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SECOND QUARTER FY79 PROGRESS REPORT ON REFILL EFFECTS PROGRAM

QUARTERLY PROGRESS REPORT
January 1, 1979 - March 31, 1979

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Prepared For
U. S. Nuclear Regulatory Commission

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ABSTRACT

This report describes work on the Creare Refill Effects Program during the second quarter of FY79. Results are summarized according to the various tasks within the program. Particular results of Flashing Transient experiments and the calculation of test results using RELAP4/MOD5 are discussed. Future plans for each of the program topics are also outlined.

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NOMENCLATURE

A^*	dimensionless area ratio
C_c	contraction coefficient
c_p	heat capacity of liquid at constant pressure
D_c	equivalent diameter of core
D_v	diameter of vessel
d_{BCL}	broken cold leg diameter
g	acceleration of gravity
h_{fg}	latent heat of vaporization
J^*_{fb}	dimensionless flux of liquid bypassed
J^*_{fd}	dimensionless flux of liquid delivered to plenum
J'_{fd}	dimensionless flux of liquid delivered through annulus
J^*_{gc}	dimensionless flux of reverse core steam
j^*_{gc}	dimensionless core steam flux based on equivalent core diameter
P_{LP}	lower plenum pressure
p^*	dimensionless break pressure drop
Δp_b	break pressure drop
Q_T	volumetric injection rate
s	annulus gap size
T_{ECC}	ECC injection temperature
ΔT_{sub}	subcooling of injected ECC
V_{LP}	lower plenum volume
W_{gc}	mass flow rate of reverse core steam
w	average annulus circumference
η_m	condensation factor in break pressure drop model
ρ_f	liquid phase density
ρ_g	gas phase density
$\Delta\rho$	$\rho_f - \rho_g$
τ	duration of steam mass flow transient

1 INTRODUCTION

This is a Quarterly Progress Report on the Creare Refill Effects Program. The general context of this work is a postulated Loss-of-Coolant Accident (LOCA) in a Pressurized Water Reactor (PWR), although many of the basic processes being studied may also apply to Boiling Water Reactors (BWRs). The program is a continuing effort to develop analytical and empirical tools which will contribute to best-estimate and licensing predictions of lower plenum filling during postulated LOCAs in PWRs and to assist in the design and specification of larger scale plenum filling tests and the predictions of those test results.

As described in detail in a previous Quarterly Report [1], the general structure of the program has been arranged around eight technical topics:

- Model Synthesis
- Flashing Transients
- Lower Plenum Voiding
- Condensation-Induced Transients
- Refill Modeling with RELAP
- Flow Topography
- Technical Support of Research Information Letters
- Technical Assistance and Review Groups

In the period January-March 1979, primary analytical efforts included the use of RELAP4/MOD5 to calculate results of flashing transient experiments, the addition of condensation effects to a pressure drop model for the broken cold leg, and continuing analyses on the topics of flow topography and lower plenum voiding. Experimental work included flashing transients in the 1/15-scale vessel, flashing transients in a transparent 1/30-scale vessel, and countercurrent flow tests with subcooled ECC in a 1/30-scale vessel. Facility upgrades included the addition of an air-actuated valve and various orifices in the broken hot leg, and also a special 15 gallon separator vessel to collect the hot leg effluent in flashing transients with both cold leg and hot leg breaks. Progress on each of the program topics is summarized briefly in Section 2. In Sections 3 and 4 of the report, flashing transient data are presented and compared with RELAP4/MOD5 calculations of the results.

2 SUMMARY OF RESULTS

2.1 Model Synthesis

During the quarter the final Topical Report on the phenomenon of superheated walls with countercurrent flow was completed [2]. The report is entitled "Analysis of Superheated Wall Effects During Refill at Small Scale," Creare TN-287 (NUREG/CR-0559). The analysis describes flooding behavior limited by heat transfer in our 1/15-scale PWR model during steam flow transients. The analysis was also used to perform a sensitivity study assessing these effects in LOFT and at PWR scale as part of the work in support of the Research Information Letter. This addition is an important milestone in our model synthesis.

2.2 Flashing Transients

Several series of flashing transient experiments were performed at 1/15-scale to scope the effects of the parameters of break size, initial pressure, initial plenum liquid mass, and reverse core steam flow. Transient measurements of plenum pressure and plenum mixture behavior were the key experimental measurements in these tests. An expanded discussion of typical results from flashing transient experiments is presented in Section 3 of this report.

An existing 1/30-scale transparent model of a PWR vessel has also been modified for flashing transient experiments. The vessel is capable of pressures up to 20 psig and has been used to visualize several blowdown transients. Slow motion films of selected transients are planned.

2.3 Lower Plenum Voiding

Recent efforts on the topic of lower plenum voiding (LPV) have been directed at obtaining data with transient steam flows and making comparisons of all existing data. A report summarizing FY79 activities on LPV will be completed during the last quarter of FY79.

Tests with transient steam flows have been performed in the 1/15 scale vessel. Three values of initial steam flow were tested. All initial values were larger than the steam flow (j^*_{gc}=0.3) at which a sudden level transition occurs [3] in steady state experiments. Results of this series of tests are shown in Figure 1 where the final water level depression is plotted against the transient duration with the initial steam flow as a parameter. The data indicate that even for high initial steam flows (j^*_{gc}=1.56) and long transients (τ=60 seconds), the final water level depression is less than the value which would result during a steady state test.

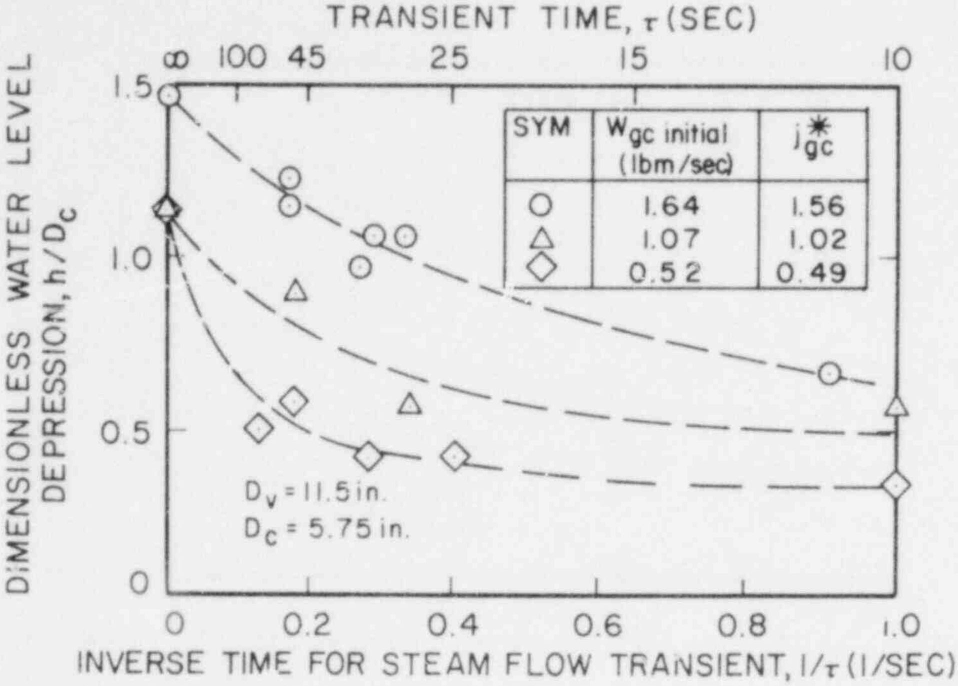


Figure 1. TRANSIENT LOWER PLENUM VOIDING AT 1/15-SCALE

Comparisons between Creare data and all data reported by Dartmouth, Battelle, and INEL have been made to help develop a better understanding of the voiding phenomenon. The Creare data at 1/30-scale were shown to compare well with data at 1/10 scale in the previous quarterly progress report [5], indicating that the j_{gc}^{*} parameter correlated data in vessels of different sizes. In Figure 2, Creare 1/30-scale steam-water data are compared with Dartmouth 1/15 scale air-water data. The data overlay nicely which suggests that the j_{gc}^{*} parameter is also appropriate for correlating both steam-water and air-water data from geometrically similar vessels.

2.4 Condensation-Induced Transients

Knowledge of the break pressure drop and condensation in the vessel during ECC bypass is a critical component of the calculation of system behavior in a PWR since the reverse core steam flow will depend in part on break pressure drop and condensation effects. These effects interact with ECC bypass by the countercurrent flow in the downcomer. A preliminary model for break pressure drop [6] achieved reasonable agreement for very high and very low ECC subcoolings. This model is written

$$\Delta p^{*} = \frac{\Lambda^{*2}}{2C_c^{\,2}} \left[J_{fb}^{*} + (1-\eta_m) J_{gc}^{*} \right]^2 \qquad (1)$$

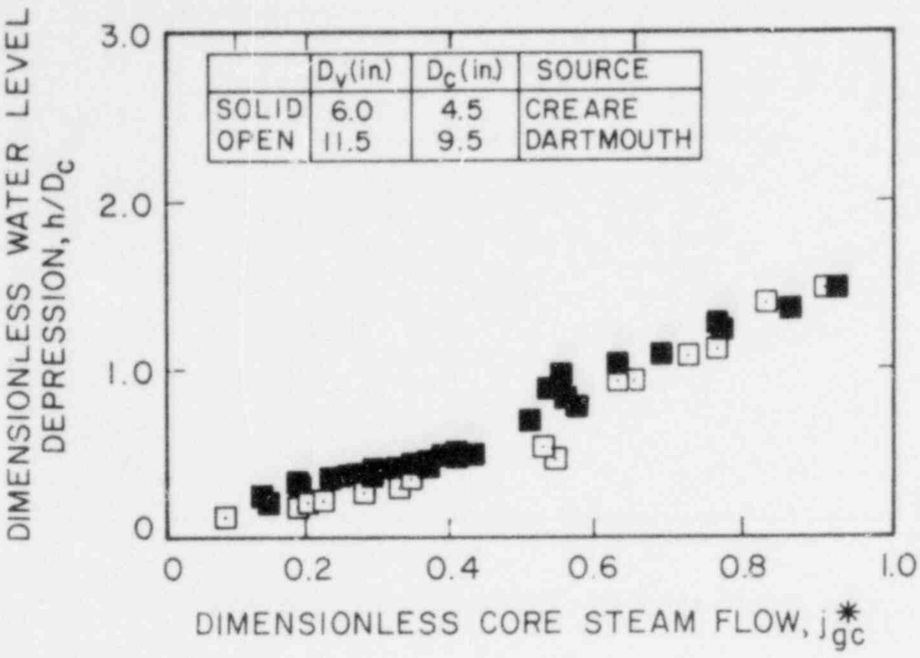


Figure 2. COMPARISON OF CREARE AND DARTMOUTH [4] LOWER PLENUM VOIDING DATA

where A* is the area ratio $4ws/\pi d_{BCL}^2$, C_c is a contraction coefficient, Δp^* is a dimensionless pressure drop $\Delta p_b/gw\Delta\rho$, and η_m represents a condensation factor. At high subcooling (ΔT_{sub}=135°F) η_m was assumed to be 1 and at low subcooling (ΔT_{sub}<40°F)/η_m was assumed to be 0 in Reference 6.

To complete the analysis of CIT experiments it is also necessary to be able to predict data at intermediate subcoolings. A model to predict these data was developed during the quarter. This model assumes that condensation occurs on the water delivered to the plenum from the downcomer. An energy balance is

$$\rho_f^{\frac{1}{2}} J_{fd}' \Delta T_{sub} = \eta_m \rho_g^{\frac{1}{2}} J_{gc}^{\star} h_{fg} \qquad (2)$$

From the continuity equation

$$\rho_f^{\frac{1}{2}} J_{fd}' + \eta_m \rho_f^{\frac{1}{2}} J_{gc}^{\star} = \rho_f^{\frac{1}{2}} J_{fd}^{\star} \qquad (3)$$

Thus, from Equations (2) and (3)

$$\eta_m = \left(\frac{\rho_f}{\rho_g}\right)^{\frac{1}{2}} \left(\frac{J^*_{fd}}{J^*_{gc}}\right) \left[\frac{C_p \Delta T_{sub}}{C_p \Delta T_{sub} + h_{fg}}\right] \tag{4}$$

And the break flow is

$$J^*_{fd} = J^*_{fin} - J^*_{fd} + \eta_m \left(\frac{\rho_g}{\rho_f}\right)^{\frac{1}{2}} J^*_{gc} \tag{5}$$

Selected comparisons of measured pressure drops and predictions using Equations (1), (4), and (5) are shown in Figure 3. The model tends to slightly overpredict most of the data at this intermediate subcooling of approximately 65°F but matches the trend of the data well with increasing steam flow.

Future plans on this topic include making additional data comparisons with the break pressure drop model to assess its broader application. Finally, the break pressure drop, countercurrent flow, and steam supply characteristic models will be integrated into a model to predict condensation-induced transients.

2.5 Refill Modeling With RELAP

RELAP4/MOD5 has been used to predict the flashing transient experiments during the quarter. Previous results from a few scoping tests [5] have suggested that the RELAP model with a constant bubble rise velocity of 10 ft/sec predicted the data well. This result was confirmed over a wide range of break sizes and initial pressures in these flashing transients. Results are discussed in Section 4 of this report.

2.6 RIL Support

In support of the Research Information Letter (RIL) on ECC Bypass being prepared by NRC, we prepared and released a technical report [8] in draft form. This report will be released in final form during FY79, coordinated with release of the RIL. These reports, together with documents prepared by other contractors, summarize the major findings of ECC bypass research to date and indicate their applicability to the licensing process.

The results include the definition of semi-empirical best-estimate and proposed evaluation models for downcomer countercurrent flow and "hot wall" effects during the refill period following a PWR LOCA. Our best-estimate model, based on small scale, separate effects data at several scales up to 2/15 of reactor scale, has been shown to accurately calculate measured behavior in LOFT. The evaluation model proposed by NRC, amounting to an extrapolation of small scale results, has been shown to be very conservative with respect to LOFT. Sensitivity calculations performed at PWR scale quantify the conservatism of licensing approaches.

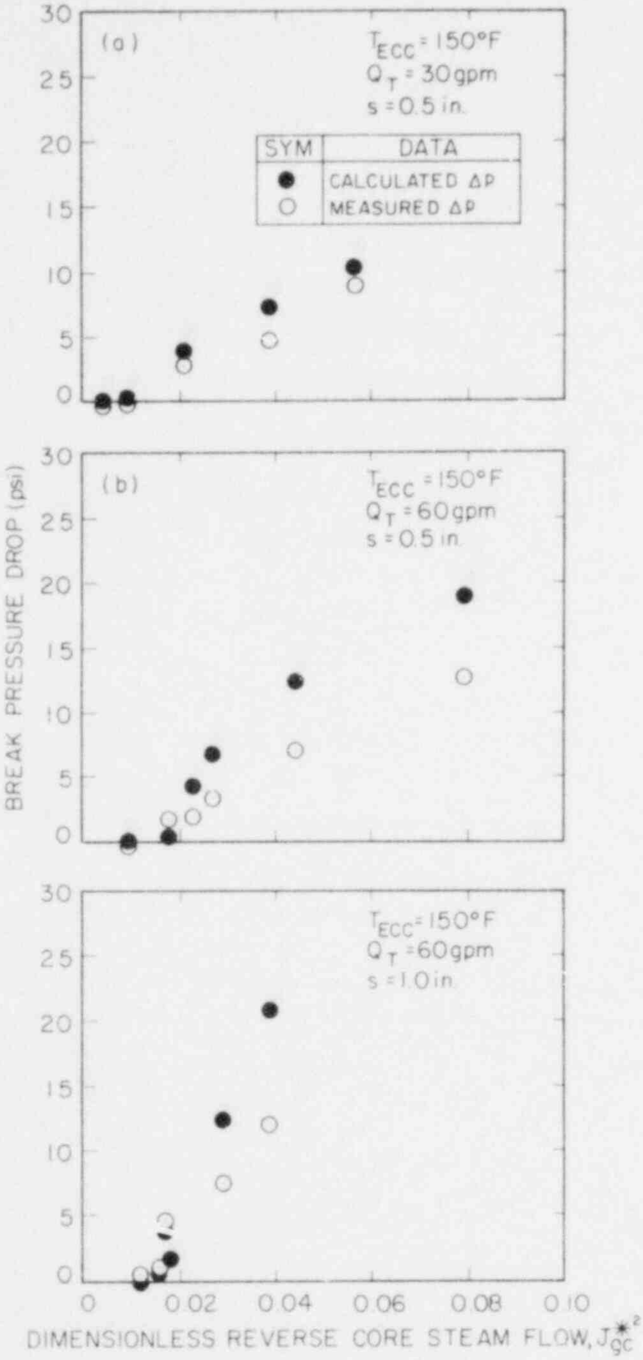


Figure 3. COMPARISON OF MEASURED AND CALCULATED BREAK PRESSURE DROP IN COUNTERCURRENT FLOW (T_{ECC}=150°F)

2.7 Flow Topography

Creare has developed an instrumentation system used to record and display two-phase flow topographies in the annulus of a 1/15-scale model of a PWR vessel. The original implementation of this sytem was described in Reference 9, and the upgrades made to it since that time have been described in our previous progress reports. During this quarter the principal activities for this task have been (1) the performance of several series of countercurrent-flow tests, and (2) the continued development of a set of analysis tools to be applied to the recorded data. The test facility and its computer interface have been modified to provide the greatest possible speed and convenience in testing; a single operator can record 8 to 10 tests in a working day.

Three series of countercurrent flow tests, comprising 26 tests, were run to produce complete penetration maps (full delivery through full bypass) at fluid injection rates of 20, 40, and 80 gpm. These tests were run with highly subcooled water and uncontrolled vessel pressure. In order to verify the stability of the test app ratus and the repeatability of test results, the 20 gpm test series was repeated, and in addition one specific test was repeated 10 times.

These tests were the first to incorporate the recording of analog signals in addition to digital conductivity probe data. We are currently recording one absolute pressure (in the lower plenum), three pressure differences, the flow rate of injected steam, and the lower plenum filling rate. Each signal is digitized at the rate of 50 pts/sec and recorded in a computer file. Figure 4 shows an example of three pressure traces recorded during a 30-second period while all injected fluid was being bypassed. Each signal shows a semi-periodic behavior with a predominant frequency of about 2 Hz. It is expected that analysis of the recorded data will allow meaningful correlations to be established between the pressure traces, the independent test parameters, and the motion of the fluid in the annulus as recorded by the conductivity sensors.

We have implemented and are continuing to refine a computer algorithm which locates the interface between the liquid and vapor phases in the annulus. Figure 5 shows the result of applying this algorithm to a series of data frames spanning a period of about two seconds. In this example, the interface is moving generally downward, but with some irregular fluctuations.

The motion of this interface as a function of time can be analyzed in various ways. For example, in Figure 6 we have plotted the mean height of the interface during a 30 second test; in Figure 6b the high-frequency portion of the curve has been removed by means of digital filter to show clearly the significant vertical movements. After the initial transient, the mean height never drops to zero (the bottom of the annulus), which is consistent with the fact that no fluid was delivered to the lower plenum during this time. In Figure 6c the second curve has been differentiated to provide a history of the mean vertical velocity of the interface. Work during the upcoming quarter will concentrate on relating interface motion to variations in test conditions and to the pressure recordings.

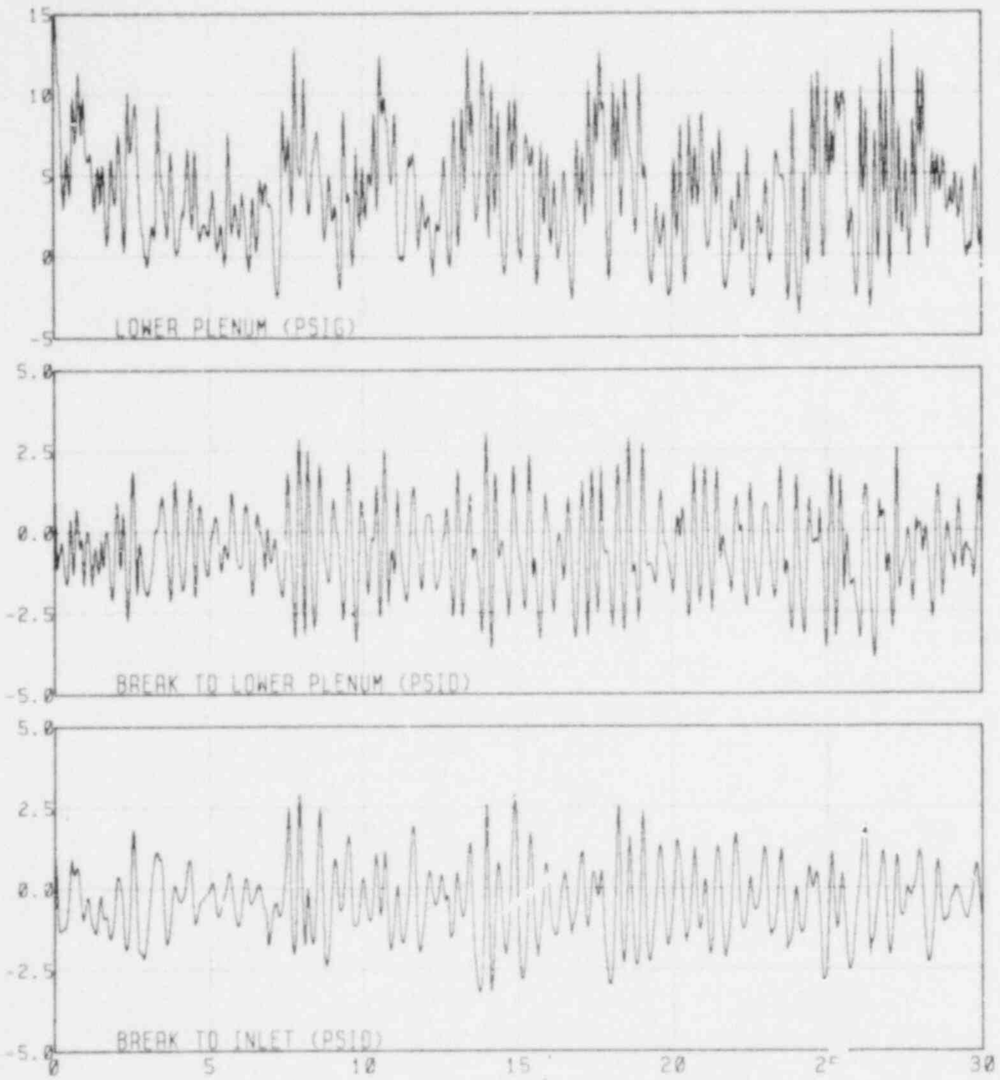


Figure 4. SAMPLE PRESSURE TRACES IN COUNTERCURRENT FLOW FROM FLOW TOPOGRAPHY EXPERIMENT

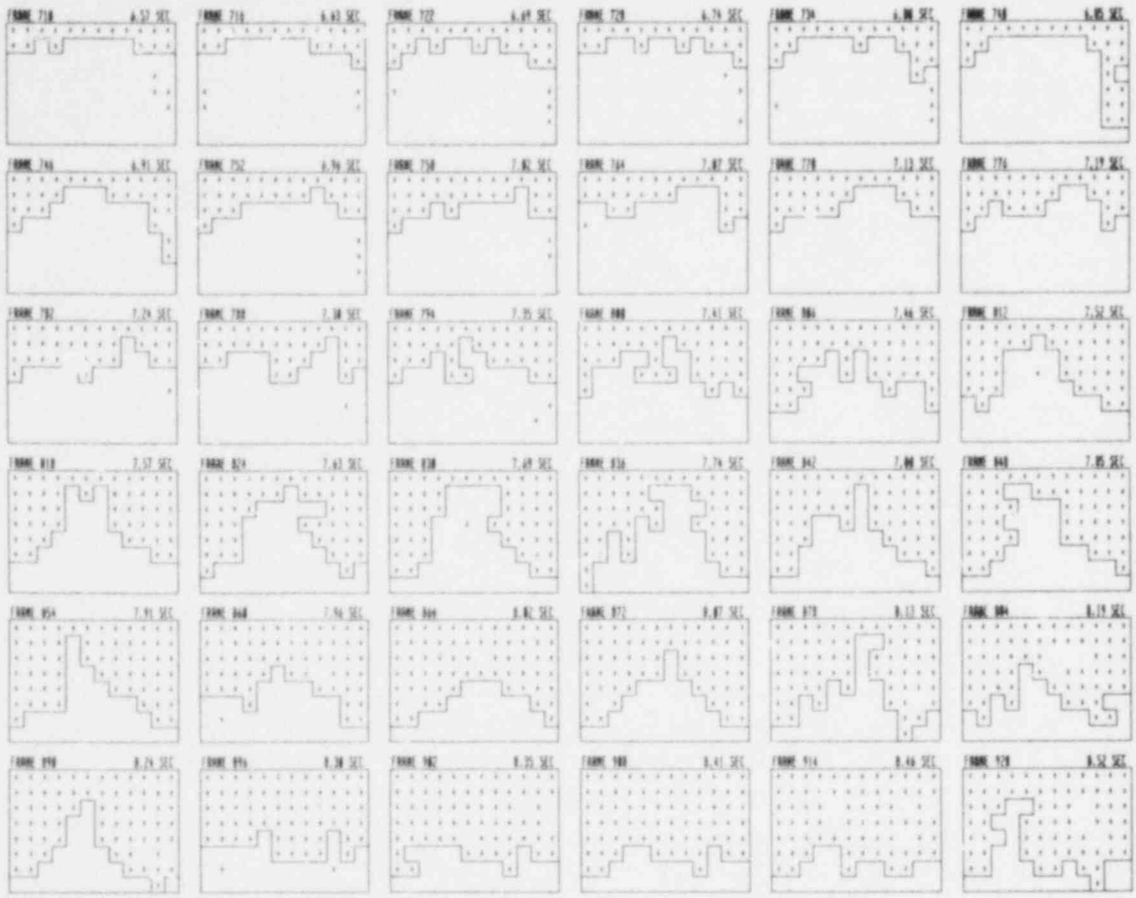
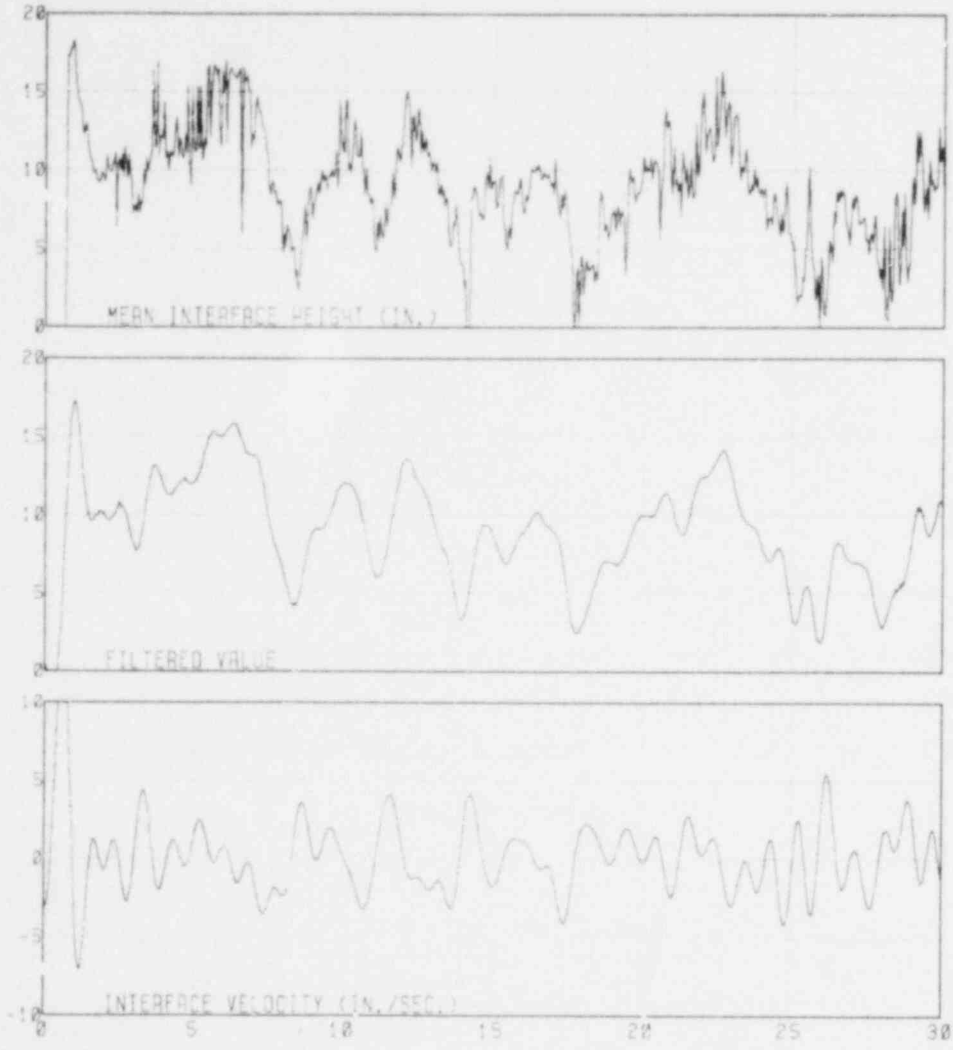


Figure 5. SAMPLE FLOW TOPOGRAPHY DISPLAY OF LIQUID-VAPOR INTERFACE DURING COUNTERCURRENT FLOW



ure 6. SAMPLE ANALYSIS OF VERTICAL MOTION OF LIQUID INTERFACE FOR FLOW TOPOGRAPHY

3 FLASHING TRANSIENTS

On the topic of flashing, several series of experiment ere performed in the 1/15-scale vessel to scope the effects of various parameters. These parameters included

- Break Size (0.25-2.3 in.)
- Initial vessel pressure (20-100 psia)
- Initial plenum liquid volume (2-15.2 gal)
- Reverse core steam mass flow (0-1.5 lbm/sec)

Transient measurements of various system parameters were made and typical results are presented below. Of particular interest is the two-phase mixture behavior in the lower plenum. Oscillatory behavior in the discharge of fluid from the vessel was observed in some tests. In Section 4, comparisons of the typical test data with predictions using RELAP4/MOD5 are presented.

Experimental Facility

The experimental facility used for the flashing transients is sketched in Figure 7. The 1/15-scale vessel was used in the configuration with a deep (15.2 gallon) lower plenum, a scaled annulus gap (0.5 in.), and an oversized broken leg pipe. The size of an orifice in the broken cold leg was varied to effect different blowdown rates.

Key vessel instrumentation included:

- Lower plenum pressure.
- Lower plenum liquid mass. A Δp cell was added to record the transient mass of liquid in the lower plenum. The upper end of the cell was placed inside the core (a stagnation region) and momentum effects in the plenum liquid were small.
- Plenum conductivity probe. By removing the shroud from the conductivity probe, the instrument read the mixture level in the plenum.
- Plenum fluid thermocouples.
- Separator conductivity probe. Although the separator vessel is large and the resolution of the instrument is ± 1 gallon it still gave useful information.
- Steam outflow. To complete the mass balance, an orifice plate measured the steam flow exiting the facility. Capacitance effects due to separator volume had minimal impact on the measurements.

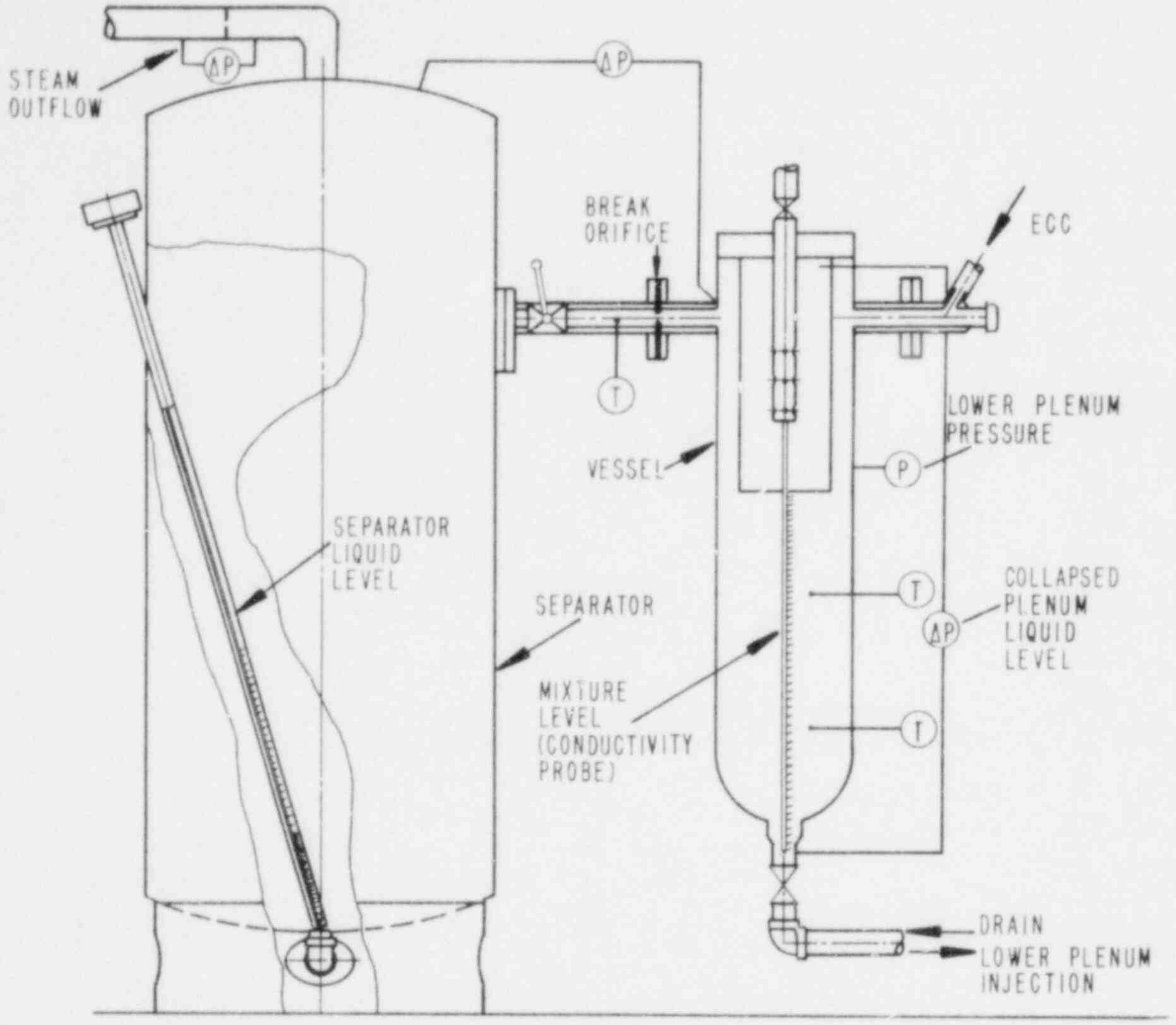


Figure 7. EXPERIMENTAL FACILITY AND INSTRUMENTATION FOR FLASHING TRANSIENT TESTS

- Separator vessel pressure.

- Annulus-to-separator differential pressure.

All instruments were recorded using a PDP 11/70 computer system, at sampling rates from 25-100 samples/sec for each channel.

Test Procedure

A small steam flow was used to pressurize the vessel with the valve in the broken cold leg nearly closed. The plenum was then filled with saturated water at the initial vessel pressure. After the plenum was filled and the initial liquid temperature checked, the steam flow was shut off and the break valve quickly opened. In some tests core steam flow was initiated at the same time the break valve was opened. Tests were concluded when the vessel had depressurized.

Test Results

Typical test results are displayed in Figure 8. This test represents a depressurization from an initial pressure of 45 psia, with the lower plenum initially full. The size of the break orifice was 1.0 in. Figure 8 also displays calculations using RELAP that will be discussed in Section 4.

Figure 8a shows the depressurization history of the vessel. Figures 8b and 8c show the remaining liquid mass and the two-phase mixture level in the lower plenum, respectively. Comparison of these latter two figures shows that most of the liquid mass has been removed from the lower plenum by about 25 seconds after the start of the test. The two-phase mixture level fluctuates near the bottom of the core barrel until about 25 seconds into the transient, and then begins a steady decline (level collapse) lasting until approximately 70 seconds into the transient.

Figure 8d shows the steam mass flow exiting from the separator vessel as a function of time. This flow decays fairly steadily with time over a period of about 70 seconds, consistent with the plenum level collapse. The liquid mass delivered to the separator vessel is shown in Figure 8e. Most of the liquid is delivered in the first 25 seconds of the transient, which is in agreement with the plenum liquid mass data (Figure 8b).

In this test, some oscillations in the plenum pressure and steam outflow are observed. These measurements (from a similar test with a larger break) are shown in Figure 9. Note that when the plenum pressure is at the low end of its oscillation, both the steam outflow and the two-phase mixture level in the plenum are high. The phasing of the oscillations in these measurements is maintained. During the tests, oscillations in the outflow are audible in the lab. These oscillations are similar to those observed by Battelle-Frankfurt [10] in a small glass model (with no core barrel hardware).

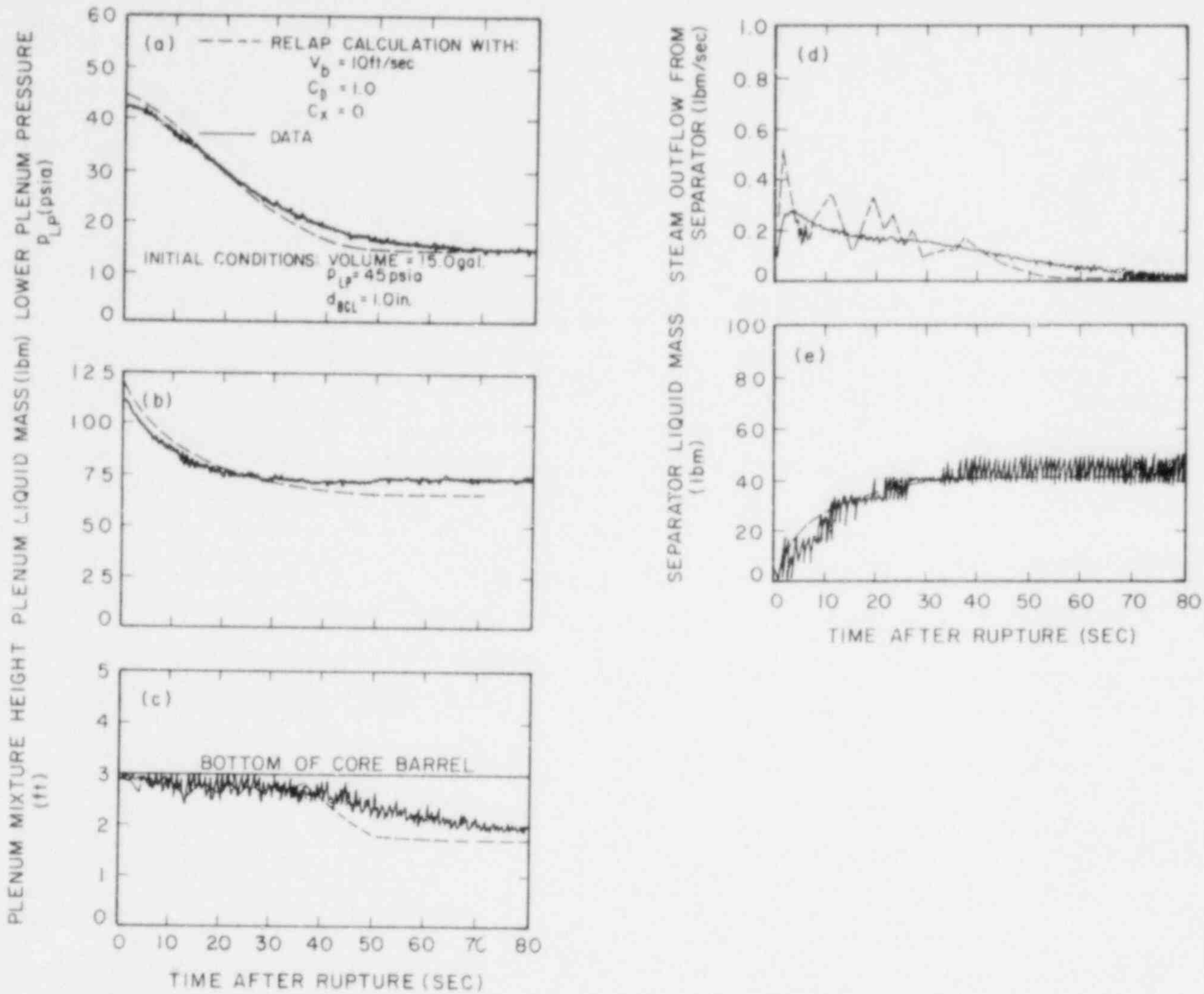


Figure 8. TYPICAL FLASHING TRANSIENT EXPERIMENTAL RESULTS

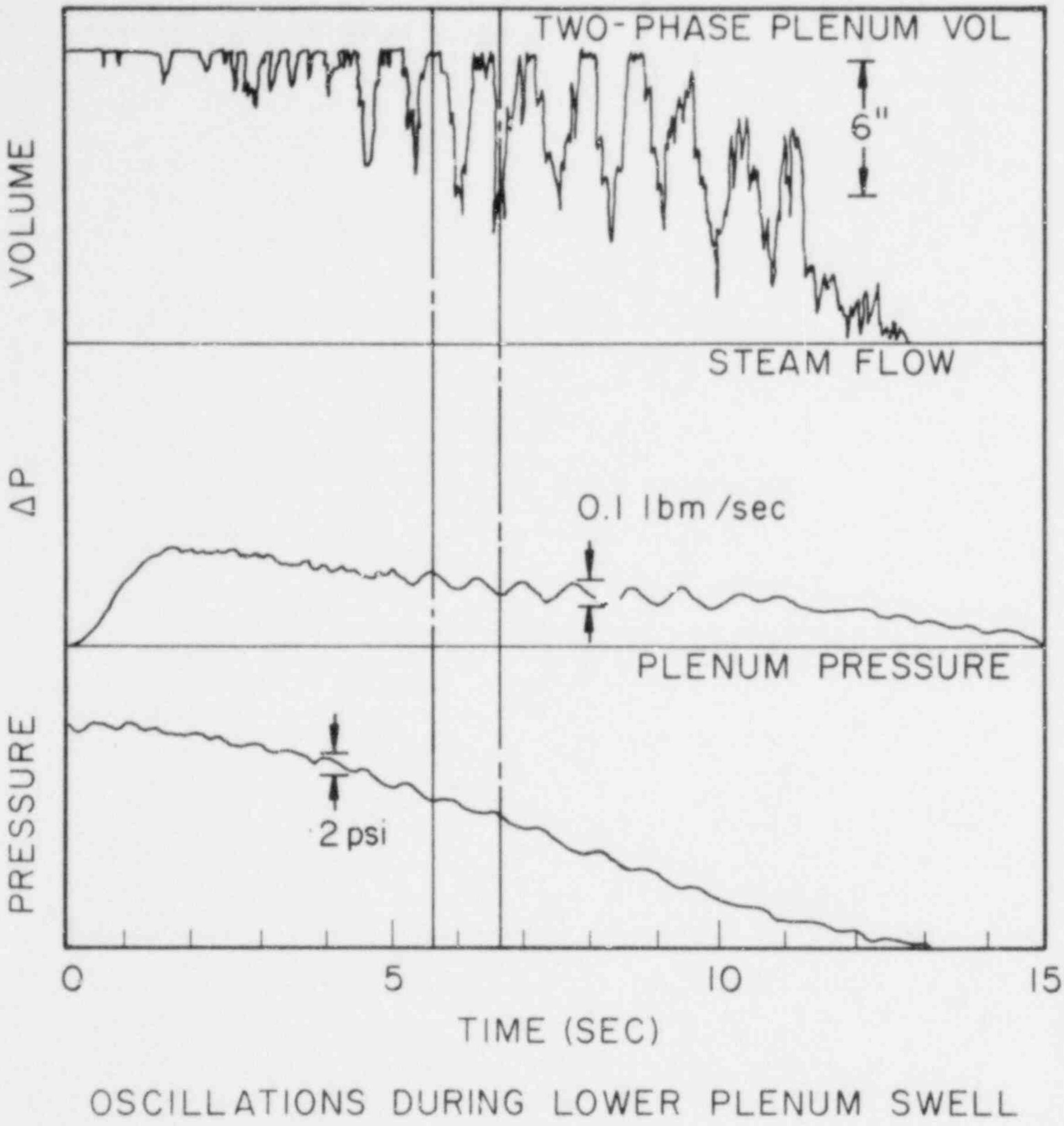


Figure 9. SAMPLE TRACES ILLUSTRATING OSCILLATORY BEHAVIOR DURING FLASHING TRANSIENTS

These data are consistent with a logical sequence of events:

1) reduced vessel pressure causes liquid to flash to steam, swelling the mixture and carrying liquid into the annulus,

2) as the two-phase mixture reaches the break orifice, the break pressure drop increases which mitigates the vessel depressurization,

3) slower depressurization causes less flashing and less carryover,

4) a smaller break pressure drop results which in turn increases the rate of depressurization, and

5) the cycle repeats.

We have described an oscillatory sequence resulting from instability of a simple system comprised of a flow resistance (the break), a compliance (the downcomer and lower plenum volume), an inertance (downcomer momentum) and a source (plenum liquid carryover and flashed steam). Such a system is likely to have regimes of stable and unstable operation as its nominal characteristics are varied.

One potential effect of these oscillations is a tendency to enhance liquid delivery to the plenum during periods of reduced break flow. Another potential effect is the promotion of early swell into and rewet of the core as intermittent downcomer liquid inventory is driven back into the plenum while the plenum is full of swelled two-phase fluid. Experiments such as Semiscale and LOFT, where the downcomer is very long and the ratio of downcomer to lower plenum volume is very oversized, will tend to distort the occurrence and effects of these potentially beneficial system flow instabilities.

Flow oscillations also tend to influence the accuracy of measurements made in the break using devices such as turbine meters. Corrections for the transient response of the device may become significant and should be reflected in uncertainty estimates.

Figure 10 summarizes the results of tests with four different break sizes and various initial pressures. The liquid fraction remaining in the lower plenum at the end of each test is plotted as a function of break size for the various pressures. It is shown that the remaining liquid fraction decreases with increasing break size or initial plenum pressure. It is also seen that even a very small blowdown pressure difference of 5 psi (initial pressure 20 psia) depletes vessel liquid mass by 40% whereas a much higher pressure difference of 85 psi depletes vessel liquid mass by 70% of its initial value.

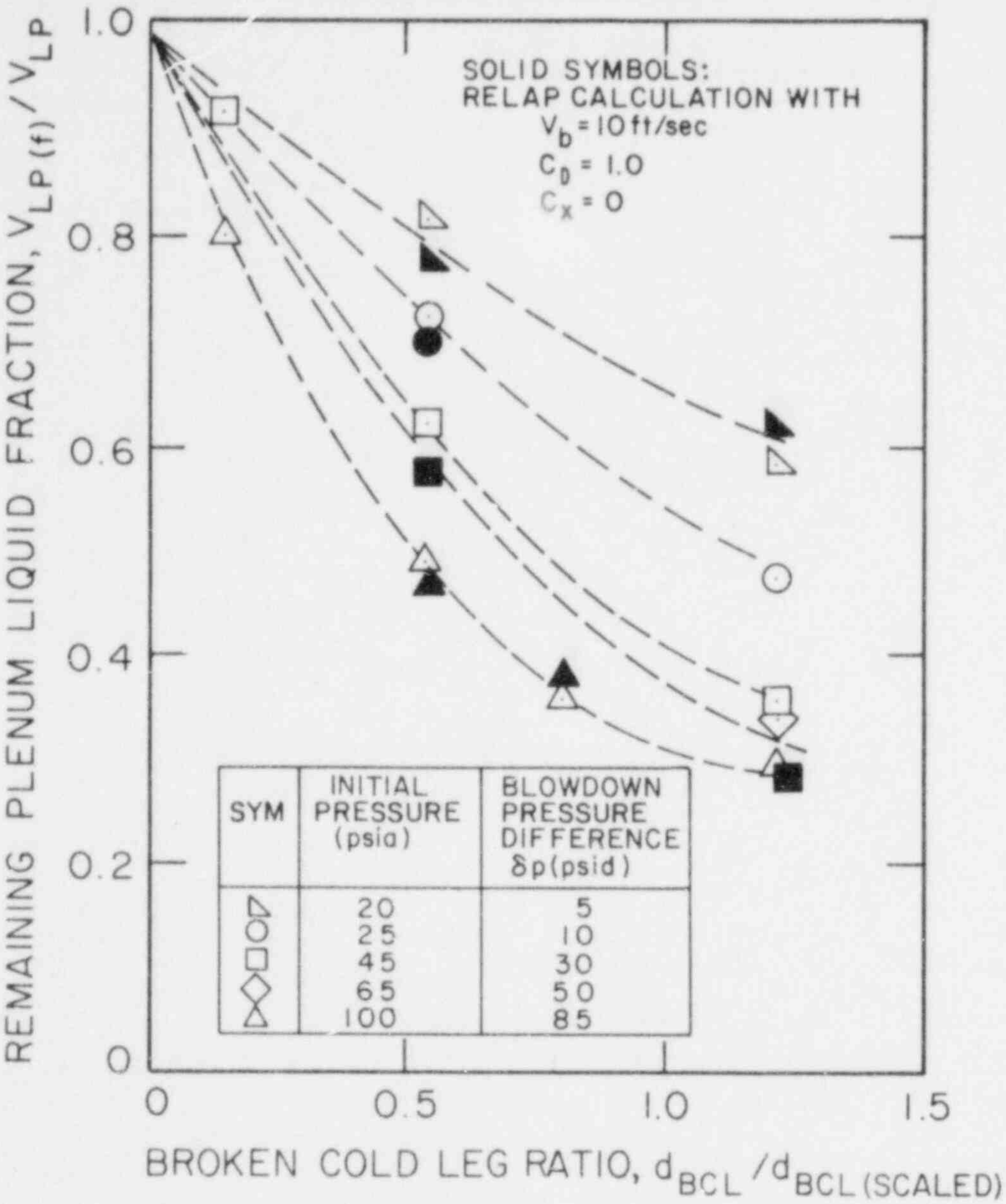


Figure 10. REMAINING PLENUM LIQUID FRACTION FOR SEVERAL BREAK ORIFICE SIZES IN FLASHING TRANSIENTS AT VARIOUS PRESSURES

Future Work

Flashing transient experiments which include hot leg breaks as well as cold leg breaks are planned. The distribution of liquid between the cold and hot leg sides of the break will be explored. It is also planned to study the parameters of vessel geometry, ECC injection rate and timing, ECC subcooling, and separator pressure in experiments during the next two quarters.

4 REFILL MODELING WITH RELAP

During the quarter, RELAP4/MOD5 has been used to predict the results of the flashing transient tests like those discussed in Section 3. RELAP successfully predicts the depressurization of the 1/15-scale vessel if a bubble rise velocity of 10 ft/sec is assumed in the lower plenum. Physically, this large value of V_b should be interpreted as an approximation to phase slip rather than as a literal velocity of single bubbles rising in liquid where V_b=1 to 3 ft/sec.

Nodalization

In modeling the 1/15-scale vessel and facility, RELAP has been nodalized with seven volumes, six junctions, and two heat slabs. The bubble rise velocity model has been used in the lower plenum region.

Comparison With Data

The RELAP input variables used in the prediction of the tests summarized in Figure 10 (Section 3) are a constant bubble rise velocity V_b=10 ft/sec, a discharge coefficient C_D=1.0, and a homogeneous bubble distribution C_x=0 in the lower plenum. As shown by the solid symbols, this model successfully predicts the mass of liquid remaining in the plenum at the end of each test, over a wide range of conditions.

The detailed transient predictions and the data are compared in Figure 8 (Section 3). The depressurization period (Figure 8a) is fairly well predicted, though the calculated value (about 50 seconds) is less than the experimental value (60 seconds). The plenum liquid mass transient (Figure 8b) is predicted very well. The two-phase mixture level (Figure 8c) is predicted to begin to decrease slightly late and then drops too rapidly, although the final level is approximately correct. The steam outflow (Figure 8d) is also well predicted if some oscillations in the RELAP prediction are averaged. The liquid mass transient in the separator vessel (Figure 8e) is also predicted well. Thus, RELAP closely predicts our test results, with the least accuracy in predicting the two-phase mixture level in the lower plenum.

Model Sensitivity

The effect of the parameter C_d in the analysis is to alter the time that the depressurization lasts. Typically, the value of C_d could range from 0.6 to 1.0. The value C_d=1.0 has been used here. Smaller values of C_d will lengthen the depressurization but will also result in more liquid remaining in the lower plenum. Still, a V_b in the range of 10 ft/sec is needed to predict the remaining liquid mass.

The third parameter, C_x represents the distribution of bubbles in the lower plenum with C_x=0 being homogeneous distribution and C_x=1 being the equivalent of a separated model (high V_b). C_x=0 is the recommended value [11] for most calculations and visual observations in the transparent vessel also indicate good mixing in the plenum during flashing transients. When $0<C_x<0.5$ there is little effect on the calculations so C_x=0 is used.

Future Work

During the quarter, the correlation of Wilson [12] for rise velocities of steam bubbles was implemented in RELAP/MOD5. This correlation relates the bubble rise velocity as a function of void fraction and calculates bubble rise velocities of about 10 ft/sec at void fractions obtained experimentally in the flashing transients. Thus, we expect the use of the Wilson correlation to improve our calculations and help unify available data from various programs. Predictions using this model are currently being compared with experimental data and the results will be presented next quarter.

During the next quarter, it is also planned to use RELAP to predict the results of tests with other parameter variations mentioned in Section 3.

5 PROGRESS SUMMARY

D··ing this quarter, RELAP4/MOD5 has been used to calculate the resul·s of flashing transient experiments and has been shown to give good agreement with data when a bubble rise velocity of 10 ft/sec is used in the lower plenum. On the condensation-induced transients task, a condensation model has been added to the break pressure drop analysis which allows pressure drops to be calculated at intermediate ECC subcooling. On the topic of flow topography, analysis and visual displays for the steam/water interface and the motion of the interface have been developed. For Lower Plenum Voiding, comparisons between Creare and Dartmou·h College voiding data have shown good agreement between air/water and steam/water experiments. In support of the Research Information Letter on ECC bypass C···re has released a DRAFT document summarizing the results of ECC bypass research at small scale.

Flashing transient experiments and analysis are the major thrust of the current program. Work in this area is pro·eeding according to plan. Both condensation-induced transients and lower plenum voiding are receiving reduced emphasis as a result of mid-year review discussions. Work in these areas is proceeding at a low level for the remainder of this year and will be discontinued in the next fiscal year. The major portion of the work in support of the Research Information Letter is completed, although some follow-up work is expected after review of the documents. Flow topography efforts will continue at approximately the same level currently in effect for the next quarter.

REFERENCES

1) Rothe, P. H. and Crowley, C. J.; SUMMARY OF FY78 PROGRESS ON CREARE REFILL EFFECTS PROGRAM; Quarterly Progress Report July 1 - September 30, 1978; Creare Technical Note TN-291 (NUREG/CR-0600), January 1979.

2) Crowley, C. J. and Rothe, P. H.; ANALYSIS OF SUPERHEATED WALL EFFECTS DURING REFILL AT SMALL SCALE; Topical Report, Creare Technical Note TN-287 (NUREG/CR-0599), March 1978.

3) Crowley, C. J. and Rothe, P. H.; PROGRESS ON LOWER PLENUM VOIDING; Quarterly Progress Report January 1 - March 31, 1978; Creare Technical Note TN-278 (NUREG/CR-0121), June 1978.

4) Desikan, B., et. al.; LOWER PLENUM VOIDING; Final Report, Thayer School of Engineering, Dartmouth College, September 1978.

5) Crowley, C. J., Rothe, P. H. and Cary, C. N.; FIRST QUARTER FY79 PROGRESS REPORT ON REFILL EFFECTS PROGRAM; Creare Technical Note TN-292 (NUREG/CR-0719), April 1979.

6) Crowley, C. J., Wallis, G. B. and Rothe, P. H.; PRELIMINARY ANALYSIS OF CONDENSATION-INDUCED TRANSIENTS; Quarterly Progress Report July 1 - September 30, 1977; Creare Technical Note TN-27? December 1977.

7) Crowley, C. J., et. al.; PRELIMINARY STUDIES OF FLASHING TRANSIENTS; Creare Technical Memorandum TM-605, September 15, 1978.

8) Rothe, P. H.; COMMENTS IN SUPPORT OF ECC BYPASS RIL; Creare Technical Memorandum TM-637, DRAFT, April 16, 1979.

9) Cary, C. N. and Block, J. A.; A SYSTEM FOR RECORDING AND DISPLAYING TWO-PHASE FLOW TOPOGRAPHIES; Creare Technical Note TN-279, April 1978.

10) Kober, K. J.; INVESTIGATION OF THE BLOWDOWN SIMULATION OF BOILING WATER REACTORS; Part I: Experiments at low Pressures; Battelle-Institute E.V., Frankfurt am Main, August 1968.

11) Idaho National Engineering Laboratory; RELAP4/MOD5 - A COMPUTER PROGRAM FOR TRANSIENT THERMAL-HYDRAULIC ANALYSIS OF NUCLEAR REACTORS AND RELATED SYSTEMS; User's Manual Volume III Checkout Applications, Appendix H (Large Cold Leg Break (Test S-02-9) INEL Semiscale; ANCR-NUREG-1335, September 1976.

12) Wilson, J. F., et. al.; THE VELOCITY OF RISING STEAM IN A BUBBLING TWO PHASE MIXTURE; Trans. of the American Nuclear Society, May 1962.

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ABSTRACT

This report describes work on the Creare Refill Effects Program during the second quarter of FY79. Results are summarized according to the various tasks within the program. Particular results of Flashing Transient experiments and the calculation of test results using RELAP4/MOD5 are discussed. Future plans for each of the program topics are also outlined.

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