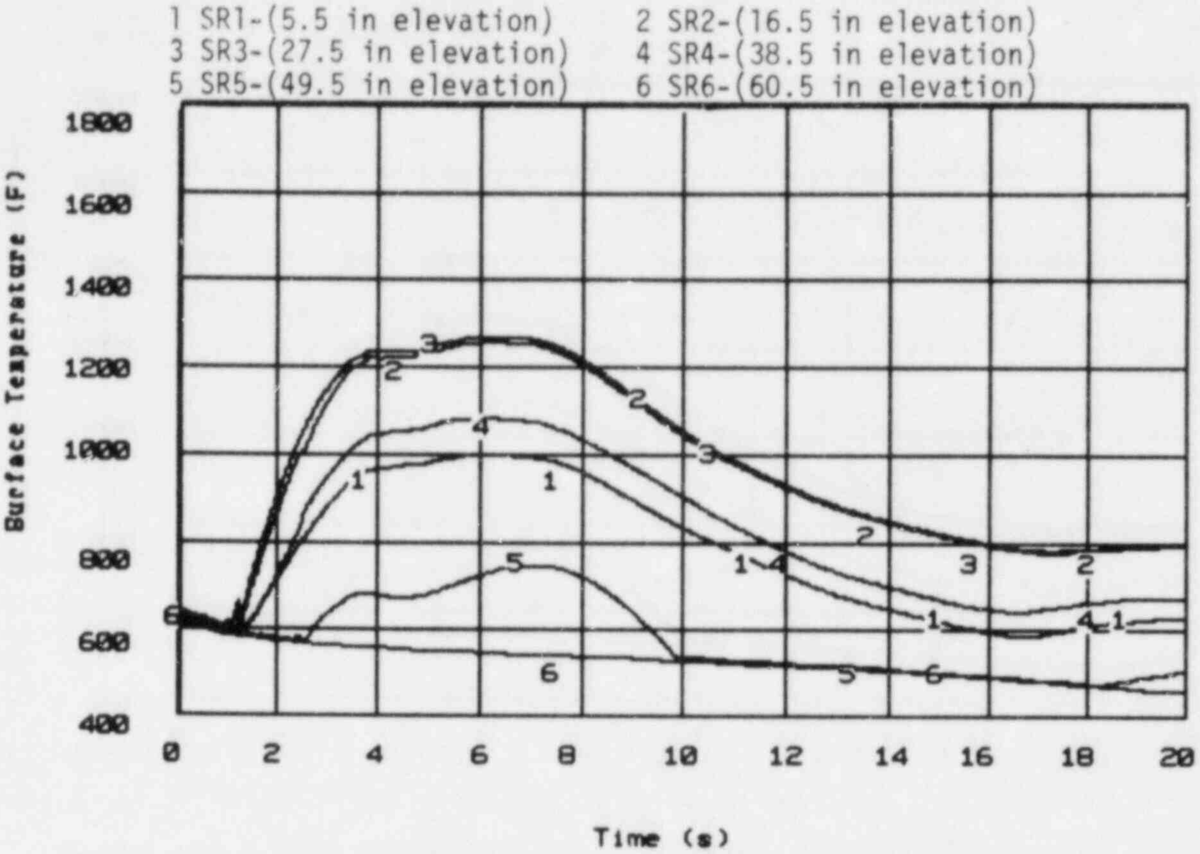
37 MW, 100 CL/100 HL, PUMPS OFF, LOCKED ROTORS

Figure 27. Hot channel mass flow



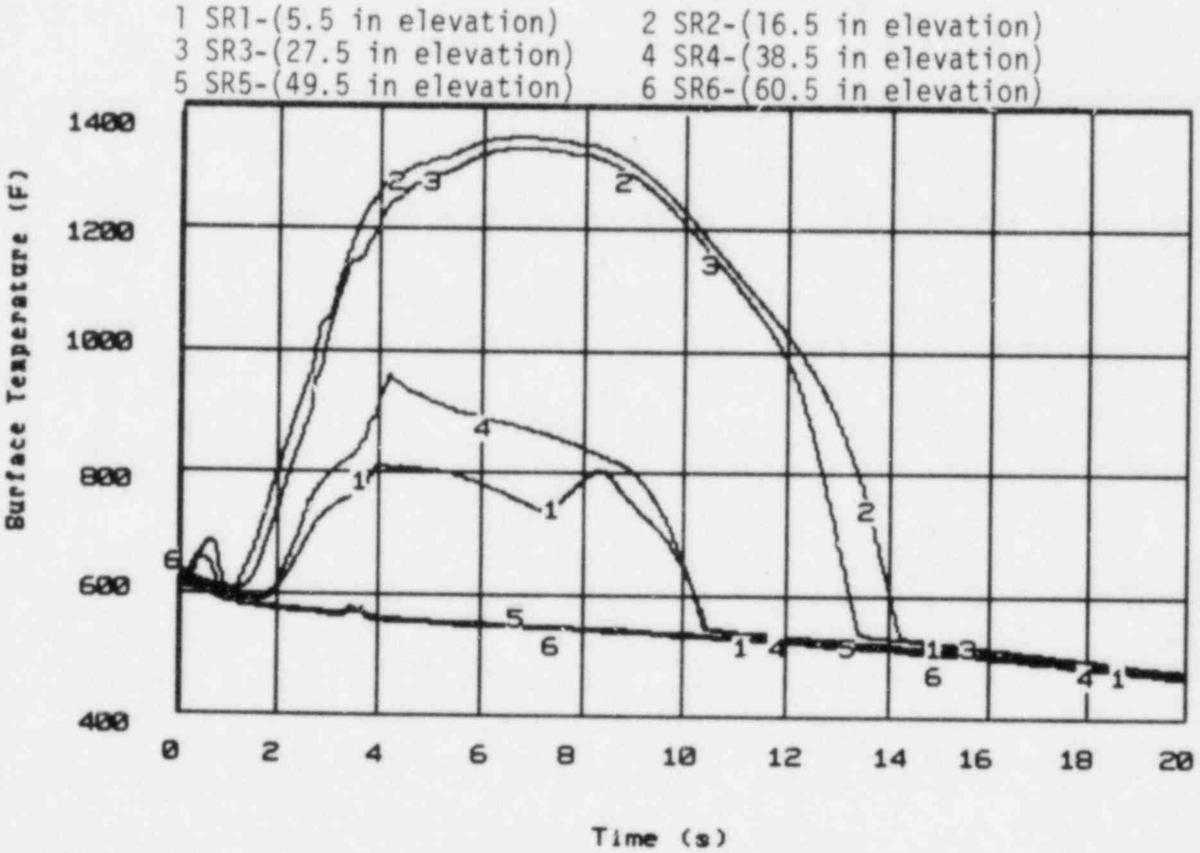
37 MW, 100 CL/100 HL, PUMPS OFF, LOCKED ROTORS

Figure 28. Hot channel average density



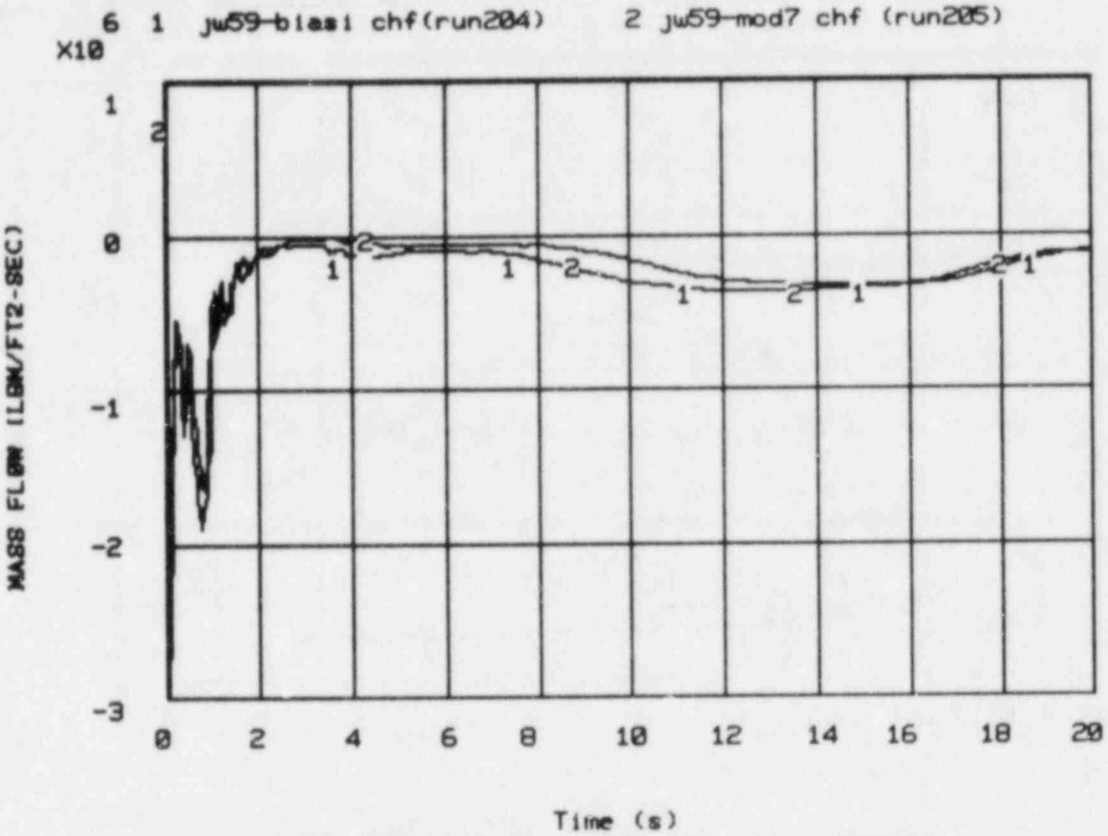
37 MW, 150 CL/5 HL, PUMPS OFF, FULL INERTIA (CWAF204, CY=1, BIASI CHF)

Figure 29. Cladding temperature



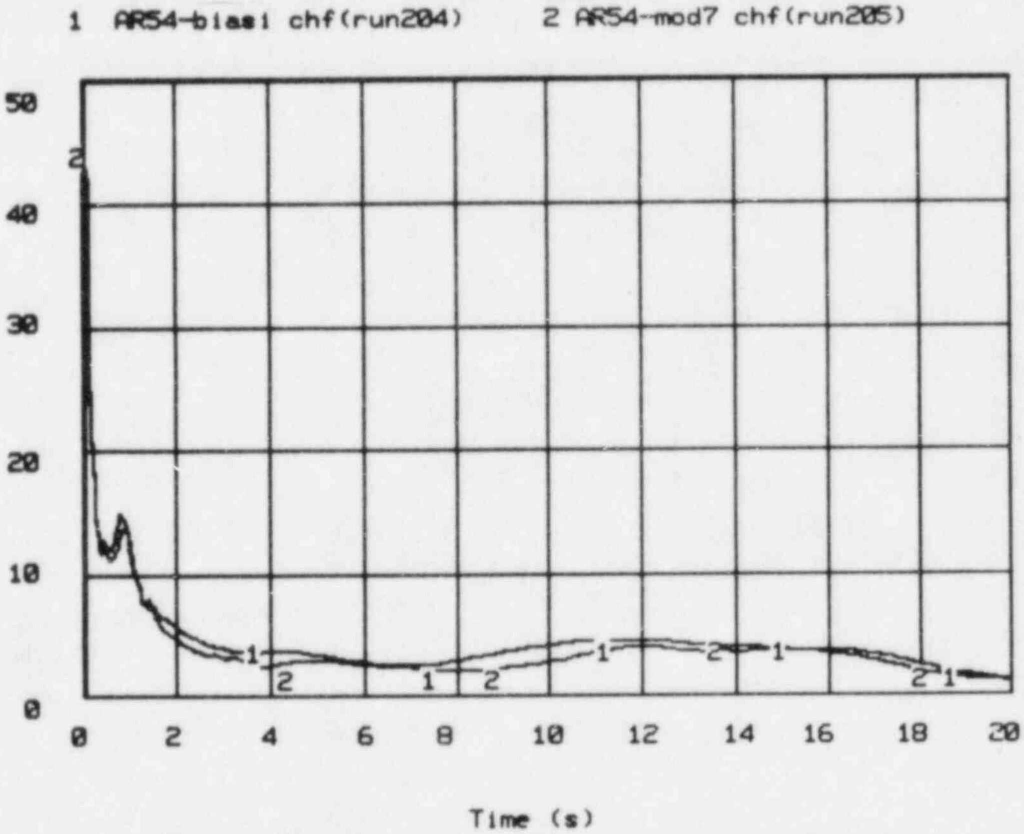
37 MW, 150 CL/5 HL, PUMPS OFF, FULL INERTIA (CWAF205, CY=1, MOD7 CHF)

Figure 30. Cladding temperature



37 MW, 150 CL/5 HL, PUMPS OFF, FULL INERTIA

Figure 31. Hot channel mass flow



37 MW, 150 CL/5 HL, PUMPS OFF, FULL INERTIA

Figure 32. Hot channel average density

CHF correlation. Using the MOD7 CHF correlation (Run 206) produced a partial rewet of the core, however both of these cases contrasted with the Zion simulations which predicted a complete rewet of the core. A limited comparison of the two analyses indicated a difference in the mass fluxes in which the Biasi and the Zuber CHF correlations were applied and in the rod initial surface temperature and heat generation rate which resulted in the difference in core response.

CONCLUSIONS

The purpose of this study was to provide analytical support as part of the planning for LOFT Test L2-5. Initial runs which were made at a 50 MW (100%) core power predicted peak cladding temperatures in excess of 1800 F. Subsequent FRAP runs indicated pin failure and it was decided to operate Test L2-5 at 37 MW (75%) core power.

The primary objective of this study was to determine analytically if conditions existed which would predict a large break blowdown without rewet. This study has shown that with the Biasi CHF correlation there is a fairly broad range of operating conditions in which RELAP4 predicted a core rewet would not occur during the blowdown. This includes various pump operational conditions and break sizes. For example with the nominal 100%CL/100%HL break size the analysis indicated that anything less than the full nominal pump flywheel inertia would not produce a core rewet. This was also true for cases run at 100%CL/100%HL and 120%CL/120%HL break sizes. When the break size was reduced to 90%CL/90%HL partial core rewet was experienced with one-half the nominal flywheel inertia, but not when the pump flywheels were disconnected.

The prediction of core response is dependent on the predicted heat transfer between the rod and the coolant. Conditions analyzed in this study using the RELAP4/MOD7 CHF correlation produced rewet of the core for hydraulic conditions where the Biasi CHF correlation did not. Differences were also noted between this analysis of LOFT and similar analyses of ZION.[7] This emphasizes the importance of the heat transfer correlation in predicting core response as was shown in Reference 5. Current work is scheduled to improve the heat transfer predictive capability. Recognizing these analytical uncertainties it is considered that the highest probability for running the L2-5 experiment without a core rewet is to establish an operational condition in LOFT which voids the core and subsequently minimizes the flow of coolant through the core.

From an operational standpoint, it is desireable to vary the pump operation and maintain the 100%CL/100%HL break sizes. The results of the pump parametric study indicate that the peak cladding temperatures and the maximum value of the minimum temperature after the peak are produced with a flywheel inertia 75% of the nominal value. This results from the minimum amount of coolant flow which occurs after the initial voiding of the core. However because the response to the lower quality coolant from the cold leg is so abrupt, it is probably conservative to allow some flow from the hot leg down through the core rather than to allow positive core flow from the cold leg. This could be accomplished by operating the pumps with 1/2 the nominal flywheel inertia or disconnecting the flywheels from the pump at the initiation of the break. The current design point for Experiment L2-5 assumes both pump flywheels will be disconnected at the initiation of the nominal 100%CL/100%HL break.

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6. Personal communication with E. W. Coryell, August 1981.

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APPENDIX A

PARAMETRIC STUDY COMPUTER SOURCE DECKS

PARAMETRIC STUDY COMPUTER SOURCE DECKS

The computer files used in the LOFT Experiment L2-5 planning study were placed into the Idaho National Engineering Laboratory configuration control under Configuration Control Number F00507. This will be maintained until December 31, 1983 unless a request is made to extend it further. A description of the individual files are as follows:

CWAF016 through CWAF206--these are common word addressable files (CWAF) which contain plot information from the RELAP4 runs and correspond to the individual runs described in Table 2 of this document.

A22--source listing of L2-3 base input deck. This was obtained from W.H. Grush and used to generate the input deck for the study.

A22UP--UPDATE program library of file "A22."

P37UPC--source file used to create UPDATE program library of changes to modify the L2-3 base deck to 2 channel, 12-volume core and make the input compatible with the MOD7 version of RELAP4.

P37UP--UPDATE program library of "P37UPC."

RELAPMO--UPDATE corrections to add the Biasi CHF correlation and MOD7 changes to RELAP4.

OBJMODS--object deck of file "RELAPMO."

FLOWD--RELAP4 model of downcomer and core used to initialize core flows.

RUN016 through RUN206--input files used in study which correspond to the individual runs described in Table 2 of this document.

The CWAF plot records are stored as individual files on the tape. The input files are grouped together as a FILESET under the file name "FILEL26."

The following data are provided on microfiche in the pouch on the inside of the report back cover:

1. APPENDIX A--SOURCE DECKS-input listings for files P37UPC and RELAPMO which are described above.

2. APPENDIX A--INPUT FILES-input listings for files RUN016 through RUN206 which are described above.

3. L2-5 200% PUMPS OFF--listing of output for RUN018, 100%CL/100%HL, Pumps-off, and flywheel disconnected. This is the proposed operational conditions for LOFT Experiment L2-5.

APPENDIX B

RESTART DATA TAPES FOR PARAMETRIC RUNS

RESTART DATA TAPES FOR PARAMETRIC RUNS

The following table defines the CWAF plot files and the restart data tapes that were created for each of the runs.

Run Number	Break Size (%CL/%HL)	Pump Operation	Plot File	Restart Tape Number
37 MW Core Power				
016	100/100	Pumps on	CWAF016, CY=1	B39724
017	100/100	Pumps off, full inertia	CWAF017, CY=1	A30685
018	100/100	Pumps off, flywheel disc.	CWAF018, CY=1	B45575
019	100/100	Pumps off, 1/2 inertia	CWAF019, CY=1	A46890
021	100/100	Pumps off, locked rotors	CWAF021, CY=1	A33288
022	100/100	Pumps off, 1 rotor locked	CWAF022, CY=1	A45369
023	110/110	Pumps off, full inertia	CWAF023, CY=1	A46425
024	110/110	Pumps off, 1/2 inertia	CWAF024, CY=1	A50906
025	110/110	Pumps off, flywheel disc.	CWAF025, CY=1	A38122
026	110/110	Pumps off, locked rotors	CWAF026, CY=1	A49885
027	100/100	Pumps off, 1/4 inertia	CWAF027, CY=1	A39635
028	100/100	Pumps off, 3/4 inertia	CWAF028, CY=1	B31297
029	120/120	Pumps off, full inertia	CWAF029, CY=1	A43224

Run Number	Break Size (%CL/%HL)	Pump Operation	Plot File	Restart Tape Number
37 MW Core Power (continued)				
030	120/120	Pumps off, 1/2 inertia	CWAF030, CY=1	A33276
031	120/120	Pumps off, flywheel disc.	CWAF031, CY=1	A44951
032	120/120	Pumps off, rotors locke	CWAF032, CY=1	A34000
033	90/ 90	Pumps off, full inertia	CWAF033, CY=1	A45346
034	90/ 90	Pumps off, 1/2 inertia	CWAF034, CY=1	A42200
035	90/ 90	Pumps off, flywheel disc.	CWAF035, CY=1	A43411
036	90/ 90	Pumps off, rotors locked	CWAF036, CY=1	A45012
037	100/100	Pumps off, 2X inertia	CWAF037, CY=1	A44459
038*	100/100	Pumps off, 1/2 inertia	CWAF038, CY=1	B37785
039	100/100	Pumps off, 1 locked rotor	CWAF039, CY=1	A33307
040	110/110	Pumps off, 3/4 inertia	CWAF040, CY=1	B38170
041	110/110	Pumps off, 2X inertia	CWAF041, CY=1	A30435
042	100/100	Pumps off 4X inertia	CWAF042, CY=1	A43582
043	100/100	Pumps off 1.5X inertia	CWAF043, CY=1	A43834
044	100/100	Pumps off .88X inertia	CWAF044, CY=1	A44117

Run Number	Break Size (%CL/%HL)	Pump Operation	Plot File	Restart Tape Number
37 MW Core Power (continued)				
045	100/100	Pumps off .62X inertia	CWAF045, CY=2	A51569
046	100/100	Pumps off 2/3 of 0 inertia RPM	CWAF046, CY=2	A50717
047	100/100	Pumps off 1/3 of 0 inertia RPM	CWAF047, CY=2	A50808
201	50/150	Pumps off, full inertia	CWAF201, CY=1	A44218
202	150/50	Pumps off, full inertia	CWAF202, CY=1	A44452
203	150/25	Pumps off, full inertia	CWAF203, CY=1	A52107
204	150/ 5	Pumps off, full inertia	CWAF204, CY=1	A42382
205*	150/ 5	Pumps off, full inertia	CWAF205, CY=1	A45578
206*	100/100	Pumps off, locked rotors	CWAF206, CY=1	A44687
50 MW Core Power				
120	100/100	Pumps off, full inertia	RSS01PLOT, CY=2	A46357
121	100/100	Pumps off, flywheel disc.	RSS01PLOT, CY=3	A49982
122	100/ 75	Pumps off, flywheel disc.	CWAF122, CY=1	A34302
123	100/100	Pumps off, 1 rotor locked	CWAF123, CY=1	A32672

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* Used MOD7 CHF correlation.

Run Number	Break Size (%CL/%HL)	Pump Operation	Plot File	Restart Tape Number
50 MW Core Power (continued)				
124	100/ 50	Pumps off, flywheel disc.	CWAF124, CY=1	A49167
125	100/ 25	Pumps off, flywheel disc.	CWAF125, CY=1	A30121

The hardcopy listing of the runs will be retained in record storage until the experiments for which this analysis has been performed has been completed.