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TRAC-PD2
Developmental Assessment

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TRAC-PD2 DEVELOPMENTAL ASSESSMENT

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ABSTRACT

The Los Alamos National Laboratory is developing the Transient Reactor Analysis Code (TRAC) to provide advanced, best-estimate predictions of postulated accidents in light water reactors. The TRAC-PD2 program provides this analysis capability for pressurized water reactors and for many thermal-hydraulic test facilities. The code features a three-dimensional treatment of the pressure vessel and its associated internals; two-phase, nonequilibrium hydrodynamic models; flow-regime-dependent constitutive relations; optional reflood tracking capability for bottom-flood and falling-film quench fronts; and consistent treatment of entire accident sequences including the generation of consistent steady-state conditions. The Los Alamos report, "TRAC-PD2: An Advanced Best-Estimate Computer Program for Pressurized Water Reactor Loss-of-Coolant Accident Analysis," LA-8709-MS (NUREG/CR-2054), provides a detailed code description.

This report describes the final results of the developmental assessment analyses conducted during the later stages of the TRAC-PD2 development. The calculations discussed in this report used the released version of TRAC-PD2 and cover separate-effects blowdown, heat transfer, and downcomer penetration tests together with integral tests from the Loss-of-Fluid Test and Semiscale facilities. Although these calculations are not an exhaustive test of the code, they demonstrate its capabilities, including automatic steady-state initialization and the complete transient from blowdown through refill and reflood. The results show good agreement between the calculated parameters and the data and indicate that the code is applicable to large-break loss-of-coolant accident analyses.

I. INTRODUCTION

The Transient Reactor Analysis Code (TRAC) is an advanced, best-estimate systems code for analyzing light water reactor (LWR) accidents. The Office of Nuclear Regulatory Research of the US Nuclear Regulatory Commission (NRC) sponsors the code development at the Los Alamos National Laboratory. We released TRAC-PD2 (Ref. 1) to the National Energy Software Center (NESC) at the Argonne National Laboratory (ANL) in October 1980. This TRAC version is the third in a series of publicly released codes intended primarily to analyze large-break loss-of-coolant accidents (LOCAs) in pressurized water reactors (PWRs). However, because of the generality incorporated into the thermal-hydraulic modeling, TRAC-PD2 can be applied directly to small-break LOCAs and some non-LOCA transients. The generality of the code also permits direct application to a large variety of analyses ranging from blowdowns in simple pipes to integral LOCA tests in multiloop test facilities to separate-effects tests. The Idaho National Engineering Laboratory (INEL) is developing a TRAC version for application to boiling-water reactors (BWRs). We will improve various models and the numerical techniques in future TRAC versions to facilitate and to enhance applications to small-break LOCAs and non-LOCA transients and to expand applications to a much wider range of non-LOCA transients.

Reference 1 describes the TRAC-PD2 code. The code is completely modular by component and by function. One-dimensional components (PIPE, TEE, VALVE, PUMP, PRIZER, ACCUM, and STGEN) describe pipes, tees, valves, pumps, pressurizers, accumulators, and steam generators. The VESSEL component provides a two-dimensional, Cartesian-geometry or a three-dimensional, cylindrical-geometry hydraulic description for a vessel and its related internals, including the reactor core. The FILL and BREAK components provide velocity and pressure boundary conditions, respectively. The one-dimensional components use a five-equation, drift-flux hydraulic model. The VESSEL component implements a complete, two-fluid, six-equation hydraulic model; thus, the code can model nonhomogeneous, nonequilibrium fluid conditions. The required constitutive relations are dependent upon the flow regime. The code also provides a comprehensive heat-transfer capability. The one-dimensional components, except for the ACCUM and the PRIZER, represent pipe walls with a one-dimensional heat-conduction solution. Lumped-parameter heat slabs represent the structural mass in the VESSEL component. The core fuel rods (or fuel-rod simulators) are represented by a two-dimensional conduction solution with dynamic fine-mesh rezoning in the axial direction to resolve large temperature gradients associated with both bottom-reflood and falling-film quench fronts. These combined code attributes provide a consistent code input and thermal-hydraulic analysis capability for generating the steady-state initial conditions and for calculating the entire LOCA sequence, including blowdown, refill, and reflood. Although the code permits renoding on restart, renoding is not required. The TRAC-Plot (TRAP) graphics program produced most of the graphics in this report.

Code assessment is a two-stage process. The first stage is the developmental assessment that is coupled closely to the code-development process. Developmental assessment principally involves posttest analyses of various thermal-hydraulic experiments. The developmental assessment primary objectives are to define the validity limits for the methods, models, and correlations in the developmental version of the code and to establish values for various empirical parameters; these objectives are achieved by comparing the calculated results with experiment data. Other objectives include the determination of code sensitivity to input data, model assumptions, and solution techniques; the recommendation of standard calculational procedures for various classes of problems; and the identification of code and model improvements or additional experiments needed to assess the advanced TRAC models.

Independent assessment is the second stage of the assessment process. Independent assessment uses publicly available, documented TRAC versions and pretest and posttest analyses. The primary objective is to determine the predictive capability of the code when applied to new tests involving different scales and facility configurations. All of the developmental assessment objectives also apply to independent assessment; however, in independent assessment, the results are factored into the future code development without updating the current, released code. Discrepancies between the calculations and the data are resolved by performing additional posttest analyses, as required. Guidance for future code development and recommendations for future experiments also are provided.

The final TRAC-PD2 developmental assessment results are reported here. We performed these analyses with the released TRAC-PD2 version; therefore, these analyses provide the initial independent assessment results for TRAC-PD2. Table I summarizes the experiments analyzed and the code areas tested. Six of the analyses in Table I involved only the one-dimensional capability of TRAC-PD2, and the remaining analyses invoked the TRAC-PD2 VESSEL component in a two-dimensional Cartesian geometry or a three-dimensional cylindrical geometry in combination with one-dimensional components. The developmental assessment analyses included separate-effects tests that generally involved one type of component; systems-effects tests that coupled several components in a single LOCA transient phase (either blowdown, refill, or reflood); and integral tests that involved several components through multiple LOCA transient phases.

The order in which Table I lists the tests reflects the order in which the tests are discussed in this report. The Edwards' pipe blowdown is relatively simple to model and provides a test of many constitutive relations in the code. The two Centro Informazoni Studi Experienze (CISE) tests are slightly more complicated than the Edwards' pipe blowdown and test the wall friction and heat-transfer correlations. The Marviken vessel blowdown tests are really very large scale critical-flow tests that also check the slip correlations.

The Thermal-Hydraulic Test Facility (THTF) provides a good test of the heat-transfer correlations in a rod bundle during blowdown. The Bennett tube experiments investigated critical heat flux (CHF) and tested the wall heat transfer in the code. The Creare tests provided data on emergency core-cooling (ECC) bypass, an important phenomenon in the LOCA blowdown phase; we used these tests to check the calculated flooding behavior in the vessel downcomer. The Full-Length Emergency Core Heat-Transfer (FLECHT) analyses tested the heat-transfer correlations and quench-front tracking during slow and fast refloods.

The Semiscale Mod-1 Test S-02-8 provided data during the blowdown phase in an integral PWR simulator with an electrically heated core. We conducted the Semiscale-nozzle critical-flow analyses primarily to investigate the noding sensitivity of the critical-flow calculation. Test S-06-3 was similar to Test S-02-8 but continued the transient through the refill and reflood phases of the large-break LOCA transient. The Loss-of-Fluid Test (LOFT) facility is a 50-MWt PWR designed to simulate the large-break LOCA. LOFT L1-4, without the nuclear core, provided blowdown and refill data at a much larger scale than the

TABLE I

TRAC-PD2 DEVELOPMENTAL ASSESSMENT ANALYSES

Number	Experiment	Thermal-Hydraulic Effects
1	Edwards' Horizontal-Pipe Blowdown (Standard Problem 1)	Separate effects, one-dimensional critical flow, phase change, slip, and wall friction
2	CISE Unheated-Pipe Blowdown (Test 4)	Same as (1) plus wall heat transfer, flow-area changes, and gravitational effects
3	CISE Heated-Pipe Blowdown (Test R)	Same as (2) plus CHF
4	Marviken Full-Scale Vessel Blowdown (Tests 4 and 24)	Same as (1) plus full-scale effects
5	THTF (Test 177)	Systems effects, two-dimensional Cartesian-geometry vessel model with rod heat transfer and rewet models
6	Bennett Tube Experiments	Separate effects, wall heat transfer, CHF, phase change, and slip
7	Creare Countercurrent Flow Tests	Systems effects, countercurrent flow, interfacial drag and heat transfer, and condensation with the VESSEL component
8	FLECHT Forced-Flooding Tests (Tests 17201 and 4831)	Systems effects, reflood heat transfer, quench-front propagation, and liquid entrainment and carryover
9	Semiscale Mod-1 Test S-02-8	Integral synergistic effects, one-dimensional flow, phase change, slip, wall friction, nozzle critical flow, three-dimensional vessel with rod heat transfer including nucleate boiling, departure from nucleate boiling (DNB), and post-DNB

TABLE I (cont.)

Number	Experiment	Thermal-Hydraulic Effects
10	Semiscale-Nozzle Critical Flow	Separate effects, one-dimensional critical flow with area change
11	Semiscale Mod-1 Test S-06-3	Same as (9) plus reflood heat transfer, quench-front propagation, and liquid entrainment and carryover
12	LOFT Nonnuclear L1-4	Integral effects during blowdown and refill, larger scale than Semiscale
13	LOFT Nuclear L2-2	Same as (11) at larger scale

Semiscale facility. LOFT L2-2, with the nuclear core installed and operating at 50% power, provided data throughout the entire LOCA. We used these integral tests in Semiscale and LOFT basically to check the entire code, including the constitutive relations, the thermal-hydraulic modeling, the numerical techniques, all of the components, and the coupling of the components into a system model.

All of the analyses in Table I are discussed in the following chapters. For each we briefly describe the facility, test, and TRAC-PD2 input. We compare the calculated results with data and discuss the results and conclusions. Section XIV summarizes the overall conclusions.

II. EDWARDS' BLOWDOWN EXPERIMENT

A. Experiment Description

The Edwards' horizontal-pipe blowdown experiment studied depressurization phenomena of initially nonflowing subcooled water.[2] The test apparatus, a 4.096-m straight steel pipe with a 0.073-m i.d., was designed for a maximum 17.24-MPa pressure at temperatures to 616.5 K. The discharge end of the horizontal pipe was sealed with a 0.0127-m-thick glass disk.

The pipe was evacuated by a vacuum pump before it was filled with demineralized water. A hydraulic pump and a control valve regulated the system pressure. Before the glass disk was ruptured, the pipe was isolated from the supply tank to prevent the discharge of cold water into the pipe during blowdown. The pipe, which was insulated with asbestos, was heated electrically. Figure 1 shows the gauge stations GS-1 to GS-7 where the pressure transducers were located. Also located at GS-5 were two aluminum-alloy disk windows that were used to measure transient void fractions through an x-ray absorption system and a temperature transducer.

The operating procedure required that degassed water completely fill the pipe. The cold pipe was checked for leaks after the initial pressurization to the 7-MPa test pressure. Next, the pressure was reduced to 3.45 MPa and heat was applied gradually for ~1.5 h. Although the water temperature increased, the system pressure was maintained at ~3.45 MPa above the saturation pressure to prevent liquid flashing. Each heater had a voltage control that was used to control the temperature variation along the pipe. Initially, the system was brought to an approximately uniform 515 K and 7 MPa. Because the isolating valve between the pipe and the storage tank was closed, the glass disk ruptured and the data were recorded automatically.

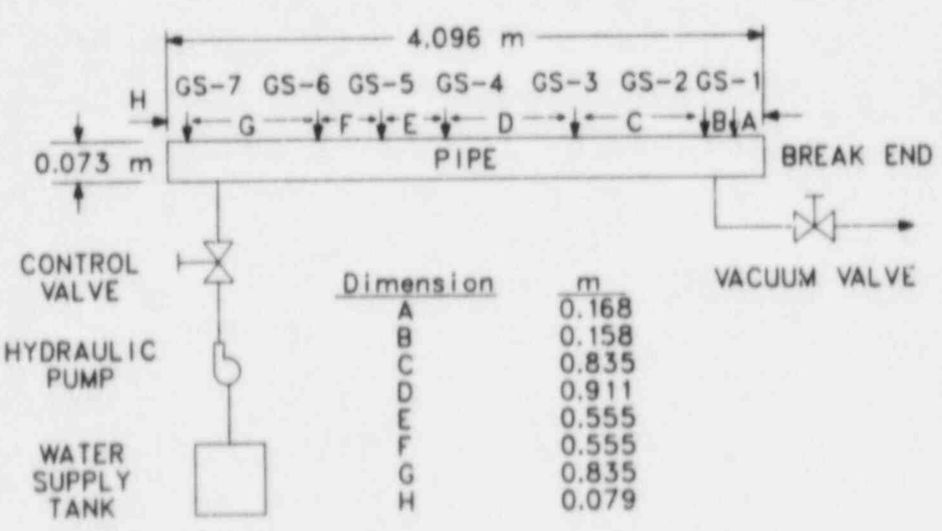


Fig. 1.
Edwards' blowdown-experiment configuration (adapted from Ref. 2).

B. TRAC-PD2 Model

The test apparatus was a straight horizontal pipe with one abrupt area change at its exit. Figure 2 shows the one-dimensional components used to model this experiment. The model included three types of components (BREAK, FILL, and PIPE) coupled in series. The 2 PIPEs were subdivided into 46 fluid cells. We performed a noding sensitivity study[3] to determine the TRAC noding (Figs. 3-5). Table II lists the locations of the measured and the calculated quantities. After a parametric study,[3] we set the annular-flow friction-factor correlation option (NFF = 4). Also, we selected an additive loss coefficient (FRIC), equal to 1.436, for the exit flow cell. This FRIC value accounted for form losses at the break caused by the two-dimensional effects that could not be simulated by the one-dimensional model. For the TRAC-PD2 developmental assessment, we used the best-estimate model developed for TRAC-P1A.

With initial conditions of uniform pressure, approximately uniform temperature, and zero-flow velocity, no steady-state calculations were required. Because the temperature distribution along the pipe may have varied as much as 9 K, an adjusted temperature distribution was used, as suggested by

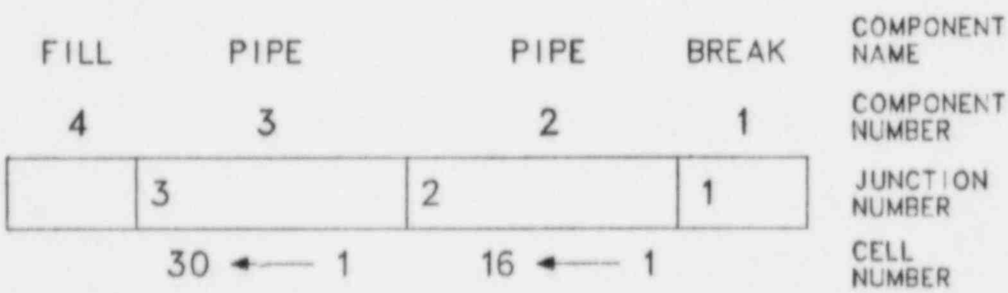


Fig. 2.
TRAC component diagram for Edwards' blowdown experiment.

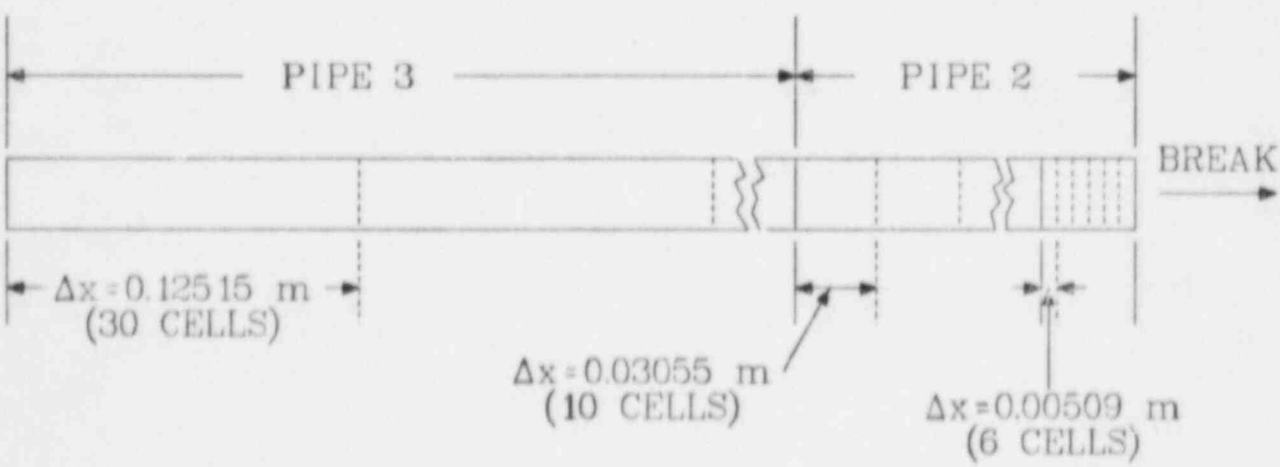


Fig. 3.
TRAC noding diagram for components 2 and 3.

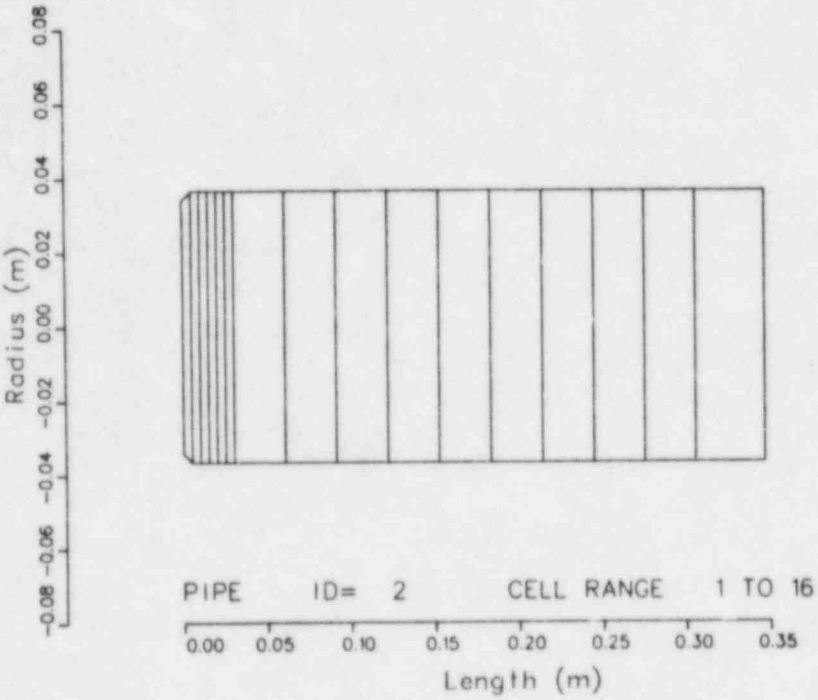


Fig. 4.
TRAP-generated noding diagram of PIPE 2 for Edwards' blowdown experiment.

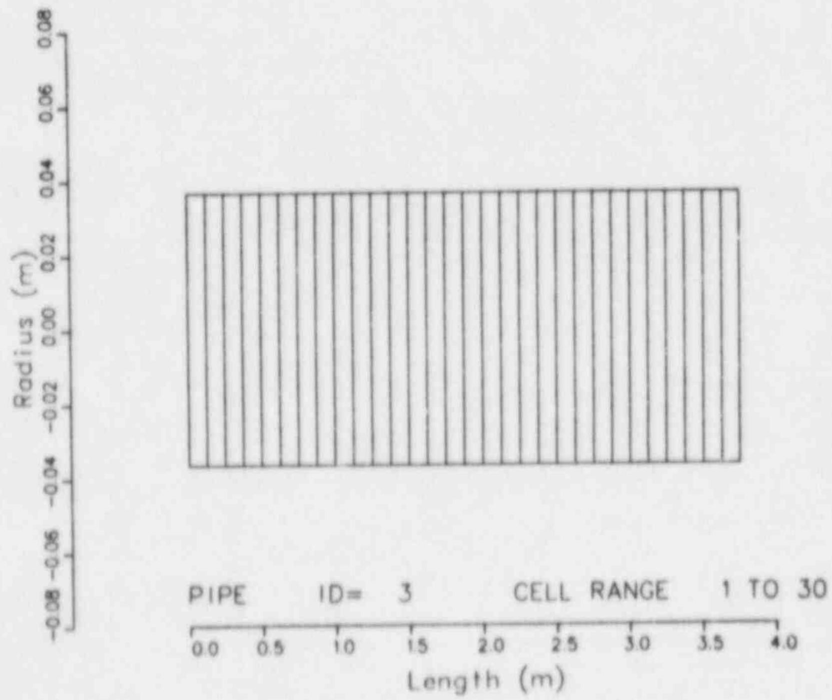


Fig. 5.
TRAP-generated noding diagram of PIPE 3 for Edwards' blowdown experiment.

TABLE II

LOCATION OF MEASURED AND CALCULATED QUANTITIES
FOR THE EDWARDS' BLOWDOWN EXPERIMENT

Measured		Calculated	
Gauge Station	Parameter	Component	Cell
GS-7	Pressure (Pa)	PIPE 3	30
GS-6	Pressure (Pa)	PIPE 3	23
GS-5	Pressure (Pa)	PIPE 3	19
GS-5	Temperature (K)	PIPE 3	19
GS-5	Void fraction	PIPE 3	19
GS-1	Pressure (Pa)	PIPE 2	11

Garner.[4] Linear interpolation was used to obtain initial temperatures at locations other than those given for the initial temperature distribution.

The FILL imposed a zero-velocity boundary condition at the closed end of the pipe. The BREAK specified a fixed 0.10-MPa boundary condition at the broken end of the pipe. The PIPE adjacent to the BREAK used the fully implicit hydrodynamics option (IHYDRO = 1) to model the high-flow velocities at the break. The other PIPE used the more efficient, partially implicit hydrodynamics option (IHYDRO = 0).

Appendix A lists the TRAC input data deck for the Edwards' blowdown experiment.

C. Data Comparisons

The calculated pressures for GS-1, GS-5, GS-6, and GS-7 (Figs. 6-9, respectively) were similar to the test results. The following observations apply to all the pressure results. From 0.0-0.2 s, the calculated pressures were within ~10% of the test values. During the midrange of the transient, 0.2-0.4 s, a faster depressurization rate was predicted than was observed. The maximum difference between the calculation and the experiment was 0.7 MPa at 0.25 s for GS-6. For the balance of the transient, 0.4-0.6 s, the calculated results agreed well with the test results. Experiment uncertainty information was not available; however, an uncertainty of ~0.3 MPa was suggested.[4]

Figure 10 compares the calculated fluid temperature with the fluid temperature measured at GS-5. After 0.2 s, the calculated saturation, liquid, and vapor temperatures were equal. The agreement with the measured temperature was excellent from 0.0-0.2 s; after 0.2 s, the calculated results dropped ~6% below the test results. Figure 11 compares the calculated and measured void fractions. The comparison was fair from 0.0-0.3 s and good after 0.3 s. The void fraction was greater than 90% after 0.3 s. The deviations between the calculated and the test results may have occurred partially because the void fraction was difficult to measure when the x-ray absorption technique was used.

D. Conclusions

This problem included some important thermal-hydraulic effects such as one-dimensional critical flow, flashing, slip, wall friction, and break flow-area reduction. Code components tested included the PIPE, FILL, and BREAK.

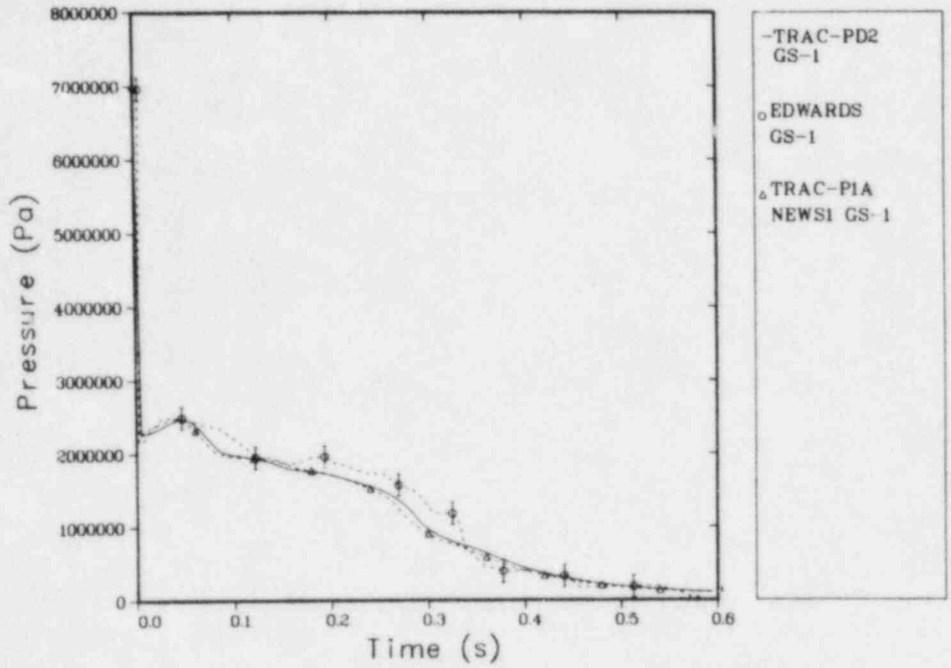


Fig. 6.
Pressure at GS-1 for Edwards' blowdown experiment.

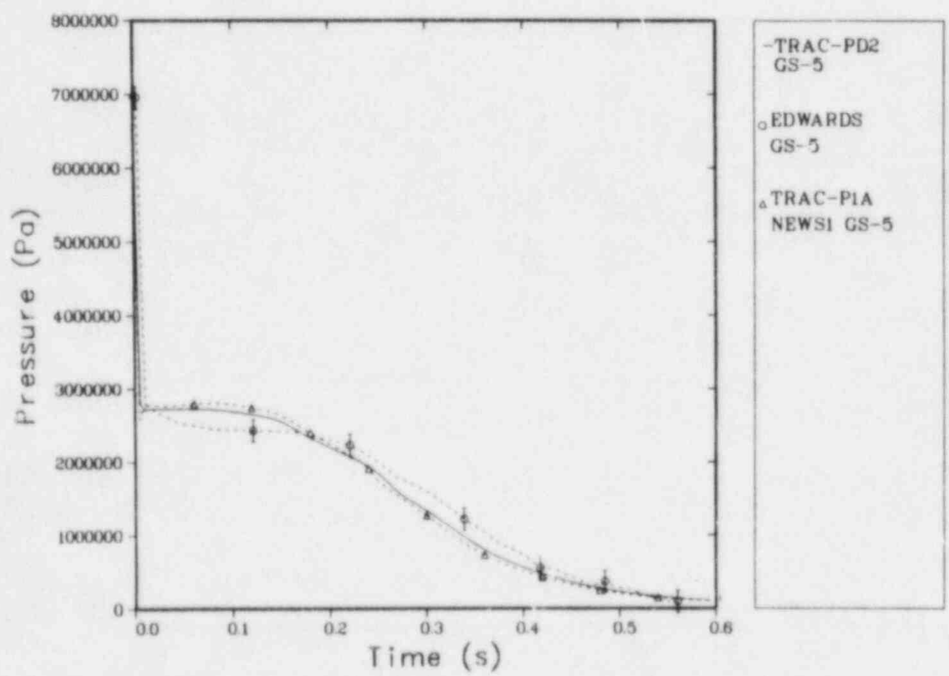


Fig. 7.
Pressure at GS-5 for Edwards' blowdown experiment.

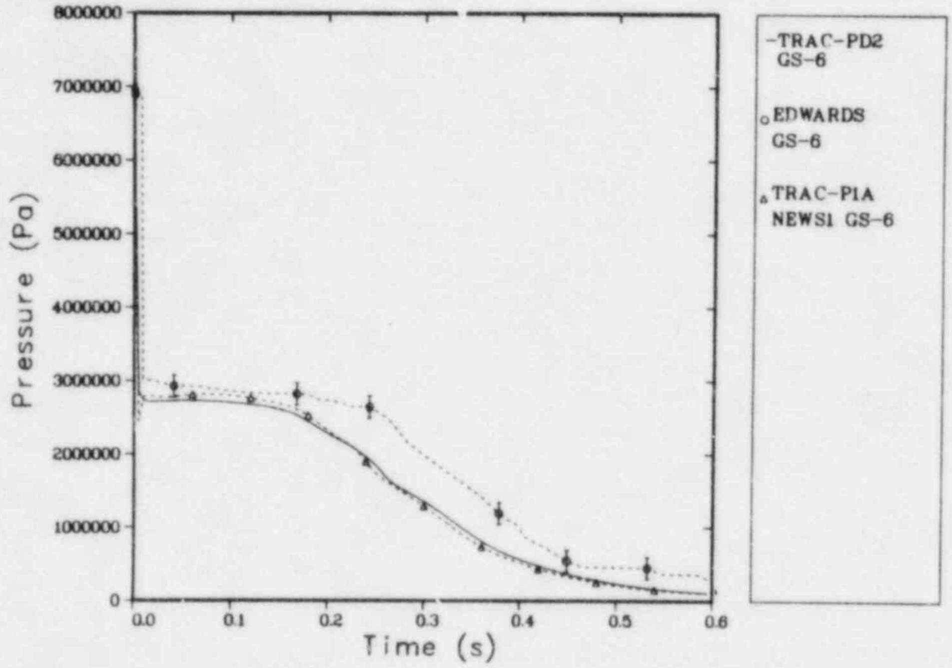


Fig. 8.
Pressure at GS-6 for Edwards' blowdown experiment.

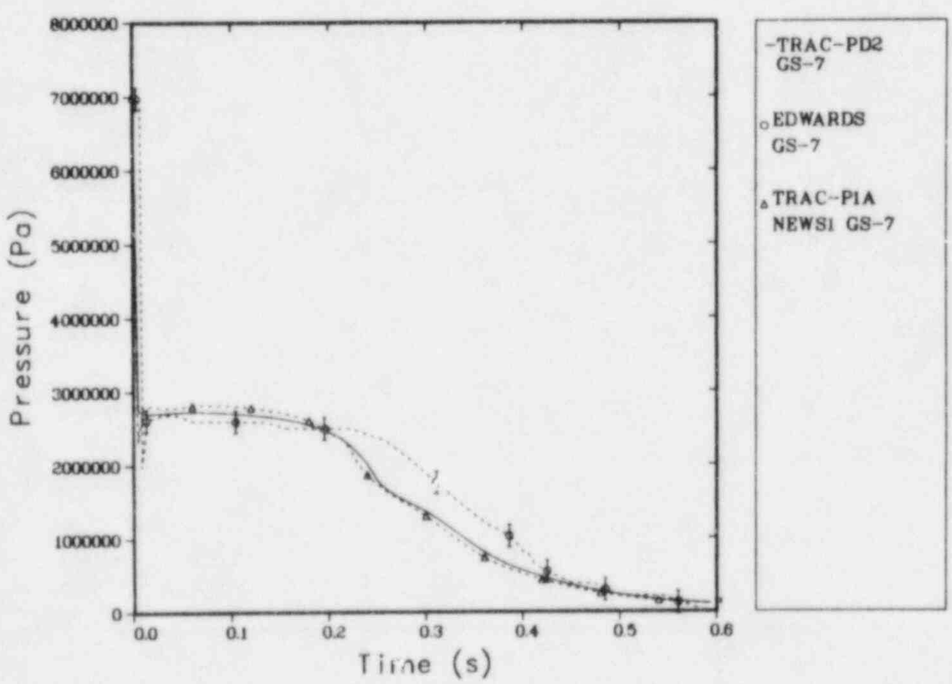


Fig. 9.
Pressure at GS-7 for Edwards' blowdown experiment.

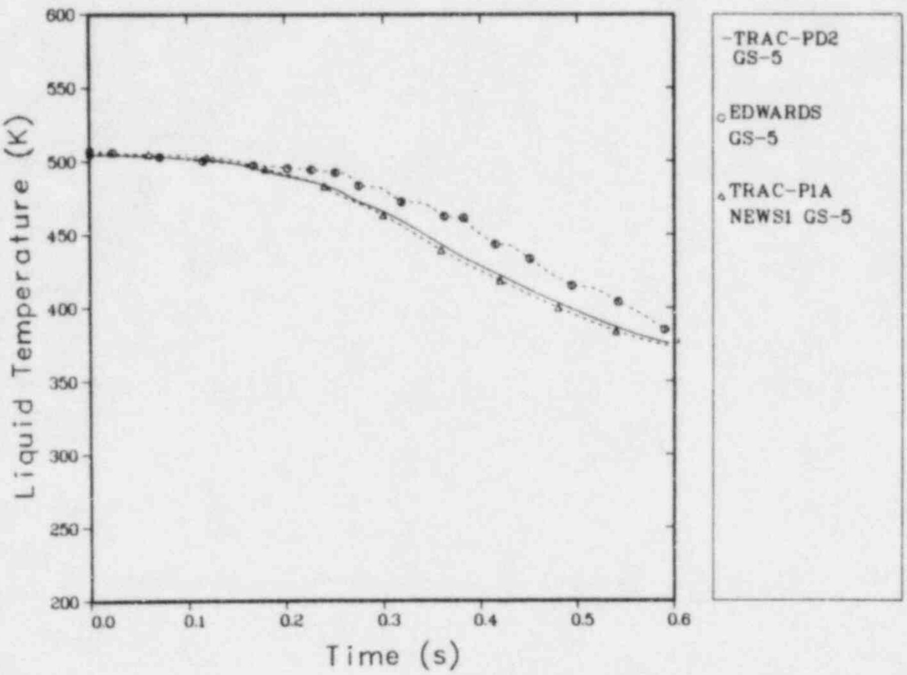


Fig. 10.
Liquid temperature at GS-5 for Edwards' blowdown experiment.

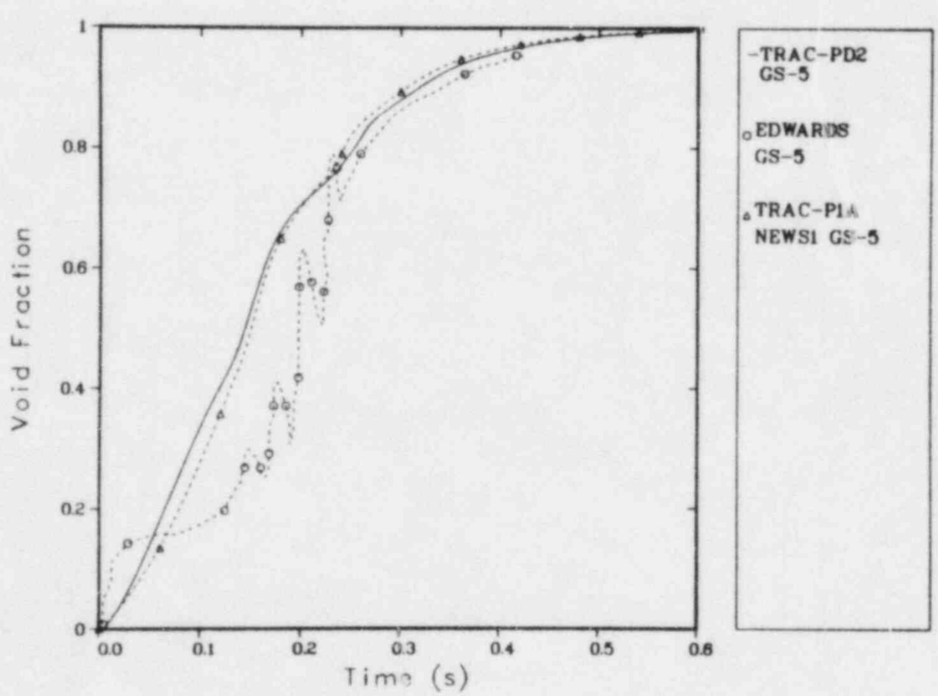


Fig. 11.
Void fraction at GS-5 for Edwards' blowdown experiment.

The TRAC-PD2 results were similar to the TRAC-P1A calculated values and, in general, were in slightly better agreement with the measurements than those from TRAC-P1A. The TRAC-PD2 calculations were in reasonable agreement with the test measurements. The mass flows and the pipe-wall temperatures were not measured. Also, there were uncertainties in the initial temperature distribution, the rupture-disk dynamics, and the effect of residual disk fragments on the flow field. Because of these factors, we cannot recommend code model improvements based on our developmental assessment analysis of the Edwards´ experiment.

The transient calculation required 31 s of central-processor-unit (CPU) time on a Control Data Corporation (CDC) 7600 computer.

III. CISE BLOWDOWN EXPERIMENTS

A. Experiment Description

The CISE vertical-pipe blowdown experiment studied depressurization and heat-transfer phenomena of initially flowing subcooled water.[5] Figure 12 shows the CISE blowdown-loop test section. Stations P4 and P7 measured the pressure, stations TF4 and TF7 measured the fluid temperature, and station THW4 measured the temperature of the heated wall. The loop consisted of the feeder, heater, and riser sections. Table III lists the test-section dimensions. Figure 13 shows a test-section schematic. The internal diameters of the loop tubing ranged from 0.01694 m for the feeder to 0.02618 m for the riser. The blowdown portion of the loop was 24.06 m long. The heated section was vertical, whereas the feeder and riser tubes were coiled helically with a ~1-m radius resulting in elevation changes of 3.6 m and 1.455 m, respectively. Tests were run with and without heat in the heater section so that comparisons could be made. We performed calculations for unheated Test 4 and heated Test R. All tubing was

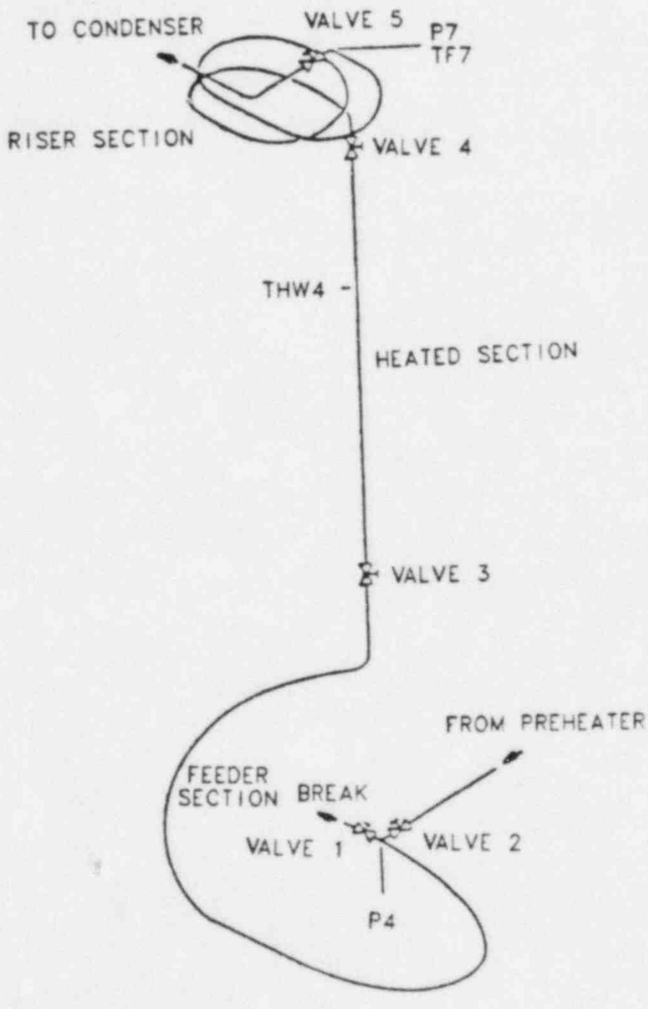


Fig. 12.
CISE test section (adapted from Ref. 6).

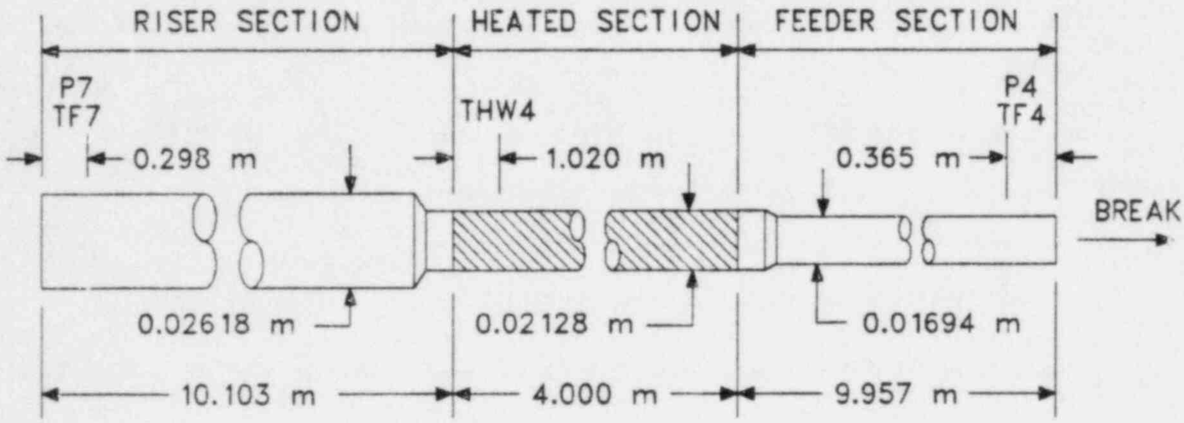


Fig. 13.
CISE test-section geometry.

TABLE III

CISE TEST-SECTION DIMENSIONS

Tube Section	Length (m)	Diameter (m)	Volume (m^3)	Wall Thickness (m)	Elevation Change (m)
Feeder	9.848	0.01694	2.22×10^{-3}	0.0015	3.600
Transition	0.072	0.01694	1.62×10^{-5}	0.0015	4.222
Transition	0.042	0.02128	1.49×10^{-5}	0.0020	4.222
Heated	4.000	0.02128	1.42×10^{-3}	0.0020	4.222
Transition	0.108	0.02128	3.84×10^{-5}	0.0020	4.222
Riser	9.995	0.02618	5.38×10^{-3}	0.0020	1.455

AISI-304 stainless steel. Only the feeder and riser tubes were insulated to reduce heat loss.

One quick-closing or quick-opening valve (valve 1) and four quick-closing valves (valves 2-5) were used to isolate not only the test section from the loop during blowdown but also the contents of the feeder, heated section, and riser. All valves were gas activated and closed or opened within 10 ms. These valves when fully opened offered no additional resistance to the flow. A 300-kW controllable power supply generated uniform axial heat in the heated section of the tube wall. For the heated test, 109.5 kW were supplied to the heater section during blowdown.

Pressure and temperature transducers were located along the test section, as indicated in Fig. 12. All transducers were connected to a digital data-acquisition system, but only selected transducers were connected to the analog strip-chart recorders.

The operating procedure required that the experiment begin with subcooled water flowing under steady-state conditions through the test loop. At time zero, depressurization was initiated by closing valves 2 and 5 and simultaneously opening valve 1, the discharge valve. Thus, the test section was isolated from the remainder of the loop in less than 20 ms. The test section discharged the liquid to the atmosphere; however, the energy input to the heater section was maintained at the initial rate. Pressure, fluid temperature, and heater wall temperatures were recorded continuously. The mass inventory was determined at selected stages of the blowdown by simultaneously closing valves 1, 3, and 4. This procedure not only isolated the contents of the feeder, heated section, and riser, but also allowed the contents to be drained through a condenser and to be weighed. The experiment was terminated when the heated-section wall temperature exceeded ~873 K.

B. TRAC-PD2 Model

The test section, composed of three tubes of different sizes connected by gradual area transitions, was modeled with the one-dimensional TRAC-PD2 components shown in Fig. 14. The model included three types of components (BREAK, FILL, and PIPE) coupled in series. The noding given in Figs. 15-19 was based on our noding sensitivity study.[3] As a result of this noding, the 4 PIPEs were subdivided into 38 fluid cells. Table IV lists the locations of the measured and calculated quantities. We set NFF to 4, based on our parametric study.[3] Gravitational effects and flow-area changes were included in the modeling. For the heated-pipe blowdown experiment, the CHF option, ICHF, was set to 1 and the outer-wall heat-transfer coefficient (HTC) to vapor, HOUTV, was set to 50 $W \cdot m^{-2} \cdot s^{-1}$ in PIPE3. Again, we used the best-estimate model developed for TRAC-P1A in this assessment.

The initial velocities, pressures, coolant temperatures, and wall temperatures approximated the steady-state test conditions for the heated and the unheated experiments. Five pipe-wall nodes with a linear 20-K temperature drop across the wall were used to model Test R. For both tests, the feeder and the riser pipe walls were modeled with two nodes using a flat initial temperature distribution across the pipe wall. Linear interpolation was used to obtain the initial fluid-cell temperatures.

Also, for both tests, four PIPEs located between a FILL and a BREAK represented the CISE facility. The FILL located at the closed end of the riser section specified a zero-velocity boundary condition. The BREAK imposed a fixed 0.1-MPa boundary condition at a distance approximately one cell away from its adjacent PIPE.

The PIPE adjacent to the BREAK used the fully implicit hydrodynamics option (IHYDRO = 1) because of the large flow velocities at the break. The other PIPEs used the partially implicit hydrodynamics option (IHYDRO = 0). For Test R, the input for the PIPE that represented the heated test section used several features that were not included in the other PIPEs. These features specified a HTC between the outer boundary of the pipe wall and the ambient air and a CHF test.

Appendix B lists the TRAC input data decks for CISE Tests 4 and R, respectively.

C. Data Comparisons

Calculated results for both tests were compared with test data from Ref. 6 and data supplied by the NRC.*

*This information was provided by W. T. Hancox to L. Shotkin, US NRC (August 31, 1976).

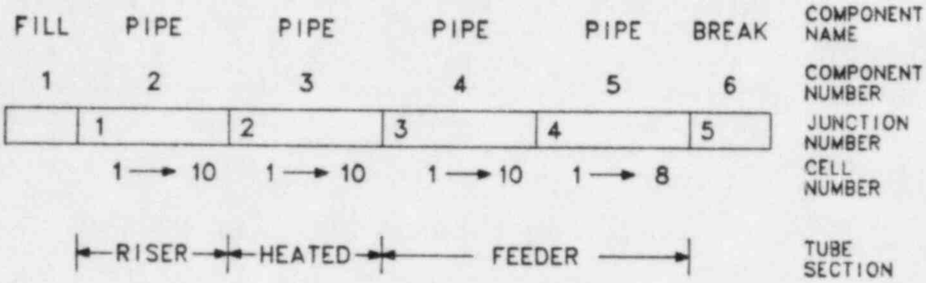


Fig. 14.
TRAC model of CISE blowdown experiments.

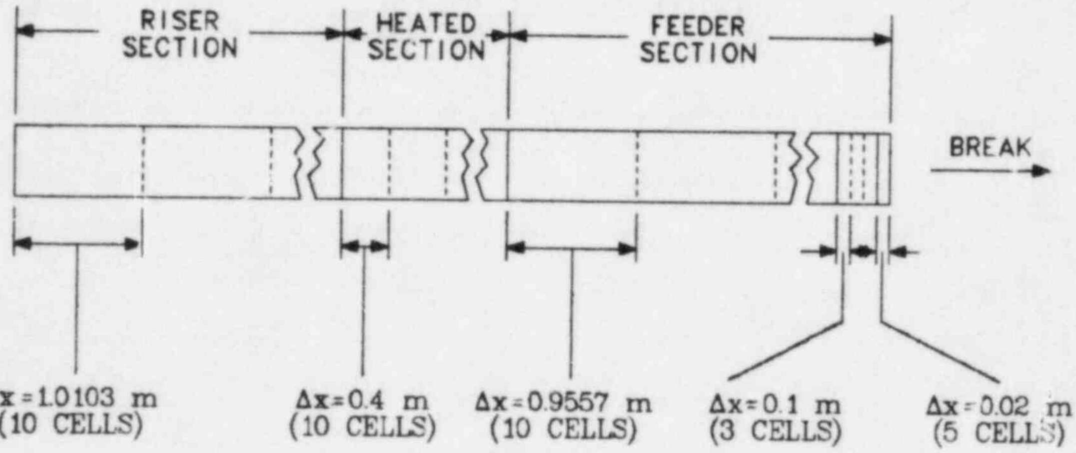


Fig. 15.
Typical TRAC noding of CISE blowdown experiments.

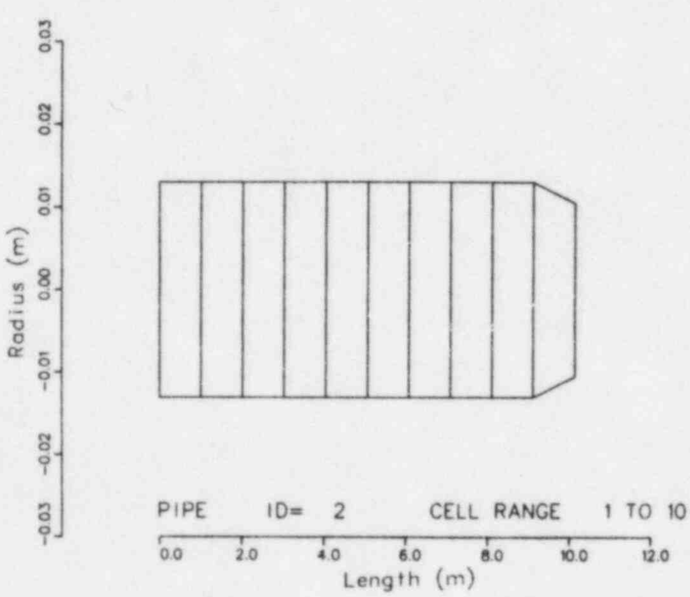


Fig. 16.
TRAP-generated noding diagram of PIPE 2 for CISE blowdown experiment.

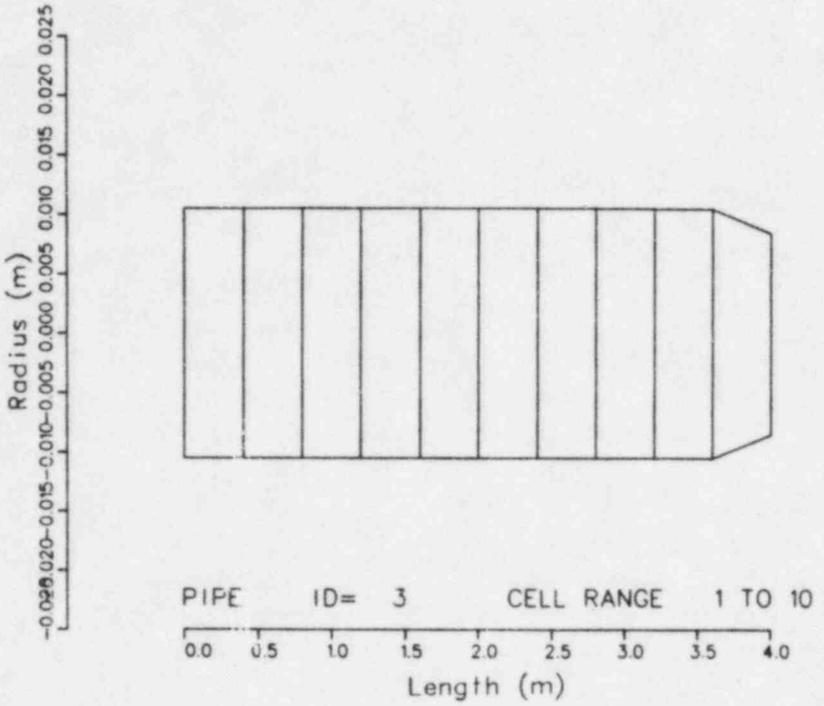


Fig. 17.
TRAP-generated noding diagram of PIPE 3 for CISE blowdown experiment.

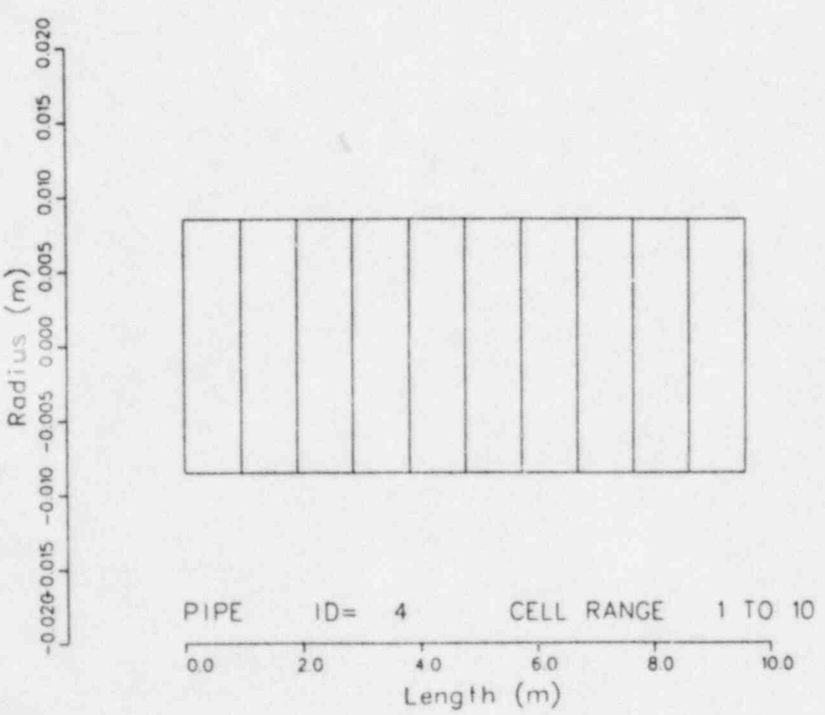


Fig. 18.
TRAP-generated noding diagram of PIPE 4 for CISE blowdown experiment.

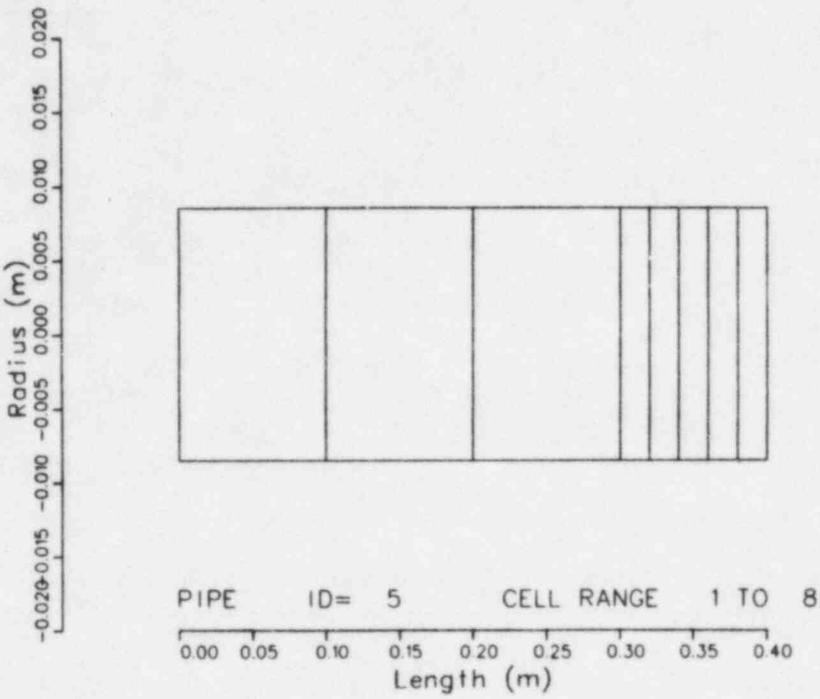


Fig. 19.
TRAP-generated noding diagram of PIPE 5 for CISE blowdown experiment.

TABLE IV

LOCATION OF MEASURED AND CALCULATED QUANTITIES
FOR CISE BLOWDOWN EXPERIMENTS

Measured		Calculated	
Measurement Station	Parameter	Component	Cell
P7	Pressure (Pa)	PIPE 2	1
TFT	Temperature (K)	PIPE 2	1
THW4	Wall temperature (K)	PIPE 3	3 (node 3)
P4	Pressure (Pa)	PIPE 5	1
TF4	Temperature (K)	PIPE 5	1
--	Mass flow ($kg \cdot s^{-1}$)	BREAK 6	--

Figure 20 compares the test fluid pressure at measurement station P7 for Test 4 with the pressures calculated by TRAC-P1A and TRAC-PD2. The comparisons were good but the calculated pressures slightly exceeded the measured results. Similar results (Fig. 21) were obtained for Test R except that agreement during the latter part of the transient was fair.

Figures 22 and 23 show that the calculated fluid pressures at measurement station P4 for Tests 4 and R, respectively, are in good overall agreement with the test results. The discrepancies early in the transient may have been caused by the assumption in the calculations that the blowdown valve opened instantaneously. Actually, this valve required ~0.01 s to open completely.

Figures 24 and 25 compare the calculated and measured fluid temperatures at measurement station TF7 for Tests 4 and R, respectively. Agreement was excellent for Test 4. For Test R, agreement was excellent for the first 1.5 s of the transient. Then, the measured temperature dipped sharply at 2 s and recovered at 2.5 s. The cause of this dip is unknown as there was no corresponding dip in the pressure, and the fluid reached saturation at this point in the transient.

The calculated fluid temperatures at measurement station TF4 were in good agreement with the test data after 1 s for Test 4 (Fig. 26) and after 2 s for Test R (Fig. 27). In both cases, the temperature response was consistent with the calculated pressures (Figs. 22 and 23).

Figures 28 and 29 compare the calculated and measured pipe-wall temperatures near the top of the heater section and at the radial midpoint of the wall, THW4, for Tests 4 and R, respectively. Agreement was good throughout the transient for Test 4. However, for Test R, the calculated time to dryout was delayed ~1 s after the measured time and the calculated temperature at dryout was ~20 K below the measured temperature. Figures 30 and 31 show the mass flows as a function of time for Tests 4 and R, respectively. The measured mass flows were determined by differencing the measured total test-section mass as a function of time; thus, measurement uncertainty may be high. Although the agreement was good for Test 4, the measurements were available only to 2 s. For this case, the calculated initial total test-section mass was slightly less than the test value. For Test R, the calculated mass flow agreed well with the data after 1 s; however, measured values were unavailable after 4 s. Because the initial fluid conditions were matched better, the calculated and measured initial total test-section masses agreed more closely than for Test 4.

Experiment uncertainty information was not provided; however, accuracy data[5] for various transducers were available. The pressure-transducer accuracy for the range of 0-11 MPa was 0.25 MPa, and the temperature-measurement uncertainty was ±2 K up to 543 K.

D. Conclusions

The CISE experiments involved the same thermal-hydraulic effects as the Edwards' experiment (Sec. II.A) plus additional ones. These additional effects included wall heat sources, flow-area changes in the multisection pipes, and gravitational effects in the vertical-pipe sections. The CISE and the Edwards' experiments used the same code components; that is, no new code components were necessary.

Because the CISE test section was longer and had a smaller diameter than the one in the Edwards' experiment, the results were more sensitive to the wall friction-factor correlation. The generally good agreement between the calculations and the test data for Test 4 indicated that the annular

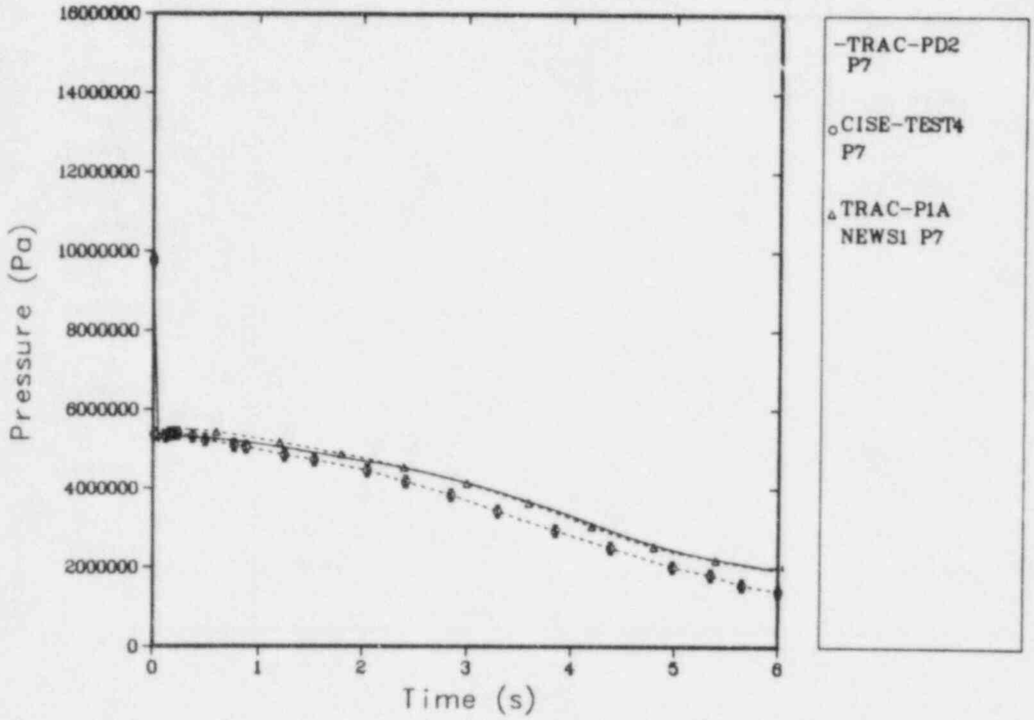


Fig. 20.
Pressure at measurement station P7 for unheated CISE experiment.

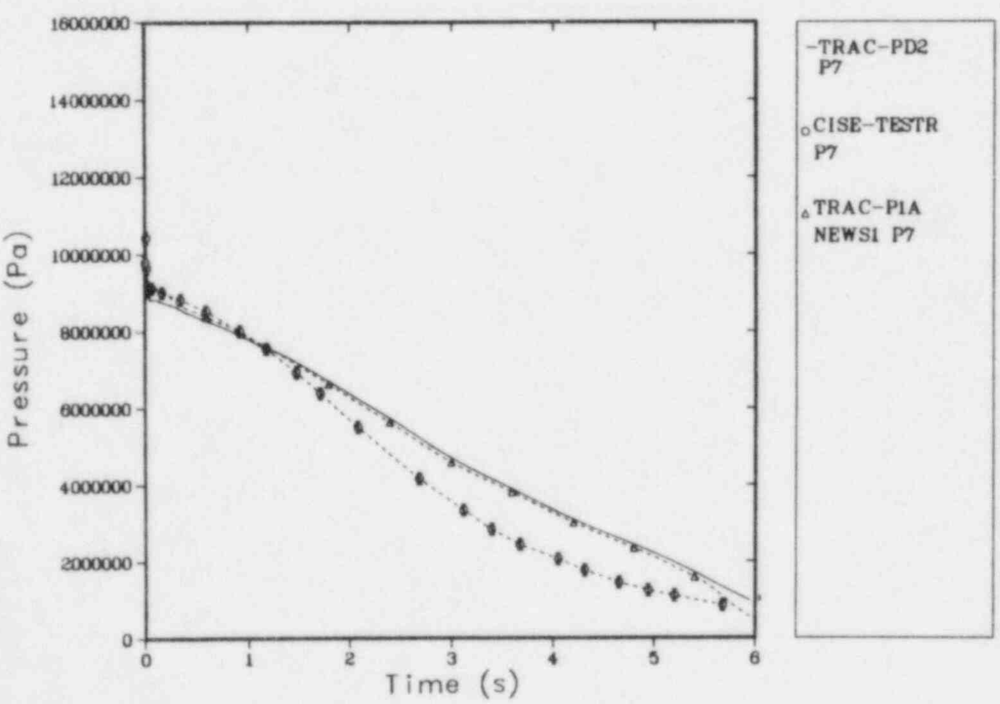


Fig. 21.
Pressure at measurement station P7 for heated CISE experiment.

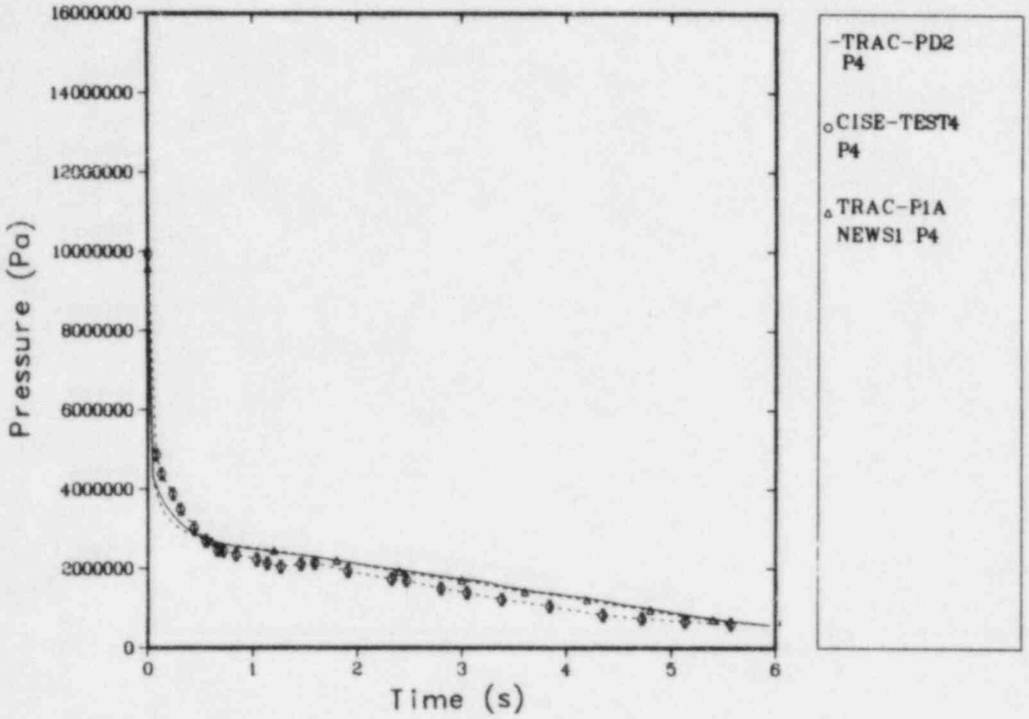


Fig. 22.
Pressure at measurement station P4 for unheated CISE experiment.

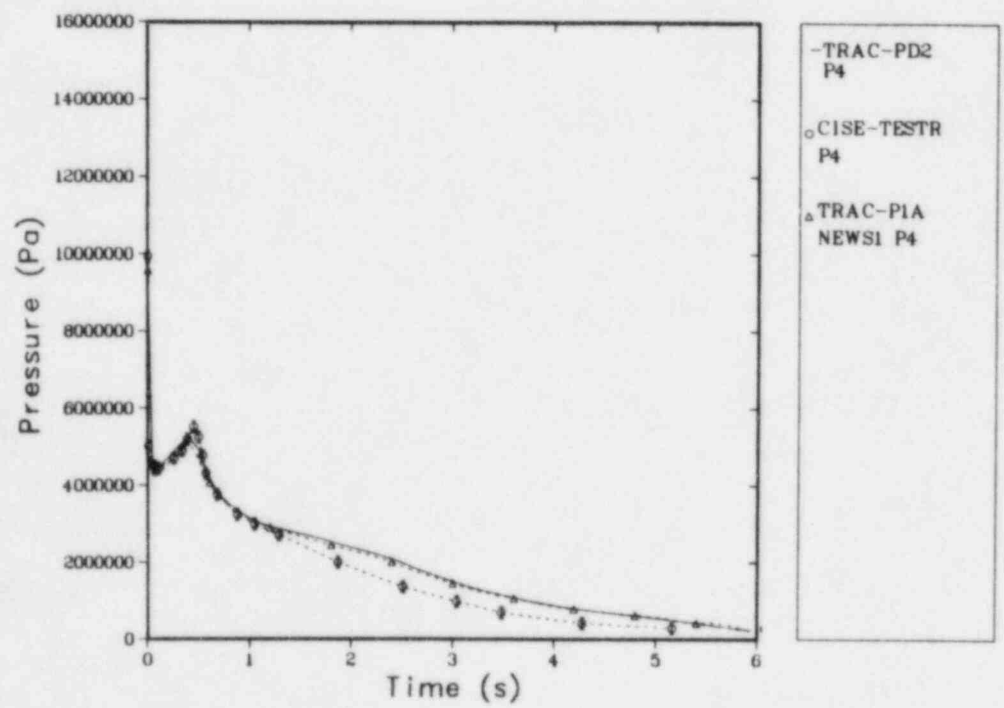


Fig. 23.
Pressure at measurement station P4 for heated CISE experiment.

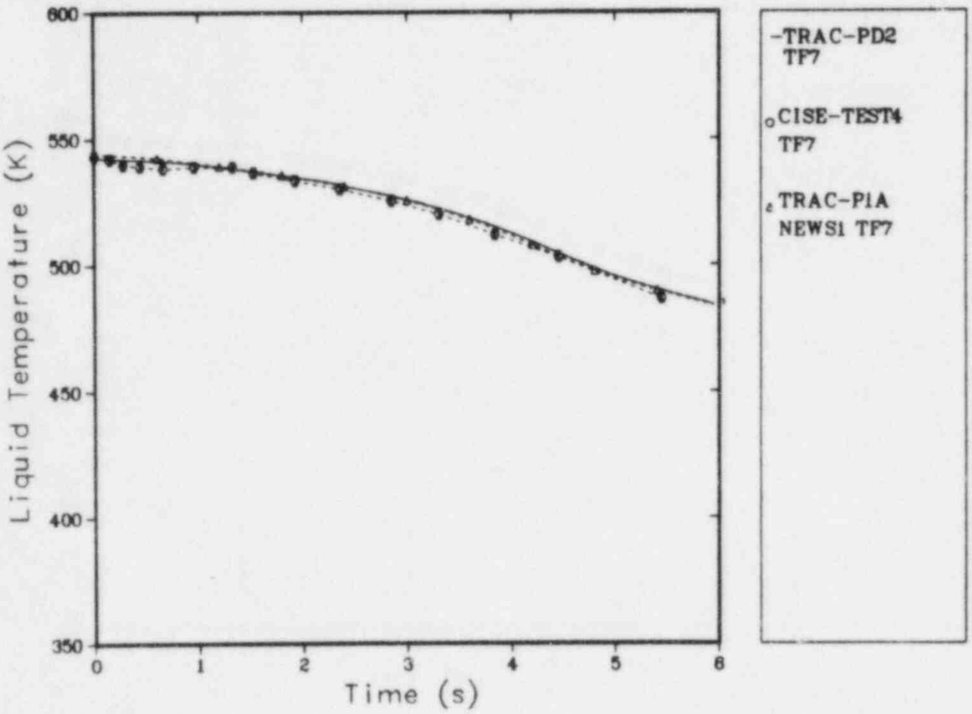


Fig. 24.
Liquid temperature at measurement station TF7 for unheated CISE experiment.

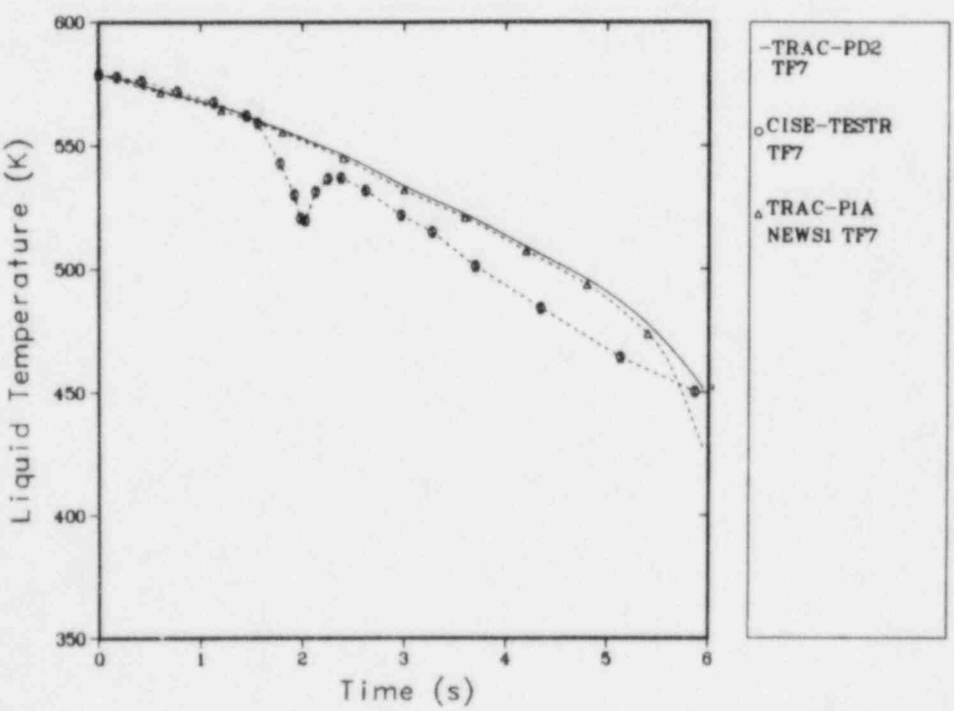


Fig. 25.
Liquid temperature at measurement station TF7 for heated CISE experiment.

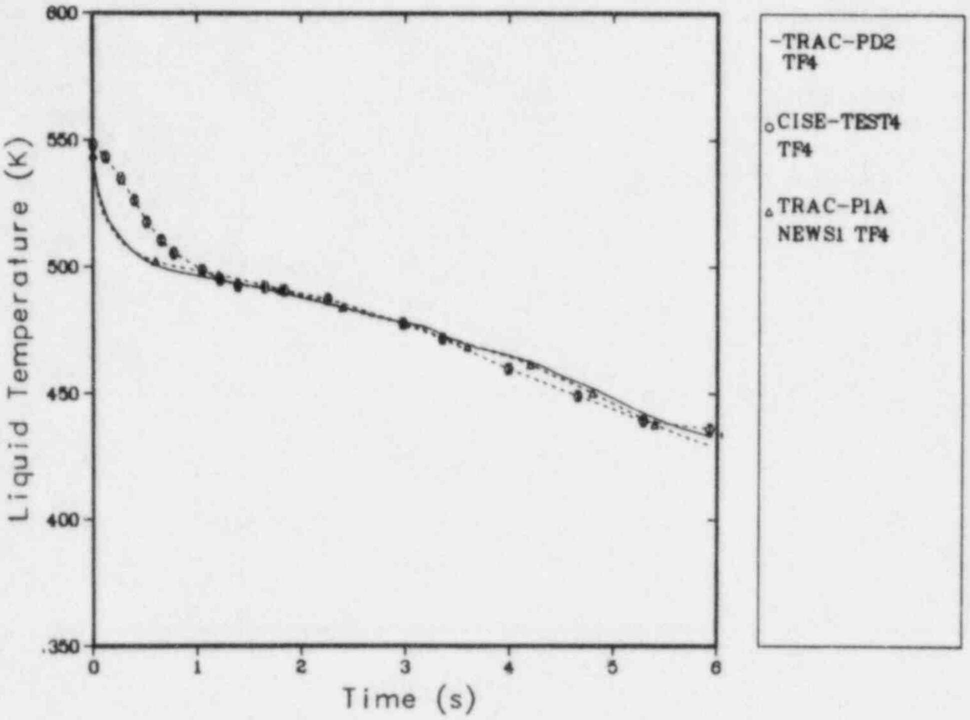


Fig. 26.
Liquid temperature at measurement station TF4 for unheated CISE experiment.

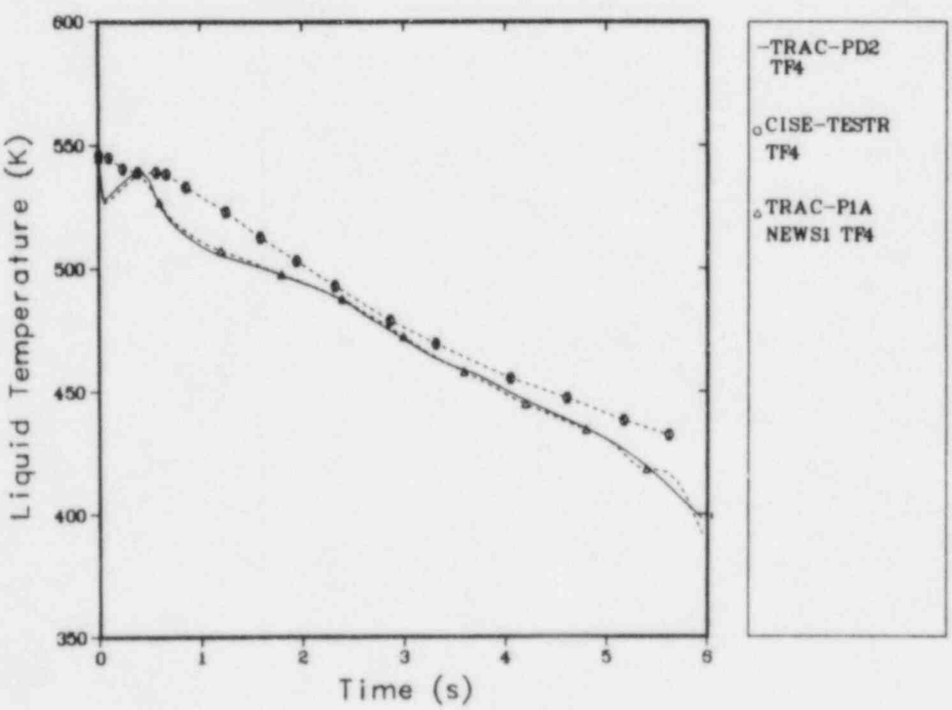


Fig. 27.
Liquid temperature at measurement station TF4 for heated CISE experiment.

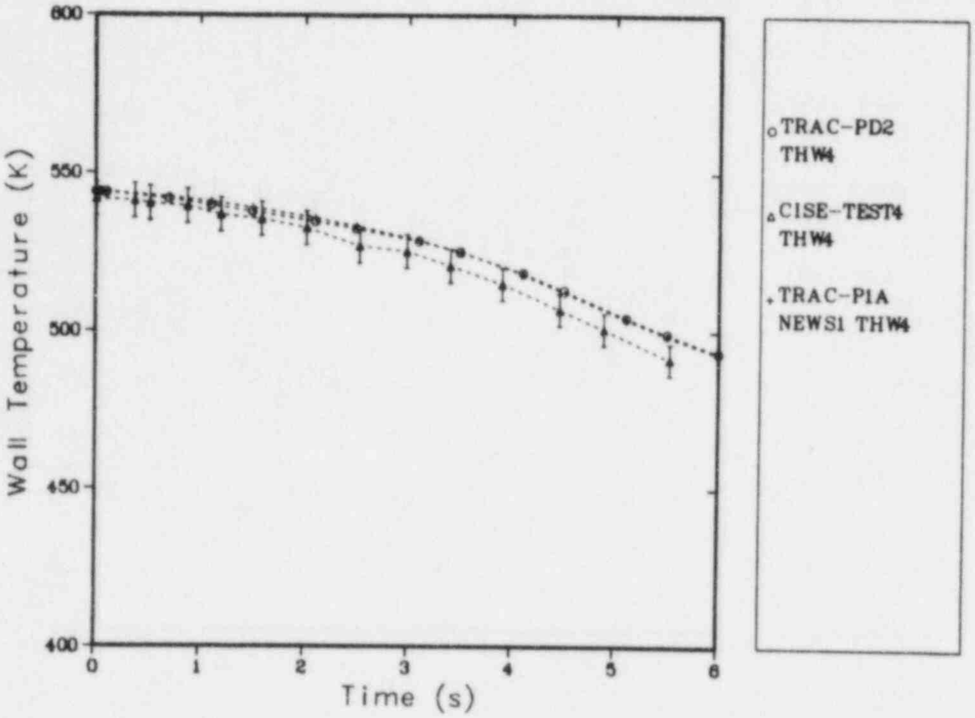


Fig. 28.
Wall temperature at measurement station THW4 for unheated CISE experiment.

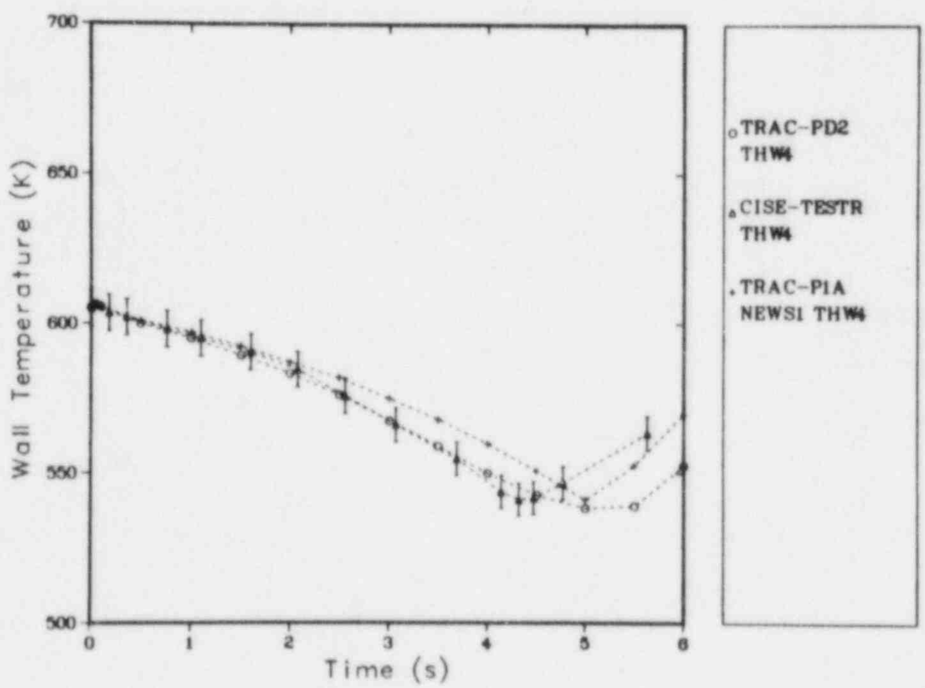


Fig. 29.
Wall temperature at measurement station THW4 for heated CISE experiment.

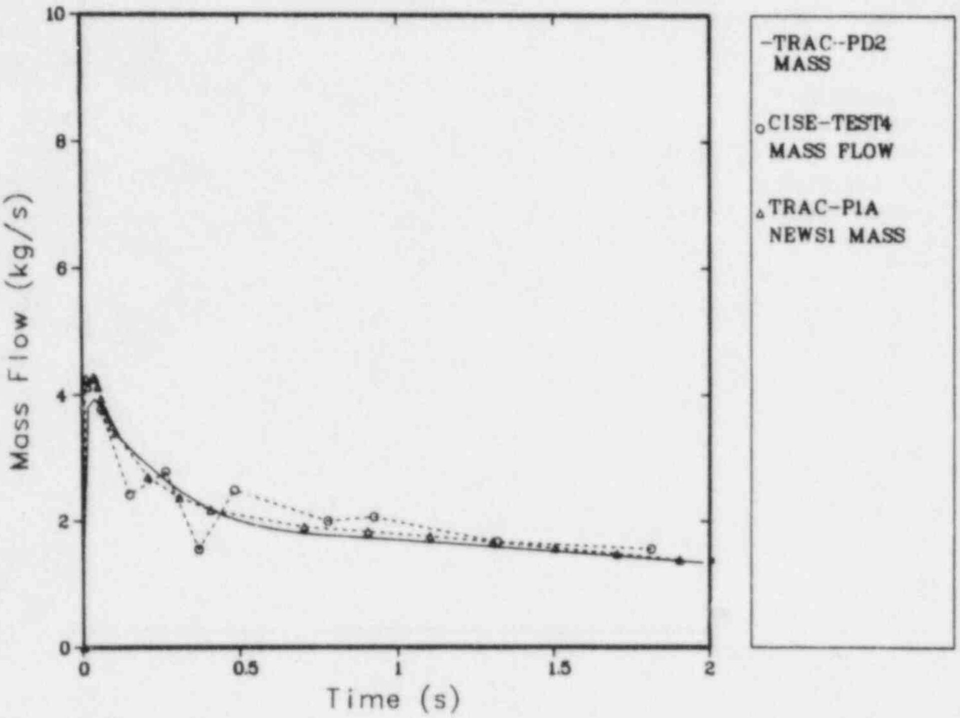


Fig. 30.
Test-section mass flow for unheated CISE experiment.

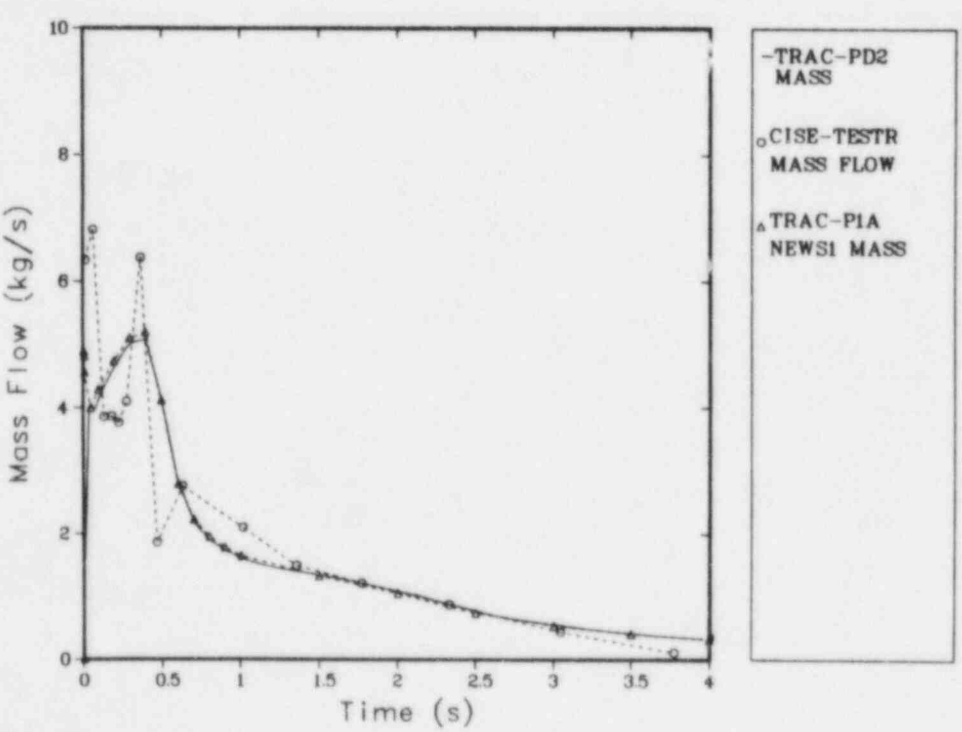


Fig. 31.
Test-section mass flow for heated CISE experiment.

friction-factor correlation (NFF = 4) was appropriate for this experiment. However, it would be desirable to incorporate flow-regime dependence into the wall-friction correlations and to specify pipe roughness through user input. Then, the code would select an appropriate friction-factor correlation based on local flow conditions and pipe roughness just as it uses local conditions for other constitutive relations.

The agreement between the TRAC-PD2 and the test results for Test R was not as good as that for Test 4. Perhaps some discrepancies were caused by measured and assumed initial conditions that were inconsistent with a calculated steady-state solution. Test R also provided a more stringent test of wall heat-transfer effects during blowdown. For both cases, the TRAC-PD2 results were very similar to TRAC-P1A calculated values except for the heated, radial midpoint wall temperature.

The transient calculations required 71 s of CPU time on a CDC 7600 computer for Test 4 and 255 s for Test R.

IV. MARVIKEN FULL-SCALE CRITICAL-FLOW TESTS 4 AND 24

A. Experiment Description

The Marviken full-scale critical-flow tests[7,8] were designed to assess the ability of computer codes to predict large pressure-vessel blowdowns. The four major components were a pressure vessel, originally designed to be part of the Marviken nuclear power plant; a discharge pipe; a test nozzle with the minimum flow area in the system; and a rupture-disk assembly. Figure 32 shows the pressure vessel. Figure 33 shows the discharge pipe, test nozzle, and the rupture-disk assembly. The elevations in both figures were measured relative to the bottom of the vessel. Stations P103, P106, and P109 measured the pressure; stations T401, T402, and T405 measured the temperature. In Test 4, the nozzle had a minimum 0.509-m diameter with a length-to-diameter (L/D) ratio of 3.1; in Test 24, the nozzle had a minimum 0.500-m diameter with an L/D ratio of 0.33.

Figures 32 and 33 show the locations of the pressure and temperature transducers along the vessel and the discharge pipe. The transducer signals were processed through a signal-conditioning unit whose channels were connected to a pulse code-modulation system.

Before both tests, the vessel was filled partially with deionized water, which was heated by removing it from the bottom of the vessel through an electric heater and adding it to the steam dome at the top of the vessel. This procedure produced a complicated initial temperature distribution in the vessel. A saturated steam dome filled the vessel region above the initial water level and the water at the nozzle inlet was subcooled substantially (60 K). Both tests were initiated by releasing the rupture disks and were terminated by closing a ball valve in the discharge pipe after 49 s for Test 4 and after 54 s for Test 24.

B. TRAC-PD2 Model

The TRAC models of Marviken Tests 4 and 24 included four components. A zero-velocity FILL modeled the vessel upper boundary; a semi-implicit PIPE modeled the vessel above the 2.6-m elevation including the maximum diameter region plus the top cupola; a fully implicit PIPE modeled the lower part of the vessel, discharge pipe, nozzle, and rupture-disk assembly; and a BREAK component provided a pressure boundary condition at the rupture-disk-assembly lower boundary.

In Test 4, the semi-implicit pipe used 15 cells, whereas the fully implicit pipe used 45. In Test 24, 15 and 27 cells were used, respectively. Parametric studies[3] for both tests that reduced the number of cells in PIPE 3 and kept the same number of cells in PIPE 2 yielded virtually identical results. Figure 34 shows the noding for the vessel and the discharge pipe. Figures 35 and 36 show the noding for the nozzle and the rupture-disk assembly for Tests 4 and 24, respectively. Figures 37-40 show the TRAP-generated noding diagrams. The calculated results were sensitive to the initial, nonuniform temperature distribution. Although the experimenters specified this temperature distribution, some averaging was necessary to describe the system with discrete fluid cells. Because it was difficult to represent accurately the steep initial temperature ramps in the vessel, we recommended that the minimum number of cells in PIPE 1 should be 15. Table V lists the locations of the measured and calculated quantities.

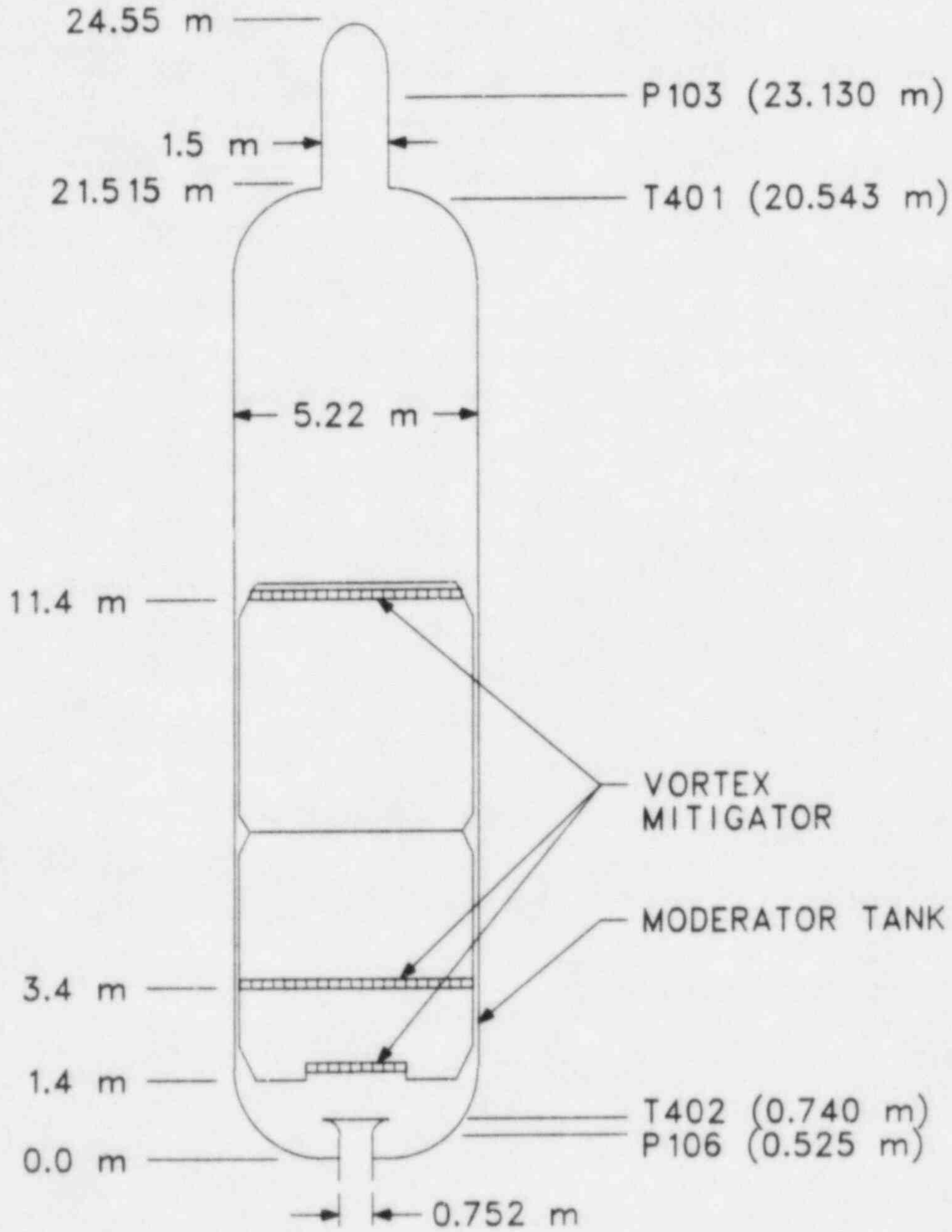


Fig. 32.
Pressure vessel for Marviken Tests 4 and 24.

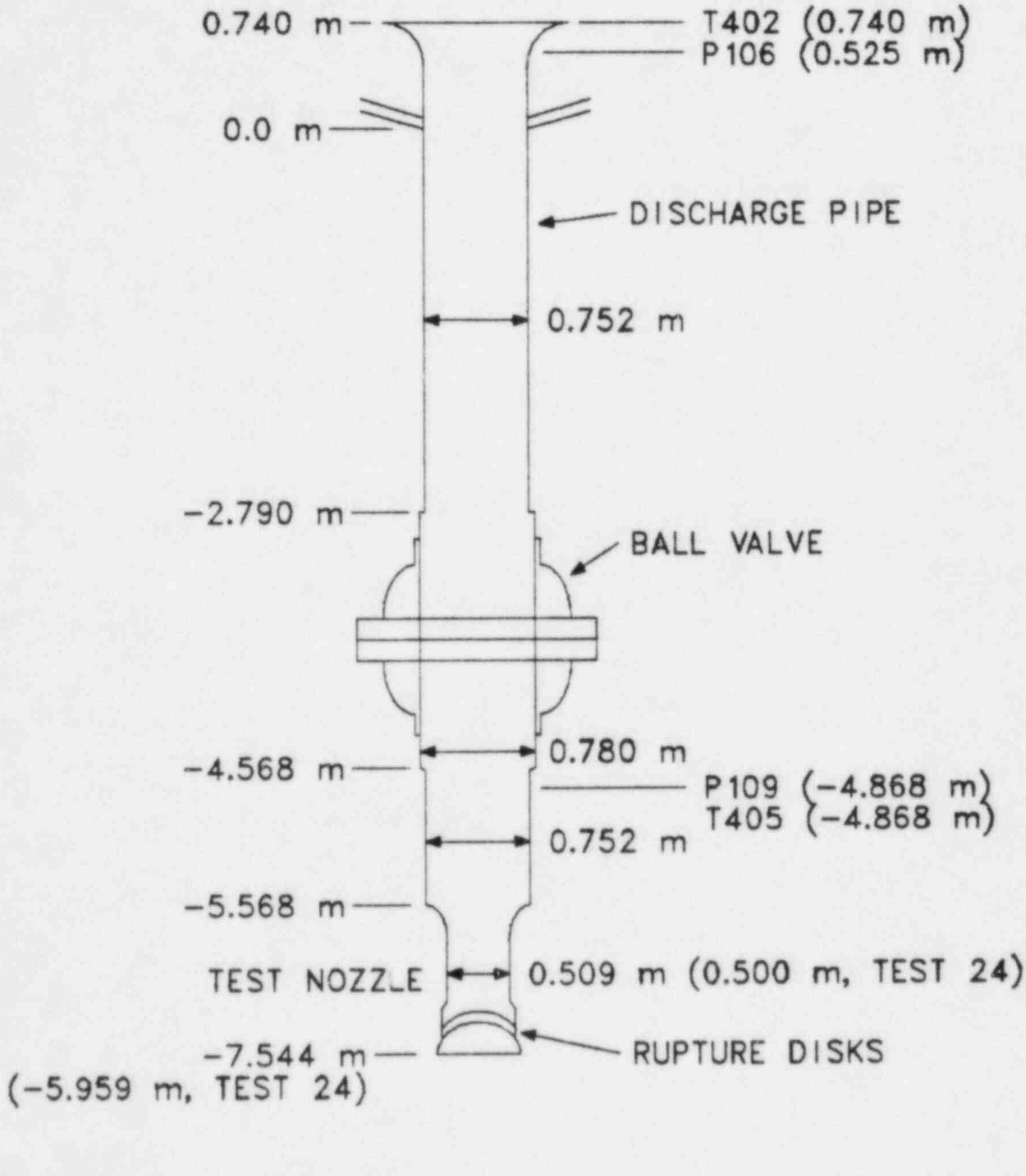
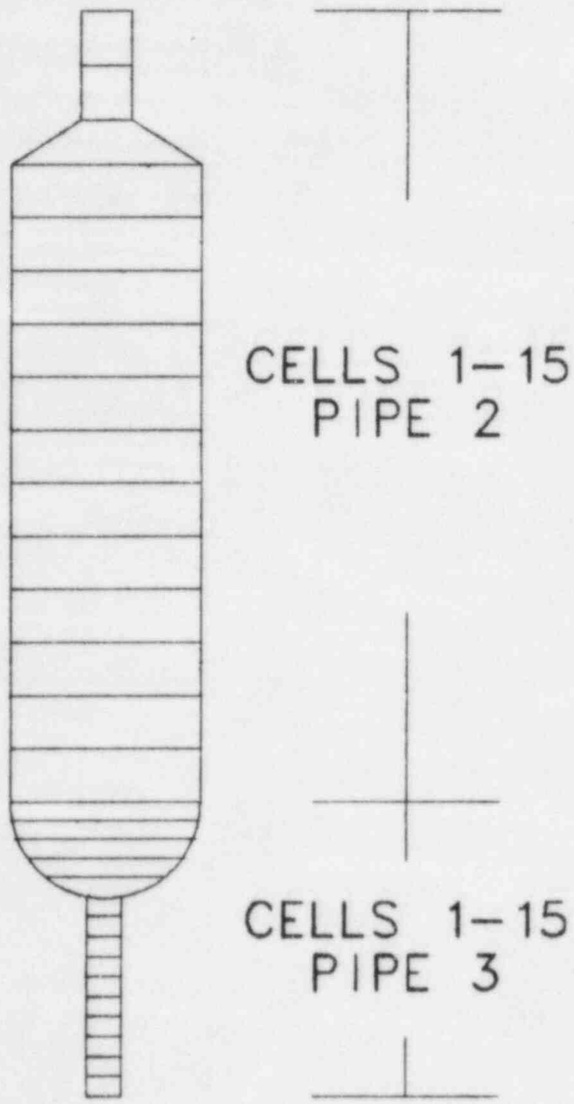


Fig. 33.
Discharge pipe, test nozzle, and rupture-disk assembly for Marviken Tests 4 and 24.



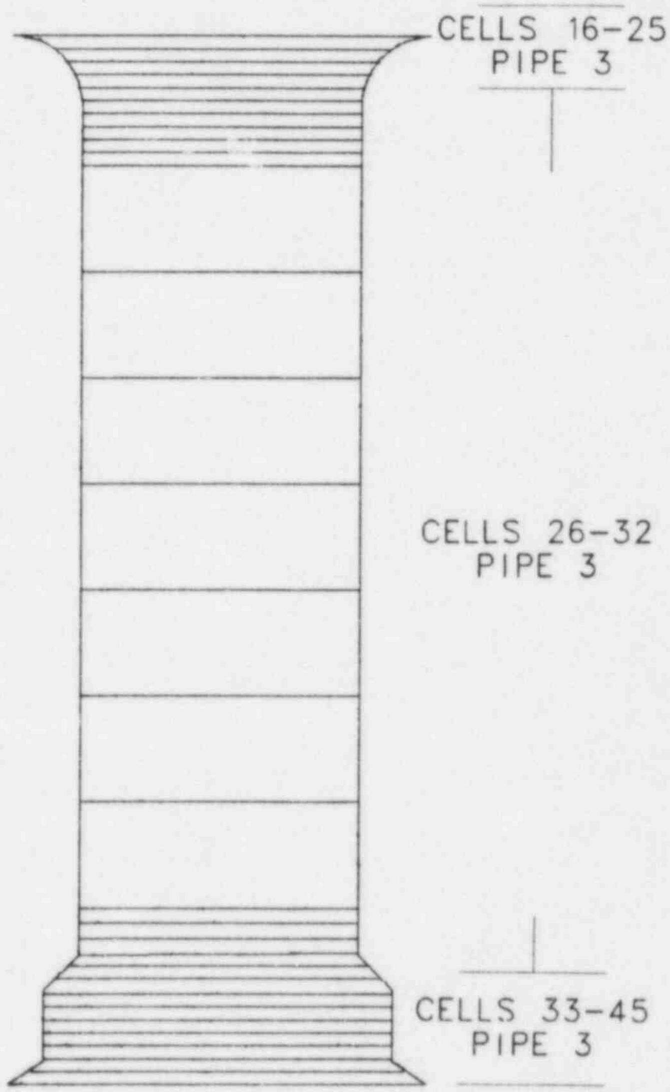


Fig. 34.
TRAC noding diagram of vessel and discharge pipe for Marviken Tests 4 and 24.

Fig. 35.
TRAC noding diagram of nozzle and rupture-disk assembly for Marviken Test 4.

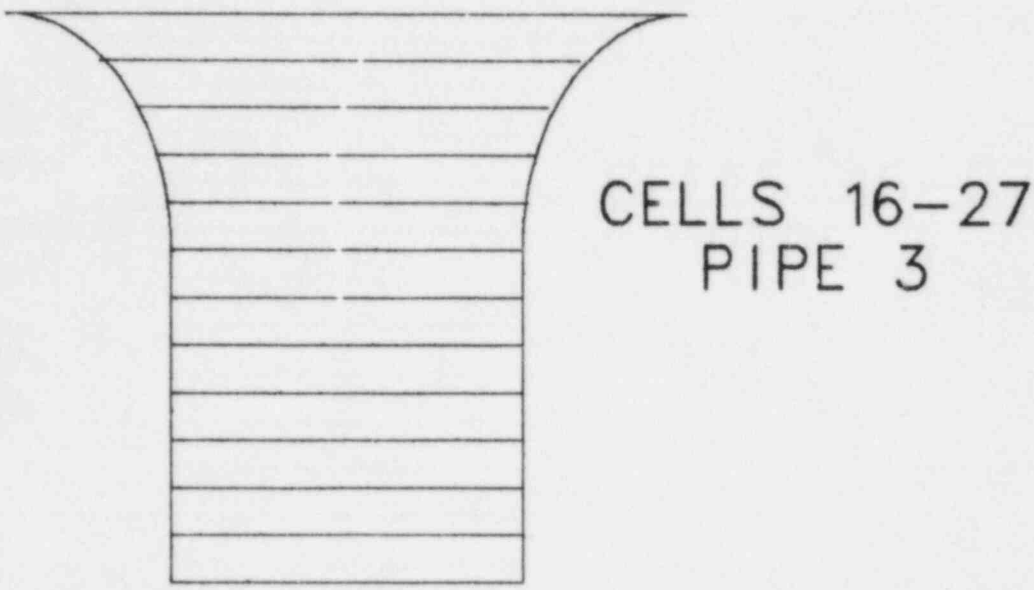


Fig. 36.
TRAC noding diagram of nozzle and rupture-disk assembly for Marviken Test 24.

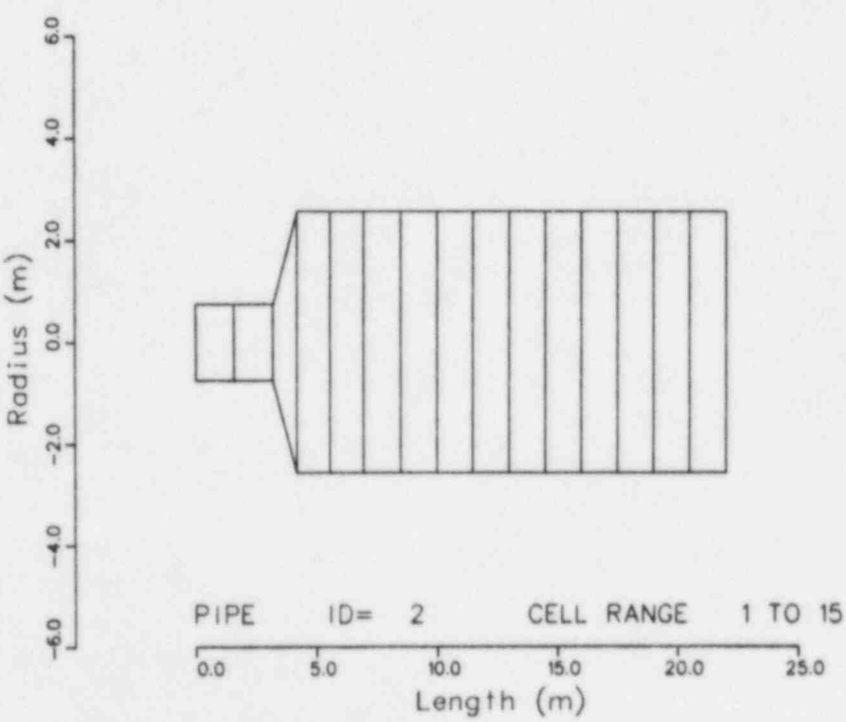


Fig. 37.
TRAP-generated noding diagram of PIPE 2 for Marviken Test 4.

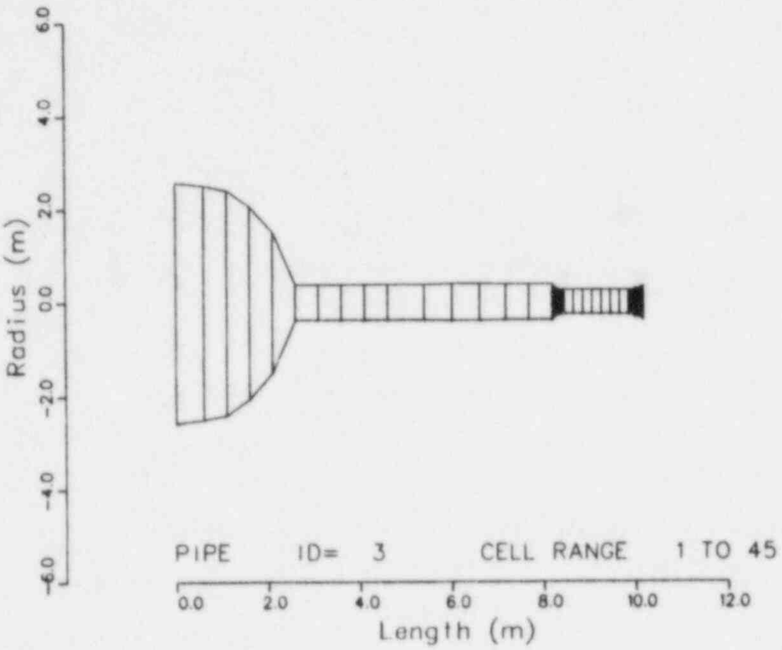


Fig. 38.
TRAP-generated noding diagram of PIPE 3 for Marviken Test 4.

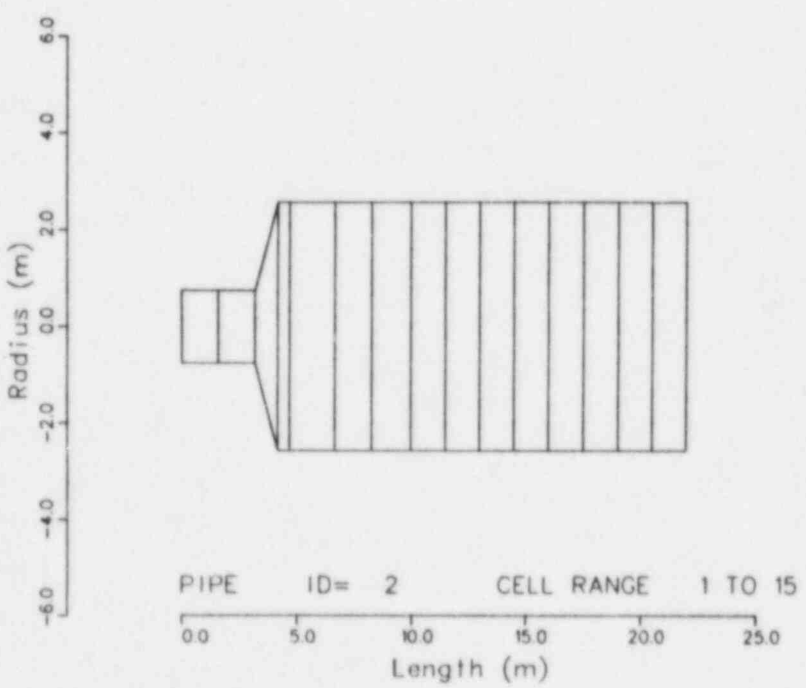


Fig. 39.
TRAP-generated noding diagram of PIPE 2 for Marviken Test 24.

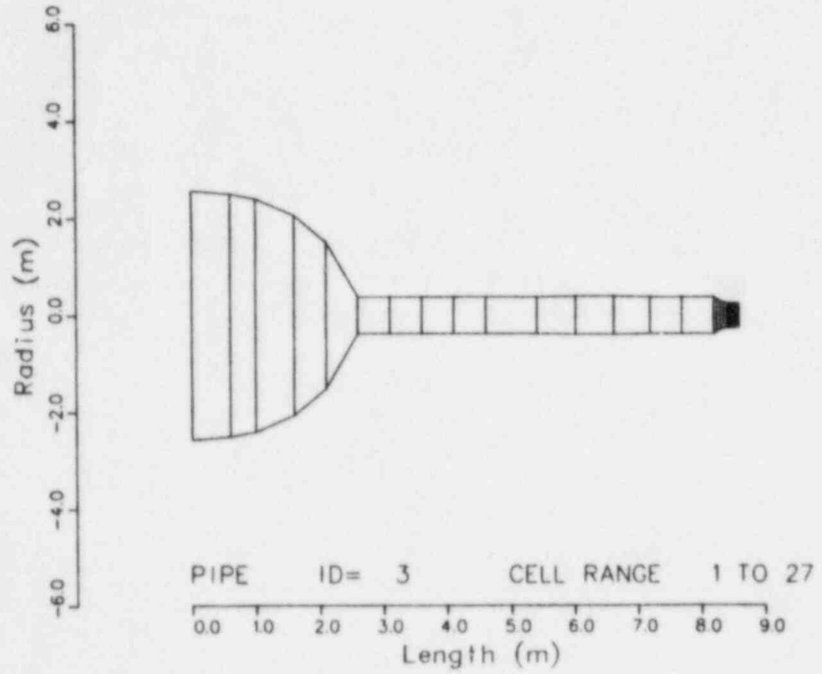


Fig. 40.
TRAP-generated noding diagram of PIPE 3 for Marviken Test 24.

TABLE V

LOCATION OF MEASURED AND CALCULATED QUANTITIES
FOR MARVIKEN BLOWDOWN EXPERIMENTS (TESTS 4 AND 24)

Measured		Calculated	
Measurement Station	Parameter	Component	Cell
P103	Pressure (Pa)	PIPE 2	2
T401	Temperature (K)	PIPE 2	3
P106	Pressure (Pa)	PIPE 3	5
T402	Temperature (K)	PIPE 3	4
P109	Pressure (Pa)	PIPE 3	14
P405	Temperature (K)	PIPE 3	14
--	Mass flow ($kg \cdot s^{-1}$)	BREAK 4	--

Because the vessel included some internal structure, the actual 5.220-m diameter was reduced to 5.136 m in the TRAC model to obtain the correct initial water mass and net available internal volume. The discharge pipe was modeled as if it were located at the vessel bottom. The annular-flow friction-factor correlation option, NFF = 4, was specified. For the TRAC-PD2 developmental assessment, we used the best-estimate model developed for TRAC-P1A. Appendix C lists the input decks for Marviken Tests 4 and 24, respectively.

C. Data Comparisons

The TRAC results were compared with the blowdown flow rate and the pressures and temperatures at several locations for Tests 4 and 24. Table VI lists the important critical-flow test conditions. The table shows that the tests were similar except the nozzle length in Test 24 was one-tenth the nozzle length in Test 4. Because the test results were qualitatively the same, the same discussion applies to both experiments.

Figures 41 and 42 compare the TRAC mass flow with the flow derived from the pitot-static velocity and the vessel differential-pressure measurements. The pitot-static data curve was valid throughout the transient, whereas the vessel differential-pressure curve was valid only after ~5 s. The TRAC results agreed closely with the initial peak, somewhat underpredicted the subcooled part of the blowdown, and agreed well when saturation occurred at the nozzle (17 s for Test 4 and 25 s for Test 24). The differences between the calculations and the data at the end of the transient resulted from the different emptying times. Figures 43-48 compare the pressures for the upper and lower vessel and the discharge pipe for both tests. During the first 3 s, there was a dip in the test data that did not appear in the calculations; the code did not calculate the dip because the constitutive relations do not permit delayed nucleation. After the dip, the code slightly underpredicted the pressure at all three locations during the subcooled depressurization. After the system reached saturation, the pressure comparisons were very good. The discrepancies at the end of the transient reflected different emptying times.

Figures 49-54 compare the fluid temperatures for Tests 4 and 24 at two locations in the vessel and one location in the discharge pipe. In Figs. 50, 51, 53, and 54 the temperature increased above the initial subcooling because the warm liquid near the top of the mixture level moved downward in the vessel and in the discharge pipe as the vessel emptied. The code did not calculate as sharp a rise in the temperature as shown in the data because the fluid conditions in a hydraulic cell were averaged as warm liquid mixed with the

TABLE VI

MARVIKEN CRITICAL-FLOW TEST CONDITIONS

Test Number	Initial Subcooling near Vessel Bottom (K)	Initial Subcooling at Nozzle Inlet (K)	Water Level (m)	Initial Pressure (MPa)	Nozzle Diameter (m)	L/D
4	36	60	17.6	4.94	0.509	3.1
24	33	76	19.88	4.96	0.500	0.3

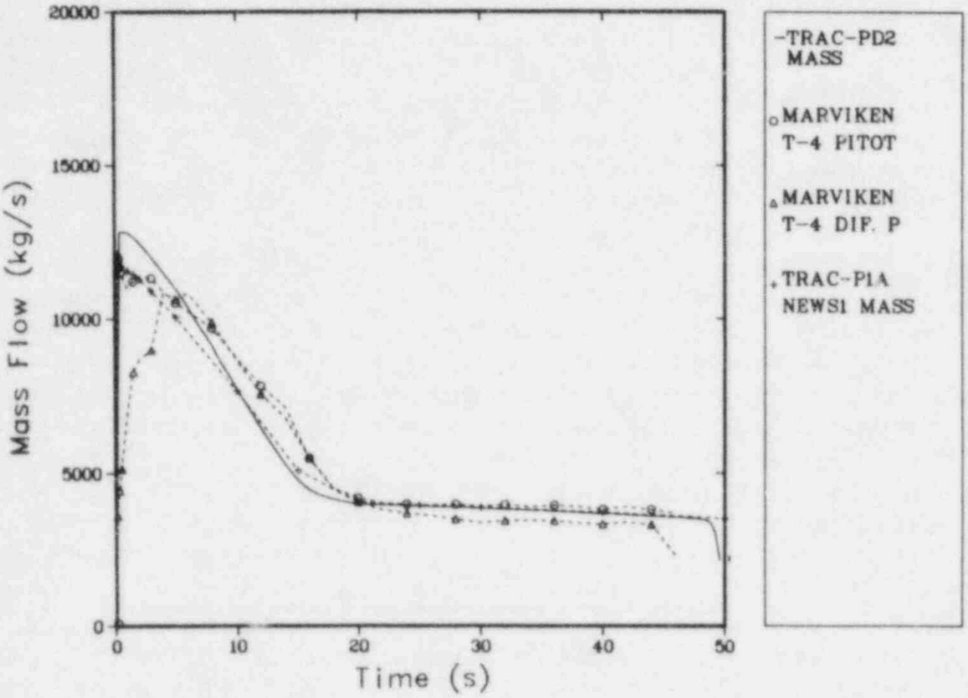


Fig. 41.
Mass flow for Marviken Test 4.

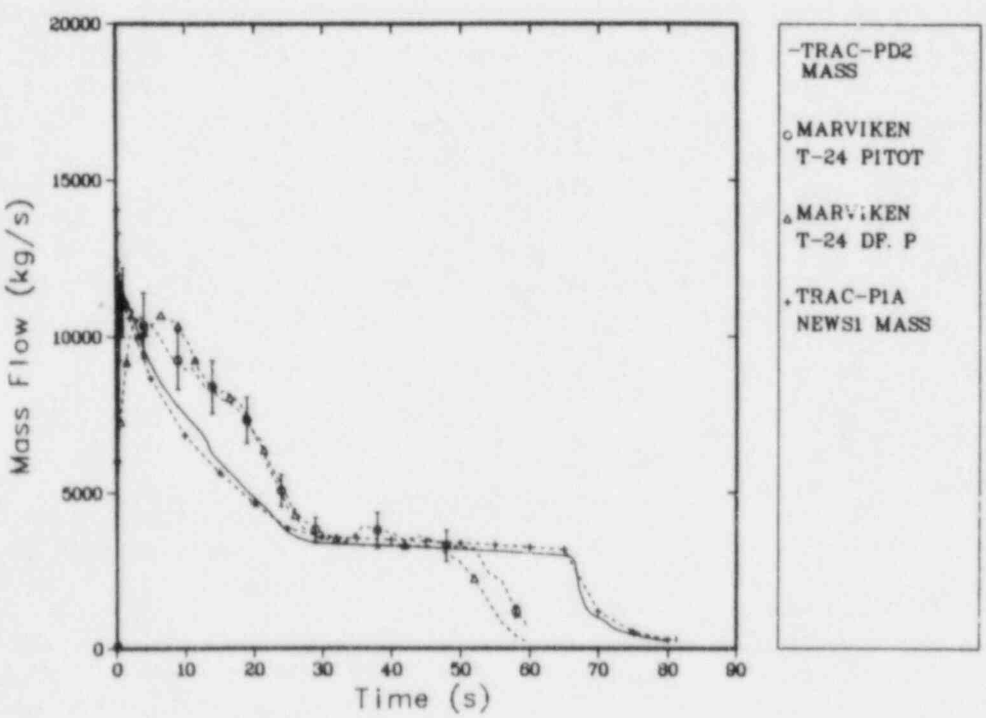


Fig. 42.
Mass flow for Marviken Test 24.

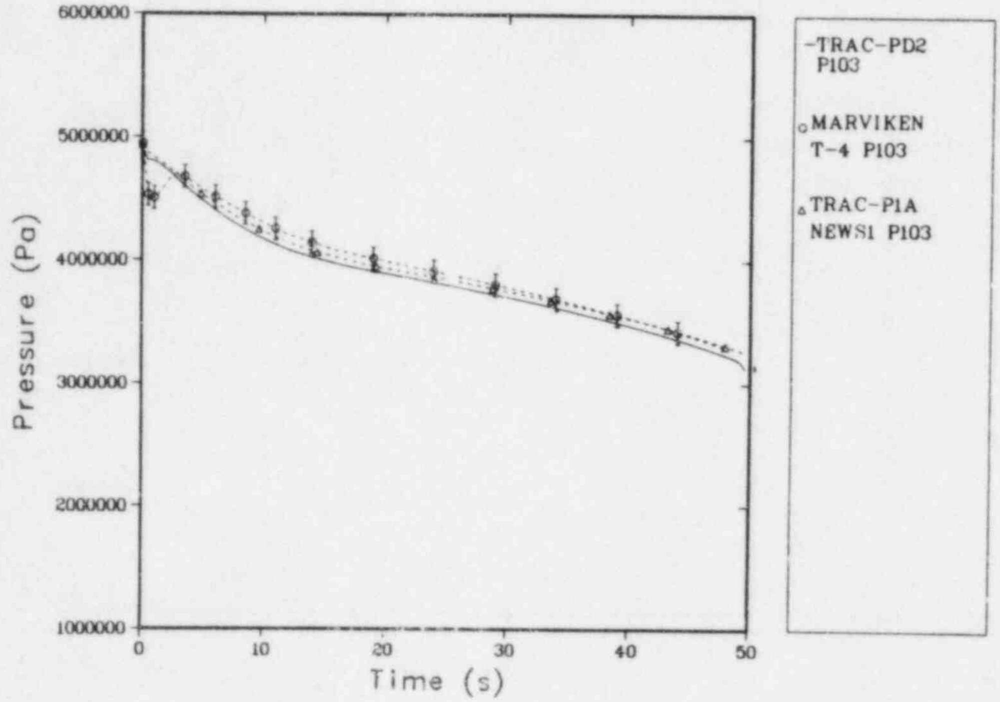


Fig. 43.
Pressure at measurement station P103 for Marviken Test 4.

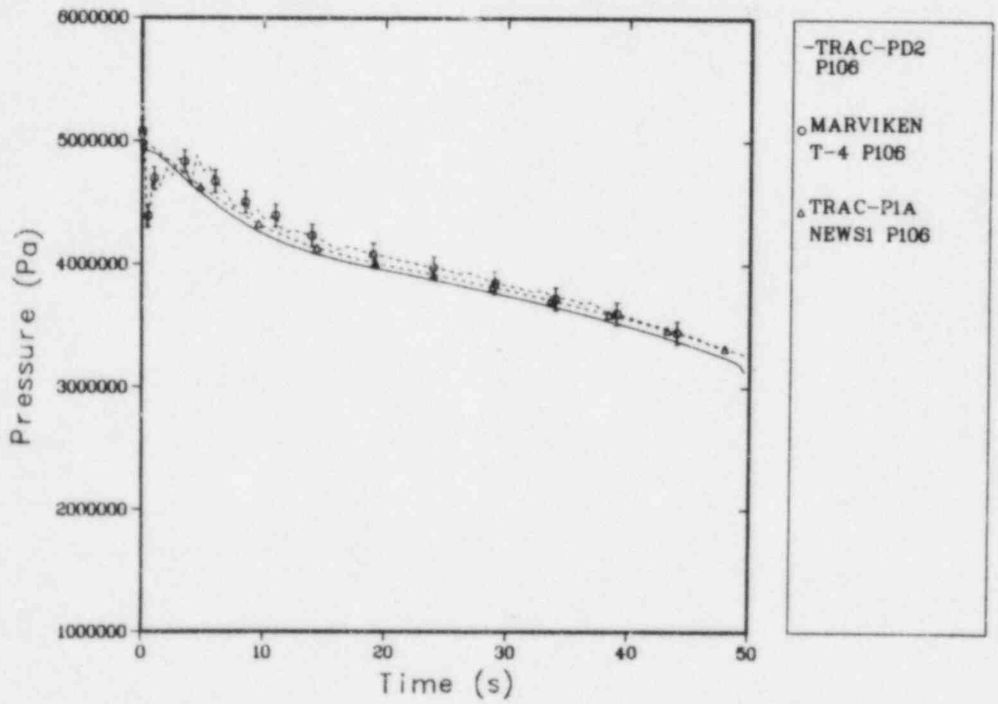


Fig. 44.
Pressure at measurement station P106 for Marviken Test 4.

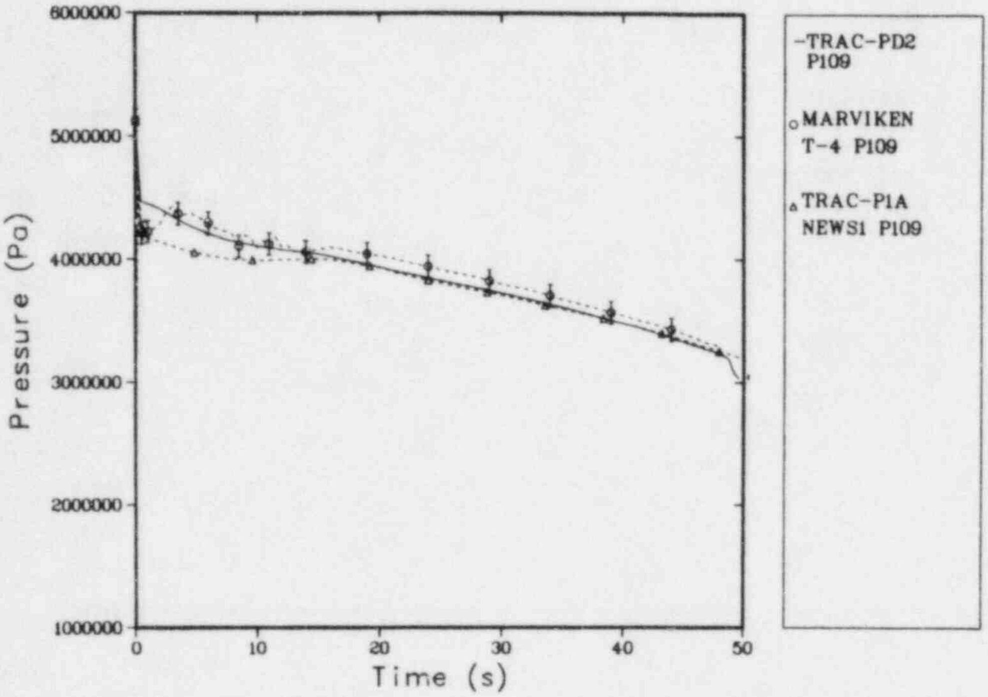


Fig. 45.
Pressure at measurement station P109 for Marviken Test 4.

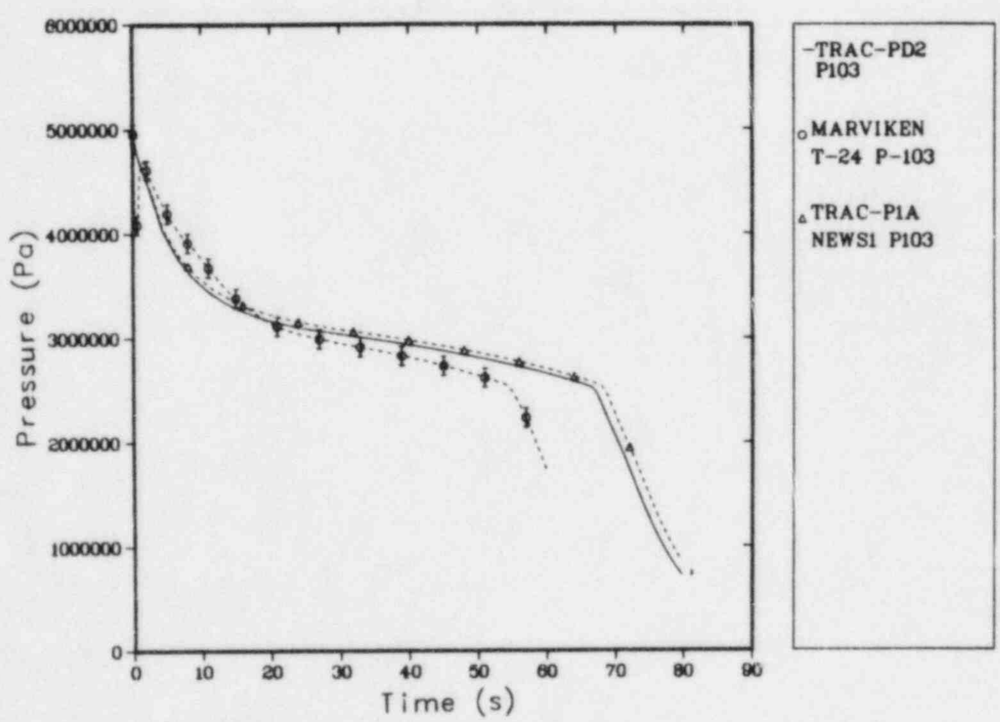


Fig. 46.
Pressure at measurement station P103 for Marviken Test 24.

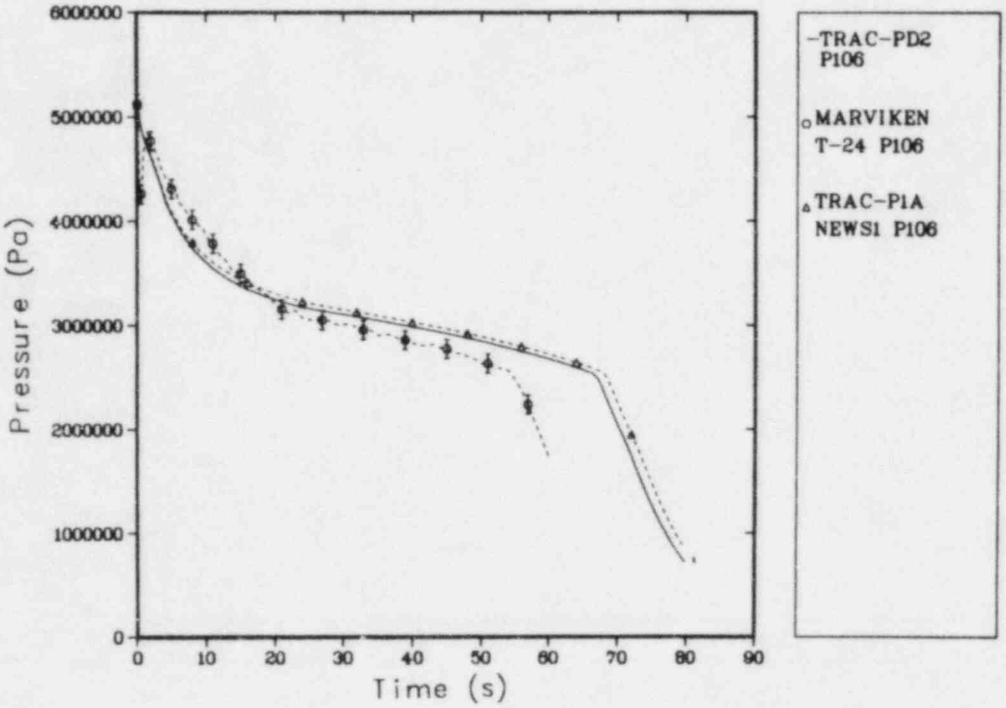


Fig. 47.
Pressure at measurement station P106 for Marviken Test 24.

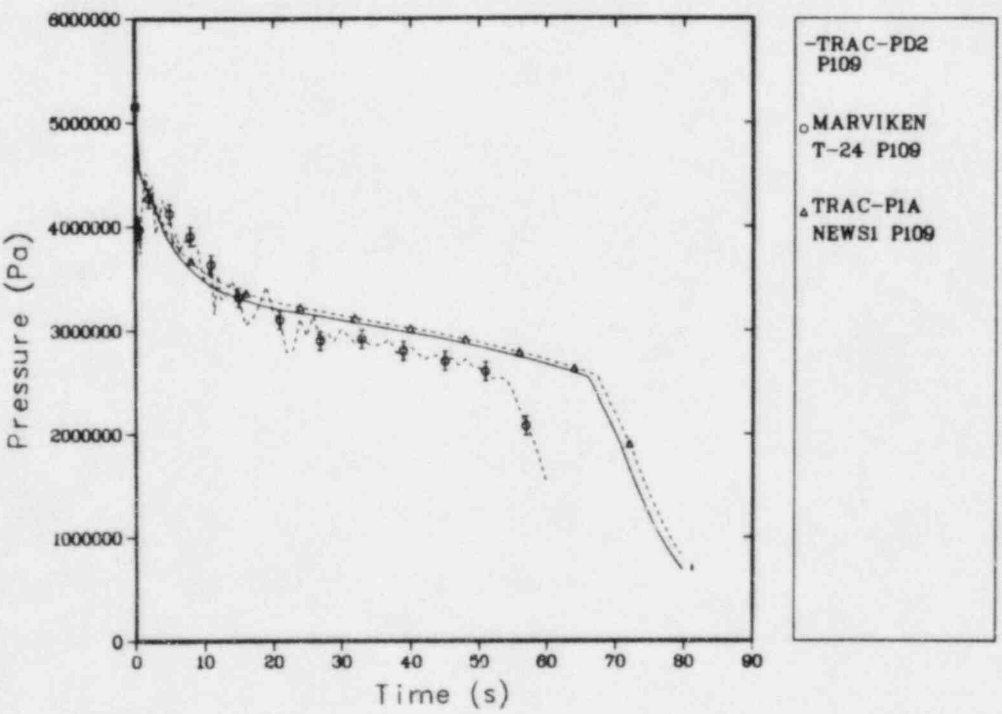


Fig. 48.
Pressure at measurement station P109 for Marviken Test 24.

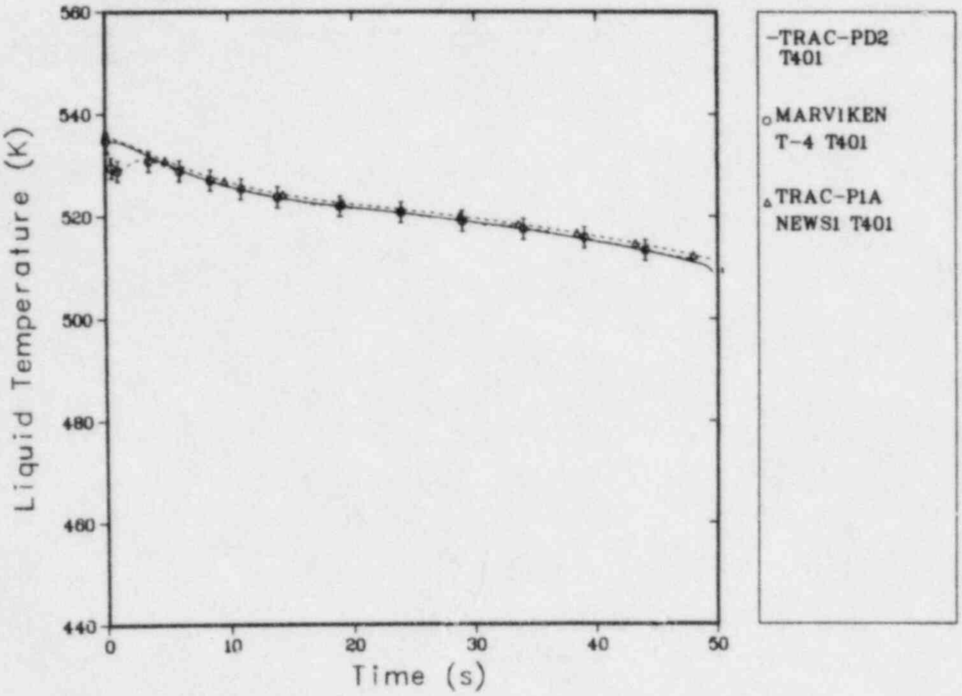


Fig. 49.
Liquid temperature at measurement station T401 for Marviken Test 4.

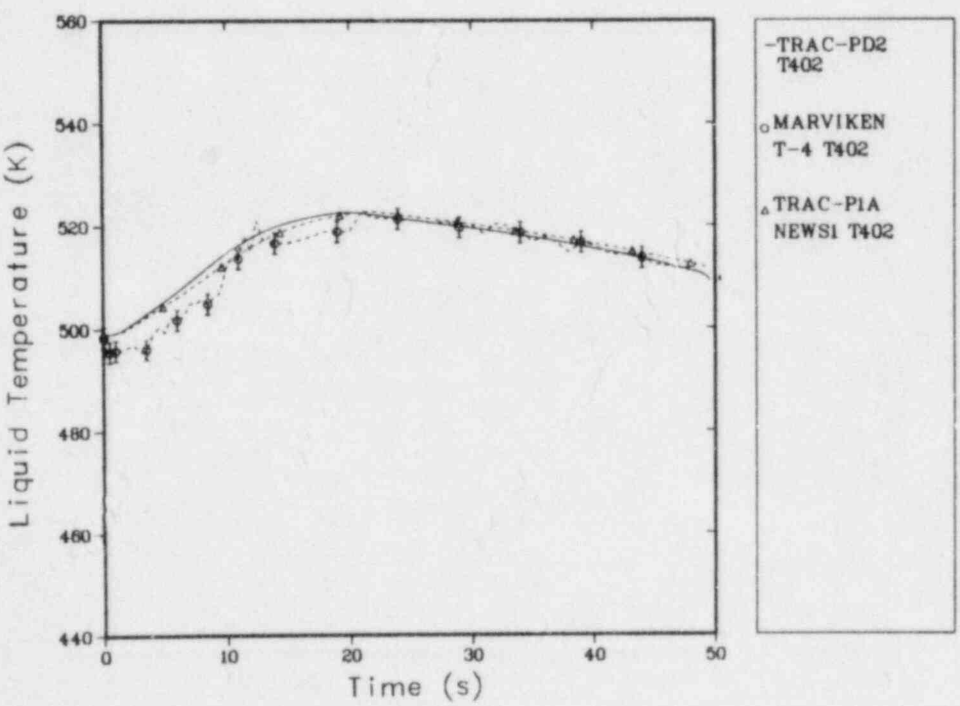


Fig. 50.
Liquid temperature at measurement station T402 for Marviken Test 4.

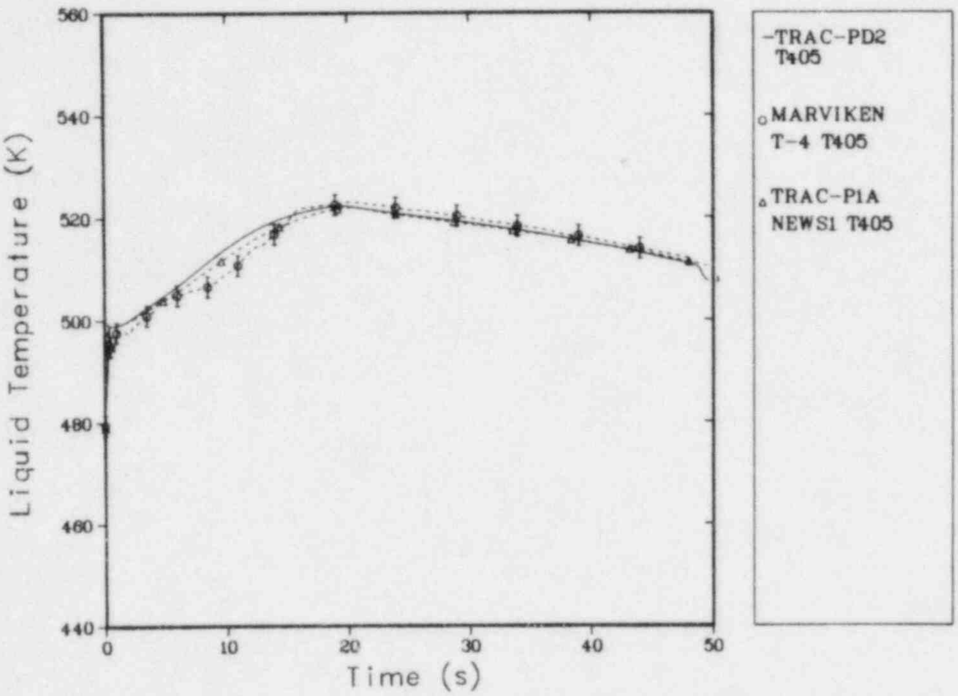


Fig. 51.
Liquid temperature at measurement station T405 for Marviken Test 4.

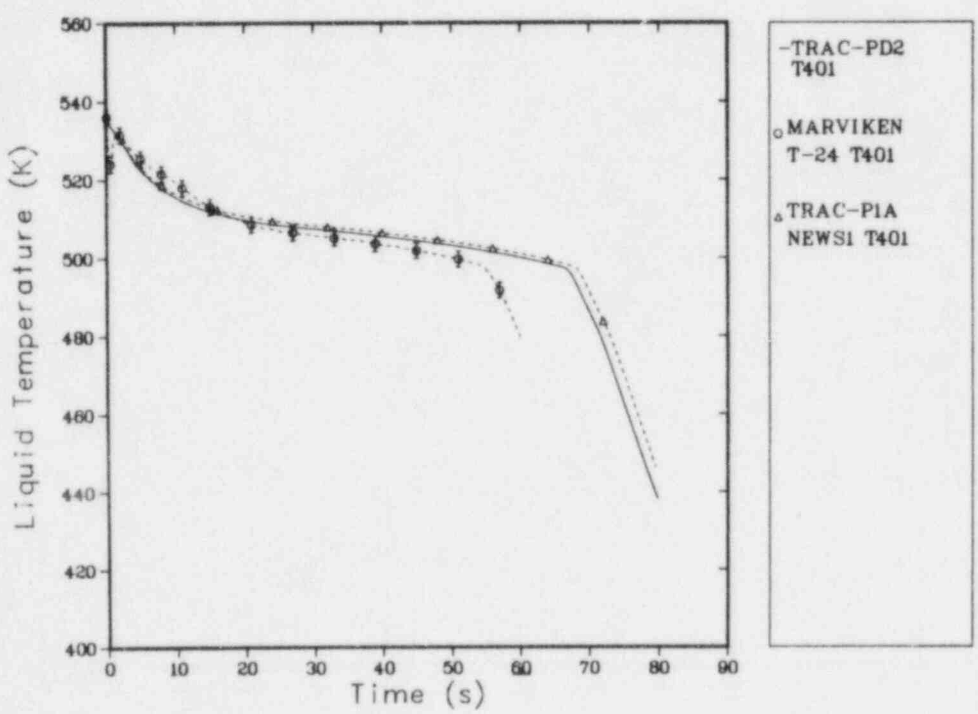


Fig. 52.
Liquid temperature at measurement station T401 for Marviken Test 24.

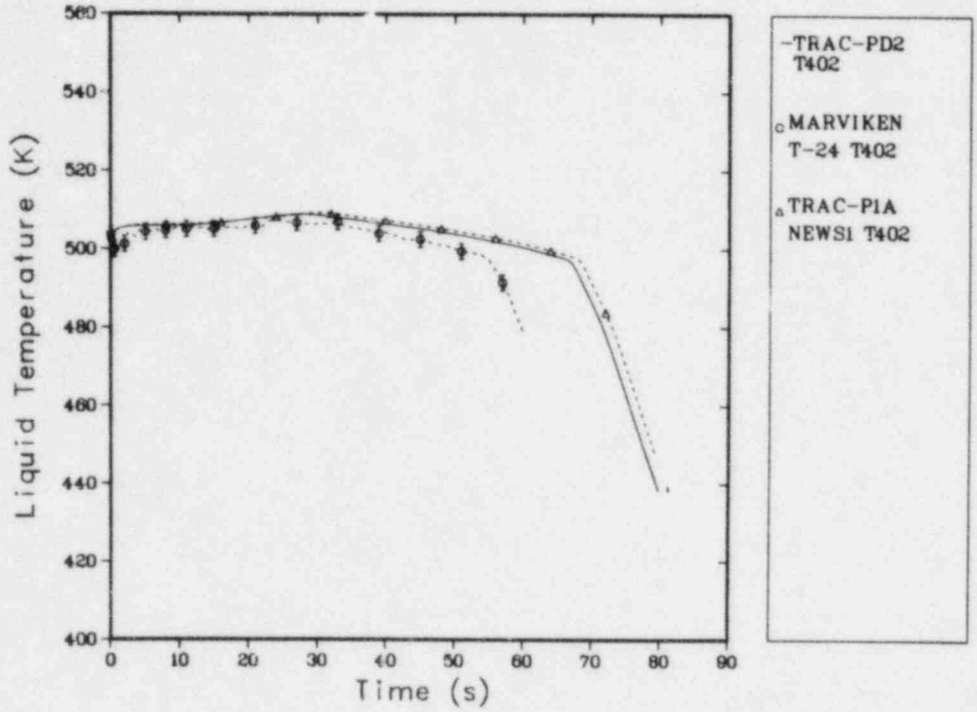


Fig. 53.
Liquid temperature at measurement station T402 for Marviken Test 24.

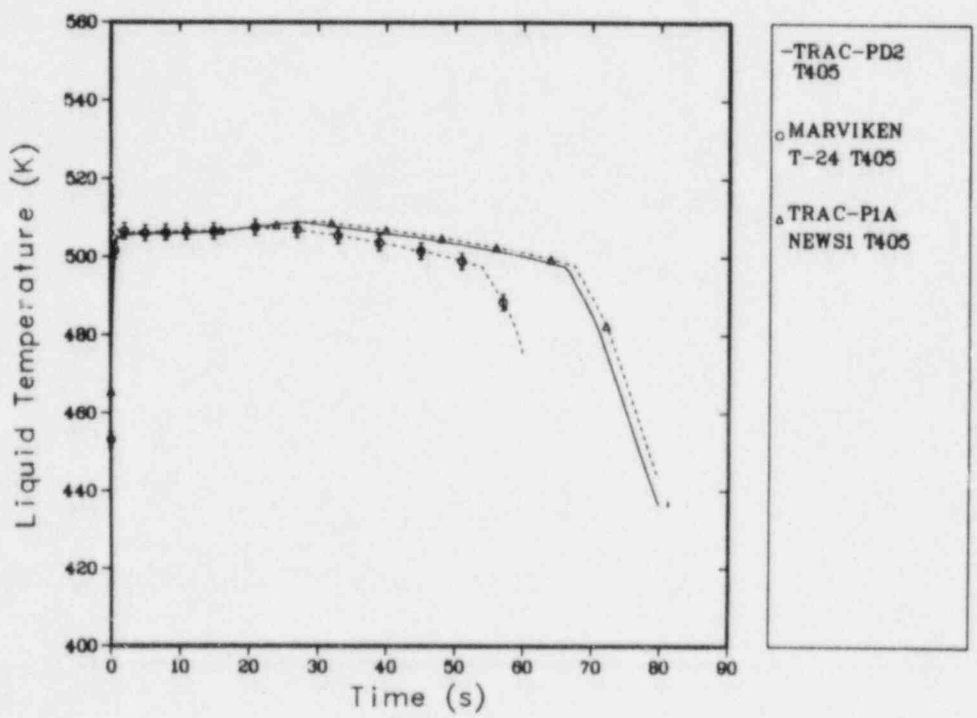


Fig. 54.
Liquid temperature at measurement station T405 for Marviken Test 24.

cooler liquid. The mixing process in a cell diffused the thermal stratification in the liquid. After the peak temperature was reached, the temperature, although slightly delayed, corresponded to the saturation curve.

In summary, when we related the data comparisons to the information in Table VI, we found that the quality of the comparisons degraded as the L/D ratio decreased. The discrepancy between emptying times increased as the mass-flux underprediction became more severe. The quality of the comparisons for other parameters such as temperature, pressure, and density was related directly to the quality of the mass-flux comparisons.

Experiment uncertainty information was provided.[7,8] For pressure data, the uncertainty was ±90 kPa; for temperature data, ±2 K. For mass-flow comparisons, the pitot-static data uncertainty was ±15% and the vessel differential-pressure data uncertainty was ±10% after 5 s.

D. Conclusions

The Marviken calculations used the same code components (PIPE, FILL, and BREAK) that the other blowdown calculations used. In addition to most of the effects present in the Edwards' and CISE experiments, the Marviken experiment included full-scale effects and large flow-area variations.

For both tests, the TRAC-PD2 results were similar to the TRAC-P1A calculated values. The comparison between the calculated and measured results indicated that the code underpredicted the flow and did not calculate correctly the nonequilibrium effects when the upstream conditions were subcooled and the critical flow was controlled by nonequilibrium effects. The longer nozzle, because of frictional effects, tended to drive the flow toward equilibrium and, thus, accounted for the improved comparisons at large L/D ratios. Once the system reached saturation, the code generally calculated the correct critical flows. The results were sensitive to the initial system temperature distribution.

The discrete nature of the hydraulic cells caused the artificial mixing of the hotter liquid near the top of the liquid region with the colder liquid farther down in the vessel and, ultimately, propagated the higher enthalpy fluid to the break earlier than demonstrated in the tests. The constitutive relations in TRAC-PD2 do not permit delayed nucleation; thus, the code did not calculate the initial dip in pressure at the beginning of the tests and forced the critical-flow calculation toward equilibrium.

In conclusion, after the early portion of the transient, the good agreement between the calculated and measured results indicated that TRAC-PD2 properly treats scale effects in one-dimensional critical-flow configurations. Also, because of these calculations we identified the possible need for a delayed-nucleation model.

The calculations for Tests 4 and 24 required 130 s of CPU time on a CDC 7600 computer.

V. THTF TEST 177 BLOWDOWN EXPERIMENT

A. Experiment Description

The THTF was designed to investigate heat transfer in an electrically heated rod bundle that simulates a PWR core. Test 177 simulated the core thermal-hydraulic response during a blowdown. Figure 55 is a schematic of the THTF.

This blowdown experiment is a nonnuclear pressurized water loop containing a 7 × 7 array of fuel-pin simulators.[9] The fuel-pin simulators had a 3.66-m heated length, a 0.010 77-m diameter, and a 82-kW input per pin. In this test, 45 of the 49 pins were electrically heated. During steady-state operation, water was pumped through the system at a nominal rate of 23 $kg \cdot s^{-1}$ and at an inlet pressure of 16 MPa. The coolant inlet and outlet temperatures were 551 and 581 K, respectively.

The transient was initiated by simultaneously opening the inlet and outlet rupture disks. Flow from both the inlet and outlet piping returned to the pressure-suppression system. During the transient, power to the electrically heated rods decreased sharply during the first 4 s then recovered to ~62% full power at 5 s, after which it decayed to zero power at 10 s. The measured volumetric flow rate at the inlet reversed direction early in the transient (<1 s) and decreased to a low flow rate after 5 s. The TRAC-PD2 program calculated that only ~8% of the initial system mass remained at 6 s. Three-dimensional flow patterns in the test section were observed frequently.

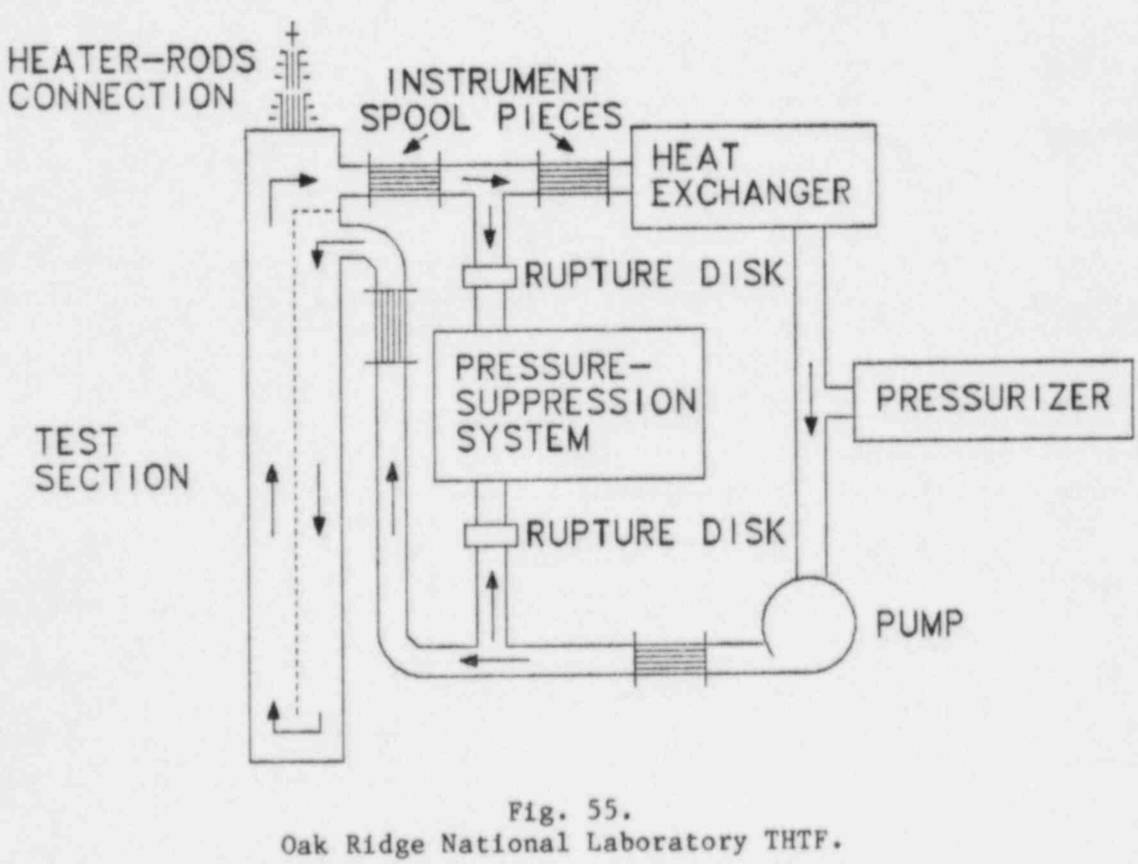


Fig. 55.
Oak Ridge National Laboratory THTF.

Pressure and temperature transducers were located in the instrument spool pieces near the inlet and the outlet (Fig. 55) to the test section. Also located there were turbine meters to measure volumetric flow and gamma densitometers to measure density. Temperatures determined by the thermocouples inside the heater rods at the lower, middle, and upper portions of the test section (levels D, G, and M, respectively) were compared with the calculated temperatures. Figure 56 shows the thermocouple locations.

B. TRAC-PD2 Model

The test facility was modeled with three types of TRAC components. In the nonnuclear pressurized water loop, the VESSEL modeled the 7 × 7 test-section array of fuel-pin simulators. A 36-cell two-dimensional Cartesian vessel geometry approximated the test-section array of fuel-pin simulators. The PIPEs were connected to the VESSEL for the inlet and outlet flows. The FILLs were connected to the PIPEs and the test velocity conditions were specified both at the inlet and at the outlet.

Four PIPEs were used, two at the inlet and two at the outlet. The component adjacent to the VESSEL used the partially implicit hydrodynamics option, whereas the component adjacent to the FILL used the fully implicit hydrodynamics option.

Because the test-section array of fuel-pin simulators was square, a VESSEL with a two-dimensional Cartesian geometry was used. Figures 56 and 57 show the 36-cell noding. The outer cells modeled the downcomer and the inner cells modeled the upward flow past the fuel-pin simulators. Table VII lists the locations of the measured and the calculated rod temperatures. Figure 56 shows their locations. Each PIPE used 10 cells of equal size.

The axial power profile was modeled with the axial cells shown in Fig. 58. The power steps do not coincide with the cell edges except at the beginning of the profile. Figure 59 displays the radial noding of a rod and a cross section of the rods that shows the thermocouple locations.

Because dryouts and rewets were measured in the test section, two rewet correlations were studied. A rewet correlation deals with the minimum stable film-boiling temperature (T_{min}). The homogeneous-nucleation, minimum, stable film-boiling temperature is the TRAC-PD2 default option. The T_{min} correlation by Iloeje et al.[10] also was considered.

We performed a steady-state calculation to establish the initial conditions and then performed the transient calculation.

Appendix D lists the steady-state and transient input decks for THTF Test 177.

C. Data Comparisons

Figures 60-62 compare the calculated rod-surface temperatures with the measured values from the lower, middle, and upper levels of the test section, respectively. The temperature scales differ for each plot (note expanded scale in Fig. 62). During the first 6 s, several rewets occurred (Figs. 60 and 62). The main rewet in Fig. 60 was calculated accurately. The rewet in Fig. 62 was not calculated because TRAC-PD2 determined that the upper test section dried out. The TRAC-PD2 calculations using the homogeneous-nucleation, minimum, stable film-boiling temperature in place of the Iloeje correlation yielded virtually identical results. No spurious rewets were observed in either case.

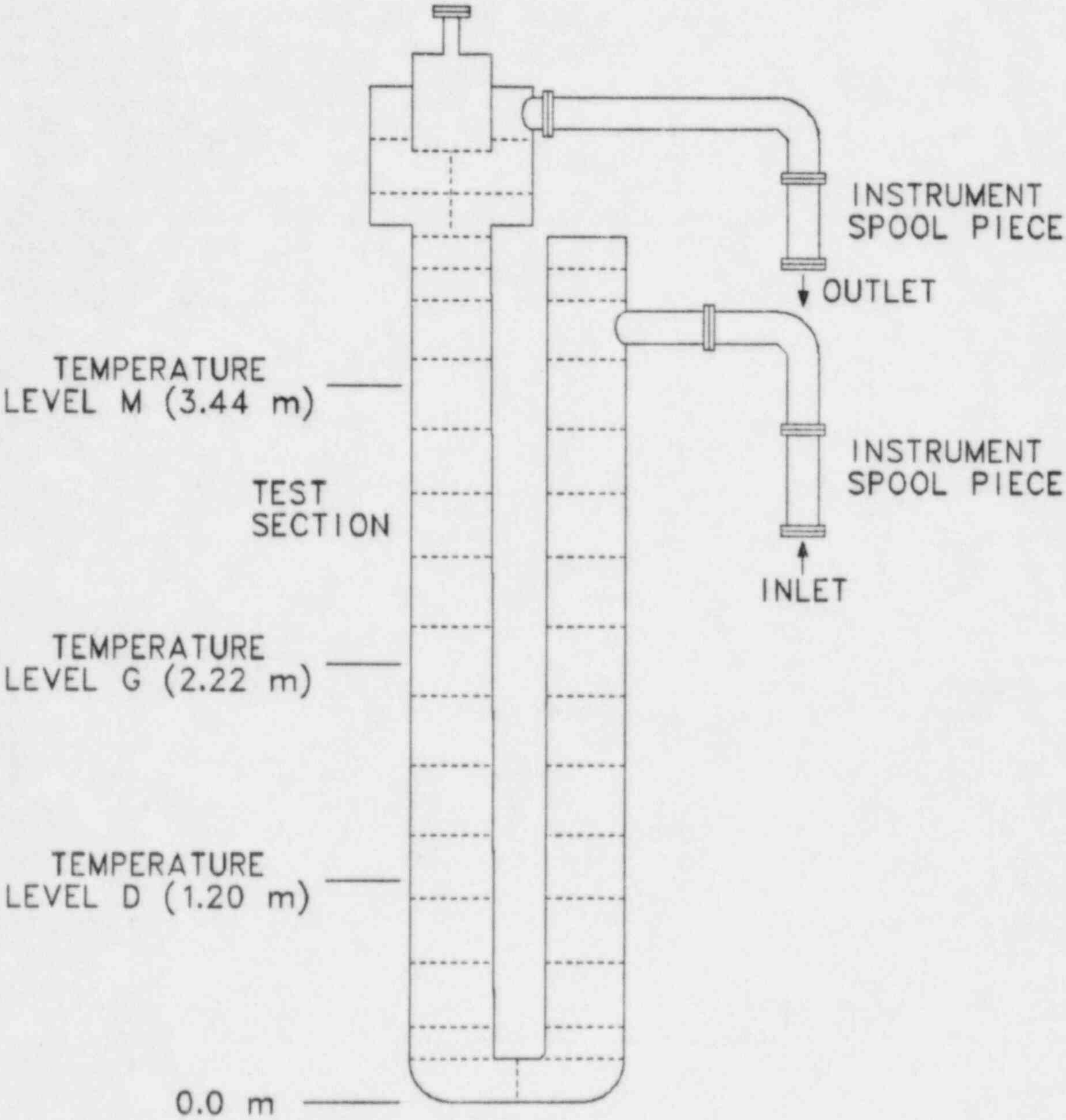


Fig. 56.
Single-channel test-section model of THTF (represents levels D, G, and M, identified in Ref. 9).

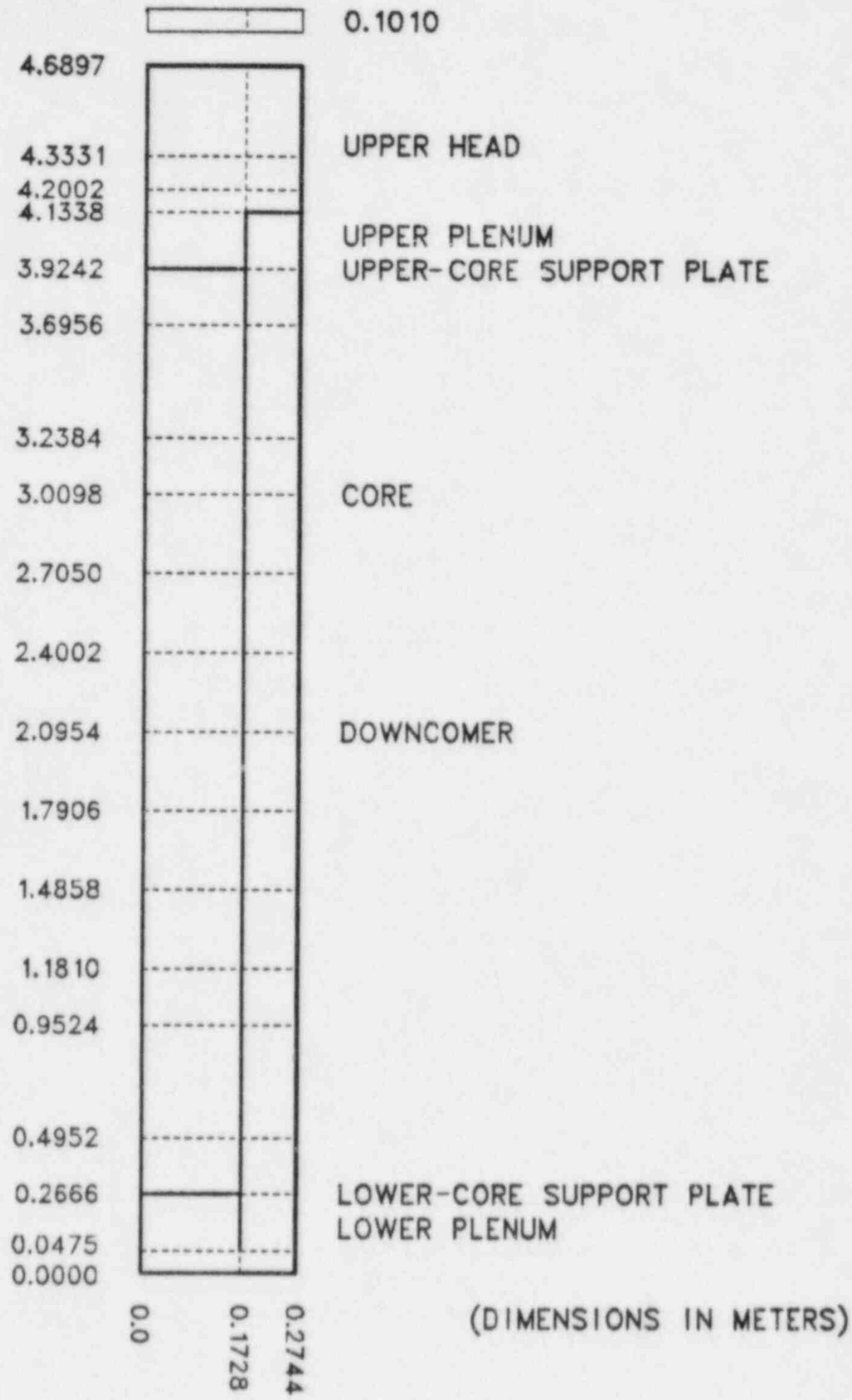


Fig. 57.
TRAP-generated model of THTF VESSEL component.

TABLE VII

LOCATION OF MEASURED AND CALCULATED QUANTITIES
FOR THTF TEST 177 BLOWDOWN EXPERIMENT

Measured		Calculated	
Level	Parameter	Component	Cell
Temperature level D	Temperature (K)	VESSEL 1	1 (axial level 5)
Temperature level G	Temperature (K)	VESSEL 1	1 (axial level 8)
Temperature level M	Temperature (K)	VESSEL 1	1 (axial level 12)
--	Mass flow ($kg \cdot s^{-1}$)	FILL 3	--
--	Mass flow ($kg \cdot s^{-1}$)	FILL 7	--

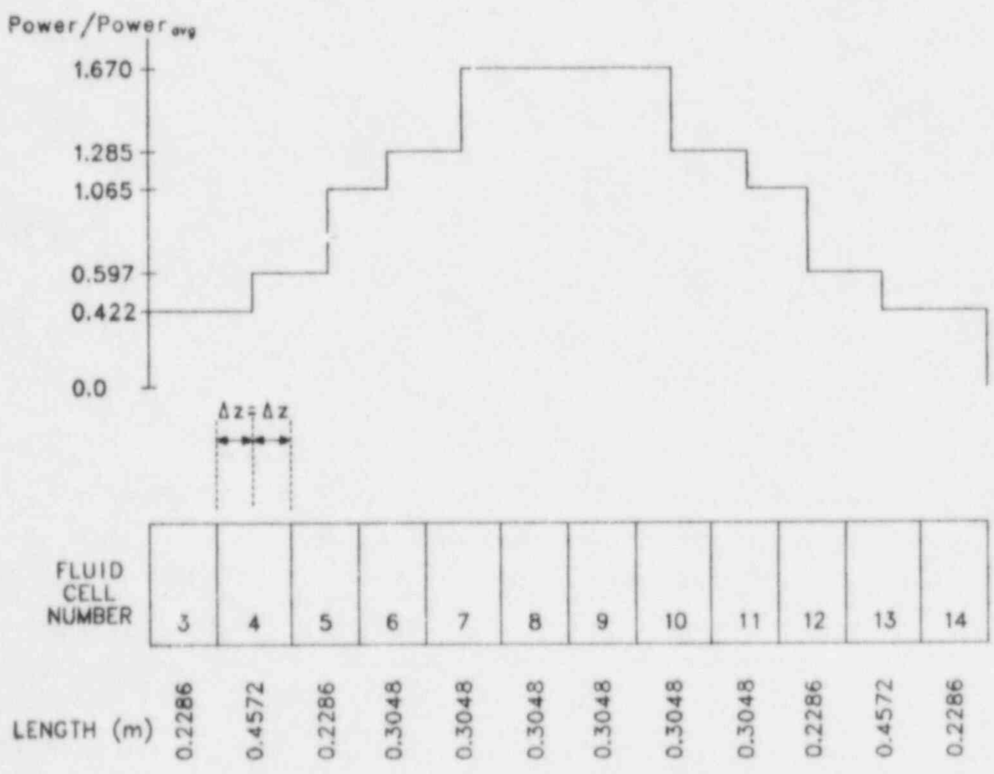


Fig. 58.
Axial power profile for THTF Test 177.

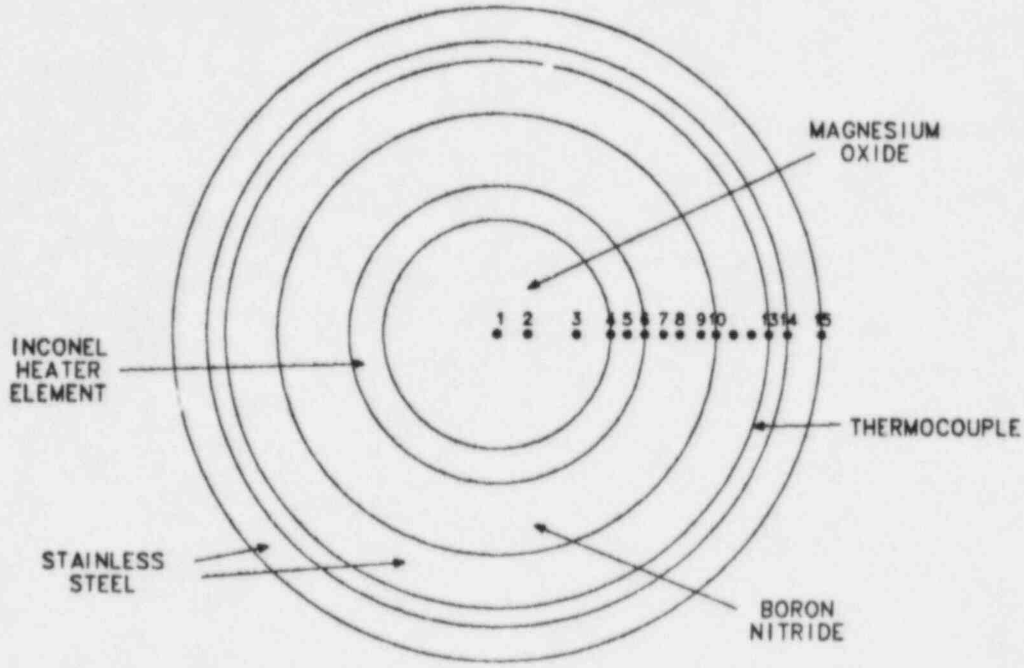


Fig. 59.
Radial noding diagram of the heater rod for THTF Test 177.

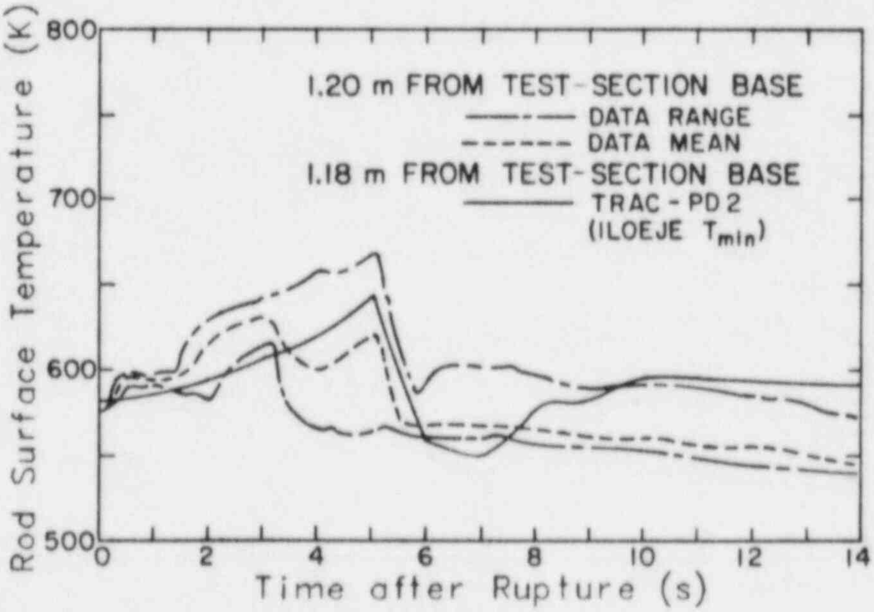


Fig. 60.
Comparison of the TRAC-calculated rod-surface temperatures with the THTF Test 177 measurements. The temperature was measured 1.20 m above the test-section base (level D, identified in Ref. 9).

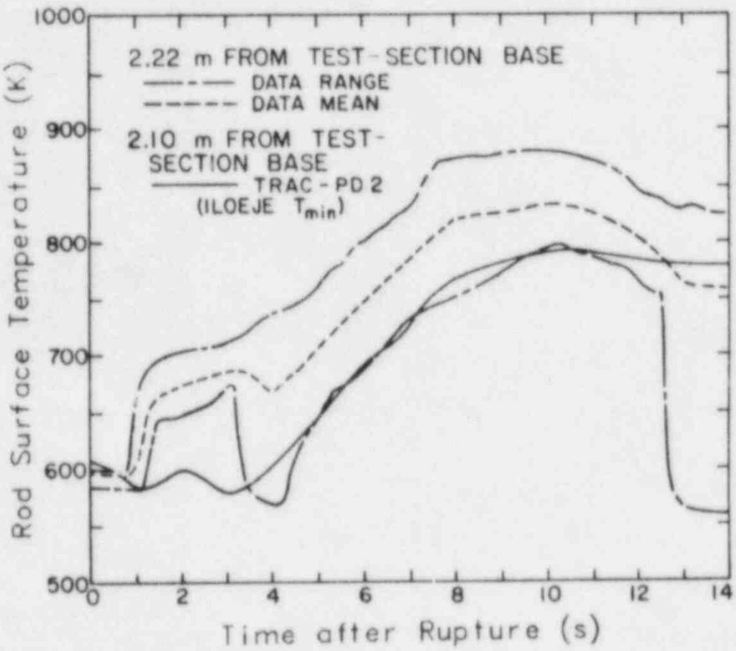


Fig. 61.
Comparison of the TRAC-calculated rod-surface temperatures with the THTF Test 177 measurements. The temperature was measured 2.22 m above the test-section base (level G, identified in Ref. 9).

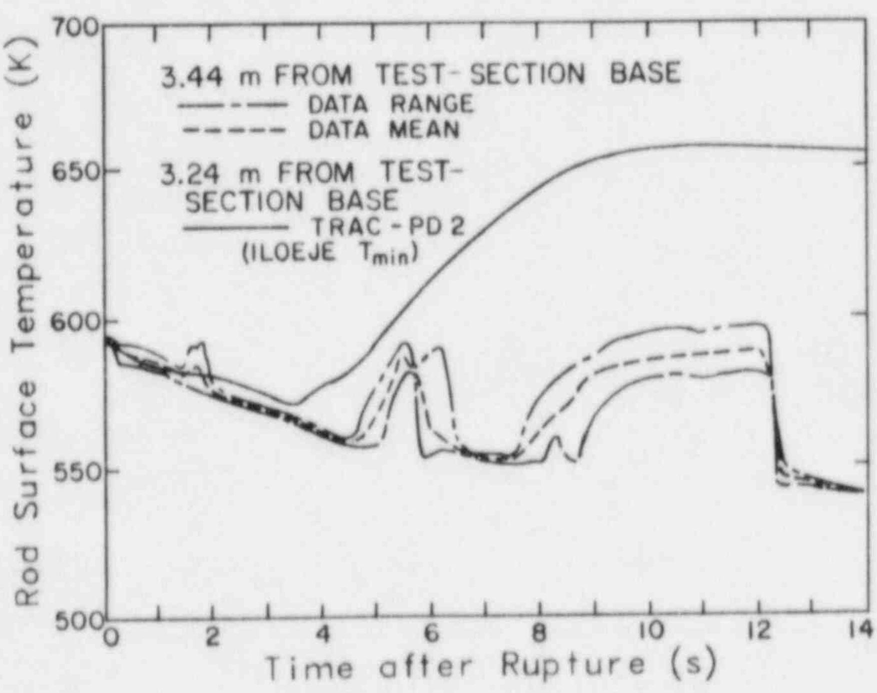


Fig. 62.
Comparison of the TRAC-calculated rod-surface temperatures with the THTF Test 177 measurements. The temperature was measured 3.44 m above the test-section base (level M, identified in Ref. 9).

D. Conclusions

Thermal-hydraulic effects assessed by Test 177 included a two-dimensional Cartesian-geometry vessel model with rod heat transfer including rewet models. Code components tested in this problem were VESSEL, PIPE, and FILL. In general, TRAC-PD2 rewet calculations were in reasonable agreement with the available measurements. Three-dimensional flow patterns in the test section were observed frequently. A one-dimensional flow model was used in the test section. The homogeneous-nucleation, minimum, stable film-boiling temperature correlation gave virtually identical results to the Iloeje correlation.

The steady-state calculation required 388 s of CPU time on a CDC 7600 computer; the transient calculation, 480 s.

VI. BENNETT TUBE EXPERIMENTS

A. Experiment Description

For the TRAC assessment, the TRAC-PD2 results were compared with data from the steady-state experiments performed by A. W. Bennett et al.[11] The data determined the variation of wall temperatures in the region beyond the dryout point for various coolant flow rates, wall heat fluxes, and coolant inlet subcoolings. The experiments consisted of circulating preheated water through a tubular test section that was heated by passing direct current through its walls.

The test section was a 5.8-m length of Nimonic 80A alloy tubing, which had a 12.6-mm i.d. and a 1.63-mm wall thickness. Busbars attached to the test section provided heated lengths of 3.66 and 5.56 m. The inside wall temperatures were determined by 27 thermocouples attached to the outer wall of the test section.

In this study we analyzed three typical test Runs 5336, 5431, and 5442. Table VIII lists the test conditions for these three experiments. In all cases the pressure was 6.895 MPa (1000 psia).

B. TRAC-PD2 Model

The facility was modeled by three TRAC components, a FILL, a PIPE, and a BREAK (Fig. 63). The FILL provided the inlet boundary conditions for the PIPE, whereas the BREAK provided the outlet boundary conditions. The specified inlet boundary conditions were a void fraction equal to zero, liquid mass flow, pressure, and temperature. The vapor pressure and temperature were specified at the pipe outlet. Appendix E lists the TRAC-PD2 steady-state input decks for Bennett Runs 5442, 5431, and 5336, respectively. Because TRAC does not permit steady-state CHF, the transient runs were made until the wall temperatures approached steady-state conditions (25 s).

C. Results

Figure 64 shows the results from Bennett Run 5442, TRAC-P1A (Ref. 12), TRAC-P1A/NEWS1, and TRAC-PD2. The TRAC-P1A program greatly overestimated the wall temperatures because it contained an interfacial heat-transfer error. Errors found after TRAC-P1A was released were described in the first TRAC

TABLE VIII

TEST CONDITIONS

Run Number	Mass Flux ($kg \cdot m^{-2} \cdot s^{-1}$)	Power (kW)	Heat Flux ($W \cdot m^{-2}$)	Inlet Subcooling (K)	Tube Length (m)
5336	664	181	8.18×10^5	26.3	5.56
5431	651	115	7.96×10^5	23.9	3.66
5442	4814	302	2.07×10^6	16.4	3.66

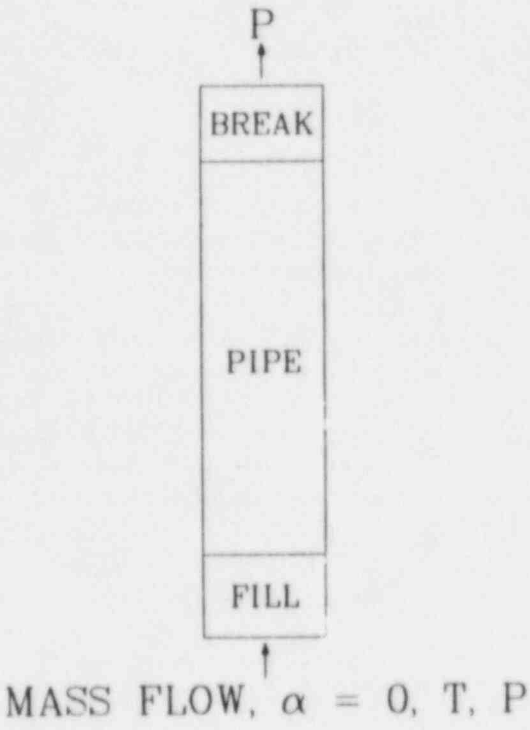


Fig. 63.
TRAC model geometry.

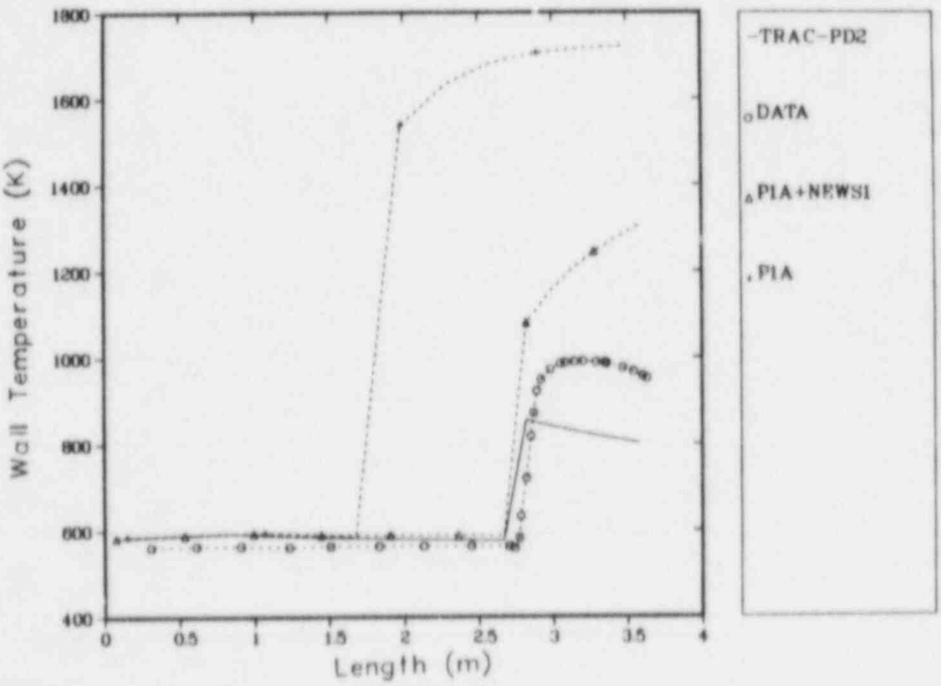


Fig. 64.
Comparison of the TRAC-calculated wall temperatures with the Bennett Run 5442 data.

newsletter,[13] and the modified code was designated TRAC-P1A/NEWS1. The TRAC-P1A/NEWS1 results (Fig. 64) agreed better with the data than the TRAC-P1A results, but the data still overpredicted the wall temperatures. Although the TRAC-PD2 results underpredicted the data, they agreed better with the data than previous predictions.

Figure 65 compares the data for Bennett Run 5336 and the TRAC predictions. The TRAC-P1A/NEWS1 version predicted the CHF point better than TRAC-PD2, but the temperature gradient near the top of the tube was steeper than indicated by the data. The difference in CHF points between the two TRAC predictions is discussed below.

Figure 66 shows the results for Bennett Run 5431. As in Run 5336, TRAC-PD2 predicted the CHF at too low an elevation in the tube. Figure 67 explains this CHF prediction. To obtain a smooth boiling curve, interpolation is used in TRAC between correlations. For void fractions between 0.96 and 1.0, linear interpolation was used to obtain the liquid and vapor HTCs. When the void-fraction cutoff point (ALPCUT) was changed from 0.96 to 0.99, much better agreement with the data was obtained for Run 5431 (Fig. 67). No change occurred in the TRAC-PD2 prediction for Run 5442 when ALPCUT was changed from 0.96 to 0.99. A value of ALPCUT equal to 0.96 was used in the code because the predicted HTC gradients were too steep for other test facilities.

Figure 68 shows a noding sensitivity study for Run 5442. Six fluid cells were too few, but 12 or 24 fluid cells resulted in approximately the same wall temperatures.

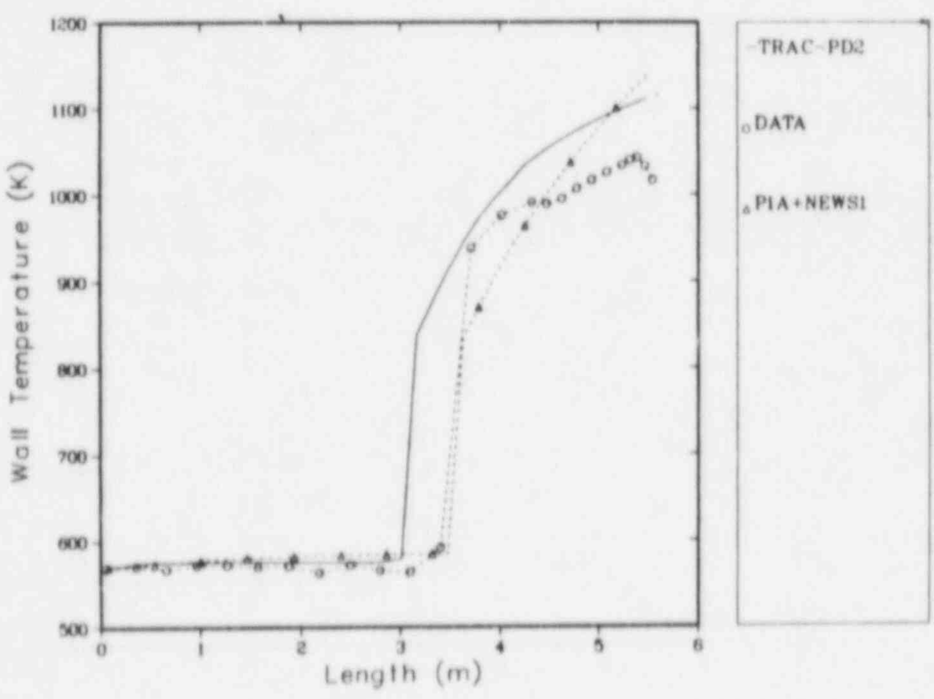


Fig. 65.
Comparison of the TRAC-calculated wall temperatures with the Bennett Run 5336 data.

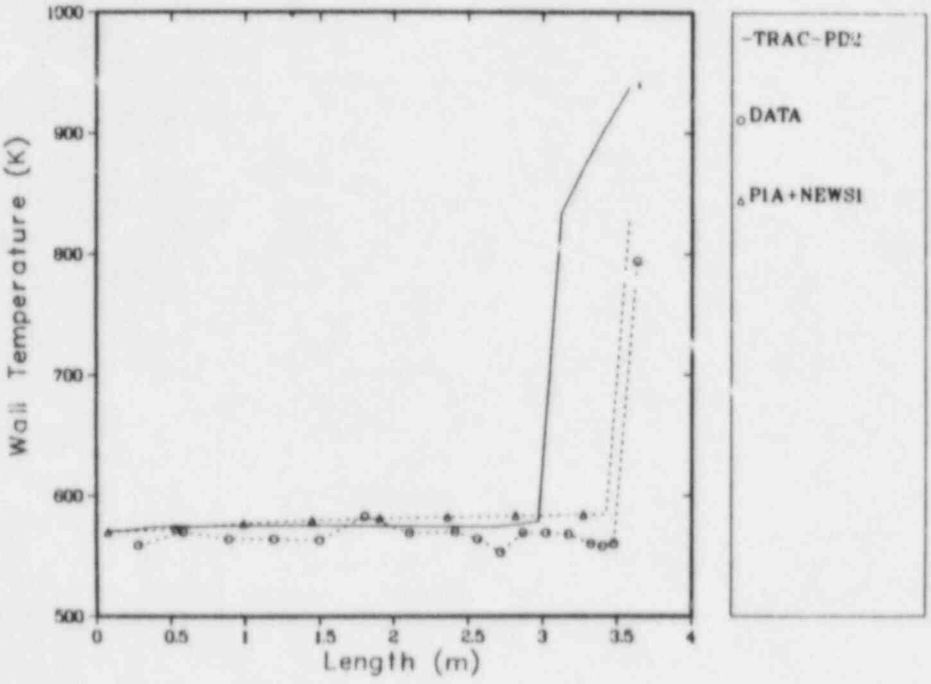


Fig. 66.
Comparison of the TRAC-calculated wall temperatures with the Bennett Run 5431 data.

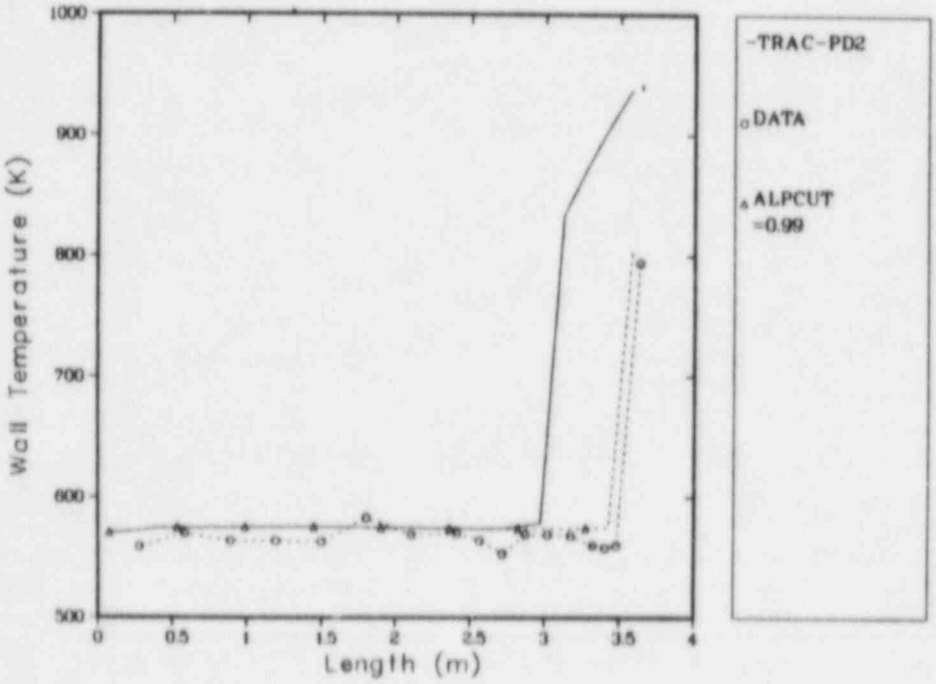


Fig. 67.
The effect of the boiling-curve interpolation on Bennett Run 5431.

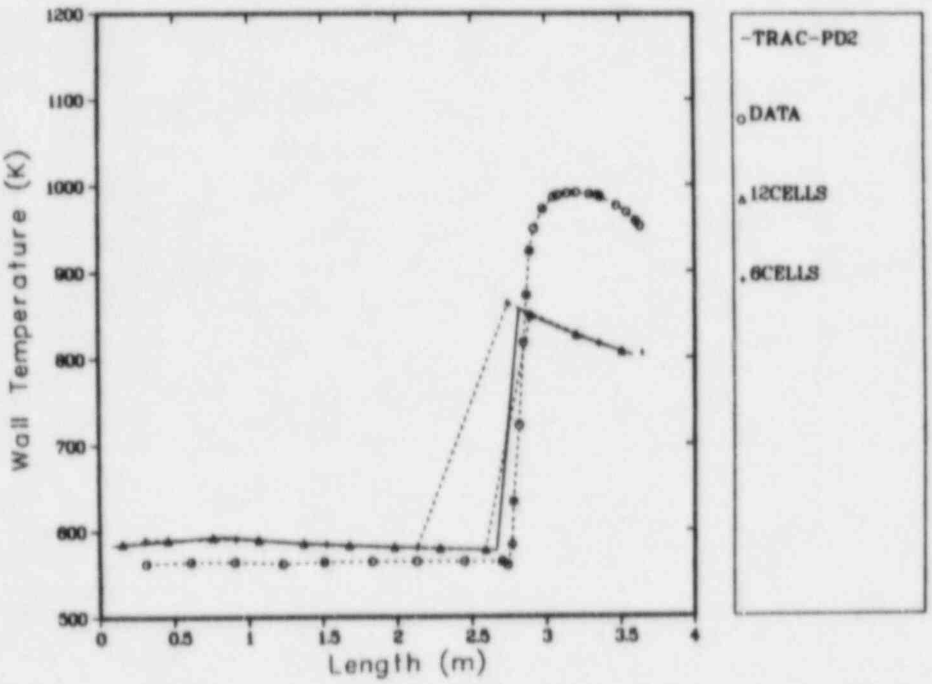


Fig. 68.
Noding sensitivity for Bennett Run 5442.

The TRAC-P1A program[12] allowed three CHF options: the Biasi correlation for high flow and the Zuber correlation for low flow, the Biasi correlation for both high and low flows, and the Bowring correlation for both high and low flows.

In TRAC-PD2 only the Biasi correlation was used but, at mass fluxes between -200 and 200 kg · m^{-2} · s^{-1}, the Biasi correlation was evaluated at 200 kg · m^{-2} · s^{-1}. Figures 69-71 show that the Bowring CHF correlation gave significantly worse results than the Biasi CHF correlation for Run 5442 (high mass flux), but the predictions using the Bowring correlation were better for Runs 5336 and 5431 (low mass flux). When the Bowring correlation was used and ALPCUT was changed from 0.96 to 0.99, the Run 5442 results were unchanged, but the CHF occurred later than in the data for Runs 5336 and 5431 (Figs. 72 and 73). The low mass-flux runs were very sensitive to the boiling curve interpolation and, overall, the Biasi correlation gave better results than the Bowring correlation.

Five options for the wall friction, in addition to an input constant, are available in TRAC-PD2. Table IX lists these options (see Ref. 1 for model details).

The value NFF = 1 was used in the base runs. Figure 74 shows the results for Bennett Run 5442 when NFF = 1, 2, or 3. Predictions using NFF = 4 were identical to those using NFF = 2; the predictions using NFF = 5 were identical to those using NFF = 1 or 3. The CHF point (Fig. 74) was slightly lower in the tube and the maximum wall temperature was a few degrees higher when the Armand correlation or the modified annular-flow model was used.

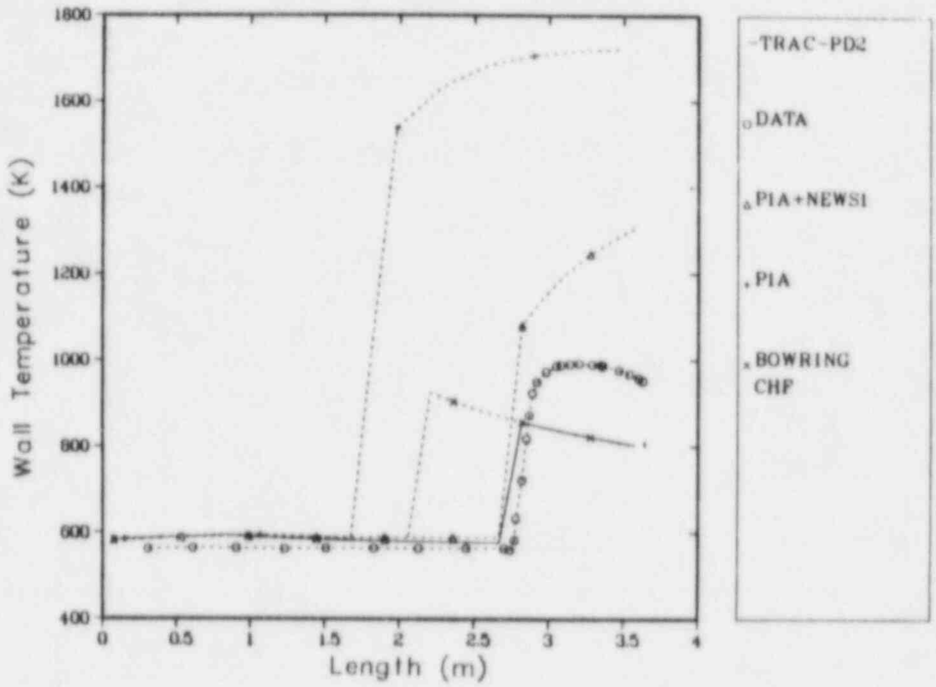


Fig. 69.
CHF correlation sensitivity for Bennett Run 5442.

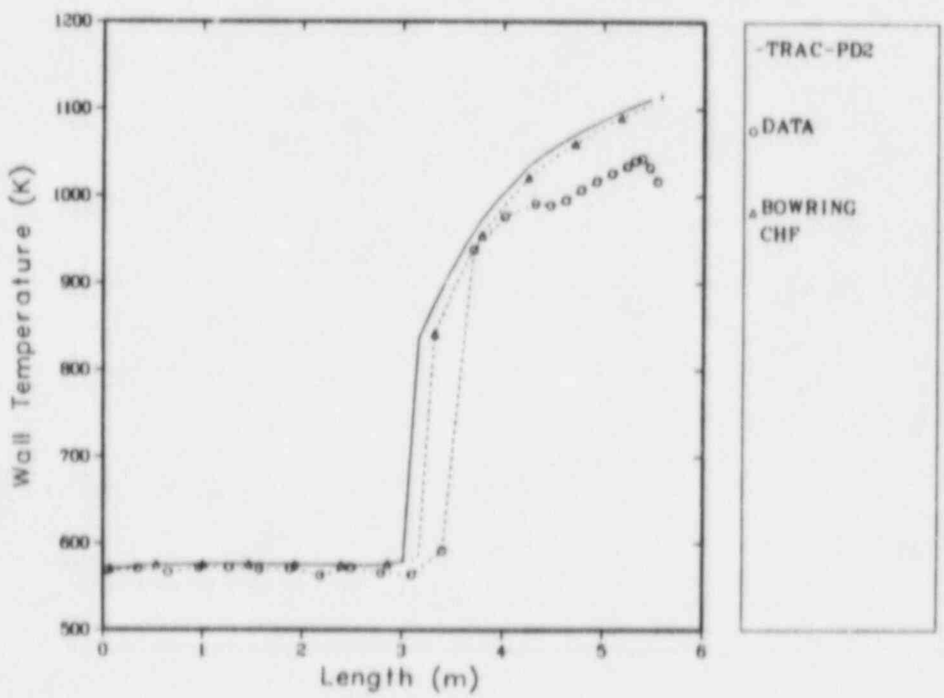


Fig. 70.
CHF correlation sensitivity for Bennett Run 5336.

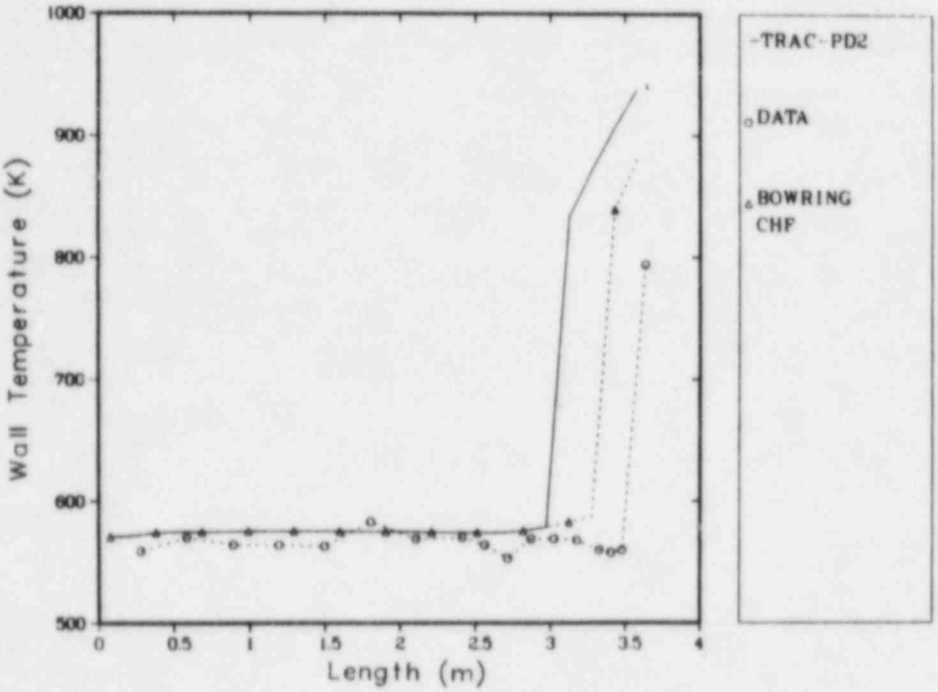


Fig. 71.
CHF correlation sensitivity for Bennett Run 5431.

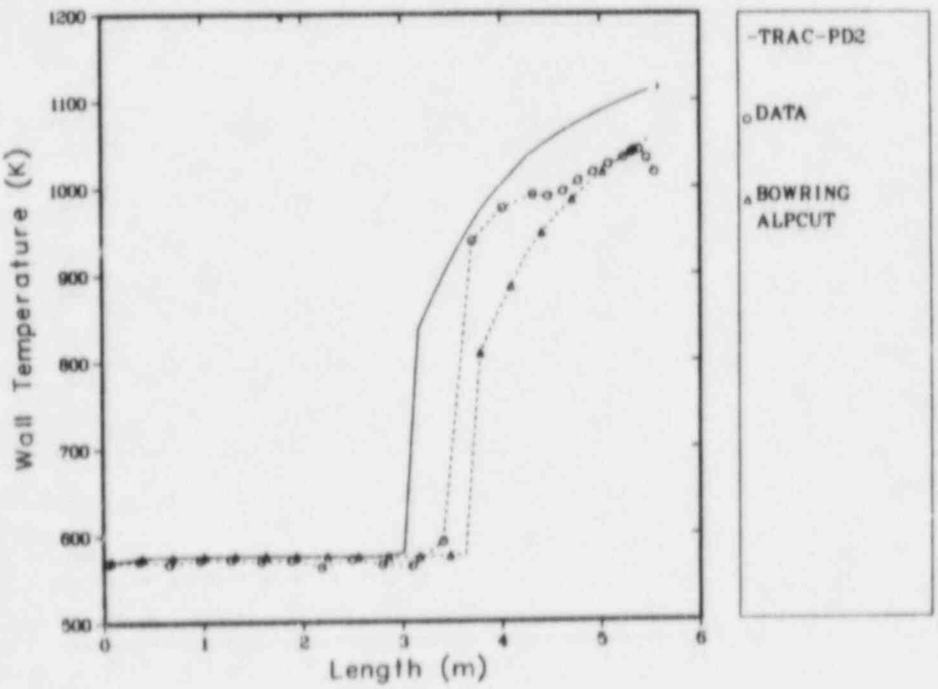


Fig. 72.
The effect of the CHF correlation and boiling-curve interpolation on Bennett Run 5336.

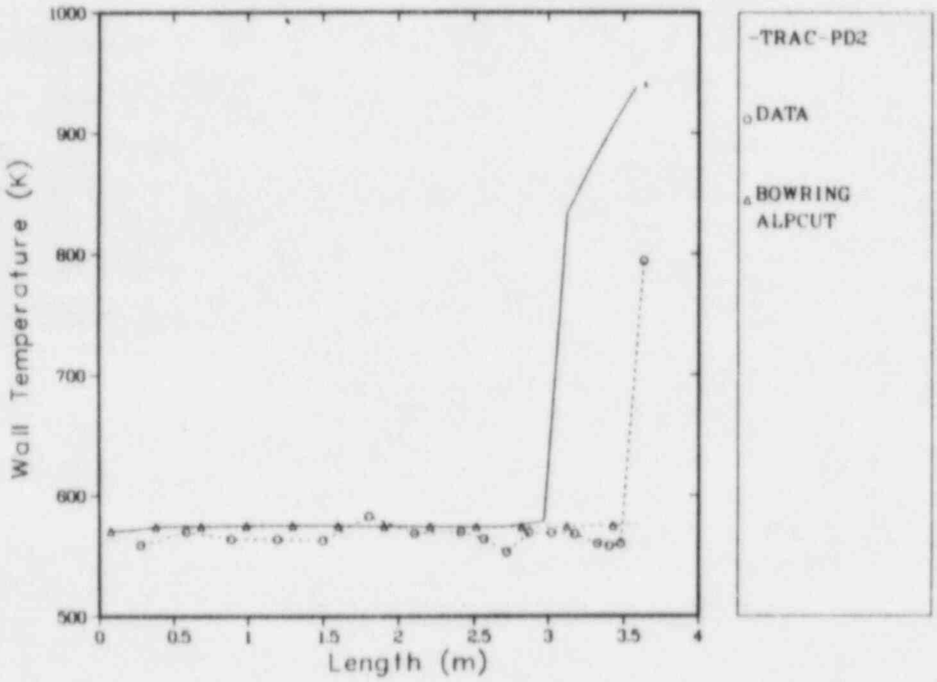


Fig. 73.
The effect of the CHF correlation and boiling-curve interpolation on Bennett Run 5431.

TABLE IX

TRAC WALL FRICTION OPTIONS

NFF Value	Option
1	Homogeneous model
2	Armand correlation
3	CISE correlation
4	Modified annular-flow model
5	Chisholm correlation

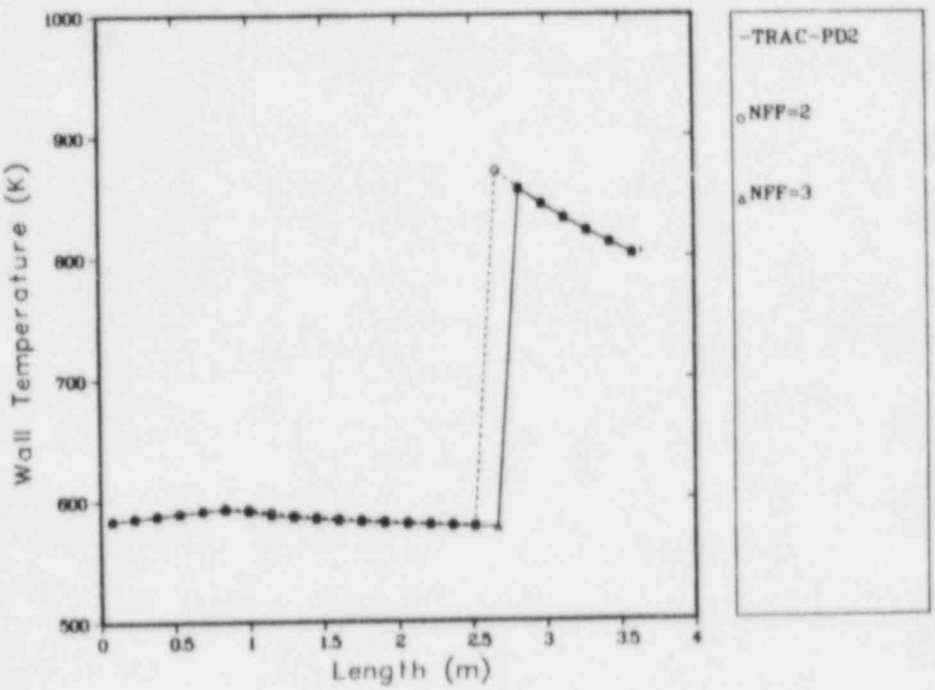


Fig. 74.
The effect of wall friction on Bennett Run 5442.

Table X lists the computer storage requirements and the computer times required for the Bennett base cases.

In general, the high mass-flux TRAC-PD2 test predictions (Run 5442) agreed better with the data than the TRAC-P1A results, whereas the low mass-flux runs showed slightly worse agreement with the data. Overall, the Biasi CHF correlation agreed better with the data than the Bowring CHF correlation, which was not included in TRAC-PD2. The low mass-flux runs were too sensitive to the boiling-curve interpolation.

After studying these results, we recommend two code improvements. First, the boiling curve should be examined and changed so that the results are not affected significantly by the interpolation method. Second, the wall friction-factor models should be examined to determine the best model, and only this model should be included in future code versions.

TABLE X

COMPUTER REQUIREMENTS FOR BENNETT PREDICTIONS

Run Number	CPU Time (s)	SCM[a] (words)	LCM[b] (words)
5336	274	3920	11055
5431	118	2696	9831
5442	201	2696	9831

[a]Small core memory.

[b]Large core memory.

VII. CREARE COUNTERCURRENT-FLOW EXPERIMENTS

A. Experiment Description

We used the Creare countercurrent-flow experiments to examine the effects of countercurrent steam-flow rate, downcomer wall superheating, and liquid subcooling on ECC penetration to the lower plenum. For this assessment, the Creare test facility was a 1/15-scale (linear dimension), multiloop, cylindrical model of a PWR downcomer region. Reference 14 describes this facility and its operation. The Creare vessel can be arranged in at least six geometrical configurations. The tests that we analyzed had a base-line configuration with a 0.0127-m (0.5-in.) downcomer gap and a deep-plenum geometry.

Four cold legs penetrated the outer surface of the vessel at 90° intervals. Three intact-loop cold legs were connected to the ECC-injection lines. One broken-loop cold leg was connected to a pressure-suppression tank. In these assessment tests, the four hot legs were blocked.

The procedures for the countercurrent-flow tests established a constant steam-flow rate through the vessel and purged air from the vessel. Steam entered at the top of the vessel, then flowed down the interior core region into the lower plenum, up the downcomer, and out the broken cold leg. After the desired steady steam-flow rate was established, water was injected simultaneously into the three intact-loop cold legs at a constant, preset flow rate. After a short transient period, the plenum began to fill. The test was run until the lower plenum was full or until the fill rate was determined from the strip-chart records. A complete penetration curve was generated by a series of such tests with fixed liquid-injection rates and temperatures but with varied steam-flow rates. The ECC penetration into the lower plenum ranged from complete delivery to complete bypass for each test series.

B. TRAC-PD2 Model

Figure 75 shows the TRAC model of the Creare vessel. The vessel was modeled with seven axial levels. Each level was subdivided into 2 radial and 8 azimuthal zones for a total of 112 mesh cells. Because level 6 had four sources (PIPEs), we selected eight rather than four azimuthal zones. Thus, an ECC-injection source did not connect directly to each cell at this level. We chose one radial segment in the downcomer because this was typical of the TRAC full-scale PWR model. The axial-level dimensions allowed resolution of several important phenomena. Levels 1 and 2 allowed pooling of the liquid in the lower plenum where the results were insensitive to the relative height of each cell. Level 3 allowed flow-pattern resolution near the bottom of the downcomer. Levels 4, 5, and 6 allowed flow-pattern resolution in the downcomer region, and level 7 provided resolution of any liquid stored in the upper part of the downcomer.

The calculational sequence was parallel to that of the Creare experiment. The steam was injected into eight PIPEs connected to cells 1-8 at level 7 by FILLs. The intact-loop cold legs were isolated by zero-velocity FILLs. The broken-loop cold leg was connected to a BREAK and the pressure was chosen to give the correct lower-plenum pressure. Thus, the correct ECC subcooling was ensured. A generalized steady-state calculation established a constant, reverse steam flow and lower-plenum pressure. The transient calculation was started from the steady-state dump. The FILLs connected to the three intact-loop cold legs ensured the correct ECC-injection flow rate and temperature.

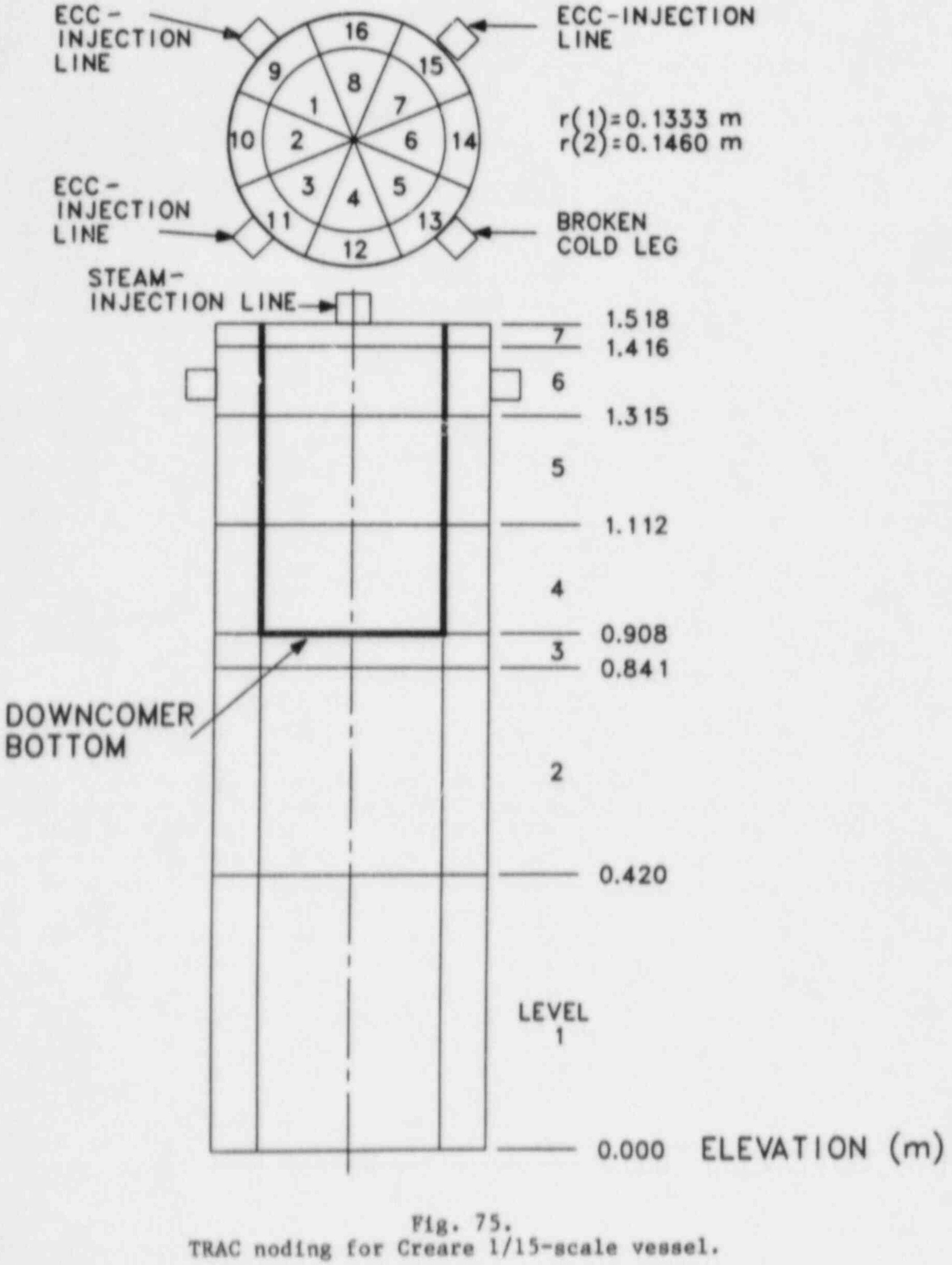


Fig. 75.
TRAC noding for Creare 1/15-scale vessel.

The instantaneous values of J^*_{gc} (the dimensionless steam flow) and J^*_{fd} (the dimensionless liquid flow) at the bottom of the downcomer, the liquid mass in the lower plenum, and the liquid mass stored in the downcomer were plotted as functions of time. The value of J^*_{gc} underwent an initial transient following ECC injection and perhaps never returned to its initial value because of steam condensation. The calculated value of J^*_{fd} was determined from the average lower-plenum fill rate just as it was in the experiment.

C. Data Comparisons

The Creare countercurrent-flow experiments covered a wide range of ECC flow rates and subcoolings. We made six TRAC calculations to generate two complete penetration curves for the following liquid injections: $1.86 \times 10^{-3}\ m^3 \cdot s^{-1}$ flow rate and 373 K (30 gal/min and 212°F) and $3.78 \times 10^{-3}\ m^3 \cdot s^{-1}$ flow rate and 339 K (60 gal/min and 150°F). The reactor-scale injection-flow rate was $3.78 \times 10^{-3}\ m^3 \cdot s^{-1}$ (60 gal/min).

We selected these curves to study two basic phenomena that are important in determining whether ECC bypass or delivery occurs. In the first case, the injected ECC was subcooled slightly; the system pressure ranged from 1-3 atm. Thus, the interfacial drag between the steam and the liquid was the major determinant of bypass. The calculated penetration curve for this case allowed an appraisal of the constitutive relationships that described interfacial momentum transfer. Moreover, because the calculations covered the ECC delivery from complete bypass to complete dumping, flow regimes in the downcomer at the bypass point differed from those at the complete delivery point.

Figure 76 compares the calculated and measured flooding curves for the low-subcooling case. Near the complete delivery steam flow, $J^*_{gc} = 0.053$, the calculated liquid flow, $J^*_{fd} = 0.047$, agreed well with the measured value of 0.051. At a higher steam-flow rate, $J^*_{gc} = 0.14$, there was almost complete bypass of the injected liquid in the experiment. At this steam-flow rate, TRAC-PD2 also predicted nearly complete bypass. The calculated steam flow was 0.005, whereas the measured value was 0.004. In the second set of tests, ECC was injected at 60 gal/min and 150°F. In this case, the ECC was subcooled significantly and the interfacial heat transfer was a significant factor in determining the quantity of ECC delivered to the lower plenum. Moreover, the penetration curves became much flatter as the ECC subcooling was raised (see Ref. 14); that is, the system tended to operate either in a complete-bypass or in a complete-delivery mode. Thus, operation in the intermediate delivery/bypass range was difficult to achieve in the experiment because the change in the steam-flow rate needed to cause a transition from complete delivery to complete bypass was very small.

Figure 77 compares the calculated and measured results for the high-subcooling case. The complete dumping location at $J^*_{gc} = 0.10$ again agreed well with the calculated results. The calculation showed that almost all of the injected liquid was delivered to the lower plenum. At a steam flow of $J^*_{gc} = 0.21$, essentially all of the liquid was bypassed both in the experiment and in the TRAC calculation. Thus, the critical end points for this relatively high-subcooling penetration case were predicted well. The calculated values for J^*_{gc} and J^*_{gd} may have oscillated during the transient. Figure 78 shows the calculated value of the downcomer liquid mass for the case with high subcooling and nearly complete delivery. Because the liquid in the downcomer was delivered periodically to the lower plenum, an oscillatory flooding rate occurred. Figure 79 shows the time-integrated delivery to the lower plenum that represented the actual quantity of liquid delivered to the lower plenum.

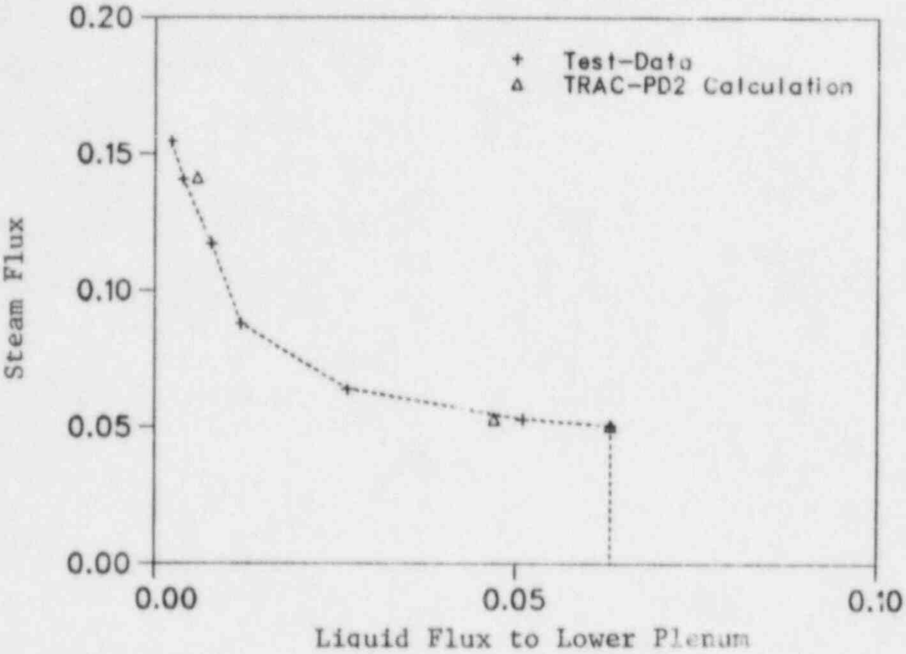


Fig. 76.
Comparison of calculated and measured flooding curves for Creare low-subcooling tests.

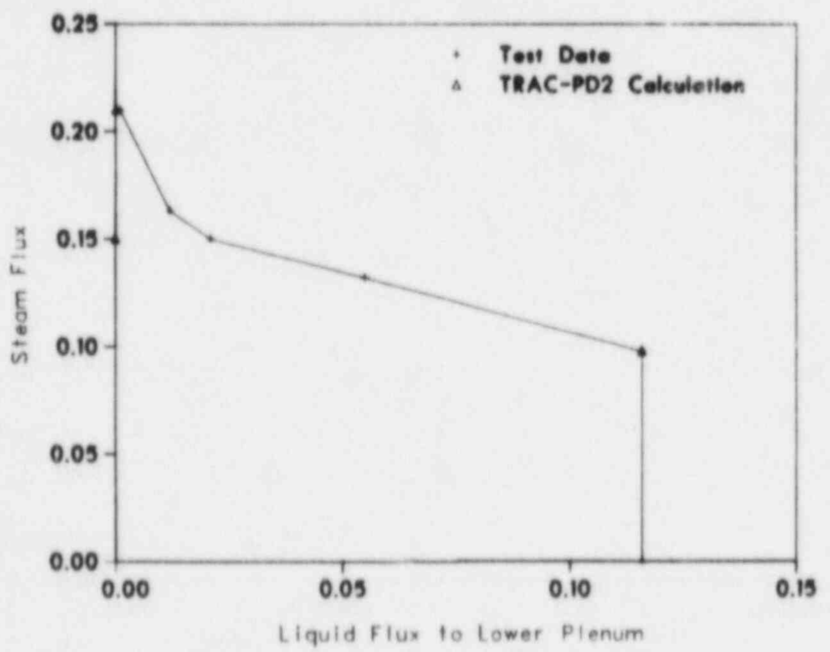


Fig. 77.
Comparison of calculated and measured flooding curves for Creare high-subcooling tests.

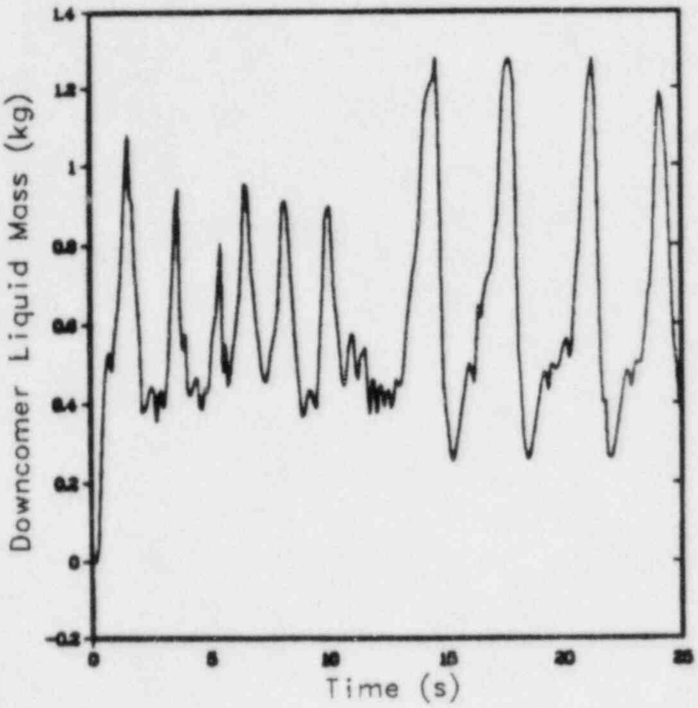


Fig. 78.
Calculated Creare downcomer liquid mass for the high-subcooling, high steam-flow test.

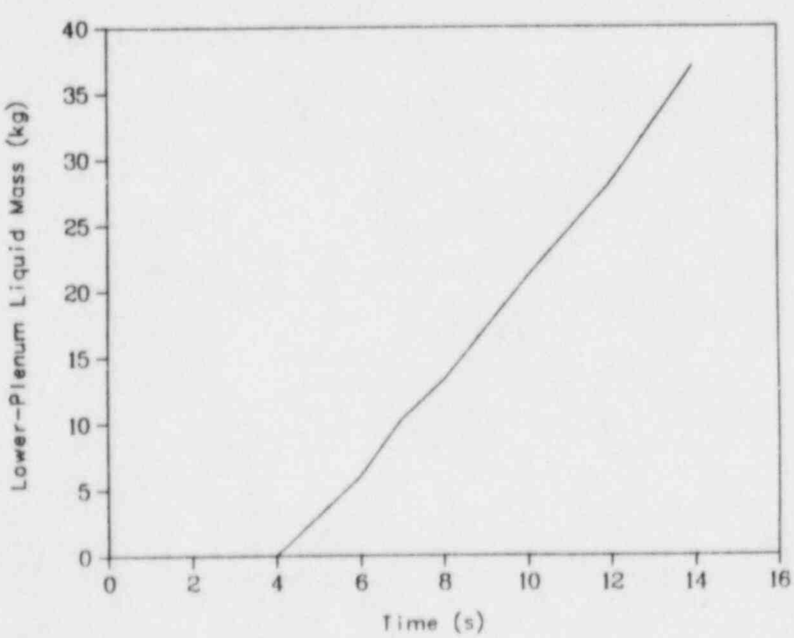


Fig. 79.
Lower-plenum liquid level for the high-subcooling, high steam-flow test.

Thus, even though the instantaneous liquid delivery to the lower plenum was erratic, the resulting collapsed water level in the lower plenum was a monotonically increasing value.

D. TRAC-PD2 Features Tested

Our calculations assessed the interfacial-momentum and heat-transfer constitutive relationships in the three-dimensional VESSEL. The comparisons between the test data and the TRAC-PD2 calculations were in good overall agreement, which indicated that TRAC-PD2 can predict satisfactorily ECC bypass and penetration in annular downcomer geometries at this scale.

E. Input Data Decks

Appendix F.I lists a typical Creare steady-state input deck used to generate the steady-state steam flow. Components 11-18 (FILLs) specified the inlet steam conditions. Component 8 (BREAK) specified the boundary pressure needed at the broken-loop cold leg to produce the correct lower-plenum pressure. Appendix F.II lists the restart input deck for the ECC-injection calculation. Only components 6, 7, and 9, which were connected to the three intact-loop cold legs, were replaced. The new FILLs specified the ECC-injection conditions. The CPU times for the steady-state, initial-condition runs ranged from 2.5-15 min; the CPU time required was sensitive to the steam velocity. The CPU times for the transient calculations with ECC-injection varied from 20-60 min; the CPU time required was determined by the steam-flow rate and the ECC temperature.

VIII. FLECHT FORCED-FLOODING TESTS

A. Experiment Description

The FLECHT program is a series of reflood heat-transfer simulation experiments to evaluate separate effects in PWR emergency core-cooling-system (ECCS) heat transfer. We selected two of these tests for the TRAC-PD2 developmental assessment. Test 4831 had a low flooding rate ($3.8\ cm \cdot s^{-1}$) and an axial-cosine power profile,[15] whereas Test 17201 had a higher flooding rate ($7.6\ cm \cdot s^{-1}$) and a skewed-axial power profile.[16]

The operating procedure for both tests was similar. The lower plenum of the test vessel housing was filled with water to the bottom of the heated rods. Electrical power was supplied to the simulated fuel rods until the initial rod-cladding temperatures were attained. Then, flooding at the specified rate was initiated, while rod power was decreased according to the desired decay curve. Rod-cladding temperatures and fluid conditions were recorded until the bundle was quenched completely.

Test 4831 was conducted in a massive, square vessel. A square rod bundle with 100 full-scale nuclear fuel-rod simulators was placed in the vessel. Ninety-one of these rods were heated electrically to produce a stepped approximation to an axial-cosine power profile. The radial-power peaking varied from 0.95 to 1.1 of the average rod power across the rod bundle.

Because of the housing mass effects in earlier tests, a cylindrical, low-mass housing was designed. Test 17201 used this new geometry. In this test, the rod bundle consisted of 105 heated rods with 7 unheated thimbles and solid spacers to reduce the flow area. Again, a radial power profile was simulated. However, an axial power profile skewed toward the top of the heated section was used.

Liquid effluents from the flooding test were separated and collected in a carryover tank, and the dry steam was exhausted to the atmosphere through an orifice to measure the liquid carryover and the vapor flow from the core. Also, a series of differential-pressure cells provided an approximate void-fraction profile of the test section. Thermocouples measured the rod-cladding and housing temperatures. A data-acquisition system recorded most of the data and provided time history plots.

B. TRAC-PD2 Model

The TRAC model for the FLECHT tests used a constant-velocity FILL, connected by a short PIPE to the VESSEL lower plenum, to inject ECC. An effluent PIPE connected the VESSEL upper plenum to a constant-pressure BREAK that modeled the carryover tank. The VESSEL was divided into 13 axial levels to facilitate the modeling of the rod axial power profile (Fig. 80). This noding necessitated some interpolation of the measured initial rod-cladding temperatures. Thus, some slight disagreement between the measured and the initial temperatures occurred at a few points. Figure 81 compares the TRAC axial power distribution to the test value. The TRAC VESSEL used heat slabs to model the housing walls.

The TRAC calculation paralleled the test procedure. The lower plenum was filled completely and the rods were heated to the initial temperature. Then, the FILL was actuated to simulate forced flooding. The calculation continued until all rods had quenched fully, as determined by the rod-cladding temperature vs time plots.

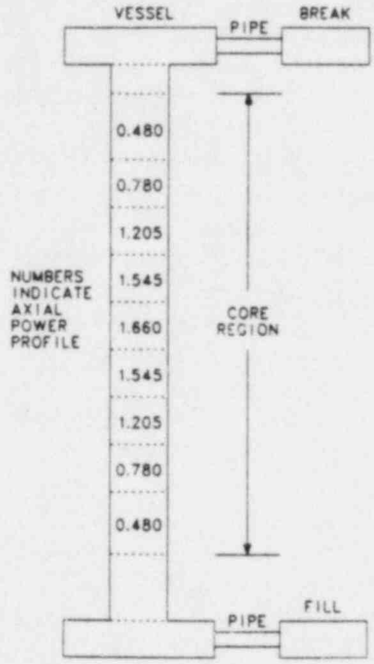


Fig. 80.
TRAC noding diagram of FLECHT forced-flooding experiments.

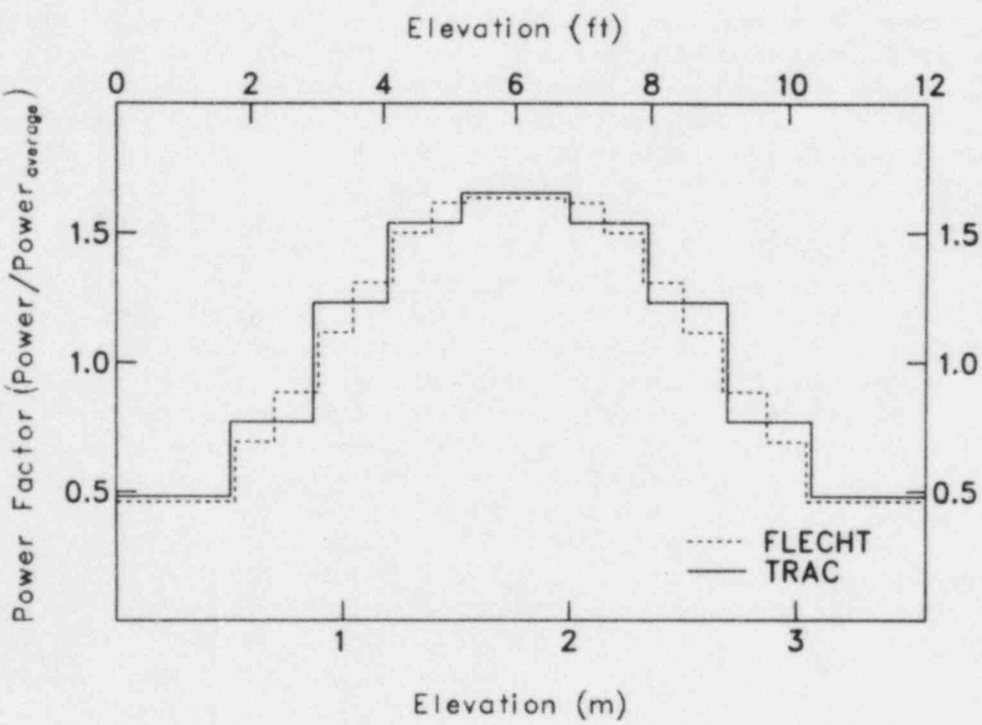


Fig. 81.
Axial power profile for FLECHT Test 4831.

C. Results

We compared the rod-cladding temperatures vs time and the carryover rates into the moisture separator. Our comparisons indicated the accuracy of the TRAC reflood and entrainment models.

In general, the TRAC-PD2 rod-cladding temperatures tended to reverse direction and to quench late. Radiation heat transfer between rods and between the rods and the housing may have caused this discrepancy. This can be an important effect, accounting for 25-30% of the total heat transfer in some cases.[15] A TRAC model that accounts for the radiation heat transfer between the rods and the wall was developed to investigate the effect caused by these phenomena. A calculation, based on a surface-to-surface radiation heat-transfer model,[17] indicated that modeling such an effect could account for most of the discrepancies between the calculated and measured quench times.

Figures 82 and 83 illustrate rod-cladding temperature traces for two levels in Test 17201. At each level, the calculated rod temperature peaked at a much higher value than in the test data. This result may have been caused partially by radiation effects, because the calculated temperature reversed direction much later than the measured temperature. Another possible error may have been an inaccurate precooling rate caused by the carryover or steam precooling models. After the temperature reversed direction, the TRAC-PD2 temperature traces usually showed a higher rod-cooling rate than the test data. Calculated quench times tended to occur 30-40 s after those in the test data; the hottest elevations had the largest discrepancies. In most cases, TRAC-PD2 predicted a quench temperature close to that in the test data, indicating a good film-boiling temperature prediction.

Figures 84 and 85 show the rod-cladding temperatures for two important elevations in Test 4831. Again, the calculated rod temperatures reverse direction and quench late. The radiation effect and the difference between the calculated and test quench temperatures readily account for this discrepancy.

The calculated total effluent mass flows agreed very well with the measured flows for both tests. Figure 86 compares the data for Test 4831 with the TRAC results. Analyzing the data from Test 17201 required greater care. In this test, much of the liquid that was removed from the core was stored in the upper plenum and, thus, was not included in the measured effluent. The TRAC-PD2 input does not model this upper-plenum storage but models the total core effluent, which is determined by including the mass stored in the upper plenum as well as the mass collected in the carryover tank.

Figure 86 shows good agreement between the measured and calculated total effluent masses for Test 4831. However, this agreement is misleading. In fact, much of the time the two-phase mixture that reached the upper plenum was virtually dry steam, because most of the liquid had evaporated or fallen into the vessel. The liquid mass flow did indicate that some liquid slugs were ejected throughout the transient. The TRAC calculation indicated that the integrated liquid mass ejected was ~70 kg at 350 s. The test liquid effluent, including the mass stored in the steam probes and the upper plenum, was 72.6 kg ± 10.8. The measured mass flow varied more smoothly than the calculated flow but the integrated results were remarkably close.

The TRAC-PD2 calculations for both FLECHT assessment problems compared quite well with the test data. This agreement indicates acceptable TRAC-PD2 reflood and entrainment models.

Appendix G lists the TRAC transient input deck for Test 17201. The input deck for Test 4831 may be found in the TRAC-P1A developmental assessment report.[3]

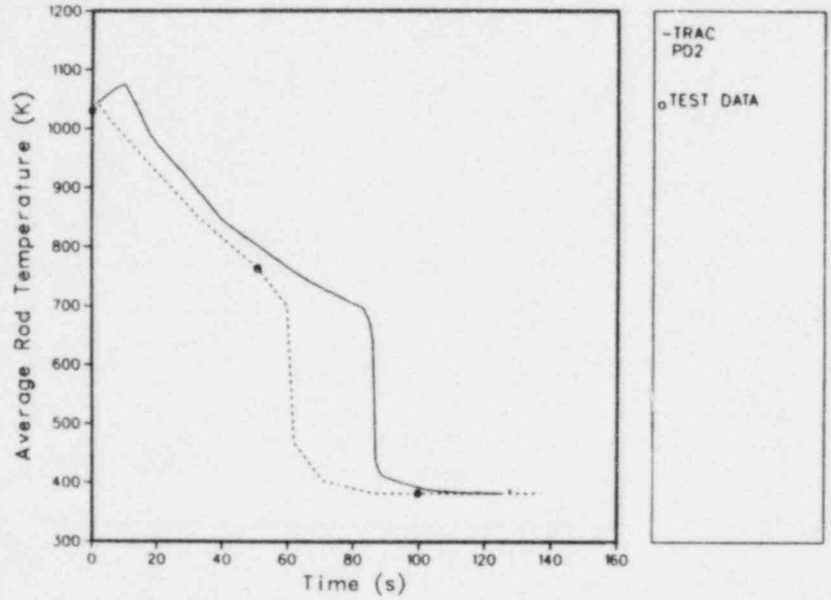


Fig. 82.
FLECHT Test 17201 rod-cladding temperatures at the 6-ft elevation compared with the TRAC-calculated temperatures.

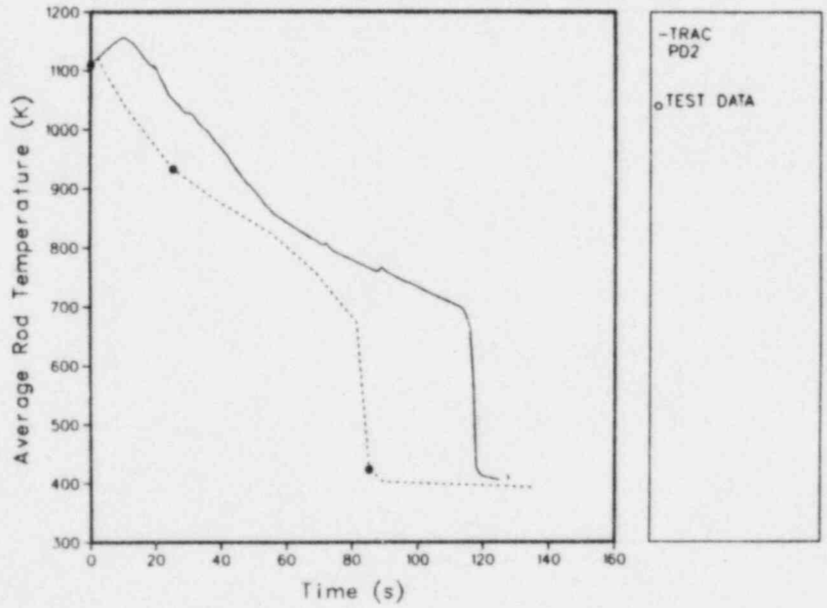


Fig. 83.
FLECHT Test 17201 rod-cladding temperatures at the 8-ft elevation compared with the TRAC-calculated temperatures.

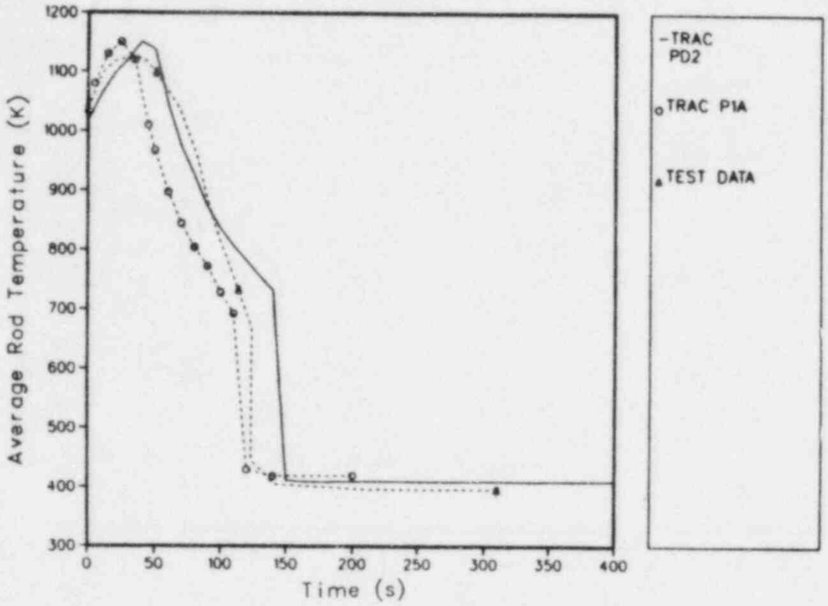


Fig. 84.
FLECHT Test 4831 rod-cladding temperatures at the 4-ft elevation compared with the TRAC-calculated temperatures.

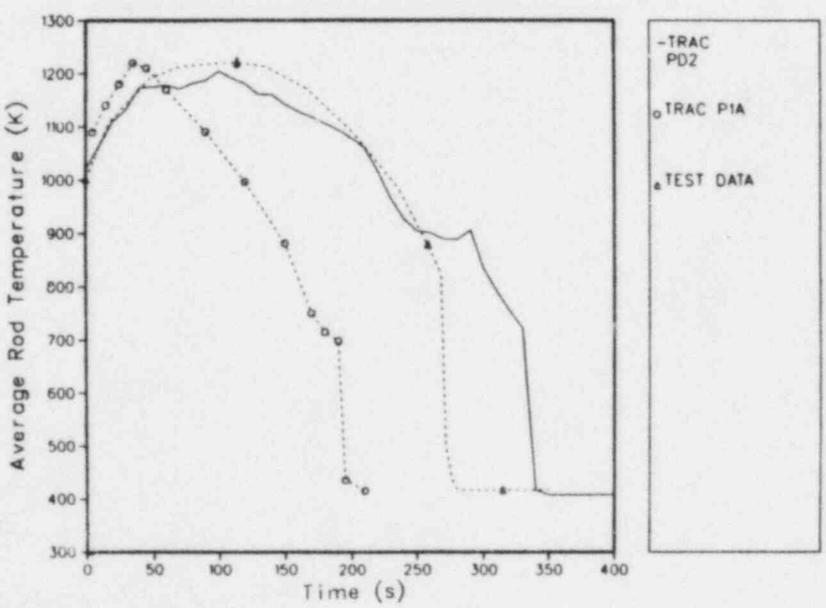


Fig. 85.
FLECHT Test 4831 rod-cladding temperatures at the 6-ft elevation compared with the TRAC-calculated temperatures.

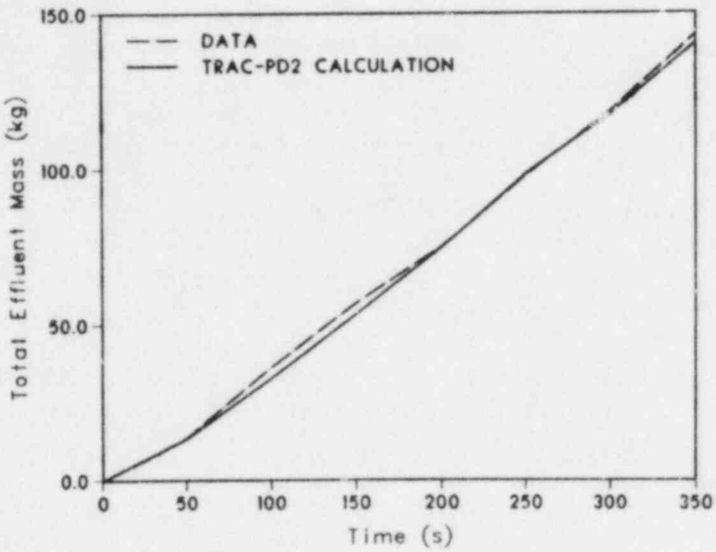


Fig. 86.
FLECHT Test 4831 total effluent mass compared with the TRAC-calculated effluent mass.

IX. SEMISCALE MOD-1 TEST S-02-8

A. Experiment Description

The Semiscale Mod-1 test apparatus[18] was an improved version of the Semiscale isothermal system. In the Mod-1 system, a core, comprised of 40 electrically heated rods with the power and volume scaled to a typical PWR in a ratio of 1 to ~2000, simulated nuclear heating.

Figure 87 shows an isometric view of the test apparatus, which consisted of a pressure vessel with simulated reactor internals; an intact loop with an active steam generator, pump, and pressurizer; a broken loop with a simulated steam generator, a simulated pump, and pipe rupture assemblies; and a pressure-suppression system with header, auxiliary steam supply, and suppression tanks. Test S-02-8 simulated a double-ended offset-shear (200%) cold-leg break. This test differed from other Mod-1 tests because the resistance of the simulated pump was reduced by a factor of ~4 below the typical value.

Before the test, the system was brought to steady-state conditions. Table XI lists the calculated and measured initial parameters. Blowdown was initiated by rupturing the two rupture disks.

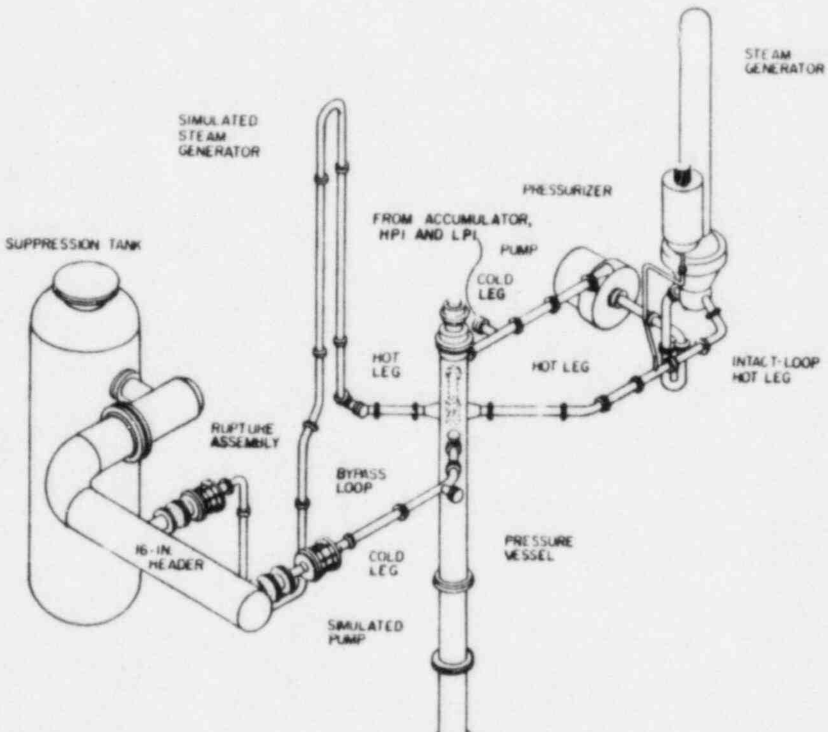


Fig. 87.
Isometric view of the Semiscale Mod-1 test apparatus (adapted from Ref. 18).

TABLE XI

CALCULATED AND MEASURED INITIAL PARAMETERS FOR SEMISCALE MOD-1 TEST S-02-8

Parameter	Test Data	TRAC-PD2 Results
Core power (MW)	1.59	1.59
Intact-loop cold-leg fluid temperature (K)	556.5	556.4
Hot- to cold-leg temperature differential (K)	37.8	38.4
Pressurizer pressure (MPa)	15.60	15.596
Pump mass flow ($kg \cdot s^{-1}$)	7.35	7.43
Pump speed ($rad \cdot s^{-1}$)	295.3	302.4
Pump differential pressure (kPa)	283.	284.35

B. TRAC-PD2 Model

The TRAC-PD2 best-estimate model of the Semiscale Mod-1 Test S-02-8 contained every component modeled by the code except an accumulator; thus, it was a good example to use in our data comparisons. As shown in Figs. 88 and 89, the system model contained 120 fluid cells in the one-dimensional components and 52 fluid cells in the VESSEL component.

Several modeling techniques were used in the TRAC model of this test to obtain a good representation of the test apparatus and to minimize the computer time needed for the calculations. In the following paragraphs, the methods used in the TRAC-P1A analysis[3] of Test S-02-8 are discussed. Then, improvements in the input description used in the TRAC-PD2 analysis of Test S-02-8 are listed.

A flow resistance, instead of a reduced flow area, was used to represent the flow distribution plates at the bottom of the core. In extremely long, thin fluid cells, such as those needed to model the Semiscale core, the large dynamic pressure head needed to reduce the flow area of the flow distribution plate could cause unwanted circulation patterns within the core.

In the blowdown loop, a series of progressively shorter cell lengths was used near the break-nozzle expansion section because the flow conditions changed more rapidly near this section in the constant-area portion of the Semiscale nozzle (Fig. 89). Thus, the change in fluid conditions from cell to cell were more nearly equal than they would have been with equal-length fluid cells.

The line to the pressurizer was calculated by the fully implicit method to eliminate Courant limits on time-step size. Because the junction between the surge line and the pressurizer was placed in the large-area section of the pressurizer (that is, a low fluid-velocity region), the fluid cells at the bottom of the semi-implicit pressurizer could be very small without using small time steps; the small cells improved the TRAC-calculated pressurizer-discharge fluid conditions.

We made the following improvements in the TRAC-PD2 analysis. The break-nozzle expansion sections were more finely noded than in the TRAC-P1A analysis. Parametric studies (Sec. VII) indicated that this finer noding produced a better calculation of the subcooled blowdown section of the transient.

In the TRAC-P1A analysis the addition of the additive-friction terms accounted for the extra flow resistance caused by the orifices in the simulated pump of the broken-loop hot leg. These terms were not multiplied by the

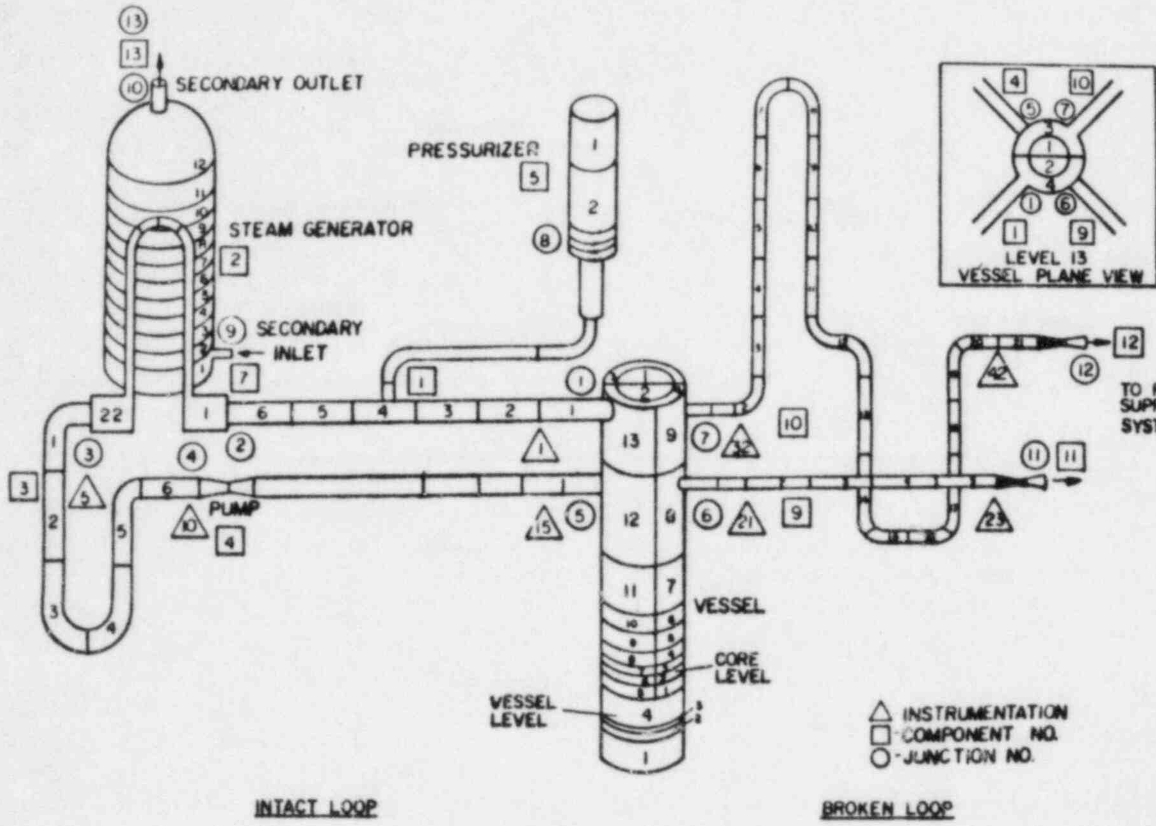


Fig. 88.
TRAC noding and component diagram for Semiscale Mod-1 system.

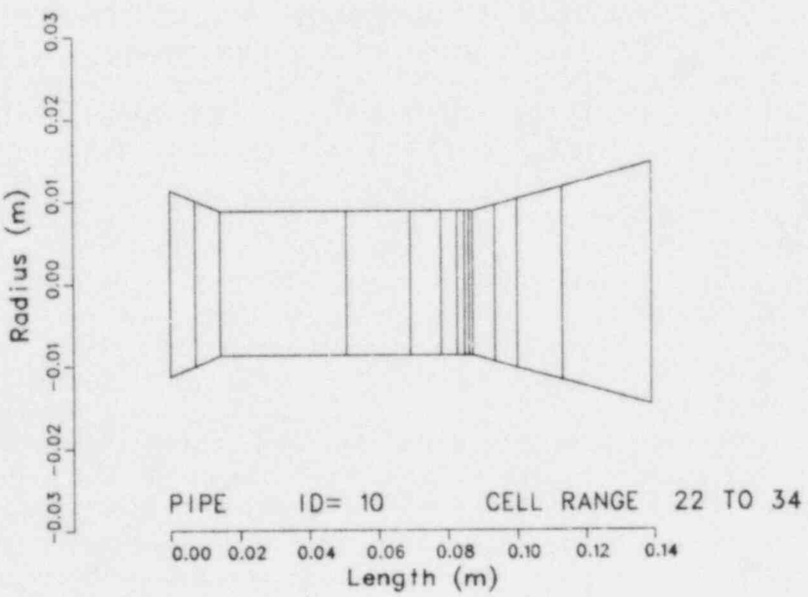


Fig. 89.
Semiscale Mod-1 nozzle noding diagram.

two-phase friction-factor multipliers; however, it seemed reasonable to expect that the orifices would exhibit two-phase flow effects. Therefore, in the TRAC-PD2 input, we deleted the additive-friction terms and decreased some of the hydraulic diameters in the broken-loop hot leg until the single-phase resistance value was the same as that reported in Test S-02-8 to account for this additional flow resistance.

We slightly increased the flow resistance of the intact-loop cold leg to account for the two turbine flow meters; thus, the calculated steady-state pressure drops in this line compared better with those in test data.

To finish the test analysis quickly, we reduced the VESSEL fluid cells from 152 to 52 by decreasing the theta segments from 4 to 2 and by reducing the number of axial levels. Because the Semiscale test apparatus performed like a one-dimensional system, it could be modeled by fewer radial and theta segments than a PWR. The axial segments were reduced from 19 to 13 by using coarser noding in the core and by decreasing the levels in the lower plenum from 4 to 3. To keep the number of levels in the lower plenum to a minimum and to prevent excessive mixing between the top and bottom of the lower plenum, we added a small amount of axial friction in the input descriptions of these levels.

The fuel-rod length was extended into the upper plenum by including the unpowered sections of the rods. We felt that this was a better way to handle the stored heat in the rods than to include the mass in the heat-slab description.

C. Data Comparisons

Differences between the calculated and measured initial conditions generally were caused by inconsistencies in the test data. For example, if the Semiscale homologous curves are correct, TRAC results for the pump head, flow rate, and speed were not totally compatible with those in the test data. These inconsistencies did not affect seriously the results of the transient analysis. Therefore, further refinement of the TRAC steady-state run was not necessary to obtain a good TRAC calculation of the blowdown transient.

The overall performance of a LOCA analysis code is determined partially by its ability to predict system pressure decay. Figure 90 compares the TRAC-calculated lower-plenum pressure (the solid line) with the Semiscale Mod-1 Test S-02-8 data[19] (the dashed line with circles). The comparison in this figure indicates that TRAC predicts system performance well. The slightly underpredicted pressure beyond 10 s probably was caused by the underpredicted superheat in the upper part of the core. These underpredictions also occurred in the TRAC-P1A analysis of this test. Figures 91 and 92 compare the calculated and measured mass flows at the inlet and the outlet of the broken-loop hot leg. At both locations the calculated results generally were within the uncertainty of the test data. The main difference between the TRAC results and the test data was that TRAC underpredicted the magnitude of the flow spike, which started at 7 s and corresponded to the intact-loop pump degradation. The TRAC-P1A predictions of these flow rates generally were similar to the TRAC-PD2 results. Figure 93 shows that both TRAC-PD2 and TRAC-P1A predicted well the broken-loop cold-leg break flows. Figure 94 compares the TRAC-PD2 and TRAC-P1A mass flows in the intact-loop pump to those for Test S-02-8. Except for a slightly advanced pump degradation, both codes calculated these flows well.

Figure 95 compares the calculated and measured mass flows into the intact-loop hot leg. Because TRAC underpredicted the magnitude both during the

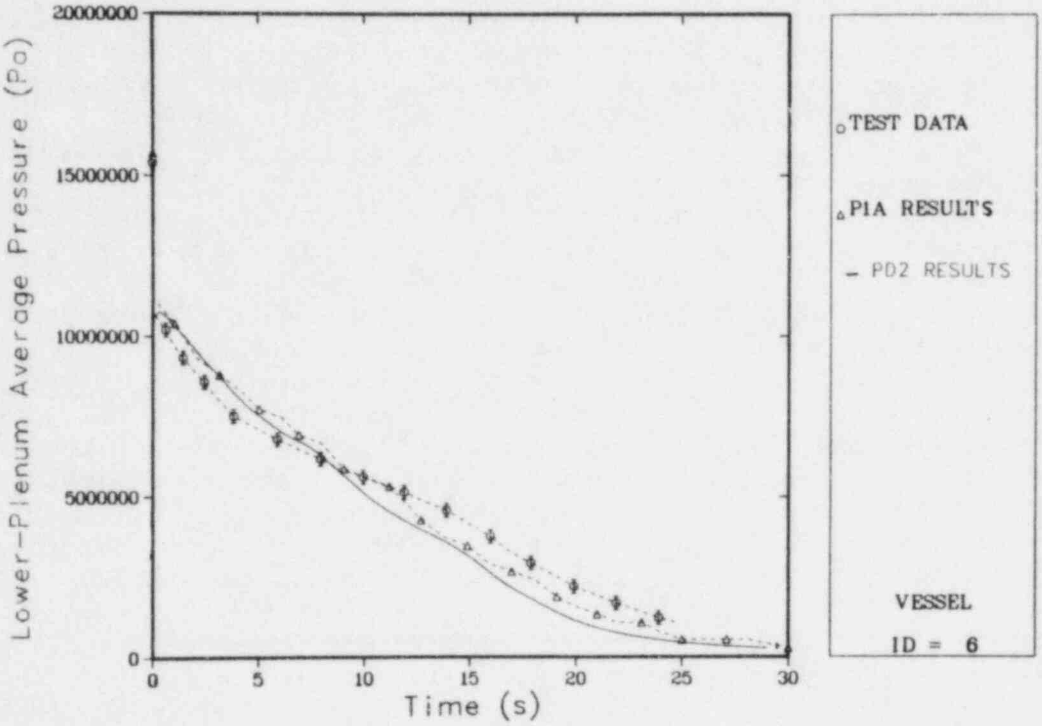


Fig. 90.
Comparison of the calculated and measured lower-plenum pressures for Semiscale Mod-1 Test S-02-8.

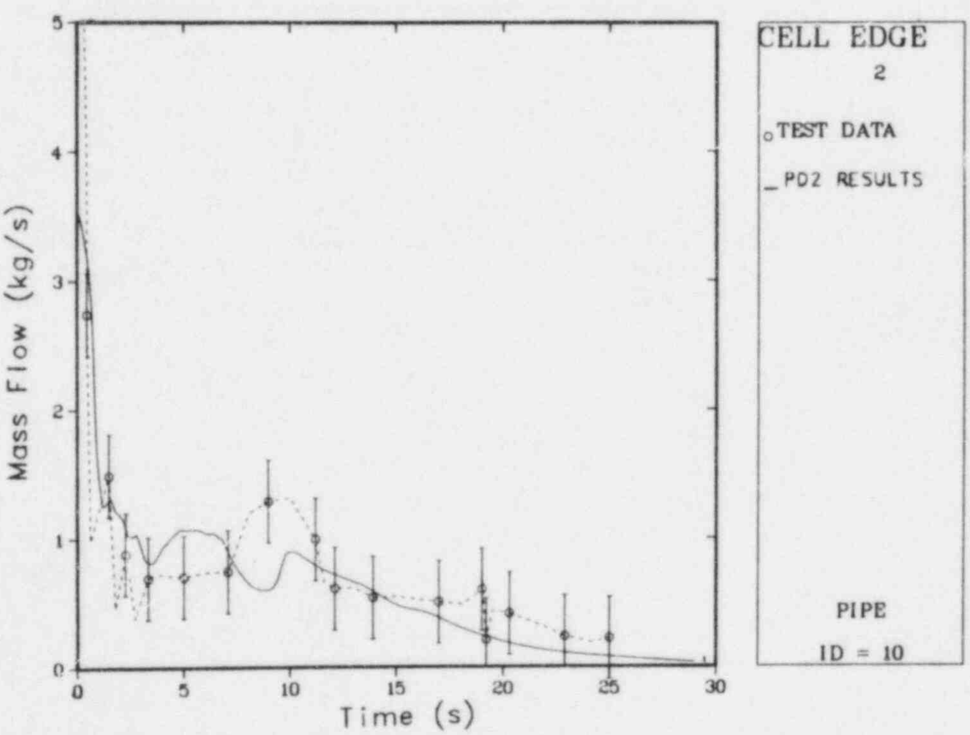


Fig. 91.
Comparison of the calculated and measured mass flows at the inlet of the broken-loop hot leg for Semiscale Mod-1 Test S-02-8.

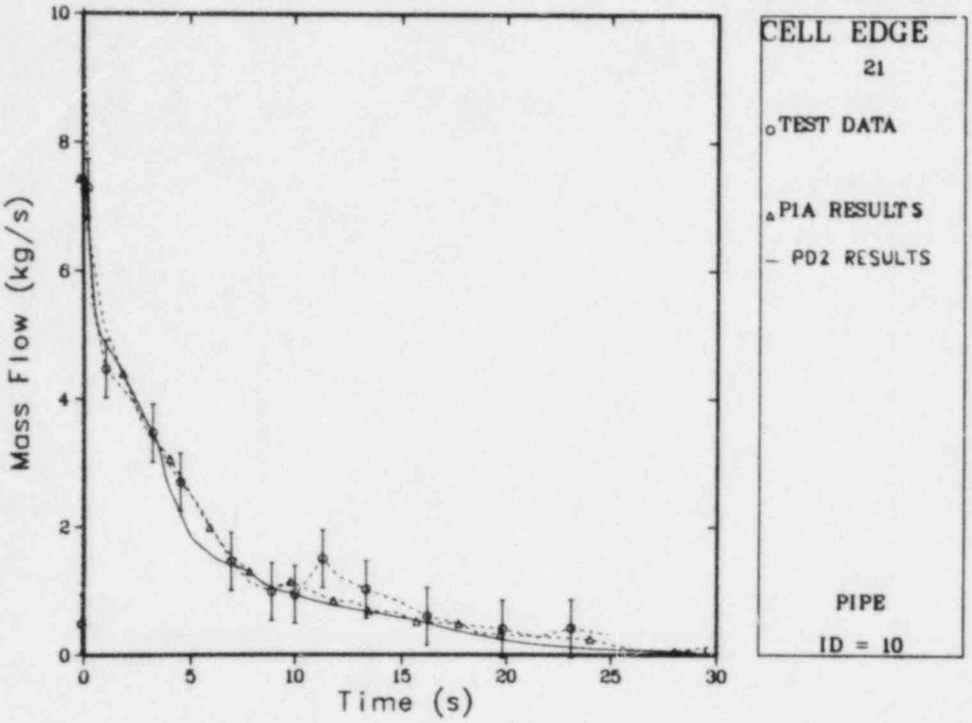


Fig. 92.
Comparison of the calculated and measured mass flows at the outlet of the broken-loop hot leg for Semiscale Mod-1 Test S-02-8.

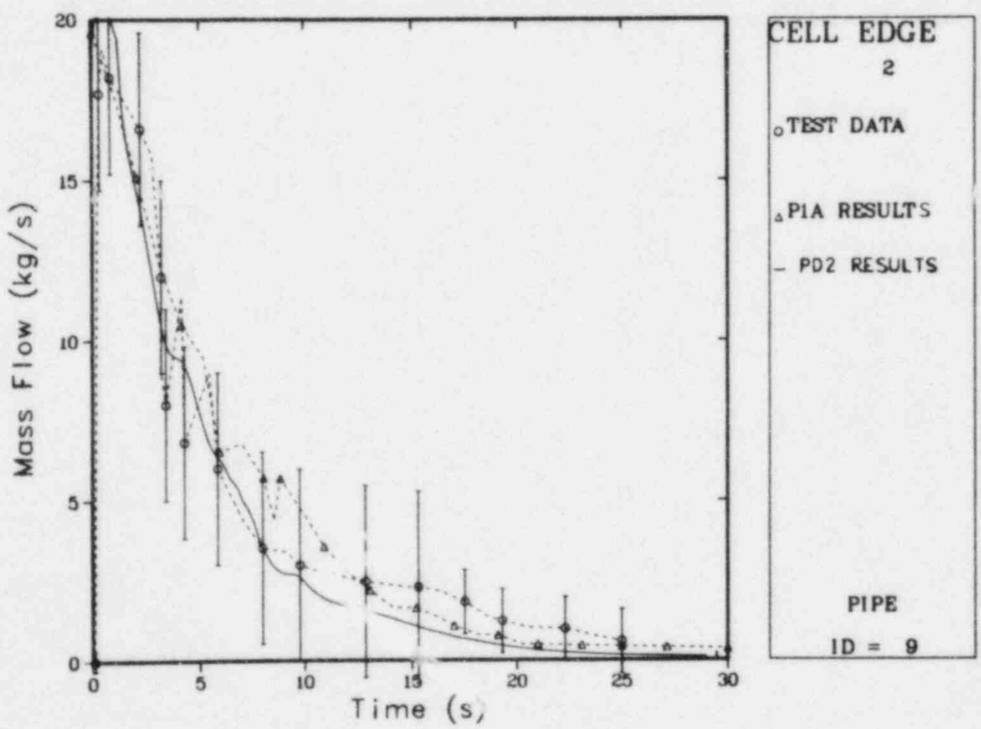


Fig. 93.
Comparison of the calculated and measured broken-loop cold-leg break flows for Semiscale Mod-1 Test S-02-8.

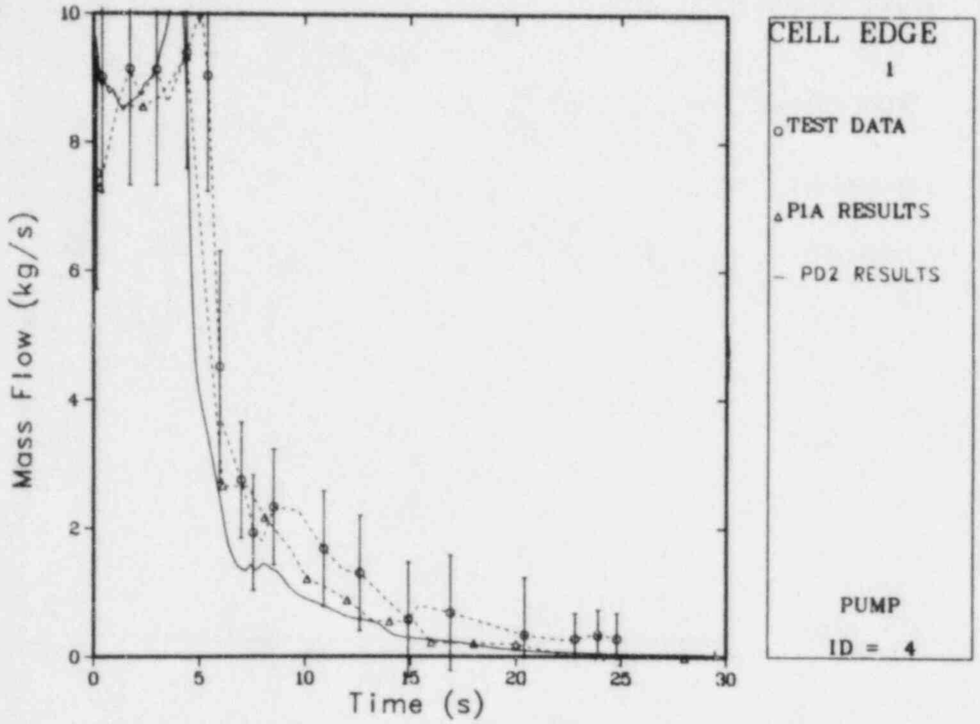


Fig. 94.
Comparison of the calculated and measured mass flows in the intact-loop pump for Semiscale Mod-1 Test S-02-8.

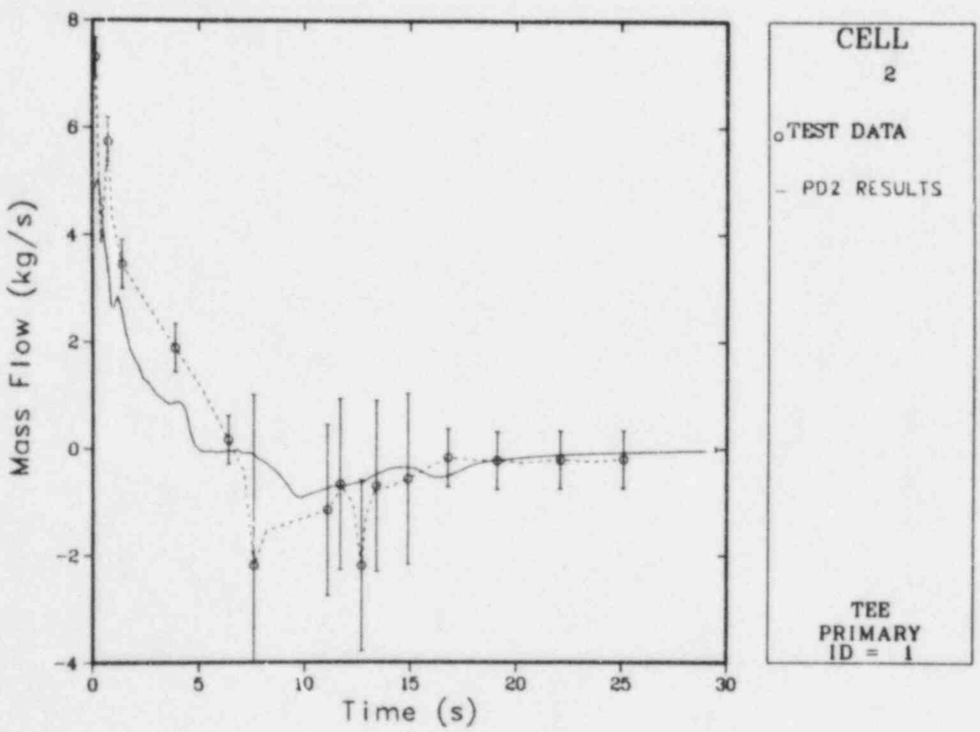


Fig. 95.
Comparison of the calculated and measured mass flows into the intact-loop hot leg for Semiscale Mod-1 Test S-02-8.

positive and the negative flows, it appears that the code underpredicted fluid density in this pipe. The timing of the flow reversal was predicted well.

Figure 96 indicates that both the TRAC-PD2 and the TRAC-P1A calculations of the pressurizer flows were very good.

In general, the TRAC predictions of the mass flows in the one-dimensional components were very good.

Figure 97 compares the calculated and measured mass flows at the entrance to the core. Although the agreement generally was good, TRAC did not predict the flow spike seen in the test data at 1.5 s. Inspection of the piping flows revealed no apparent reason for this discrepancy. Comparison of the calculated and measured temperature profiles in the lower plenum indicated that the TRAC predictions matched the test data well.

Figures 98-100 compare the calculated and measured cladding temperatures in the lower, middle, and upper core, respectively. The TRAC predictions matched the test data well at all three locations, although the calculated time to dryout at the lower and middle core was late. There was a general trend to make predictions that were in the lower range of the test data in the upper core and that were in the upper range of the test data in the lower core. These comparisons did not explain the spike at ~1.5 s in the core inlet flow in the test data. Perhaps, some physical phenomena in the Semiscale Mod-1 core or lower plenum were not modeled.

In general, both TRAC-PD2 and TRAC-P1A calculated well the response of the Semiscale Mod-1 system to a blowdown transient.

D. Conclusions

Semiscale Test S-02-8 assessed the ability of the TRAC-PD2 code to predict accurately the thermal-hydraulic response of a PWR system without ECC injection during blowdown. Except for an accumulator (ACCUM), all TRAC components were included in this problem. The results of this analysis were comparable to those obtained with TRAC-P1A; in general, both codes produced very good results.

Running times on a CDC 7600 computer for the steady-state and blowdown calculations were 10 and 19 min, respectively. These running times were reasonable based on the complexity of the model and were an order of magnitude faster than those for the TRAC-P1A calculations. Approximately half of this increased speed was caused by TRAC-PD2 improvements, which allowed larger time steps to be used.

Appendix H lists the steady-state and transient restart data decks for Semiscale Mod-1 Test S-02-8.

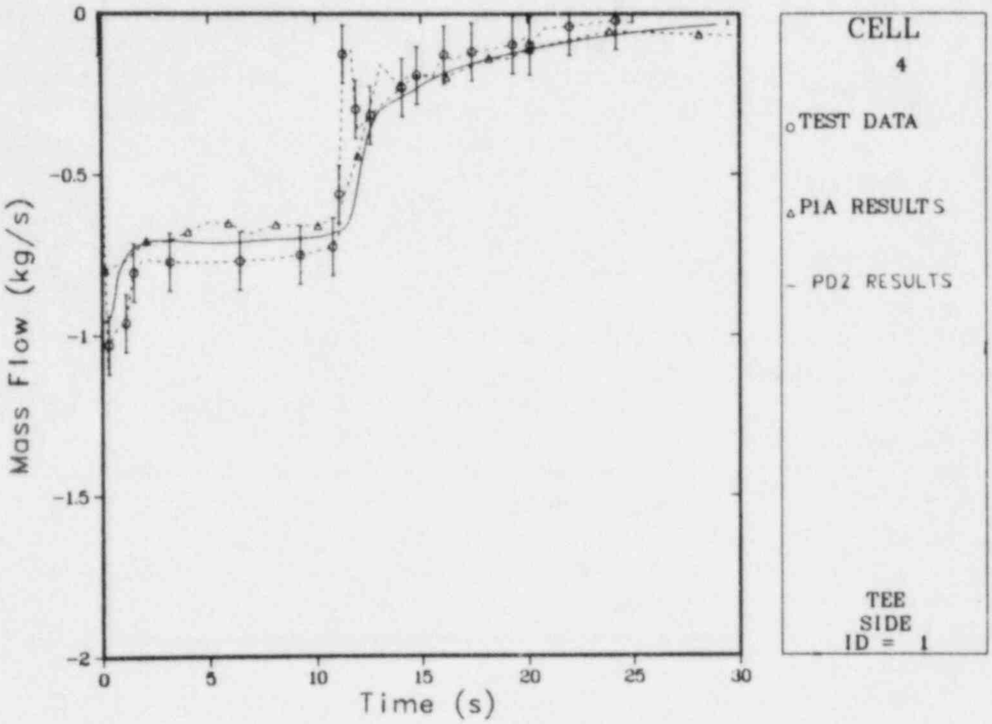


Fig. 96.
Comparison of the calculated and measured pressurizer flows for Semiscale Mod-1 Test S-02-8.

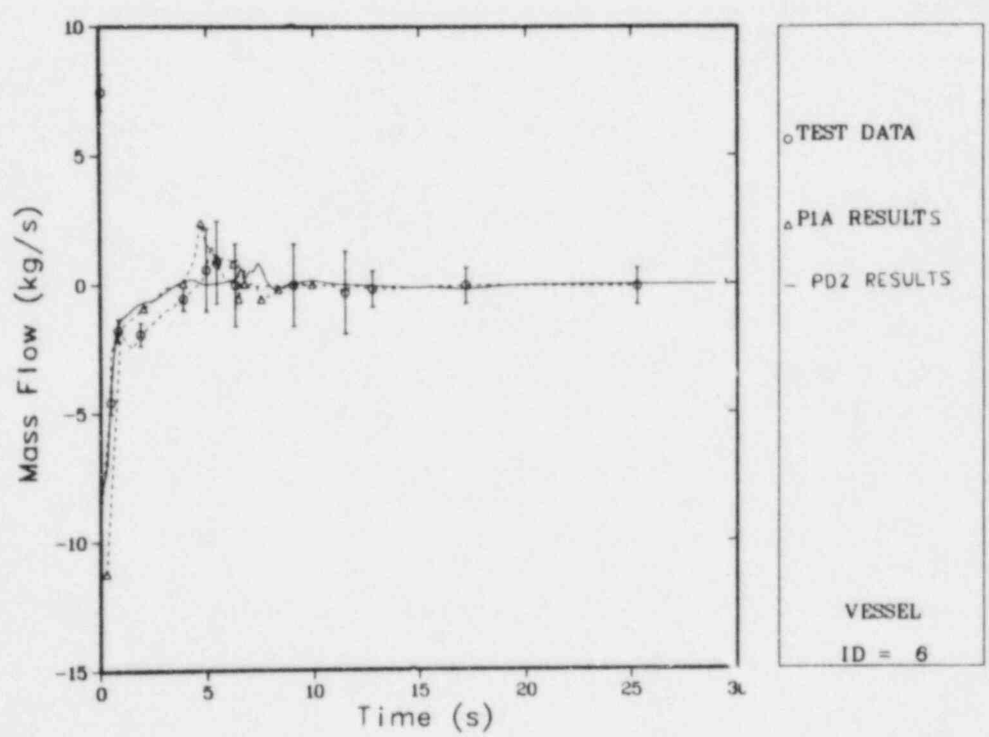


Fig. 97.
Comparison of the calculated and measured mass flows at the entrance to the core for Semiscale Mod-1 Test S-02-8.

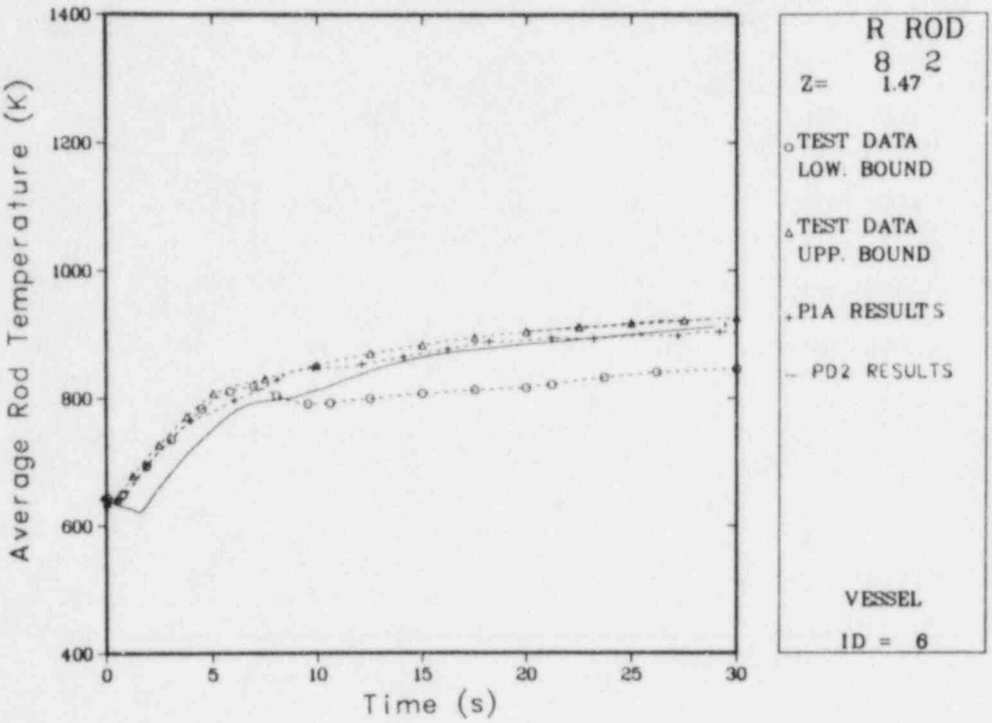


Fig. 98.
Comparison of the calculated and measured cladding temperatures in the lower core for Semiscale Mod-1 Test S-02-8.

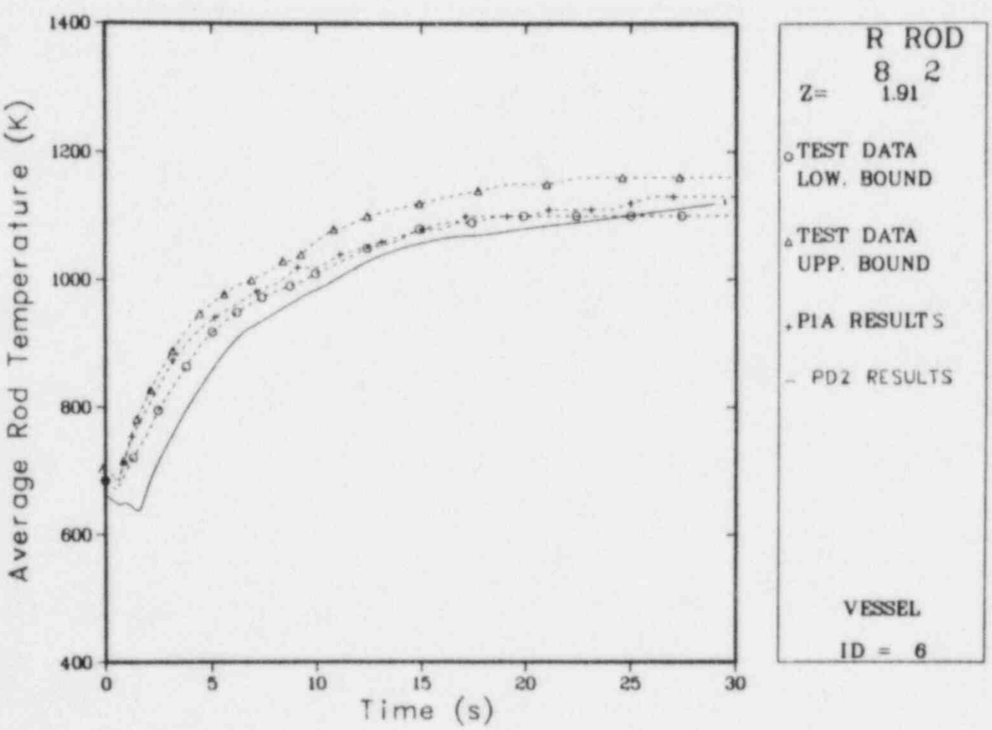


Fig. 99.
Comparison of the calculated and measured cladding temperatures in the middle core for Semiscale Mod-1 Test S-02-8.

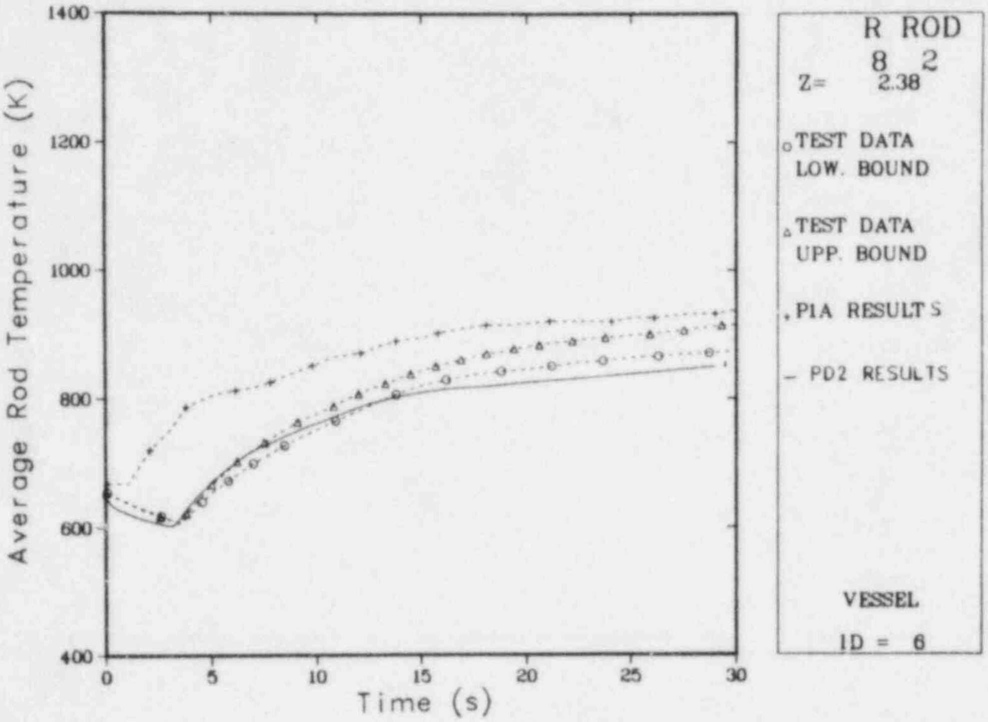


Fig. 100.
Comparison of the calculated and measured cladding temperatures in the upper core for Semiscale Mod-1 Test S-02-8.

X. SEMISCALE NOZZLE

Section IX described the Semiscale system. For our data comparisons the Semiscale broken-loop cold-leg nozzle was isolated from the rest of the system and test data were used for the boundary conditions in the TRAC input. We used the S-02-8 data as a basis for a detailed look at critical flow through a nozzle.

A. TRAC-PD2 Model

Figure 101 illustrates the TRAC PIPE noding used to describe the broken-loop cold-leg nozzle for this study. The volume was divided progressively more finely as it approached the end of the constant flow-area section of the nozzle. This method allowed a reasonable number of very small cells as the fluid reached the critical velocity, whereas an evenly divided nozzle would have required an exorbitant number of volumes. The noding of the nozzle-exit section also was important. A sensitivity study showed that at least four volumes in the exit section improved the predictions for the subcooled portion of the blowdown.

The input boundary conditions were the pressure, temperature, void fraction at the nozzle entrance, and pressure at the nozzle exit. Although the boundary conditions were obtained from the data for the cold-leg entrance, they were applied at the nozzle entrance. We excluded the remainder of the cold leg in the TRAC model because we wanted to minimize the numerical diffusion of sharp changes in the fluid conditions. The time delay between flow entering and exiting the cold-leg piping was very small and did not affect the data

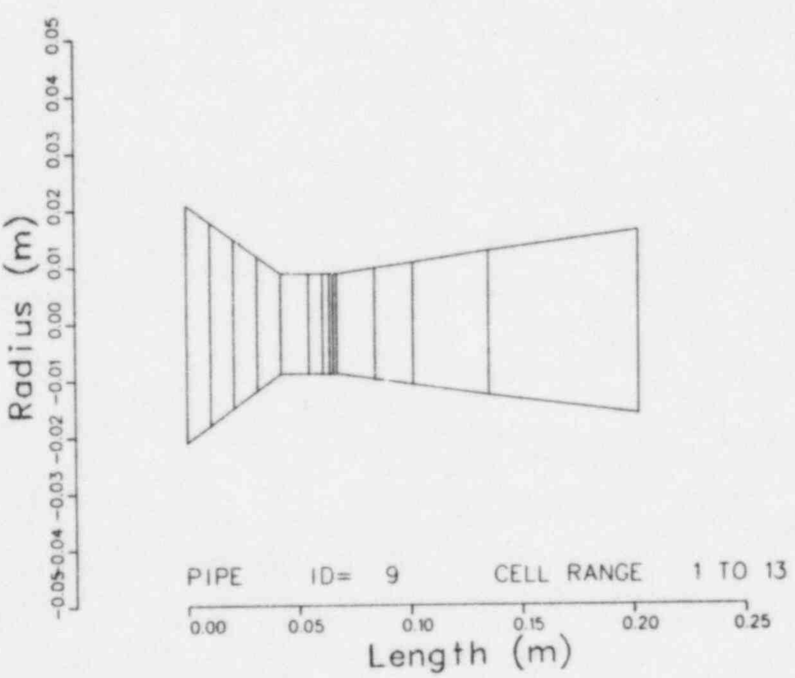


Fig. 101.
Volume diagram of Semiscale Test S-02-8 broken-loop cold-leg nozzle.

significantly. Figures 102-104 compare some of the boundary conditions for the cold-leg nozzle entrance to the test data. Figure 104 shows the density used to obtain the void fraction in Fig. 103. The test density was not totally compatible with the fluid temperature; thus, the test density was less than that used as a boundary condition by TRAC in the first ~2.5 s.

B. Results

Figures 105 and 106 compare the TRAC-calculated mass flow and mixture velocity at the nozzle entrance to the test data. Although these data comparisons were almost equivalent for most of the transient, the mixture-velocity comparison was superior to the mass-flow comparison, especially during the first 2 s of the transient, because the inaccuracy in the measured density was excluded. Figure 106 shows excellent agreement between the TRAC results and the test data during the first 1.5 s, if one accounts for the response time of the turbine flow meter. Thus, the TRAC model predicted mass flows well in a highly subcooled situation. From ~2-3 s, TRAC increasingly underpredicted the mass flows, whereas the test data did not indicate the beginning of boiling in the nozzle until vapor appeared at its entrance. A TRAC nucleation time-delay model is needed to predict this part of the transient precisely. When the void fraction was between 0.05-0.2 (3.5-6.0 s into the transient), the TRAC results agreed well with the test data. When the entrance void fraction varied from 0.2-0.95 (6.0-13.0 s), the TRAC results indicated a higher mixture velocity than the test data. If this discrepancy was caused by a TRAC overprediction rather than by an error in the test data, then the causes probably were associated with the interfacial heat-transfer or the slip correlations. At

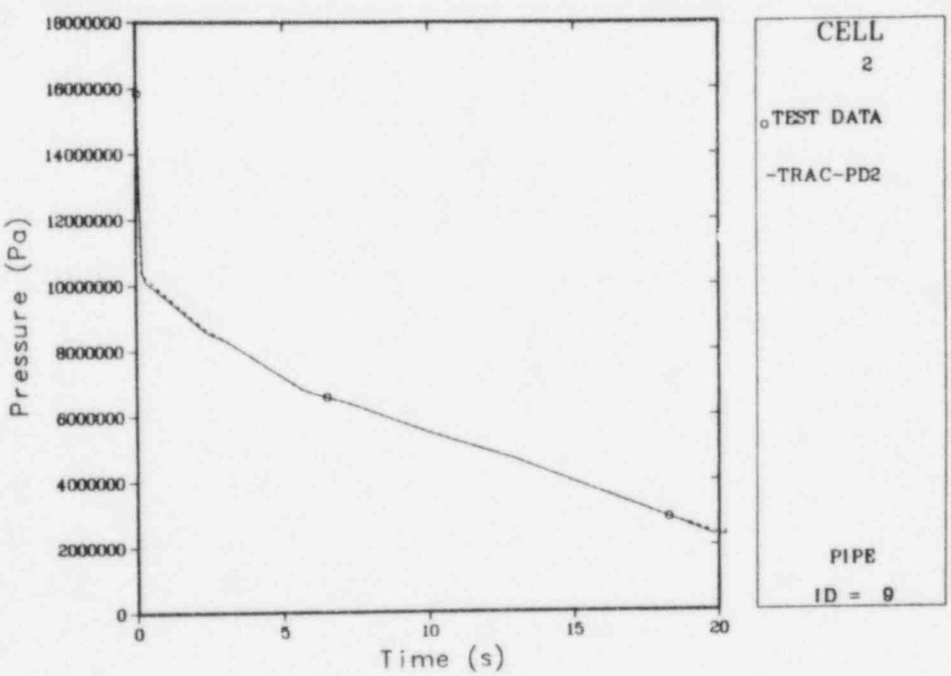


Fig. 102.
Comparison of the upstream pressure boundary condition and the measured pressure for the Semiscale nozzle study.

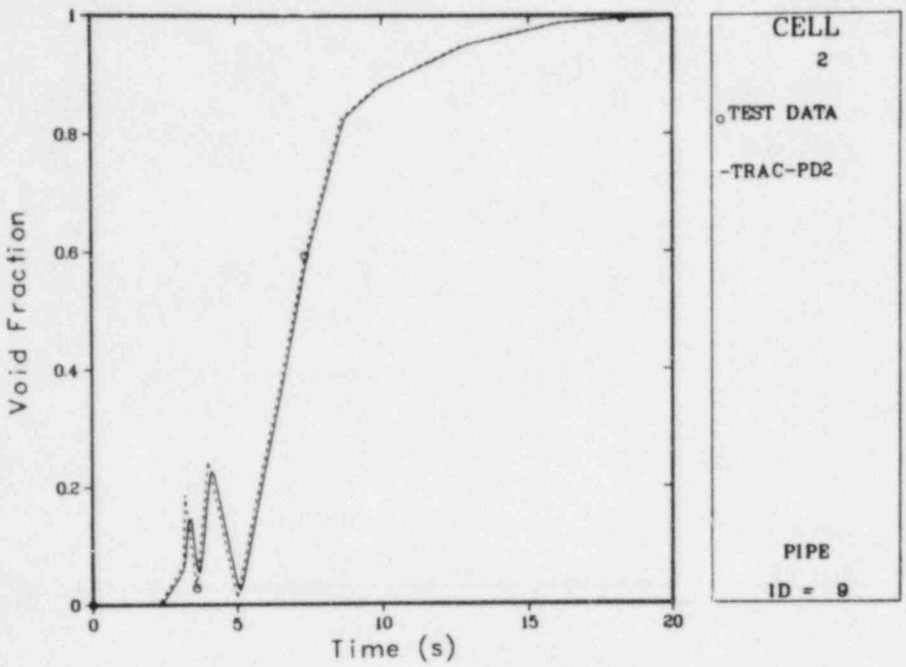


Fig. 103.
Comparison of the upstream void-fraction boundary condition and the measured void fraction for the Semiscale nozzle study.

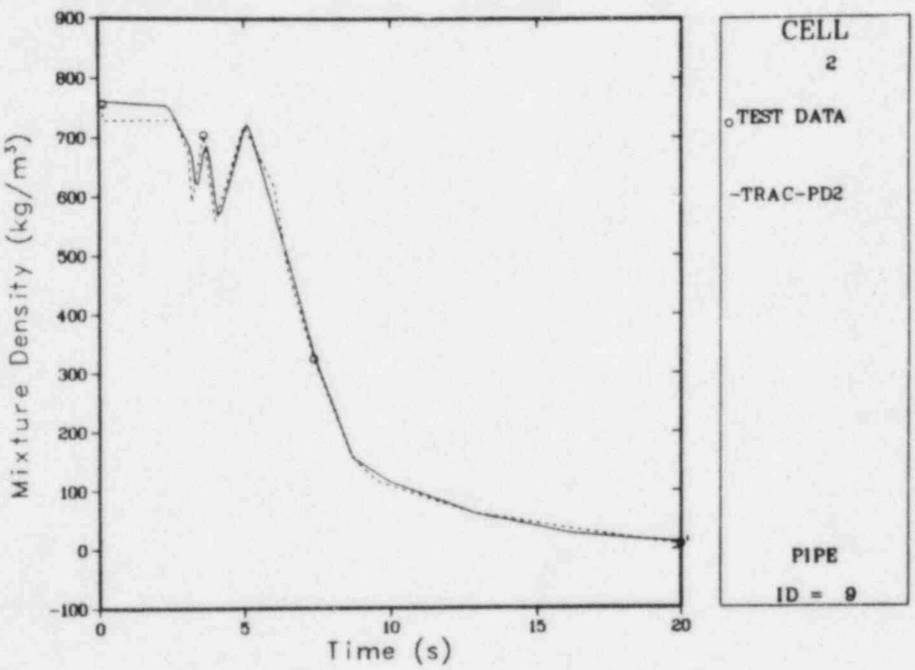


Fig. 104.
Comparison of the upstream density boundary condition and the measured mixture density for the Semiscale nozzle study.

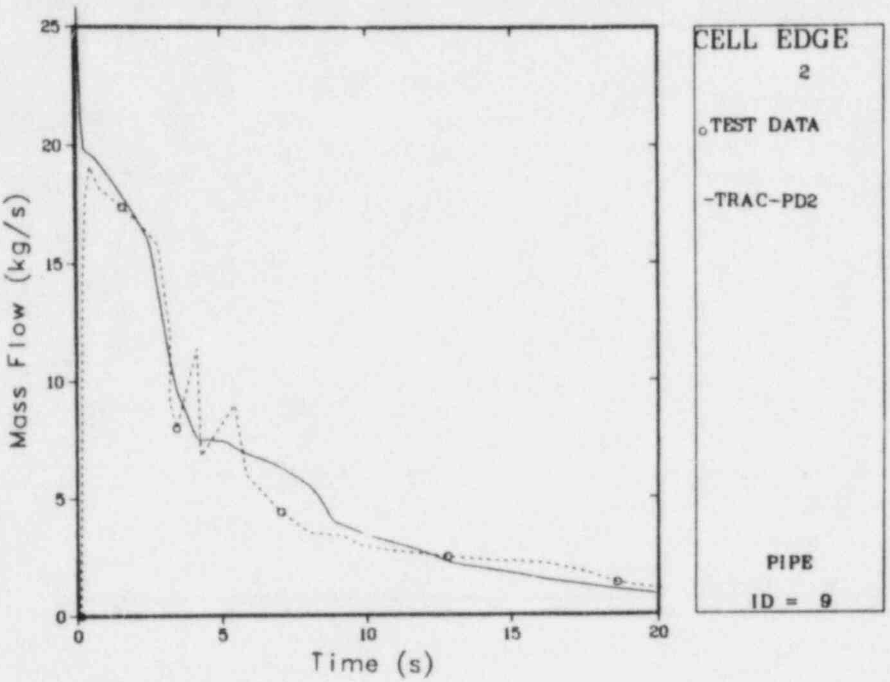


Fig. 105.
Comparison of the calculated and measured mass flows for the Semiscale nozzle study.

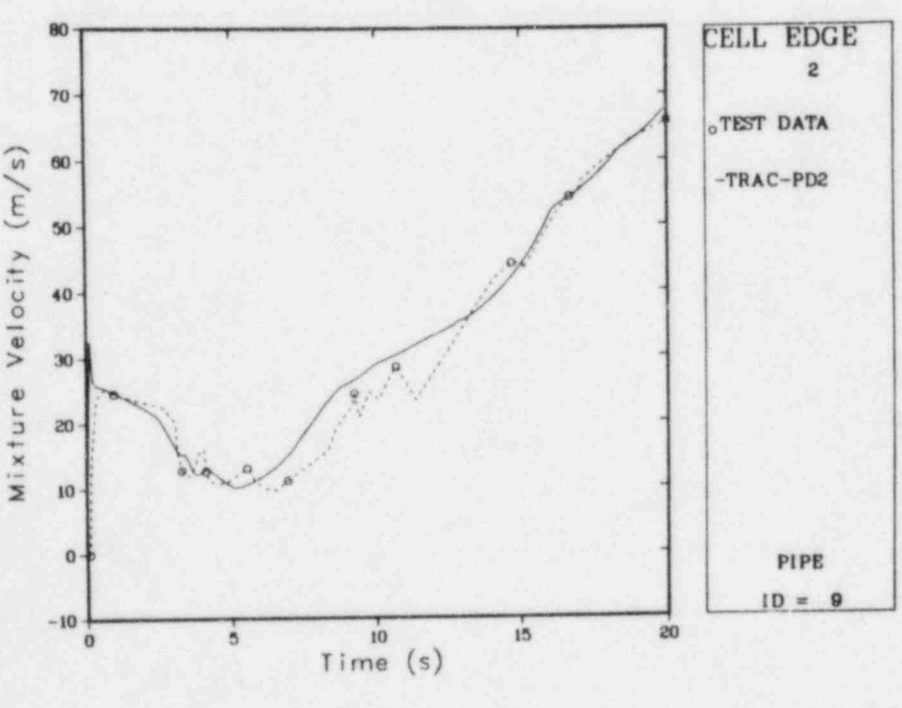


Fig. 106.
Comparison of the calculated and measured mixture velocities for the Semiscale nozzle study.

10 s, the TRAC-calculated temperatures for the fluid, vapor, and interface indicated that the fluids were very close to thermal equilibrium. Because minimum flow generally results from thermal equilibrium, the slip correlations probably were responsible for the overpredicted fluid velocities.

When the entrance void fractions were above 0.95 (after 13 s), the calculated mixture velocities compared well with the test values. The fluid velocity at these high void fractions was very dependent on the input void fraction and, thus, very sensitive to small inaccuracies in the measured density. Consequently, deviations of up to 30% between the TRAC-calculated velocities and the test values might have been caused by the error limits of the density data and would have been acceptable.

C. Conclusions

We conclude that TRAC calculates mass flows well for nozzles similar in size and area ratio to the Semiscale Test S-02-8 nozzle. More specifically, TRAC calculates highly subcooled flow very well, underpredicts flows with low subcooling, predicts well fluid flows with void fractions between 0.05-0.2 and over 0.95, and slightly overpredicts fluid flows with void fractions between 0.2-0.95. The overall predicted break flow appeared adequate to model a Semiscale test blowdown accurately.

Our sensitivity studies indicated that the nozzle section before the end of the constant-area section must be finely noded to predict the saturated blowdown accurately, whereas the expansion section of the nozzle must have at least four nodes to calculate the subcooled portion of the blowdown accurately. The TRAC calculations required 10.69 s of CPU time on a CDC 7600 computer.

XI. SEMISCALE MOD-1 TEST S-06-3

A. Experiment Description

The system used for Semiscale Test S-06-3 (Ref. 20) essentially was the same as that described in Sec. VI except that an accumulator, a high-pressure injection system (HPIS), and a low-pressure injection system (LPIS) to the intact-loop cold leg were added. Other system differences were a higher resistance in the simulated pump and in the active steam generator and a core that consisted of 4 high-power rods (1.485 times the average power), 32 low-power rods (0.939 times the average power), and 4 unpowered rods.

B. TRAC-PD2 Model

The input description used to model Test S-06-3 essentially was the same as that described for Test S-02-8 (Sec. VI) except for the additions needed to model the accumulator and the HPIS and LPIS. Figure 107 shows a noding diagram of Semiscale Test S-06-3.

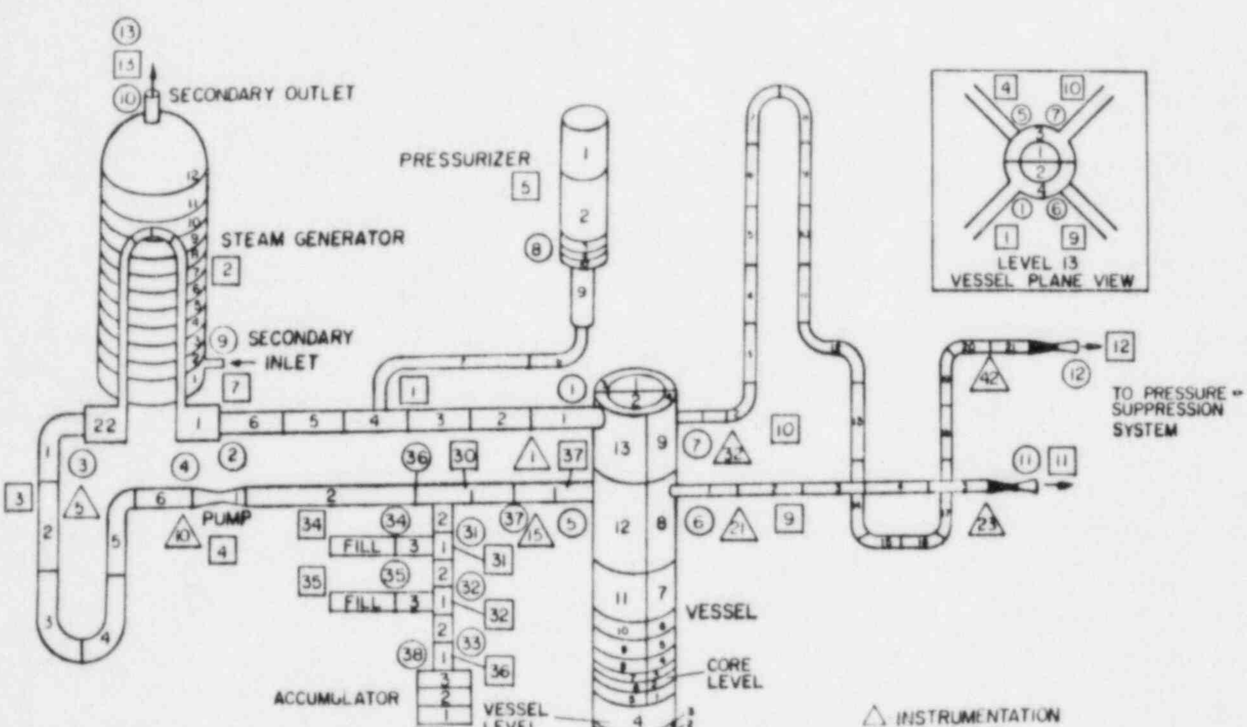


Fig. 107.
TRAC noding diagram of Semiscale Test S-06-3.

We made five changes to the input description for Test S-02-8 to model Test S-06-3.

1. The resistance of the intact-loop steam generator was increased to account for the high-resistance orifice (3.43 cm) used in Test S-06-3.
2. The resistance of the broken-loop simulated pump was changed from 48 to 147 units.
3. Several nodes were combined to increase the length of the node at the pump exit to make the pump less sensitive to ECC backup.
4. The number of nodes in the pressurizer was increased to model the stratified temperature profile in Test S-06-3.
5. The system power level was lowered from 1.59 to 1.004 MW. The number of active rods per theta segment was changed from 19.5 to 18, and hot rods were included to predict both the higher and lower than average rod temperature histories.

We originally modeled the HPIS and LPIS by adding FILL components. However, we discovered that the FILLs acted as dead-end pipes; thus, a high-pressure spike anywhere in the system caused a reflection that decreased the pressure in the volume connected to the FILL below the range of the TRAC thermal-properties routines. We solved this problem by adding a flow resistance between this volume and the rest of the system.

During the transient calculation, we found that the detailed noding of the cold-leg break nozzle necessary to predict the blowdown break flows accurately caused calculational difficulties when the system and break pressures became equal. However, this finely detailed noding was not needed when the pressures were equal because the break flows were subsonic. Consequently, after ~36 s, the finely noded nozzle (Fig. 108) for the broken-loop cold leg was replaced by the coarsely noded nozzle shown in Fig. 109; this new noding includes some of the upstream piping volume to increase cell volume.

C. Data Comparisons

Table XII compares the TRAC-calculated and measured initial conditions for the start of the blowdown. The correlation between the two was sufficient to allow an accurate transient analysis.

Because different time scales were needed to present the calculational results clearly, our transient analysis was limited to curves representing only the blowdown and to curves representing both the blowdown and the reflood.

Figure 110 compares the TRAC-calculated and measured lower-plenum pressures. During the first 5 s, there clearly was a faster rate of pressure decay in the TRAC calculation than in the test data. To determine the reason for this discrepancy, we compared TRAC-calculated mass and volumetric flows in and out of the core with the test values; our results indicated that the TRAC predictions were sufficient to allow an accurately predicted lower-plenum pressure. The temperature profiles of the heater rods also did not indicate any reason for this discrepancy. Heat-slab masses and the water volume in the core were reasonable. During this same 5-s interval, the TRAC-calculated pressure decay for Test S-02-8 also was accurate. In summary, we could not determine any reason for the discrepancy between the TRAC results and the test data.

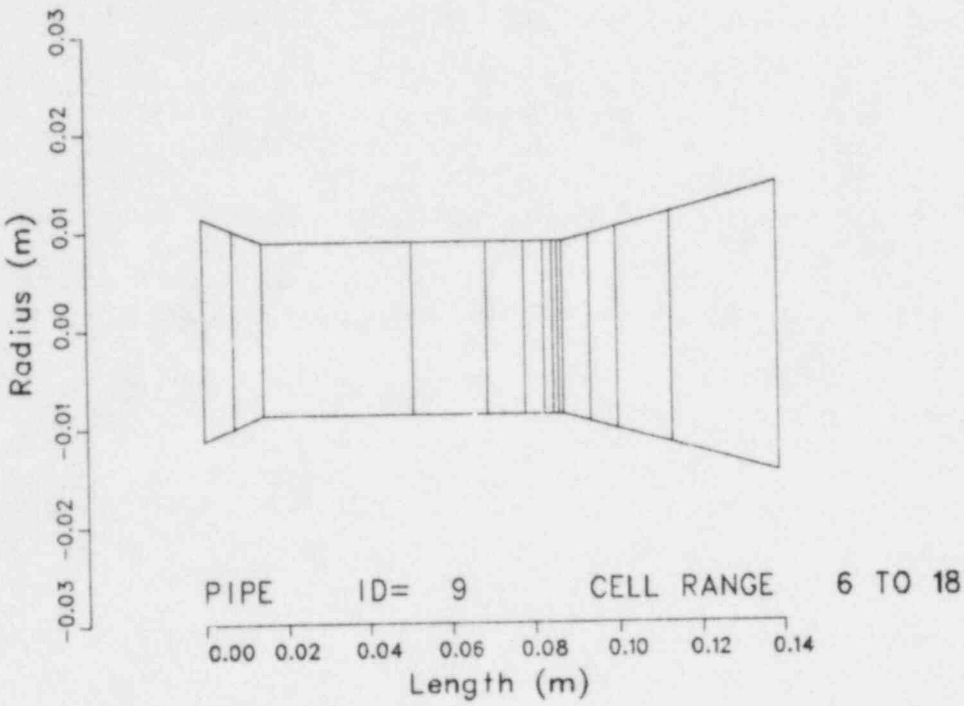


Fig. 108.
Finely noded break nozzle for Semiscale Test S-06-3.

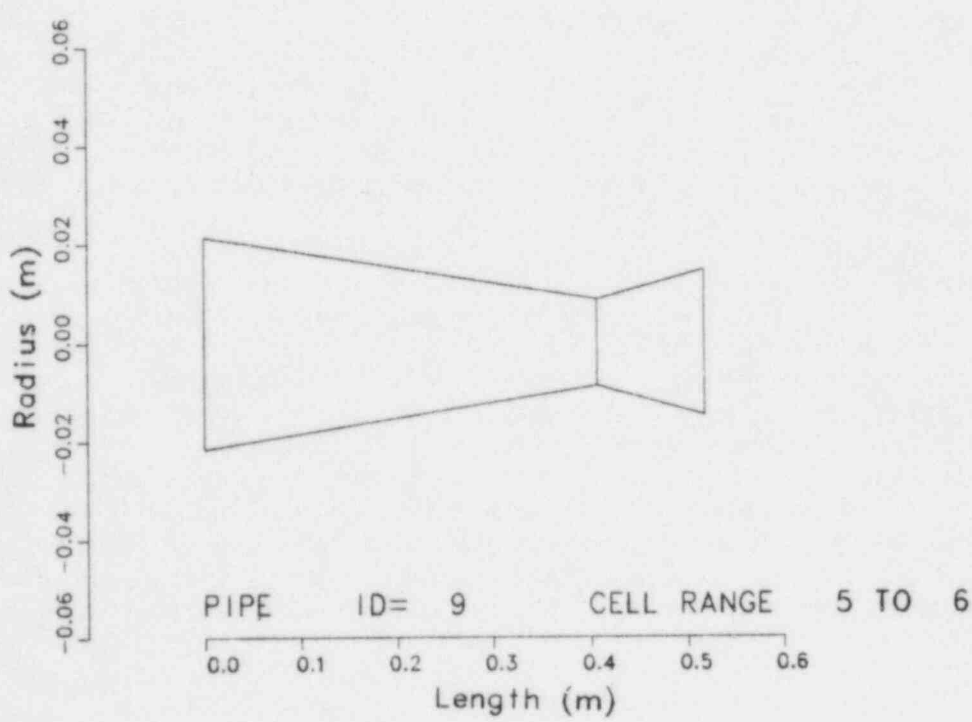


Fig. 109.
Coarsely noded cold-leg break nozzle for Semiscale Test S-06-3.

TABLE XII

CALCULATED AND MEASURED INITIAL CONDITIONS FOR SEMISCALE MOD-1 TEST S-06-3

Parameter	Test Data	TRAC-PD2 Results
Core power (MW)	1.004	1.004
Intact-loop cold-leg temperature (K)	563.	562.4
Hot- to cold-leg temperature differential (K)	34.1	33.7
Pressurizer pressure (MPa)	15.77	15.769
Pump mass flow ($kg \cdot s^{-1}$)	5.02	5.208
Pump speed ($rad \cdot s^{-1}$)	169.5	170.
Pump differential pressure (kPa)	80.	72.99

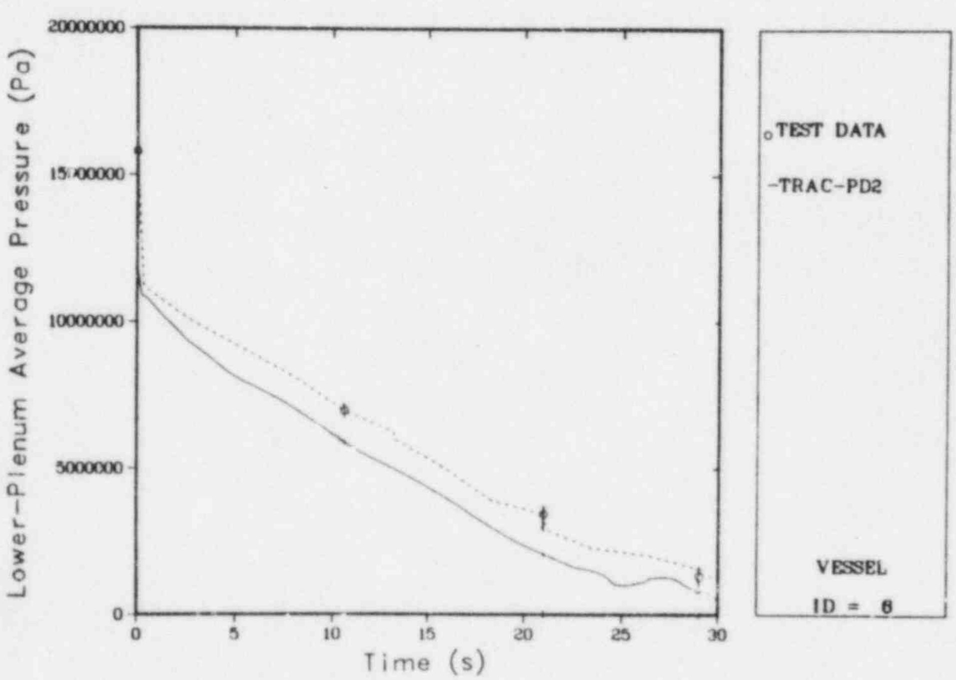


Fig. 110.
Comparison of the TRAC-calculated and measured lower-plenum pressures for Semiscale Test S-06-3.

Figures 111 and 112 compare the mass and volumetric flows at the entrance to the broken-loop cold leg. The comparisons between the TRAC calculations and the test data were remarkably good.

Figure 113 compares the mass flows at the entrance to the broken-loop hot leg. Again, the comparisons between the TRAC results and the test data were very good and well within the accuracy of the experiment data. Figure 114 shows the calculated volumetric flow into the broken-loop hot leg. In Test S-02-8 the inclusion of two-phase flow effects in the simulated pump had little effect on the TRAC predictions; however, their inclusion in Test S-06-3 markedly improved the the TRAC results and, thus, the comparisons with the test data.

Figures 115 and 116 compare the mass and volumetric flows at the inlet to the intact-loop hot leg. The agreement between the TRAC results and the test data was excellent. Because this TRAC calculation used finer detail in the pressurizer component, better agreement was obtained for Test S-06-3 than for Test S-02-8.

Figure 117 compares the TRAC-calculated and measured mass flows at the pressurizer exit. The averaging of the flow rate shown by the calculation probably was caused by the numerically induced mixing of the hot and cold fluids within the pressurizer during blowdown.

Figures 118 and 119 compare the mass and volumetric flows at the pump exit. The TRAC calculations matched the test data well. The most noticeable difference between the two figures was that the calculated pump degradation, indicated by the decrease in mass flow at ~5 s in Fig. 117, occurred earlier than indicated by the test data.

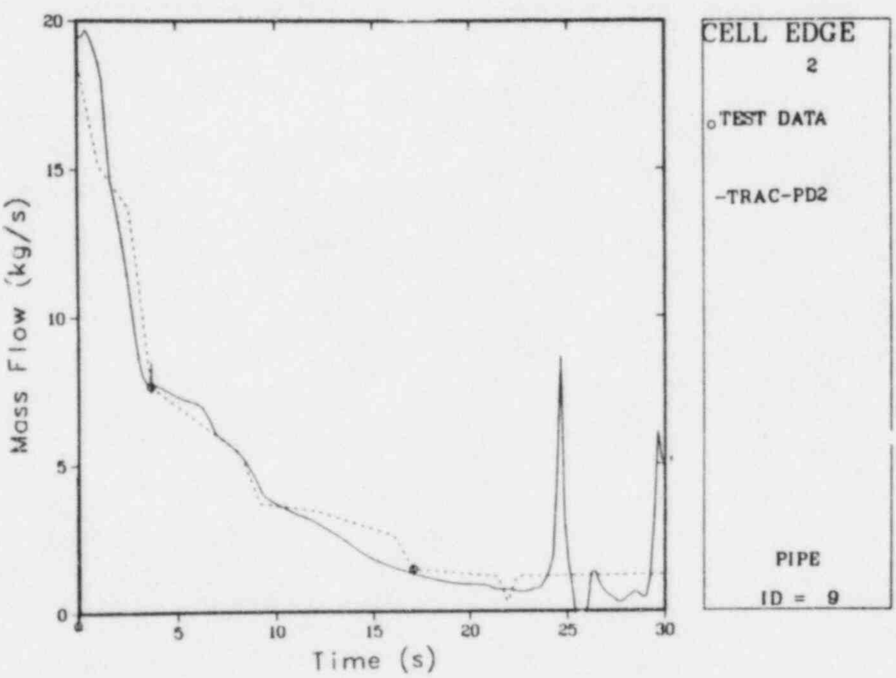


Fig. 111.
Comparison of the TRAC-calculated and measured mass flows at the entrance to the broken-loop cold leg for Semiscale Test S-06-3.

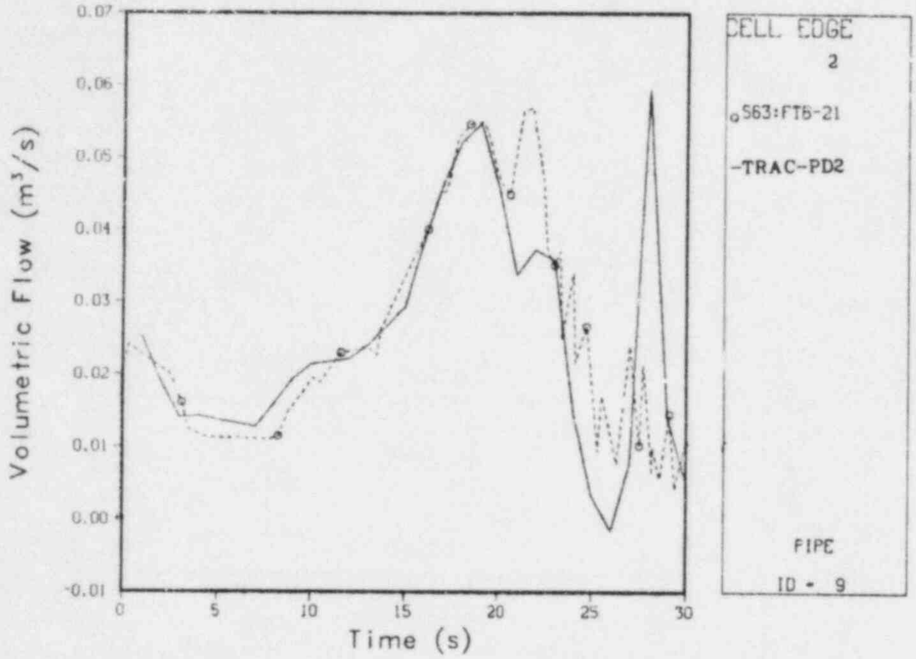


Fig. 112.
Comparison of the TRAC-calculated and measured volumetric flows at the entrance to the broken-loop cold leg for Semiscale Test S-06-3.

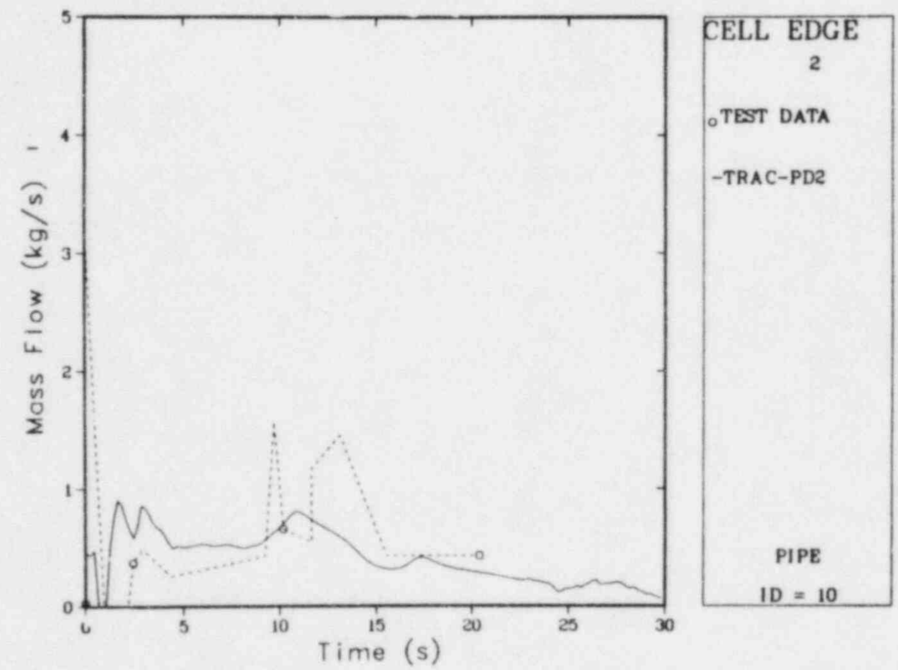


Fig. 113.
Comparison of the TRAC-calculated and measured mass flows at the entrance to the broken-loop hot leg for Semiscale Test S-06-3.

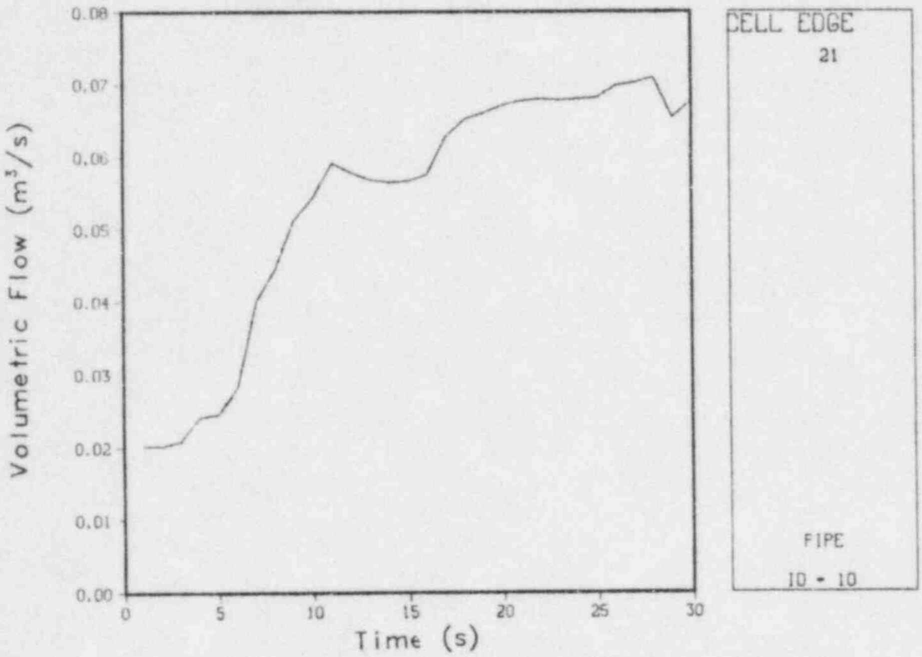


Fig. 114.
Volumetric flow at the entrance to the broken-loop hot leg for Semiscale Test S-06-3.

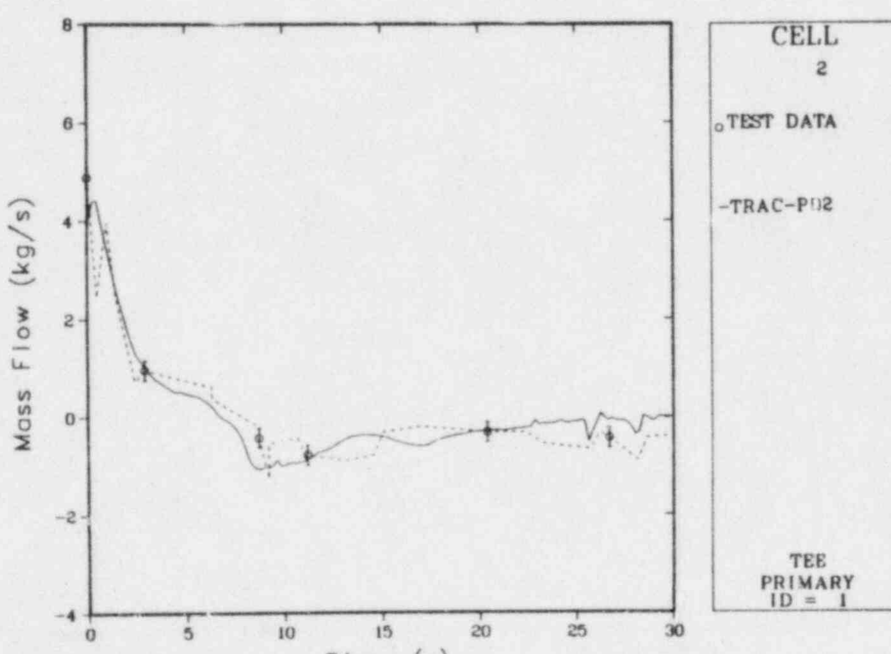


Fig. 115.
Comparison of the TRAC-calculated and measured mass flows at the entrance to the intact-loop hot leg for Semiscale Test S-06-3.

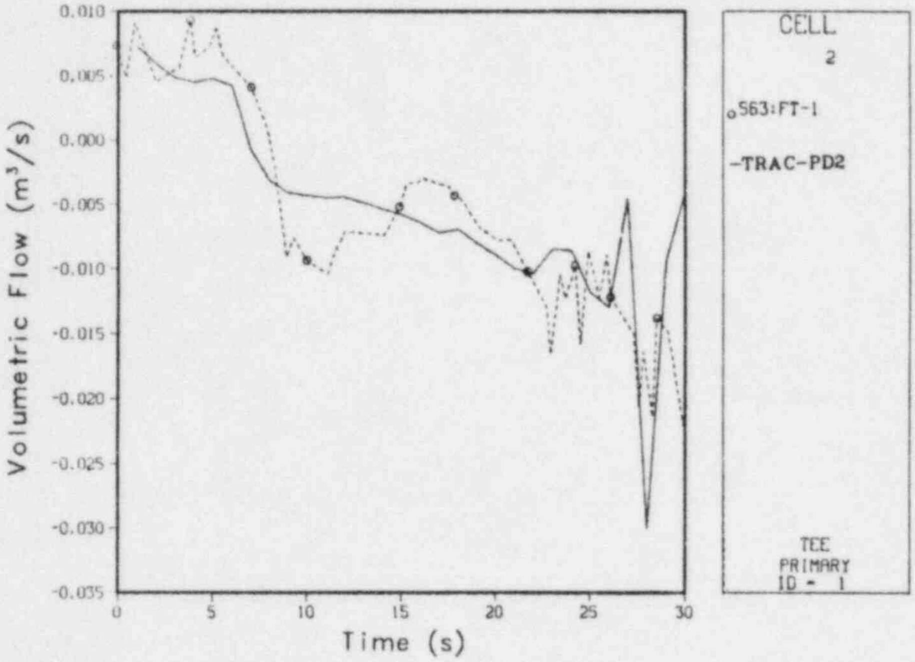


Fig. 116.
Comparison of the TRAC-calculated and measured volumetric flows at the entrance to the intact-loop hot leg for Semiscale Test S-06-3.

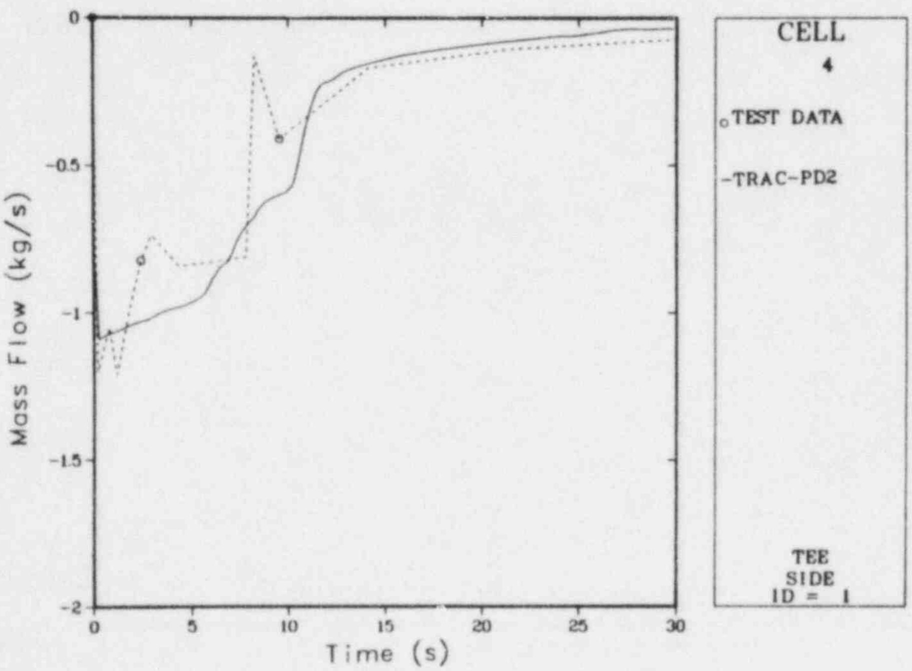


Fig. 117.
Comparison of the TRAC-calculated and measured mass flows at the pressurizer exit for Semiscale Test S-06-3.

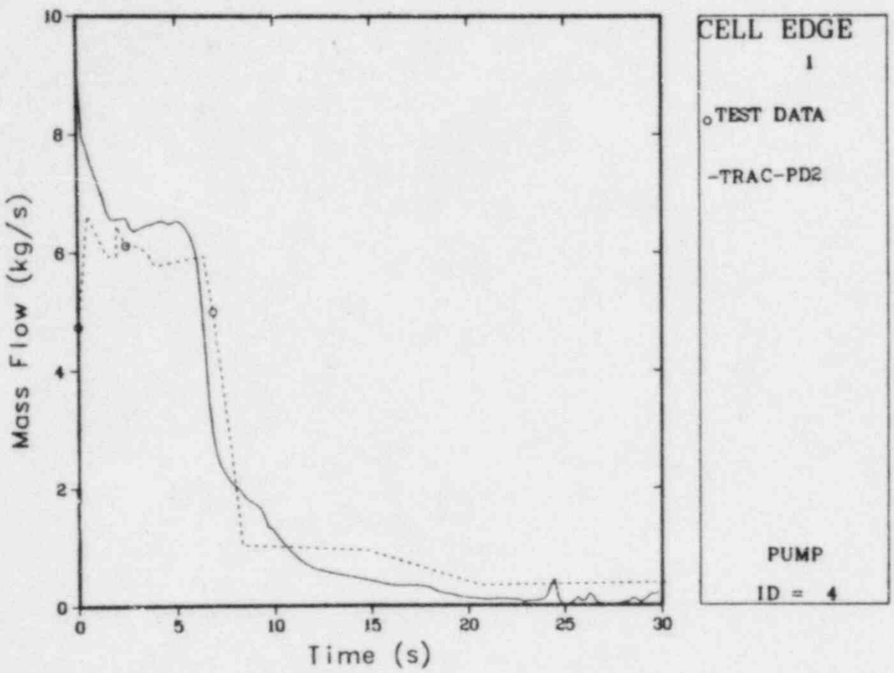


Fig. 118.
Comparison of the TRAC-calculated and measured mass flows at the pump exit for Semiscale Test S-06-3.

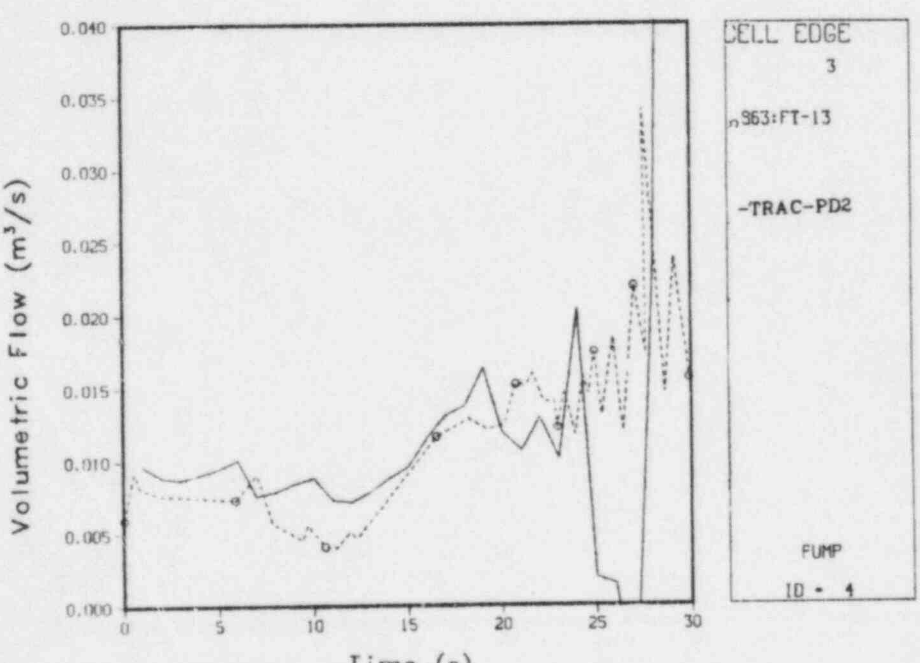


Fig. 119.
Comparison of the TRAC-calculated and measured volumetric flows at the pump exit for Semiscale Test S-06-3.

In summary, the TRAC-calculated pipe flows during the blowdown transient showed excellent agreement with the test data, and any improvements in TRAC probably would affect the predicted rod-cladding temperatures insignificantly.

Figure 120 compares the mixture velocities from the accumulator. Two factors may have caused the deviation between the calculation and the test data. The initial fluctuation in the calculated results at 10 s was caused by flashing of the liquid in the pressure-dependent valve that controls the flow from the accumulator. The steep increase in velocity that occurred at ~20 s in the experiment was calculated at ~15 s by TRAC because of the more rapid decrease in the calculated system pressure between 0 and 5 s than was measured in the test. The overall flow rate and the voiding time of the accumulator were calculated well by TRAC.

Figure 121 compares the mass flows at the core entrance. Although the calculated pipe flows in the hot and cold legs to the vessel and the heat transfer within the core agreed well with the test data, the TRAC calculations for Semiscale Tests S-02-8 and S-06-3 tended to underpredict the degree of negative core flow between 1 and 6 s. We could find no apparent cause for this TRAC underprediction in either test.

The cladding temperature data were plotted for different core levels both for the low-power rods (0.939 times the average power) and for the high-power rods (1.485 times the average power). The core hydraulics were linked to a set of average-power rods. Because there was no direct feedback from the low- or the high-power rods to the hydraulics, a CHF in the high-power rods did not affect the rate of steam generation within the core unless it was matched by a CHF in the average-power rods.

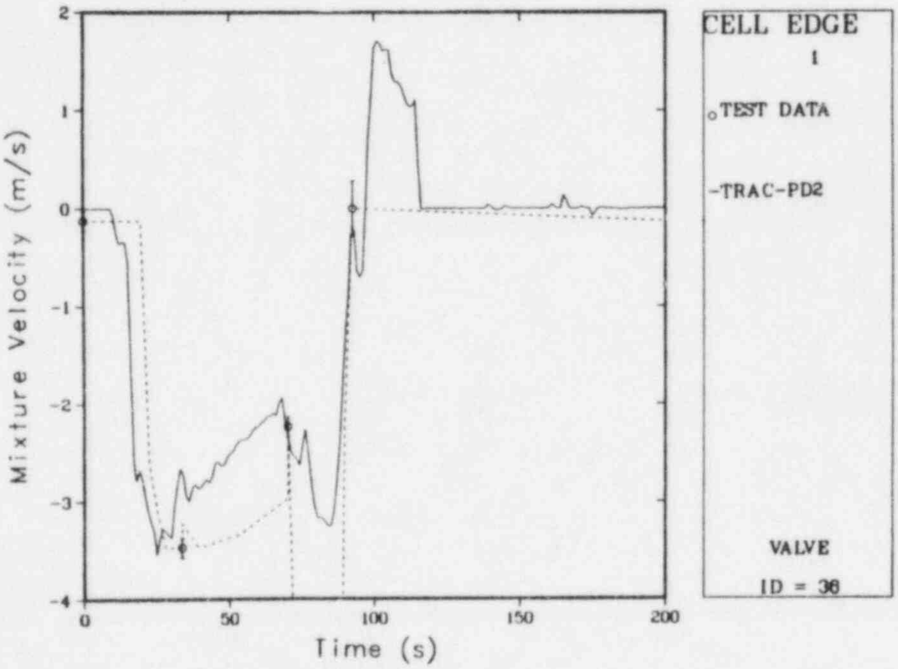


Fig. 120.
Comparison of the TRAC-calculated and measured mixture velocities at the accumulator exit for Semiscale Test S-06-3.

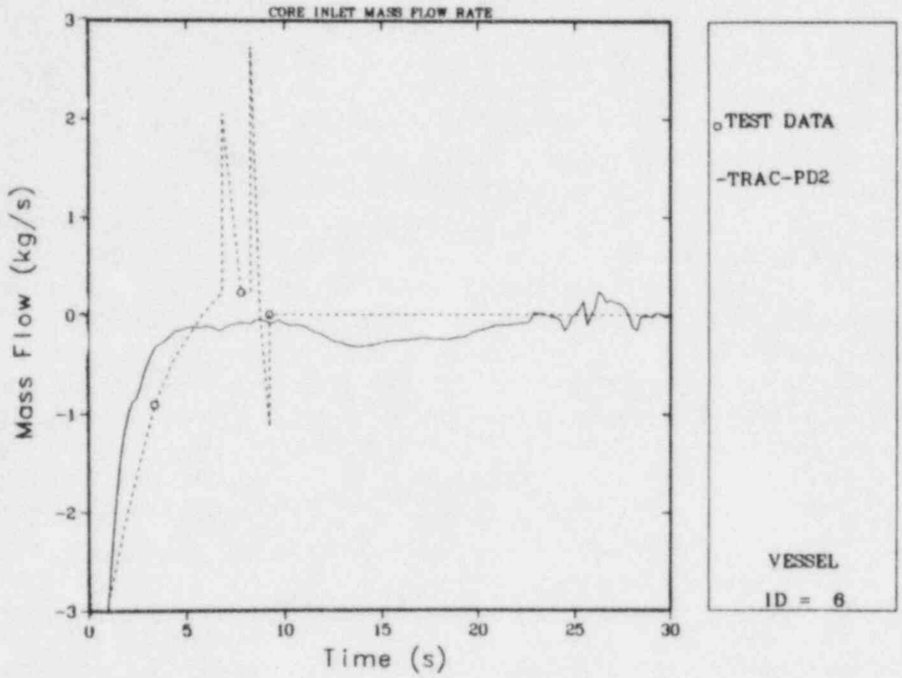


Fig. 121.
Comparison of the TRAC-calculated and measured mass flows at the core entrance for Semiscale Test S-06-3.

Figures 122-124 compare the calculated and measured cladding temperatures for the 32 low-power rods located in the lower, middle, and upper core. The comparisons for all three levels were good.

Figures 125-127 compare the cladding temperatures for the high-power rods in the lower, middle, and upper core. The highest power region of the core was located between z = 1.7856 m and z = 2.03961 m. For the elevations below the middle of the high-power core region (Figs. 122-124), TRAC predicted the CHF at the correct time, underpredicted the peak cladding temperature from 70-90 K, calculated the quench time within ~10 s, and predicted the general trend of the temperature profile well. The calculated CHF in the upper core (Fig. 127) occurred ~4 s later than the CHF in the test. The calculated peak cladding temperature was ~140 K below the test value, the quench time occurred ~40 s earlier than in the test, and the temperature profile diverged from the test data. In the TRAC model of the Semiscale core, one of the two theta segments contained slightly more liquid than the other after the initial voiding of the core and the upper plenum. This difference in liquid volume produced a pressure differential that caused most of the flow through the core to pass through the theta segment with the least liquid. Thus, this theta segment did not void completely. The TRAC-PD2 program contains CHF and transition boiling correlations that are very sensitive to small amounts of water when the void fraction is close to 1.0. Therefore, the rod-cladding temperature in one theta segment may vary greatly from that of a rod in another segment. In our analysis of Test S-06-3, the hot rod was located in the theta segment in which a small amount of water remained. Thus, the calculated hot-rod temperature profiles were not as good as the profiles for the low-power

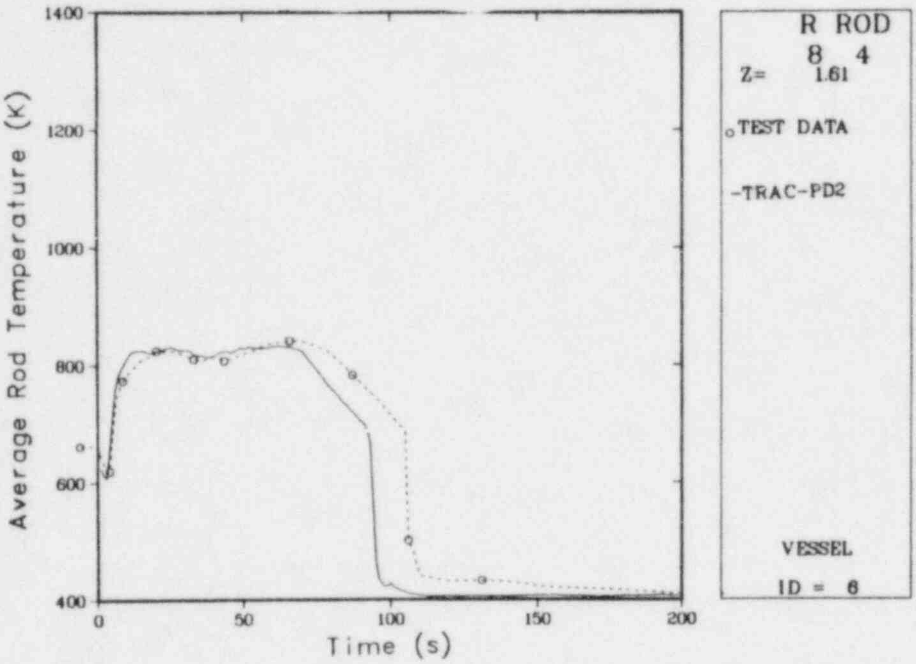


Fig. 122.
Comparison of the TRAC-calculated and measured cladding temperatures for the 32 low-power rods in the lower core.

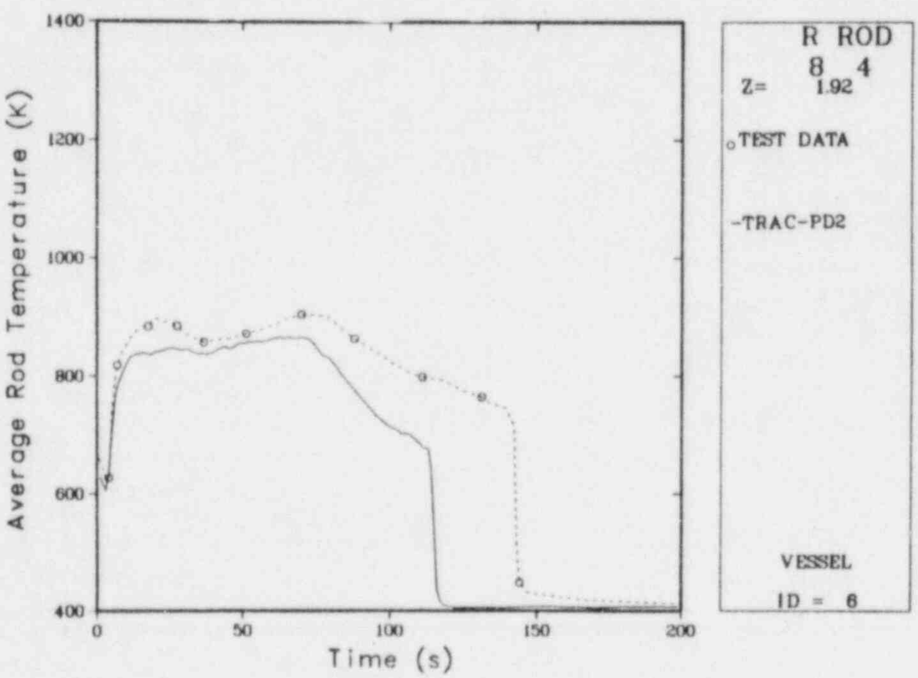


Fig. 123.
Comparison of the TRAC-calculated and measured cladding temperatures for the 32 low-power rods in the midcore.

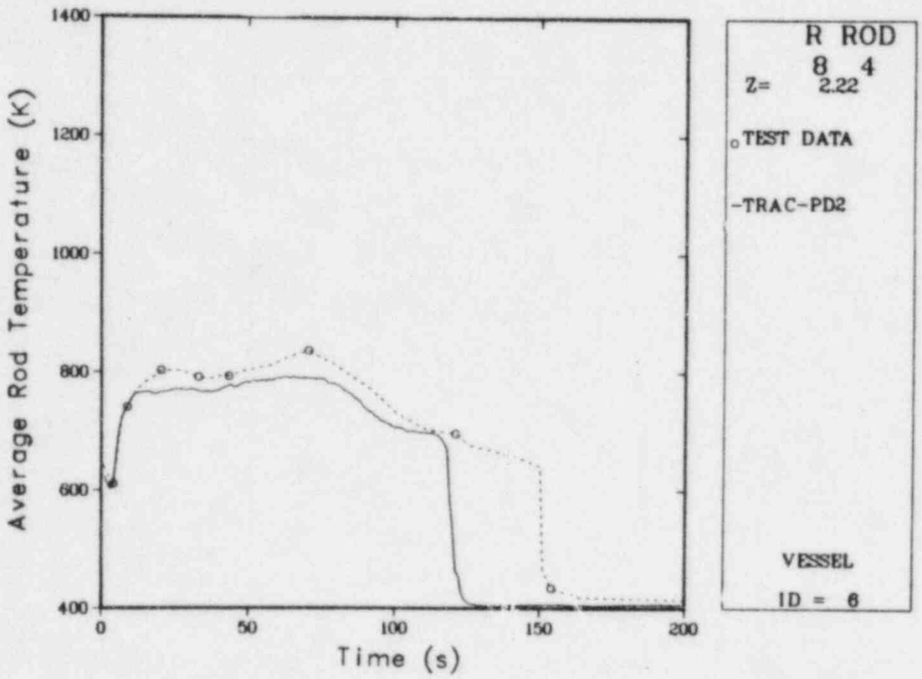


Fig. 124.
Comparison of the TRAC-calculated and measured cladding temperatures for the 32 low-power rods in the upper core.

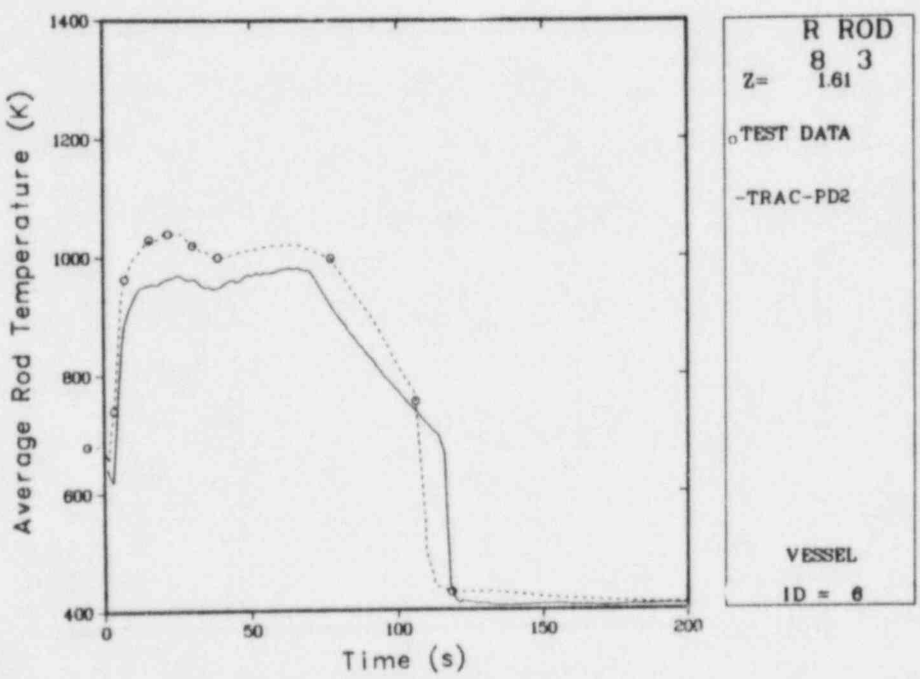


Fig. 125.
Comparison of the TRAC-calculated and measured cladding temperatures for the high-power rods in the lower core for Semiscale Test S-06-3.

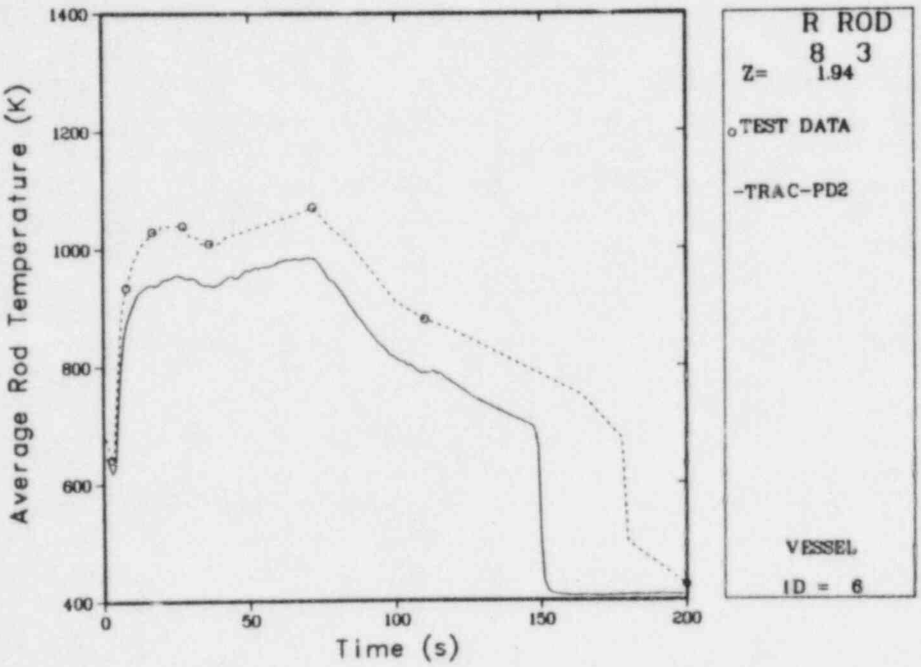


Fig. 126.
Comparison of the TRAC-calculated and measured cladding temperatures for the high-power rods in the midcore for Semiscale Test S-06-3.

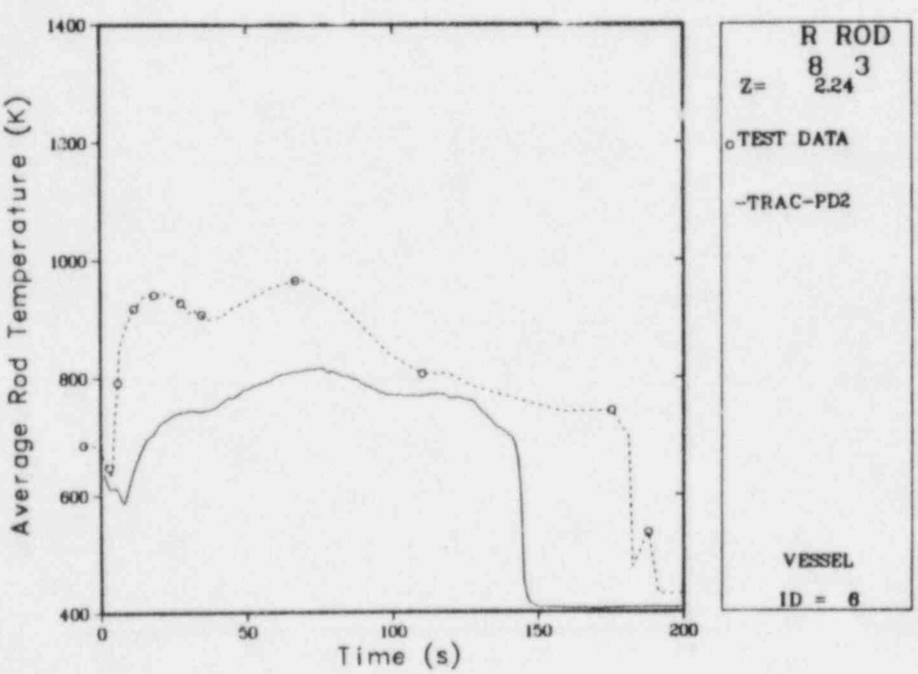


Fig. 127.
Comparison of the TRAC-calculated and measured cladding temperatures for the high-power rods in the upper core for Semiscale Test S-06-3.

rods. Also, because there were only four high-power rods in the core, it was unreasonable to model a separate, small flow channel for the hot rods. Therefore, the code based the core-hydraulics calculations on the average rod power, which was more typical of the low-power rods than the high-power rods.

Semiscale Test S-06-3 was run with a 5-, 6-, and 12-level core. We found that the use of the 6- and 12-level cores produced similar results, but the use of the 5-level core lowered the maximum cladding temperature over 100 K. After further investigation we concluded that the highest powered step of the heater rod should be modeled with two axial core levels.

D. Conclusions

In general, the TRAC-calculated results for Semiscale Test S-06-3 were good. The TRAC results for the one-dimensional components were excellent. The fluid flow in the vessel was predicted well. The cladding temperatures were predicted well for the low- and high-power rods below the middle of the high-power core region. Newly developed input description techniques produced noticeable improvements in the calculated results.

The steady-state and transient calculations required ~6 min and ~317 min, respectively, of CPU time on a CDC 7600 computer.

Appendix I lists the steady-state and transient-restart input decks for Semiscale Mod-1 Test S-06-3.

XII. LOFT NONNUCLEAR EXPERIMENT L1-4

A. Experiment Description

The LOFT facility[21] is a scale model of a large PWR. The volume-scale ratio between the LOFT system and the large PWR is approximately 1:60; flow and break areas also are scaled using the same ratio. The LOFT L1-4 system consisted of a pressure vessel: an intact loop with a pressurizer, steam generator, and two pumps; a blowdown loop with a simulated steam generator, a simulated pump, and two quick-opening valves (17.5 ms to open fully); and a pressure-suppression system. Figure 128 shows the major LOFT components.

The pressure vessel contained upper and lower plenums, a downcomer, and a core support barrel. For Test L1-4 a hydraulic core simulator provided the flow resistance of the fuel-rod bundles. The blowdown loop was a volume-scale representation of one loop in a large four-loop PWR. The simulated steam generator and pump consisted of piping containing many orifice plates to achieve the desired hydraulic resistance. The intact loop had a volume approximately three times larger than the blowdown loop and represented three intact loops of a large four-loop PWR. The intact loop had a U-tube steam generator, two centrifugal pumps, and a pressurizer. The pressure-suppression system simulated the large volume and the back pressure of the large PWR containment building and contained the blowdown effluent.

Test L1-4, the fourth in a series of five nonnuclear isothermal blowdown experiments performed as part of the LOFT integral test program, is US Standard Problem 7. The purposes of Test L1-4 were to obtain data on the delayed HPIS and LPIS cold-leg injection, to obtain data for the evaluation of downcomer

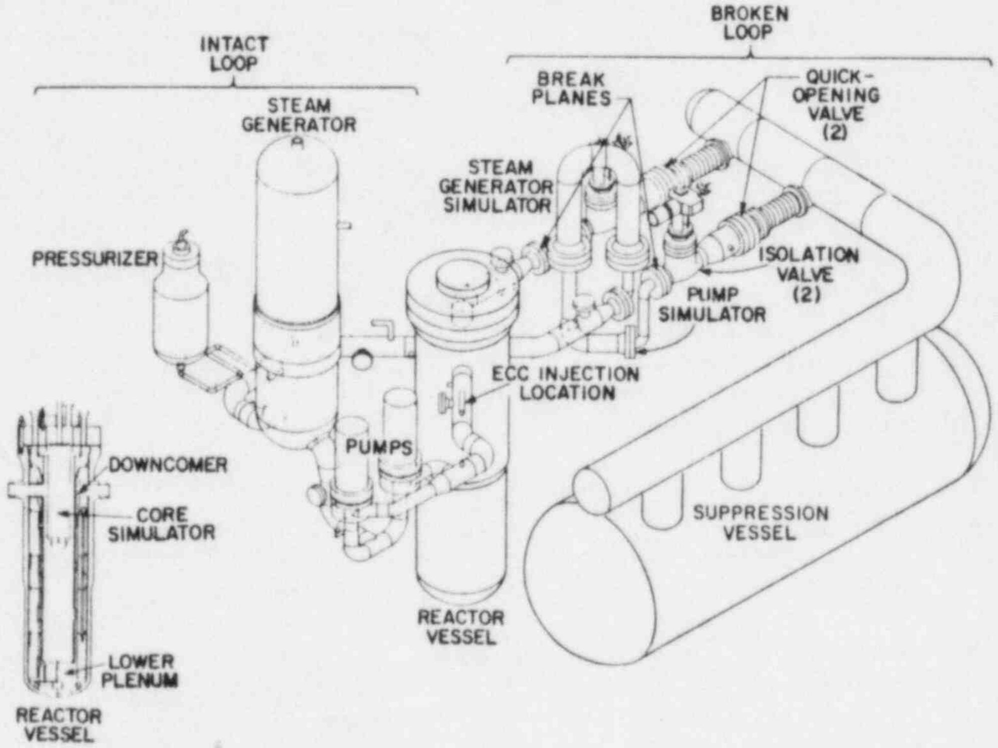


Fig. 128.
Major LOFT components.

bypass and mixing of the ECC with the primary coolant, and to obtain thermal-hydraulic data for comparison with test predictions and other test data for code assessment purposes.

Before the blowdown test, the primary system was brought to its initial temperature (552 K), pressure (15.75 MPa), and flow rate (268.4 $kg \cdot s^{-1}$), using the work energy addition of the primary-coolant pumps. Isothermal conditions were obtained in the nonflowing blowdown loop by recirculation lines connected to the intact loop. Before the system temperature exceeded 366.3 K, the steam-generator secondary side was drained to the zero-power water level (2.59 m from the top of the tube sheet).

Immediately before blowdown, the pressurizer heaters were de-energized and the blowdown was initiated by opening the two quick-opening valves, which simulated a 200% (that is, a 100% break area in each leg), double-ended, offset-shear break in the cold leg. Electrical power to the primary-system motor generator was terminated within 1 s after blowdown initiation; this power loss allowed the flywheels and the fluid-dynamic forces to slow the pumps.

The ECC was injected into the intact-loop cold leg during blowdown. Accumulator injection was initiated at a system low-pressure trip of 4.24 MPa. The HPIS pump was preset to inject at $1.085 \times 10^{-3}\ m^3 \cdot s^{-1}$ and to initiate at 22 s after blowdown. The LPIS pump was initiated no sooner than 35.5 s after the blowdown began; its flow rate, dependent upon the LOFT system pressure, varied from 0-0.01 $m^3 \cdot s^{-1}$.

The TRAC calculations predicted the system thermal-hydraulic response for 70 s after the blowdown began.

B. TRAC-PD2 Model

Figure 128 shows the LOFT components, interconnected in series and in parallel branches. The system was complicated further by area changes and orifice plates. The TRAC program used one-dimensional components to model the blowdown and intact loops and a three-dimensional VESSEL (Fig. 129) to model the reactor vessel.

The TRAC model used 28 components with 29 junctions for a total of 205 fluid cells. Figures 130-136 display the component noding diagrams for the LOFT system. The reactor vessel was divided into 9 axial, 2 radial, and 4 azimuthal segments for a total of 72 fluid cells. The upper and lower plenums contained six and eight fluid cells, respectively. Typical cell dimensions were ~0.2-2.0 m, except near the breaks where the length varied from 0.0127-0.1 m. The semi-implicit option was used for all the components except the broken pipes where the fully implicit option was used. The TRAC ECC system (Fig. 136) consisted of an accumulator (ACCUM) connected to a series of two TEEs. These TEEs were connected to two FILLs that specified the HPIS and LPIS flows. The HPIS was set to initiate at 22 s, whereas the LPIS began at a 14.4-bar pressure. The accumulator VALVE (component 27) tripped open at a 42.6-bar pressure.

Because of the simplicity of the TRAC-PD2 PUMP module, the pump speeds were constrained to agree with the test data through input.

C. TRAC-Calculated Results

1. Steady-State Results. The TRAC calculation for LOFT L1-4 was performed in two stages. First, steady-state conditions were obtained by running a generalized steady-state calculation starting from an initial zero-flow rate, with a uniform pressure and temperature and with the two quick-opening valves closed. Figures 137 and 138 show that the initiation of the two

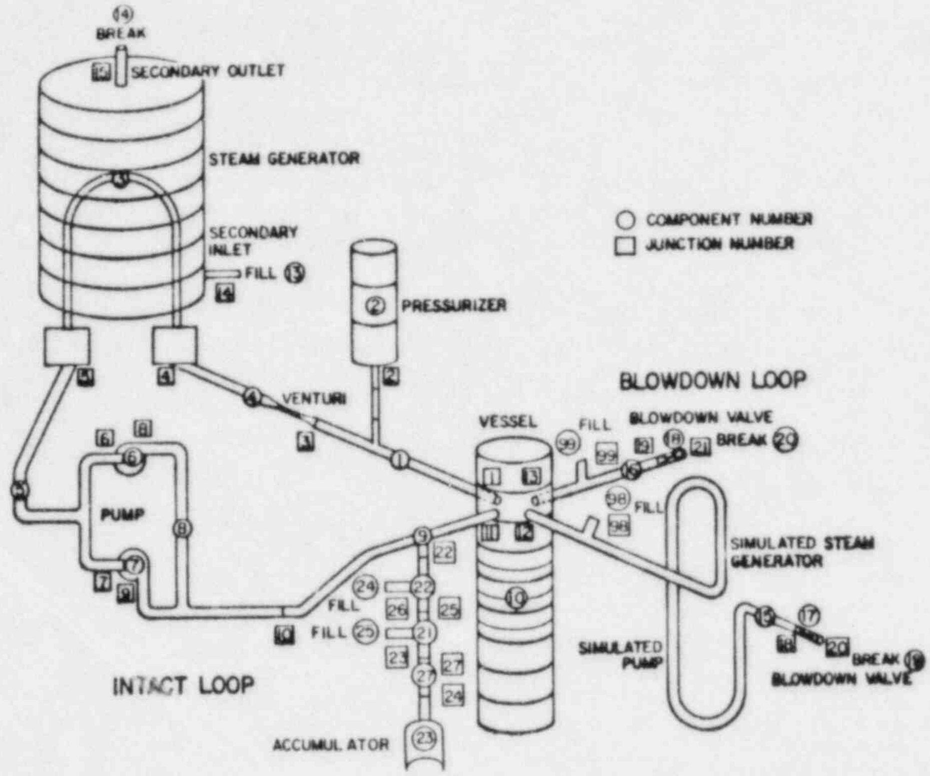


Fig. 129.
TRAC model of LOFT L1-4.

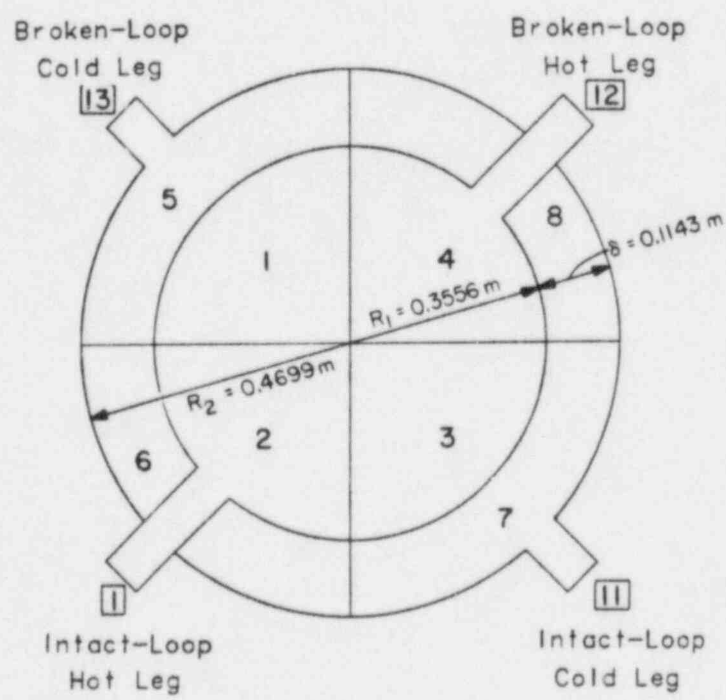


Fig. 130.
LOFT L1-4 reactor-vessel horizontal noding diagram for level 8.

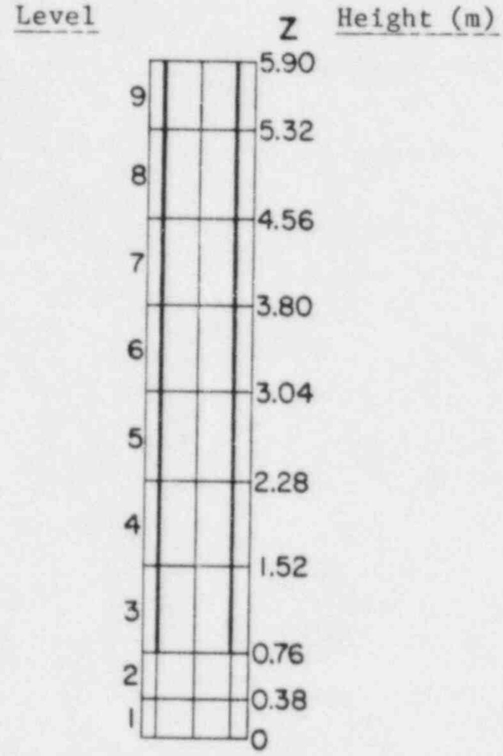


Fig. 131.
LOFT L1-4 reactor-vessel axial noding diagram.

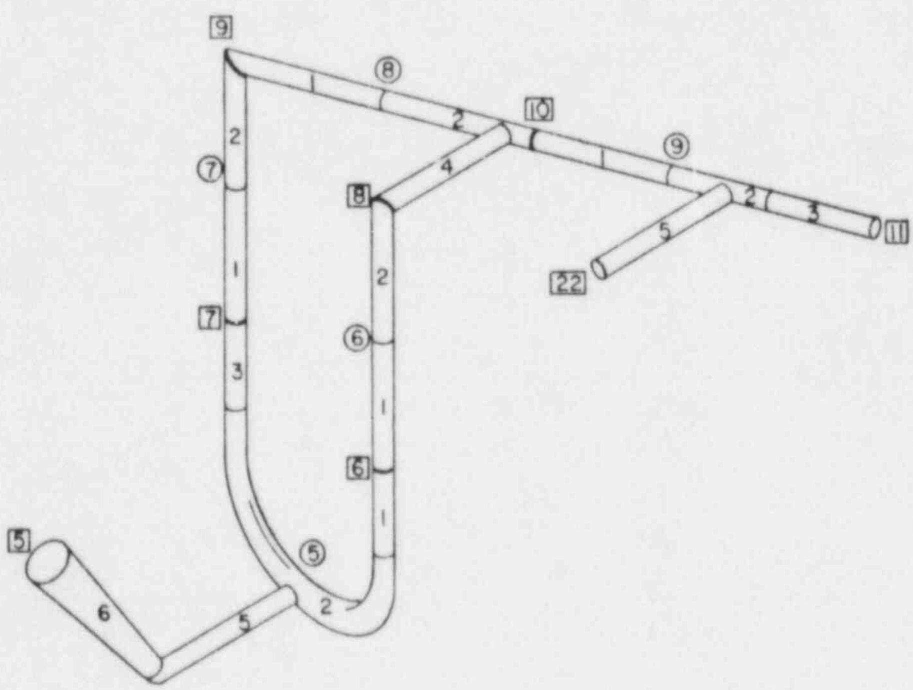


Fig. 132.
LOFT L1-4 intact-loop cold-leg noding diagram.

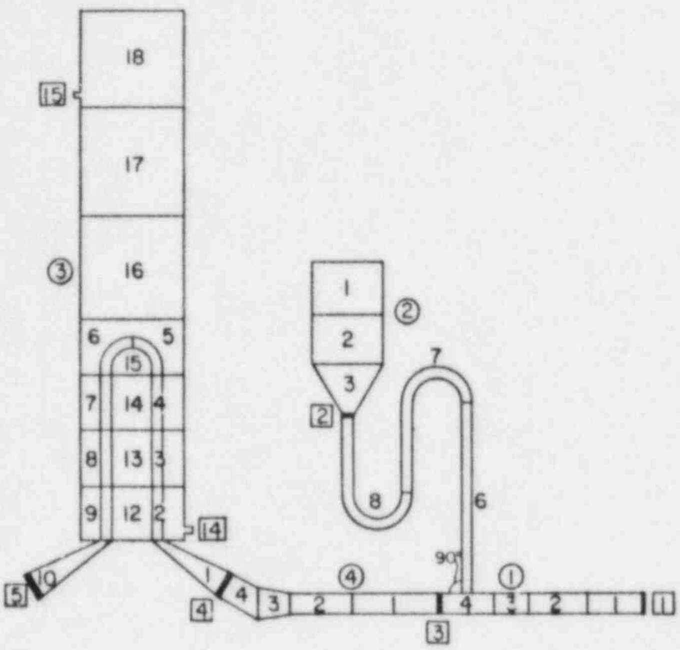


Fig. 133.
LOFT L1-4 intact-loop hot-leg noding diagram.

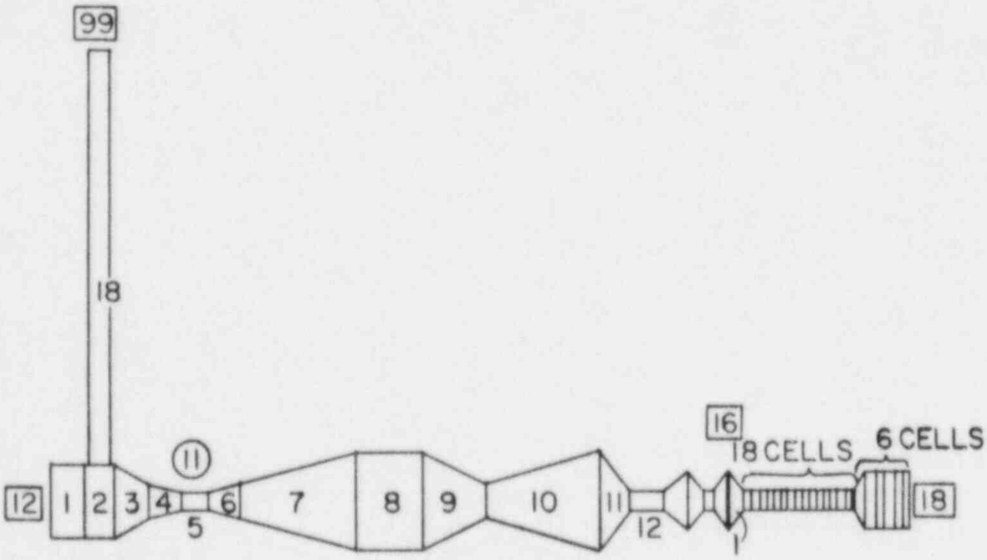


Fig. 134.
LOFT L1-4 broken-loop hot-leg noding diagram.

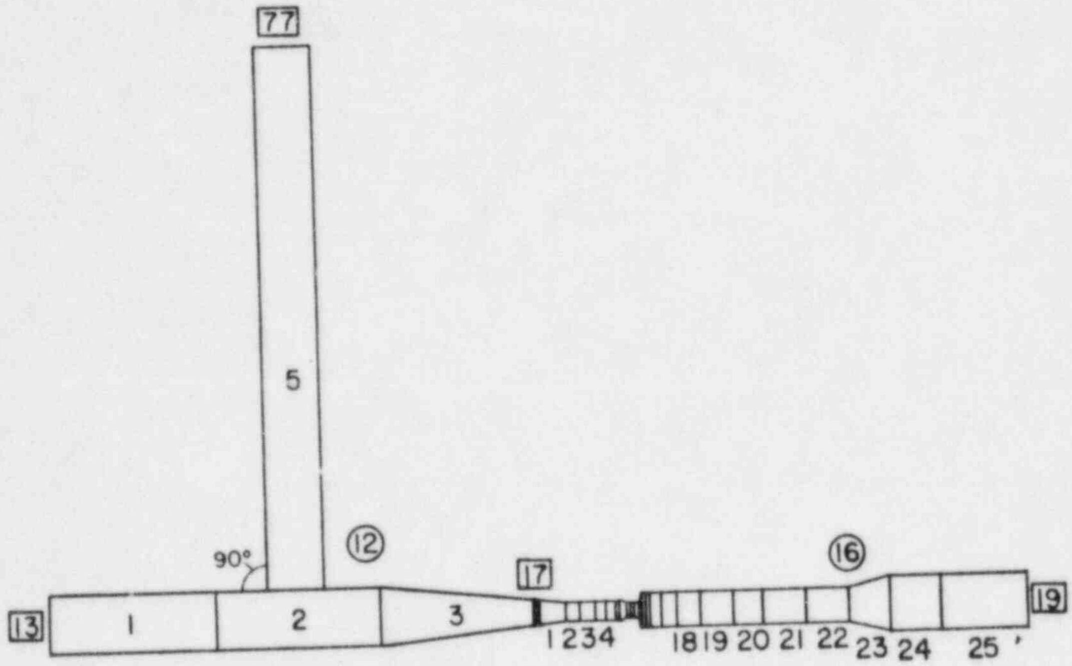


Fig. 135.
LOFT L1-4 broken-loop cold-leg noding diagram.

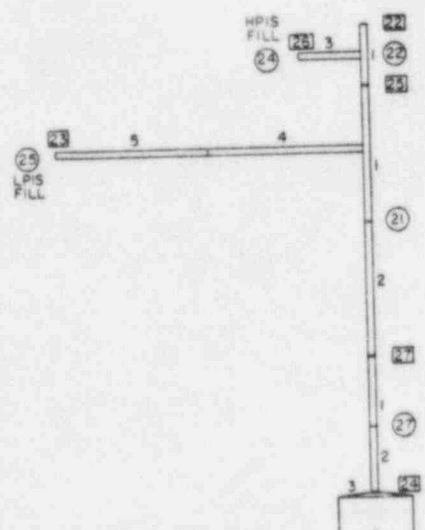


Fig. 136.
LOFT L1-4 ECCS noding diagram.

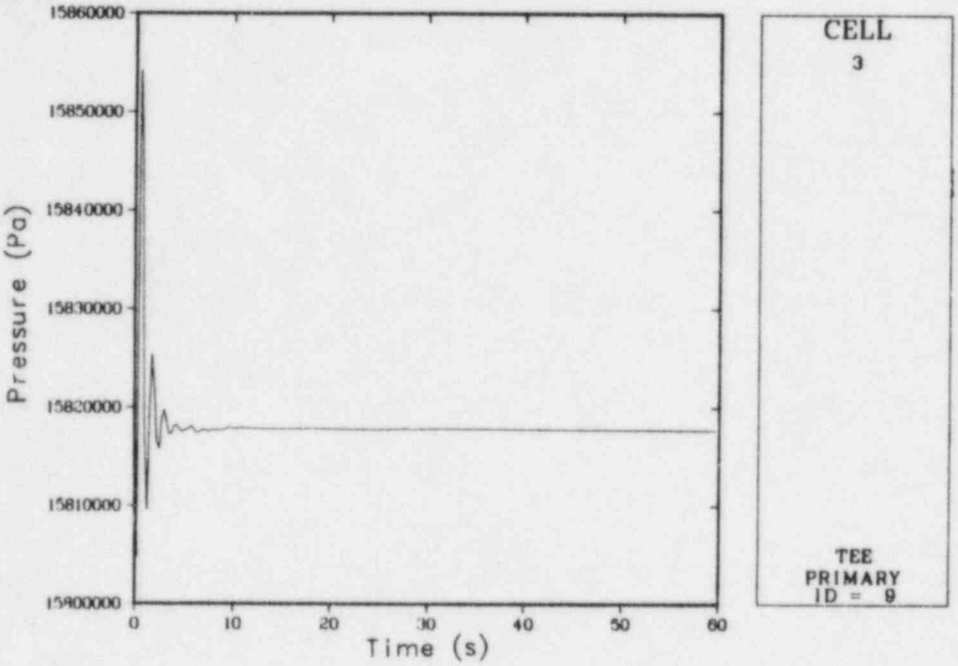


Fig. 137.
LOFT L1-4 steady-state intact-loop pressure.

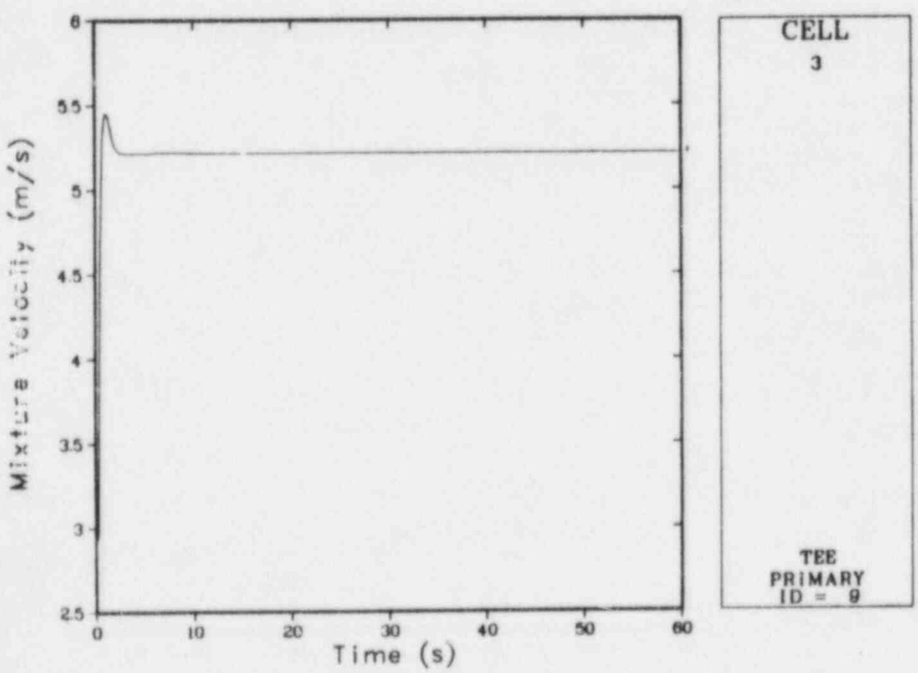


Fig. 138.
LOFT L1-4 steady-state intact-loop mixture velocity.

pumps at time zero caused the system pressure and flow rate to approach their steady-state values quickly after one loop cycle time (3-4 s). The liquid temperature, however, continued to oscillate (Fig. 139) and was driven by the slow approach to steady state in the steam-generator secondary side (Fig. 140). As can be seen in Fig. 140, the secondary-side conditions had not converged fully at 60 s, but they were close enough to convergence that they did not affect the transient results seriously. The steady-state calculation used 6.2 min of CPU time, which was negligible compared to the time used by the transient calculation (168.5 min). The average time-step size for the steady-state calculation was 70 ms. Table XIII shows that all of the calculated steady-state parameters were close to the measured values.

2. Transient Results. The transient calculation was initiated by activating the two quick-opening VALVES (components 17 and 18) at the restart from the steady-state dump. In this section we compare the results of a TRAC-PD2 calculation with test data and a TRAC-P1A/NEWS1 (Ref. 13) calculation. The test results were obtained by digitizing curves from the LOFT L1-4 data report.[22]

The most important parameters in any LOFT blowdown experiment are the broken-loop mass and enthalpy flow rates. As can be seen in Figs. 141 and 142, the TRAC-PD2 results for mass flows in the broken loop agreed well with the test data. A fine mesh, not a choking model, was used at choking locations to resolve steep pressure gradients. Figure 141 indicates ECC bypass to the broken-loop cold leg. Figure 143 also indicates ECC bypass and shows the average mass density in the broken-loop cold leg. The TRAC-PD2 results did not predict liquid flow in the broken-loop hot leg at ~23 s. Figure 144 shows a

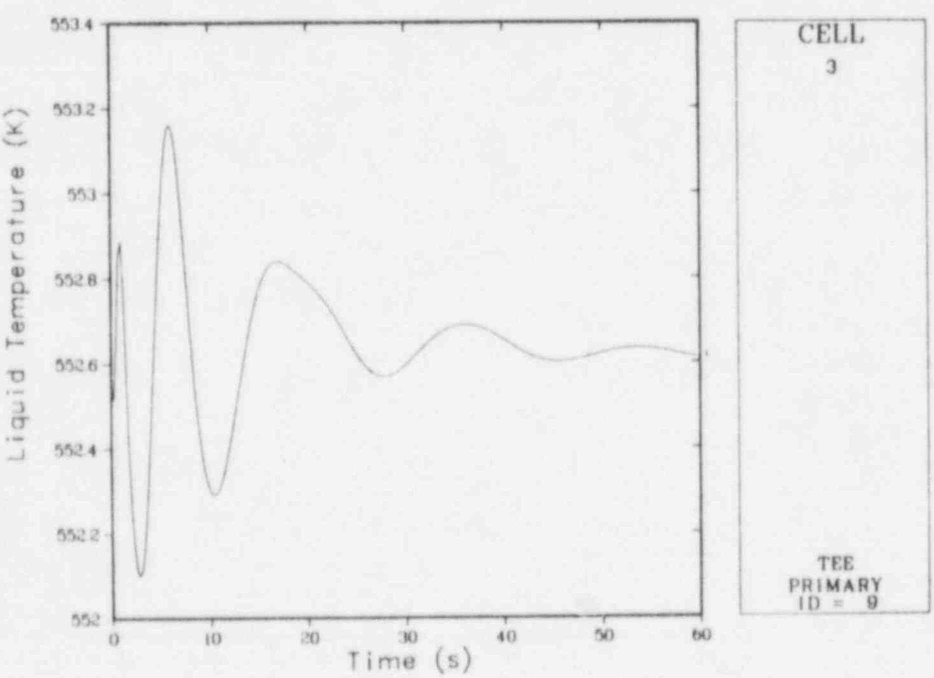


Fig. 139.
LOFT L1-4 steady-state intact-loop liquid temperature.

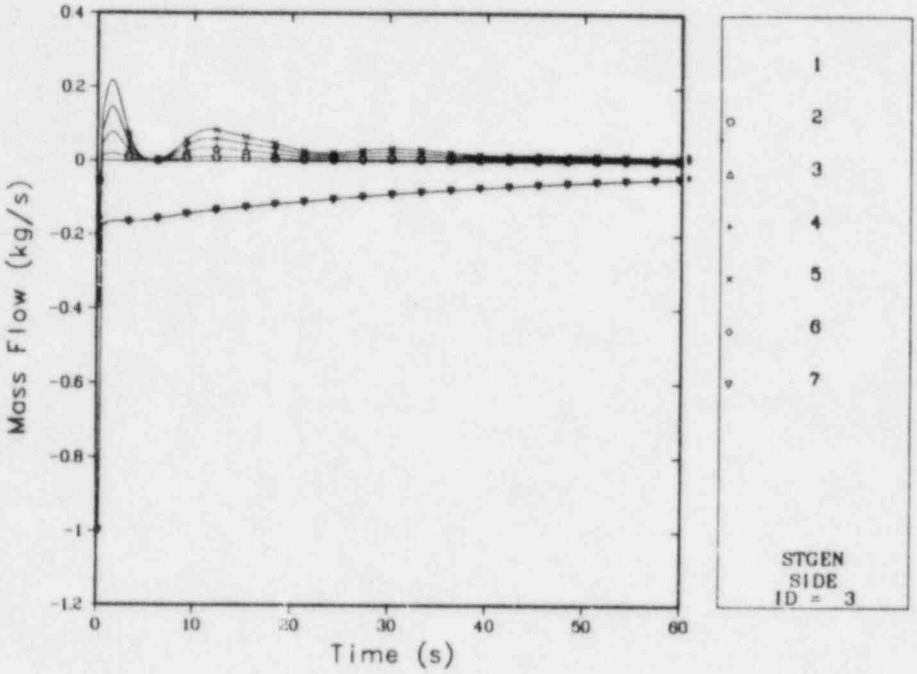


Fig. 140.
Comparison of the LOFT L1-4 steady-state mass flows on the steam-generator secondary side.

TABLE XIII

CALCULATED AND MEASURED INITIAL CONDITIONS FOR LOFT L1-4

Parameters	TRAC-Calculated	Measured
Intact-loop mass-flow rate ($kg \cdot s^{-1}$)	255.4	268.40
Pressurizer pressure (MPa)	15.75	15.75
Pressurizer liquid mass (kg)	435.2	418.80
Pressurizer liquid level (m)	1.17	1.16
Steam-generator primary-side pressure (MPa)	15.72	15.75
Steam-generator primary-side inlet temperature (K)	552.6	554.00
Steam-generator primary-side outlet temperature (K)	552.6	552.00
Steam-generator secondary-side temperature (K)	552.4	552.00
Steam-generator secondary-side pressure (MPa)	6.66	6.65
Core inlet temperature (K)	552.6	552.00
Core outlet temperature (K)	552.6	554.00
Differential pressure in intact loop across primary pumps 1 and 2 (MPa)	0.155	0.140

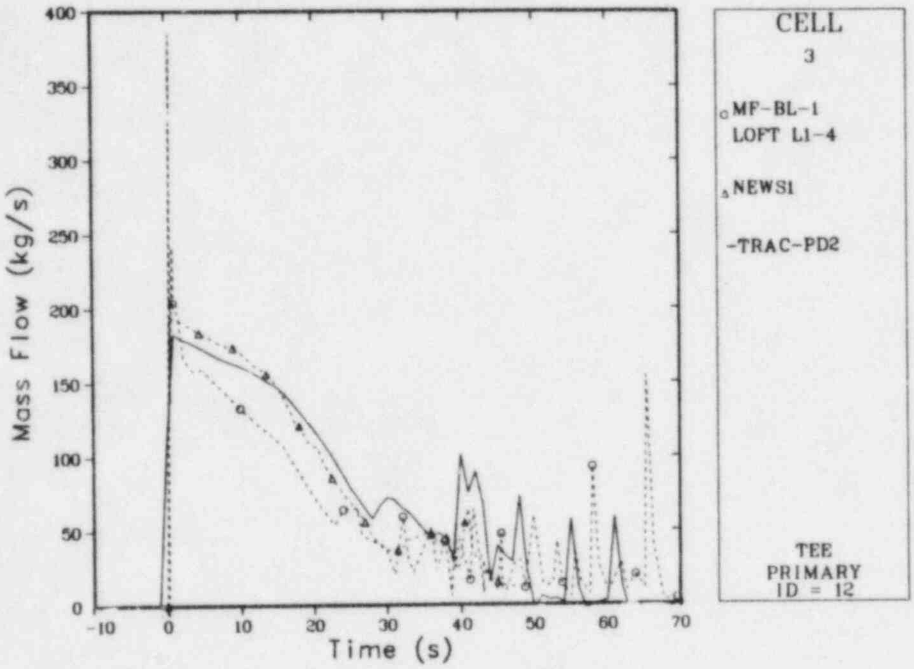


Fig. 141.
Comparison of the TRAC-calculated and measured broken-loop cold-leg mass flows for LOFT L1-4.

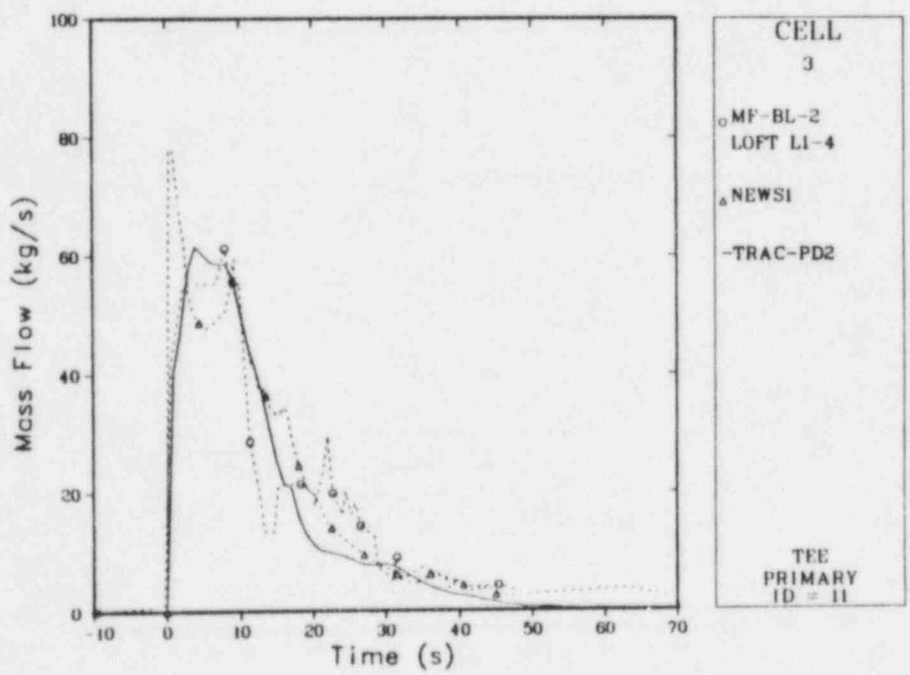


Fig. 142.
Comparison of the TRAC-calculated and measured broken-loop hot-leg mass flows for LOFT L1-4.

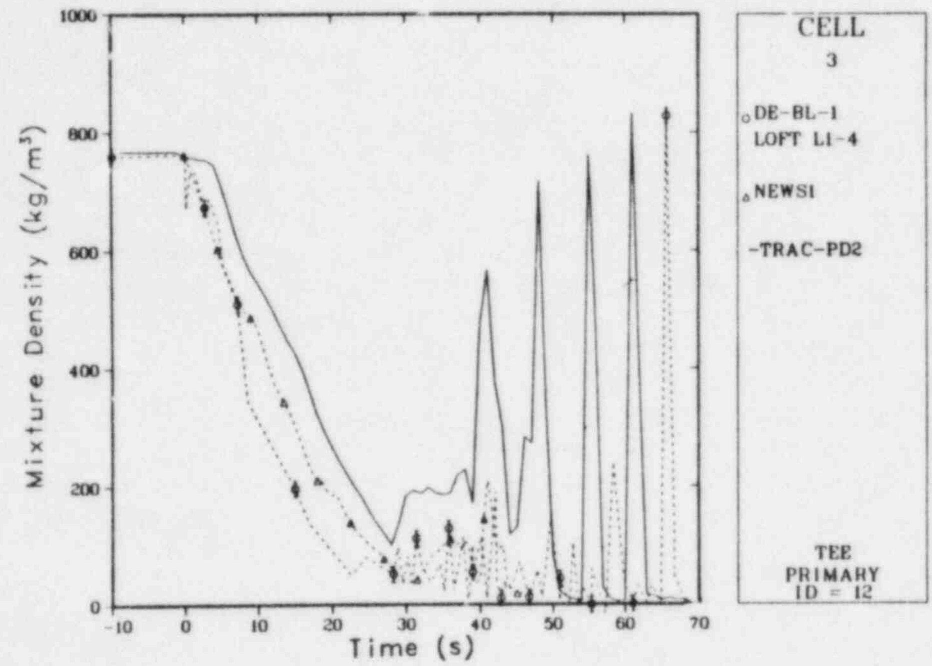


Fig. 143.
Comparison of the TRAC-calculated and measured broken-loop cold-leg average densities for LOFT L1-4.

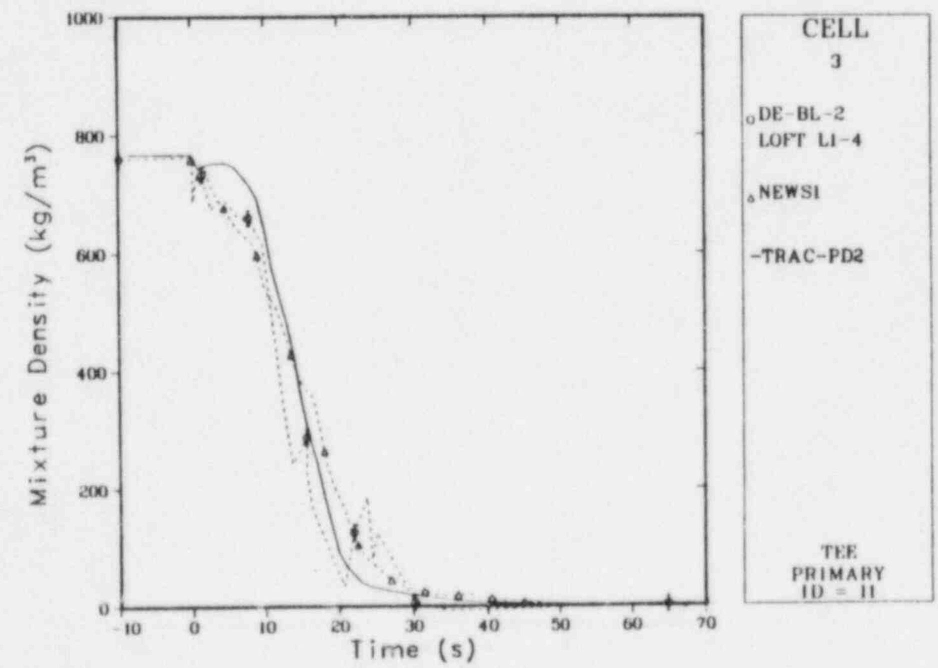


Fig. 144.
Comparison of the TRAC-calculated and measured broken-loop hot-leg average densities for LOFT L1-4.

measured increase in density at this time in the broken-loop hot leg. Figure 145 compares the TRAC-calculated and measured liquid temperatures in the broken-loop cold leg. The data agreed well with the TRAC-PD2 results until 35 s, when the TRAC-calculated pressure (Fig. 146) decreased below the measured value. Because the fluid tended to remain near saturation in this test, the lower calculated liquid temperature was predictable.

Figures 147 and 148 compare the predicted and measured pressures in the pressurizer and intact-loop cold leg. Again, TRAC-PD2 predicted lower pressures later in the transient than measured in the test. A possible cause of these discrepancies might have been the lumped-parameter model used in the VESSEL for structural heat transfer. To keep the heat flux at reasonable levels early in the transient, the effective thickness of the heat slab was limited to 2 cm. However, late in the transient, this thickness resulted in lower heat fluxes, which probably caused the lower pressures and temperatures.

Figure 149 compares the measured and predicted water levels in the pressurizer. The calculation predicted an initial faster voiding but a later retention of some system liquid for a longer period than the experiment showed. An underestimated surge-line flow resistance possibly caused these discrepancies between the calculated and measured results.

Flow resistance in the broken legs was predicted well by TRAC. Figures 150-152 show the differential pressures across the steam-generator simulator, the pump simulator, and the cold-leg break plane, respectively.

Figures 153-155 show that TRAC-PD2 predicted the refilling of the core simulator well. Figures 153 and 154 compare the downcomer liquid levels near the broken- and intact-loop cold legs, respectively. The measurements were

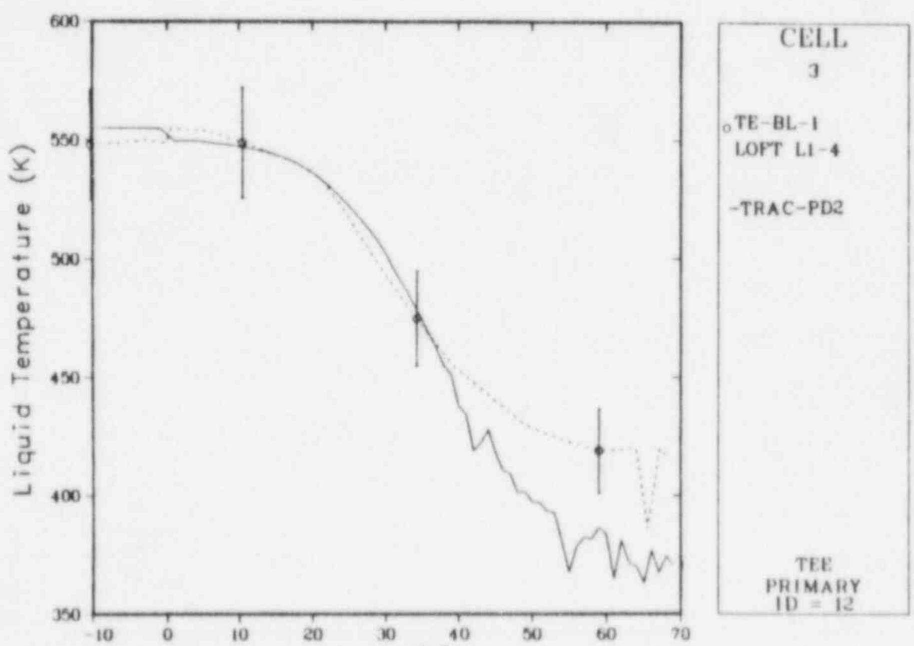


Fig. 145.
Comparison of the TRAC-calculated and measured broken-loop cold-leg liquid temperatures for LOFT L1-4.

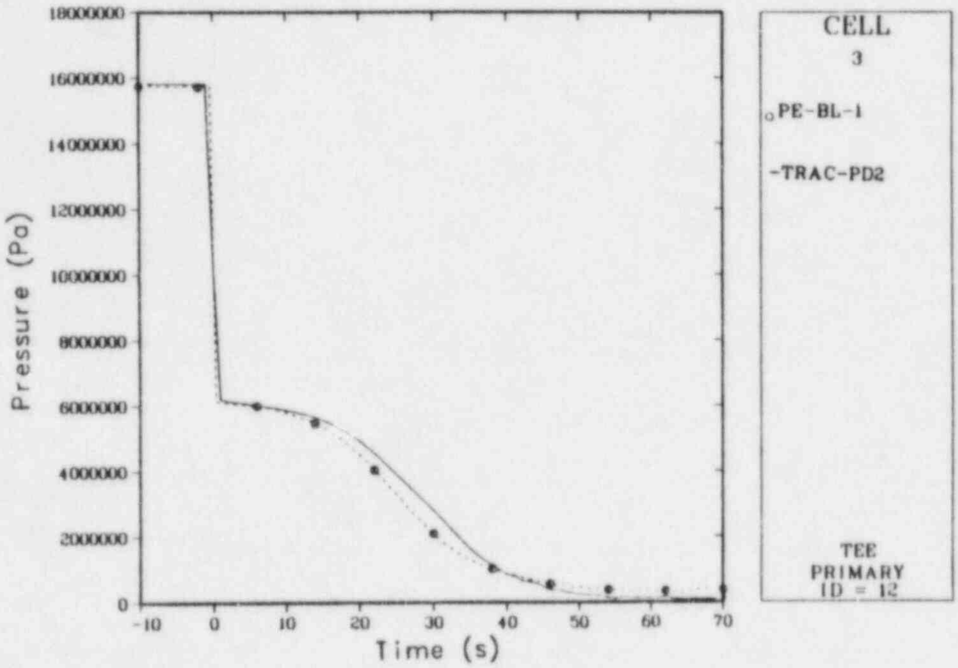


Fig. 146.
Comparison of the TRAC-calculated and measured broken-loop cold-leg pressures for LOFT L1-4.

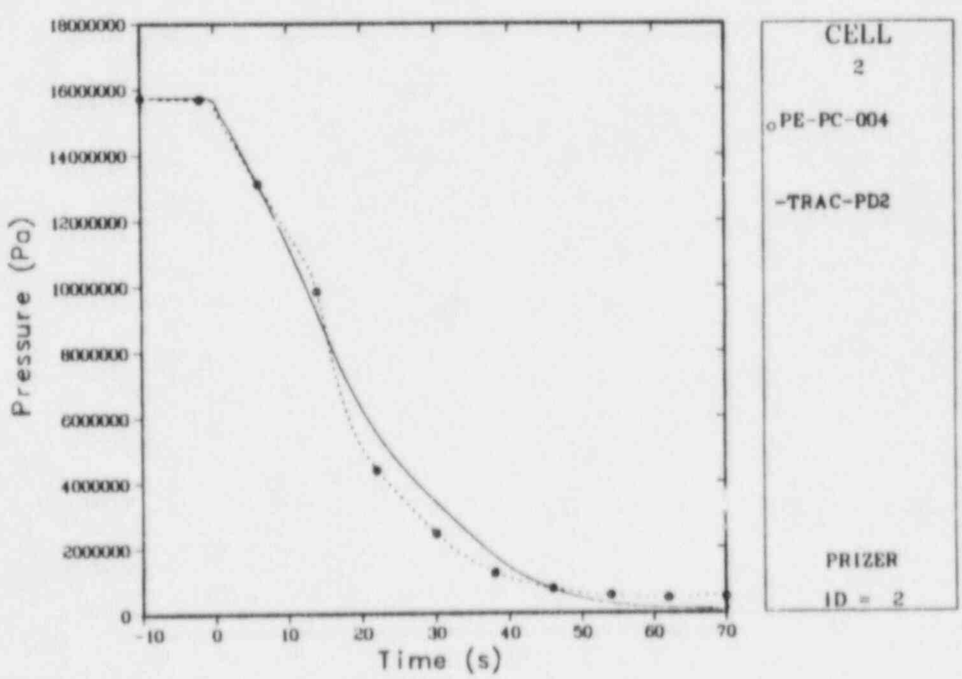


Fig. 147.
Comparison of the TRAC-calculated and measured pressurizer pressures for LOFT L1-4.

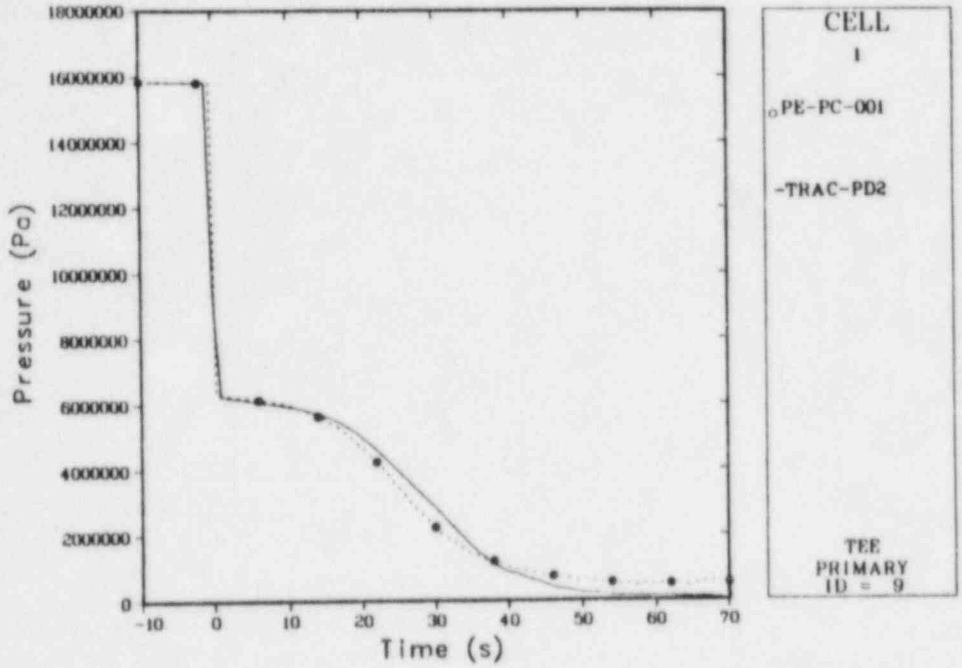


Fig. 148.
Comparison of the TRAC-calculated and measured intact-loop cold-leg pressures for LOFT L1-4.

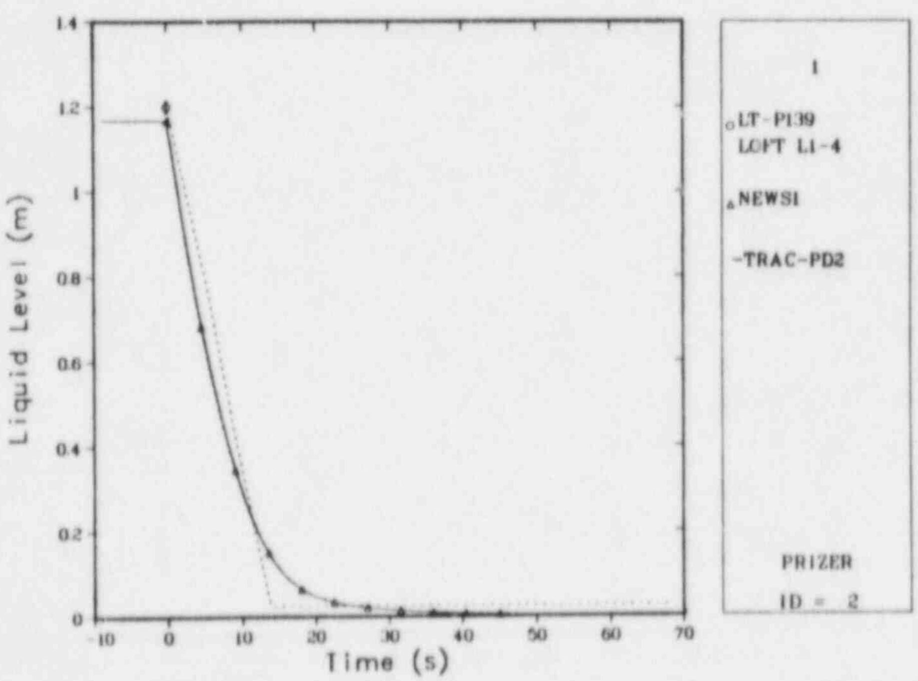


Fig. 149.
Comparison of the TRAC-calculated and measured pressurizer liquid levels for LOFT L1-4.

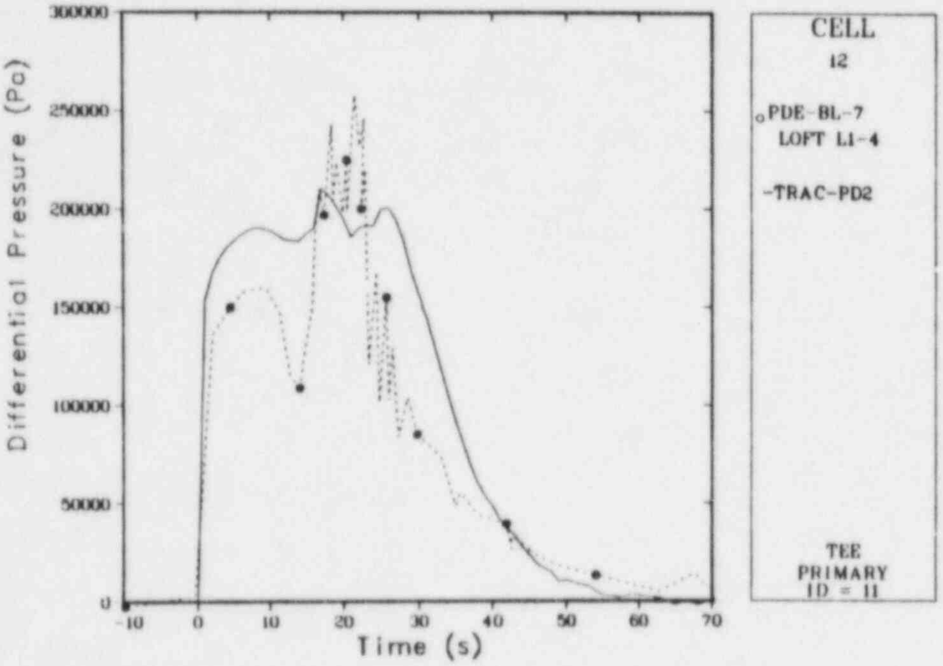


Fig. 150.
Comparison of the TRAC-calculated and measured differential pressures across the steam-generator simulator for LOFT L1-4.

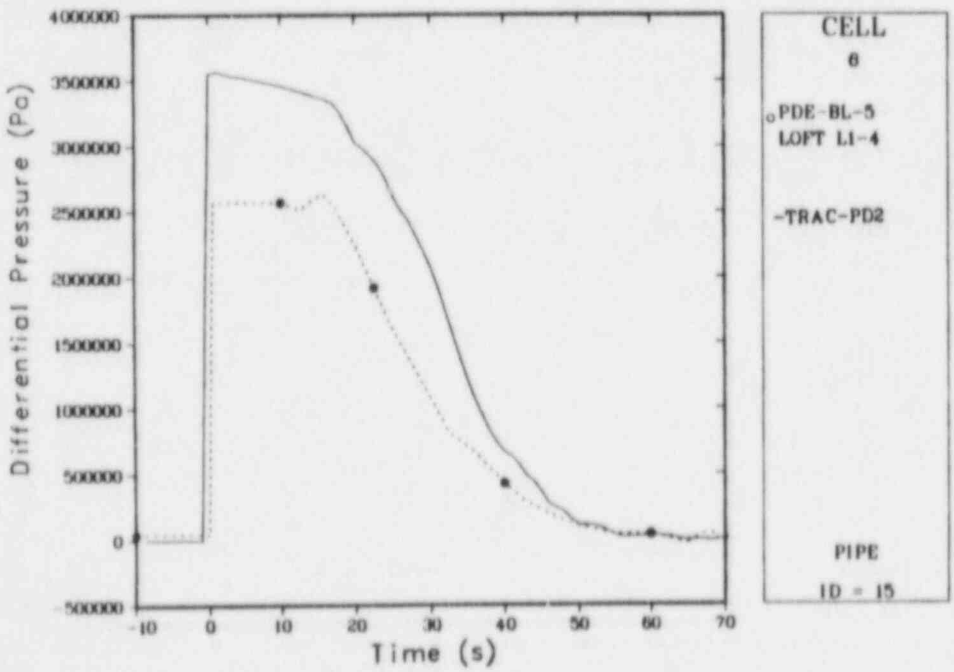


Fig. 151.
Comparison of the TRAC-calculated and measured differential pressures across the pump simulator for LOFT L1-4.

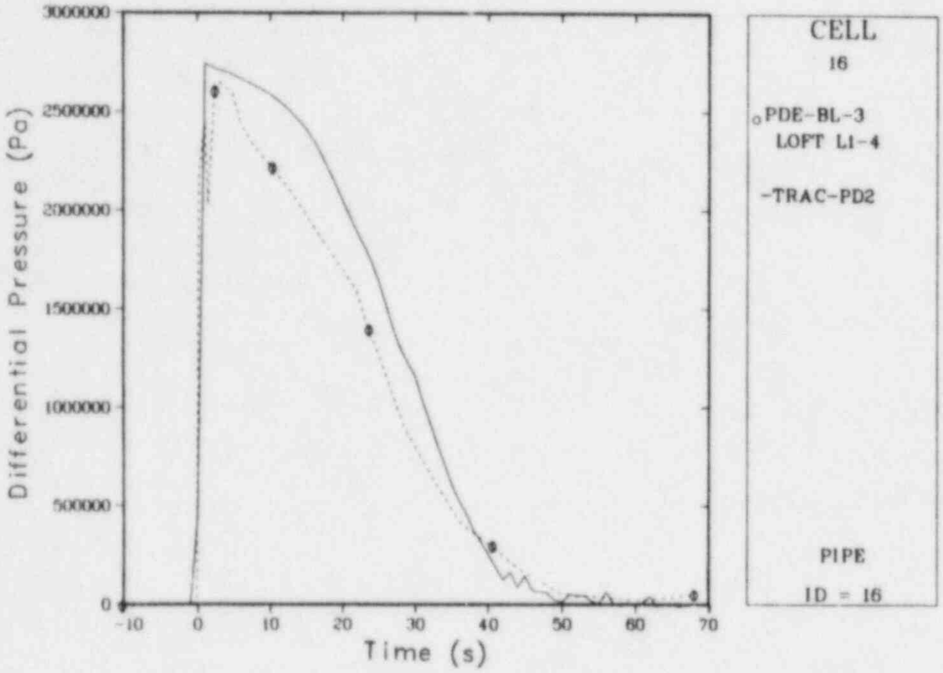


Fig. 152.
Comparison of the TRAC-calculated and measured differential pressures across the cold-leg break plane for LOFT L1-4.

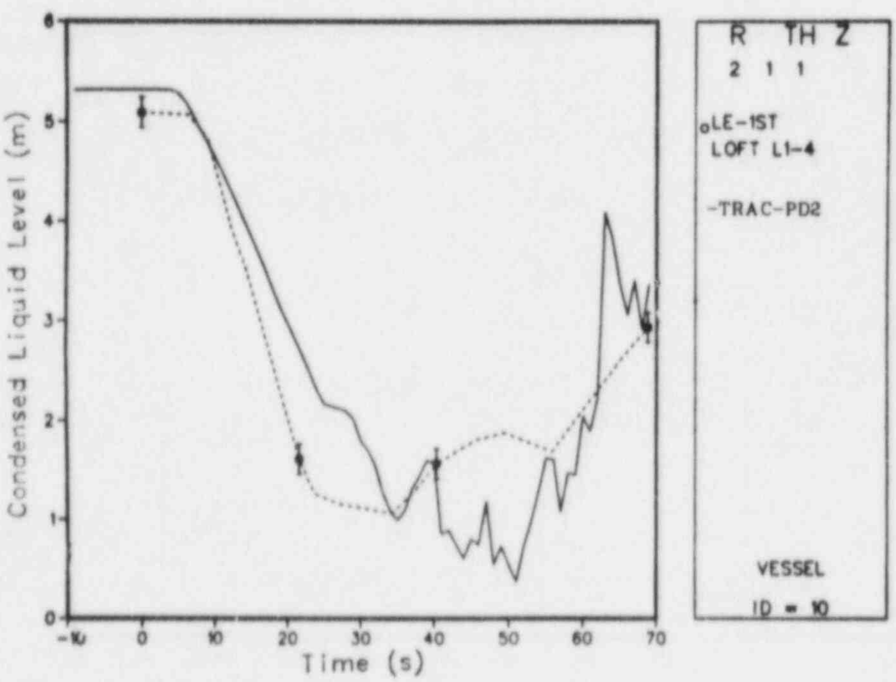


Fig. 153.
Comparison of the TRAC-calculated and measured downcomer liquid levels near the broken-loop cold leg for LOFT L1-4.

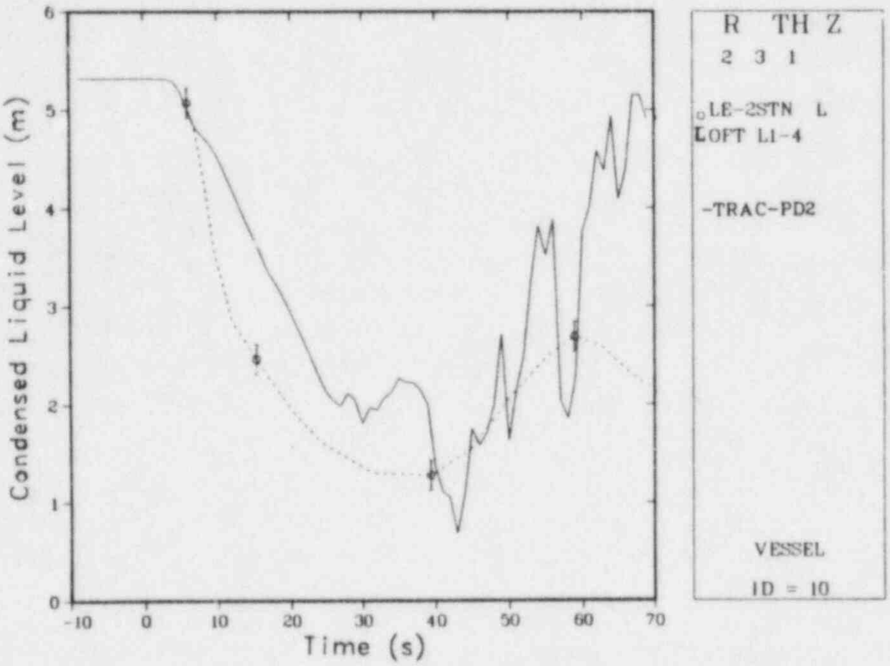


Fig. 154.
Comparison of the TRAC-calculated and measured downcomer liquid levels near the intact-loop cold leg for LOFT L1-4.

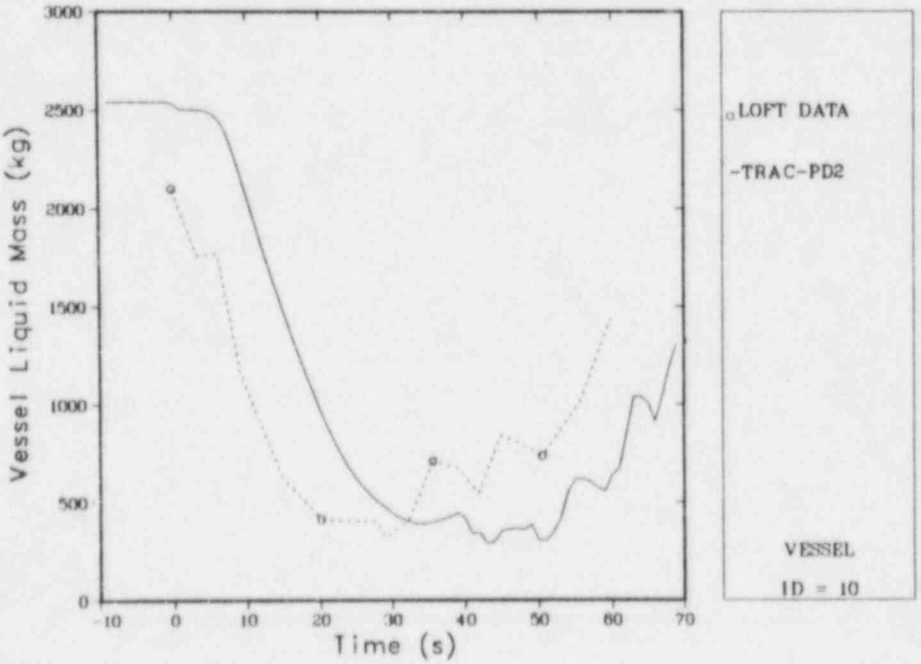


Fig. 155.
Comparison of the TRAC-calculated and measured vessel liquid mass inventories for LOFT L1-4.

performed with conductivity probes and, therefore, were subjective. Figure 155 compares the TRAC-calculated and measured total vessel liquid mass inventories. Data for Fig. 155 were obtained from the LOFT L1-4 quick-look report.[23]

D. Parametric Studies

To test the hypothesis that reduced heat-slab thickness accounted for the observed lower pressures and temperatures late in the L1-4 blowdown, we performed a calculation with the correct structural mass. (In some cells this mass was an order of magnitude greater than that used in the best-estimate model.) The calculated pressures were substantially higher than the test values; therefore, we concluded that this reduced thickness probably caused the differences in pressure between the TRAC results and the test data late in the transient.

E. TRAC-PD2 Features Tested

The LOFT L1-4 experiment assessed the ability of TRAC-PD2 to represent the geometry of a PWR system under blowdown and ECC injection conditions. The fuel-rod heat-transfer and reflood models were not used to analyze this experiment.

The generally good agreement between the TRAC-PD2 results and the experiment increased our confidence that TRAC can analyze PWR blowdown accidents and ECC injection well. However, the inability of the lumped-parameter heat-slab model to represent the time history of energy added to the system from structural materials in the VESSEL is a shortcoming in the TRAC code.

F. Input Data Decks

Appendix J lists the steady-state and transient input decks for LOFT L1-4. The transient includes the L1-4 blowdown and refill. All component data were retrieved from the dump at the end of the steady-state calculation.

The CPU times on a CDC 7600 were 6.2 min for the 60-s steady-state calculation and 168.5 min for the 70-s transient calculation.

XIII. LOFT NUCLEAR EXPERIMENT L2-2

A. Experiment Description

Test L2-2 (Ref. 24) not only was the first test in the LOFT power-ascension test series but also was the first nuclear-power test in the LOFT facility. The test was run at 50% maximum power (26.25-kW · m^{-1} maximum linear heat generation) and simulated a 200% double-ended cold-leg-break LOCA. Test L2-2 differed from Test L1-4 in that it had a nuclear core at power and, consequently, had a core ΔT of ~23 K at blowdown initiation. The purpose of Test L2-2 was to investigate the behavior of the LOFT system during blowdown, refill, and reflood under these conditions.

The LOFT nuclear core contained 1300 unpressurized fuel rods arranged in five-square and four-triangular fuel modules (Fig. 156). The rods had an active 1.68-m length and an 0.0107-m o.d. The core had thermocouples externally mounted on selected fuel rods and self-powered neutron detectors. Figure 156 designates the instrumented rods.

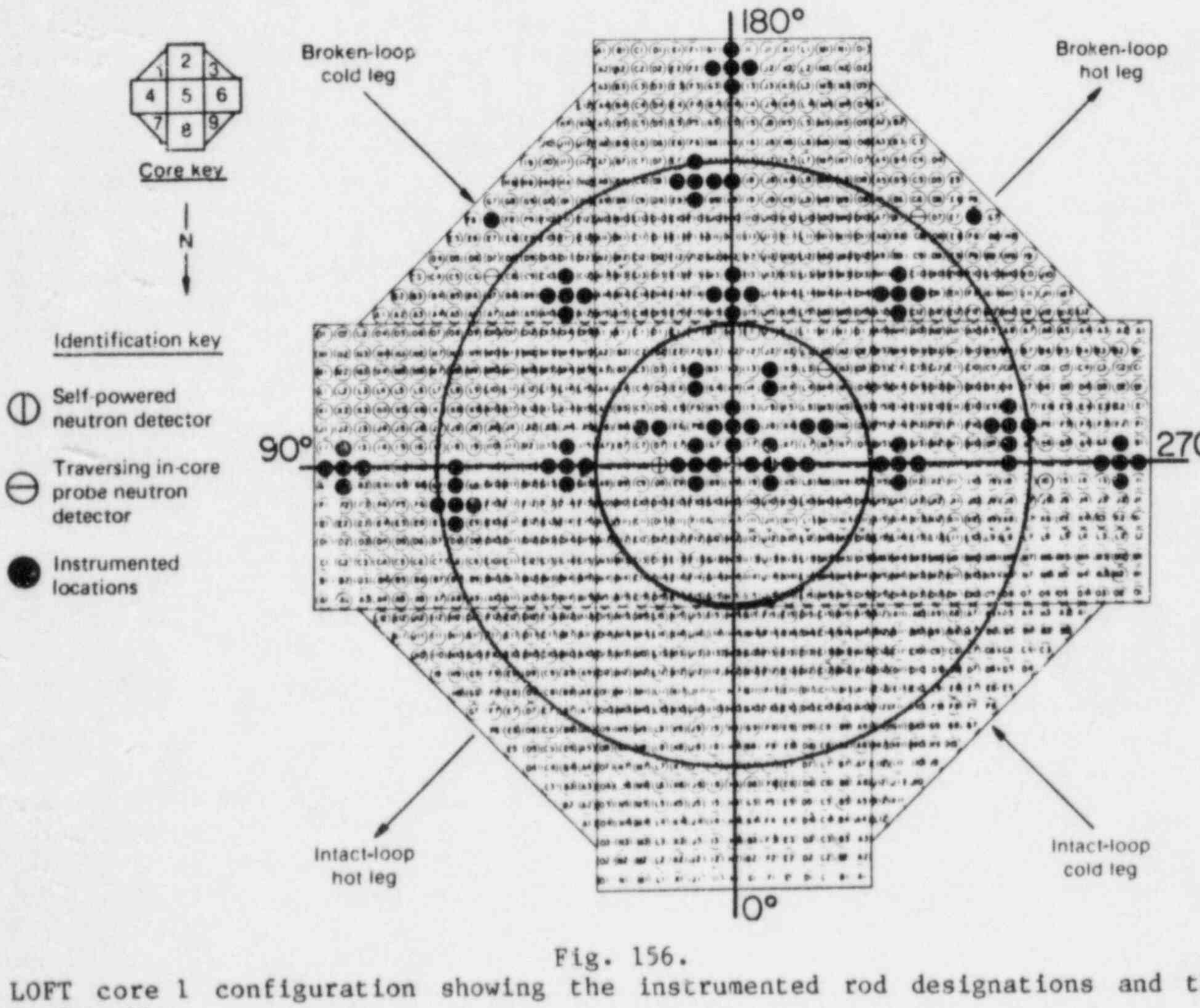


Fig. 156.
LOFT core 1 configuration showing the instrumented rod designations and the TRAC noding.

The sections outside of the core were not modified between Tests L1-4 and L2-2; however, instrumentation was added to some of the external pipes.

At the start of Test L2-2, the intact-loop mass flow was 194.2 kg $\cdot$ s^{-1}, the steam control valves were closed, and the control rods were inserted into the core. The resulting power transient followed the predicted decay curve. The pressurizer heaters were not energized during this test. The fuel-rod temperatures were especially important. During Test L2-2, the rod-surface temperatures were expected to go through DNB, and this proved to be the case. The surprising test result was how quickly all the fuel rods were rewet after DNB. Before the test, rewet was expected to occur during reflood, at least in the high-power section of the core; however, the test showed that all the rods rewet during the blowdown phase. Consequently, the maximum cladding temperature in this experiment was considerably below the predictions.

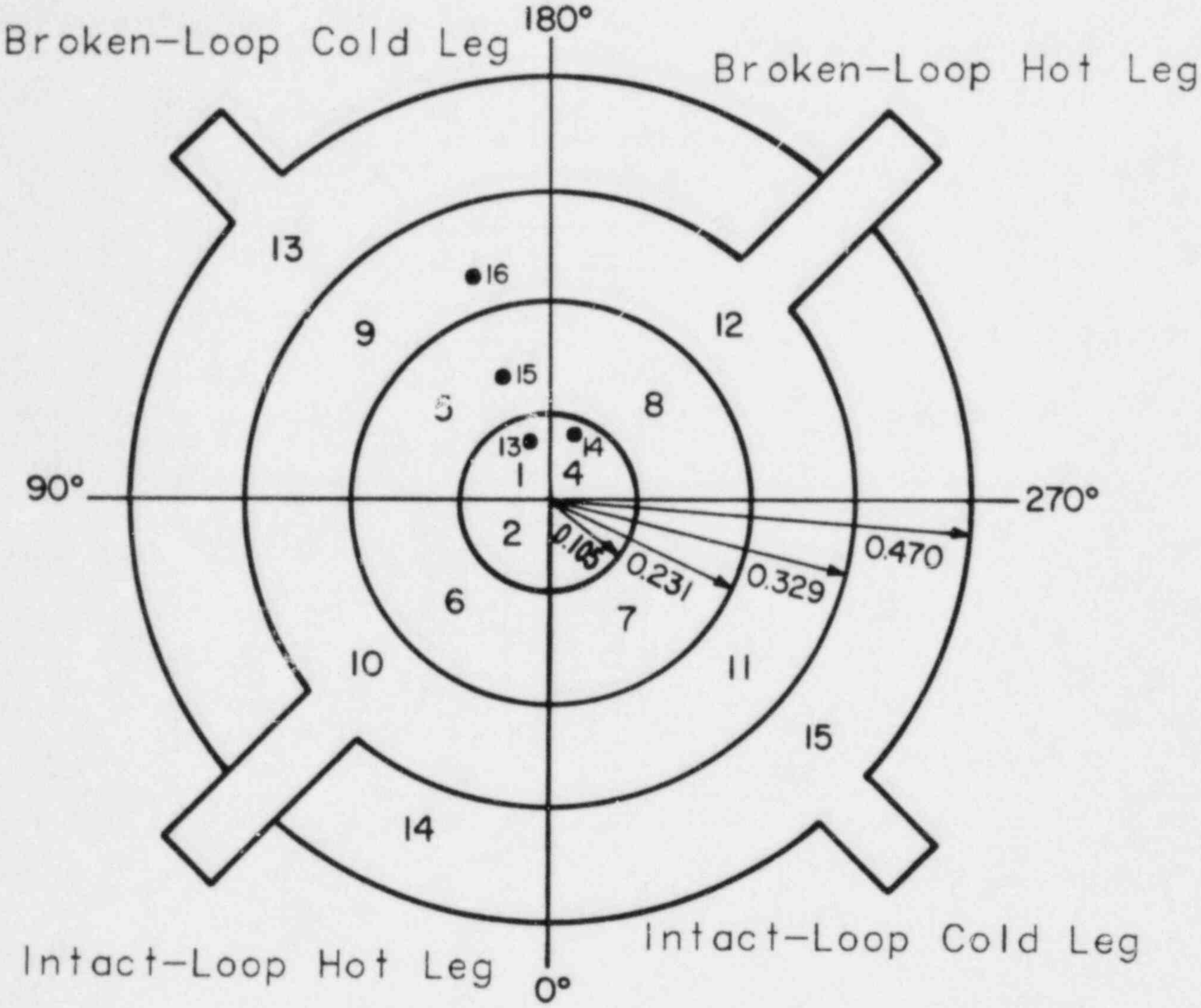
B. TRAC-PD2 Model

The TRAC-PD2 model for Test L2-2 was similar to that used for Test L1-4 except for the VESSEL noding. The HPIS and LPIS FILLs were reversed from those in the L1-4 model; that is, component 24 was the LPIS and component 25 was the HPIS for Test L2-2. The broken legs were modeled with single TEEs, components 15 and 16, rather than the combination of TEEs and PIPEs used in Test L1-4. Figures 157 and 158 show the L2-2 VESSEL noding. The radial subdivisions of the core region were selected to approximate the three regions of the LOFT power distribution. As shown in Fig. 156, the innermost radial region corresponded to the central fuel bundle; the second, to the middle power region; and the third, to the outer, low-power region. In addition to the average-power rods required by TRAC, the L2-2 model also included auxiliary rods that modeled specific instrumented rods. Figure 157 shows these auxiliary rods and their peaking factors. Note that some instrumented rods had peaking factors below 1.

The axial VESSEL division (Fig. 158) was similar to that used for Test L1-4, except that it included finer noding in the core region (levels 4-8). These levels were chosen to allow representation of the LOFT rod axial power profile. Figure 159 compares the TRAC-PD2 axial power profile with the L2-2 test profile and shows the noding used in the core conduction calculation before reflood.

There was considerable uncertainty about the state of the fuel pellets before the test began. This uncertainty arose because it was difficult to account for the fuel-pin behavior during the power variations that preceded the test. We studied this uncertainty effect by conducting a parametric study that used varying fuel radial geometries. Figure 160 shows the base-case fuel radial noding. The geometric variations were made by changing only the location of the fuel-pellet surface. The interior nodes and the cladding geometry were not changed.

The ECCS for Test L2-2 was modeled by an accumulator (ACCUM), a VALVE, two TEES, and two FILLs. The VALVE controlled the ACCUM flow. The VALVE was programmed to open instantaneously when the local pressure fell below 42.2 bar. The HPIS and LPIS were modeled with FILLs. The HPIS FILL started to inject at 1.58×10^{-3} m^3 $\cdot$ s^{-1}, 3 s after the pressurizer level fell below 0.23 m. The LPIS model was a pressure-dependent FILL that had a zero-flow rate for local pressures above 15.2 bar.



Rod Number	Rod Peaking Factor
13	1.064
14	1.064
15	1.151
16	0.592

Fig. 157.
LOFT L2-2 VESSEL noding diagram (level 11) and rod locations.

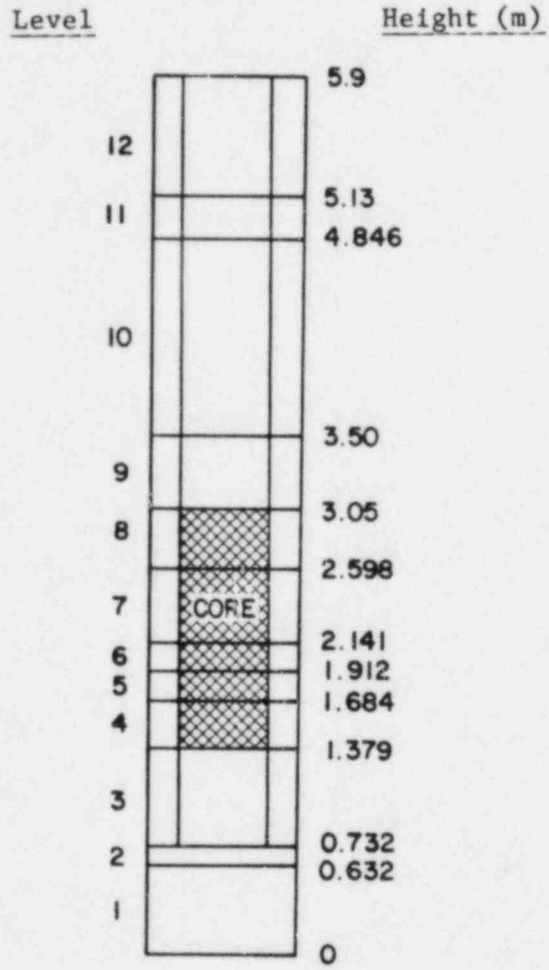


Fig. 158.
LOFT L2-2 VESSEL axial noding diagram.

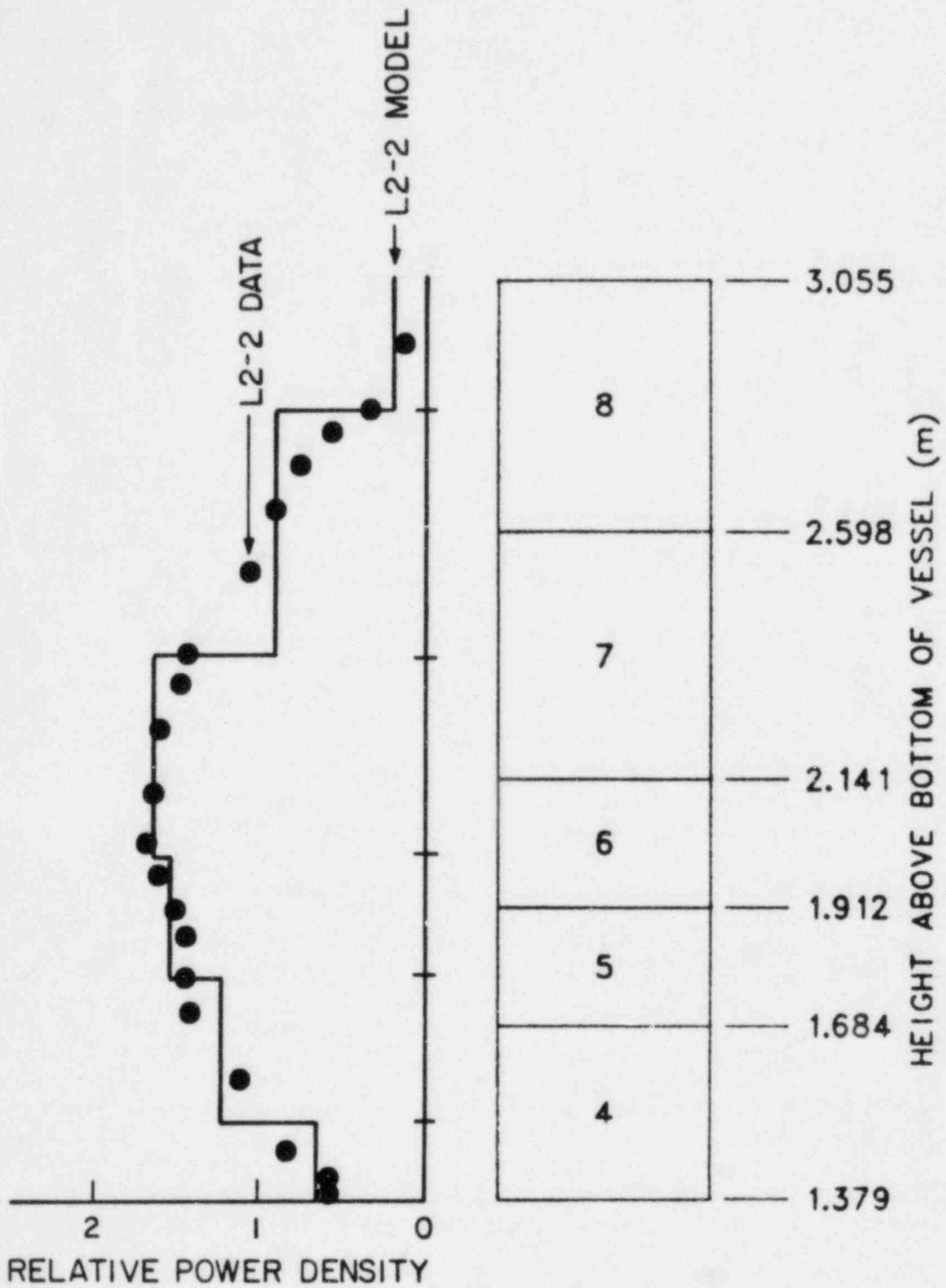


Fig. 159.
LOFT L2-2 core axial noding diagram and power profile.

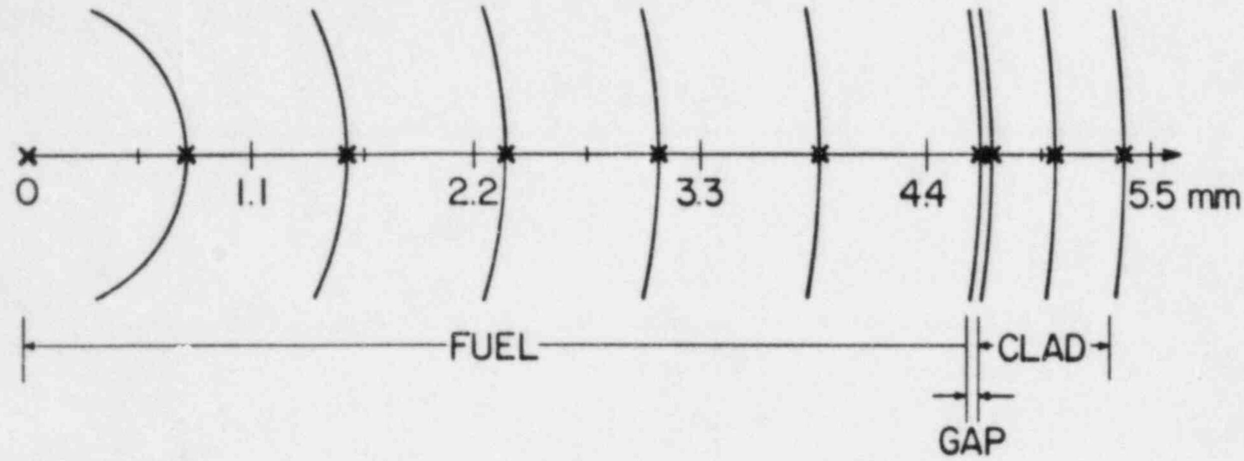


Fig. 160.
LOFT L2-2 fuel-rod radial noding diagram.

C. TRAC-Calculated Results

1. Steady-State Results. The base-case calculation for Test L2-2 was performed in two stages. The steady-state calculation used the generalized steady-state option. The transient began from the resulting dump. Figures 161-171 display the calculated steady-state results for the important parameters. These figures show that the steady-state solution was approximated closely after 30 s. However, convergence did not occur in the 55.7-s calculation because there were mass balance problems on the steam-generator secondary side (Fig. 169). Table XIV compares the steady-state TRAC-calculated results and the test measurements. Closer agreement could have been obtained by adjusting the pump speeds and the steam-generator secondary-side conditions, but the accuracy achieved was sufficient for this large-break loss-of-coolant experiment (LOCE). The differences between the calculated and measured maximum heat-generation rates and the maximum cladding temperatures did not indicate disagreement necessarily between the experiment and the calculation. The heat-generation rates differed because we averaged the nodes in the calculation and the measured peak cladding temperature reflected only thermocouple locations.

The CPU time for the first 30 s of the steady-state calculation was 20.7 min, whereas the CPU time for the complete 55.7-s calculation was 28.3 min. The average time step for the calculation was 22 ms. The problem required 94203 words of LCM and a maximum SCM dynamic area of 7278 words.

2. Transient Results. We divided the calculated transient results into two sections, fluid and rod temperature, to make the information more understandable. The test results in this section were retrieved primarily from tapes provided by the NRC Reactor Safety Research Data Bank at EG&G Idaho, Inc. The data retrieval and error estimation, based on Table XXXVI in Ref. 25, were performed automatically to prevent mistakes.

The 69-s transient calculation required 5.5 h of CPU time on a CDC 7600, used an average 5.8-ms time step, and accessed the same memory as the steady-state calculation. Table XV lists statistics for subsections of the calculation. The code encountered some water-packing problems and occasional convergence problems that required smaller time-step sizes; however, these

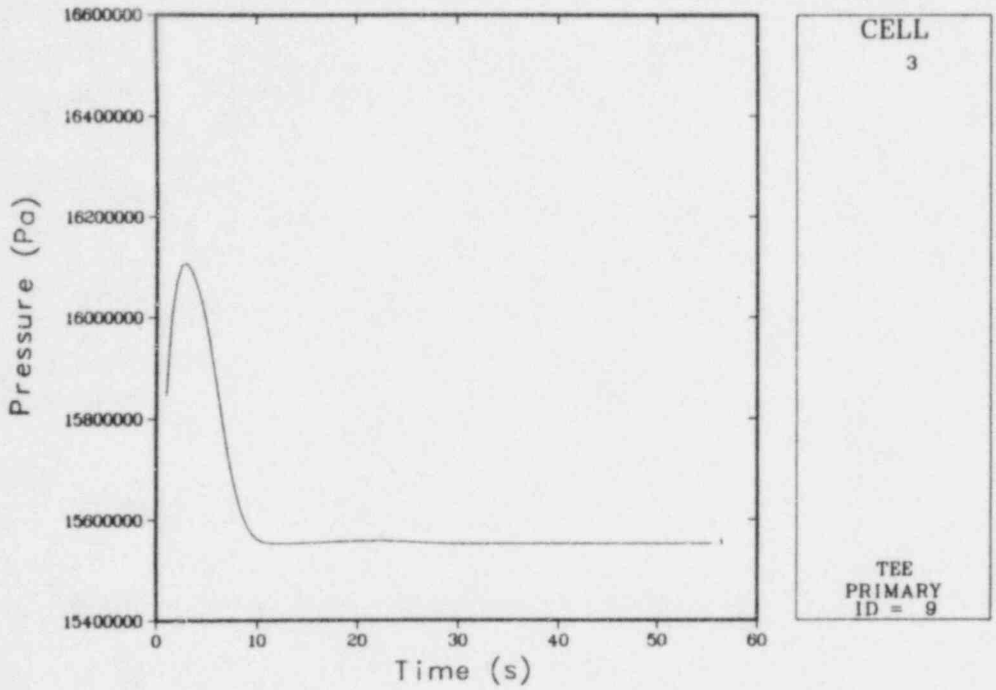


Fig. 161.
LOFT L2-2 steady-state pressure in the intact-loop cold leg.

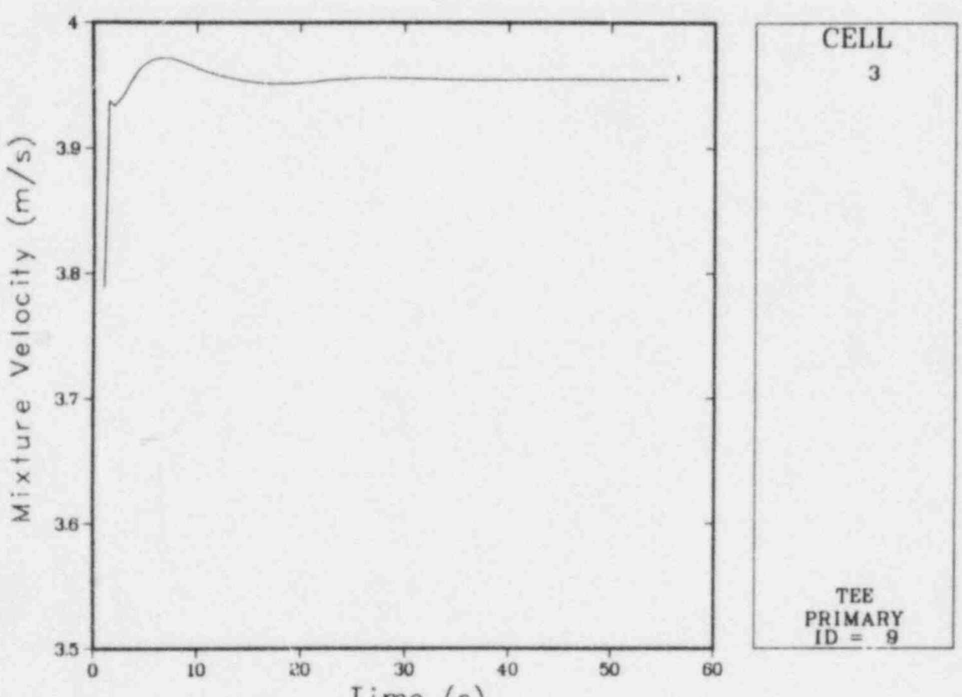


Fig. 162.
LOFT L2-2 steady-state mixture velocity in the intact-loop cold leg.

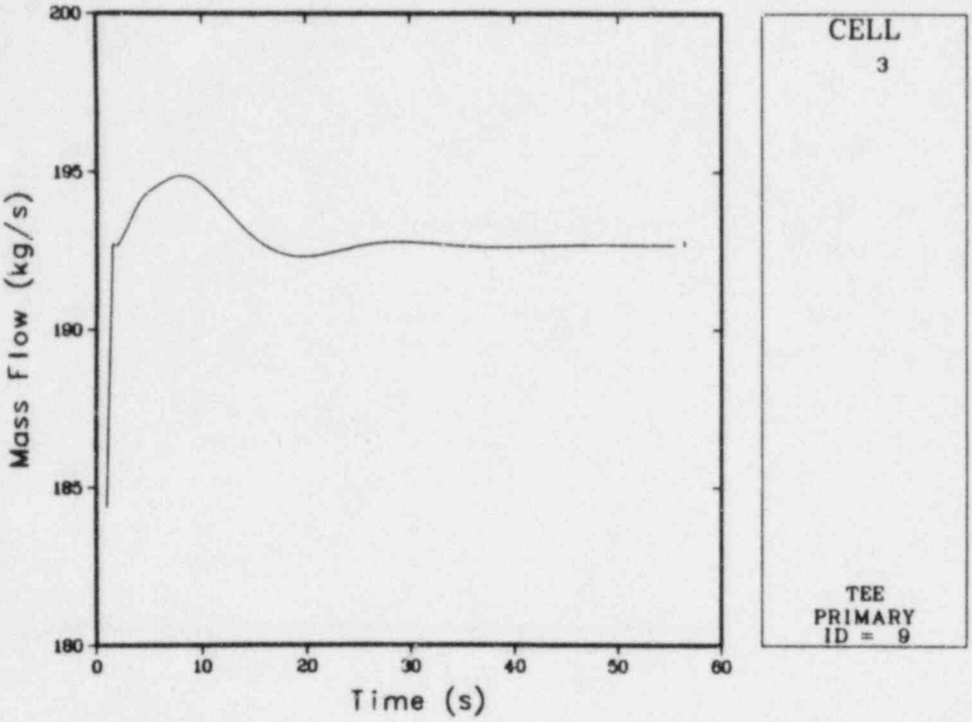


Fig. 163.
LOFT L2-2 steady-state mass flow in the intact-loop cold leg.

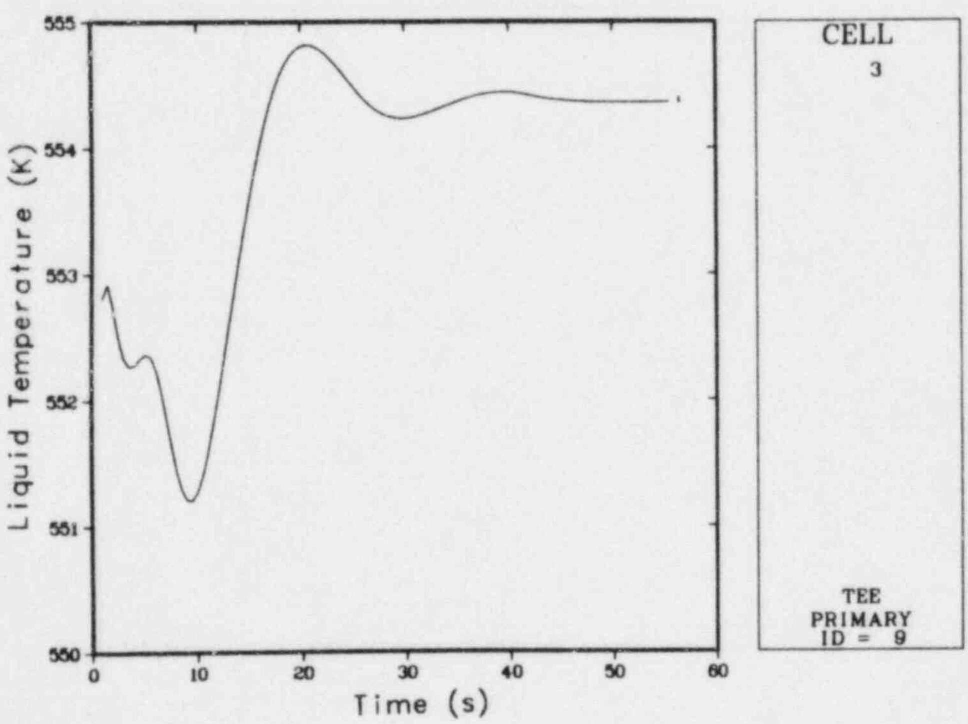


Fig. 164.
LOFT L2-2 steady-state liquid temperature in the intact-loop cold leg.

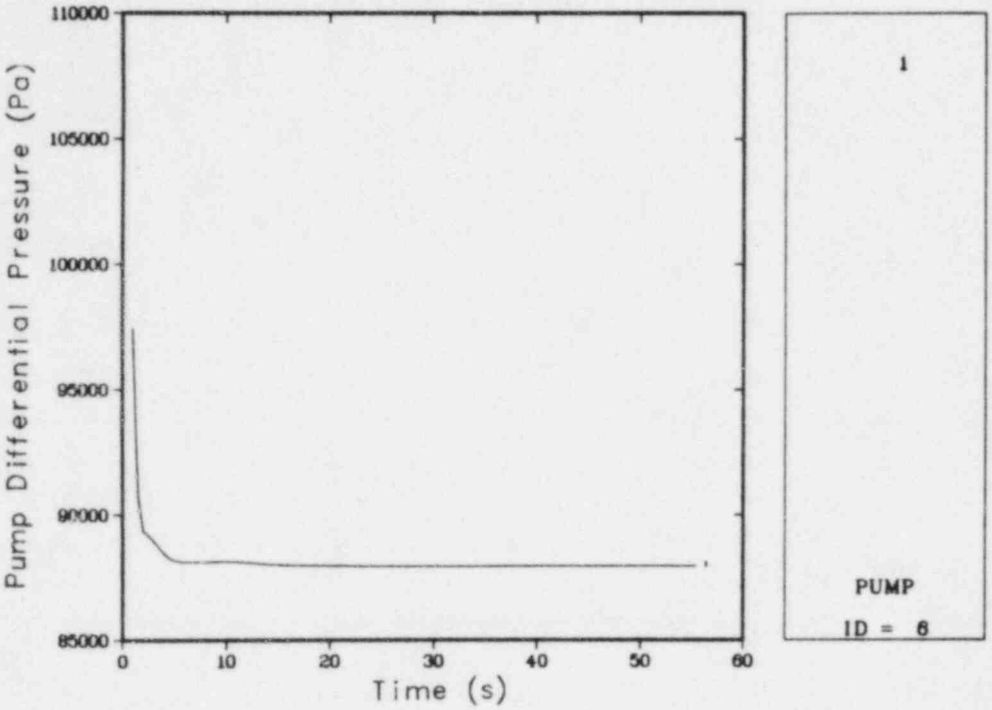


Fig. 165.
LOFT L2-2 steady-state pressure differential across pump 6.

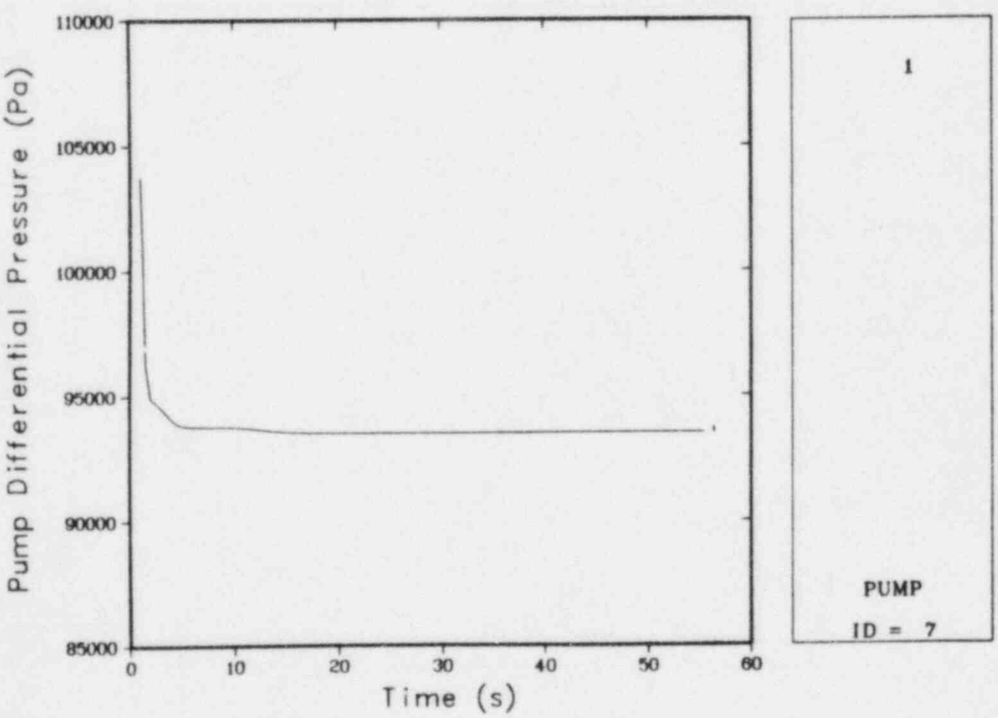


Fig. 166.
LOFT L2-2 steady-state pressure differential across pump 7.

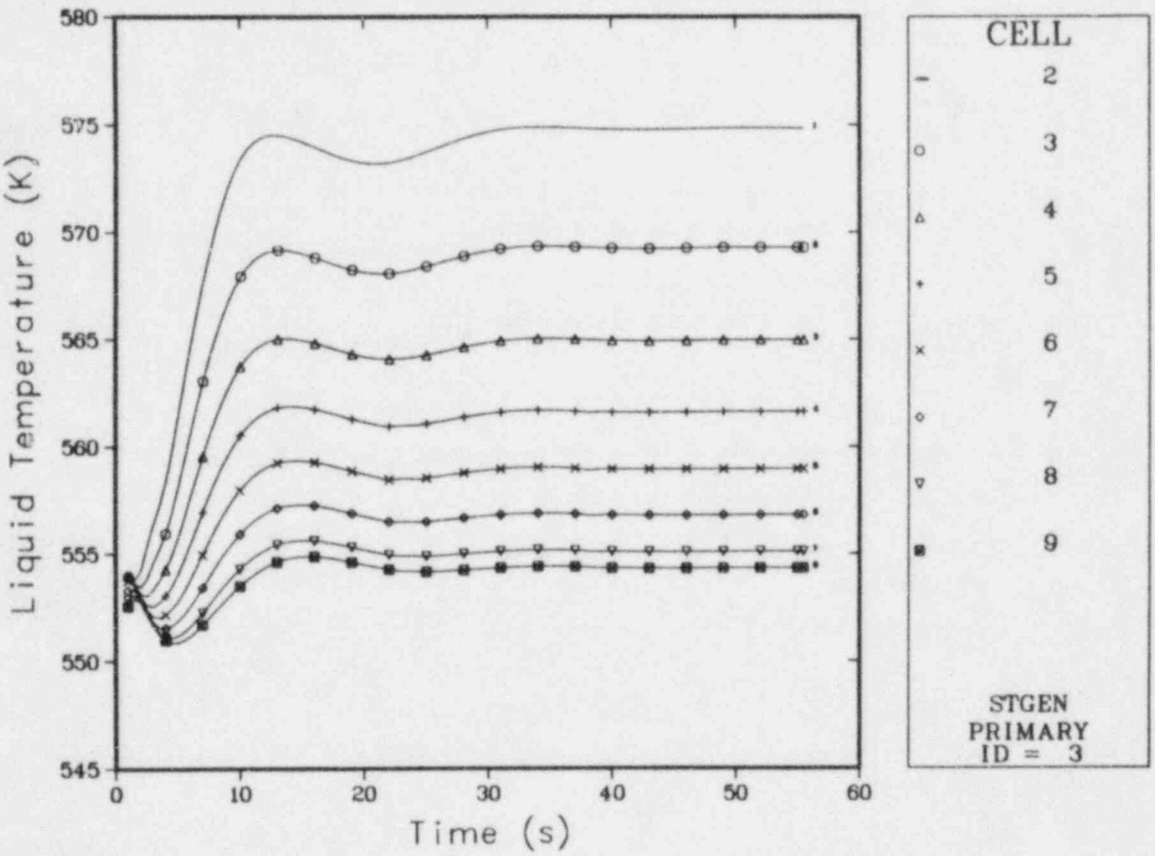


Fig. 167.
LOFT L2-2 steady-state steam-generator primary-side liquid temperatures.

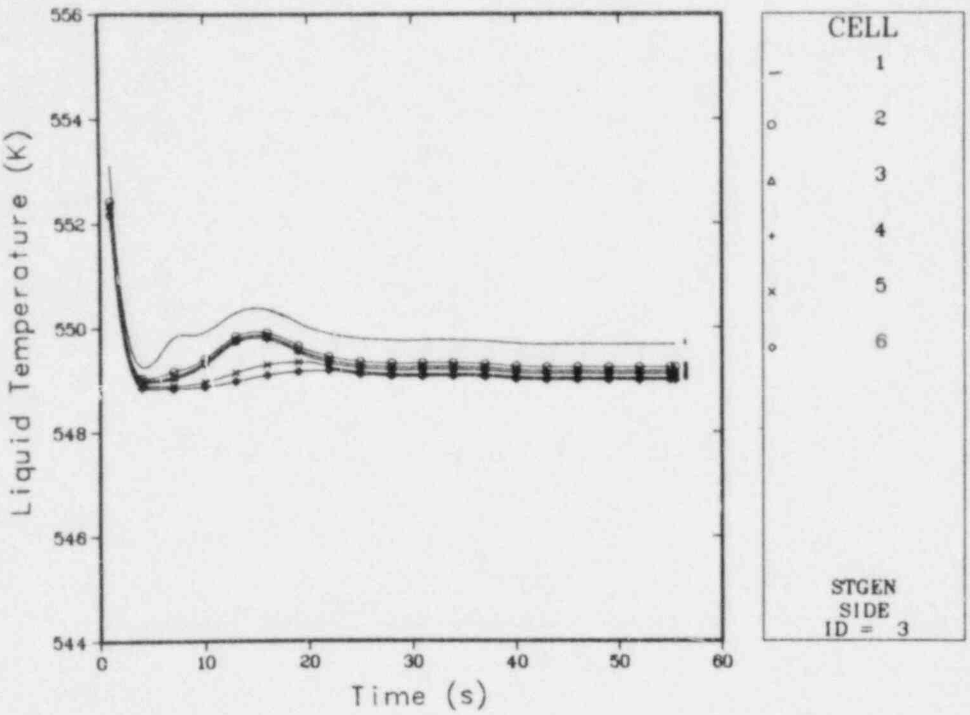


Fig. 168.
LOFT L2-2 steady-state steam-generator secondary-side liquid temperatures.

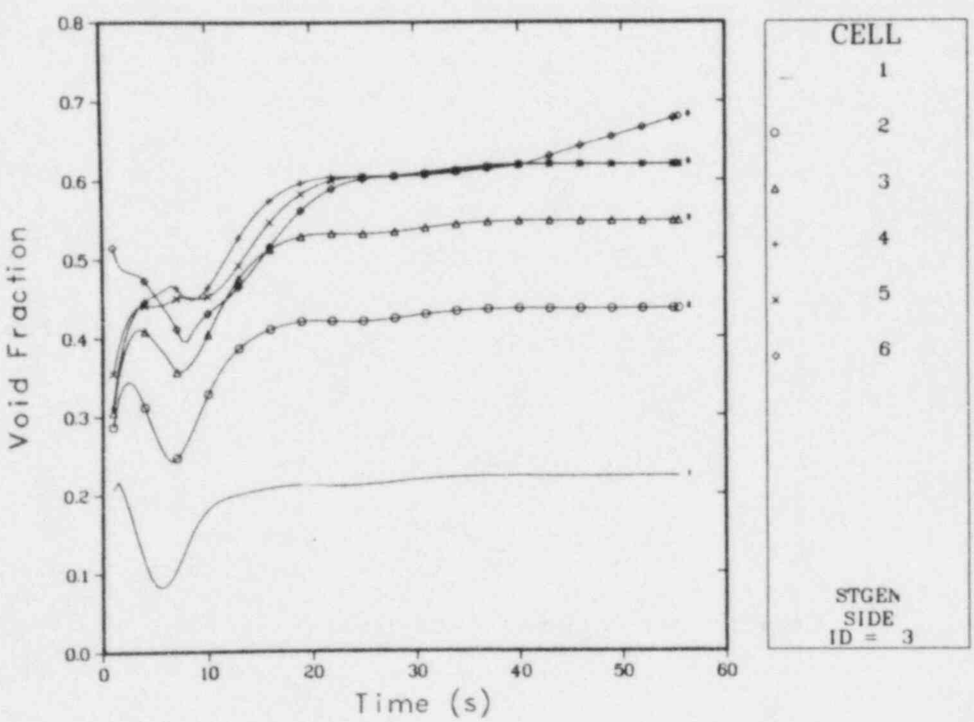


Fig. 169.
LOFT L2-2 steady-state steam-generator secondary-side void fractions.

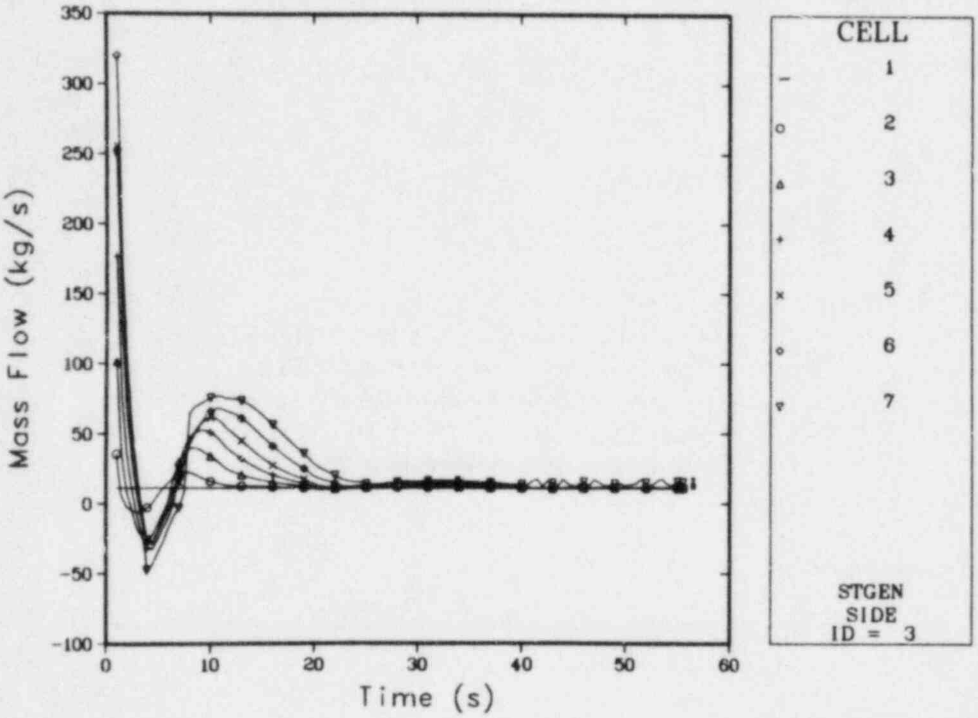


Fig. 170.
LOFT L2-2 steady-state steam-generator secondary-side mass flows.

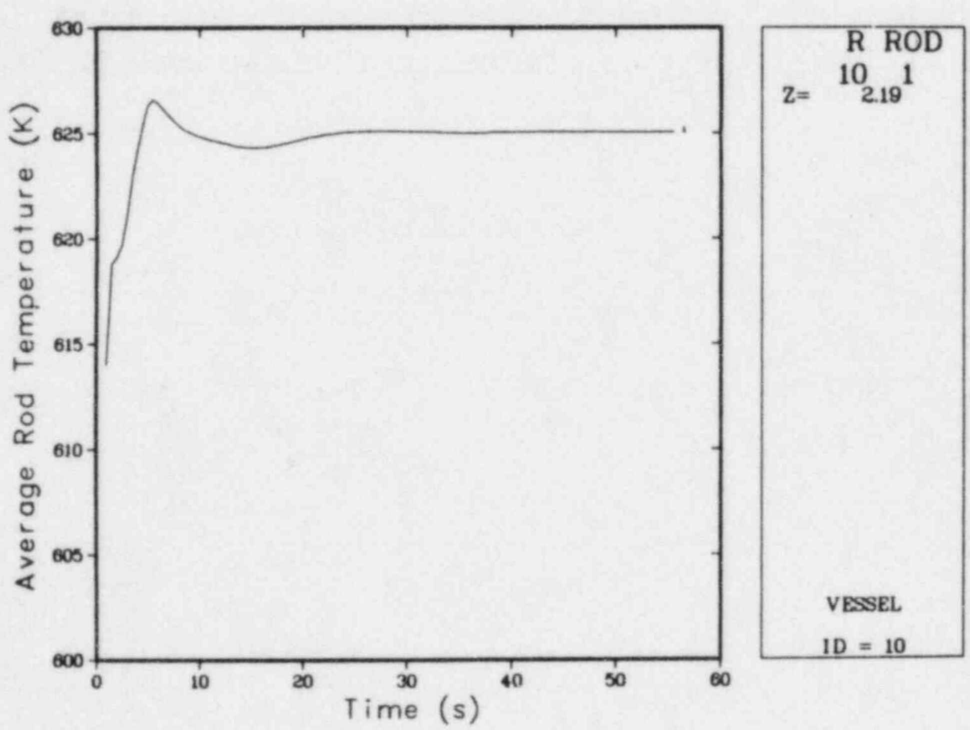


Fig. 171.
LOFT L2-2 steady-state fuel-rod cladding-surface temperatures.

TABLE XIV

CALCULATED AND MEASURED INITIAL CONDITIONS FOR LOFT L2-2

Parameters	TRAC-Calculated	Measured
Intact-loop mass flow rate ($kg \cdot s^{-1}$)	192.7	194.2
Pressurizer pressure (MPa)	15.5	15.6
Pressurizer liquid level (m)	1.10	1.09
Steam-generator primary-side inlet temperature (K)	578.7	580.4
Steam-generator primary-side outlet temperature (K)	554.3	557.7
Steam-generator secondary-side temperature (K)	549	553
Steam-generator secondary-side inlet mass flow ($kg \cdot s^{-1}$)	11.2	12.7
Steam-generator secondary-side outlet mass flow ($kg \cdot s^{-1}$)	14.7	12.7
Intact-loop differential pressure across primary pump 6 (kPa)	88.0	88.0
Intact-loop differential pressure across primary pump 7 (kPa)	94.0	93.0
Core power (MW)	24.88	24.88
Maximum linear heat-generation rate ($kW \cdot m^{-1}$)	23.76	26.37
Maximum cladding temperature (K)	626.5	610[a]
Accumulator pressure (MPa)	4.11	4.11
Accumulator temperature (K)	300.8	300.8

[a]The temperature was affected by its location in the thermal boundary layer on the rod.

TABLE XV

LOFT L2-2 STATISTICS

Time Period (s)	Number of Time Steps	CPU Time (s)	Final Time-Step Size (ms)	Average Time-Step Size (ms)	CPU Time/ Time Step (s)
0 → 15.	2853	3395	1.85	4.42	1.19
15. → 38.8	2585	3572	7.10	9.21	1.38
38.8 → 47.6	1809	3680	2.04	4.86	2.03
47.6 → 52.0	1590	3709	4.42	2.77	2.33
52.0 → 55.3	949	1922	2.97	3.48	2.03
55.3 → 69.0	2210	3628	20.0	6.20	1.64
0 → 69	11996	19906		5.75	1.66

difficulties, which were overcome by the code automatically, insignificantly degraded the code performance.

a. Fluid Results. In general, agreement was excellent between the measured and TRAC-calculated fluid conditions for this LOFT test. For Tests L1-4 and L2-2, TRAC calculated a low system pressure late in the transient. Again, we believe that the TRAC-PD2 structural heat-transfer models for the VESSEL were inadequate.

Table XVI lists the major calculated and observed sequence of events for LOFT L2-2. The primary discrepancy between the calculation and the data was the behavior of the accumulator. The TRAC calculation injected the accumulator inventory over a longer period of time than was observed experimentally. Thus, the accumulator did not empty during the calculation, whereas the LOFT accumulator emptied at 49 s. Consequently, TRAC calculated the filling of the lower plenum later in the transient than shown in the data but predicted the filling of the core reasonably well. Also, TRAC predicted the time of the maximum cladding temperature later than shown in the data because of delayed liquid flow through the core. The calculated peak cladding temperature (~795 K) was quite close to the observed value (~780 K); however, this parameter was dependent on the selection of initial fuel-rod conditions.

i. Intact-Loop Results. Figures 172-178 compare the TRAC-calculated and measured parameters of the intact-loop components. Figures 172 and 175 also show the low system pressure late in the transient. The cold ECCS injection from 25-40 s significantly affected the measured cold-leg temperature (Fig. 177) but insignificantly affected the calculated result. This discrepancy was caused by measurement problems. The higher wall temperatures at low void fractions greatly affected the thermocouples. The increased

TABLE XVI

SEQUENCE OF EVENTS FOR LOFT L2-2

Event	Time (s)	
	Calculated	Observed
Blowdown initiation	0	0
End of subcooled blowdown	0.1	0.07
HPIS initiation	12	12
Pressurizer emptied	15	15
Accumulator flow initiation	17	18
LPIS initiation	29	29
Lower plenum filled with liquid	~50	35
End of saturated blowdown	~45	44
Accumulator emptied	--	49
Core filled with liquid	~60	55
Maximum cladding-temperature time	7	4

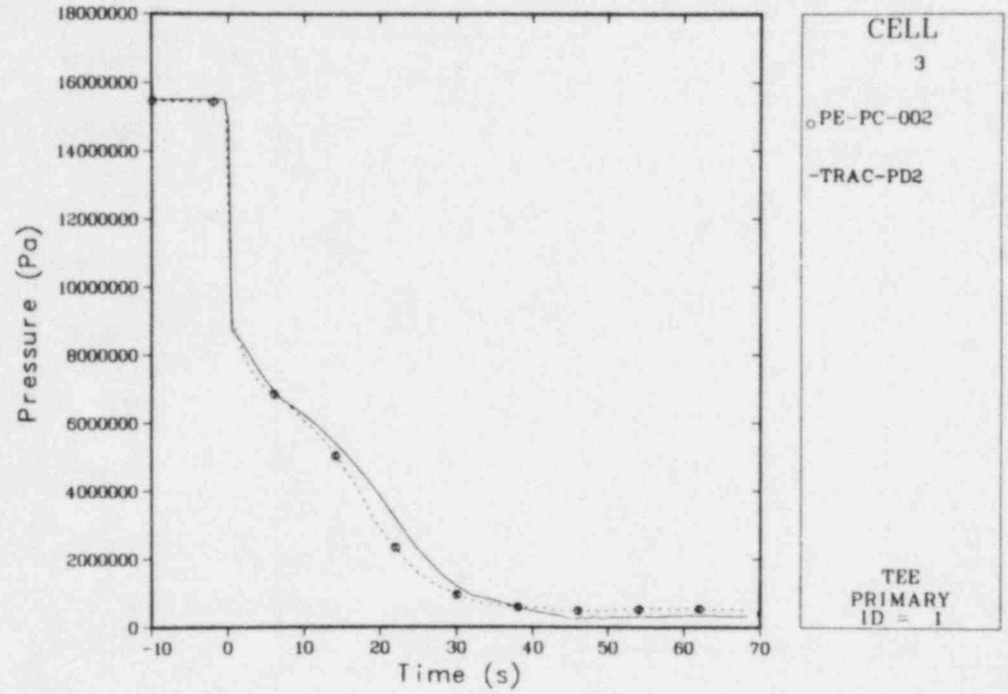


Fig. 172.
Comparison of the TRAC-calculated and measured intact-loop hot-leg pressures for LOFT L2-2.

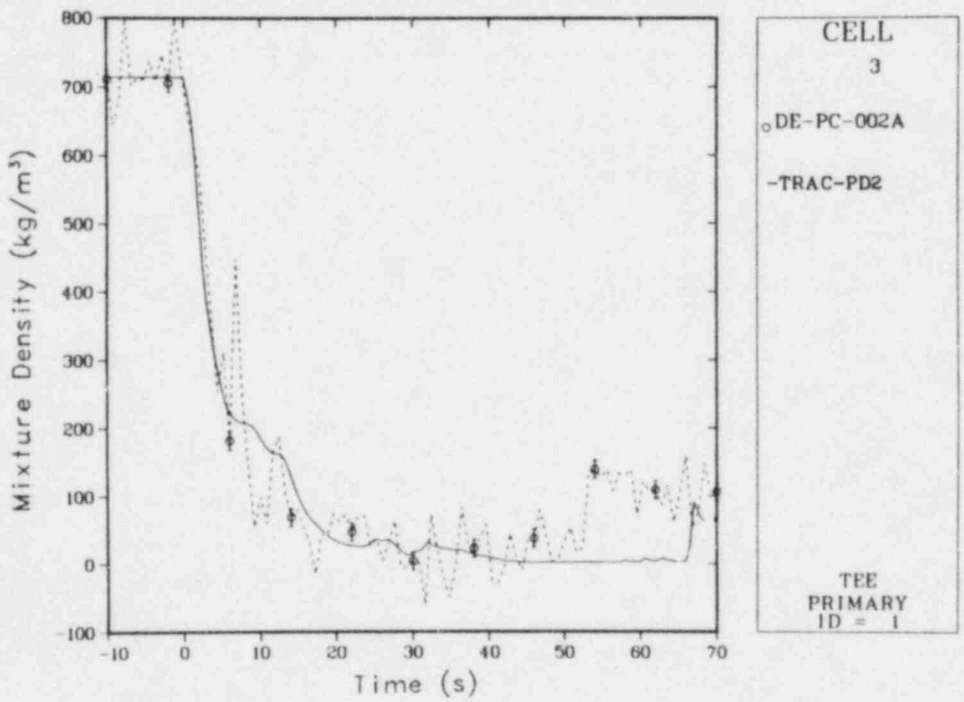


Fig. 173.
Comparison of the TRAC-calculated and measured intact-loop hot-leg mixture densities for LOFT L2-2.

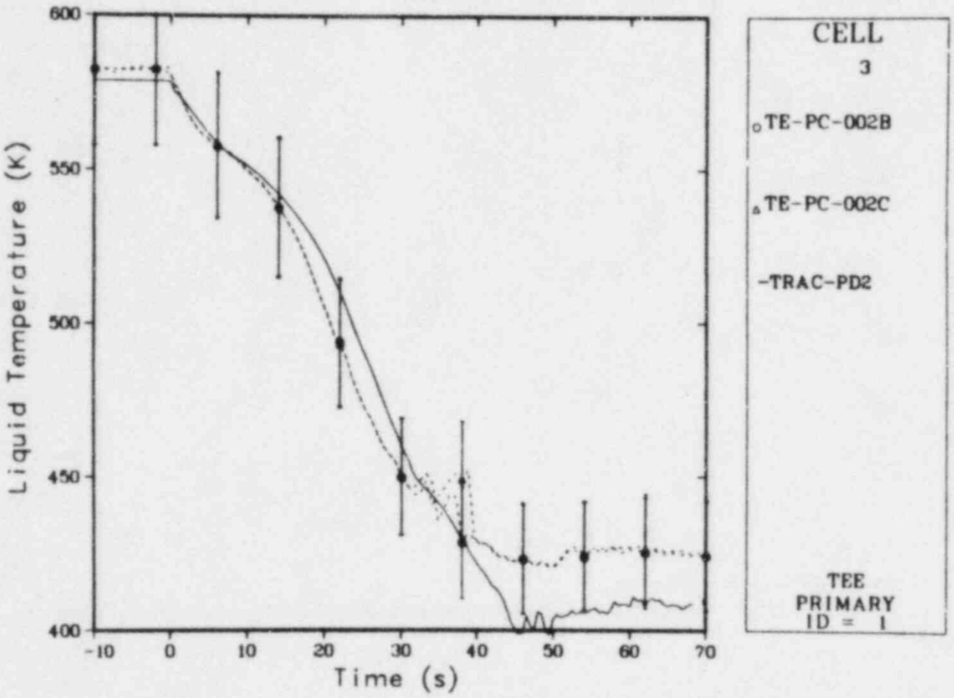


Fig. 174.
Comparison of the TRAC-calculated and measured intact-loop hot-leg liquid temperatures for LOFT L2-2.

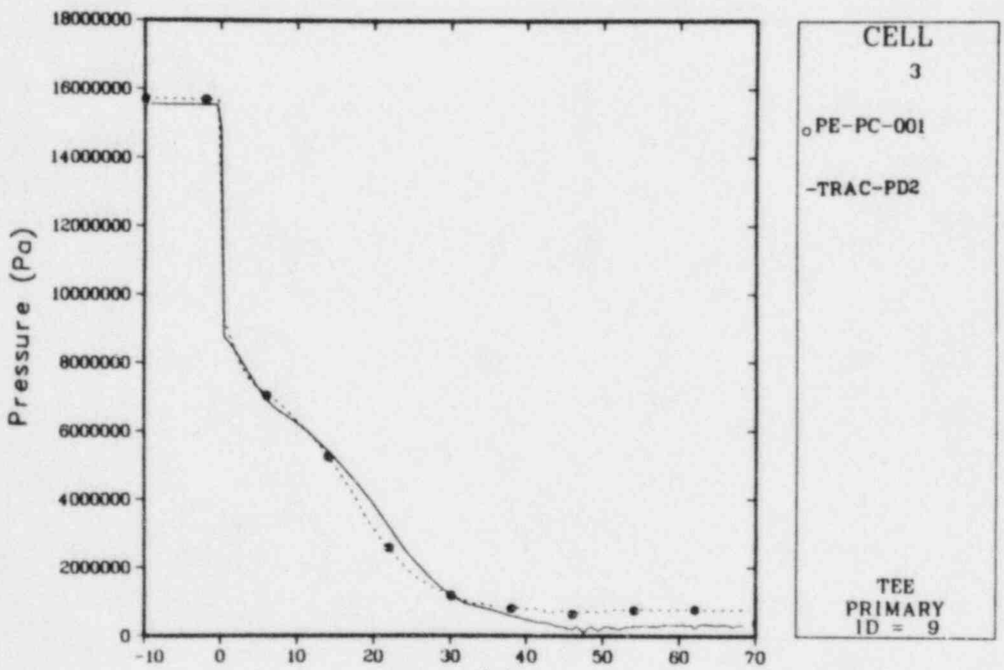


Fig. 175
Comparison of the TRAC-calculated and measured intact-loop cold-leg pressures for LOFT L2-2.

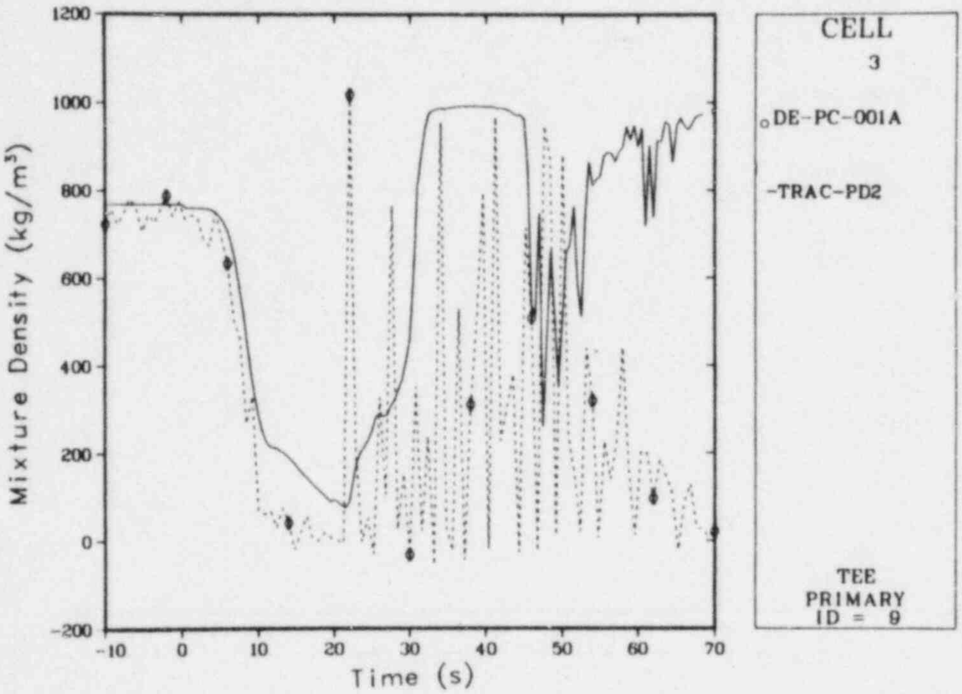


Fig. 176.
Comparison of the TRAC-calculated and measured intact-loop cold-leg mixture densities for LOFT L2-2.

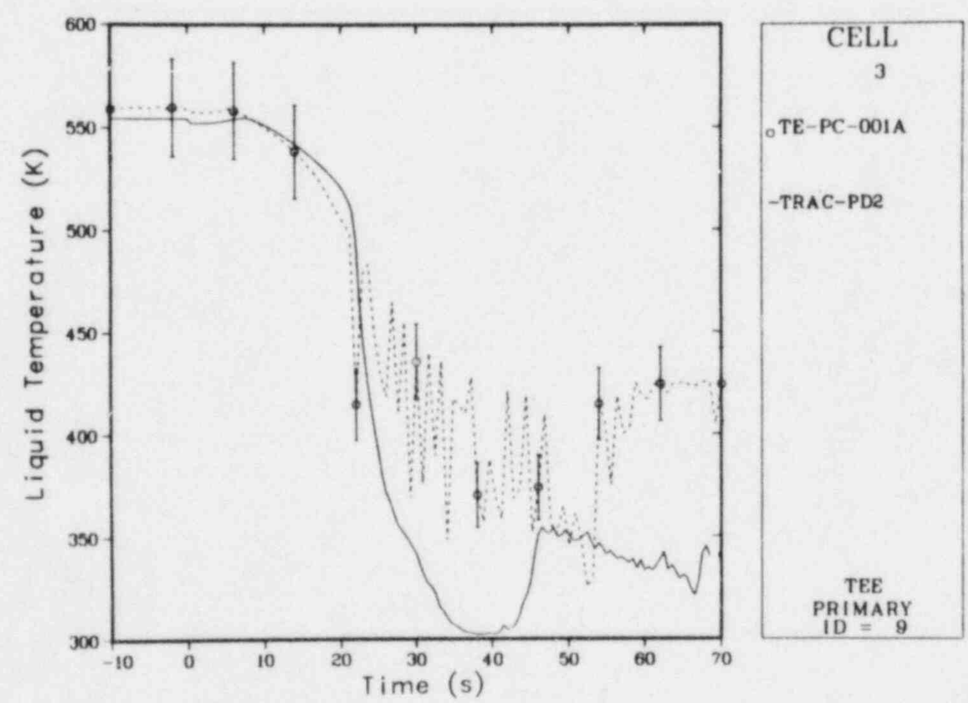


Fig. 177.
Comparison of the TRAC-calculated and measured intact-loop cold-leg liquid temperatures for LOFT L2-2.

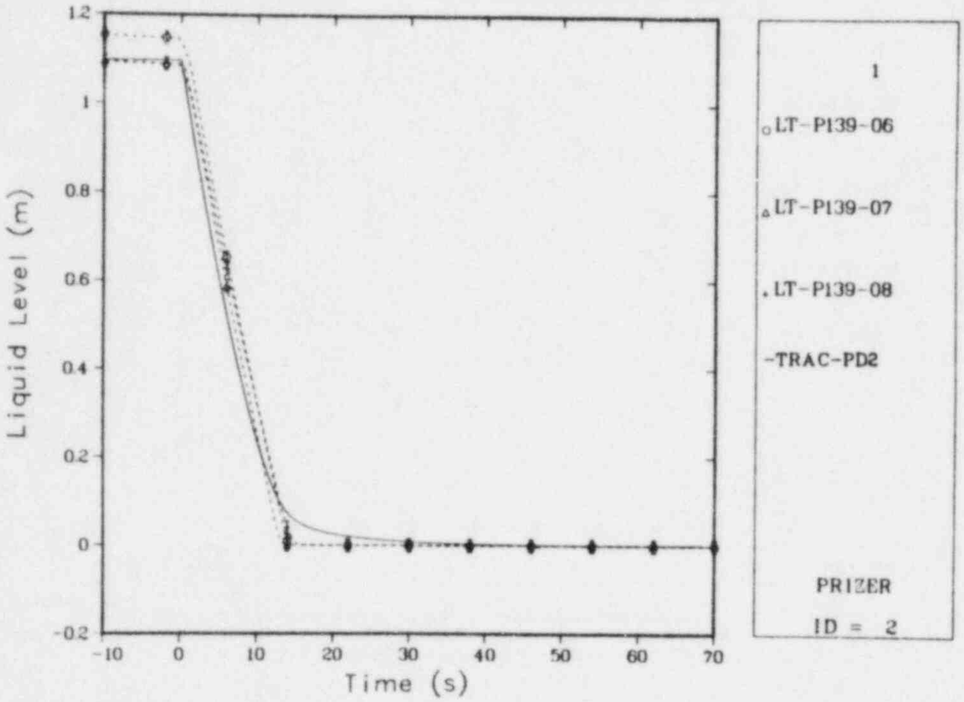


Fig. 178.
Comparison of the TRAC-calculated and measured pressurizer liquid levels for LOFT L2-2.

hot-leg fluid density (Fig. 173) measured at ~53 s, but not calculated until later in the transient, was caused by the filling of the downcomer at this time. The fluctuations in the calculated densities were smoothed by mesh-cell averaging. The large discrepancy between the mixture densities (Fig. 176) after 50 s in the intact-loop cold leg was caused by the continuation of accumulator flow in the calculation. The difference between the TRAC-calculated and measured fluid temperatures after 53 s in the intact-loop cold leg (Fig. 177) again was caused by the thermocouple measurement of the wall temperatures when the void fraction was high.

Figure 178 compares the TRAC-calculated and measured pressurizer water levels. Agreement was excellent, although there was a small discrepancy when the pressurizer emptied because the donor-cell technique used an average void fraction for convection out of the bottom pressurizer component.

ii. ECCS Results. Figures 179-183 compare the TRAC-calculated and measured HPIS, LPIS, and accumulator flows; the accumulator pressures; and the accumulator liquid levels. The data in Figs. 179-180 were evaluated by dividing the measured volumetric flow rates by the appropriate flow area. Because they were modeled with variable FILLs, the TRAC HPIS and LPIS reacted in exact accordance with the LOFT specifications. Thus, the differences in Figs. 179-180 reflect errors in the calculated local pressures and the specified performance. These differences did not influence the overall results significantly; the ECCS for Test L2-2 was dominated by the behavior of the accumulator. As we mentioned previously and as Fig. 181 shows, the TRAC accumulator model did not represent accurately the test system. Before ~48 s, the calculated mass flow was ~320 kg less than the test value; after 48 s, TRAC

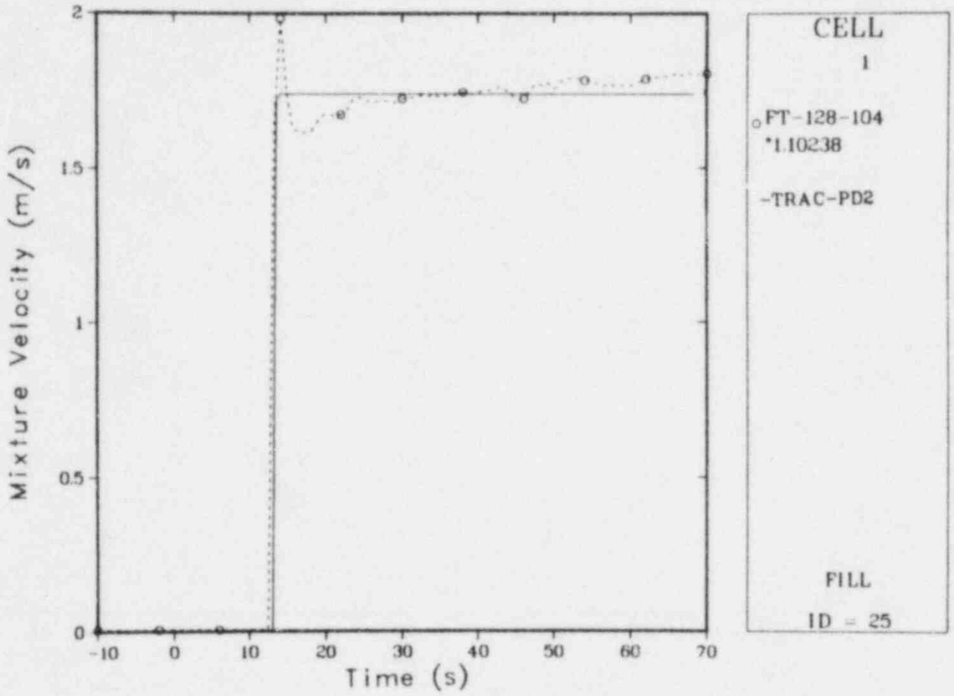


Fig. 179.
Comparison of the TRAC-calculated and measured HPIS flows for LOFT L2-2.

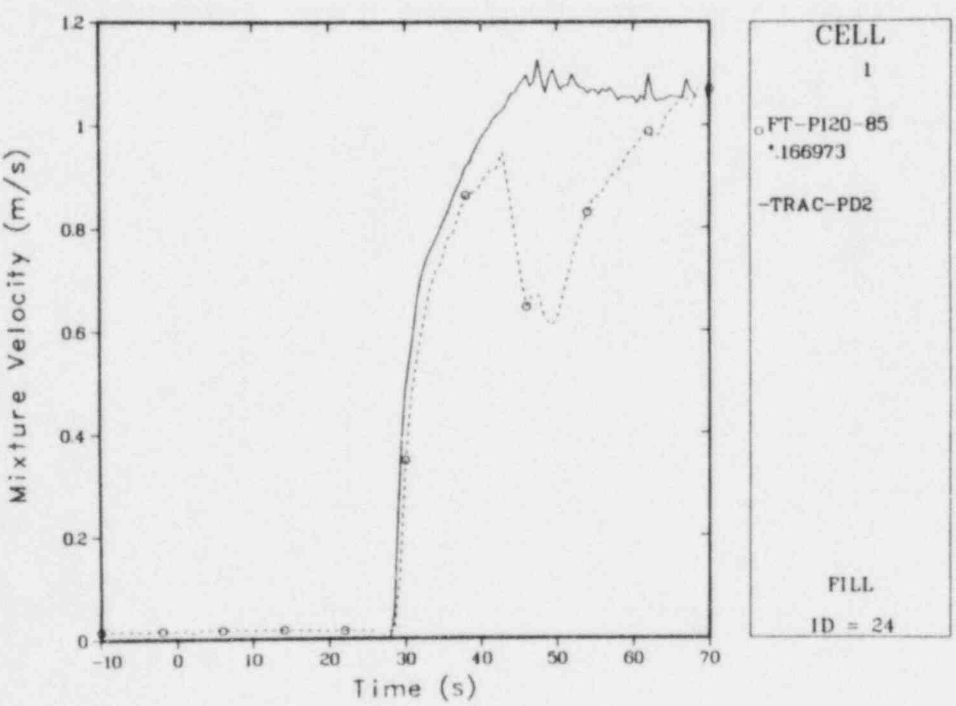


Fig. 180.
Comparison of the TRAC-calculated and measured LPIS flows for LOFT L2-2.

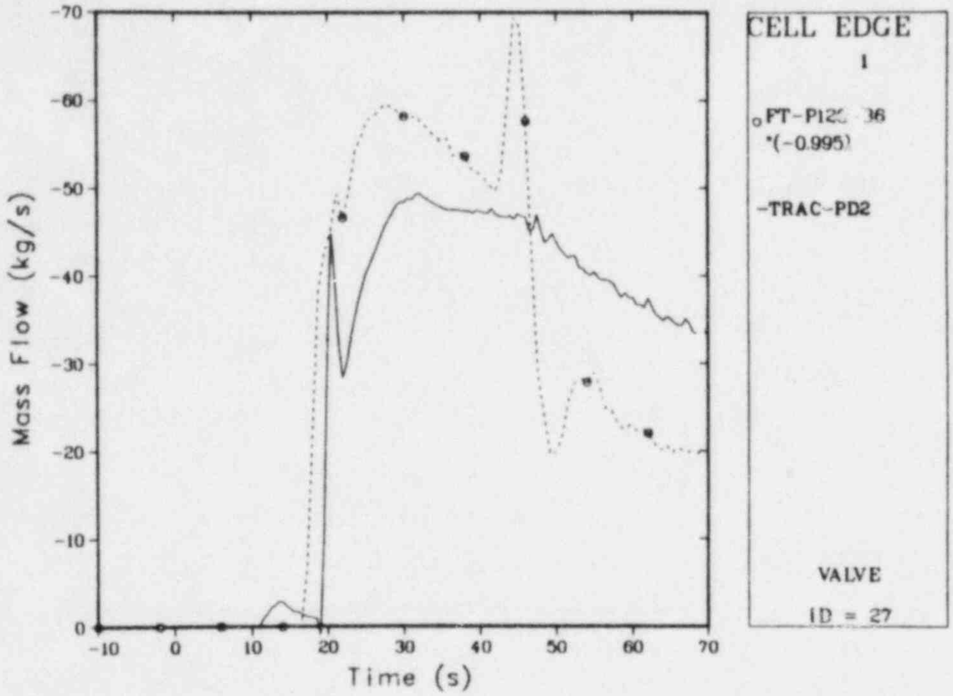


Fig. 181.
Comparison of the TRAC-calculated and measured accumulator flows for LOFT L2-2.

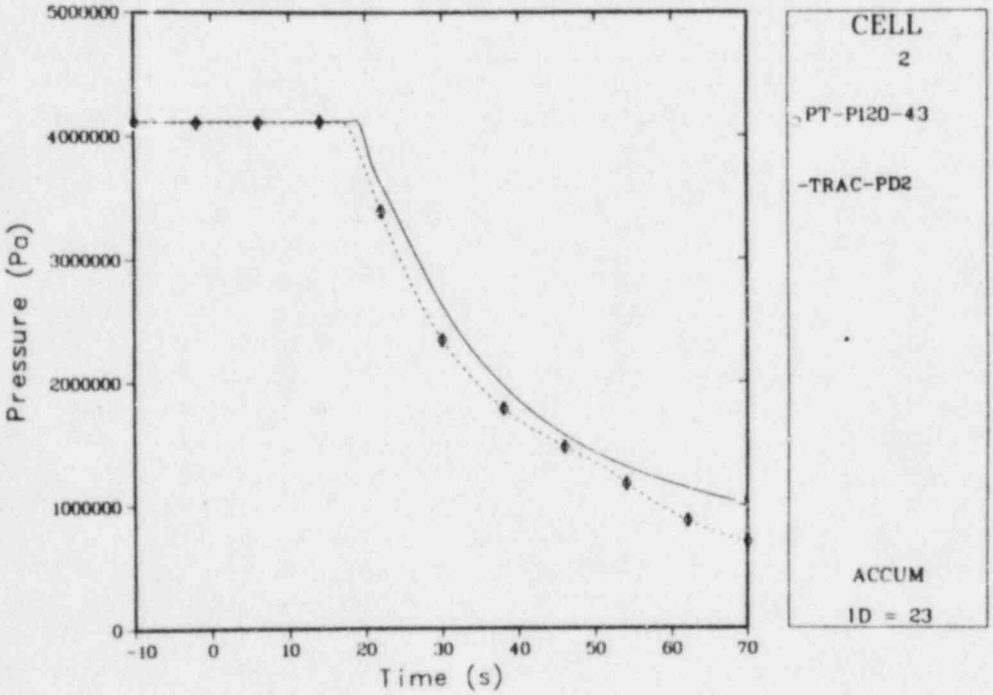


Fig. 182.
Comparison of the TRAC-calculated and measured accumulator pressures for LOFT L2-2.

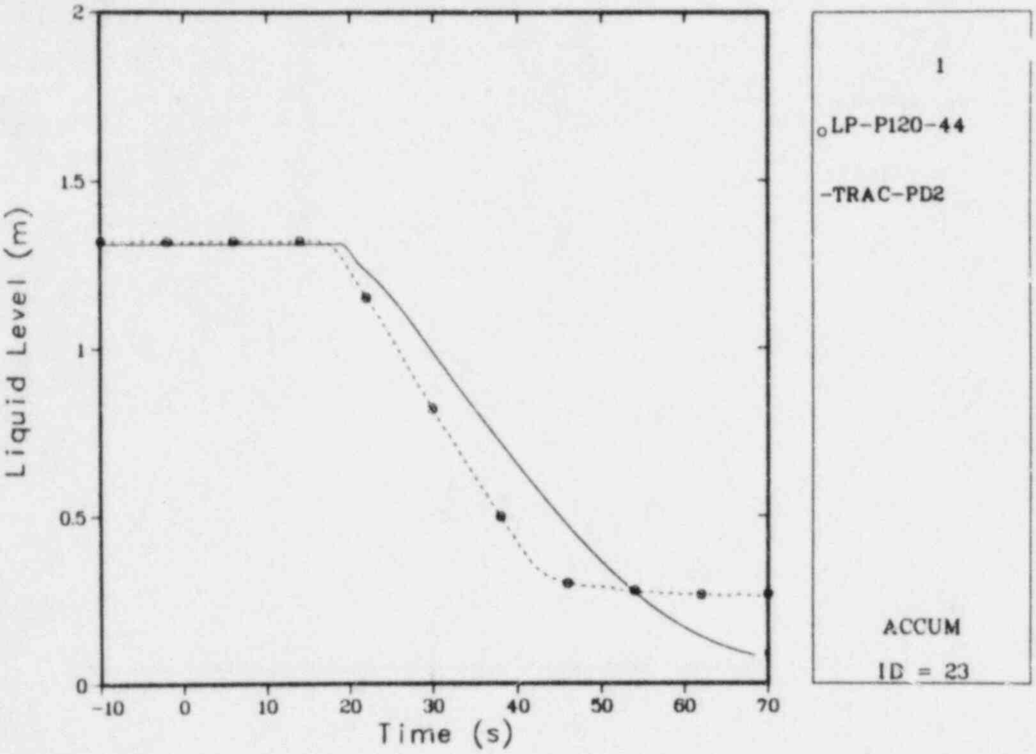


Fig. 183.
Comparison of the TRAC-calculated and measured accumulator liquid levels for LOFT L2-2.

added the 320 kg to the system mass flow. The low initial flow and the resulting long flow period markedly changed the refill and reflood portions of the calculation. The test data in Fig. 181 were evaluated by multiplying the measured volumetric flow rate by the calculated density of the accumulator fluid, 995 kg $\cdot$ m^{-3}. The underpredicted calculated accumulator mass flows resulted from a low driving-pressure difference (accumulator pressure minus the intact-loop cold-leg pressure) and uncertainty in the flow resistance of the ECC line. Figure 183 compares the TRAC-calculated and measured accumulator liquid levels. In the experiment, this level was inferred from a pressure differential whose lower level was at ~0.25 m. This fact may explain why the data failed to show the emptying of the accumulator; however, Fig. 181 infers the emptying. Because this measurement was made downstream from the accumulator, a small flow continued after the accumulator emptied.

iii. Broken-Loop Results. Figures 184-193 plot the fluid conditions in the broken-loop legs. The broken-loop hot-leg mixture-density comparison (Fig. 184) showed the delayed filling of the reactor core; in Fig. 185, the delayed filling was exhibited by the lower calculated mass flow through the broken-loop hot leg. The high temperatures measured later in the transient (Fig. 186) reflected vapor superheat and possibly some effect of the hot piping walls; because this figure compares the calculated liquid temperature to the data, the superheat did not appear in the calculated curve.

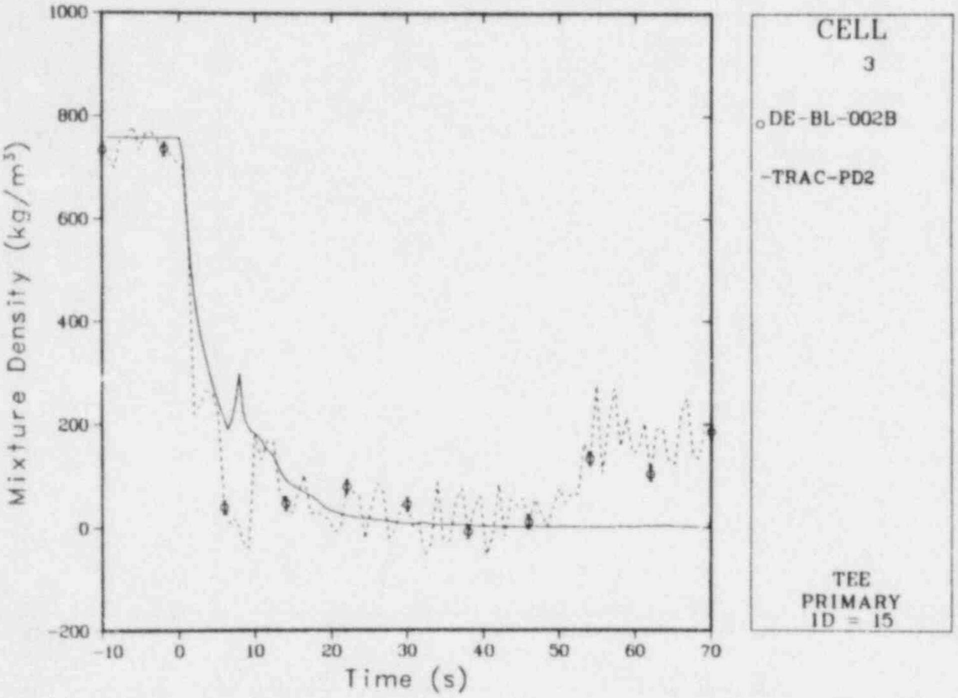


Fig. 184.
Comparison of the TRAC-calculated and measured broken-loop hot-leg mixture densities for LOFT L2-2.

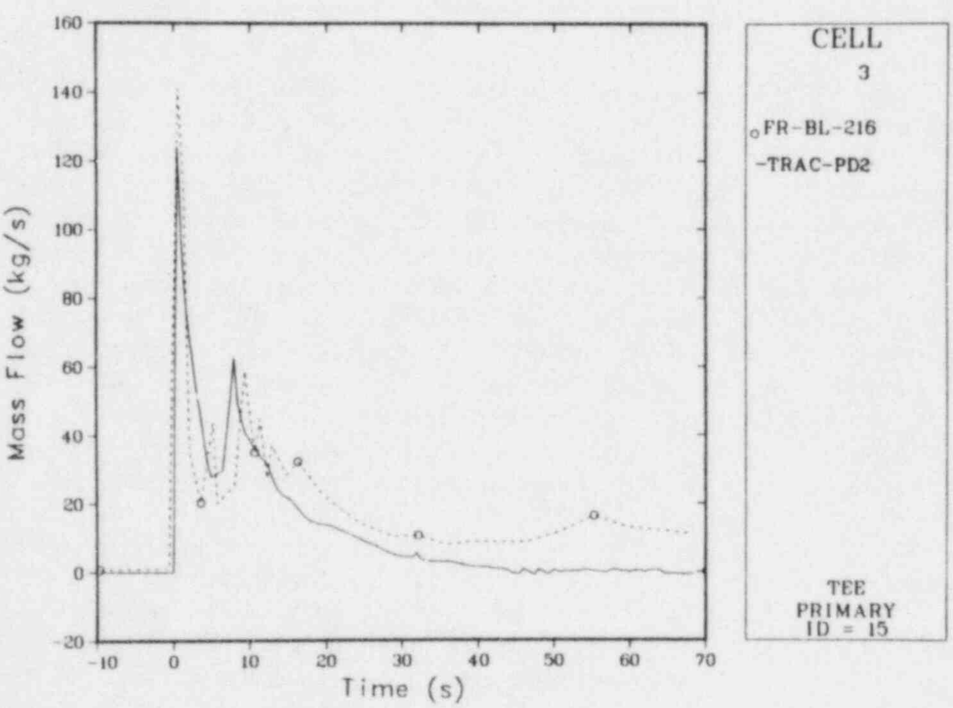


Fig. 185.
Comparison of the TRAC-calculated and measured broken-loop hot-leg mass flows for LOFT L2-2.

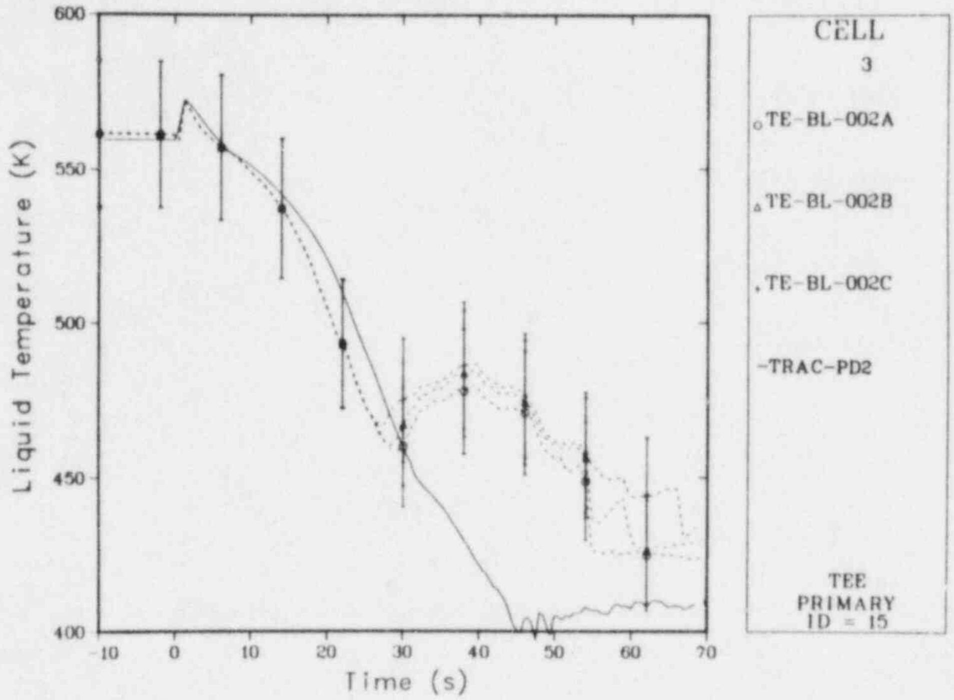


Fig. 186.
Comparison of the TRAC-calculated and measured broken-loop hot-leg liquid temperatures for LOFT L2-2.

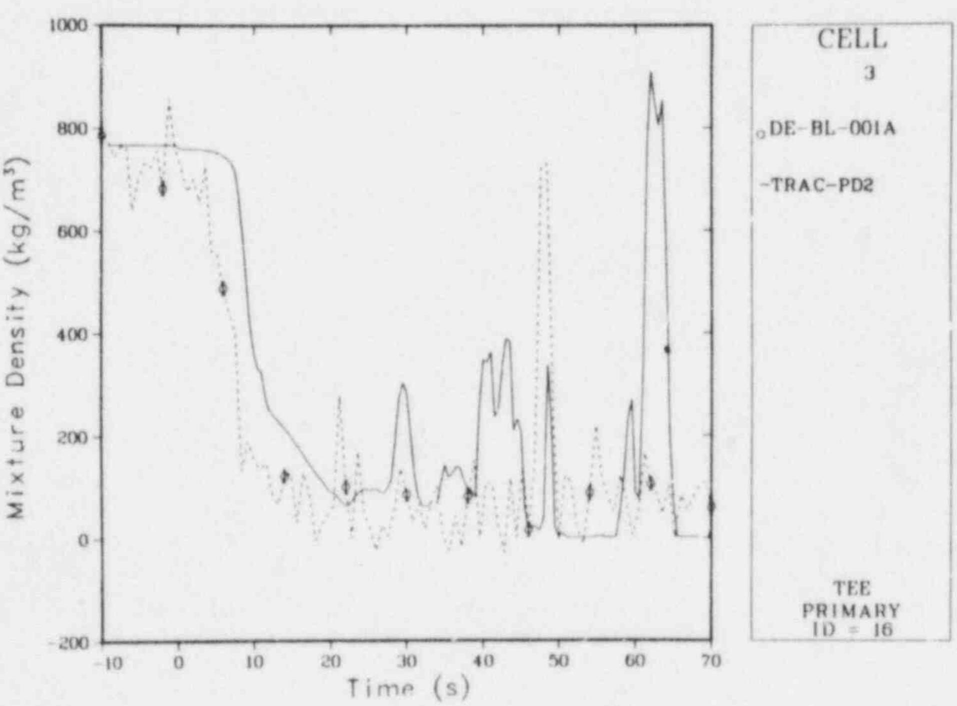


Fig. 187.
Comparison of the TRAC-calculated and measured broken-loop cold-leg mixture densities for LOFT L2-2.

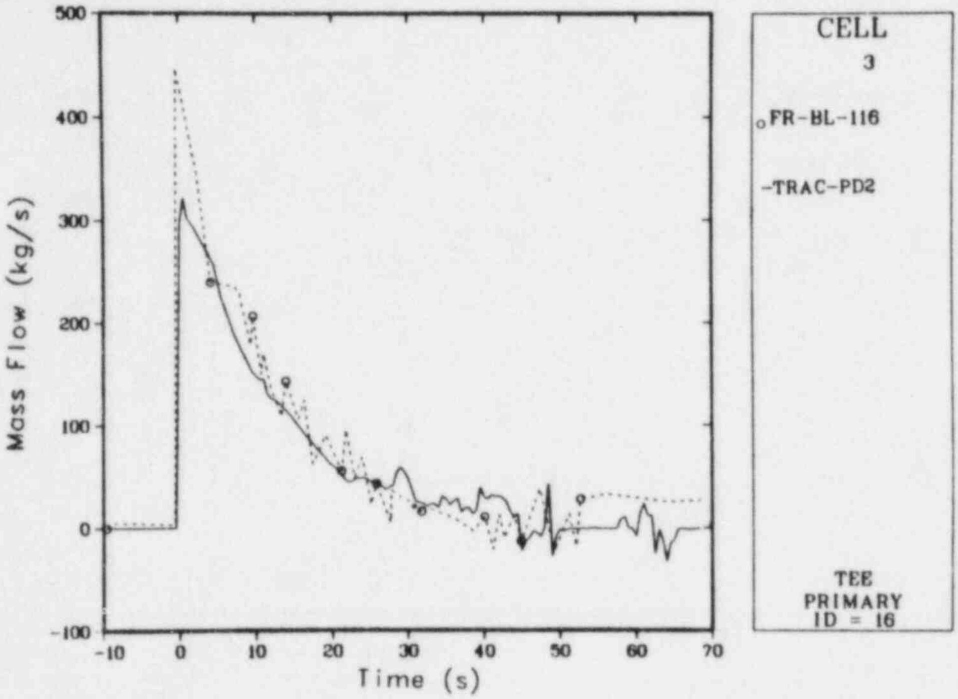


Fig. 188.
Comparison of the TRAC-calculated and measured broken-loop cold-leg mass flows for LOFT L2-2.

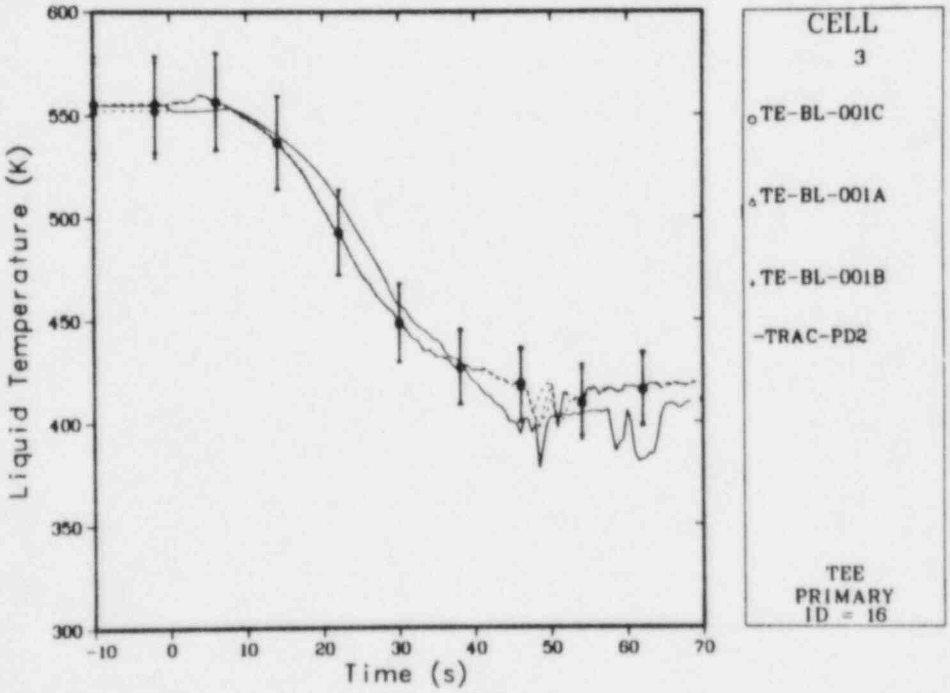


Fig. 189.
Comparison of the TRAC-calculated and measured broken-loop cold-leg liquid temperatures for LOFT L2-2.

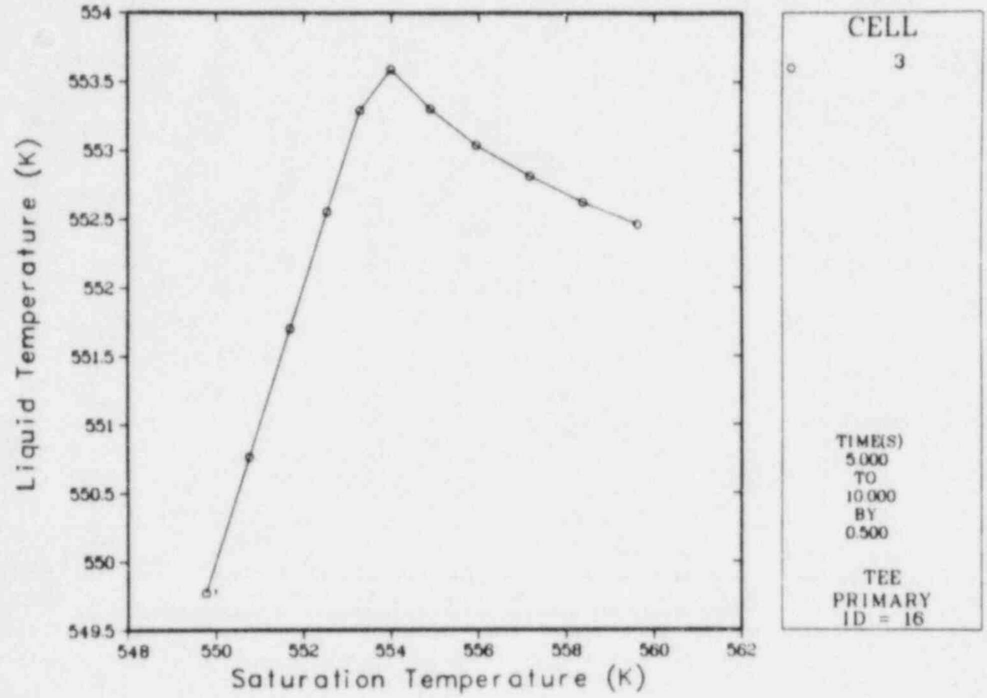


Fig. 190.
The calculated broken-loop cold-leg liquid vs the calculated saturation temperatures for LOFT L2-2.

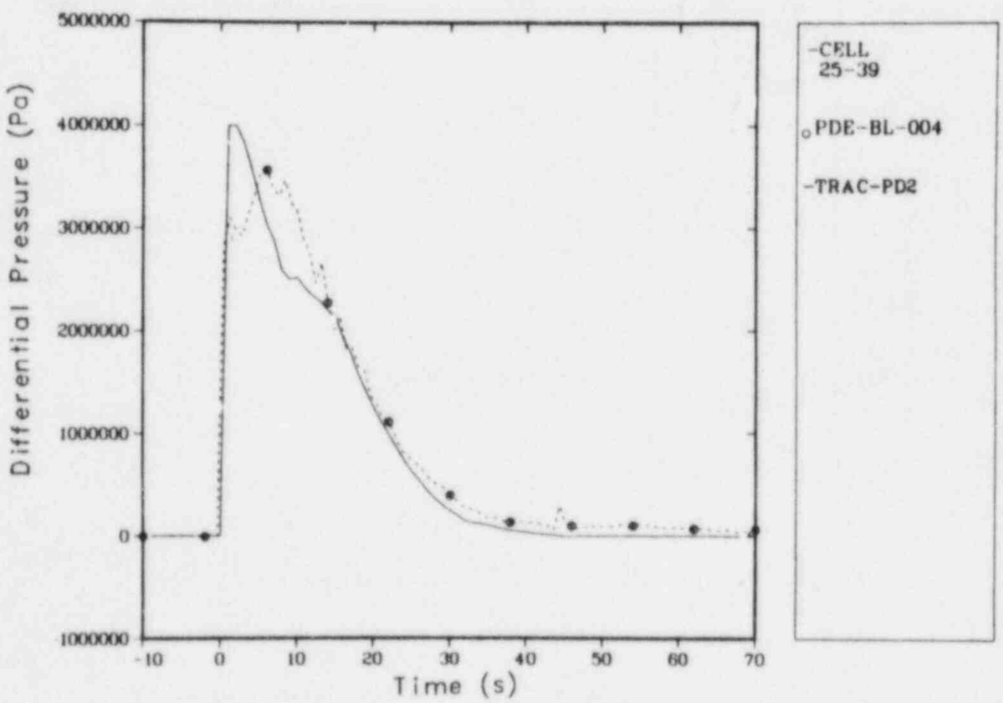


Fig. 191.
Comparison of the pressure differentials across the hot-leg break plane for LOFT L2-2.

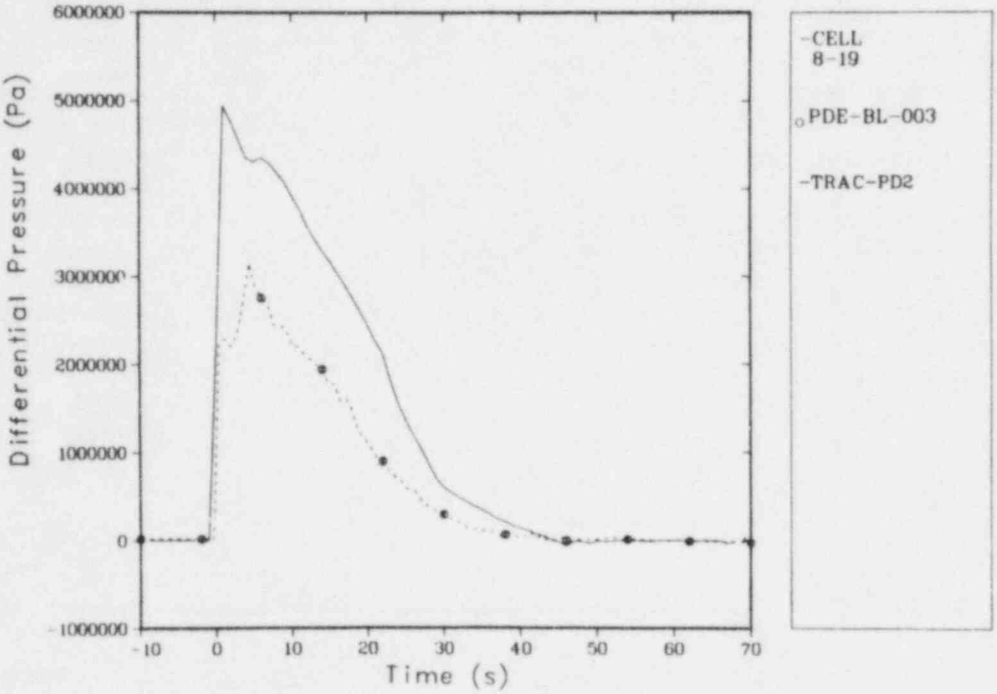


Fig. 192.
Comparison of the pressure differentials across the cold-leg break plane for LOFT L2-2.

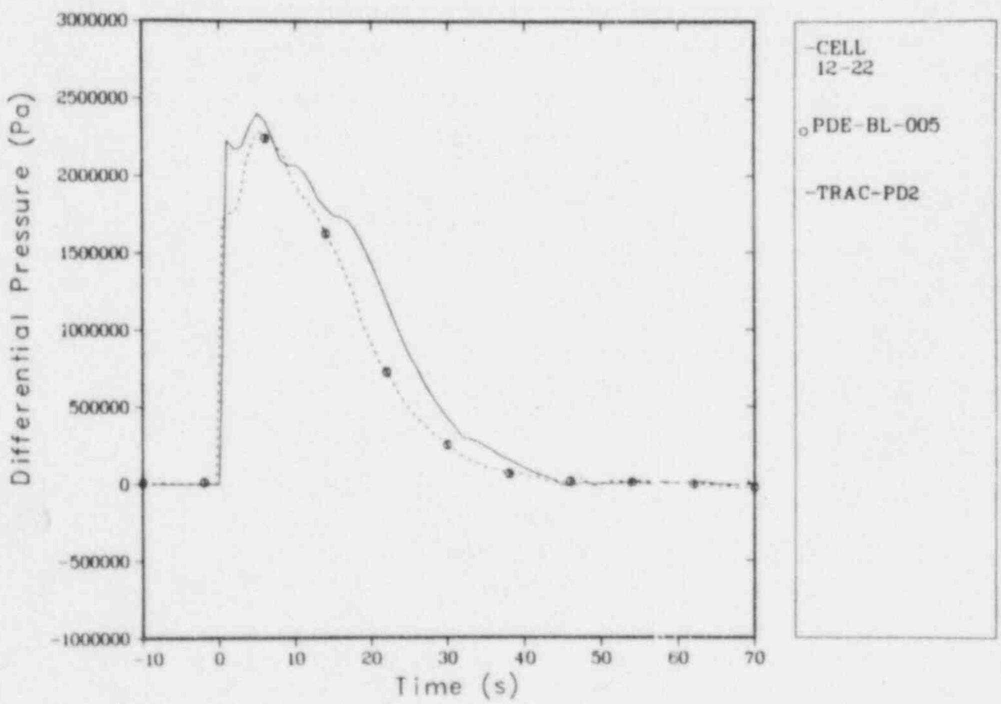


Fig. 193.
Comparison of the pressure differentials across the pump simulator for LOFT L2-2.

Figures 187-189 compare the broken-loop cold-leg conditions. Figure 187 shows ECC bypass in the calculated and measured broken-loop cold-leg mixture densities. The density spikes did not correlate well between the experiment and the calculation, but they showed similar behavior. The calculated broken-loop cold-leg mass flow (Fig. 188) agreed well with the measurement, except for the first 10 s of the transient. Figure 190 shows that this period corresponded to the subcooled critical flow at this location and that the fluid entering the broken-loop cold leg reached saturation at 8 s. During the period of subcooled critical flow, TRAC substantially underpredicted the mass flow because the code lacked an accurate bubble nucleation model.[26] Figures 191-193 compare the TRAC-calculated and the measured differential pressures in the broken loops. Agreement was excellent across the hot-leg break plane (Fig. 191) and across the pump simulator (Fig. 193); however, the pressure differential calculated across the cold-leg break plane was considerably below the measured value. In Fig. 188 this difference did not affect the mass flow rate beyond 10 s, because the flow was choked at this location even with the lower pressure differential. The error may have occurred because the modeling of the flow path downstream of the break plane did not reflect accurately the pressure tap location and the nozzle jet.

iv. Additional Calculated Results. To augment the comparisons with test data provided previously, we have included some interesting calculated results for which there were no comparable test data. Figures 194 and 195 show the calculated total liquid mass in the vessel and core, respectively. The vessel had not refilled completely at 70 s, because the cold liquid was more dense than the original liquid in the vessel; thus, the ultimate total mass would have been 2500 kg. We continued the TRAC calculation until 100 s, at which point liquid was still filling the vessel. Figure 195 shows the total liquid mass in the VESSEL core section. The liquid pulse at ~10 s caused the early fuel-rod quenching. This plot also displays the filling of the lower plenum (at ~50 s when the core mass began its abrupt increase) and the complete reflooding of the core (between 60 and 70 s when the mass became stable). Figures 196 and 197 display the total heat transfer to the fluid from the fuel rods and vessel structural material. In Fig. 196 the pulse at ~10 s resulted from the rod quenching associated with the liquid pulse in Fig. 195. The pulses at ~50 s corresponded to the final quenching of the core during reflood. The large nonphysical spikes (Fig. 197) resulted from the inadequate structural heat-transfer models (Sec. XII.C.2). Figure 198 shows the void fraction at each axial level within the core. Both the fluid pulse from Fig. 195 and the eventual reflooding of the core are more detailed in this figure.

b. Rod Temperature Results. To determine the correct fuel-rod geometry for this calculation, we performed a parametric study, which is discussed further in Sec. XIII.B. In this section we compare the TRAC-calculated and measured temperatures at the surface of the fuel-rod cladding and present some fluid results that affect the comparisons. The results discussed in this section were obtained from the base-case calculation performed with the optimum rod geometry.

The comparison of the TRAC-calculated and measured fuel-rod temperatures must be considered carefully. The data showed that local effects strongly influenced the temperature of the rods and caused wide variations in the measured temperatures. The TRAC calculations did not account for these local variations and, therefore, must be compared to a variety of data. Agreement or disagreement of the TRAC-calculated fuel-rod temperatures with specific data did not invalidate the calculation. Meaningful TRAC results existed only at a

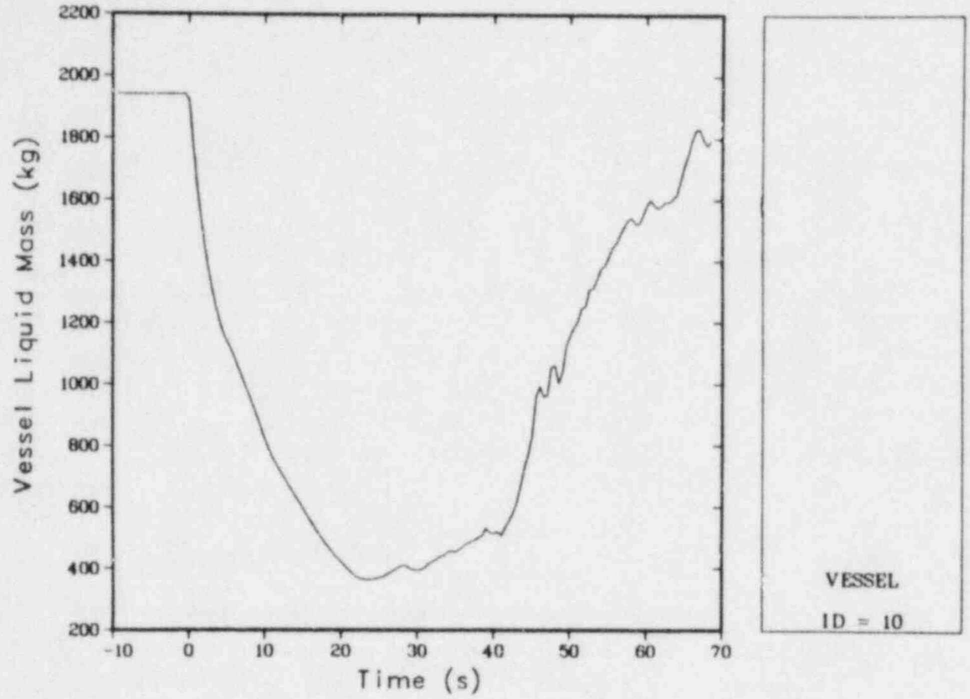


Fig. 194.
LOFT L2-2 calculated vessel liquid mass.

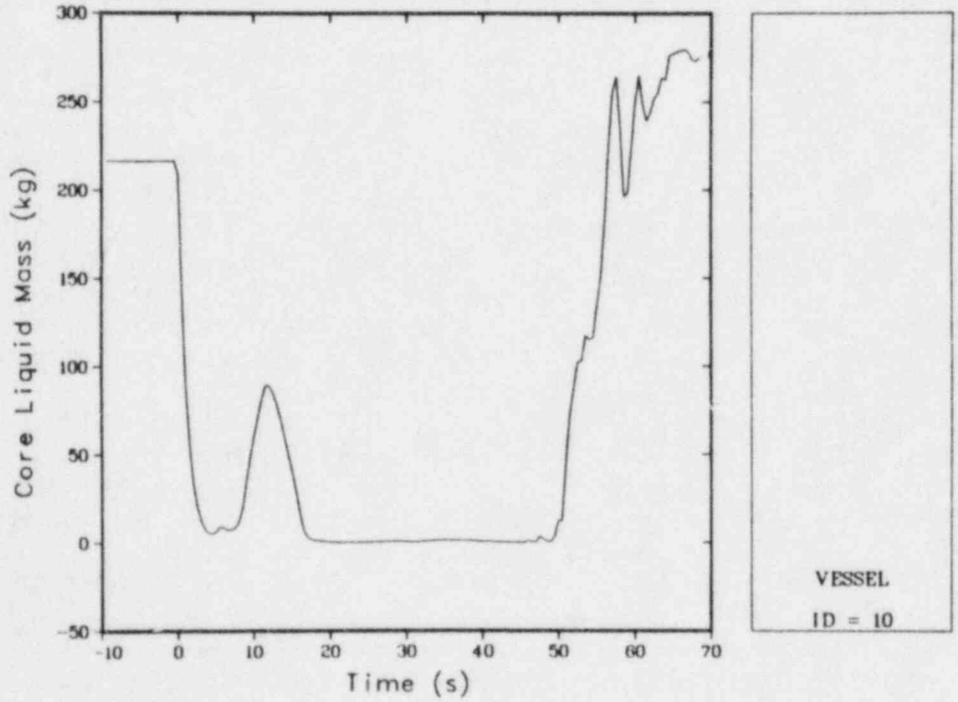


Fig. 195.
LOFT L2-2 calculated core liquid mass.

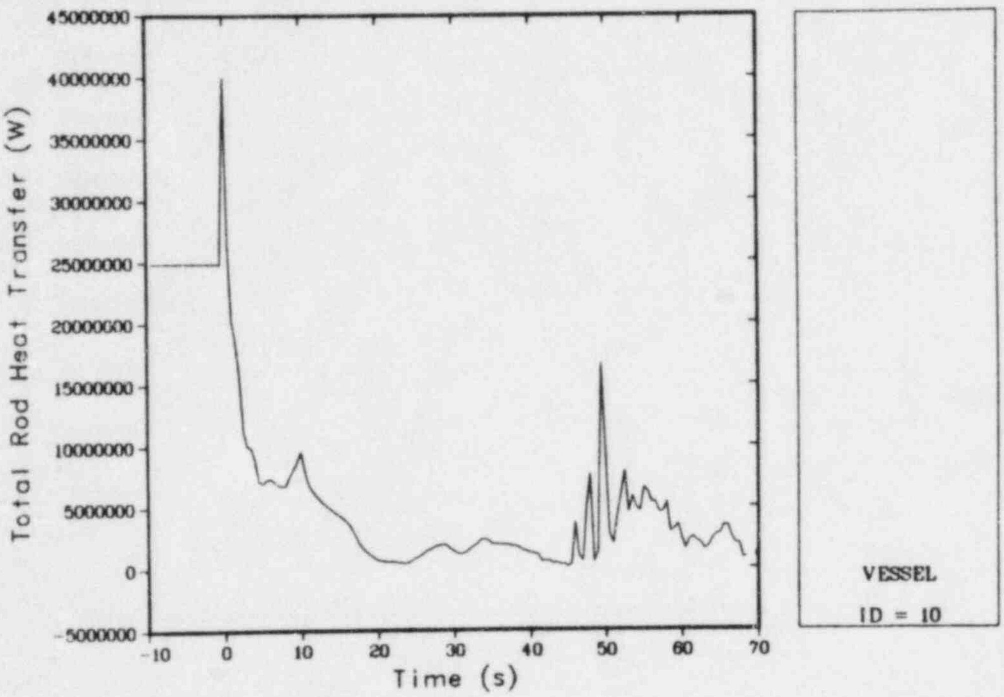


Fig. 196.
LOFT L2-2 calculated total rod heat transfer.

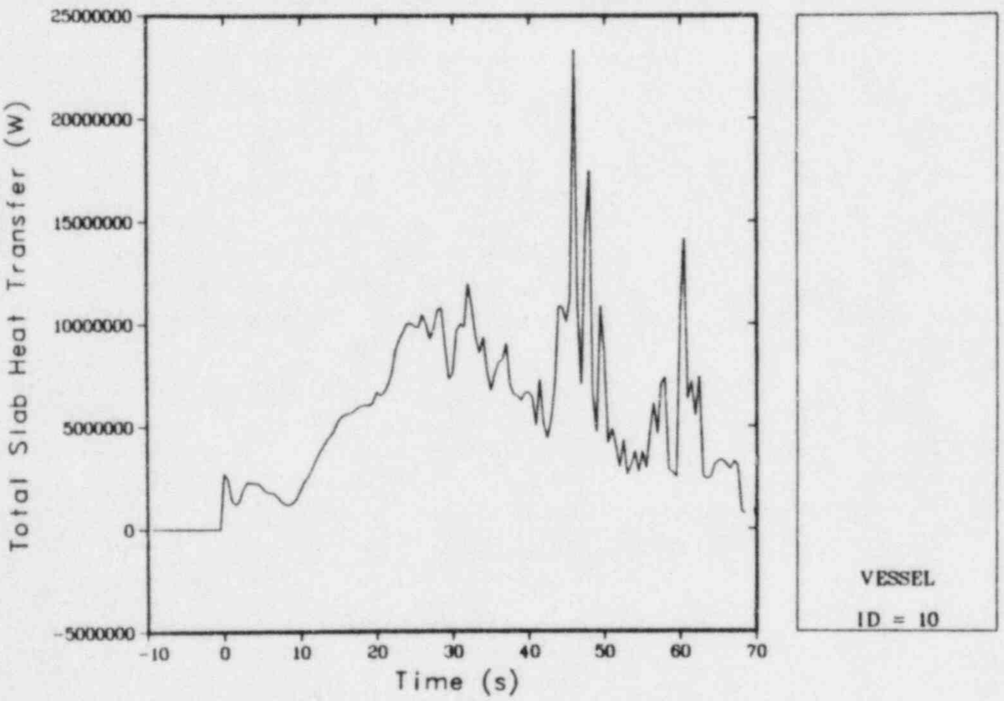


Fig. 197.
LOFT L2-2 calculated total slab heat transfer.

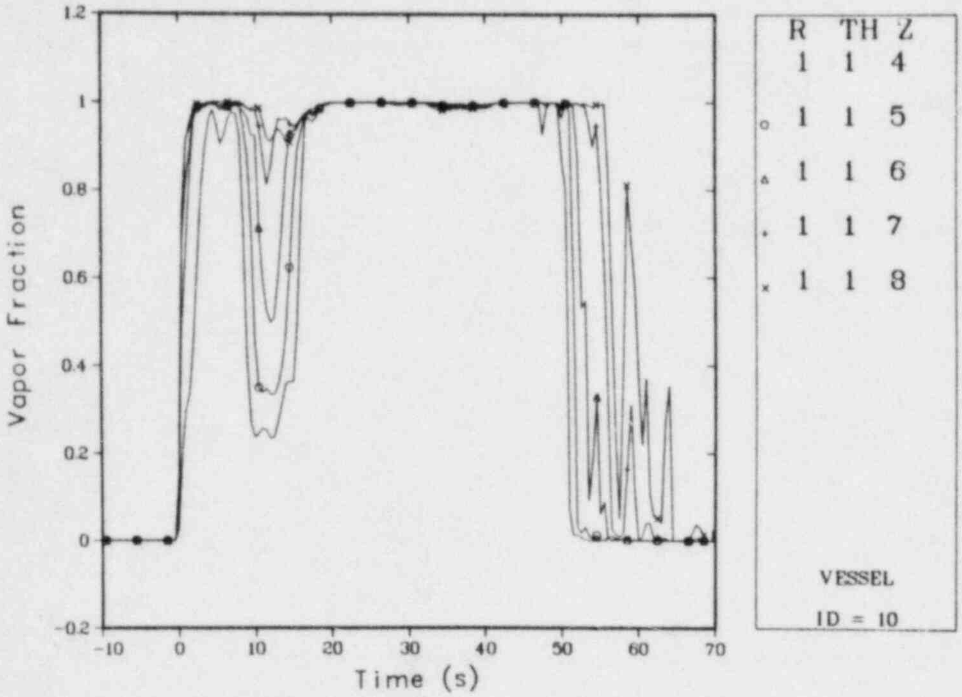


Fig. 198.
LOFT L2-2 calculated core vapor fractions.

few specific axial locations before the reflood portion of the calculation. To alleviate the misleading nature of the test results, we grouped the measurements taken at nearby axial and horizontal points. Table XVII specifies the measurements by their group number and their TRAC-PD2 and measurement axial location. Separate plots compare the calculated results with the individual groups.

i. Central Fuel Module. Figures 199-205 compare the calculated and measured results for the central fuel module. Figure 199 compares the calculated cladding-surface temperatures at six axial locations for TRAC-PD2 fuel rod 1. Several important features are evident in this plot. The rod-surface temperature changed during the dryouts and rewets that occurred before the core reflood at ~50 s. These dryouts and rewets occurred simultaneously throughout the axial length of this rod, although the magnitude of the temperature excursions differed depending on the axial position. The variations in magnitude (Fig. 159) primarily resulted from the change in power along the rod. The calculation predicted the peak fuel-rod cladding-surface temperature during the blowdown phase, immediately before the first rewet; thus, the TRAC prediction agreed with the test data. Thereafter, the rod temperatures decreased regularly, with occasional increases caused by subsequent dryouts. Figure 200 compares the calculated rod-surface temperatures at the axial midplane for rods 1-4, 13, and 14. These were the only rods in the central radial zone represented in the calculation. Generally, these calculated results showed little azimuthal variation. The variations caused by the auxiliary-rod peaking factors were small. The results agreed between rods 1 and 13 and between rods 4 and 14; however, the two rods in the fourth azimuthal segment (rods 4 and 14) did not experience the second

TABLE XVII

FUEL-ROD TEMPERATURE MEASUREMENTS

Group Number	TRAC-PD2 Axial Location	Rod[a]	Measurement Axial Location
1	2.14	5D6	2.14
		5D6	2.19
		5F4	2.14
2	2.14	5F8	2.09
		5F8	2.19
		5F9	2.14
3	2.14	5G6	2.14
		5H6	2.09
		5H6	2.19
4	2.14	5J7	2.14
		5J8	2.09
		5J8	2.19
5	2.14	5J4	2.14
		5L6	2.14
		5L6	2.19
6	1.65	5F9	1.66
		5G6	1.66
		5J7	1.66
7	2.95	5F9	2.95
		5G6	2.95
		5J7	2.95
8	2.14	1B11	2.09
		1B11	2.19
9	2.14	4E8	2.14
		4F8	2.19
10	2.14	4G14	2.14
		4F8	2.19
11	2.14	2E8	2.14
		2F8	2.09
		2F8	2.19
12	2.14	2G14	2.14
		2H14	2.09
		2H14	2.19

[a]The first digit of the rod identifier specifies the fuel module; the following letter and digit specify the rod row and column (Fig. 156).

TABLE XVII (cont.)

Group Number	TRAC-PD2 Axial Location	Rod[a]	Measurement Axial Location
13	2.14	3B11	2.09
14	2.14	6F8	2.09
		6F8	2.19
		6E8	2.14
15	2.14	6G14	2.14
		6H14	2.09
		6H14	2.19
16	2.03	2H3	2.04
		4H3	2.04
		6H3	2.04
		1F7	2.04
		3F7	2.04

[a]The first digit of the rod identifier specifies the fuel module; the following letter and digit specify the rod row and column (Fig. 156).

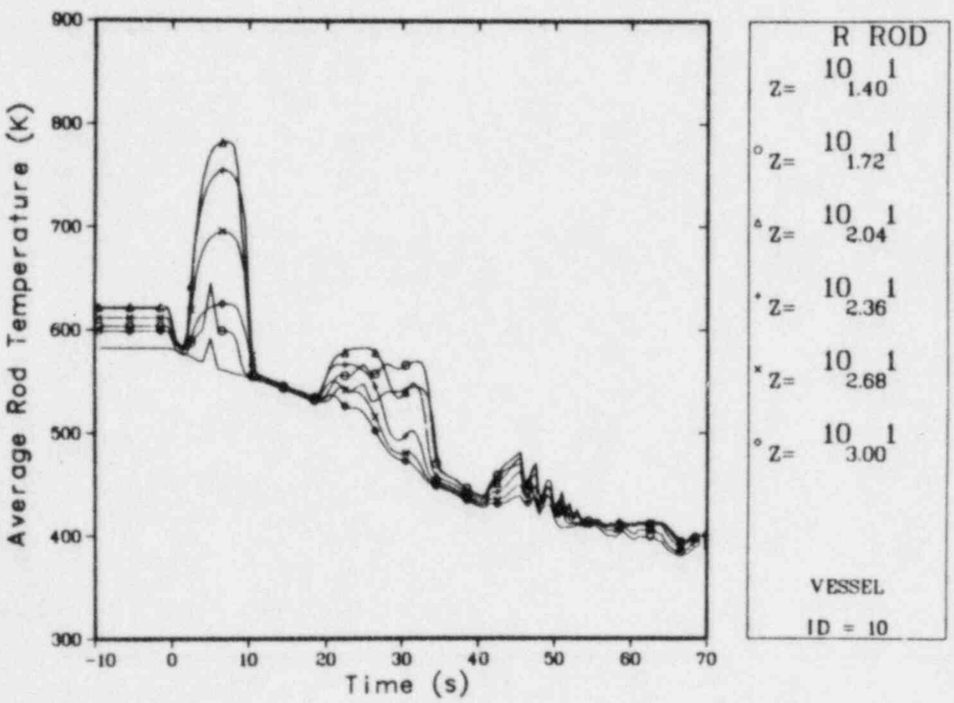


Fig. 199.
Axial comparison of the calculated central-rod cladding-surface temperatures for LOFT L2-2.

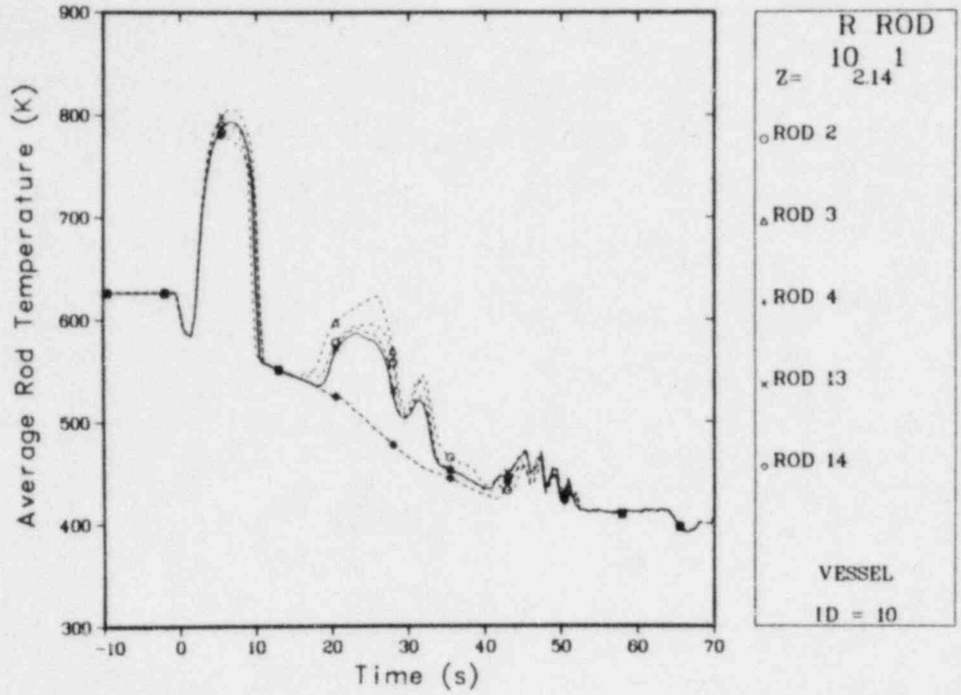


Fig. 200.
Azimuthal comparison of the calculated central-rod midplane cladding-surface temperatures for LOFT L2-2.

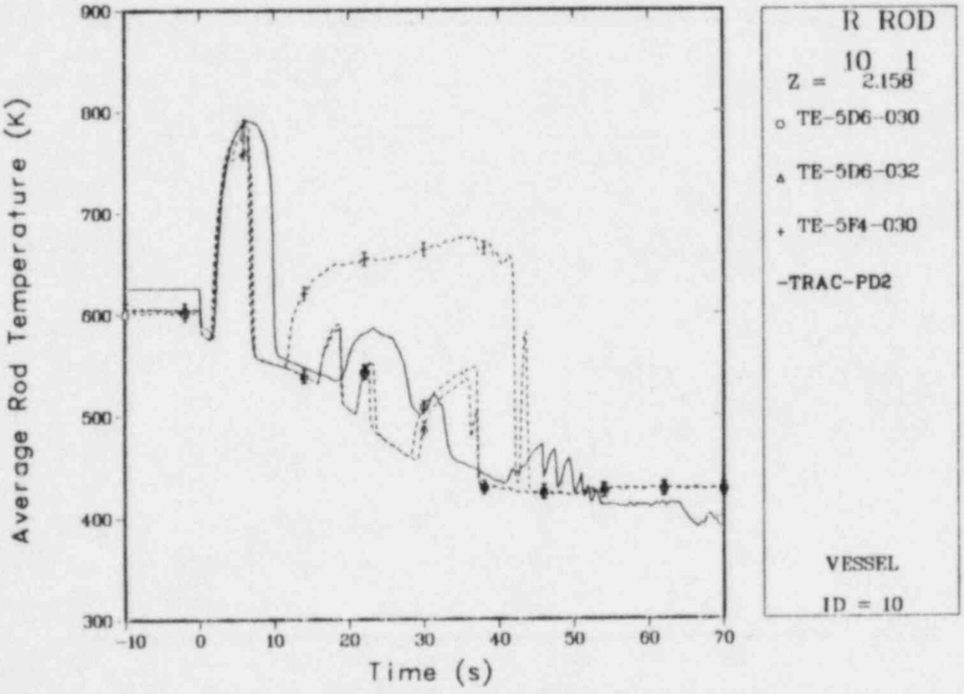


Fig. 201.
Comparison of the calculated central-rod midplane cladding-surface temperatures and group 1 data for LOFT L2-2.

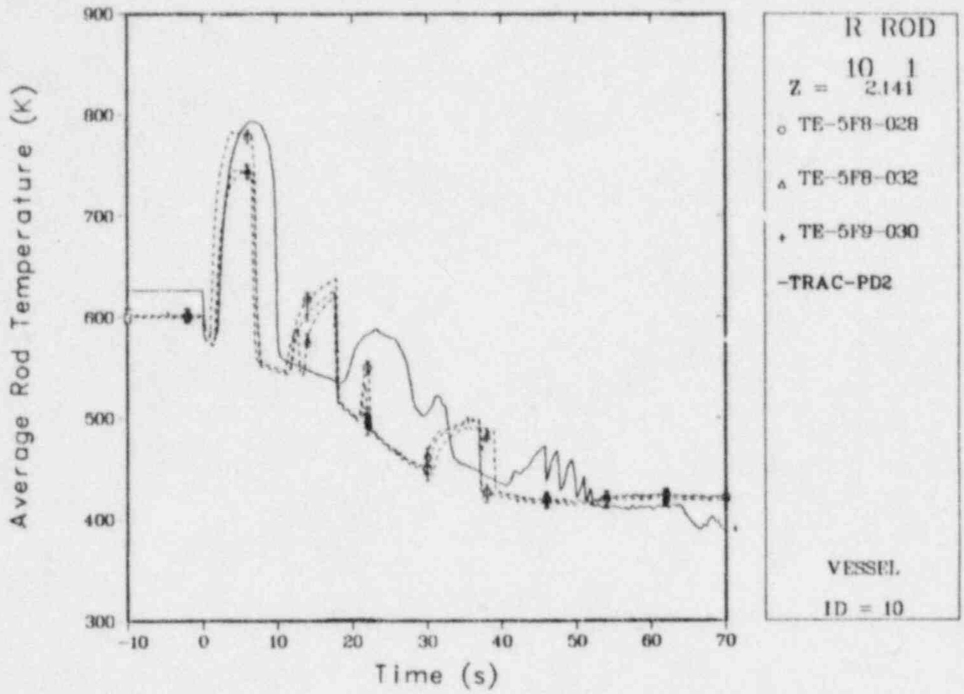


Fig. 202.
Comparison of the calculated central-rod midplane cladding-surface temperatures and group 2 data for LOFT L2-2.

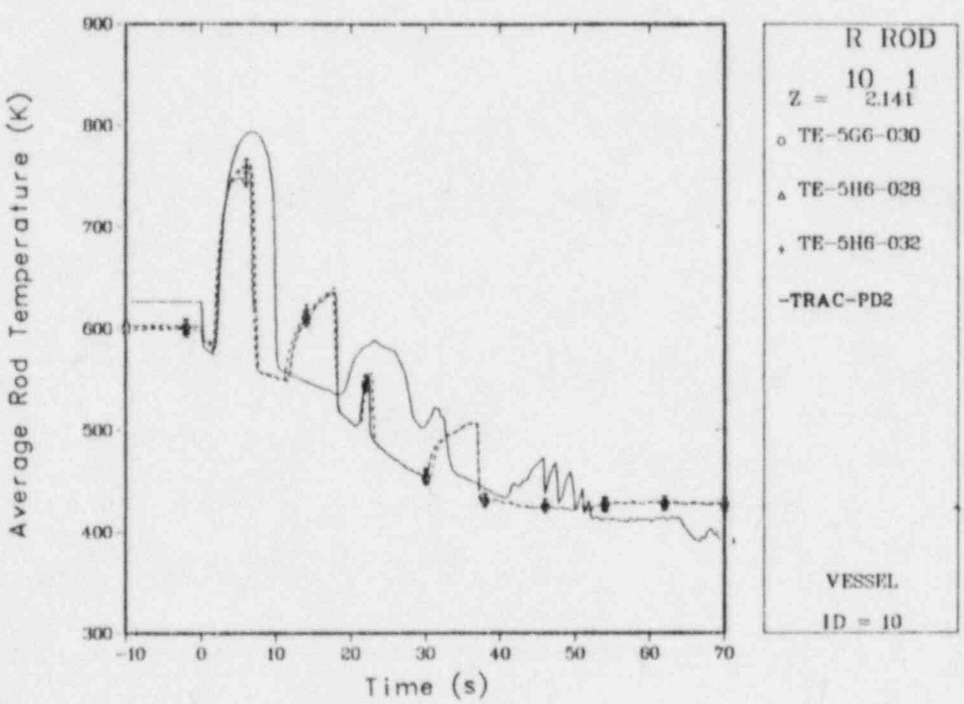


Fig. 203.
Comparison of the calculated central-rod midplane cladding-surface temperatures and group 3 data for LOFT L2-2.

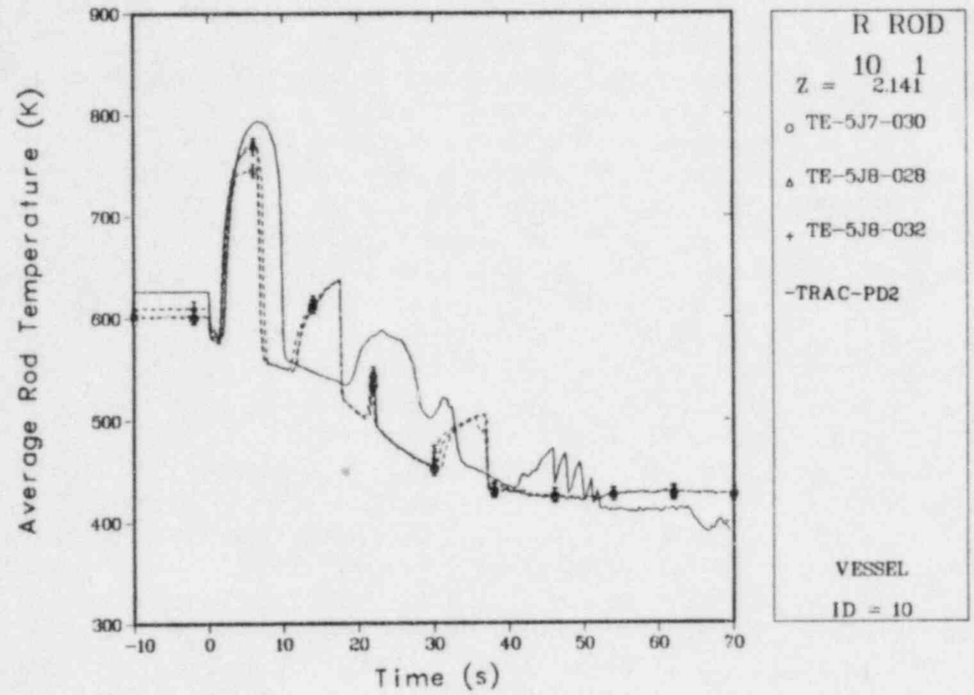


Fig. 204.
Comparison of the calculated central-rod midplane cladding-surface temperatures and group 4 data for LOFT L2-2.

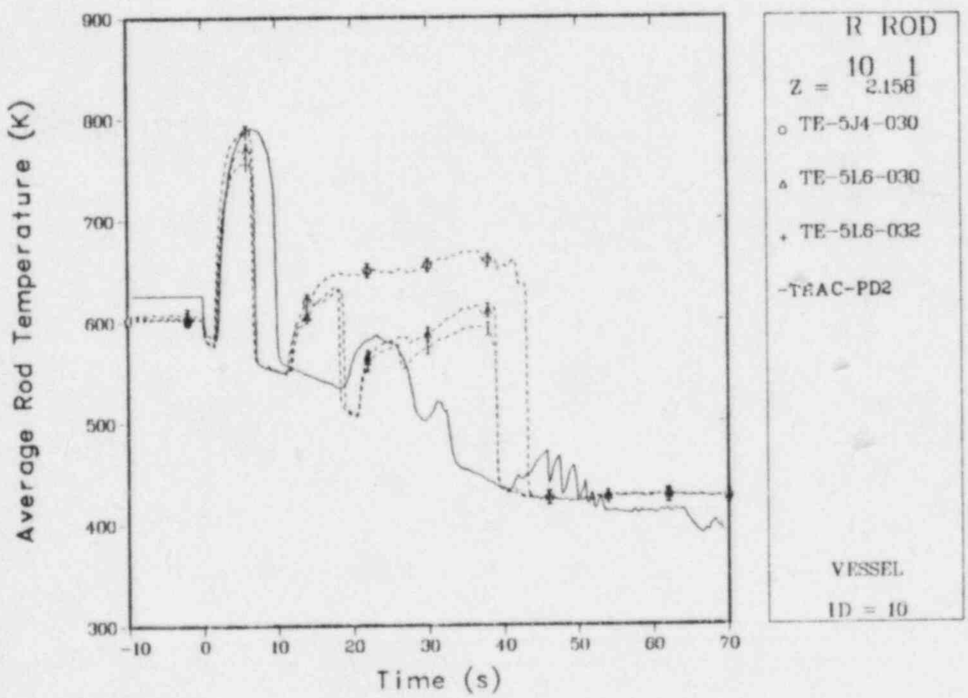


Fig. 205.
Comparison of the calculated central-rod midplane cladding-surface temperatures and group 5 data for LOFT L2-2.

dryout because the flow out of the adjacent broken-loop hot leg decreased the void fraction in azimuthal region 4 (Fig. 206).

Figures 201-205 compare the calculated results for rod 1 with the test data from groups 1-5. The wide variations in the test data were attributed to local effects (for example, adjacent rod power, grid spacer locations, local fluid conditions). Some general trends were apparent. The dryouts and rewets occurred similarly in the calculation and the data. The first rewet and subsequent dryouts and rewets occurred later in the calculation than in the data. Figure 198 shows the cause of the first rewet. The decrease in vapor fraction during the interval 8-18 s was caused by the liquid surging from the downcomer through the lower plenum and up into the core region. This surge was caused by the relative magnitudes of the intact- and broken-loop cold-leg mass flows and by flashing of liquid in the downcomer and lower plenum. We found that the pressure differential across the vessel diminished when the cold-leg temperature saturated at ~8 s (Fig. 190) because the system pressure decreased. The calculated saturation was delayed because of the reduced broken-loop cold-leg mass flow, which we ascribed to the inadequate subcooled critical-flow model.

Figures 207-210 compare the rod cladding-surface temperatures at axial levels below and above the midplane. These results were similar to those obtained at the midplane. However, low in the core, the code calculated a delayed DNB, which seemed to coincide with a delayed loss of fluid from the bottom level of the core (Fig. 198). Again, this discrepancy probably was caused by the reduced broken-loop cold-leg mass flow. The comparatively small computed temperature increases probably were caused by the inadequate TRAC fuel-rod model. The initial stored energy in the fuel rods was critical in

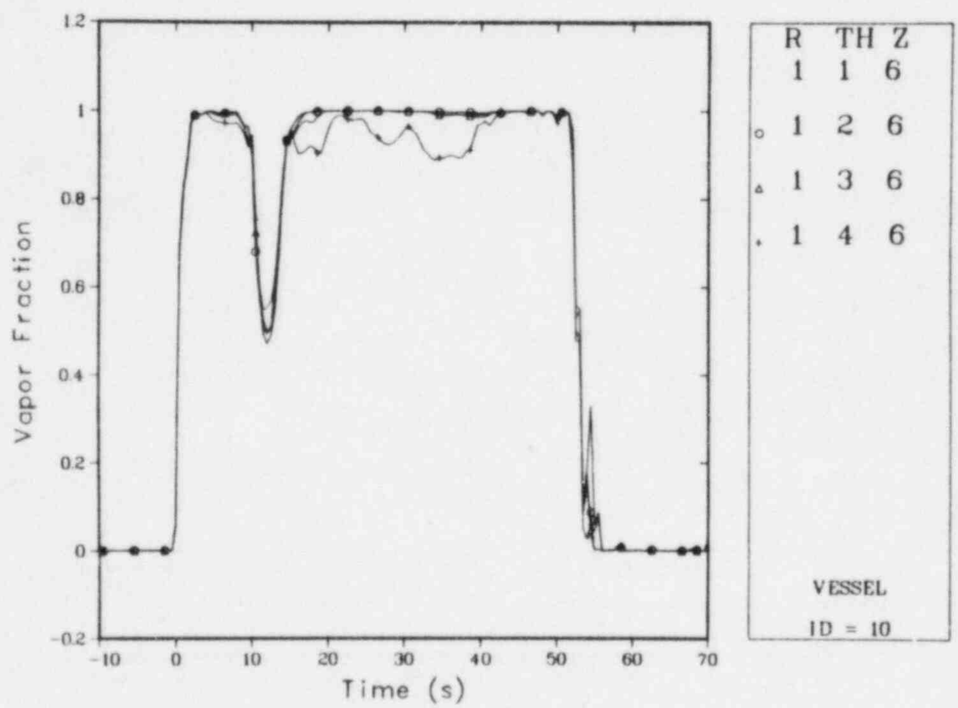


Fig. 206.
Comparison of the calculated vessel void fractions for LOFT L2-2.

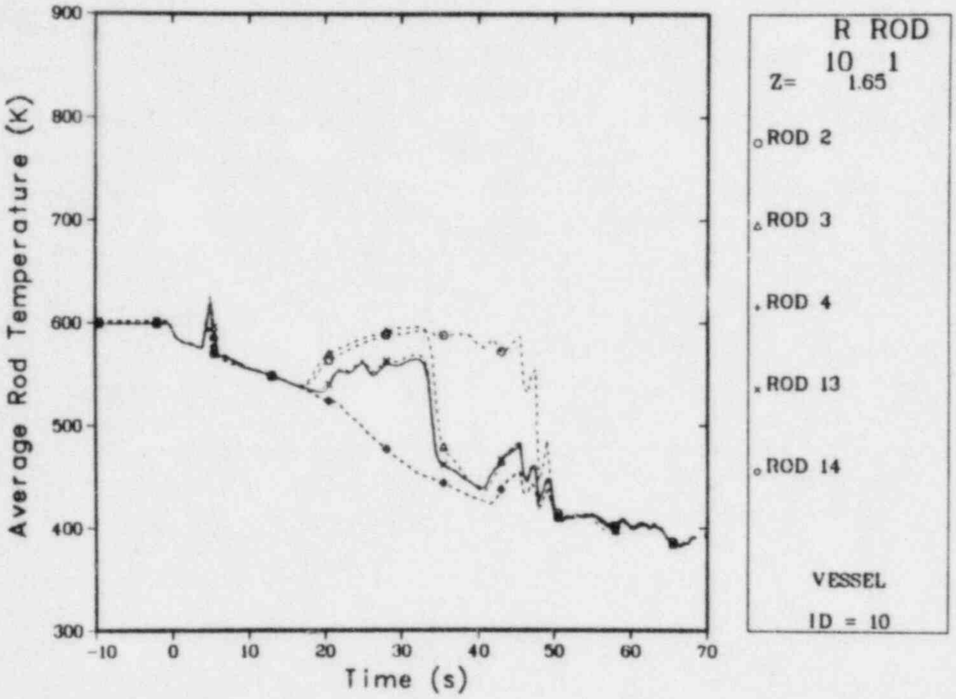


Fig. 207.
Azimuthal comparison of the calculated central-rod low-plane cladding-surface temperatures for LOFT L2-2.

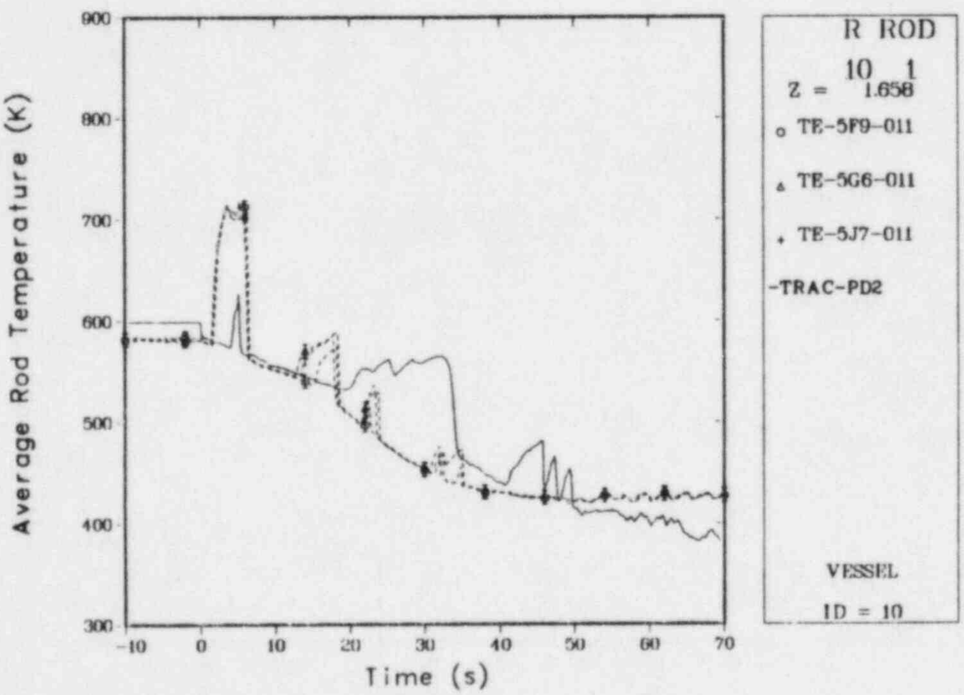


Fig. 208.
Comparison of the calculated central-rod low-plane cladding-surface temperatures and the group 6 data for LOFT L2-2.

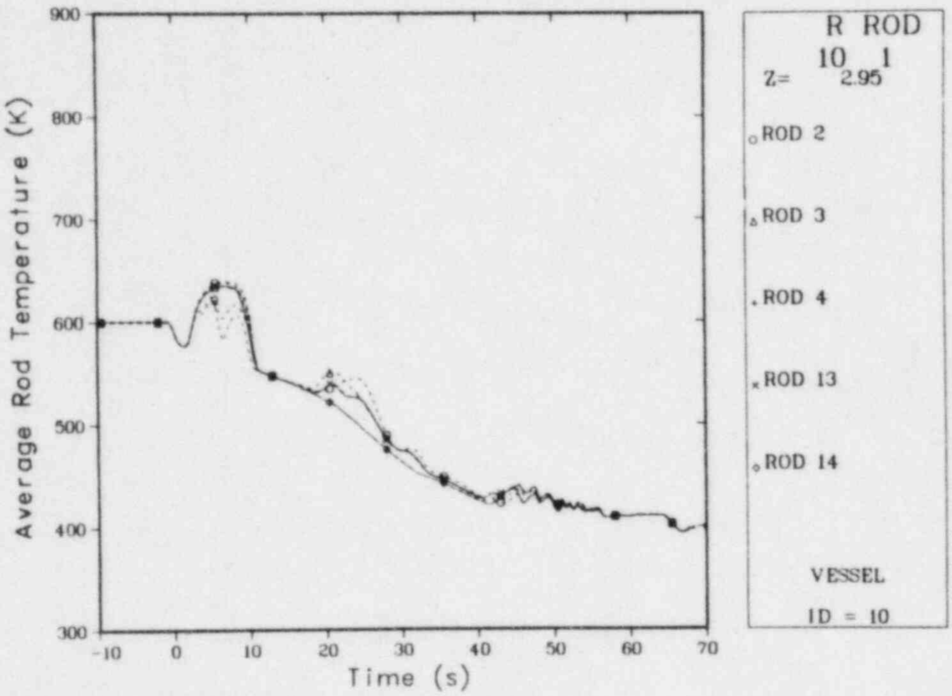


Fig. 209.
Azimuthal comparison of the calculated central-rod high-plane cladding-surface temperatures for LOFT L2-2.

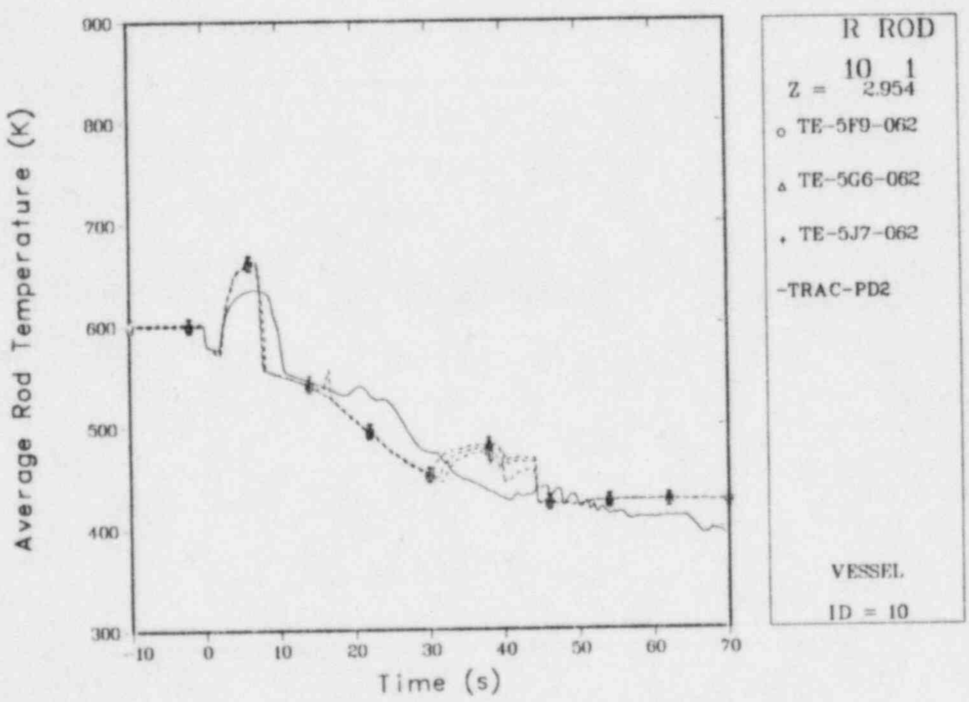


Fig. 210.
Comparison of the calculated central-rod high-plane cladding-surface temperatures and the group 7 data for LOFT L2-2.

determining the magnitude of the first rod-temperature maximum. Unfortunately, the TRAC-PD2 fuel-rod model did not permit axial variation of the fuel-cladding gap size. Therefore, it was impossible to predict accurately the maximum cladding temperature along the entire length of the fuel rods. We chose to match the midplane temperature in the base-case calculation, which resulted in low temperatures above and below that location.

ii. Second Radial Zone. Figures 211-219 compare the calculated and test results at the axial midplane of rods in the second TRAC radial zone of the core (Fig. 157). Figure 211 compares the calculated results for the four average rods and the one hot rod in the second radial zone. Again, the rod in the fourth azimuthal zone behaved differently from the others. The comparisons between the data and the calculations in Figs. 212-219 agreed better than those in the central module. The first calculated rewet occurred earlier in the second ring than in the first, in good agreement with the data, and the timing of the second dryout and rewet was better in the second zone.

Figures 220 and 221 compare the calculated and measured rod cladding-surface temperatures in the outermost radial core ring. The results were similar to those for the second radial ring.

D. Parametric Studies

Before Test L2-2, the LOFT facility had been operated at power for long periods of time. This type of operation modifies the state of the fuel rods by cracking and relocating the fuel. Reasonable modifications to the TRAC fuel-rod description can cause significant changes in the energy stored in the fuel rods before the transient begins and, thus, can cause large differences in the

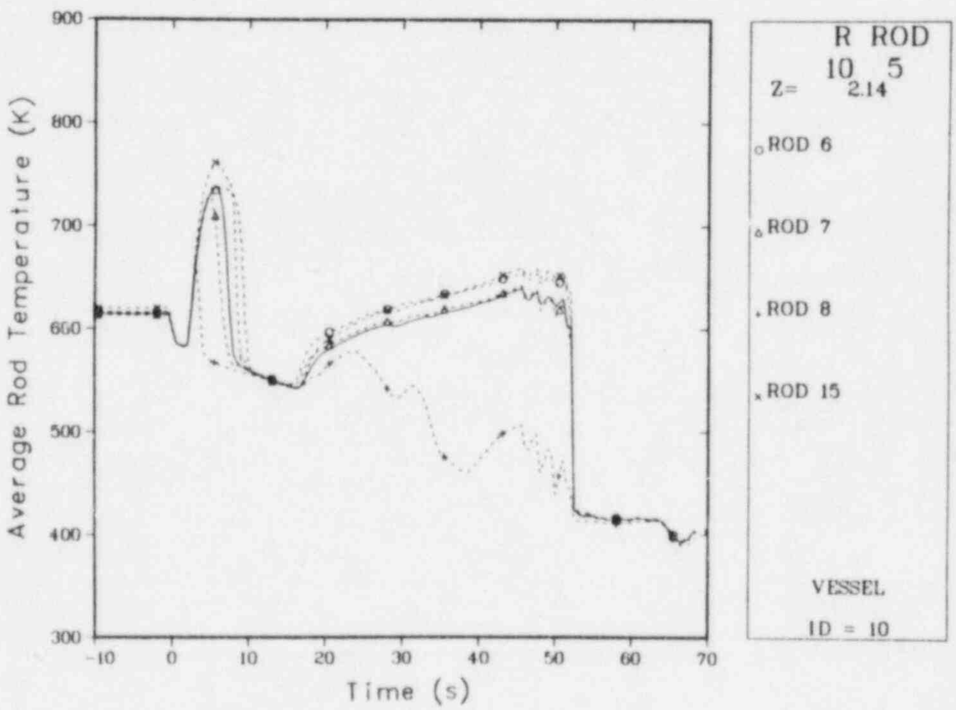


Fig. 211.
Comparison of the calculated second radial-zone midplane cladding-surface temperatures for LOFT L2-2.

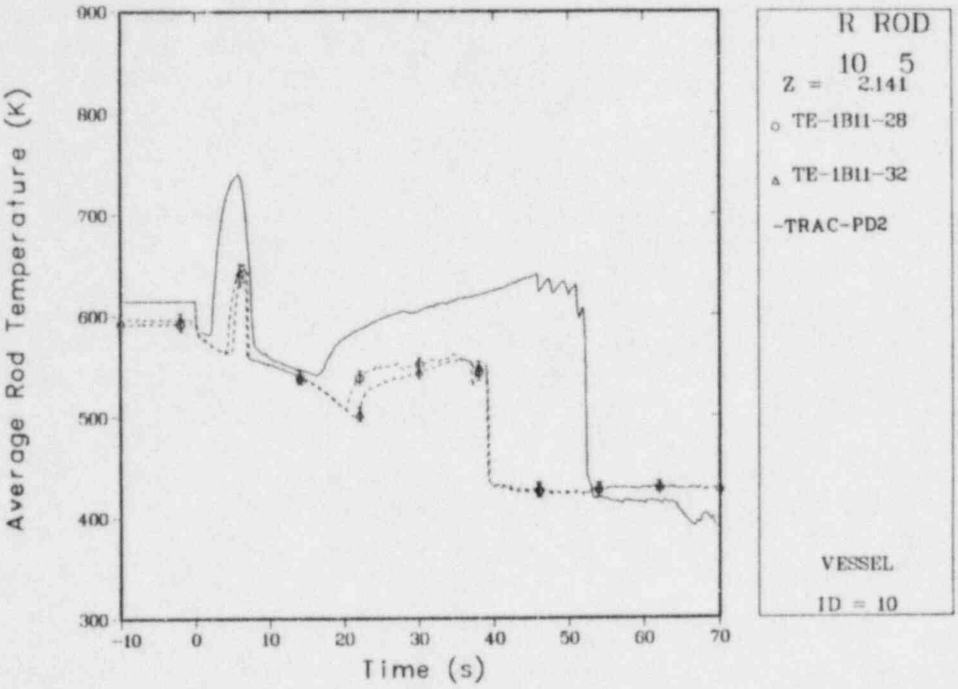


Fig. 212.
Comparison of the calculated second radial-zone midplane cladding-surface temperatures and group 8 data for LOFT L2-2.

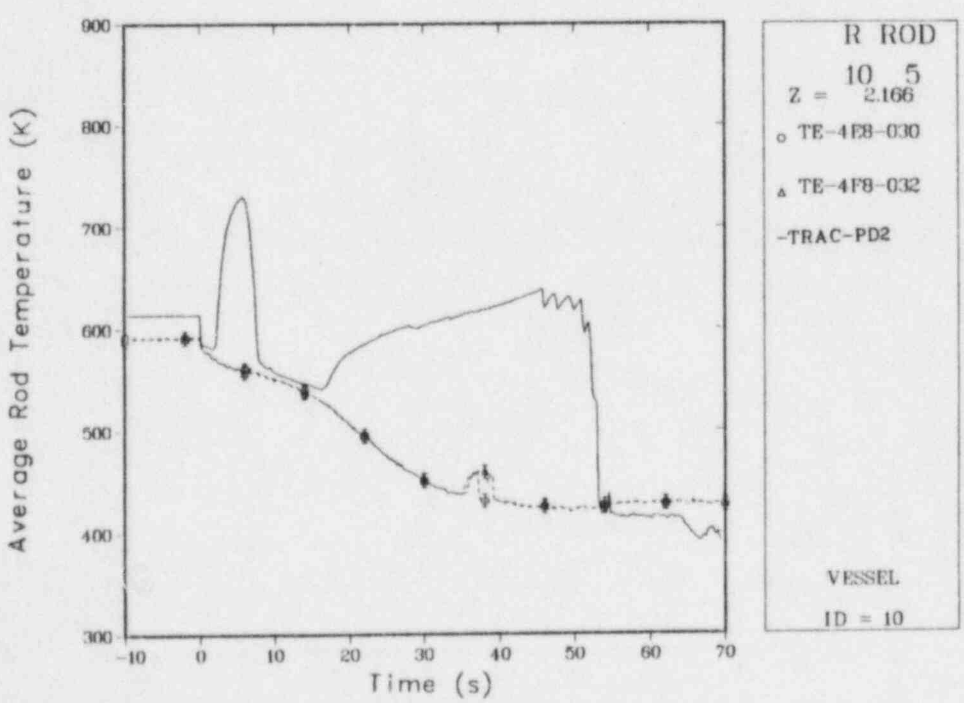


Fig. 213.
Comparison of the calculated second radial-zone midplane cladding-surface temperatures and group 9 data for LOFT L2-2.

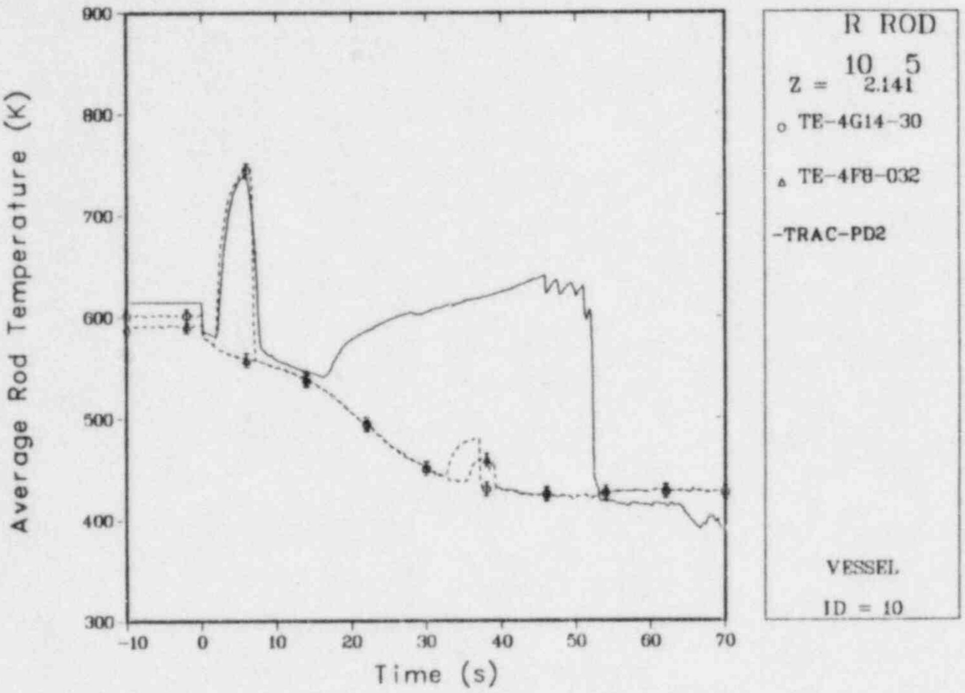


Fig. 214.
Comparison of the calculated second radial-zone midplane cladding-surface temperatures and group 10 data for LOFT L2-2.

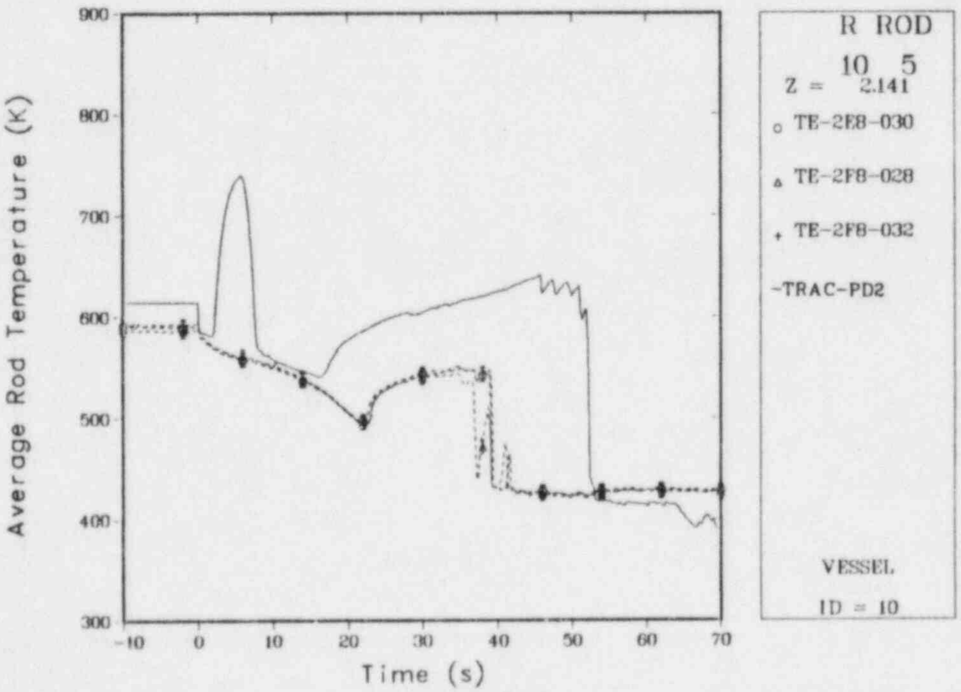


Fig. 215.
Comparison of the calculated second radial-zone midplane cladding-surface temperatures and group 11 data for LOFT L2-2.

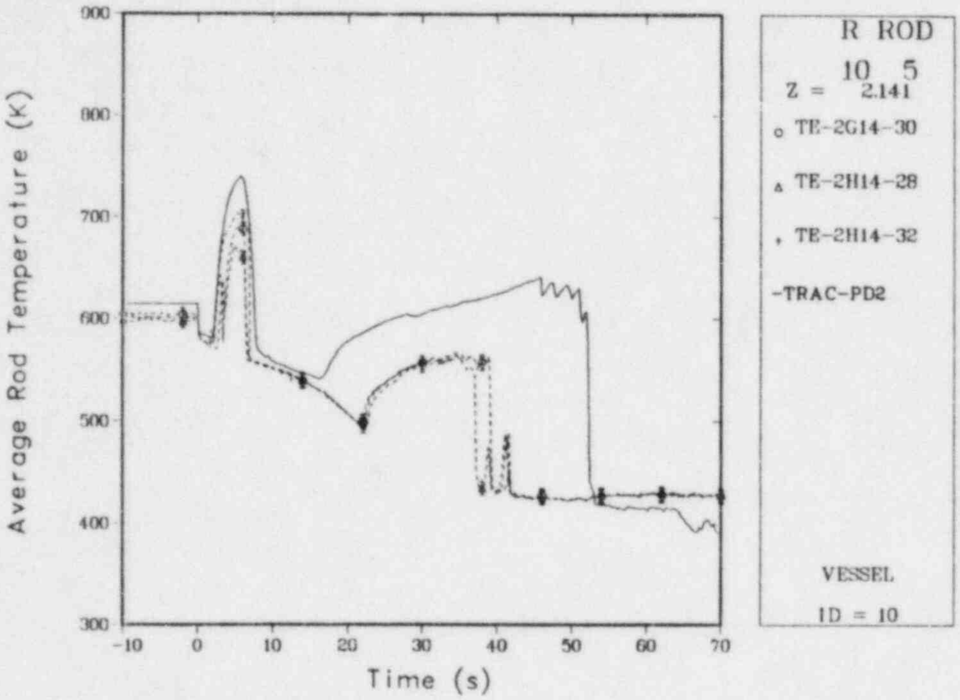


Fig. 216.
Comparison of the calculated second radial-zone midplane cladding-surface temperatures and group 12 data for LOFT L2-2.

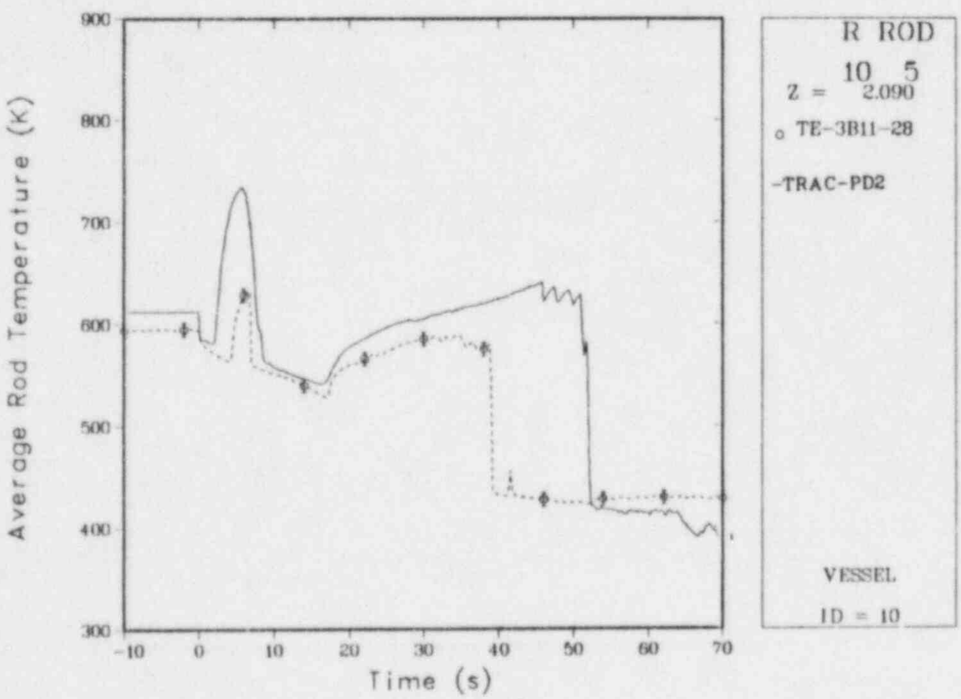


Fig. 217.
Comparison of the calculated second radial-zone midplane cladding-surface temperatures and group 13 data for LOFT L2-2.

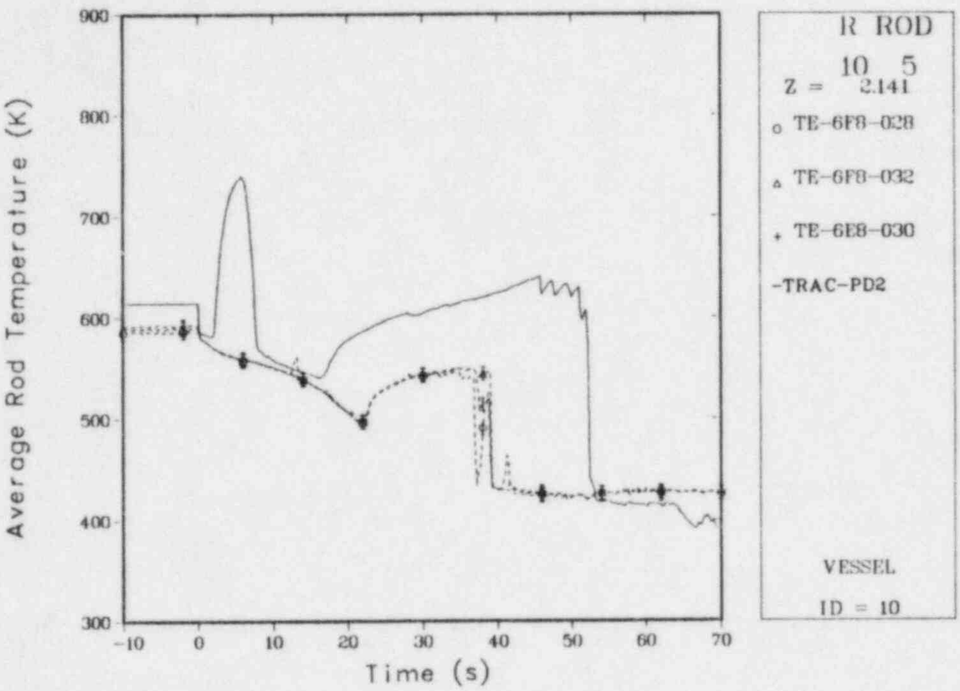


Fig. 218.
Comparison of the calculated second radial-zone midplane cladding-surface temperatures and group 14 data for LOFT L2-2.

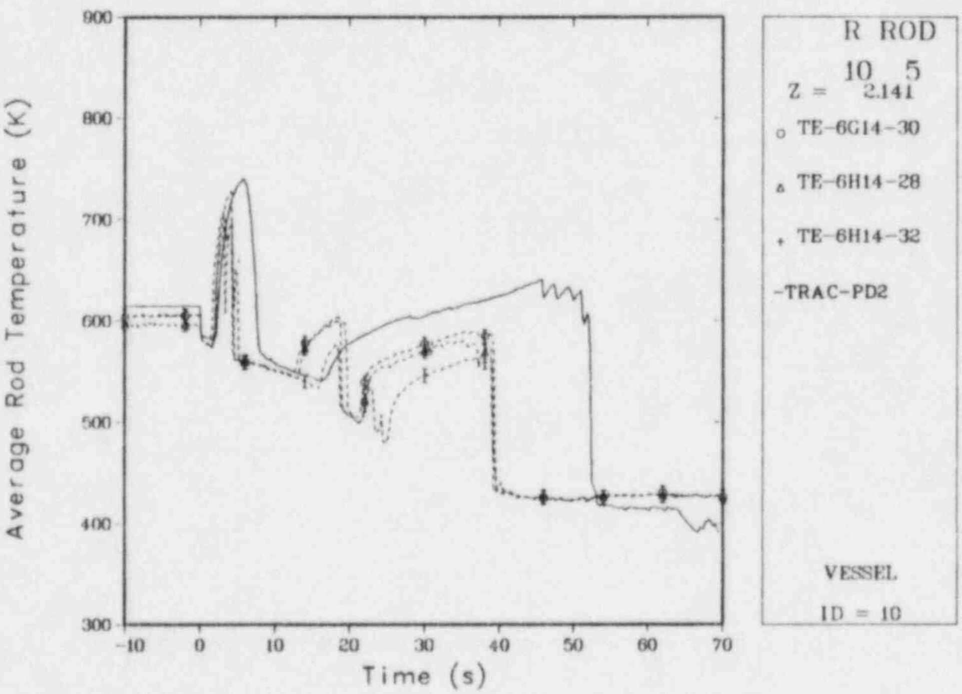


Fig. 219.
Comparison of the calculated second radial-zone midplane cladding-surface temperatures and group 15 data for LOFT L2-2.

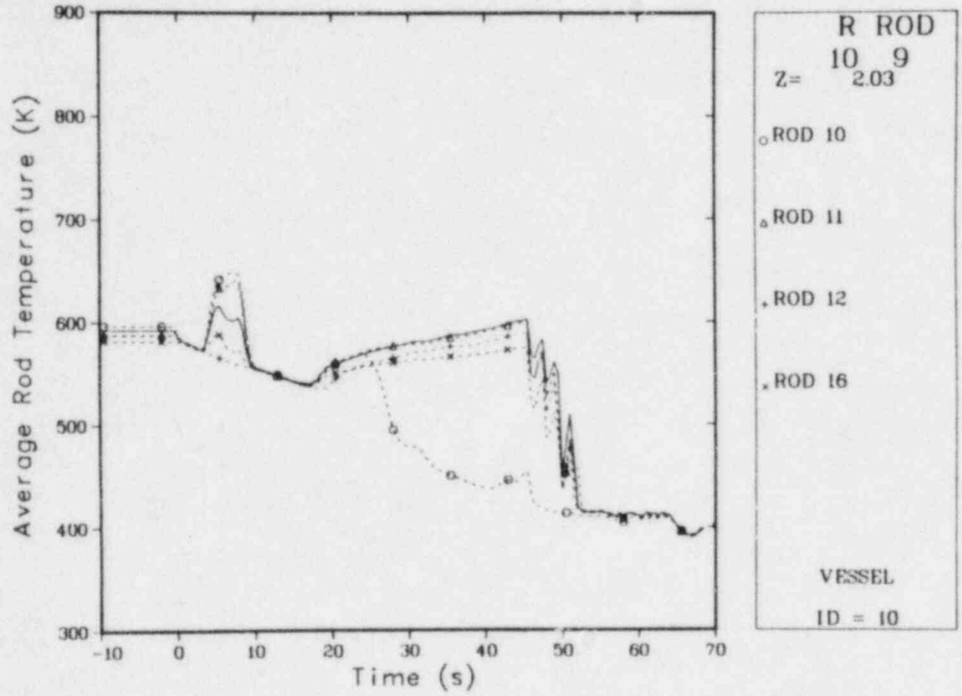


Fig. 220.
Azimuthal comparison of calculated outer radial-zone midplane cladding-surface temperatures for LOFT L2-2.

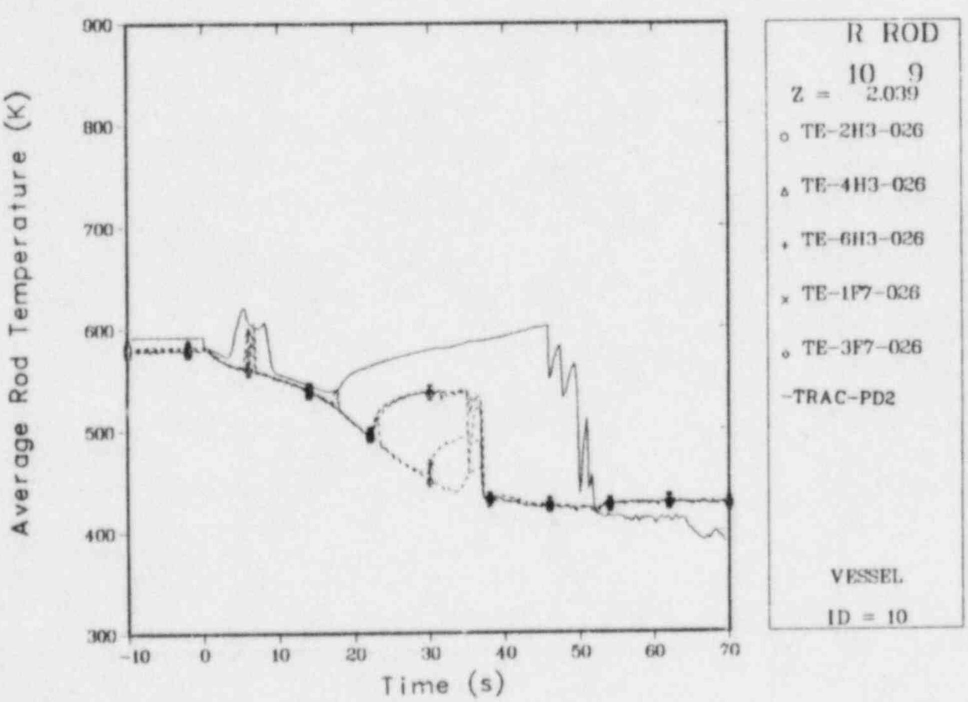


Fig. 221.
Comparison of calculated outer radial-zone midplane cladding-surface temperatures and group 16 data for LOFT L2-2.

maximum cladding temperature. This result agreed with the previously published results.[27,28] Unfortunately, we did not know the state of the fuel rods because they were sealed within the test vessel, nor did we know the initial fuel stored energy because thermocouples were located only on the outer cladding-surface in LOFT. Therefore, we conducted a study of four fuel-rod descriptions to choose the optimum for the TRAC-PD2 base-case calculation.

In this report we discuss only four of the rod descriptions that we investigated. Table XVIII lists these models. Three models used the capabilities of the standard TRAC-PD2 program. The fourth required a simple modification to the code itself. In the first three models, the location of the fuel-pellet surface differed. Model 1 placed the fuel-pellet surface at the location required in the LOFT fuel-rod manufacturing specifications; thus, it had a 0.0953-mm fuel-cladding gap. The second model arbitrarily set the gap dimension to 0.0796 mm and the third, to 0.0002 mm. A FRAPCON-1 (Ref. 29) calculation was the basis for determining the size of the third model. INEL personnel developed the FRAPCON-1 code* to simulate the behavior of fuel rods during operational power transients. We used a calculation that followed the LOFT power history up to the initiation of Test L2-2. As we examined the results of the FRAPCON-1 calculation, we noticed another effect, the variation of the fuel conductivity, which strongly influenced the initial rod stored energy. Because TRAC-PD2 evaluated metal conductivities from MATPRO[30] without accounting for cracking, we had to modify the code to adjust for this change in the fuel. The fourth calculation was performed with the fuel conductivity corrected to 74% of its theoretical value and with a 0.0002-mm gap; thus, these parameters agreed with those in the FRAPCON-1 calculation.

Figures 222-224 compare the calculated pressures, mass flows, and void fractions in the intact-loop cold leg for the four models. The results were essentially identical, indicating that the fuel-rod description did not affect the hydraulic response of the calculation.

Table XVIII compares the calculated steady-state gap conductance for the four calculations at the midplane of rod 1 with the FRAPCON-1 results. Figure 225 shows the radial temperature distribution calculated at the same spot. Case 4, which used the corrected conductivity and a 0.0002-m gap, agreed better with the FRAPCON-1 results than cases 1-3. Figure 226 compares the four calculated transient responses of the fuel-rod surface at the axial midplane of rod 1 with some typical data for this location. As we expected, the model using the FRAPCON-1 conditions gave the best overall agreement with the data. Because this model required a modified code, it could not be used as the base case for the TRAC-PD2 developmental assessment. Therefore, we chose the 0.0796-mm gap model for our base-case calculation.

However, Figs. 208 and 210 show that this gap did not give good results below or above the midplane. This conclusion was reasonable because the fuel power history at these locations differed from that at the midplane. Because TRAC-PD2 did not allow for axial changes in the fuel-rod geometry, we had to choose which of the three gap sizes to apply uniformly. Because the peak cladding temperature occurred at the midplane, we felt that it was most important to match the fuel-rod conditions there. Similarly, the fuel rods located outside of module 5 experienced a different history from the central rods. Again, TRAC-PD2 did not permit variation of fuel-rod geometry from rod

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*W. Driscol and G. Berna of INEL provided copies of FRAPCON-1 and the FRAPCON LOFT input deck. The input format for FRAPCON-1 is given in Ref. 29.

TABLE XVIII

LOFT L2-2 FUEL-ROD MODELS FOR SENSITIVITY STUDY

Model	Outside Fuel Pellet Radius (mm)	Gap Width (mm)	Conductance Gap ($W \cdot m^{-2} \cdot K^{-1}$)	Fuel Conductivity Factor
1	4.6469	0.0953	3926	1.0
2	4.6626	0.0796	4741	1.0
3	4.7420	0.0002	28370	1.0
4	4.7420	0.0002	28370	0.74
FRAPCON	--	--	37000	0.74

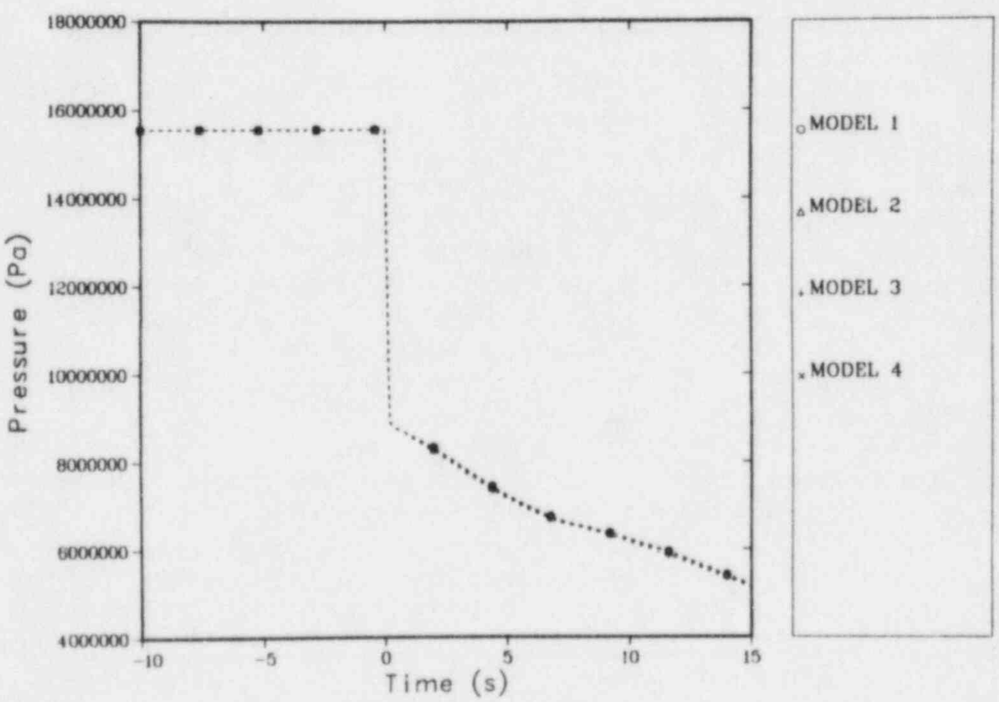

Fig. 222.
LOFT L2-2 parametric-study pressures.

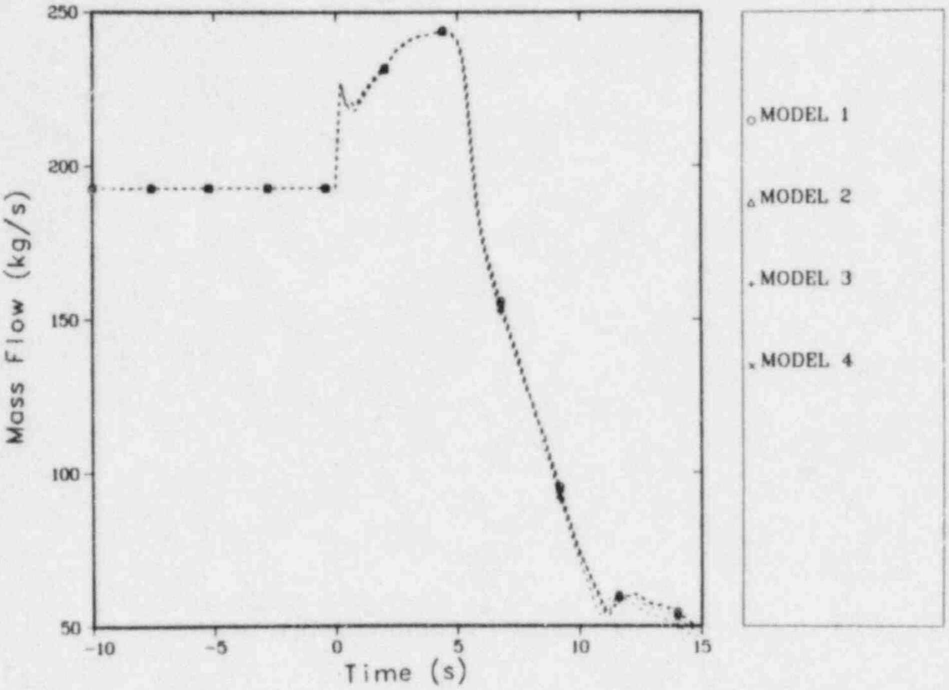

Fig. 223.
LOFT L2-2 parametric-study mass flows.

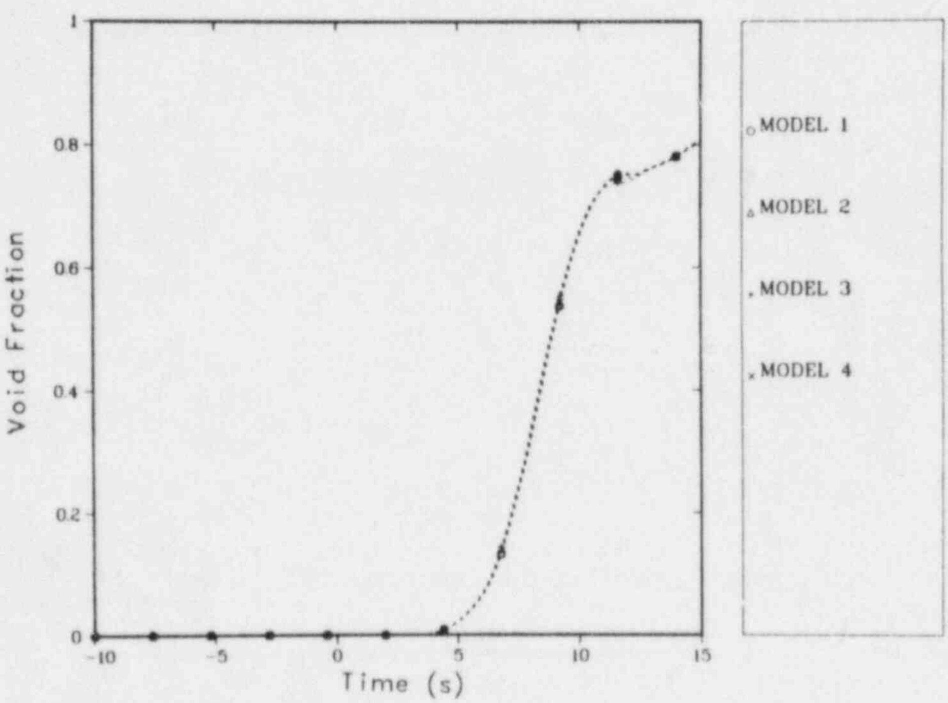

Fig. 224.
LOFT L2-2 parametric-study void fractions.

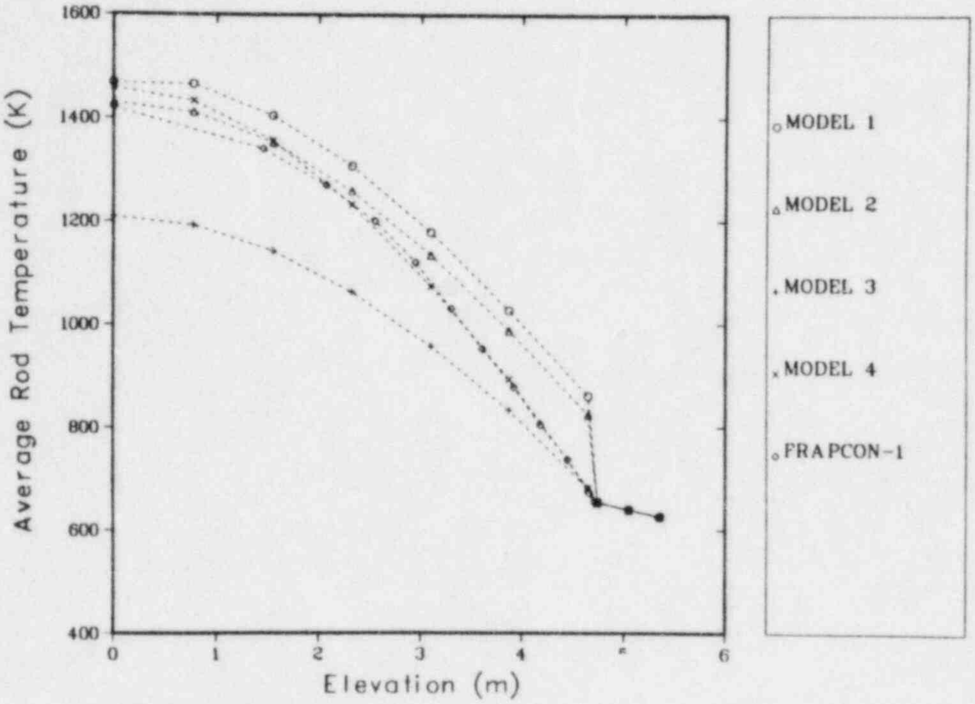

Fig. 225.
LOFT L2-2 calculated radial temperature distribution at the midplane of rod 1.

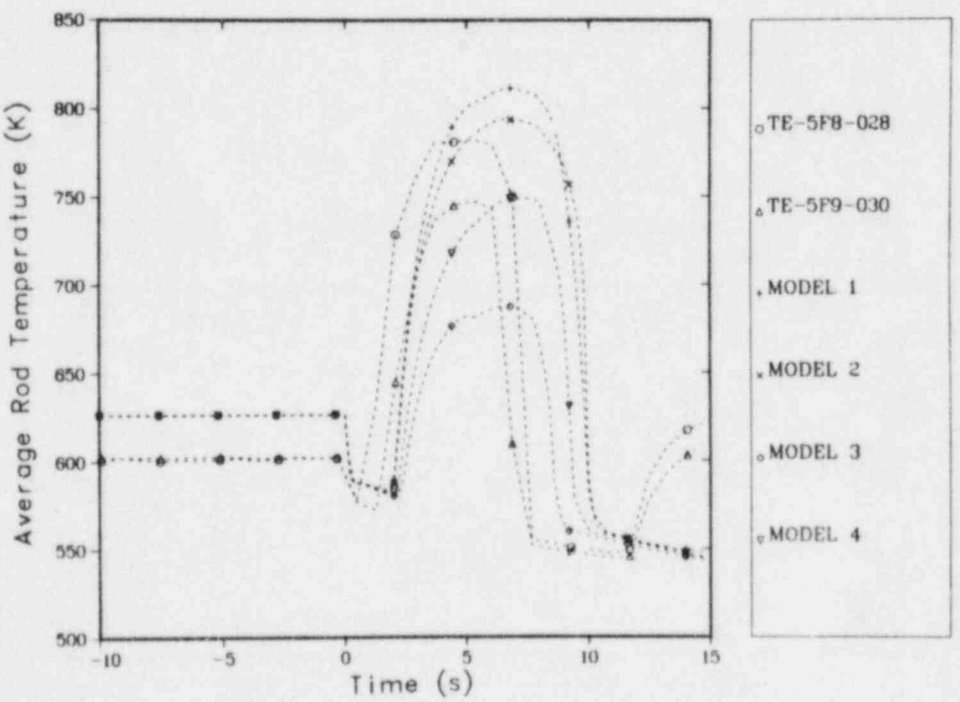

Fig. 226.
LOFT L2-2 transient response of the fuel-rod surface at the axial midplane of rod 1.

to rod and we were forced to retain the 0.0796-mm gap. The results in Figs. 212-219 and Fig. 221 did not deteriorate appreciably from the use of this gap size, but this may have been fortuitous.

E. TRAC-PD2 Features Tested

The LOFT L2-2 calculation tested all TRAC-PD2 features that were necessary to perform a large-break LOCA calculation for a full-scale PWR. Only this calculation included nuclear-power fuel rods. No other assessment calculation showed significant effects caused by subcooled critical flow. Finally, LOFT L2-2 provided the most physical example of the interaction between cold ECC liquid and a complete system, including mixing phenomena, core bypass, and eventual reflood.

F. Conclusions and Recommendations

The agreement between the TRAC-PD2 calculations and the data for LOFT Test L2-2 generally was quite good. In the cases where there was a large discrepancy between the calculated and measured results, we have identified possible test difficulties or suggested TRAC modifications to improve the agreement. Our recommendations are

- improve the treatment of heat transfer from structural materials in the vessel by eliminating the lumped-parameter heat-slab model (also suggested because of the LOFT L1-4 results);
- improve the treatment of bubble nucleation, particularly in the case of subcooled critical flow; and
- allow variations in the fuel-rod geometry and fuel conductivity, both axially within a rod and between rods in different core regions.

This final recommendation might be extended to provide an automated method of coupling TRAC with a fuel-rod simulation code, such as FRAPCON-1, to obtain accurate initial conditions.

G. Input Data Decks

Appendix K lists the steady-state and transient input decks for LOFT L2-2. All component and trip data were obtained from the dump taken at the conclusion of the steady-state calculation.

XIV. CONCLUSIONS

The tests described briefly in Table I and subsequently analyzed in this report have served a dual purpose for TRAC-PD2. First, the tests constitute a minimal set of calculations that, in the final analyses presented here, represent the initial independent assessment of the code, covering the full range of LOCA phenomena and demonstrating the integral-system calculational capability. Second, the tests and their analyses with earlier, developmental versions of TRAC-PD2 have formed the basis of quality assurance for the code, that is, developmental assessment. Toward the end of the development process resulting in TRAC-PD2, we ran these analyses many times as changes were made to the code. Through the repeated analyses of the same tests, we found and corrected many code errors and improved some of the code models and constitutive relations. Although we do not claim that the code is free of errors, this process has reduced substantially the errors and made the code more robust and easier to use, at least in terms of code failures and error messages indicating calculational difficulties.

The code calculated many things very well. The results from the separate-effects tests, including the Edwards' pipe blowdown, the two CISE tests, the two Marviken critical-flow tests, and the Bennett tube experiments, generally compared very well with the test data and did not indicate problems with the components and constitutive equations that are important to the large-break LOCA analysis. In particular, these tests indicated that the calculation of critical flow and wall heat transfer is good.

The analyses of the Creare tests demonstrated that TRAC-PD2 can calculate well the ECC-bypass phenomena under conditions of high or low flows and high or low subcooling of the injected ECC liquid. We ran two complete flooding curves from complete bypass to total delivery. The curve based on low-subcooling injection showed that the three-dimensional VESSEL component can calculate accurately the coarse, overall multidimensional flows important to downcomer penetration. In addition to verifying the three-dimensional numerics and field equations in the code, the low-subcooling case also yielded indirect evidence that the interfacial-drag model in the code is adequate for this purpose. The high-subcooling case further verified the results of the low-subcooling case and indicated that the interfacial-condensation model in TRAC-PD2 also is adequate for calculating downcomer penetration.

The two FLECHT tests demonstrated the validity of the new dynamic fine mesh in the fuel-rod conduction model for tracking quench fronts during the reflood phase of a large-break LOCA. The results for Tests S-06-3 and L2-2 also support this conclusion. Not only does the fine-mesh scheme work, but it can track accurately the quench fronts during both slow and fast refloods. This major change in TRAC-PD2 resolved problems with the reflood analysis in TRAC-P1A (Ref. 3) associated with fast refloods. We no longer observe in the calculations the quench front artificially stalling at axial cell boundaries in the core.

The results of the separate-effects analyses of critical flow (the two Marviken tests and the Semiscale-nozzle study) demonstrated the validity of the TRAC-PD2 scheme for calculating critical flow using the fully implicit, one-dimensional numerics together with a detailed noding scheme. The fully implicit one-dimensional numerics allow the code to exceed the material Courant limit on time steps and, therefore, do not affect adversely the execution time when short cells are used. The detailed noding scheme permits representation of flow-area changes leading to the choking plane and resolution of large pressure gradients upstream of the choking plane. This detail is necessary for calculating correctly the fluid conditions at the choking plane. The results for Marviken Test 24, with its low L/D ratio, suggested that this scheme as it is implemented in TRAC-PD2 may break down in cases where nonequilibrium effects are important. In such cases, appreciable superheat exists in the liquid upstream of the choking plane. The analyses for Test L1-4 and L2-2 confirm the problem, although the results were not affected adversely. The superheat in the liquid upstream of the choking plane works through the TRAC-PD2 constitutive models to generate vapor unrealistically and to drive the calculation toward equilibrium. Although this problem is not important to large-break LOCA analyses, it can have a significant impact on small-break LOCA analyses where the period of subcooled critical flow is very long. The resolution of this problem with TRAC-PD2 lies in alternate noding schemes for critical flow in small-break LOCA analyses and comparisons of calculated results to existing critical-flow models. The long-term resolution of the problem requires that a delayed-nucleation model and/or a critical-flow model be included in the code.

The analyses for LOFT L1-4 and L2-2 indicated that the lumped-parameter heat slabs in the TRAC-PD2 VESSEL are inadequate in that the stored energy in the slabs is allowed to dissipate too rapidly into the adjacent fluid. This problem is not overly significant for large-break LOCA analyses because the problem time is short and because the active portion of the vessel structural mass can be estimated and modeled. For small-break LOCA analyses this problem can have significant impact on the calculated course of the transient by adversely affecting the time history of the energy content of the fluid in the primary system. Resolution of the problem requires the implementation of at least a one-dimensional heat slab in the VESSEL similar to those in the one-dimensional components.

Many of the analyses demonstrated the capability of the code to initialize itself to the correct steady-state conditions by running a generalized steady-state calculation. The resulting steady-state conditions are consistent with the models and numerics that are used for transient analyses. The analysis of Semiscale Test S-06-3 demonstrated that the user can renode and otherwise change components on restart at any point in the calculational sequence. The analyses for LOFT L1-4 and L2-2 showed that it is unnecessary to change components at any time after the beginning of the steady-state calculation; in particular, for these two tests we input at the beginning of the steady-state calculation all of the components necessary for the transient calculation, and we started the transient calculation from the steady-state restart dump with the most simple input deck possible.

The analyses of Semiscale Tests S-02-8 and S-06-3 and LOFT L1-4 and L2-2 have demonstrated the capability of the TRAC-PD2 code to perform integral calculations with complete representations of the primary systems through all phases of the large-break LOCA scenario (steady state, blowdown, refill, and reflood). The calculations of these tests compared well with the appropriate data. All of the analyses in this report indicate that TRAC-PD2 is a very versatile, flexible, robust thermal-hydraulic code that is well suited to large-break LOCA analyses and that may be applied to a large variety of other thermal-hydraulic problems.

REFERENCES

1. "TRAC-PD2, An Advanced Best-Estimate Computer Program for Pressurized Water Reactor Loss-of-Coolant Accident Analysis," Los Alamos National Laboratory report LA-8709-MS, NUREG/CR-2054 (April 1981).

2. A. R. Edwards and T. P. O'Brien, "Studies of Phenomena Connected with the Depressurization of Water Reactors," J. of Brit. Nucl. Ener. Soc. 9, 125-135 (April 1970).

3. "TRAC-P1A Developmental Assessment," Los Alamos Scientific Laboratory report LA-8056-MS, NUREG/CR-1059 (October 1979).

4. R. W. Garner, "Comparative Analyses of Standard Problems--Standard Problem One (Straight Pipe Depressurization Experiments)," Aerojet Nuclear Company report I-212-74-5.1 (October 1973).

5. A. Premoli and W. T. Hancox, "An Experimental Investigation of Subcooled Blowdown with Heat Addition," Specialists Meeting on Transient Two-Phase Flow, S. Banerjee and K. R. Weaver, Eds., (Atomic Energy of Canada, Ltd., Mississauga, Ontario, 1978) pp. 550-579.

6. W. T. Hancox and A. Premoli, "Standard Problem 3: Subcooled Blowdown with Heat Addition," Submission to Committee on the Safety of Nuclear Installations Ad Hoc Group on Emergency Core Cooling, Bethesda, Maryland (Revised March 1976).

7. "Results from Test 4, The Marviken Full-Scale Critical Flow Tests," Joint Reactor Safety Experiments in the Marviken Power Station, Sweden, Marviken report MXC-204 (September 1979).

8. "Results from Test 24, The Marviken Full-Scale Critical Flow Tests," Joint Reactor Safety Experiments in the Marviken Power Station, Sweden, Marviken report MXC-224 (September 1979).

9. C. B. Mullins, C. R. Hyman, W. G. Craddick, T. M. Anklam, and R. A. Hedrick, "PWR Blowdown Heat-Transfer Separate-Effects Program Data Evaluation Report--THTF Test Series II," Oak Ridge National Laboratory report ORNL/NUREG-53, NUREG/CR-0539 (April 1979).

10. O. C. Iloeje, D. N. Plummer, P. Griffith, and W. M. Rohsenow, "An Investigation of the Collapse and Surface Rewet in Film Boiling in Forced Vertical Flow," J. Heat Trans. 97, 166-172 (May 1975). Note that this reference has several misprints in Eq. (5): 0.217 should be 0.127 and g_c should be g in the 1/3 power term.

11. A. W. Bennett, G. F. Hewitt, H. A. Kearsey, and R. K. F. Keeys, "Heat Transfer to Steam-Water Mixtures Flowing in Uniformly Heated Tubes in which the Critical Heat Flux Has Been Exceeded," Atomic Energy Research Establishment, Harwell, England, report AERE-R5373 (1967).

12. "TRAC-P1A: An Advanced Best-Estimate Computer Program for PWR LOCA Analysis," Los Alamos Scientific Laboratory report LA-7777-MS, NUREG/CR-0665 (May 1979).

13. "TRAC Newsletter No. 1," Los Alamos Scientific Laboratory publication (July 1979).

14. C. J. Crowley, J. A. Block, and C. N. Cary, "Downcomer Effects in a 1/15-Scale PWR Geometry--Experimental Data Report," Creare, Inc. report NUREG-0281 (May 1977).

15. E. R. Rosal, L. E. Hochreiter, M. F. McGuire, and M. C. Krepinevich, "FLECHT Low Flooding Rate Cosine Test Series Data Report," Westinghouse Electric Corporation report WCAP-8651 (1975).

16. E. R. Rosal, C. E. Conway, and M. C. Krepinevich, "FLECHT Low Flooding Rate Skewed Test Series Data Report," Westinghouse Electric Corporation report WCAP-9108 (May 1977).

17. E. M. Sparrow and R. D. Cess, Radiation Heat Transfer (Brooks/Cole Publishing Co., Belmont, California, 1966).

18. L. J. Ball, D. J. Hanson, K. A. Dietz, and D. J. Olson, "Semiscale Program Description," Idaho National Engineering Laboratory report TREE-NUREG-1210 (May 1978).

19. H. S. Crapo and K. E. Sackett, "Exp[illegible]tal Data Report for Semiscale Mod-1 Test S-02-8 (Blowdown Heat Transfer Test)," Aerojet Nuclear Company report ANCR-NUREG-1238 (August 1976).

20. B. L. Collins, M. L. Patton, Jr., K. E. Sackett, and K. Stanger, "Experimental Data Report for Semiscale Mod-1 Test S-06-3 (LOFT Counterpart Test)," EG&G Idaho, Inc. report NUREG/CR-0251 (July 1978).

21. H. C. Robinson, "LOFT System and Test Description (Loss-of-Coolant Experiments Using a Core Simulator)," Idaho National Engineering Laboratory report TREE-NUREG-1019 (November 1976).

22. D. L. Batt, "Experiment Data Report for LOFT Nonnuclear Test L1-4," Idaho National Engineering Laboratory report TREE-NUREG-1084 (July 1977).

23. H. C. Robinson, "Quick-Look Report on LOFT Nonnuclear Experiment L1-4," Idaho National Engineering Laboratory report QLR-L1-4 (June 1977).

24. M. McCormick-Barger, "Experiment Data Report for LOFT Power Ascension Test L2-2," Idaho National Engineering Laboratory report NUREG/CR-0492, TREE-1322 (1979).

25. D. L. Reeder, "LOFT System and Test Description (5.5-ft Nuclear Core 1 Loces)," EG&G Idaho, Inc. report NUREG/CR-0247, TREE-1208 (July 1978).

26. James F. Jackson and M. G. Stevenson, "Nuclear Reactor Safety: October 1-December 31, 1979," Los Alamos Scientific Laboratory report LA-8299-PR, NUREG/CR-1516 (May 1980).

27. D. A. Niebruegge, E. L. Tolman, and C. W. Solbrig, "Best-Estimate Fuel Rod Modeling Techniques," Nucl. Sci. Eng. 68, 363-368 (1978).

28. E. L. Tolman, W. E. Driskell, and E. W. Coryell, "Fuel Rod Stored-Energy Estimates for the LOFT LOCA Tests, "Amer. Nucl. Soc. Trans. 34, 484 (1980).

29. G. A. Berna, M. P. Bohn, and D. R. Coleman, "FRAPCON-1: A Computer Code for the Steady State Analysis of Oxide Fuel Rods," Idaho National Engineering Laboratory report CDAP-TR-78-032-R1 (1978).

30. D. L. Hagrman, G. A. Reymann, and R. E. Mason, "MATPRO-Version 11 (Rev. 1): A Handbook of Material Properties for Use in the Analysis of Light Water Reactor Fuel Behavior," EG&G Idaho, Inc. report NUREG/CR-0497, TREE-1280, Rev. 1 (February 1980).

APPENDIX A

TRAC INPUT DECK FOR EDWARDS' BLOWDOWN EXPERIMENT

```
              1         2         3         4         5         6         7
CARD 1234567890123456789012345678901234567890123456789012345678901234567890

             2             0
EDWARDS BLOWDOWN EXPERIMENT MODEL NO. 1
Q9CA 25.4 GOPD2
             0 0.
             0             1             4             3             0
   .100000E-02   .100000E-02   .100000E+01 0.
            10            20            20             0             0
  0          1  0          2  0          3  0          4  0          0
FILL                       4             4
             3
  1.205000E-01  5.060000E-04                              5.148000E+02
  6.996100E+06
PIPE                       2             2
            16             0             1             2             6
             0             1
  0.            0.            0.            0.            0.
  0.
R 6 5.0917E-03R 9 3.0550E-02R 1 4.1000E-02E
R 6 2.1400E-05R 9 1.2840E-04R 1 1.7230E-04E
R 1 3.6566E-03R16 4.2030E-03E
R 1 1.4360E+00R16 0.        E
F   0.        E
F   7.3152E-02E
F            4E
F   0.        E
F   0.        E
    4.9830E+02    4.9827E+02    4.9823E+02    4.9820E+02    4.9817E+02
    4.9813E+02    4.9810E+02    4.9807E+02    4.9803E+02    4.9800E+02
    4.9797E+02    4.9793E+02    4.9790E+02    4.9787E+02    4.9783E+02
    4.9780E+02E
    4.9830E+02    4.9827E+02    4.9823E+02    4.9820E+02    4.9817E+02
    4.9813E+02    4.9810E+02    4.9807E+02    4.9803E+02    4.9800E+02
    4.9797E+02    4.9793E+02    4.9790E+02    4.9787E+02    4.9783E+02
    4.9780E+02E
F   6.9961E+06E
PIPE                       3             3
            30             0             2             3             6
             0             0
  0.            0.            0.            0.            0.
  0.
```

```
                 1         2         3         4         5         6         7
CARD    1234567890123456789012345678901234567890123456789012345678901234567890

  41    R29 1.2515E-01R 1 1.2050E-01E
  42    R29 5.2600E-04R 1 5.0600E-04E
  43    F   4.2030E-03E
  44    F   0.        E
  45    F   0.        E
  46    F   7.3152E-02E
  47    F            4E
  48    F   0.        E
  49    F   0.        E
  50    R 1 4.9780E+02R 1 4.9908E+02R 1 5.0037E+02R 1 5.0165E+02R 1 5.0293E+02
  51    R 1 5.0422E+02R 2 5.0550E+02R 1 5.0528E+02R 1 5.0507E+02R 1 5.0485E+02
  52    R 1 5.0463E+02R 1 5.0442E+02R 2 5.0420E+02R 1 5.0453E+02R 1 5.0485E+02
  53    R 1 5.0518E+02R 2 5.0550E+02R 1 5.0597E+02R 1 5.0643E+02R 2 5.0690E+02
  54    R 1 5.0645E+02R 1 5.0600E+02R 1 5.0555E+02R 1 5.0510E+02R 1 5.0465E+02
  55    R 1 5.0420E+02E
  56    R 1 4.9780E+02R 1 4.9908E+02R 1 5.0037E+02R 1 5.0165E+02R 1 5.0293E+02
  57    R 1 5.0422E+02R 2 5.0550E+02R 1 5.0528E+02R 1 5.0507E+02R 1 5.0485E+02
  58    R 1 5.0463E+02R 1 5.0442E+02R 2 5.0420E+02R 1 5.0453E+02R 1 5.0485E+02
  59    R 1 5.0518E+02R 2 5.0550E+02R 1 5.0597E+02R 1 5.0643E+02R 2 5.0690E+02
  60    R 1 5.0645E+02R 1 5.0600E+02R 1 5.0555E+02R 1 5.0510E+02R 1 5.0465E+02
  61    R 1 5.0420E+02E
  62    F   6.9961E+06E
  63    BREAK                      1             1
  64                 1
  65      5.091700E-03  0.214000E-04  1.000000E+00  3.731500E+02  1.013535E+05
  66          1.0E-5           0.1       15.1E-3
  67          1.0E-3        1.0E-4           1.0
  68          1.0E-5           0.1           0.6
  69            0.05         0.005           1.0
  70     -1.000000E+00
```

APPENDIX B

TRAC INPUT DECKS FOR CISE BLOWDOWN EXPERIMENTS (TESTS 4 AND R)

I. TRAC INPUT DECK FOR CISE UNHEATED BLOWDOWN EXPERIMENT (TEST 4)

```
                1         2         3         4         5         6         7
CARD   1234567890123456789012345678901234567890123456789012345678901234567890

   1               2             0
   2   CISE UNHEATED BLOWDOWN EXPERIMENT MODEL NO. 1
   3   Q9CA 25.4 GOPD2
   4               0  0.
   5               0             1             6             5             0
   6      .100000E-02   .100000E-02   .100000E+01  0.
   7              10            20            20             0             0
   8     0          1  0          2  0          3  0          4  0          5
   9     0          6  0          0  0          0  0          0  0          0
  10   FILL                        1             1
  11               1
  12     1.010300E+00  5.364000E-04                              5.835000E+02
  13     9.820000E+06
  14   PIPE                        2             2
  15              10             2             1             2             6
  16               0             0
  17     1.300000E-02  2.000000E-03  0.            0.            3.000000E+02
  18     3.000000E+02
  19   F   1.0103E+00E
  20   F   5.3640E-04E
  21   R10 5.3093E-04R 1 3.4636E-04E
  22   F   0.        E
  23   R10-1.4300E-01R 1-1.0000E+00E
  24   R10 2.6000E-02R 1 2.1000E-02E
  25   F            4E
  26   F   0.        E
  27   R10-1.3000E+00R 1-1.9930E+00E
  28   F   5.4400E+02E
  29   F   5.4400E+02E
  30       9.7800E+06    9.7822E+06    9.7844E+06    9.7867E+06    9.7889E+06
  31       9.7911E+06    9.7933E+06    9.7956E+06    9.7978E+06    9.8000E+06E
  32   F   0.        E
  33   F   5.4400E+02E
  34   PIPE                        3             3
  35              10             5             2             3             6
  36               0             0
  37     1.050000E-02  2.000000E-03  0.                        5.000000E+01  3.000000E+02
  38     3.000000E+02
  39   F   4.0000E-01E
  40   F   1.3854E-04E
```

```
                 1         2         3         4         5         6         7
CARD    1234567890123456789012345678901234567890123456789012345678901234567890

 41     R10 3.4636E-04R 1 2.2698E-04E
 42     F   0.         E
 43     F  -1.0000E+00E
 44     R10 2.1000E-02R 1 1.7000E-02E
 45     F            4E
 46     F   0.         E
 47     R10-1.9930E+00R 1-3.0410E+00E
 48     F   5.4400E+02E
 49     F   5.4400E+02E
 50         9.8000E+06    9.8067E+06    9.8133E+06    9.8200E+06    9.8267E+06
 51         9.8333E+06    9.8400E+06    9.8467E+06    9.8533E+06    9.8600E+06E
 52     F   0.         E
 53     F   5.4400E+02E
 54     PIPE                       4             4
 55                10            2             3             4             6
 56                 0            0
 57       8.500000E-03  1.500000E-03  0.            0.            3.000000E+02
 58       3.000000E+02
 59     F   9.5570E-01E
 60     F   2.1690E-04E
 61     F   2.2698E-04E
 62     F   0.         E
 63     R 1-1.0000E+00R10-3.6600E-01E
 64     F   1.7000E-02E
 65     F            4E
 66     F   0.         E
 67     F  -3.0410E+00E
 68     F   5.4400E+02E
 69     F   5.4400E+02E
 70         9.8600E+06    9.8667E+06    9.8733E+06    9.8800E+06    9.8867E+06
 71         9.8933E+06    9.9000E+06    9.9067E+06    9.9133E+06    9.9200E+06E
 72     F   0.         E
 73     F   5.4400E+02E
 74     PIPE                       5             5
 75                 8            2             4             5             6
 76                 0            1
 77       8.500000E-03  1.500000E-03  0.            0.            3.000000E+02
 78       3.000000E+02
 79     R 3 1.0000E-01R 5 2.0000E-02E
 80     R 3 2.2700E-05R 5 4.5400E-06E
 81     F   2.2698E-04E
 82     F   0.         E
 83     R 1-3.6600E-01R 8 0.         E
 84     F   1.7000E-02E
 85     F            4E
```

```
                 1         2         3         4         5         6         7
CARD    1234567890123456789012345678901234567890123456789012345678901234567890

  86    F   0.         E
  87    R 1-3.0410E+00R 8 0.        E
  88    F   5.4400E+02E
  89    F   5.4400E+02E
  90    F   9.9200E+06E
  91    F   0.         E
  92    F   5.4400E+02E
  93    BREAK                      6             6
  94                 5
  95      2.000000E-02  4.540000E-06  1.000000E+00  3.730000E+02  1.000000E+05
  96      1.000000E-05  1.000000E-01  1.000000E-01
  97      1.000000E-02  1.000000E-02  1.000000E+00
  98      1.000000E-05  5.000000E-03  5.000000E-01
  99      1.000000E-01  1.000000E-02  1.000000E+00
 100      1.000000E-05  1.000000E-02  6.000000E+00
 101      2.000000E-01  2.000000E-02  1.000000E+01
 102     -1.000000E+00
```

II. TRAC INPUT DECK FOR CISE HEATED BLOWDOWN EXPERIMENT (TEST R)

```
                 1         2         3         4         5         6         7
CARD    1234567890123456789012345678901234567890123456789012345678901234567890

   1                 2             0
   2    CISE HEATED BLOWDOWN EXPERIMENT MODEL NO. 1
   3    Q9CA 25.4 GOPD2
   4                 0 0.
   5                 0             1             6             5             0
   6       .100000E-02   .100000E-02   .100000E+01 0.
   7                10            20            20             0             0
   8      0          1  0          2  0          3  0          4  0          5
   9      0          6  0          0  0          0  0          0  0          0
  10    FILL                       1             1
  11                 1
  12      1.010300E+00  5.364000E-04                              5.835000E+02
  13      9.820000E+06
  14    PIPE                       2             2
  15                10             2             1             2             6
  16                 0             0
  17      1.300000E-02  2.000000E-03  0.            0.            3.000000E+02
  18      3.000000E+02
  19    F   1.0103E+00E
  20    F   5.3640E-04E
  21    R10 5.3093E-04R 1 3.4636E-04E
  22    F   0.        E
  23    R10-1.4300E-01R 1-1.0000E+00E
  24    R10 2.6000E-02R 1 2.1000E-02E
  25    F            4E
  26    F   0.        E
  27    R10-1.3000E+00R 1-1.9930E+00E
  28    F   5.7900E+02E
  29    F   5.7900E+02E
  30        9.7800E+06    9.7822E+06    9.7844E+06    9.7867E+06    9.7889E+06
  31        9.7911E+06    9.7933E+06    9.7956E+06    9.7978E+06    9.8000E+06E
  32    F   0.        E
  33    F   5.7900E+02E
  34    PIPE                       3             3
  35                10             5             2             3             6
  36                 1             0
  37      1.050000E-02  2.000000E-03  0.            5.000000E+01  3.000000E+02
  38      3.000000E+02
  39    F   4.0000E-01E
  40    F   1.3854E-04E
  41    R10 3.4636E-04R 1 2.2698E-04E
  42    F   0.        E
  43    F  -1.0000E+00E
  44    R10 2.1000E-02R 1 1.7000E-02E
  45    F            4E
```

```
               1         2         3         4         5         6         7
CARD  1234567890123456789012345678901234567890123456789012345678901234567890

  46  F   0.        E
  47  R10-1.9930E+00R 1-3.0410E+00E
  48      5.7900E+02    5.7500E+02    5.7100E+02    5.6700E+02    5.6300E+02
  49      5.5900E+02    5.5500E+02    5.5100E+02    5.4700E+02    5.4300E+02E
  50      5.7900E+02    5.7500E+02    5.7100E+02    5.6700E+02    5.6300E+02
  51      5.5900E+02    5.5500E+02    5.5100E+02    5.4700E+02    5.4300E+02E
  52      9.8000E+06    9.8067E+06    9.8133E+06    9.8200E+06    9.8267E+06
  53      9.8333E+06    9.8400E+06    9.8467E+06    9.8533E+06    9.8600E+06E
  54  F   1.8940E+08E
  55      5.9600E+02    6.0100E+02    6.0600E+02    6.1100E+02    6.1600E+02
  56      5.9500E+02    6.0000E+02    6.0500E+02    6.1000E+02    6.1500E+02
  57      5.9500E+02    6.0000E+02    6.0500E+02    6.1000E+02    6.1500E+02
  58      5.9500E+02    6.0000E+02    6.0500E+02    6.1000E+02    6.1500E+02
  59      5.9500E+02    6.0000E+02    6.0500E+02    6.1000E+02    6.1500E+02
  60      5.9200E+02    5.9700E+02    6.0200E+02    6.0700E+02    6.1200E+02
  61      5.8700E+02    5.9200E+02    5.9700E+02    6.0200E+02    6.0700E+02
  62      5.8100E+02    5.8600E+02    5.9100E+02    5.9600E+02    6.0100E+02
  63      5.7800E+02    5.8300E+02    5.8800E+02    5.9300E+02    5.9800E+02
  64      5.7500E+02    5.8000E+02    5.8500E+02    5.9000E+02    5.9500E+02E
  65  PIPE                       4             4
  66                10           2             3             4             6
  67                 0           0
  68    8.500000E-03  1.500000E-03  0.            0.            3.000000E+02
  69    3.000000E+02
  70  F   9.5570E-01E
  71  F   2.1690E-04E
  72  F   2.2698E-04E
  73  F   0.        E
  74  R 1-1.0000E+00R10-3.6600E-01E
  75  F   1.7000E-02E
  76  F            4E
  77  F   0.        E
  78  F  -3.0410E+00E
  79      5.4300E+02    5.4333E+02    5.4367E+02    5.4400E+02    5.4433E+02
  80      5.4467E+02    5.4500E+02    5.4533E+02    5.4567E+02    5.4600E+02E
  81      5.4300E+02    5.4333E+02    5.4367E+02    5.4400E+02    5.4433E+02
  82      5.4467E+02    5.4500E+02    5.4533E+02    5.4567E+02    5.4600E+02E
  83      9.8600E+06    9.8667E+06    9.8733E+06    9.8800E+06    9.8867E+06
  84      9.8933E+06    9.9000E+06    9.9067E+06    9.9133E+06    9.9200E+06E
  85  F   0.        E
  86  F   5.4400E+02E
  87  PIPE                       5             5
  88                 8           2             4             5             6
  89                 0           1
  90    8.500000E-03  1.500000E-03  0.            0.            3.000000E+02
```

```
                 1         2         3         4         5         6         7
CARD    1234567890123456789012345678901234567890123456789012345678901234567890
-----   ----------------------------------------------------------------------

 91       3.000000E+02
 92     R 3 1.0000E-01R 5 2.0000E-02E
 93     R 3 2.2700E-05R 5 4.5400E-06E
 94     F   2.2698E-04E
 95     F   0.        E
 96     R 1-3.6600E-01R 8 0.        E
 97     F   1.7000E-02E
 98     F            4E
 99     F   0.        E
100     R 1-3.0410E+00R 8 0.        E
101         5.4460E+02    5.4200E+02    5.3970E+02    5.3800E+02    5.3450E+02
102         5.2900E+02    5.2350E+02    5.1850E+02E
103         5.4460E+02    5.4200E+02    5.3970E+02    5.3800E+02    5.3450E+02
104         5.2900E+02    5.2350E+02    5.1850E+02E
105     F   9.9200E+06E
106     F   0.        E
107     F   5.4400E+02E
108     BREAK                      6             6
109                  5
110       2.000000E-02  4.540000E-06  1.000000E+00  3.730000E+02  1.000000E+05
111       1.000000E-05  1.000000E-05  1.000000E-05
112       1.000000E-05  1.000000E-05  1.000000E+10
113       1.000000E-05  1.000000E-04  1.000000E-02
114       1.000000E-03  1.000000E-03  1.000000E+10
115       1.000000E-04  1.000000E-04  1.000000E-01
116       1.000000E-02  1.000000E-02  1.000000E+10
117       5.000000E-04  5.000000E-04  5.000000E-01
118       1.000000E-01  1.000000E-01  1.000000E+10
119       5.000000E-04  1.000000E-02  6.000000E+00
120       1.000000E-01  1.000000E-01  1.000000E+10
121      -1.000000E+00
```

APPENDIX C

TRAC INPUT DECKS FOR MARVIKEN TESTS 4 AND 24

I. TRAC INPUT DECK FOR MARVIKEN TEST 4

```
                 1         2         3         4         5         6         7
CARD  1234567890123456789012345678901234567890123456789012345678901234567890

   1              2             0
   2  MARVIKEN III TEST 4 DETAILED NODING MODEL NO. 1
   3  Q9CA 25.4 GOPD2
   4              0 0.
   5              0             1             4             3             0
   6    .100000E-02   .100000E-02   .100000E-01   .100000E+00
   7             30            80            80             0             0
   8    0         1  0          2  0          3  0          4  0          0
   9  FILL                      1           128
  10              1             1             0             0
  11          1.550        2.7391           1.0            .0         535.6
  12       4940000.
  13  PIPE                      2           128
  14             15             0             1             2             1
  15              1             0
  16    2.610000E+00  1.000000E-01  0.            0.            3.000000E+02
  17    3.000000E+02
  18  R 1 1.5500E+00R 1 1.6000E+00R 1 1.0000E+00R 2 1.4000E+00R10 1.5000E+00E
  19  R 1 2.7391E+00R 1 2.8274E+00R 1 9.5118E+00R 2 2.9005E+01R10 3.1076E+01E
  20  R 3 1.7671E+00R13 2.0718E+01E
  21  F   0.        E
  22  F  -1.0000E+00E
  23  R 3 1.5000E+00R13 5.1360E+00E
  24  F             4E
  25  R 5 1.0000E+00R10 0.        E
  26  F   0.        E
  27  R10 5.3620E+02R 1 5.2300E+02R 1 5.1000E+02R 2 5.0600E+02R 1 5.0100E+02E
  28  R10 5.3620E+02R 1 5.2300E+02R 1 5.1000E+02R 2 5.0600E+02R 1 5.0100E+02E
  29  R 1 4.9340E+06R 3 4.9350E+06R 2 4.9360E+06R 1 4.9490E+06R 1 4.9610E+06
  30  R 1 4.9730E+06R 1 4.9850E+06R 1 4.9970E+06R 1 5.0090E+06R 1 5.0220E+06
  31  R 1 5.0340E+06R 1 5.0460E+06E
  32  PIPE                      3           128
  33             45             0             2             3             1
  34              1             1
  35    2.550000E-01  1.000000E-01  0.            0.            3.000000E+02
  36    3.000000E+02
  37  R 1 6.0000E-01R 8 5.0000E-01R 1 7.9000E-01R 1 6.1000E-01R 1 6.0000E-01
  38  R 1 5.6800E-01R 2 5.0000E-01R10 2.5000E-02R 7 2.0000E-01R10 2.5000E-02
  39  R 1 2.0000E-02R 2 2.8000E-02E
  40  R 1 1.2104E+01R 1 9.4300E+00R 1 7.7925E+00R 1 4.9886E+00R 1 1.5474E+00
```

```
                1             2             3             4             5             6             7
CARD    1234567890123456789012345678901234567890123456789012345678901234567890

  41    R 4 2.2210E-01R 1 3.5090E-01R 1 2.8110E-01R 1 2.8670E-01R 1 2.6180E-01
  42    R 2 2.2210E-01R 1 1.0213E-02R 1 8.5590E-03R 1 7.3090E-03R 1 6.4930E-03
  43    R 1 5.8340E-03R 1 5.3000E-03R 4 5.0870E-03R 7 4.0696E-02R 4 5.0870E-03
  44    R 1 5.5610E-03R 1 6.5520E-03R 4 7.0690E-03R 1 5.6550E-03R 1 8.7490E-03
  46    R 1 2.0718E+01R 1 1.9635E+01R 1 1.8096E+01R 1 1.3203E+01R 1 7.0686E+00
  47    R 6 4.4410E-01R 2 4.7780E-01R 3 4.4410E-01R 1 3.7390E-01R 1 3.1170E-01
  48    R 1 2.7340E-01R 1 2.4630E-01R 1 2.2060E-01R16 2.0350E-01R 1 2.4190E-01
  49    R 6 2.8270E-01R 1 3.4320E-01R 1 4.0940E-01E
  50    F        .0000E
  51    F  -1.0000E+00E
  52    R 1 5.1360E+00R 1 5.0000E+00R 1 4.8000E+00R 1 4.1000E+00R 1 3.0000E+00
  53    R 6 7.5200E-01R 2 7.8000E-01R 3 7.5200E-01R 1 6.9000E-01R 1 6.3000E-01
  54    R 1 5.9000E-01R 1 5.6000E-01R 1 5.3000E-01R16 5.0900E-01R 1 5.5500E-01
  55    R 6 6.0000E-01R 1 6.6100E-01R 1 7.2200E-01E
  56    F            4E
  57    F   0.        E
  58    F   0.        E
  59    R 5 4.9900E+02R 1 4.9800E+02R 2 4.9700E+02R 1 4.9600E+02R 1 4.9500E+02
  60    R 1 4.9400E+02R 1 4.9200E+02R 1 4.8400E+02R 1 4.7900E+02R 1 4.7600E+02
  61    R30 4.7500E+02E
  62    R 5 4.9900E+02R 1 4.9800E+02R 2 4.9700E+02R 1 4.9600E+02R 1 4.9500E+02
  63    R 1 4.9400E+02R 1 4.9200E+02R 1 4.8400E+02R 1 4.7900E+02R 1 4.7600E+02
  64    R30 4.7500E+02E
  65    R 1 5.0550E+06R 1 5.0600E+06R 1 5.0640E+06R 1 5.0680E+06R 1 5.0720E+06
  66    R 1 5.0760E+06R 1 5.0810E+06R 1 5.0850E+06R 1 5.0890E+06R 1 5.0940E+06
  67    R 1 5.1000E+06R 1 5.1050E+06R 1 5.1100E+06R 1 5.1150E+06R 1 5.1190E+06
  68    R 2 5.1210E+06R 4 5.1220E+06R 4 5.1230E+06R 1 5.1240E+06R 1 5.1260E+06
  69    R 1 5.1280E+06R 1 5.1290E+06R 1 5.1310E+06R 1 5.1330E+06R 1 5.1340E+06
  70    R 1 5.1350E+06R 4 5.1360E+06R 5 5.1370E+06R 3 5.1380E+06E
  71    BREAK                      4           128
  72                 3             0             0             0
  73              .028       .010522           1.0          373.       101700.
  74            .00001          .050           5.0
  75                .1            .1           5.0
  76            .00001          .050           56.
  77               1.0            .1           10.
  78              -1.0
```

II. TRAC INPUT DECK FOR MARVIKEN TEST 24

```
                  1         2         3         4         5         6         7
CARD   1234567890123456789012345678901234567890123456789012345678901234567890

   1                2             0
   2   MARVIKEN III TEST 24 MODEL NO. 1
   3   Q9CA 25.4 GOPD2
   4                0  0.
   5                0             1             4             3             0
   6      .100000E-02   .100000E-02   .100000E-01   .100000E+00
   7               30            80            80             0             0
   8      0         1   0         2   0         3   0         4   0         0
   9   FILL                       1           128
  10                1             1             0             0
  11            1.550        2.7391           1.0            .0        536.56
  12         4960000.
  13   PIPE                       2           128
  14               15             0             1             2             1
  15                1             0
  16     2.568000E+00  1.000000E-01  0.            0.            3.000000E+02
  17     3.000000E+02
  18   R 1 1.5500E+00R 1 1.6000E+00R 1 1.0000E+00R 1 5.2000E-01R 1 1.9800E+00
  19   R 1 1.6000E+00R 1 1.7000E+00R 8 1.5000E+00E
  20   R 1 2.7391E+00R 1 2.8274E+00R 1 9.5118E+00R 1 1.0773E+01R 1 4.1021E+01
  21   R 1 3.3148E+01R 1 3.5220E+01R 8 3.1076E+01E
  22   R 3 1.7671E+00R13 2.0718E+01E
  23   F   4.0000E-02E
  24   F  -1.0000E+00E
  25   R 3 1.5000E+00R13 5.1360E+00E
  26   F            4E
  27   R 4 1.0000E+00R11 0.        E
  28   F   0.        E
  29   R 5 5.3656E+02R 1 5.3300E+02R 1 5.0740E+02R 1 5.0661E+02R 1 5.0655E+02
  30   R 1 5.0648E+02R 1 5.0641E+02R 1 5.0634E+02R 1 5.0628E+02R 1 5.0621E+02
  31   R 1 5.0610E+02E
  32   R 5 5.3656E+02R 1 5.3300E+02R 1 5.0740E+02R 1 5.0661E+02R 1 5.0655E+02
  33   R 1 5.0648E+02R 1 5.0641E+02R 1 5.0634E+02R 1 5.0628E+02R 1 5.0621E+02
  34   R 1 5.0610E+02E
  35   R 4 4.9600E+06R 1 4.9604E+06R 1 4.9755E+06R 1 4.9892E+06R 1 5.0027E+06
  36   R 1 5.0153E+06R 1 5.0277E+06R 1 5.0400E+06R 1 5.0524E+06R 1 5.0646E+06
  37   R 1 5.0769E+06R 1 5.0892E+06E
  38   PIPE                       3           128
  39               27             0             2             3             1
  40                1             1
  41     2.500000E-01  1.000000E-01  0.            0.            3.000000E+02
  42     3.000000E+02
  43   R 1 6.0000E-01R 1 4.0000E-01R 1 6.0000E-01R 6 5.0000E-01R 1 7.9000E-01
  44   R 1 6.1000E-01R 1 6.0000E-01R 1 5.6800E-01R 2 5.0000E-01R 4 5.0000E-02
  45   R 6 2.5000E-02R 1 2.0000E-02R 1 2.1000E-02E
```

```
                 1         2         3         4         5         6         7
CARD    1234567890123456789012345678901234567890123456789012345678901234567890
------------------------------------------------------------------------------

  46    R 1 1.2104E+01R 1 7.5440E+00R 1 9.3509E+00R 1 4.9886E+00R 1 1.5474E+00
  47    R 4 2.2210E-01R 1 3.5090E-01R 1 2.8110E-01R 1 2.8670E-01R 1 2.6180E-01
  48    R 2 2.2210E-01R 1 1.9601E-02R 1 1.5116E-02R 1 1.2234E-02R 1 1.0784E-02
  49    R 1 5.0270E-03R 5 4.9090E-03R 1 3.9270E-03R 1 4.1230E-03E
  50    R 1 2.0718E+01R 1 1.9635E+01R 1 1.8096E+01R 1 1.3203E+01R 1 7.0686E+00
  51    R 6 4.4410E-01R 2 4.7780E-01R 3 4.4410E-01R 1 3.4210E-01R 1 2.6420E-01
  52    R 1 2.2560E-01R 1 2.0590E-01R 8 1.9630E-01E
  53    F   0.        E
  54    F  -1.0000E+00E
  55    R 1 5.1360E+00R 1 5.0000E+00R 1 4.8000E+00R 1 4.1000E+00R 1 3.0000E+00
  56    R 6 7.5200E-01R 2 7.8000E-01R 3 7.5200E-01R 1 6.6000E-01R 1 5.8000E-01
  57    R 1 5.3600E-01R 1 5.1200E-01R 8 5.0000E-01E
  58    F            4E
  59    F   0.        E
  60    F   0.        E
  61    R 1 5.0573E+02R 1 5.0522E+02R 1 5.0444E+02R 1 5.0318E+02R 1 5.0011E+02
  62    R 1 4.9701E+02R 1 4.9382E+02R 1 4.9037E+02R 1 4.8692E+02R 1 4.8246E+02
  63    R 1 4.7758E+02R 1 4.7331E+02R 1 4.6920E+02R 1 4.6544E+02R 1 4.6191E+02
  64    R12 4.6015E+02E
  65    R 1 5.0573E+02R 1 5.0522E+02R 1 5.0444E+02R 1 5.0318E+02R 1 5.0011E+02
  66    R 1 4.9701E+02R 1 4.9382E+02R 1 4.9037E+02R 1 4.8692E+02R 1 4.8246E+02
  67    R 1 4.7758E+02R 1 4.7331E+02R 1 4.6920E+02R 1 4.6544E+02R 1 4.6191E+02
  68    R12 4.6015E+02E
  69        5.0978E+06    5.1019E+06    5.1060E+06    5.1105E+06    5.1146E+06
  70        5.1187E+06    5.1229E+06    5.1270E+06    5.1312E+06    5.1367E+06
  71        5.1426E+06    5.1478E+06    5.1528E+06    5.1574E+06    5.1618E+06
  72        5.1642E+06    5.1646E+06    5.1651E+06    5.1655E+06    5.1658E+06
  73        5.1660E+06    5.1663E+06    5.1665E+06    5.1667E+06    5.1669E+06
  74        5.1671E+06    5.1673E+06E
  75    BREAK                    4            128
  76                 3           0              0             0
  77              .021     .004123            1.0        373.25       101700.
  78            .00001        .020             5.
  79                .1          .1             5.
  80            .00001        .050            80.
  81                1.          .1            80.
```

APPENDIX D

TRAC STEADY-STATE AND TRANSIENT INPUT DECKS FOR THTF TEST 177

I. TRAC STEADY-STATE INPUT DECK FOR THTF TEST 177

```
                 1         2         3         4         5         6         7
CARD    1234567890123456789012345678901234567890123456789012345678901234567890

   1               5
   2    *
   3    *
   4    ORNL THTF MODEL NO. 1
   5    Q9CA 25.4 GOPD2
   6    *
   7               0       0.0
   8               1         0        11        10         0
   9         1.E-03   1.0E-05   1.0E-02   1.0E-01
  10              10         0        10         0         0
  11               1         2         3         4         5
  12               6         7         8         9        10
  13             11E
  14    VESSEL               1         1
  15              18         2         1         4
  16              15         1         1        14         2
  17               1
  18               0         0         0         1
  19             5.0      50.0     0.005
  20          8009.2 4023988.6      15.6       0.0   100000.
  21           1.334
  22              15        12         6
  23               0         0         0         0       100
  24        3695850.       0.0       0.0
  25          0.0475    0.2666    0.4952    0.9524    1.1810
  26          1.4858    1.7906    2.0954    2.4002    2.7050
  27          3.0098    3.2384    3.6956    3.9242    4.1338
  28          4.2002    4.3331   4.6897E
  29           .1728   .27440E
  30          .1010E
  31              15         2         3         1
  32              14         2         3         3
  33              18         2         3         6
  34              18         1         2        10
  35             0.0       0.0       0.0       1.0       1.0
  36             1.0       0.0       0.0       0.0       0.0
  37             0.0       0.0       0.0       0.0      0.0E
  38            1.0E
  39           0.422     0.422     0.597     1.065     1.285
  40           1.670     1.670     1.670     1.285     1.065
```

CARD		1	2	3	4	5	6	7
	1234567890123456789012345678901234567890123456789012345678901234567890							
41		0.597	0.422	0.422E		
42		45.0E				
43		0.0	0.0012813	0.0025626	0.002830519	0.003098438
44		0.003521805	0.003945172	0.004368539	0.00455902	0.004749501
45		0.004939982	0.005130463	0.00513201	0.005258997	0.005385984E
46		4	4	10	10	4
47		4	4	7	7	7
48		7	3	7	7E	
49		0.0	3695850.	1.38	1000000.S	
50		1.5	500000.	2.0	500000.S	
51		3.5	750000.	4.0	750000.S	
52		4.5	2000000.	5.0	2250000.S	
53		7.0	2250000.	7.5	900000.S	
54		8.5	750000.	10.5	0.E	
55	F	0E				
56	F	0.0E				
57	F	0.0E				
58	F	0.0E				
59	F	0.0E				
60	F	0.0E				
61	F	0.0E				
62	F	0.0E				
63	F	0.0E				
64		.0836	.0836E			
65		1.7917	419.E			
66		0.0	0.0E			
67		.33	.15E			
68		0.0	0.0E			
69		0.0	0.0E			
70		0.0	0.0E			
71		0.0	0.0E			
72		.5717	1.0E			
73		0.0	0.0E			
74		.5717	1.0E			
75		1.0	0.0E			
76		0.0	0.0E			
77		.05	.05E			
78		1.0	0.0E			
79		550.7	550.7E			
80		0.0	0.0E			
81		0.0	0.0E			
82		0.0	0.0E			
83		0.0	0.0E			
84		0.0	0.0E			
85		0.0	0.0E			

CARD	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
86	-4.5	0.0E					
87	550.7	550.7E					
88	550.7	550.7E					
89	15.9E06	15.9E06E					
90	.089	.144E					
91	19.25	117.E					
92	0.0	0.0E					
93	.386	0.0E					
94	0.0	0.0E					
95	0.0	0.0E					
96	.386	0.0E					
97	0.0	0.0E					
98	.5717	1.0E					
99	0.0	0.0E					
100	.5717	1.0E					
101	0.0	0.0E					
102	0.0	0.0E					
103	.0063	.0546E					
104	0.0	0.0E					
105	550.7	550.7E					
106	0.0	0.0E					
107	0.0	0.0E					
108	0.0	0.0E					
109	0.0	0.0E					
110	0.0	0.0E					
111	4.84	-1.6E					
112	0.0	0.0E					
113	550.7	550.7E					
114	550.7	550.7E					
115	15.9E06	15.9E06E					
116	.093	.1595E					
117	20.05	36.15E					
118	0.0	0.0E					
119	.2285	0.0E					
120	0.0	0.0E					
121	0.0	0.0E					
122	.2285	0.0E					
123	0.0	0.0E					
124	.5717	1.0E					
125	0.0	0.0E					
126	.5717	1.0E					
127	0.0	0.0E					
128	0.0	0.0E					
129	.0063	.0546E					
130	0.0	0.0E					

CARD	1234567890123456789012345678901234567890123456789012345678901234567890	
131	551.	550.7E
132	0.0	0.0E
133	0.0	0.0E
134	0.0	0.0E
135	0.0	0.0E
136	0.0	0.0E
137	4.84	-1.6E
138	0.0	0.0E
139	551.	550.7E
140	551.	550.7E
141	15.9E06	15.9E06E
142	.185	.317E
143	40.1	72.5E
144	0.0	0.0E
145	.464	0.0E
146	0.0	0.0E
147	0.0	0.0E
148	.464	0.0E
149	0.0	0.0E
150	.5717	1.0E
151	0.0	0.0E
152	.5717	1.0E
153	0.0	0.0E
154	0.0	0.0E
155	.0063	.0546E
156	0.0	0.0E
157	554.	550.7E
158	0.0	0.0E
159	0.0	0.0E
160	0.0	0.0E
161	0.0	0.0E
162	0.0	0.0E
163	4.84	-1.6E
164	0.0	0.0E
165	554.	550.7E
166	554.	550.7E
167	15.9E06	15.9E06E
168	.092	.159E
169	20.0	36.10E
170	0.0	0.0E
171	.298	0.0E
172	0.0	0.0E
173	0.0	0.0E
174	.298	0.0E
175	0.0	0.0E

CARD	1234567890123456789012345678901234567890123456789012345678901234567890	
176	.5717	1.0E
177	0.0	0.0E
178	.5717	1.0E
179	0.0	0.0E
180	0.0	0.0E
181	.0063	.0546E
182	0.0	0.0E
183	557.	550.7E
184	0.0	0.0E
185	0.0	0.0E
186	0.0	0.0E
187	0.0	0.0E
188	0.0	0.0E
189	4.84	-1.6E
190	0.0	0.0E
191	557.	550.7E
192	557.	550.7E
193	15.9E06	15.9E06E
194	.123	.178E
195	26.7	48.25E
196	0.0	0.0E
197	.348	0.0E
198	0.0	0.0E
199	0.0	0.0E
200	.348	0.0E
201	0.0	0.0E
202	.5717	1.0E
203	0.0	0.0E
204	.5717	1.0E
205	0.0	0.0E
206	0.0	0.0E
207	.0063	.0546E
208	0.0	0.0E
209	560.	550.7E
210	0.0	0.0E
211	0.0	0.0E
212	0.0	0.0E
213	0.0	0.0E
214	0.0	0.0E
215	4.84	-1.6E
216	0.0	0.0E
217	560.	550.7E
218	560.	550.7E
219	15.9E06	15.9E06E
220	.123	.178E

```
              1         2         3         4         5         6         7
CARD 1234567890123456789012345678901234567890123456789012345678901234567890

221             26.7         48.25E
222              0.0           0.0E
223             .348           0.0E
224              0.0           0.0E
225              0.0           0.0E
226             .348           0.0E
227              0.0           0.0E
228            .5717           1.0E
229              0.0           0.0E
230            .5717           1.0E
231              0.0           0.0E
232              0.0           0.0E
233            .0063         .0546E
234              0.0           0.0E
235             563.         550.7E
236              0.0           0.0E
237              0.0           0.0E
238              0.0           0.0E
239              0.0           0.0E
240              0.0           0.0E
241             4.84          -1.6E
242              0.0           0.0E
243             563.         550.7E
244             563.         550.7E
245          15.9E06       15.9E06E
246             .123          .178E
247             26.7         48.25E
248              0.0           0.0E
249             .348           0.0E
250              0.0           0.0E
251              0.0           0.0E
252             .348           0.0E
253              0.0           0.0E
254            .5717           1.0E
255              0.0           0.0E
256            .5717           1.0E
257              0.0           0.0E
258              0.0           0.0E
259            .0063         .0546E
260              0.0           0.0E
261             566.         550.7E
262              0.0           0.0E
263              0.0           0.0E
264              0.0           0.0E
265              0.0           0.0E
```

CARD	1234567890123456789012345678901234567890123456789012345678901234567890	
266	0.0	0.0E
267	4.84	-1.6E
268	0.0	0.0E
269	566.	550.7E
270	566.	550.7E
271	15.9E06	15.9E06E
272	.123	.178E
273	26.7	48.25E
274	0.0	0.0E
275	.348	0.0E
276	0.0	0.0E
277	0.0	0.0E
278	.348	0.0E
279	0.0	0.0E
280	.5717	1.0E
281	0.0	0.0E
282	.5717	1.0E
283	0.0	0.0E
284	0.0	0.0E
285	.0063	.0546E
286	0.0	0.0E
287	569.	550.7E
288	0.0	0.0E
289	0.0	0.0E
290	0.0	0.0E
291	0.0	0.0E
292	0.0	0.0E
293	4.84	-1.6E
294	0.0	0.0E
295	569.	550.7E
296	569.	550.7E
297	15.9E06	15.9E06E
298	.123	.178E
299	26.7	48.25E
300	0.0	0.0E
301	.348	0.0E
302	0.0	0.0E
303	0.0	0.0E
304	.348	0.0E
305	0.0	0.0E
306	.5717	1.0E
307	0.0	0.0E
308	.5717	1.0E
309	0.0	0.0E
310	0.0	0.0E

```
                1         2         3         4         5         6         7
CARD   1234567890123456789012345678901234567890123456789012345678901234567890

 311           .0063         .0546E
 312             0.0           0.0E
 313            572.          550.7E
 314             0.0           0.0E
 315             0.0           0.0E
 316             0.0           0.0E
 317             0.0           0.0E
 318             0.0           0.0E
 319            4.84          -1.6E
 320             0.0           0.0E
 321            572.          550.7E
 322            572.          550.7E
 323         15.9E06       15.9E06E
 324            .175          .211E
 325            26.6          48.10E
 326             0.0           0.0E
 327            .398           0.0E
 328             0.0           0.0E
 329             0.0           0.0E
 330            .398           0.0E
 331             0.0           0.0E
 332           .5717           1.0E
 333             0.0           0.0E
 334           .5717           1.0E
 335             0.0           0.0E
 336             0.0           0.0E
 337           .0063         .0546E
 338             0.0           0.0E
 339            575.          550.7E
 340             0.0           0.0E
 341             0.0           0.0E
 342             0.0           0.0E
 343             0.0           0.0E
 344             0.0           0.0E
 345            4.84          -1.6E
 346             0.0           0.0E
 347            575.          550.7E
 348            575.          550.7E
 349         15.9E06       15.9E06E
 350            .093          .159E
 351            20.1           36.3E
 352             0.0           0.0E
 353            .305           0.0E
 354             0.0           0.0E
 355             0.0           0.0E
```

CARD	1234567890123456789012345678901234567890123456789012345678901234567890	
356	.305	0.0E
357	0.0	0.0E
358	.5717	1.0E
359	0.0	0.0E
360	.5717	1.0E
361	0.0	0.0E
362	0.0	0.0E
363	.0063	.0546E
364	0.0	0.0E
365	578.	550.7E
366	0.0	0.0E
367	0.0	0.0E
368	0.0	0.0E
369	0.0	0.0E
370	0.0	0.0E
371	4.84	-1.6E
372	0.0	0.0E
373	578.	550.7E
374	578.	550.7E
375	15.9E06	15.9E06E
376	.186	.319E
377	40.1	72.3E
378	0.0	0.0E
379	.29	0.0E
380	0.0	0.0E
381	0.0	0.0E
382	.29	0.0E
383	0.0	0.0E
384	.5717	1.0E
385	0.0	0.0E
386	.5717	1.0E
387	0.0	0.0E
388	0.0	0.0E
389	.0063	.0546E
390	0.0	0.0E
391	581.	550.7E
392	0.0	0.0E
393	0.0	0.0E
394	0.0	0.0E
395	0.0	0.0E
396	0.0	0.0E
397	4.84	-1.6E
398	0.0	0.0E
399	581.	550.7E
400	581.	550.7E

CARD	1234567890123456789012345678901234567890123456789012345678901234567890
401	15.9E06 15.9E06E
402	.093 .1595E
403	20.05 36.15E
404	0.0 0.0E
405	.2285 0.0E
406	0.0 0.0E
407	0.0 0.0E
408	.2285 0.0E
409	0.0 0.0E
410	.5717 1.0E
411	0.0 0.0E
412	.5717 1.0E
413	0.0 0.0E
414	0.0 0.0E
415	.0063 .0546E
416	0.0 0.0E
417	582. 550.7E
418	0.0 0.0E
419	0.0 0.0E
420	0.0 0.0E
421	0.0 0.0E
422	0.0 0.0E
423	4.84 -1.6E
424	0.0 0.0E
425	582. 550.7E
426	582. 550.7E
427	15.9E06 15.9E06E
428	.085 .11E
429	18.3 24.9E
430	0.0 0.0E
431	.2055 0.0E
432	0.0 0.0E
433	0.0 0.0E
434	.2055 0.0E
435	0.0 0.0E
436	.5717 1.0E
437	0.0 0.0E
438	.5717 0.0E
439	0.0 0.0E
440	0.0 0.0E
441	.0063 .0546E
442	0.0 0.0E
443	582. 550.70E
444	0.0 0.0E
445	0.0 0.0E

```
                   1         2         3         4         5         6         7
CARD      1234567890123456789012345678901234567890123456789012345678901234567890

 446            0.0          0.0E
 447            0.0          0.0E
 448            0.0          0.0E
 449           4.84         -1.6E
 450            0.0          0.0E
 451           582.       550.70E
 452           582.       550.70E
 453        15.9E06      15.9E06E
 454            0.0          .054E
 455            0.0         12.12E
 456            0.0          0.0E
 457            0.0          0.0E
 458            0.0          0.0E
 459            0.0          0.0E
 460            0.0          0.0E
 461            0.0          0.0E
 462          .5717          1.0E
 463            0.0          0.0E
 464          .5717          1.0E
 465            1.0          0.0E
 466            0.0          0.0E
 467          .0063         .0546E
 468            1.0          0.0E
 469           582.          582.E
 470            0.0          0.0E
 471            0.0          0.0E
 472            0.0          0.0E
 473            0.0          0.0E
 474            0.0          0.0E
 475            3.0          3.0E
 476            0.0          0.0E
 477           582.          582.E
 478           582.          582.E
 479        15.9E06      15.9E06E
 480            0.0          .107E
 481            0.0         24.24E
 482            0.0          0.0E
 483            0.0          0.0E
 484            0.0          0.0E
 485            0.0          0.0E
 486            0.0          0.0E
 487            0.0          0.0E
 488          .5717          1.0E
 489            0.0          0.0E
 490          .5717          1.0E
```

```
               1         2         3         4         5         6         7
CARD  1234567890123456789012345678901234567890123456789012345678901234567890

 491              1.0           0.0E
 492              0.0           0.0E
 493            .0063         .0546E
 494              1.0           0.0E
 495             582.           582.E
 496              0.0           0.0E
 497              0.0           0.0E
 498              0.0           0.0E
 499              0.0           0.0E
 500              0.0           0.0E
 501             4.84           1.6E
 502              0.0           0.0E
 503             582.           582.E
 504             582.           582.E
 505          15.9E06       15.9E06E
 506              0.0           .23E
 507              0.0          51.2E
 508              0.0           0.0E
 509              0.0           0.0E
 510              0.0           0.0E
 511              0.0           0.0E
 512              0.0           0.0E
 513              0.0           0.0E
 514            .5717           1.0E
 515              0.0           0.0E
 516              0.0           0.0E
 517              0.0           0.0E
 518              0.0           0.0E
 519           0.0063        0.0546E
 520              0.0           0.0E
 521             582.           582.E
 522              0.0           0.0E
 523              0.0           0.0E
 524              0.0           0.0E
 525              0.0           0.0E
 526              0.0           0.0E
 527              0.0       3.13439E
 528              0.0           0.0E
 529             582.           582.E
 530             582.           582.E
 531          15.9E06       15.9E06E
 532  F           0.0E
 533  F       558.58E
 534  PIPE                          2             2
 535               10             0             1             2            6
```

```
               1         2         3         4         5         6         7
CARD  1234567890123456789012345678901234567890123456789012345678901234567890

 536              0             1
 537
 538
 539  F     0.024129E
 540  F   0.00014976E
 541  F    0.0062068E
 542  F          0.0E
 543  F          0.0E
 544  F      0.08889E
 545  F            4E
 546  F          0.0E
 547  F          0.0E
 548  F       558.58E
 549  F       558.58E
 550  F    1.5887E07E
 551  FILL                       3             3
 552              2             1             0             0
 553        0.024129    0.00014976           0.0           0.0        619.90
 554       1.5887E07           0.0
 555  PIPE                       4             4
 556             10            10             4             3             6
 557              3             1
 558         0.04445        0.0127           0.0           0.0         560.0
 559           300.0
 560  F      0.07765E
 561  F     0.000482E
 562  F      0.00621E
 563  F          0.0E
 564  F          1.0E
 565  F       0.0889E
 566  F            4E
 567  F          0.0E
 568  F       4.4113E
 569  F       550.70E
 570  F       550.70E
 571  F    1.5887E07E
 572  F          0.0E
 573  F        300.0E
 574  PIPE                       5             5
 575             10            10             5             4             6
 576              3             1
 577         0.04445      0.007314           0.0           0.0         560.0
 578           300.0
 579  F      0.09143E
 580  F   0.00056747E
```

```
              1         2         3         4         5         6         7
CARD 1234567890123456789012345678901234567890123456789012345678901234567890

581  F      0.00621E
582  F          0.0E
583  F          1.0E
584  F       0.0889E
585  F            4E
586  F          0.0E
587  F       4.4113E
588  F       550.70E
589  F       550.70E
590  F    1.5887E07E
591  F          0.0E
592  F        300.0E
593  BREAK                      6             6
594              5             0             0             0
595        0.09143    0.00056747           0.0        550.70     1.6036E07
596  FILL                       7             7
597              8             1             0             0
598        0.09143    0.00056747           0.0       -5.1711        581.43
599      1.5679E07   -2.2757E+01
600  PIPE                       8             8
601             10            10             6             7             6
602              3             1
603         0.0445      0.007366           0.0           0.0         560.0
604          300.0
605  F      0.15251E
606  F     0.000947E
607  F      0.00621E
608  F          0.0E
609  F          0.0E
610  F       0.0889E
611  F            4E
612  F          0.0E
613  F       5.1711E
614  F       581.43E
615  F       581.43E
616  F    1.5679E07E
617  F          0.0E
618  F        300.0E
619  PIPE                       9             9
620             10            10             7             8             6
621              3             1
622         0.0445      0.012700           0.0           0.0         560.0
623          300.0
624  F      0.09143E
625  F   0.00056747E
```

```
              1         2         3         4         5         6         7
CARD 1234567890123456789012345678901234567890123456789012345678901234567890

626  F      0.00621E
627  F          0.0E
628  F         -1.0E
629  F       0.0889E
630  F            4E
631  F          0.0E
632  F       5.1711E
633  F       581.43E
634  F       581.43E
635  F    1.5679E07E
636  F          0.0E
637  F        300.0E
638  FILL                       10            10
639               9             1             0             0
640           0.635    0.00002011           0.0           0.0        550.70
641       1.5887E07           0.0
642  PIPE                       11            11
643               1             0             9            10            6
644               0             1
645
646
647  F        0.635E
648  F   0.00002011E
649  F   0.00003167E
650  F          0.0E
651  F         -1.0E
652  F      0.00635E
653  F            4E
654  F          0.0E
655  F          0.0E
656  F       550.70E
657  F       550.70E
658  F    1.5887E07E
659          1.0E-3          0.01          20.0        1000.0
660          1.0E+1        1.0E+1          20.0           1.0
661            -1.0
```

II. TRAC TRANSIENT INPUT DECK FOR THHTF TEST 177

```
                 1         2         3         4         5         6         7
CARD    1234567890123456789012345678901234567890123456789012345678901234567890

   1             2
   2    THTF TEST 177 MODEL NO. 1
   3    Q9CA 26.0 GOPD2
   4            -1          0.0
   5             0            1          11          10           0
   6        1.E-03      1.0E-05     1.0E-02     1.0E-01
   7           100            0          10           0           0
   8             1            2           3           4           5
   9             6            7           8           9          10
  10           11E
  11    FILL                  6           6
  12             5            2           0          47
  13       0.09143   0.00056747         0.0      4.7120      550.70
  14     1.6036E07   2.2703E+01
  15           0.0       4.7120         0.2    -0.5537S
  16           0.5      -2.2149         1.0    -2.7143S
  17           2.0      -2.9097         3.0    -2.9640S
  18          4.00       -2.703        4.25     -2.277S
  19          4.50       -1.532        4.75     -1.630S
  20          5.00       -1.543        5.25     -1.619S
  21          5.50       -1.575        5.75     -1.369S
  22          6.00       -1.054        6.25     -0.869S
  23          6.50       -0.869        6.75     -0.869S
  24          7.00       -0.869        7.25     -1.206S
  25          7.50       -1.836        7.75     -2.401S
  26          8.00       -1.760        8.25     -1.119S
  27          8.50       -1.032        8.75     -0.891S
  28          9.00       -0.869        9.25     -1.401S
  29          9.50       -2.716        9.75     -3.477S
  30         10.00       -2.347       10.25     -2.390S
  31         10.50       -1.662       10.75     -1.260S
  32         11.00       -1.325       11.25     -1.510S
  33         11.50       -1.184       11.75     -0.891S
  34         12.00       -0.869       12.25     -1.021S
  35         12.50       -1.184       12.75     -2.216S
  36         13.00       -2.173       13.25     -2.249S
  37         13.50       -1.836       13.75     -2.564S
  38         14.00      -1.825E
  39    FILL                  7           7
  40             8            2           0         112
  41       0.09143   0.00056747         0.0     -5.1711      581.43
  42     1.5679E07  -2.2757E+01
  43           0.0       -5.171        0.10     -4.813S
  44          0.15       -4.205        0.20     -3.661S
  45          0.25       -3.454        0.30     -3.488S
```

	1 2 3 4 5 6 7			
CARD	1234567890123456789012345678901234567890123456789012345678901234567890			
46	0.35	-3.553	0.40	-3.748S
47	0.50	-4.161	0.55	-4.313S
48	0.60	-4.443	0.65	-4.519S
49	0.70	-4.563	0.75	-4.563S
50	0.80	-4.476	0.85	-4.357S
51	0.90	-4.086	0.95	-3.824S
52	1.00	-3.488	1.05	-3.086S
53	1.10	-2.802	1.15	-2.347S
54	1.20	-2.152	1.25	-1.847S
55	1.30	-1.424	1.35	-1.358S
56	1.40	-1.151	1.45	-0.869S
57	1.50	-0.869	1.55	-0.869S
58	1.60	-0.869	1.65	-0.869S
59	1.70	-0.869	1.75	-0.869S
60	1.80	-0.869	1.85	-0.869S
61	1.90	-0.869	2.30	-0.869S
62	2.35	-0.869	2.40	-0.869S
63	2.45	-0.880	2.50	-0.955S
64	2.55	-1.163	2.60	-1.466S
65	2.65	-1.554	2.70	-1.554S
66	2.75	-1.608	2.80	-1.750S
67	2.85	-1.934	2.90	-2.118S
68	2.95	-2.270	3.00	-2.314S
69	3.05	-3.509	3.10	-2.705S
70	3.15	-2.749	3.20	-2.716S
71	3.25	-2.987	3.30	-3.563S
72	3.35	-3.955	3.40	-4.064S
73	3.45	-4.454	3.50	-4.574S
74	3.55	-4.498	3.60	-4.302S
75	3.65	-4.270	3.70	-4.357S
76	3.75	-4.498	3.80	-4.519S
77	3.85	-4.367	3.90	-4.390S
78	3.95	-4.769	4.00	-4.802S
79	4.25	-4.465	4.50	-5.161S
80	4.75	-6.030	5.00	-6.573S
81	5.25	-7.409	5.50	-8.246S
82	5.75	-9.050	6.00	-10.071S
83	6.25	-10.397	6.50	-10.386S
84	6.75	-10.473	7.00	-10.549S
85	7.25	-8.213	7.50	-5.367S
86	7.75	-5.834	8.00	-4.052S
87	8.25	-5.150	8.50	-6.062S
88	8.75	-5.204	9.00	-5.193S
89	9.25	-3.118	9.50	-2.205S
90	9.75	-2.032	10.00	-2.564S

```
               1         2         3         4         5         6         7
CARD  1234567890123456789012345678901234567890123456789012345678901234567890

  91           10.25        -3.096         10.50        -3.542S
  92           10.75        -3.618         11.00        -3.085S
  93           11.25        -3.585         11.50        -3.998S
  94           11.75        -4.411         12.00        -4.932S
  95           12.25        -5.595         12.50        -5.823S
  96           12.75        -5.258         13.00        -4.509S
  97           13.25        -4.183         13.50        -4.204S
  98           13.75        -4.020         14.00        -3.553E
  99  FILL                      10            10
 100               9             1             0             0
 101           0.635    0.00002011           0.0           0.0        619.90
 102       1.5887E07           0.0
 103  END
 104          1.0E-3          0.01          14.0        1000.0
 105          5.0E-1        1.0E-2          14.0           1.0
 106            -1.0
```

APPENDIX E

TRAC STEADY-STATE INPUT DECKS FOR BENNETT RUNS 5442, 5431, AND 5336

I. TRAC STEADY-STATE INPUT DECK FOR BENNETT RUN 5442

```
                1         2         3         4         5         6         7
CARD  1234567890123456789012345678901234567890123456789012345678901234567890

   1              1             0             0
   2      DATA COMPARISONS - TRAC-PD2 VS BENNETT VERTICAL TUBE - RUN 5442
   3              0 0.
   4              0             1             3             2             0
   5    .100000E-02  .100000E-04  .100000E-01  .100000E+00
   6             10            20            10             1             0
   7    0          1  0          2  0        3E  0          0  0          0
   8              1             0           0.0           0.0
   9              0             0             0             0
  10  FILL                      1            01
  11              1             8             1             3
  12         0.1542     1.910E-05           0.0           0.0         541.5
  13       6.895E06
  14           0.0           0.0          0.01        .60175         100.0
  15        .60175
  16  PIPE                      2             2
  17             24             5             1             2            10
  18              1             0
  19   6.310000E-03  1.620000E-03  0.            0.            2.000000E+02
  20   2.000000E+02
  21  F   1.5240E-01E
  22  F   1.9100E-05E
  23  F   1.2500E-04E
  24  F   0.        E
  25  F   1.0000E+00E
  26  F   1.2600E-02E
  27  F            1E
  28  F   0.        E
  29  F   0.        E
  30  F   5.3740E+02E
  31  F   5.3740E+02E
  32  F   6.8900E+06E
  33  F   1.1340E+09E
  34  F   5.3740E+02E
  35  BREAK                     3            03
  36              2             0             0             0
  37         0.1524     1.910E-05           1.0         557.9       6.89E06
  38        0.00001           1.0          25.0           0.0
  39            1.0           0.1          25.0
  40           -1.0
```

II. TRAC STEADY-STATE INPUT DECK FOR BENNETT RUN 5431

```
              1         2         3         4         5         6         7
CARD 1234567890123456789012345678901234567890123456789012345678901234567890

   1              1             0             0
   2     DATA COMPARISONS - TRAC-PD2 VS BENNETT VERTICAL TUBE - RUN 5431
   3              0  0.
   4              0             1             3             2             0
   5    .100000E-02   .100000E-04   .100000E-01   .100000E+00
   6             10            20            10             1             0
   7   0          1  0          2  0         3E  0          0  0          0
   8              1             0           0.0           0.0
   9              0             0             0             0
  10 FILL                       1            01
  11              1             8             1             3
  12         0.1524     1.910E-05           0.0           0.0         534.0
  13       6.895E06
  14           0.0           0.0          0.01       .081375         100.0
  15       .081375
  16 PIPE                       2             2
  17             24             5             1             2            10
  18              1             0
  19   6.310000E-03  1.620000E-03  0.            0.            2.000000E+02
  20   2.000000E+02
  21 F   1.5240E-01E
  22 F   1.9100E-05E
  23 F   1.2500E-04E
  24 F   0.        E
  25 F   1.0000E+00E
  26 F   1.2600E-02E
  27 F            1E
  28 F   0.        E
  29 F   0.        E
  30 F   5.3400E+02E
  31 F   5.3400E+02E
  32 F   6.8900E+06E
  33 F   4.3500E+08E
  34 F   5.3400E+02E
  35 BREAK                      3            03
  36              2             0             0             0
  37         0.1524     1.910E-05           1.0         557.9       6.89E06
  38        0.00001           1.0          25.0           0.0
  39            1.0           0.1          25.0
  40           -1.0
```

III. TRAC STEADY-STATE INPUT DECK FOR BENNETT RUN 5336

```
              1         2         3         4         5         6         7
CARD 1234567890123456789012345678901234567890123456789012345678901234567890
---- ----------------------------------------------------------------------

   1              1             0             0
   2     DATA COMPARISONS - TRAC-PD2 VS BENNETT VERTICAL TUBE - RUN 5431
   3              0  0.
   4              0             1             3             2             0
   5    .100000E-02   .100000E-04   .100000E-01   .100000E+00
   6             10            20            10             1             0
   7   0          1  0          2  0          3E 0          0  0          0
   8              1             0           0.0           0.0
   9              0             0             0             0
  10 FILL                       1            01
  11              1             8             1             3
  12         0.1524     1.910E-05           0.0           0.0         534.0
  13       6.895E06
  14           0.0           0.0          0.01       .081375         100.0
  15       .081375
  16 PIPE                       2             2
  17             24             5             1             2            10
  18              1             0
  19   6.310000E-03  1.620000E-03  0.            0.            2.000000E+02
  20   2.000000E+02
  21 F   1.5240E-01E
  22 F   1.9100E-05E
  23 F   1.2500E-04E
  24 F   0.        E
  25 F   1.0000E+00E
  26 F   1.2600E-02E
  27 F            1E
  28 F   0.        E
  29 F   0.        E
  30 F   5.3400E+02E
  31 F   5.3400E+02E
  32 F   6.8900E+06E
  33 F   4.3500E+08E
  34 F   5.3400E+02E
  35 BREAK                      3            03
  36              2             0             0             0
  37         0.1524     1.910E-05           1.0         557.9       6.89E06
  38        0.00001           1.0          25.0           0.0
  39            1.0           0.1          25.0
  40           -1.0
```

APPENDIX F

TYPICAL TRAC STEADY-STATE AND RESTART INPUT DECKS FOR CREARE COUNTERCURRENT-FLOW EXPERIMENTS

I. TYPICAL TRAC INPUT DECK FOR CREARE STEADY-STATE RUN

```
                 1         2         3         4         5         6         7
CARD    1234567890123456789012345678901234567890123456789012345678901234567890

  1              1
  2     CREARE CCFLOW WITH 30GPM 215K ECC AND J*GC=.043 LPP=1.04 BAR
  3
  4              1              0             25             24              1
  5        1.0E-3          1.E-5         1.0E-3
  6             10             50             10              1
  7             11              2              3              4              5
  8              6              7              8              9             10
  9             12             13             14             15             16
 10             17             18             19             20             21
 11             22             23             24             25              1
 12           2000              0           99.0            0.0
 13
 14     VESSEL                  1              1
 15              7              2              8             12
 16              7              3              1
 17
 18
 19
 20         8026.0          502.0           17.3            0.6            1.0
 21            1.0
 22
 23
 24
 25          0.420          0.841          0.908          1.112          1.315
 26          1.416         1.518E
 27         0.1333        0.1460E
 28         0.7854         1.5710         2.3500         3.1420          3.927
 29          4.712         5.4980        6.2830E
 30              6              9              3              1
 31              6             11              3              2
 32              6             13              3              3
 33              6             15              3              4
 34              7              5              2              9
 35              7              1              2             60
 36              7              2              2             61
 37              7              3              2             62
 38              7              4              2             63
 39              7              6              2             64
 40              7              7              2             65
```

```
                1         2         3         4         5         6         7
CARD  1234567890123456789012345678901234567890123456789012345678901234567890

  41                7             8             2             66
  42  F          0.0E
  43  F          0.0E
  44  F          0.0E
  45  F          0.0E
  46  F          0.0E
  47  F          0.0E
  48  F          0.0E
  49  F          0.0E
  50  F          1.0E
  51  F          1.0E
  52  F          1.0E
  53  F          1.0E
  54  F         0.01E
  55  F         0.01E
  56  F         0.01E
  57  F        395.0E
  58  F          1.0E
  59  F          0.0E
  60  F          0.0E
  61  F          0.0E
  62  F          0.0E
  63  F          0.0E
  64  F          0.0E
  65  F        395.0E
  66  F        395.0E
  67  F       1.1E05E
  68  F          0.0E
  69  F          0.0E
  70  F          0.0E
  71  F          0.0E
  72  F          0.0E
  73  F          0.0E
  74  F          0.0E
  75  F          0.0E
  76  F          1.0E
  77  F          1.0E
  78  F          1.0E
  79  F          1.0E
  80  F         0.01E
  81  F         0.01E
  82  F         0.01E
  83  F        395.0E
  84  F          1.0E
  85  F          0.0E
```

```
               1         2         3         4         5         6         7
CARD  1234567890123456789012345678901234567890123456789012345678901234567890

  86  F          0.0E
  87  F          0.0E
  88  F          0.0E
  89  F          0.0E
  90  F          0.0E
  91  F        395.0E
  92  F        395.0E
  93  F       1.1E05E
  94  F         0.0 E
  95  F         0.0 E
  96  F          0.0E
  97  F          0.0E
  98  F          0.0E
  99  F          0.0E
 100  F          0.0E
 101  F          0.0E
 102  F          1.0E
 103  F          1.0E
 104  F          1.0E
 105  F          1.0E
 106  F         0.01E
 107  F         0.01E
 108  F         0.01E
 109  F        395.0E
 110  F          1.0E
 111  F          0.0E
 112  F          0.0E
 113  F          0.0E
 114  F          0.0E
 115  F          0.0E
 116  F          0.0E
 117  F        395.0E
 118  F        395.0E
 119  F       1.1E05E
 120  F         0.0 E
 121  F         0.0 E
 122  F          0.0E
 123  F          0.0E
 124  F          0.0E
 125  F          0.0E
 126  F          0.0E
 127  F          0.0E
 128  R 8       1.00R 8        1.0E
 129  F          1.0E
 130  F          1.0E
```

```
               1         2         3         4         5         6         7
CARD  1234567890123456789012345678901234567890123456789012345678901234567890

 131  F          1.0E
 132  F         0.01E
 133  F         0.01E
 134  F         0.01E
 135  F        395.0E
 136  F          1.0E
 137  F          0.0E
 138  F          0.0E
 139  F          0.0E
 140  F          0.0E
 141  F          0.0E
 142  F          0.0E
 143  F        395.0E
 144  F        395.0E
 145  F       1.1E05E
 146  F         0.0 E
 147  F         0.0 E
 148  F          0.0E
 149  F          0.0E
 150  F          0.0E
 151  F          0.0E
 152  F          0.0E
 153  F          0.0E
 154  R 8       1.00R 8        1.0E
 155  F          1.0E
 156  F          1.0E
 157  F          1.0E
 158  F         0.01E
 159  F         0.01E
 160  F         0.01E
 161  F        395.0E
 162  F          1.0E
 163  F          0.0E
 164  F          0.0E
 165  F          0.0E
 166  F          0.0E
 167  F          0.0E
 168  F          0.0E
 169  F        395.0E
 170  F        395.0E
 171  F       1.1E05E
 172  F       0.0   E
 173  F       0.0   E
 174  F          0.0E
 175  F          0.0E
```

```
               1         2         3         4         5         6         7
CARD  1234567890123456789012345678901234567890123456789012345678901234567890

 176  F          0.0E
 177  F          0.0E
 178  F          0.0E
 179  F          0.0E
 180  R 8       1.00           1.0          0.59           1.0          0.59
 181            1.0          0.59           1.0          0.59E
 182  R 8        1.0           1.0          0.25           1.0          0.25
 183            1.0          0.25           1.0          0.25E
 184  R 8        1.0           1.0          0.31           1.0          0.31
 185            1.0           0.3           1.0          0.31E
 186  F          1.0E
 187  F         0.01E
 188  F         0.01E
 189  F         0.01E
 190  F        395.0E
 191  F          1.0E
 192  F          0.0E
 193  F          0.0E
 194  F          0.0E
 195  F          0.0E
 196  F          0.0E
 197  F          0.0E
 198  F        395.0E
 199  F        395.0E
 200  F       1.1E05E
 201  F         0.0 E
 202  F         0.0 E
 203  F          0.0E
 204  F          0.0E
 205  F          0.0E
 206  F          0.0E
 207  F          0.0E
 208  F          0.0E
 209  R 8       1.00R 8        1.0E
 210  F          1.0E
 211  F          1.0E
 212  F          1.0E
 213  F         0.01E
 214  F         0.01E
 215  F         0.01E
 216  F        395.0E
 217  F          1.0E
 218  F          0.0E
 219  F          0.0E
 220  F          0.0E
```

```
               1         2         3         4         5         6         7
CARD  1234567890123456789012345678901234567890123456789012345678901234567890

221   F          0.0E
222   F          0.0E
223   F          0.0E
224   F        395.0E
225   F        395.0E
226   F       1.1E05E
227   PIPE                      10            10
228                1             0             9            10
229                0             1
230
231
232   F          2.0E
233   F      2.40E-2E
234   F      2.53E-4E
235   F          0.1E
236   F          0.0E
237   F          0.1E
238   F            0E
239   F          1.0E
240   F          0.0E
241   F       395.00E
242   F        395.0E
243   F      1.05E05E
244   PIPE                      19            19
245                1             0            50            60
246                0             1
247
248
249   F          2.0E
250   F      2.40E-2E
251   F      2.53E-4E
252   F          0.1E
253   F          0.0E
254   F          0.1E
255   F            0E
256   F          1.0E
257   F          0.0E
258   F       395.00E
259   F        395.0E
260   F      1.05E05E
261   PIPE                      20            20
262                1             0            51            61
263                0             1
264
265
```

```
                1         2         3         4         5         6         7
CARD   1234567890123456789012345678901234567890123456789012345678901234567890

 266   F          2.0E
 267   F       2.40E-2E
 268   F       2.53E-4E
 269   F          0.1E
 270   F          0.0E
 271   F          0.1E
 272   F            0E
 273   F          1.0E
 274   F          0.0E
 275   F        395.00E
 276   F         395.0E
 277   F       1.05E05E
 278   PIPE                        21            21
 279                 1              0            52            62
 280                 0              1
 281
 282
 283   F          2.0E
 284   F       2.40E-2E
 285   F       2.53E-4E
 286   F          0.1E
 287   F          0.0E
 288   F          0.1E
 289   F            0E
 290   F          1.0E
 291   F          0.0E
 292   F        395.00E
 293   F         395.0E
 294   F       1.05E05E
 295   PIPE                        22            22
 296                 1              0            53            63
 297                 0              1
 298
 299
 300   F          2.0E
 301   F       2.40E-2E
 302   F       2.53E-4E
 303   F          0.1E
 304   F          0.0E
 305   F          0.1E
 306   F            0E
 307   F          1.0E
 308   F          0.0E
 309   F        395.00E
 310   F         395.0E
```

```
                 1         2         3         4         5         6         7
CARD  1234567890123456789012345678901234567890123456789012345678901234567890

 311  F      1.05E05E
 312  PIPE                      23            23
 313              1             0            54            64
 314              0             1
 315
 316
 317  F          2.0E
 318  F      2.40E-2E
 319  F      2.53E-4E
 320  F          0.1E
 321  F          0.0E
 322  F          0.1E
 323  F            0E
 324  F          1.0E
 325  F          0.0E
 326  F       395.00E
 327  F        395.0E
 328  F      1.05E05E
 329  PIPE                      24            24
 330              1             0            55            65
 331              0             1
 332
 333
 334  F          2.0E
 335  F      2.40E-2E
 336  F      2.53E-4E
 337  F          0.1E
 338  F          0.0E
 339  F          0.1E
 340  F            0E
 341  F          1.0E
 342  F          0.0E
 343  F       395.00E
 344  F        395.0E
 345  F      1.05E05E
 346  PIPE                      25            25
 347              1             0            56            66
 348              0             1
 349
 350
 351  F          2.0E
 352  F      2.40E-2E
 353  F      2.53E-4E
 354  F          0.1E
 355  F          0.0E
```

```
                  1         2         3         4         5         6         7
CARD     1234567890123456789012345678901234567890123456789012345678901234567890

 356     F        0.1E
 357     F          0E
 358     F        1.0E
 359     F        0.0E
 360     F     395.00E
 361     F      395.0E
 362     F    1.05E05E
 363     FILL                     11                  11
 364                10
 365               0.1           0.1                 1.0                28.2                375.0
 366           1.05E05
 367     FILL                     12                  12
 368                50
 369               0.1           0.1                 1.0                28.2                375.0
 370           1.05E05
 371     FILL                     13                  13
 372                51
 373               0.1           0.1                 1.0                28.2                375.0
 374           1.05E05
 375     FILL                     14                  14
 376                52
 377               0.1           0.1                 1.0                28.2                375.0
 378           1.05E05
 379     FILL                     15                  15
 380                53
 381               0.1           0.1                 1.0                28.2                375.0
 382           1.05E05
 383     FILL                     16                  16
 384                54
 385               0.1           0.1                 1.0                28.2                375.0
 386           1.05E05
 387     FILL                     17                  17
 388                55
 389               0.1           0.1                 1.0                28.2                375.0
 390           1.05E05
 391     FILL                     18                  18
 392                56
 393               0.1           0.1                 1.0                28.2                375.0
 394           1.05E05
 395     PIPE                      2                   2
 396                 1             0                   1                   5                    1
 397                 0             0
 398
 399
 400     F        0.1E
```

```
               1         2         3         4         5         6         7
CARD  1234567890123456789012345678901234567890123456789012345678901234567890

401   F      1.78E-4E
402   F      1.78E-3E
403   F          0.1E
404   F          0.0E
405   F      4.76E-2E
406   F            0E
407   F          1.0E
408   F          0.0E
409   F        395.0E
410   F        395.0E
411   F       1.12E5E
412   PIPE                       3             3
413                1             0             2             6             1
414                0             0
415
416
417   F          0.1E
418   F      1.78E-4E
419   F      1.78E-3E
420   F          0.1E
421   F          0.0E
422   F      4.76E-2E
423   F            0E
424   F          1.0E
425   F          0.0E
426   F        395.0E
427   F        395.0E
428   F       1.12E5E
429   PIPE                       4             4
430                1             0             3             7             1
431                0             0
432
433
434   F          1.6E
435   F      2.84E-3E
436   F      1.78E-3E
437   F        0.001E
438   F          0.0E
439   F      4.76E-2E
440   F            0E
441   F          1.0E
442   F          0.0E
443   F        395.0E
444   F        395.0E
445   F       1.12E5E
```

```
               1         2         3         4         5         6         7
CARD  1234567890123456789012345678901234567890123456789012345678901234567890

 446  PIPE                       5             5
 447               1             0             4             8             1
 448               0             0
 449
 450
 451  F          0.1E
 452  F      1.78E-4E
 453  F      1.78E-3E
 454  F          0.1E
 455  F          0.0E
 456  F      4.76E-2E
 457  F            0E
 458  F          1.0E
 459  F          0.0E
 460  F        395.0E
 461  F        395.0E
 462  F       1.12E5E
 463  FILL                       6             6
 464               5
 465              .1           0.1           0.0           0.0         395.0
 466         1.05E05
 467  FILL                       7             7
 468               6
 469              .1           0.1           0.0           0.0         395.0
 470         1.05E05
 471  FILL                       9             9
 472               8
 473              .1           0.1           0.0           0.0         395.0
 474         1.05E05
 475  BREAK                      8             8
 476               7                                         3
 477             0.1           0.1           1.0         380.0       1.05E05
 478          0.1E-4           0.1          50.0
 479            5.00          0.10           5.0
 480  -1.0
```

II. TYPICAL TRAC RESTART INPUT DECK FOR CREARE TRANSIENT RUN

```
               1         2         3         4         5         6         7
CARD  1234567890123456789012345678901234567890123456789012345678901234567890

   1               1
   2  CREARE CCFLOW  30 GPM ECC FLOW RESTART DECK
   3            -9342          20.0
   4                             1            25            24             1
   5          1.0E-3        1.0E-5        1.0E-2
   6              10            50                           1
   7              11             2             3             4             5
   8               6             7             8             9            10
   9              12            13            14            15            16
  10              17            18            19            20            21
  11              22            23            24            25             1
  12            2000             0          99.0           0.0
  13
  14  FILL                       6             6
  15               5
  16              .1           0.1           0.0        0.3545         374.0
  17          1.12E5
  18  FILL                       7             7
  19               6
  20              .1           0.1           0.0        0.3545         374.0
  21          1.12E5
  22  FILL                       9             9
  23               8
  24              .1           0.1           0.0        0.3545         374.0
  25          1.12E5
  26  END
  27          1.0E-4           0.1          50.0
  28            5.00          0.10           5.0
  29  -1.0
```

APPENDIX G

TRAC TRANSIENT INPUT DECK FOR FLECHT TEST 17201

```
                1         2         3         4         5         6         7         8
CARD  12345678901234567890123456789012345678901234567890123456789012345678901234567890

  1             2
  2      FLECHT SKEWED PROFILE LOW FLOODING RATE TEST NO. 17201   01/08/79
  3            (V = 6 IN/SEC     TIN = 127.0 F     TCLAD = 1630 F)
  4             0         0.0
  5             0           1           5           4           0
  6       1.0E-03     1.0E-05     1.0E-02     1.0E-1
  7            10           0          10           1           0
  8             1           2           3           4           5E
  9          1001           0     1.0E-05         0.0
 10             0           0           0
 11   FILL                  1          01
 12             1           2           0           3
 13     3.048E-01   3.956E-03         0.0         0.0       326.0
 14     3.100E+05
 15           0.0         0.0     1.0E-05      0.1524      1.0E03
 16       0.1524E
 17   PIPE                  2          02                            INLET
 18             1           0           1           2           6
 19             0           0
 20     8.890E-02   4.775E-03         0.0         0.0       300.0
 21         300.0
 22   F 3.048E-01E
 23   F 3.956E-03E
 24   F 1.293E-02E
 25   F       0.0E
 26   F       0.0E
 27   F 1.544E-02E
 28   F         1E
 29   F       0.0E
 30   F       0.0E
```

```
              1         2         3         4         5         6         7         8
CARD 12345678901234567890123456789012345678901234567890123456789012345678901234567890

  31 F        326.0E
  32 F        326.0E
  33 F     3.10E+05E
  34 PIPE                       3            03                              OUTLET
  35             1             0             3             4             6
  36             0             0
  37     8.890E-02     4.775E-03           0.0           0.0         300.0
  38         300.0
  39 F    3.048E-01E
  40 F    3.956E-03E
  41 F    1.298E-02E
  42 F          0.0E
  43 F          0.0E
  44 F    1.544E-02E
  45 F            1E
  46 F          1.0E
  47 F          0.0E
  48 F        403.9E
  49 F        403.9E
  50 F     2.758E05E
  51 BREAK                      4            04
  52             4             0             0             0
  53     3.048E-01     3.956E-03           1.0         403.9      2.758E05
  54 VESSEL                     5            05
  55            16             1             1             2
  56             0             0             0            15             2
  57             1
  58             0             0             0             1
  59       4.0E+00       5.0E+01       5.0E-03
  60     7.8488E03      4.663E02       4.33E01          0.80        6.0E04
  61         1.336
  62             9            12             7          1001
  63          1001             0             0             0           100
  64       0.00E05           0.0           0.0
  65        0.1524        0.4064        0.8636        1.1684        1.4732
```

```
                 1         2         3         4         5         6         7         8
CARD    12345678901234567890123456789012345678901234567890123456789012345678901234567890

  66            1.7780        2.0828        2.3876        2.6924        2.9972
  67            3.2258        3.5306        3.6830        3.8354        4.0640
  68            4.2164E
  69            0.1576E
  70            0.1576E
  71                 1             1            -2             2
  72                16             1             2             3
  73    R 2          0.0R 3          1.0R 4          0.0E
  74    F            1.0E
  75              0.48          0.52          0.59          0.66          0.71
  76              0.77          0.83          0.89          0.95          1.00
  77              1.00          0.90          0.66          0.53E
  78             100.0E
  79               0.0     4.445E-04     8.890E-04     1.397E-03     1.905E-03
  80         3.328E-03     4.750E-03     5.055E-03     5.359E-03E
  81                 4             4             5             5             4
  82                 4             8             8E
  83               0.0      0.000E05          10.0      0.000E05          20.0
  84          0.000E05          30.0      5.538E05          50.0      5.277E05
  85              70.0      5.084E05         100.0      4.867E05         150.0
  86          4.608E05         200.0      4.326E05         300.0      3.945E05
  87             500.0      3.499E05        1000.0      2.963E05E
  88    R13          3E
  89    F            0.0E
  90    F            0.0E
  91    F            0.0E
  92    F            0.0E
  93    F            0.0E
  94    F            0.0E
  95    F            0.0E
  96    F            0.0E
  97    F            0.0E                                                     LEVEL 1
  98    F            0.0E                                                     (LOWER
  99    F            0.0E                                                     PLENUM)
 100    F            0.0E
```

```
                   1         2         3         4         5         6         7         8
CARD   12345678901234567890123456789012345678901234567890123456789012345678901234567890

 101   F         0.0E
 102   F         0.0E
 103   F         0.0E
 104   F         0.0E
 105   F   5.228E-01E
 106   F         0.0E
 107   F   5.228E-01E
 108   F         0.0E
 109   F         0.0E
 110   F   1.544E-02E
 111   F         0.0E
 112   F         0.0E
 113   F         0.0E
 114   F         0.0E
 115   F         0.0E
 116   F         0.0E
 117   F         0.0E
 118   F         0.0E
 119   F         0.0E
 120   F       405.0E
 121   F       350.0E
 122   F    2.758E05E
 123   F         0.0E                                                          LEVEL 2
 124   F         0.0E                                                          (UNHEATED
 125   F         0.0E                                                          SECTION)
 126   F         0.0E
 127   F         0.0E
 128   F         0.0E
 129   F         0.0E
 130   F         0.0E
 131   F   5.228E-01E
 132   F         0.0E
 133   F   5.228E-01E
 134   F         0.0E
 135   F         0.0E
```

```
               1         2         3         4         5         6         7         8
CARD  12345678901234567890123456789012345678901234567890123456789012345678901234567890

 136  F    1.544E-02E
 137  F          0.0E
 138  F          0.0E
 139  F          0.0E
 140  F          0.0E
 141  F          0.0E
 142  F          0.0E
 143  F          0.0E
 144  F          0.0E
 145  F          0.0E
 146  F        405.0E
 147  F        400.0E
 148  F    2.7580E05E
 149  F          0.0E                                                        LEVEL 3
 150  F          0.0E                                                        (FIRST
 151  F          0.0E                                                        HEATED
 152  F          0.0E                                                        SECTION)
 153  F          0.0E
 154  F          0.0E
 155  F          0.0E
 156  F          0.0E
 157  F    5.228E-01E
 158  F          0.0E
 159  F    5.228E-01E
 160  F          0.0E
 161  F          0.0E
 162  F    1.544E-02E
 163  F          0.0E
 164  F        425.0E
 165  F          1.0E
 166  F          0.0E
 167  F          0.0E
 168  F          0.0E
 169  F          0.0E
 170  F          0.0E
```

```
              1         2         3         4         5         6         7         8
CARD 12345678901234567890123456789012345678901234567890123456789012345678901234567890

171  F         0.0E
172  F       630.0E
173  F       405.0E
174  F   2.7580E05E
175  F         0.0E
176  F         0.0E
177  F         0.0E
178  F         0.0E
179  F         0.0E
180  F         0.0E
181  F         0.0E
182  F         0.0E
183  F   5.228E-01E
184  F         0.0E
185  F   5.228E-01E
186  F         0.0E
187  F         0.0E
188  F   1.544E-02E
189  F         0.0E
190  F       425.0E
191  F         1.0E
192  F         0.0E
193  F         0.0E
194  F         0.0E
195  F         0.0E
196  F         0.0E
197  F         0.0E
198  F       675.0E
199  F       405.0E
200  F   2.7580E05E
201  F         0.0E
202  F         0.0E
203  F         0.0E
204  F         0.0E
205  F         0.0E
```

```
                 1         2         3         4         5         6         7         8
CARD    12345678901234567890123456789012345678901234567890123456789012345678901234567890

 206    F         0.0E
 207    F         0.0E
 208    F         0.0E
 209    F   5.228E-01E
 210    F         0.0E
 211    F   5.228E-01E
 212    F         0.0E
 213    F         0.0E
 214    F   1.544E-02E
 215    F         0.0E
 216    F       430.0E
 217    F         1.0E
 218    F         0.0E
 219    F         0.0E
 220    F         0.0E
 221    F         0.0E
 222    F         0.0E
 223    F         0.0E
 224    F       720.0E
 225    F       405.0E
 226    F   2.7580E05E
 227    F         0.0E
 228    F         0.0E
 229    F         0.0E
 230    F         0.0E
 231    F         0.0E
 232    F         0.0E
 233    F         0.0E
 234    F         0.0E
 235    F   5.228E-01E
 236    F         0.0E
 237    F   5.228E-01E
 238    F         0.0E
 239    F         0.0E
 240    F   1.544E-02E
```

```
                  1         2         3         4         5         6         7         8
CARD     12345678901234567890123456789012345678901234567890123456789012345678901234567890

 241     F          0.0E
 242     F        435.0E
 243     F          1.0E
 244     F          0.0E
 245     F          0.0E
 246     F          0.0E
 247     F          0.0E
 248     F          0.0E
 249     F          0.0E
 250     F        775.0E
 251     F        405.0E
 252     F    2.7580E05E
 253     F          0.0E
 254     F          0.0E
 255     F          0.0E
 256     F          0.0E
 257     F          0.0E
 258     F          0.0E
 259     F          0.0E
 260     F          0.0E
 261     F    5.228E-01E
 262     F          0.0E
 263     F    5.228E-01E
 264     F          0.0E
 265     F          0.0E
 266     F    1.544E-02E
 267     F          0.0E
 268     F        440.0E
 269     F          1.0E
 270     F          0.0E
 271     F          0.0E
 272     F          0.0E
 273     F          0.0E
 274     F          0.0E
 275     F          0.0E
```

```
              1         2         3         4         5         6         7         8
CARD 12345678901234567890123456789012345678901234567890123456789012345678901234567890

 276 F      805.0E
 277 F      405.0E
 278 F  2.7580E05E
 279 F        0.0E
 280 F        0.0E
 281 F        0.0E
 282 F        0.0E
 283 F        0.0E
 284 F        0.0E
 285 F        0.0E
 286 F        0.0E
 287 F  5.228E-01E
 288 F        0.0E
 289 F  5.228E-01E
 290 F        0.0E
 291 F        0.0E
 292 F  1.544E-02E
 293 F        0.0E
 294 F      455.0E
 295 F        1.0E
 296 F        0.0E
 297 F        0.0E
 298 F        0.0E
 299 F        0.0E
 300 F        0.0E
 301 F        0.0E
 302 F      840.0E
 303 F      405.0E
 304 F  2.7580E05E
 305 F        0.0E
 306 F        0.0E
 307 F        0.0E
 308 F        0.0E
 309 F        0.0E
 310 F        0.0E
```

```
                1         2         3         4         5         6         7         8
CARD   12345678901234567890123456789012345678901234567890123456789012345678901234567890

 311   F        0.0E
 312   F        0.0E
 313   F  5.228E-01E
 314   F        0.0E
 315   F  5.228E-01E
 316   F        0.0E
 317   F        0.0E
 318   F  1.544E-02E
 319   F        0.0E
 320   F      480.0E
 321   F        1.0E
 322   F        0.0E
 323   F        0.0E
 324   F        0.0E
 325   F        0.0E
 326   F        0.0E
 327   F        0.0E
 328   F      875.0E
 329   F      405.0E
 330   F  2.7580E05E
 331   F        0.0E
 332   F        0.0E
 333   F        0.0E
 334   F        0.0E
 335   F        0.0E
 336   F        0.0E
 337   F        0.0E
 338   F        0.0E
 339   F  5.228E-01E
 340   F        0.0E
 341   F  5.228E-01E
 342   F        0.0E
 343   F        0.0E
 344   F  1.544E-02E
 345   F        0.0E
```

```
                1         2         3         4         5         6         7         8
CARD   12345678901234567890123456789012345678901234567890123456789012345678901234567890

 346   F       497.0E
 347   F         1.0E
 348   F         0.0E
 349   F         0.0E
 350   F         0.0E
 351   F         0.0E
 352   F         0.0E
 353   F         0.0E
 354   F       925.0E
 355   F       405.0E
 356   F    2.7580E05E
 357   F         0.0E
 358   F         0.0E
 359   F         0.0E
 360   F         0.0E
 361   F         0.0E
 362   F         0.0E
 363   F         0.0E
 364   F         0.0E
 365   F    5.228E-01E
 366   F         0.0E
 367   F    5.228E-01E
 368   F         0.0E
 369   F         0.0E
 370   F    1.544E-02E
 371   F         0.0E
 372   F       490.0E
 373   F         1.0E
 374   F         0.0E
 375   F         0.0E
 376   F         0.0E
 377   F         0.0E
 378   F         0.0E
 379   F         0.0E
 380   F       975.0E
```

```
                 1         2         3         4         5         6         7         8
CARD    12345678901234567890123456789012345678901234567890123456789012345678901234567890

 381    F        405.0E
 382    F    2.7580E05E
 383    F          0.0E
 384    F          0.0E
 385    F          0.0E
 386    F          0.0E
 387    F          0.0E
 388    F          0.0E
 389    F          0.0E
 390    F          0.0E
 391    F    5.228E-01E
 392    F          0.0E
 393    F    5.228E-01E
 394    F          0.0E
 395    F          0.0E
 396    F    1.544E-02E
 397    F          0.0E
 398    F        470.0E
 399    F          1.0E
 400    F          0.0E
 401    F          0.0E
 402    F          0.0E
 403    F          0.0E
 404    F          0.0E
 405    F          0.0E
 406    F       1015.0E
 407    F        405.0E
 408    F    2.7580E05E
 409    F          0.0E
 410    F          0.0E
 411    F          0.0E
 412    F          0.0E
 413    F          0.0E
 414    F          0.0E
 415    F          0.0E
```

```
                 1         2         3         4         5         6         7         8
CARD    12345678901234567890123456789012345678901234567890123456789012345678901234567890

 416    F         0.0E
 417    F   5.228E-01E
 418    F         0.0E
 419    F   5.228E-01E
 420    F         0.0E
 421    F         0.0E
 422    F   1.544E-02E
 423    F         0.0E
 424    F       450.0E
 425    F         1.0E
 426    F         0.0E
 427    F         0.0E
 428    F         0.0E
 429    F         0.0E
 430    F         0.0E
 431    F         0.0E
 432    F       990.0E
 433    F       405.0E
 434    F   2.7580E05E
 435    F         0.0E
 436    F         0.0E
 437    F         0.0E
 438    F         0.0E
 439    F         0.0E
 440    F         0.0E
 441    F         0.0E
 442    F         0.0E
 443    F   5.228E-01E
 444    F         0.0E
 445    F   5.228E-01E
 446    F         0.0E
 447    F         0.0E
 448    F   1.544E-02E
 449    F         0.0E
 450    F       435.0E
```

CARD	1 2 3 4 5 6 7 8 12345678901234567890123456789012345678901234567890123456789012345678901234567890
451	F 1.0E
452	F 0.0E
453	F 0.0E
454	F 0.0E
455	F 0.0E
456	F 0.0E
457	F 0.0E
458	F 940.0E
459	F 405.0E
460	F 2.7580E05E
461	F 0.0E
462	F 0.0E
463	F 0.0E
464	F 0.0E
465	F 0.0E
466	F 0.0E
467	F 0.0E
468	F 0.0E
469	F 5.228E-01E
470	F 0.0E
471	F 5.228E-01E
472	F 0.0E
473	F 0.0E
474	F 1.544E-02E
475	F 0.0E
476	F 419.0E
477	F 1.0E
478	F 0.0E
479	F 0.0E
480	F 0.0E
481	F 0.0E
482	F 0.0E
483	F 0.0E
484	F 800.0E
485	F 405.0E

```
                1         2         3         4         5         6         7         8
CARD   12345678901234567890123456789012345678901234567890123456789012345678901234567890

486    F     2.7580E05E
487    F           0.0E                                                  LEVEL 16
488    F           0.0E                                                  (UPPER
489    F           0.0E                                                  PLENUM)
490    F           0.0E
491    F           0.0E
492    F           0.0E
493    F           0.0E
494    F           0.0E
495    F     5.228E-01E
496    F           0.0E
497    F     5.228E-01E
498    F           0.0E
499    F           0.0E
500    F     1.544E-02E
501    F           0.0E
502    F           0.0E
503    F           1.0E
504    F           0.0E
505    F           0.0E
506    F           0.0E
507    F           0.0E
508    F           0.0E
509    F           0.0E
510    F         405.0E
511    F         405.0E
512    F     2.7580E05E
513    F           0.0E                                                  VESSEL
514    R 9       800.0R 9      824.9R 9      866.6R 9      922.1R 9      966.6  ROD
515    R 9      1011.0R 9     1052.7R 9     1094.3R 9     1122.1R 9     1138.8  DATA
516    R 9      1094.3R 9     1027.7R 9      922.1R 9      800.0E
517             1.0E-06       1.0E+00      18.0E+00
518             3.0E+00       1.0E-02       3.0E+00
519                -1.0
```

APPENDIX H

TRAC STEADY-STATE AND TRANSIENT INPUT DECKS FOR SEMISCALE MOD-1 TEST S-02-8

I. TRAC STEADY-STATE INPUT DECK FOR SEMISCALE MOD-1 TEST S-02-8

```
                  1         2         3         4         5         6         7         8
CARD     12345678901234567890123456789012345678901234567890123456789012345678901234567890

  1                   3             0
  2      SP5 SS USING TRAC VER 26.0
  3      SP5SPD26   S63 TYPE VESSEL ,AND PUMP
  4      STEADY STATE
  5                   0  0.
  6                   1             0            13            13            01
  7         1.00000E-02   1.00000E-05   1.00000E-03  0.
  8                  10            00            10             3             0
  9        0          1  0          2  0          3  0          4  0          5
 10        0          7  0          8  0          9  0         10  0         11
 11        0         12  0         13  0          6  0          0  0          0
 12                 100             0   .100000E+04  0.
 13                   0             0             0             0
 14                1000             0   .100000E+04  0.
 15                   0             0             0             0
 16                 900             0    .10000E+04             0
 17                   0             0             0             0
 18      TEE                        1             0
 19                   4             1             7  0.                       3
 20                   0             6             1             2             0
 21        3.335020E-02  1.112520E-02  0.            0.            2.950000E+02
 22        2.950000E+02
 23                   1             5             8
 24        9.425000E-03  3.911600E-03  0.            0.            2.950000E+02
 25        2.950000E+02
 26      F   5.1480E-01E
 27      F   1.7986E-03E
 28          3.4942E-02F   3.4942E-03E
 29      F   0.        E
 30      R 6 0.        R 1 1.0000E+00E
```

```
              1         2         3         4         5         6         7         8
CARD 12345678901234567890123456789012345678901234567890123456789012345678901234567890

  31 F   6.6700E-02E
  32 F            4E
  33 F   0.        E
  34 F   0.        E
  35 F   5.9640E+02E
  36 F   5.9640E+02E
  37 F   1.5596E+07E
  38 F   0.        E
  39 F   5.9640E+02E
  40     5.0000E-02    1.6720E+00    7.2000E-01    2.0300E-01    4.0000E-03E
  41     1.7471E-04    7.1745E-05    3.0895E-05    7.0930E-04    9.1040E-05E
  42     3.4942E-03R 3 4.2910E-05R 1 3.4940E-03    2.2760E-02E
  43 F   6.8000E-03E
  44 F   1.0000E+00E
  45     6.6700E-02R 3 7.3900E-03R 1 6.6700E-02R 1 1.7000E-01E
  46 F            4E
  47 F   0.        E
  48 F   0.        E
  49 F   5.9640E+02E
  50 F   5.9640E+02E
  51 F   1.5596E+07E
  52 F   0.        E
  53 F   5.9640E+02E
  54 STGEN                      2             0
  55             22             3             2             3            10
  56              1             0             0             1
  57   5.100000E-03  1.200000E-03
  58             12             9            10
  59 R 1 4.6000E-01R20 2.5680E-01R 1 4.6000E-01E
  60 R 1 9.6278E-03R20 1.1398E-03R 1 9.6278E-03E
  61 R 1 3.4942E-03R21 4.4000E-03R 1 3.4942E-03E
  62 R 1 0.        R21 9.3000E-02R 1 0.        E
  63 R11 1.0000E+00R 1 0.        R11-1.0000E+00E
  64 R 1 6.6700E-02R21 1.0200E-02R 1 6.6700E-02E
  65 R 1         4R21         1R 1         4E
```

```
                  1         2         3         4         5         6         7         8
CARD     12345678901234567890123456789012345678901234567890123456789012345678901234567890

  66     F    0.          E
  67     F    0.          E
  68          5.9640E+02     5.9440E+02     5.9240E+02     5.9040E+02     5.8840E+02
  69          5.8640E+02     5.8440E+02     5.8240E+02     5.8040E+02     5.7840E+02
  70          5.7640E+02     5.7440E+02     5.7240E+02     5.7040E+02     5.6840E+02
  71          5.6640E+02     5.6440E+02     5.6240E+02     5.6040E+02     5.5840E+02
  72          5.5640E+02     5.5440E+02E
  73          5.9640E+02     5.9440E+02     5.9240E+02     5.9040E+02     5.8840E+02
  74          5.8640E+02     5.8440E+02     5.8240E+02     5.8040E+02     5.7840E+02
  75          5.7640E+02     5.7440E+02     5.7240E+02     5.7040E+02     5.6840E+02
  76          5.6640E+02     5.6440E+02     5.6240E+02     5.6040E+02     5.5840E+02
  77          5.5640E+02     5.5440E+02E
  78     F    1.5596E+07E
  79     F    5.5000E+02E
  80     F    2.5680E-01E
  81     R10  1.1210E-02R 2  7.5000E-02E
  82     R11  4.3830E-02R 2  9.2000E-03E
  83     F    0.          E
  84     F    1.0000E+00E
  85     F    1.8800E-02E
  86     F             4E
  87     R 2  0.          R 1  3.0300E-01R 1  3.6722E-01R 1  4.3144E-01R 1  4.9567E-01
  88     R 1  5.5989E-01R 1  6.2411E-01R 1  6.8833E-01R 1  7.5256E-01R 1  8.1678E-01
  89     R 1  8.8100E-01E
  90          5.0000E-03     5.2400E-03     5.5000E-03     7.9000E-01     9.0222E-01
  91          1.0144E+00     1.1267E+00     1.2389E+00     1.3511E+00     1.4633E+00
  92          1.5756E+00     1.6878E+00     1.8000E+00E
  93     R 1  5.1700E+02R 1  5.3820E+02R10  5.4430E+02E
  94     R 1  5.1700E+02R 1  5.3820E+02R10  5.4430E+02E
  95          5.5700E+06     5.5691E+06     5.5682E+06     5.5673E+06     5.5664E+06
  96          5.5655E+06     5.5645E+06     5.5636E+06     5.5627E+06     5.5618E+06
  97          5.5609E+06     5.5600E+06E
  98     R 1  0.          R20  4.0000E-01R 1  0.          E
  99     F    5.5330E-01E
 100     PIPE                          3              0
```

```
                1             2             3             4             5             6             7             8
CARD  12345678901234567890123456789012345678901234567890123456789012345678901234567890

 101               6             1             3             4             7
 102               3             0
 103    3.324800E-02  1.112520E-02  0.            0.            2.950000E+02
 104    2.950000E+02
 105  R 3 5.1000E-01R 3 4.6140E-01E
 106  R 3 1.7820E-03R 3 1.6122E-03E
 107  F   3.4942E-03E
 108  F   0.        E
 109  R 1-1.0000E+00R 1 0.        R 1-1.0000E+00R 2 1.0000E+00R 2 0.        E
 110  F   6.6700E-02E
 111  F            4E
 112  F   0.        E
 113  F   0.        E
 114  F   5.5440E+02E
 115  F   5.5440E+02E
 116  F   1.5596E+07E
 117  F   0.        E
 118  F   5.5440E+02E
 119  PUMP                       4             0
 120               7             1             4             5             7
 121               0             0             1             0             1
 122               0             0
 123    3.324800E-02  1.112520E-02  0.            0.            2.945000E+02
 124    2.950000E+02
 125    5.739000E+02  4.345000E+01  1.148000E-02  1.000000E+03  3.728000E+02
 126    2.662000E+00  0.            3.730000E+00  3.024000E+02
 127               1
 128  R 2 5.8350E-01R 5 4.8430E-01E
 129  R 2 2.0388E-03R 5 1.6922E-03E
 130  F   3.4942E-03E
 131  F   0.        E
 132  F   0.        E
 133  F   6.6700E-02E
 134  F            4E
 135  F   0.        E
```

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              1         2         3         4         5         6         7         8
CARD 12345678901234567890123456789012345678901234567890123456789012345678901234567890

136  F   0.        E
137  F   5.5440E+02E
138  F   5.5440E+02E
139  F   1.5596E+07E
140  F   0.        E
141  F   5.5440E+02E
142  PRIZER                     5             0
143               4             8
144    8.000000E+03  1.559600E+07  1.000000E+05  1.000000E-01
145  R 2 5.0000E-01R 1 1.2840E-01R 1 2.0000E-02E
146  R 2 1.1730E-02R 1 3.0125E-03R 1 4.6920E-04E
147  F   2.2760E-02E
148  F   0.        E
149  F  -1.0000E+00E
150  F   1.7000E-01E
151  F            4E
152  R 1 1.0000E+00R 3 0.        E
153  F   0.        E
154  F   5.9640E+02E
155  F   5.9640E+02E
156  F   1.5596E+07E
157  VESSEL                     6
158              13             2             2             4
159              12             3             1            13             4
160               1
161               0             0             0             2
162      10.0          20.0          5.0000E-03
163        8026.            502.           17.3           .6      60000.
164           1.334
165              10             7            07          1000
166             900             0             0             0           150
167       1.590 E+6             0             0E
168      .3659         .6098         .7318         1.2522        1.6585
169      1.849         1.9759        2.1664        2.4203        2.9282
170      3.955         4.981         6.2220
```

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                 1         2         3         4         5         6         7         8
CARD  12345678901234567890123456789012345678901234567890123456789012345678901234567890

171       .0750572      .0857252
172       3.1415926     6.2831853 E
173                 13             4             3             1
174                 13             3             3             7
175                 12             4             3             6
176                 12             3             3             5
177                 0.            1.            1.            1.F           0.
178   F   1.
179       4.983         17.667        19.           19.           17.667
180       9.933         .187      F   0.0       E
181       19.5          19.5      E
182       0.0           .0008001      .0013462      .0018923      .0027178
183       .0035433      .0043688      .0047105      .0050523      .0053594
184   R 1          4R 2          5R 3          4R 3          8E
185       0.                1.59E+6      .1             1.59E+6      .63
186        1.10229E6        1.9       1.05505 E+6       8.1         .39997 E+6  PWTB
187        20.            .0803 E+6     1000.          .0803 E+6                PWTB
188   F            3                                                           NFAX
189   F   0.                                                                  FPUO2
190   F   1.                                                                  FTD
191   F   0.                                                                  GMIX
192   F   0.                                                                  GMLES
193   F   0.                                                                  PGAPT
194   F   0.                                                                  PLVOL
195   F   0.                                                                  PSLEN
196   F   0.                                                                  CLENN
197   R 2 .0088      R 2 .1012     E
198   R 2 .44        R 2 5.06      E
199   F   .005                                                                LEVEL  1
200   F   50.0                                                                LEVEL  1
201   F   .005                                                                LEVEL  1
202   F   .005                                                                LEVEL  1
203   F   50.0                                                                LEVEL  1
204   F   .005                                                                LEVEL  1
205   F   1.                                                                  LEVEL  1
```

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                 1         2         3         4         5         6         7         8
CARD    12345678901234567890123456789012345678901234567890123456789012345678901234567890

206     F   1.                                                              LEVEL  1
207     F   1.                                                              LEVEL  1
208     F   1.                                                              LEVEL  1
209     R 2     0.0750R 2     0.0107E
210     R 2     0.0750R 2     0.0107E
211     R 2     0.0750R 2     0.0107E
212     F        554.4E
213     F   0.                                                              LEVEL  1
214     F   0.                                                              LEVEL  1
215     F   0.                                                              LEVEL  1
216     F   0.                                                              LEVEL  1
217     F   0.                                                              LEVEL  1
218     F   0.                                                              LEVEL  1
219     F   0.                                                              LEVEL  1
220     F   562.0                                                           LEVEL  1
221     F   562.0                                                           LEVEL  1
222     F   1.5596 E+7                                                      LEVEL  1
223     R 2 0.0       R 2 .0656     E
224     R 2 0.0       R 2 3.2800    E
225     F   .005                                                            LEVEL  2
226     F   50.0                                                            LEVEL  2
227     F   .005                                                            LEVEL  2
228     F   .005                                                            LEVEL  2
229     F   50.0                                                            LEVEL  2
230     F   .005                                                            LEVEL  2
231     F   1.                                                              LEVEL  2
232     F   1.                                                              LEVEL  2
233     F   .91468                                                          LEVEL  2
234     F   1.                                                              LEVEL  2
235     R 2     0.0750R 2     0.0107E
236     R 2     0.0750R 2     0.0107E
237     R 2     0.0750R 2     0.0107E
238     R 2 0.        R 2 562.0     E
239     F   0.                                                              LEVEL  2
240     F   0.                                                              LEVEL  2
```

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              1         2         3         4         5         6         7         8
CARD 12345678901234567890123456789012345678901234567890123456789012345678901234567890

241  F   0.                                                                  LEVEL  2
242  F   0.                                                                  LEVEL  2
243  F   0.                                                                  LEVEL  2
244  F   0.                                                                  LEVEL  2
245  F   0.                                                                  LEVEL  2
246  F   562.0                                                               LEVEL  2
247  F   562.0                                                               LEVEL  2
248  F   1.5596 E+7                                                          LEVEL  2
249  R 2 0.0       F 2 .0328     E
250  R 2 0.0       R 2 1.640     E
251  F   .005                                                                LEVEL  3
252  F   .005                                                                LEVEL  3
253  F   .005                                                                LEVEL  3
254  F   .005                                                                LEVEL  3
255  F   .005                                                                LEVEL  3
256  F   .005                                                                LEVEL  3
257  F   1.                                                                  LEVEL  3
258  F   1.                                                                  LEVEL  3
259  F   .91468                                                              LEVEL  3
260  F   1.                                                                  LEVEL  3
261  R 2     0.0750R 2     0.0107E
262  R 2     0.0750R 2     0.0107E
263  R 2     0.0750R 2     0.0107E
264  R 2 0.          R 2 562.0     E
265  F   0.                                                                  LEVEL  3
266  F   0.                                                                  LEVEL  3
267  F   0.                                                                  LEVEL  3
268  F   0.                                                                  LEVEL  3
269  F   0.                                                                  LEVEL  3
270  F   0.                                                                  LEVEL  3
271  F   0.                                                                  LEVEL  3
272  F   562.0                                                               LEVEL  3
273  F   562.0                                                               LEVEL  3
274  F   1.5596 E+7                                                          LEVEL  3
275  R 4 .2628     E
```

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               1         2         3         4         5         6         7         8
CARD  12345678901234567890123456789012345678901234567890123456789012345678901234567890

 276  R 4 13.14     E
 277  F   .005                                                             LEVEL  4
 278  R 2  23.      F   0.
 279  F   .005
 280  F   .005
 281  R 2  23.      F   0.
 282  F   .005                                                             LEVEL  4
 283  R 2 .61160    R 2 1.0                                                LEVEL  4
 284  R 2 .91468    R 2 1.0                                                LEVEL  4
 285  R 2 .2758     R 2 1.                                                 LEVEL
 286  F   1.                                                               LEVEL  4
 287  R 2     0.0750R 2     0.0213E
 288  R 2     0.0750R 2     0.0213E
 289  R 2     0.0750R 2     0.0213E
 290  F         554.2E
 291  F   0.                                                               LEVEL  4
 292  F   0.                                                               LEVEL  4
 293  F   0.                                                               LEVEL  4
 294  F   0.                                                               LEVEL  4
 295  F   0.                                                               LEVEL  4
 296  F   0.                                                               LEVEL  4
 297  F   0.                                                               LEVEL  4
 298  F   562.0                                                            LEVEL  4
 299  F   562.0                                                            LEVEL  4
 300  F   1.5596 E+7                                                       LEVEL  4
 301  R 4 .20544    E
 302  R 4 10.272    E
 303  F   .005                                                             LEVEL  5
 304  F   .005                                                             LEVEL  5
 305  F   .005                                                             LEVEL  5
 306  F   .005                                                             LEVEL  5
 307  F   .005                                                             LEVEL  5
 308  F   .005                                                             LEVEL  5
 309  R 2 .2758     R 2 1.                                                 LEVEL  5
 310  R 2 .38       R   1.                                                 LEVEL  5
```

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                1         2         3         4         5         6         7         8
CARD  12345678901234567890123456789012345678901234567890123456789012345678901234567890

 311  R 2 .2758     R 2 1.                                                    LEVEL  5
 312  F   0.                                                                  LEVEL  5
 313  R 2    .010719R 2      0.0213E
 314  R 2    .010719R 2      0.0213E
 315  R 2    .010719R 2      0.0213E
 316  R 2 0.        R 2 562.0      E
 317  F   0.                                                                  LEVEL  5
 318  F   0.                                                                  LEVEL  5
 319  F   0.                                                                  LEVEL  5
 320  F   0.                                                                  LEVEL  5
 321  F   0.                                                                  LEVEL  5
 322  F   0.                                                                  LEVEL  5
 323  F   0.                                                                  LEVEL  5
 324  R 2 562.0     R 2 562.0                                                 LEVEL  5
 325  R 2 562.0     R 2 562.0                                                 LEVEL  5
 326  F   1.5596 E+7                                                          LEVEL  5
 327  R 4 .0963     E
 328  R 4 4.815     E
 329  F   .005                                                                LEVEL  6
 330  F   .005                                                                LEVEL  6
 331  F   .005                                                                LEVEL  6
 332  F   .005                                                                LEVEL  6
 333  F   .005                                                                LEVEL  6
 334  F   .005                                                                LEVEL  6
 335  R 2 .2758     R 2 1.                                                    LEVEL  6
 336  R 2 .38       R 2 1.                                                    LEVEL  6
 337  R 2 .2758     R 2 1.                                                    LEVEL  6
 338  F   0.                                                                  LEVEL  6
 339  R 2    .010719R 2      0.0213E
 340  R 2    .010719R 2      0.0213E
 341  R 2    .010719R 2      0.0213E
 342  R 2 0.        R 2 562.0      E
 343  F   0.                                                                  LEVEL  6
 344  F   0.                                                                  LEVEL  6
 345  F   0.                                                                  LEVEL  6
```

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               1         2         3         4         5         6         7         8
CARD  12345678901234567890123456789012345678901234567890123456789012345678901234567890

346   F   0.                                                                  LEVEL  6
347   F   0.                                                                  LEVEL  6
348   F   0.                                                                  LEVEL  6
349   F   0.                                                                  LEVEL  6
350   R 2 562.0     R 2 562.0                                                 LEVEL  6
351   R 2 562.0     R 2 562.0                                                 LEVEL  6
352   F   1.5596 E+7                                                          LEVEL  6
353   R 4 .0642     E
354   R 4 1.284     E
355   F    .005                                                                LEVEL 7
356   F    .005                                                                LEVEL 7
357   F    .005                                                                LEVEL 7
358   F    .005                                                                LEVEL 7
359   F    .005                                                                LEVEL 7
360   F    .005                                                                LEVEL 7
361   R 2 .2758     R 2 1.                                                     LEVEL 7
362   R 2 .38       R 2 1.                                                     LEVEL 7
363   R 2 .2758     R 2 1.                                                     LEVEL 7
364   F   0.                                                                   LEVEL 7
365   R 2    .010719R 2     0.0213E                                            LEVEL 7
366   R 2    .010719R 2     0.0213E                                            LEVEL 7
367   R 2    .010719R 2     0.0213E                                            LEVEL 7
368   R 2 0.        R 2 562.0     E                                            LEVEL 7
369   F   0.                                                                   LEVEL 7
370   F   0.                                                                   LEVEL 7
371   F   0.                                                                   LEVEL 7
372   F   0.                                                                   LEVEL 7
373   F   0.                                                                   LEVEL 7
374   F   0.                                                                   LEVEL 7
375   F   0.                                                                   LEVEL 7
376   R 2 562.0     R 2 562.0                                                  LEVEL 7
377   R 2 562.0     R 2 562.0                                                  LEVEL 7
378   F   1.5596 E+7                                                           LEVEL 7
379   R 4 .0963     E
380   R 4 4.1926    E
```

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              1         2         3         4         5         6         7         8
CARD 12345678901234567890123456789012345678901234567890123456789012345678901234567890

381  F   .005                                                                LEVEL 8
382  F   .005                                                                LEVEL 8
383  F   .005                                                                LEVEL 8
384  F   .005                                                                LEVEL 8
385  F   .005                                                                LEVEL 8
386  F   .005                                                                LEVEL 8
387  R 2 .2758     R 2 1.                                                    LEVEL 8
388  R 2 .38       R 2 1.                                                    LEVEL 8
389  R 2 .2758     R 2 1.                                                    LEVEL 8
390  F   0.                                                                  LEVEL 8
391  R 2    .010719R 2     0.0213E                                           LEVEL 8
392  R 2    .010719R 2     0.0213E                                           LEVEL 8
393  R 2    .010719R 2     0.0213E                                           LEVEL 8
394  R 2 0.        R 2 562.0     E                                           LEVEL 8
395  F   0.                                                                  LEVEL 8
396  F   0.                                                                  LEVEL 8
397  F   0.                                                                  LEVEL 8
398  F   0.                                                                  LEVEL 8
399  F   0.                                                                  LEVEL 8
400  F   0.                                                                  LEVEL 8
401  F   0.                                                                  LEVEL 8
402  R 2 562.0     R 2 562.0                                                 LEVEL 8
403  R 2 562.0     R 2 562.0                                                 LEVEL 8
404  F   1.5596 E+7                                                          LEVEL 8
405  R 4 .284     E
406  R 4 6.42      E
407  F   .005                                                                LEVEL 9
408  F   .005                                                                LEVEL 9
409  F   .005                                                                LEVEL 9
410  F   .005                                                                LEVEL 9
411  F   .005                                                                LEVEL 9
412  F   .005                                                                LEVEL 9
413  R 2 .2758     R 2 1.                                                    LEVEL 9
414  R 2 .38       R 2 1.                                                    LEVEL 9
415  R 2 .2758     R 2 1.                                                    LEVEL 9
```

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                   1         2         3         4         5         6         7         8
CARD      12345678901234567890123456789012345678901234567890123456789012345678901234567890

 416      F   0.                                                              LEVEL 9
 417      R 2    .010719R 2     0.0213E                                       LEVEL 9
 418      R 2    .010719R 2     0.0213E                                       LEVEL 9
 419      R 2    .010719R 2     0.0213E                                       LEVEL 9
 420      R 2 0.        R 2 562.0     E                                       LEVEL 9
 421      F   0.                                                              LEVEL 9
 422      F   0.                                                              LEVEL 9
 423      F   0.                                                              LEVEL 9
 424      F   0.                                                              LEVEL 9
 425      F   0.                                                              LEVEL 9
 426      F   0.                                                              LEVEL 9
 427      F   0.                                                              LEVEL 9
 428      R 2 562.0     R 2 562.0                                             LEVEL 9
 429      R 2 562.0     R 2 562.0                                             LEVEL 9
 430      F   1.5596 E+7                                                      LEVEL 9
 431      R 4 .2568     E
 432      R 4 12.84     E
 433      F   .005                                                            LEVEL 10
 434      F   .005                                                            LEVEL 10
 435      F   .005                                                            LEVEL 10
 436      F   .005                                                            LEVEL 10
 437      F   .005                                                            LEVEL 10
 438      F   .005                                                            LEVEL 10
 439      R 2 .2758     R 2 1.                                                LEVEL 10
 440      R 2 .38       R 2 1.                                                LEVEL 10
 441      R 2 .2758     R 2 1.                                                LEVEL 10
 442      F   0.                                                              LEVEL 10
 443      R 2    .010719R 2     0.0213E                                       LEVEL 10
 444      R 2    .010719R 2     0.0213E                                       LEVEL 10
 445      R 2    .010719R 2     0.0213E                                       LEVEL 10
 446      R 2 0.        R 2 562.0     E                                       LEVEL 10
 447      F   0.                                                              LEVEL 10
 448      F   0.                                                              LEVEL 10
 449      F   0.                                                              LEVEL 10
 450      F   0.                                                              LEVEL 10
```

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              1         2         3         4         5         6         7         8
CARD 12345678901234567890123456789012345678901234567890123456789012345678901234567890

451  F   0.                                                                  LEVEL 10
452  F   0.                                                                  LEVEL 10
453  F   0.                                                                  LEVEL 10
454  R 2 562.0     R 2 562.0                                                 LEVEL 10
455  R 2 562.0     R 2 562.0                                                 LEVEL 10
456  F   1.5596 E+7                                                          LEVEL 10
457  R 4 .5134      E
458  R 4 25.67      E
459  F   .005                                                              LEVEL 11
460  F   .005                                                              LEVEL 11
461  F   .005                                                              LEVEL 11
462  F   .005                                                              LEVEL 11
463  F   .005                                                              LEVEL 11
464  F   .005                                                              LEVEL 11
465  R 2 .2758     R 2 1.                                                  LEVEL 11
466  R 2 .38       R 2 1.                                                  LEVEL 11
467  R 2 .2758     R 2 1.                                                  LEVEL 11
468  F   0.                                                                LEVEL 11
469  R 2     0.1576R 2     0.0213E                                         LEVEL 11
470  R 2     0.1576R 2     0.0213E                                         LEVEL 11
471  R 2     0.1576R 2     0.0213E                                         LEVEL 11
472  R 2 596.4     R 2 555.4     E                                         LEVEL 11
473  F   0.                                                                LEVEL 11
474  F   0.                                                                LEVEL 11
475  F   0.                                                                LEVEL 11
476  F   0.                                                                LEVEL 11
477  F   0.                                                                LEVEL 11
478  F   0.                                                                LEVEL 11
479  F   0.                                                                LEVEL 11
480  F   596.4                                                             LEVEL 11
481  F   596.4                                                             LEVEL 11
482  F   1.5596 E+7                                                        LEVEL 11
483  R 4 .513       E
484  R 4 25.65      E
485  F   .005                                                              LEVEL 12
```

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                 1         2         3         4         5         6         7         8
CARD    12345678901234567890123456789012345678901234567890123456789012345678901234567890

 486    F   .005                                                              LEVEL 12
 487    F   .005                                                              LEVEL 12
 488    F   .005                                                              LEVEL 12
 489    F   .005                                                              LEVEL 12
 490    F   .005                                                              LEVEL 12
 491    R 2 .2758     R 2 1.719                                               LEVEL 12
 492    R 2 .38       R 2 1.                                                  LEVEL 12
 493    R 2 .2758     R 2 0.0                                                 LEVEL 12
 494    F   0.                                                                LEVEL 12
 495    R 2     0.1576R 2     0.0213E                                         LEVEL 12
 496    R 2     0.1576R 2     0.0213E                                         LEVEL 12
 497    R 2     0.1576R 2     0.0213E                                         LEVEL 12
 498    R 2 596.4     R 2 555.4     E                                         LEVEL 12
 499    F   0.                                                                LEVEL 12
 500    F   0.                                                                LEVEL 12
 501    F   0.                                                                LEVEL 12
 502    F   0.                                                                LEVEL 12
 503    F   0.                                                                LEVEL 12
 504    F   0.                                                                LEVEL 12
 505    F   0.                                                                LEVEL 12
 506    F   596.4                                                             LEVEL 12
 507    F   596.4                                                             LEVEL 12
 508    F   1.5596 E+7                                                        LEVEL 12
 509    R 2 .63735    R 2 .356      E
 510    R 2 31.87     R 2 17.80     E
 511    F   .005                                                              LEVEL 13
 512    F   .005                                                              LEVEL 13
 513    F   .005                                                              LEVEL 13
 514    F   .005                                                              LEVEL 13
 515    F   .005                                                              LEVEL 13
 516    F   .005                                                              LEVEL 13
 517    R 2 .4947     R 2 .56       E
 518    R 2 .38       R 2 .56                                                 LEVEL 13
 519    F   0.                                                                LEVEL 13
 520    R 2 .0155     R 2 0.0       E
```

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              1         2         3         4         5         6         7         8
CARD 12345678901234567890123456789012345678901234567890123456789012345678901234567890

521  R 2     0.0750R 2     0.0107E                                         LEVEL 13
522  R 2     0.0750R 2     0.0107E                                         LEVEL 13
523  R 2     0.0750R 2     0.0107E                                         LEVEL 13
524  F        596.4E                                                       LEVEL 13
525  F   0.                                                                LEVEL 13
526  F   0.                                                                LEVEL 13
527  F   0.                                                                LEVEL 13
528  F   0.                                                                LEVEL 13
529  F   0.                                                                LEVEL 13
530  F   0.                                                                LEVEL 13
531  F   0.                                                                LEVEL 13
532  F   596.4                                                             LEVEL 13
533  F   596.4                                                             LEVEL 13
534  F   1.5596 E+7                                                        LEVEL 13
535  F   0.                                                                  ROD DATA
536  F   640.0
537  F   0.                                                                  ROD DATA
538  F   640.0
539  FILL                       7
540               9             4           100             3
541      .26           .01           0.            .05           490.5
542        55.7 E+5
543      0.            .05           .1            0.            1000.
544      0.
545  BREAK                      8
546              13
547       .26             2.0 E-3     .93           543.8          55.6 E+5
548  PIPE                       9             0
549               1             0             6            11             7
550               0             0
551    0.            0.            0.            0.            0.
552    0.
553  F   5.0000E-01E
554  F   5.0000E-03E
555  F   1.0000E-03E
```

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              1         2         3         4         5         6         7         8
CARD 12345678901234567890123456789012345678901234567890123456789012345678901234567890

556  F   0.         E
557  F   0.         E
558  F   3.6000E-02E
559  F            4E
560  F   0.         E
561  F   0.         E
562  F   5.5440E+02E
563  F   5.5440E+02E
564  F   1.5596E+07E
565  PIPE                      10             0
566               1             0             7            12             7
567               0             0
568    0.            0.            0.            0.            0.
569    0.
570  F   5.0000E-01E
571  F   5.0000E-03E
572  F   1.0000E-03E
573  F   0.         E
574  F   0.         E
575  F   3.6000E-02E
576  F            4E
577  F   0.         E
578  F   0.         E
579  F   5.5440E+02E
580  F   5.5440E+02E
581  F   1.5596E+07E
582  FILL                      11
583              11             1
584    .1            .001        0.            0.            554.4
585       1.5596E+7
586  FILL                      12
587              12             1
588    .1            .001        0.            0.            596.4
589       1.5596E+7
590  VALVE                     13             0
```

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               1         2         3         4         5         6         7         8
CARD  12345678901234567890123456789012345678901234567890123456789012345678901234567890

591                2             0            10            13             0
592                0             0
593     0.            0.            0.            0.            0.
594     0.
595                3           100             3             0             2
596     9.200000E-03  1.880000E-02  0.
597   F   5.0000E-01E
598   F   4.6000E-03E
599   F   9.2000E-03E
600   F   0.        E
601   F   0.        E
602   F   1.8800E-02E
603   F            4E
604   F   8.8100E-01E
605   F   1.8000E+00E
606   F   5.4430E+02E
607   F   5.4430E+02E
608   F   5.5600E+06E
609       0.            1.0000E+00    1.0000E-01    0.            1.0000E+03
610       0.        E
611      .000105        0.10          588.          1000.
612              4.0           .10           4.0            1.
613              -1.
```

II. TRAC TRANSIENT RESTART INPUT DECK FOR SEMISCALE MOD-1 TEST S-02-8

```
                   1         2         3         4         5         6         7         8
CARD      12345678901234567890123456789012345678901234567890123456789012345678901234567890

   1                   3             0
   2      SP5 USING TRAC VER 26.0
   3      SP5TPD27   FINAL RUN ?
   4      RESTART USING SP5SPD2R6
   5                  -1  0.
   6                   0             1            13            13            01
   7         .100000E-02   .500000E-05  0.            0.
   8                  10           000            20             3             0
   9        0          1  0          2  0          3  0          4  0          5
  10        0          6  0          7  0          8  0          9  0         10
  11        0         11  0         12  0         13  0          0  0          0
  12                 100             0   .100000E+01  0.
  13                   0             0             0             0
  14                1000             0  0.            0.
  15                   0             0             0             0
  16                 900             0    0.0           0.
  17                   0             0             0             0
  18      PIPE                       9             0
  19                  18             1             6            11             7
  20                  01             1
  21        3.335000E-02  1.112520E-02  0.            0.             2.930000E+02
  22        2.930000E+02
  23      R 1 5.3486E-01R 2 4.0399E-01R 2 4.0747E-01R 2 7.2070E-03R 1 3.6417E-02
  24      R 1 1.8208E-02R 1 9.1040E-03R 1 4.5520E-03R 1 2.2760E-03R 2 1.1380E-03
  25      R 2 6.4756E-03R 1 1.2951E-02R 1 2.5903E-02E
  26      R 1 1.8689E-03R 2 1.4116E-03R 2 7.0990E-04R 1 2.5906E-06R 1 2.0151E-06
  27      R 1 8.8202E-06R 1 4.4101E-06R 1 2.2050E-06R 1 1.1025E-06R 1 5.5126E-07
  28      R 2 2.7563E-07S
  29      R 1 1.7065E-06R 1 1.9942E-06R 1 4.9523E-06R 1 1.4434E-05E
  30          3.4942E-02S
```

```
               1         2         3         4         5         6         7         8
CARD  12345678901234567890123456789012345678901234567890123456789012345678901234567890

  31  R 2 3.4942E-03R 2 1.4455E-03R 1 4.0190E-04R 1 3.1700E-04R 8 2.4218E-04
  32  R 1 2.8487E-04R 1 3.3103E-04R 1 4.3374E-04R 1 6.8072E-04E
  33  F   0.        E
  34  F   0.        E
  35  R 1 4.8260E-02R 2 6.6700E-02R 2 4.2900E-02R 1 2.2620E-02R 1 2.0090E-02
  36  R 8 1.7560E-02S
  37  R 1 1.9045E-02R 1 2.0530E-02R 1 2.3500E-02R 1 2.9440E-02E
  38  F            4E
  39  F   0.0000E+00E
  40  F   0.        E
  41  I 2 555.3         553.2     F   553.2     E
  42  I 2 555.3         553.2     F   553.2     E
  43  F   1.5596E+07E
  44  F   0.        E
  45  I 2 555.3          553.2    F   553.2     E
  46  PIPE                      10             0
  47              34             3             7            12             7
  48              01             1
  49    3.335000E-02  1.112520E-02  0.            0.            2.930000E+02
  50    2.930000E+02
  51  R 1 5.1690E-01R 1 3.8570E-01R10 5.1530E-01R 2 6.4260E-01R 1 4.5840E-01
  52  R 2 4.0640E-01R 2 5.2780E-01R 2 3.2790E-01R 2 7.2070E-03R 1 3.6417E-02
  53  R 1 1.8208E-02R 1 9.1040E-03R 1 4.5520E-03R 1 2.2760E-03R 2 1.1380E-03
  54  R 2 6.4756E-03R 1 1.2951E-02R 1 2.5903E-02E
  55  R 1 1.8066E-03R 1 1.3479E-03R10 1.5843E-03R 2 9.2880E-04R 1 6.6261E-04
  56  R 2 7.4050E-04R 2 6.0175E-04R 2 4.9514E-04R 1 2.5906E-06R 1 2.0151E-06
  57  R 1 8.8202E-06R 1 4.4101E-06R 1 2.2050E-06R 1 1.1025E-06R 1 5.5126E-07
  58  R 2 2.7563E-07S
  59  R 1 1.7065E-06R 1 1.9942E-06R 1 4.9523E-06R 1 1.4434E-05E
  60  R 1 3.4942E-02R 2 3.4949E-03R 9 3.7378E-03R 3 1.4455E-03R 3 2.4475E-04
  61  R 3 1.1401E-03R 1 4.0190E-04R 1 3.1700E-04R 8 2.4218E-04S
  62  R 1 2.8487E-04R 1 3.3103E-04R 1 4.3374E-04R 1 6.8072E-04E
  63  R 2 1.1000E+01R11 1.2500E+00R 1 1.3000E+00R 6 .05600E-02R15 0.            E
  64  R 1 0.        R 1 5.0000E-01R 5 1.0000E+00R 4-1.0000E+00R 1-5.0000E-01
  65  R 2-1.0000E+00R 2 0.        R 3 1.0000E+00R16 0.        E
```

```
                 1         2         3         4         5         6         7         8
CARD    12345678901234567890123456789012345678901234567890123456789012345678901234567890

  66    R 1 4.8260E-02R 2 6.6700E-02R 9 6.8990E-02R 3 4.2900E-02R 3 .99323E-02
  67    R 3 3.8100E-02R 1 2.2620E-02R 1 2.0090E-02R 8 1.7560E-02S
  68    R 1 1.9045E-02R 1 2.0530E-02R 1 2.3500E-02R 1 2.9440E-02E
  69    F            4E
  70    F   0.        E
  71    F   0.        E
  72    R14  592.1    I 4 592.1        585.9      F   585.9
  73    R14  592.1    I 4 592.1        585.9      F   585.9
  74    F   1.5596E+07E
  75    F   0.        E
  76    R14  592.1    I 4 592.1        585.9      F    585.9
  77    BREAK                     11
  78                 11
  79            .13589   7.13949 E-5  1.000000E+00    396.7         2.206 E+05
  80    BREAK                     12
  81                 12
  82            .13589   7.13949 E-5  1.000000E+00    396.7         2.206 E+05
  83    PRIZER                     5              0
  84                  4            8
  85      8.000000E+03  1.559600E+07  1.000000E+05  1.000000E-01
  86    R 2 5.0000E-01R 1 1.2840E-01R 1 2.0000E-02E
  87    R 2 1.1730E-02R 1 3.0125E-03R 1 4.6920E-04E
  88    F   2.2760E-02E
  89    F   0.        E
  90    F  -1.0000E+00E
  91    F   1.7000E-01E
  92    F            4E
  93    R 1 1.0000E+00R 3 0.        E
  94    R 4 0.        R 1 4.2524E-03E
  95    F   6.1840E+02E
  96    F   6.1840E+02E
  97    F   1.5596E+07E
  98    END
  99            1.0E-5        2.0E-2             .01          .01
 100            .01           .005              2.           .5
```

```
                 1         2         3         4         5         6         7         8
CARD    12345678901234567890123456789012345678901234567890123456789012345678901234567890

101             1.0E-5        2.0E-2           .10          .10
102             .10           .05               2.           .5
103             1.0E-5        2.0E-2           1.0          1.0
104             1.0           2.0E-1            2.           .5
105             1.0E-5        2.0E-2           10.          10.
106             2.0           2.0E-1            2.           .5
107             1.0E-5        2.0E-2          29.1          1.0
108             5.0           2.0E-1            5.           .5
109        -1.
```

APPENDIX I

TRAC STEADY-STATE AND TRANSIENT INPUT DECKS FOR SEMISCALE MOD-1 TEST S-06-3

I. TRAC STEADY-STATE INPUT DECK FOR SEMISCALE MOD-1 TEST S-06-3

```
                1         2         3         4         5         6         7         8
CARD   12345678901234567890123456789012345678901234567890123456789012345678901234567890

   1                3             0
   2   S63 SS USING TRAC VER 26.0
   3   S63SPD31  INCREASE FRIC IN INT. LOOP
   4   STEADY STATE
   5                0  0.
   6                1             0            21            21             1
   7      1.00000E-02   1.00000E-05  01.00000E-03  0.
   8               10             0            20             4             0
   9     0          1  0          2  0          3  0          4  0        105
  10     0          7  0          8  0          9  0         10  0         11
  11     0         12  0         13  0         30  0         31  0         32
  12     0         33  0         34  0         35  0         36  0         37
  13     0         6E 0          0  0          0  0          0  0          0
  14              100             0   .100000E+04  0.
  15                0             0             0             0
  16             1000             0   .100000E+04  0.
  17                0             0             0             0
  18              900             0   .100000E+04  0.
  19                0             0             0             0
  20             2000            -1   .423800E+07  0.
  21               32             2             1             0
  22   TEE                        1             0
  23                4             1             7  3.000000E-06             0
  24                0             6             1             2             0
  25     3.335020E-02  1.112520E-02  0.            0.            2.950000E+02
  26     2.950000E+02
  27                1             5             8
  28     9.425000E-03  3.911600E-03  0.            0.            2.950000E+02
  29     2.950000E+02
  30   F   5.1480E-01E
```

```
                 1         2         3         4         5         6         7         8
CARD    12345678901234567890123456789012345678901234567890123456789012345678901234567890

 31     F   1.7986E-03E
 32         3.4942E-02F   3.4942E-03E
 33         0.0           00.00         00.00     F   0.0       E
 34     R 6 0.        R 1 1.0000E+00E
 35     F   6.6700E-02E
 36     F            4E
 37     F   0.        E
 38     F   0.        E
 39     F   5.9640E+02E
 40     F   5.9640E+02E
 41     F   1.5596E+07E
 42     F   0.        E
 43     F   5.9640E+02E
 44         5.0000E-02    1.6720E+00    7.2000E-01    2.0300E-01    4.0000E-03E
 45         1.7471E-04    7.1745E-05    3.0895E-05    7.0930E-04    9.1040E-05E
 46         3.4942E-03R 3 4.2910E-05R 1 3.4940E-03    2.2760E-02E
 47     F   6.8000E-03E
 48     F   1.0000E+00E
 49         6.6700E-02R 3 7.3900E-03R 1 6.6700E-02R 1 1.7000E-01E
 50     F            4E
 51     F   0.        E
 52     F   0.        E
 53     F   5.9640E+02E
 54     F   5.9640E+02E
 55     F   1.5596E+07E
 56     F   0.        E
 57     F   5.9640E+02E
 58     STGEN                      2             0
 59                22             3             2             3            10
 60                 1             0             0             1
 61       5.100000E-03  1.200000E-03
 62                12             9            10
 63     R 1 4.6000E-01R20 2.5680E-01R 1 4.6000E-01E
 64     R 1 9.6278E-03R20 1.1398E-03R 1 9.6278E-03E
 65     R 1 3.4942E-03R21 4.4000E-03R 1 3.4942E-03E
```

```
                 1         2         3         4         5         6         7         8
CARD    12345678901234567890123456789012345678901234567890123456789012345678901234567890

  66    R 1 0.        R21 2.4400E-02R 1 0.        E
  67    R11 1.0000E+00R 1 0.        R11-1.0000E+00E
  68    R 1 6.6700E-02R21 1.0200E-02R 1 6.6700E-02E
  69    R 1          4R21          1R 1          4E
  70    F   0.        E
  71    F   0.        E
  72        5.9640E+02    5.9440E+02    5.9240E+02    5.9040E+02    5.8840E+02
  73        5.8640E+02    5.8440E+02    5.8240E+02    5.8040E+02    5.7840E+02
  74        5.7640E+02    5.7440E+02    5.7240E+02    5.7040E+02    5.6840E+02
  75        5.6640E+02    5.6440E+02    5.6240E+02    5.6040E+02    5.5840E+02
  76        5.5640E+02    5.5440E+02E
  77        5.9640E+02    5.9440E+02    5.9240E+02    5.9040E+02    5.8840E+02
  78        5.8640E+02    5.8440E+02    5.8240E+02    5.8040E+02    5.7840E+02
  79        5.7640E+02    5.7440E+02    5.7240E+02    5.7040E+02    5.6840E+02
  80        5.6640E+02    5.6440E+02    5.6240E+02    5.6040E+02    5.5840E+02
  81        5.5640E+02    5.5440E+02E
  82    F   1.5596E+07E
  83    F   5.5000E+02E
  84    F   2.5680E-01E
  85    R10 1.1210E-02R 2 7.5000E-02E
  86    R11 4.3830E-02R 2 9.2000E-03E
  87    F   0.        E
  88    F   1.0000E+00E
  89    F   1.8800E-02E
  90    F            4E
  91    R 2 0.        R 1 3.0300E-01R 1 3.6722E-01R 1 4.3144E-01R 1 4.9567E-01
  92    R 1 5.5989E-01R 1 6.2411E-01R 1 6.8833E-01R 1 7.5256E-01R 1 8.1678E-01
  93    R 1 8.8100E-01E
  94        5.0000E-03    5.2400E-03    5.5000E-03    7.9000E-01    9.0222E-01
  95        1.0144E+00    1.1267E+00    1.2389E+00    1.3511E+00    1.4633E+00
  96        1.5756E+00    1.6878E+00    1.8000E+00E
  97    R 1 5.1700E+02R 1 5.3820E+02R10 5.4430E+02E
  98    R 1 5.1700E+02R 1 5.3820E+02R10 5.4430E+02E
  99        5.5700E+06    5.5691E+06    5.5682E+06    5.5673E+06    5.5664E+06
 100        5.5655E+06    5.5645E+06    5.5636E+06    5.5627E+06    5.5618E+06
```

```
                   1         2         3         4         5         6         7         8
CARD      12345678901234567890123456789012345678901234567890123456789012345678901234567890

101           5.5609E+06    5.5600E+06E
102       R 1 0.        R20 4.0000E-01R 1 0.        E
103       F   5.5330E-01E
104       PIPE                       3             0
105                    6             1             3             4             7
106                    3             0
107         3.324800E-02  1.112520E-02  0.            0.            2.950000E+02
108         2.950000E+02
109       R 3 5.1000E-01R 3 4.6140E-01E
110       R 3 1.7820E-03R 3 1.6122E-03E
111       F   3.4942E-03E
112       F   0.        E
113       R 1-1.0000E+00R 1 0.        R 1-1.0000E+00R 2 1.0000E+00R 2 0.        E
114       F   6.6700E-02E
115       F            4E
116       F   0.        E
117       F   0.        E
118       F   5.5440E+02E
119       F   5.5440E+02E
120       F   1.5596E+07E
121       F   0.        E
122       F   5.5440E+02E
123       PUMP                       4             0
124                    2             1             4            36             7
125                    0             0             1             0             1
126                    0             0
127         3.324800E-02  1.112520E-02  0.            0.            2.945000E+02
128         2.950000E+02
129         5.739000E+02  4.345000E+01  1.148000E-02  1.000000E+03  3.728000E+02
130         2.662000E+00  0.            3.730000E+00  1.700000E+02
131                    1
132           11.670E-01    14.529E-01E
133           4.0776E-03    5.0766E-03E
134       F   3.4942E-03E
135           0.0           .0076     E
```

```
               1         2         3         4         5         6         7         8
CARD  12345678901234567890123456789012345678901234567890123456789012345678901234567890

136   F   0.        E
137   F   6.6700E-02E
138   F            4E
139   F   0.        E
140   F   0.        E
141   F   5.5440E+02E
142   F   5.5440E+02E
143   F   1.5596E+07E
144   F   0.        E
145   F   5.5440E+02E
146   PIPE                      37             0
147                1             1            37             5             7
148                0             0
149     3.224800E-02  1.112500E-02  0.            0.            2.950000E+02
150     2.950000E+02
151   F   4.8430E-01E
152   F   1.6922E-03E
153   F   3.4942E-03E
154       0.0           .0076    E
155   F   0.        E
156   F   6.6700E-02E
157   F            4E
158   F   0.        E
159   F   0.        E
160   F   5.5440E+02E
161   F   5.5440E+02E
162   F   1.5596E+07E
163   F   0.        E
164   F   5.5440E+02E
165   VESSEL                     6
166               13             2             2             4
167               12             3             1            13             4
168                1
169                0             0             0             4
170       10.0          20.0          5.0000E-03
```

```
                 1         2         3         4         5         6         7         8
CARD    12345678901234567890123456789012345678901234567890123456789012345678901234567890

171           8026.            502.           17.3           .6      60000.
172              1.334
173                 10            22             7          1000
174                900             0             0             0           150
175          1.004 E+6             0             0E
176         .3659         .6098         .7318         1.2522        1.6585
177         1.849         1.9759        2.1664        2.4203        2.9282
178         3.955         4.981         6.2220
179         .0750572      .0857252
180         3.1415926     6.2831853 E
181                 13             4             3             1
182                 13             3             3             7
183                 12             4             3             6
184                 12             3             3             5
185                 0.            1.            1.            1.F           0.
186     F   1.
187                  1             2
188         1.4850        .9390     E
189         4.983         17.667        19.           19.           17.667
190         9.933         .187      F   0.0       E
191         18.0          18.0      E
192         0.0           .0008001      .0013462      .0018923      .0027178
193         .0035433      .0043688      .0047105      .0050523      .0053594
194     R 1          4R 2          5R 3          4R 3          8E
195         0.0           1.0040E+06    2.0           .60000E+06S
196         2.5            .5750E+06    3.0           .60000E+06S
197         3.3           1.0000E+06    5.1          1.00000E+06S
198         6.0            .5000E+06    7.3           .20000E+06S
199         11.0           .2000E+06    11.6          .17500E+06S
200         15.0           .1700E+06    16.0          .08000E+06S
201         17.2           .0800E+06    17.8          .15500E+06S
202         19.5           .1550E+06    20.0          .05000E+06S
203         26.8           .0500E+06    27.2          .02000E+06S
204         36.0           .0200E+06    40.0          .05000E+06S
205         100.           .0400E+06     300.         .04000E+06E
```

```
                 1         2         3         4         5         6         7         8
CARD    12345678901234567890123456789012345678901234567890123456789012345678901234567890

 206    F            3                                                         NFAX
 207    F   0.                                                                 FPUO2
 208    F   1.                                                                 FTD
 209    F   0.                                                                 GMIX
 210    F   0.                                                                 GMLES
 211    F   0.                                                                 PGAPT
 212    F   0.                                                                 PLVOL
 213    F   0.                                                                 PSLEN
 214    F   0.                                                                 CLENN
 215    R 2 .0088         R 2 .1012       E
 216    R 2 .44           R 2 5.06        E
 217    F   .005                                                               LEVEL  1
 218    F   50.0                                                               LEVEL  1
 219    F   .005                                                               LEVEL  1
 220    F   .005                                                               LEVEL  1
 221    F   50.0                                                               LEVEL  1
 222    F   .005                                                               LEVEL  1
 223    F   1.                                                                 LEVEL  1
 224    F   1.                                                                 LEVEL  1
 225    F   1.                                                                 LEVEL  1
 226    F   1.                                                                 LEVEL  1
 227    R 2     0.0750R 2      0.0107E
 228    R 2     0.0750R 2      0.0107E
 229    R 2     0.0750R 2      0.0107E
 230    F        554.4E
 231    F   0.                                                                 LEVEL  1
 232    F   0.                                                                 LEVEL  1
 233    F   0.                                                                 LEVEL  1
 234    F   0.                                                                 LEVEL  1
 235    F   0.                                                                 LEVEL  1
 236    F   0.                                                                 LEVEL  1
 237    F   0.                                                                 LEVEL  1
 238    F   562.0                                                              LEVEL  1
 239    F   562.0                                                              LEVEL  1
 240    F   1.5596 E+7                                                         LEVEL  1
```

```
                  1         2         3         4         5         6         7         8
CARD     12345678901234567890123456789012345678901234567890123456789012345678901234567890

241      R 2 0.0       R 2 .0656     E
242      R 2 0.0       R 2 3.2800    E
243      F   .005                                                            LEVEL  2
244      F   50.0                                                            LEVEL  2
245      F   .005                                                            LEVEL  2
246      F   .005                                                            LEVEL  2
247      F   50.0                                                            LEVEL  2
248      F   .005                                                            LEVEL  2
249      F   1.                                                              LEVEL  2
250      F   1.                                                              LEVEL  2
251      F   .91468                                                          LEVEL  2
252      F   1.                                                              LEVEL  2
253      R 2     0.0750R 2     0.0107E
254      R 2     0.0750R 2     0.0107E
255      R 2     0.0750R 2     0.0107E
256      R 2 0.        R 2 562.0     E
257      F   0.                                                              LEVEL  2
258      F   0.                                                              LEVEL  2
259      F   0.                                                              LEVEL  2
260      F   0.                                                              LEVEL  2
261      F   0.                                                              LEVEL  2
262      F   0.                                                              LEVEL  2
263      F   0.                                                              LEVEL  2
264      F   562.0                                                           LEVEL  2
265      F   562.0                                                           LEVEL  2
266      F   1.5596 E+7                                                      LEVEL  2
267      R 2 0.0       R 2 .0328     E
268      R 2 0.0       R 2 1.640     E
269      F   .005                                                            LEVEL  3
270      F   .005                                                            LEVEL  3
271      F   .005                                                            LEVEL  3
272      F   .005                                                            LEVEL  3
273      F   .005                                                            LEVEL  3
274      F   .005                                                            LEVEL  3
275      F   1.                                                              LEVEL  3
```

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              1         2         3         4         5         6         7         8
CARD 12345678901234567890123456789012345678901234567890123456789012345678901234567890

276  F   1.                                                                LEVEL  3
277  F   .91468                                                            LEVEL  3
278  F   1.                                                                LEVEI  3
279  R 2     0.0750R 2      0.0107E
280  R 2     0.0750R 2      0.0107E
281  R 2     0.0750R 2      0.0107E
282  R 2 0.        R 2 562.0     E
283  F   0.                                                                LEVEL  3
284  F   0.                                                                LEVEL  3
285  F   0.                                                                LEVEL  3
286  F   0.                                                                LEVEL  3
287  F   0.                                                                LEVEL  3
288  F   0.                                                                LEVEL  3
289  F   0.                                                                LEVEL  3
290  F   562.0                                                             LEVEL  3
291  F   562.0                                                             LEVEL  3
292  F   1.5596 E+7                                                        LEVEL  3
293  R 4 .2628     E
294  R 4 13.14     E
295  F   .005                                                              LEVEL  4
296  R 2  23.      F   0.
297  F   .005
298  F   .005
299  R 2  23.      F   0.
300  F   .005                                                              LEVEL  4
301  R 2 .61160    R 2 1.0                                                 LEVEL  4
302  R 2 .91468    R 2 1.0                                                 LEVEL  4
303  R 2 .2758     R 2 1.                                                  LEVEL
304  F   1.                                                                LEVEL  4
305  R 2     0.0750R 2      0.0213E
306  R 2     0.0750R 2      0.0213E
307  R 2     0.0750R 2      0.0213E
308  F        554.2E
309  F   0.                                                                LEVEL  4
310  F   0.                                                                LEVEL  4
```

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               1         2         3         4         5         6         7         8
CARD  12345678901234567890123456789012345678901234567890123456789012345678901234567890

 311  F   0.                                                                  LEVEL  4
 312  F   0.                                                                  LEVEL  4
 313  F   0.                                                                  LEVEL  4
 314  F   0.                                                                  LEVEL  4
 315  F   0.                                                                  LEVEL  4
 316  F   562.0                                                               LEVEL  4
 317  F   562.0                                                               LEVEL  4
 318  F   1.5596 E+7                                                          LEVEL  4
 319  R 4 .20544    E
 320  R 4 10.272    E
 321  F   .005                                                                LEVEL  5
 322  F   .005                                                                LEVEL  5
 323  F   .005                                                                LEVEL  5
 324  F   .005                                                                LEVEL  5
 325  F   .005                                                                LEVEL  5
 326  F   .005                                                                LEVEL  5
 327  R 2 .2758     R 2 1.                                                    LEVEL  5
 328  R 2 .38       R 2 1.                                                    LEVEL  5
 329  R 2 .2758     R 2 1.                                                    LEVEL  5
 330  F   0.                                                                  LEVEL  5
 331  R 2    .010719R 2     0.0213E
 332  R 2    .010719R 2     0.0213E
 333  R 2    .010719R 2     0.0213E
 334  R 2 0.        R 2 562.0     E
 335  F   0.                                                                  LEVEL  5
 336  F   0.                                                                  LEVEL  5
 337  F   0.                                                                  LEVEL  5
 338  F   0.                                                                  LEVEL  5
 339  F   0.                                                                  LEVEL  5
 340  F   0.                                                                  LEVEL  5
 341  F   0.                                                                  LEVEL  5
 342  R 2 562.0     R 2 562.0                                                 LEVEL  5
 343  R 2 562.0     R 2 562.0                                                 LEVEL  5
 344  F   1.5596 E+7                                                          LEVEL  5
 345  R 4 .0963     E
```

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               1         2         3         4         5         6         7         8
CARD  12345678901234567890123456789012345678901234567890123456789012345678901234567890

 346  R 4 4.815     E
 347  F   .005                                                                LEVEL  6
 348  F   .005                                                                LEVEL  6
 349  F   .005                                                                LEVEL  6
 350  F   .005                                                                LEVEL  6
 351  F   .005                                                                LEVEL  6
 352  F   .005                                                                LEVEL  6
 353  R 2 .2758     R 2 1.                                                    LEVEL  6
 354  R 2 .38       R 2 1.                                                    LEVEL  6
 355  R 2 .2758     R 2 1.                                                    LEVEL  6
 356  F   0.                                                                  LEVEL  6
 357  R 2    .010719R 2     0.0213E
 358  R 2    .010719R 2     0.0213E
 359  R 2    .010719R 2     0.0213E
 360  R 2 0.        R 2 562.0     E
 361  F   0.                                                                  LEVEL  6
 362  F   0.                                                                  LEVEL  6
 363  F   0.                                                                  LEVEL  6
 364  F   0.                                                                  LEVEL  6
 365  F   0.                                                                  LEVEL  6
 366  F   0.                                                                  LEVEL  6
 367  F   0.                                                                  LEVEL  6
 368  R 2 562.0     R 2 562.0                                                 LEVEL  6
 369  R 2 562.0     R 2 562.0                                                 LEVEL  6
 370  F   1.5596 E+7                                                          LEVEL  6
 371  R 4 .0642     E
 372  R 4 1.284     E
 373  F   .005                                                                LEVEL 7
 374  F   .005                                                                LEVEL 7
 375  F   .005                                                                LEVEL 7
 376  F   .005                                                                LEVEL 7
 377  F   .005                                                                LEVEL 7
 378  F   .005                                                                LEVEL 7
 379  R 2 .2758     R 2 1.                                                    LEVEL 7
 380  R 2 .38       R 2 1.                                                    LEVEL 7
```

```
              1         2         3         4         5         6         7         8
CARD 12345678901234567890123456789012345678901234567890123456789012345678901234567890

381  R 2 .2758     R 2 1.                                                    LEVEL 7
382  F   0.                                                                  LEVEL 7
383  R 2    .010719R 2     0.0213E                                           LEVEL 7
384  R 2    .010719R 2     0.0213E                                           LEVEL 7
385  R 2    .010719R 2     0.0213E                                           LEVEL 7
386  R 2 0.        R 2 562.0     E                                           LEVEL 7
387  F   0.                                                                  LEVEL 7
388  F   0.                                                                  LEVEL 7
389  F   0.                                                                  LEVEL 7
390  F   0.                                                                  LEVEL 7
391  F   0.                                                                  LEVEL 7
392  F   0.                                                                  LEVEL 7
393  F   0.                                                                  LEVEL 7
394  R 2 562.0     R 2 562.0                                                 LEVEL 7
395  R 2 562.0     R 2 562.0                                                 LEVEL 7
396  F   1.5596 E+7                                                          LEVEL 7
397  R 4 .0963     E
398  R 4 4.1926    E
399  F   .005                                                                LEVEL 8
400  F   .005                                                                LEVEL 8
401  F   .005                                                                LEVEL 8
402  F   .005                                                                LEVEL 8
403  F   .005                                                                LEVEL 8
404  F   .005                                                                LEVEL 8
405  R 2 .2758     R 2 1.                                                    LEVEL 8
406  R 2 .38       R 2 1.                                                    LEVEL 8
407  R 2 .2758     R 2 1.                                                    LEVEL 8
408  F   0.                                                                  LEVEL 8
409  R 2    .010719R 2     0.0213E                                           LEVEL 8
410  R 2    .010719R 2     0.0213E                                           LEVEL 8
411  R 2    .010719R 2     0.0213E                                           LEVEL 8
412  R 2 0.        R 2 562.0     E                                           LEVEL 8
413  F   0.                                                                  LEVEL 8
414  F   0.                                                                  LEVEL 8
415  F   0.                                                                  LEVEL 8
```

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              1         2         3         4         5         6         7         8
CARD 12345678901234567890123456789012345678901234567890123456789012345678901234567890

416  F   0.                                                                  LEVEL 8
417  F   0.                                                                  LEVEL 8
418  F   0.                                                                  LEVEL 8
419  F   0.                                                                  LEVEL 8
420  R 2 562.0     R 2 562.0                                                 LEVEL 8
421  R 2 562.0     R 2 562.0                                                 LEVEL 8
422  F   1.5596 E+7                                                          LEVEL 8
423  R 4 .284     E
424  R 4 6.42      E
425  F   .005                                                                LEVEL 9
426  F   .005                                                                LEVEL 9
427  F   .005                                                                LEVEL 9
428  F   .005                                                                LEVEL 9
429  F   .005                                                                LEVEL 9
430  F   .005                                                                LEVEL 9
431  R 2 .2758     R 2 1.                                                    LEVEL 9
432  R 2 .38       R 2 1.                                                    LEVEL 9
433  R 2 .2758     R 2 1.                                                    LEVEL 9
434  F   0.                                                                  LEVEL 9
435  R 2    .010719R 2     0.0213E                                           LEVEL 9
436  R 2    .010719R 2     0.0213E                                           LEVEL 9
437  R 2    .010719R 2     0.0213E                                           LEVEL 9
438  R 2 0.        R 2 562.0     E                                           LEVEL 9
439  F   0.                                                                  LEVEL 9
440  F   0.                                                                  LEVEL 9
441  F   0.                                                                  LEVEL 9
442  F   0.                                                                  LEVEL 9
443  F   0.                                                                  LEVEL 9
444  F   0.                                                                  LEVEL 9
445  F   0.                                                                  LEVEL 9
446  R 2 562.0     R 2 562.0                                                 LEVEL 9
447  R 2 562.0     R 2 562.0                                                 LEVEL 9
448  F   1.5596 E+7                                                          LEVEL 9
449  R 4 .2568     E
450  R 4 12.84     E
```

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              1         2         3         4         5         6         7         8
CARD 12345678901234567890123456789012345678901234567890123456789012345678901234567890

 451 F   .005                                                                LEVEL 10
 452 F   .005                                                                LEVEL 10
 453 F   .005                                                                LEVEL 10
 454 F   .005                                                                LEVEL 10
 455 F   .005                                                                LEVEL 10
 456 F   .005                                                                LEVEL 10
 457 R 2 .2758     R 2 1.                                                    LEVEL 10
 458 R 2 .38       R 2 1.                                                    LEVEL 10
 459 R 2 .2758     R 2 1.                                                    LEVEL 10
 460 F   0.                                                                  LEVEL 10
 461 R 2    .010719R 2     0.0213E                                           LEVEL 10
 462 R 2    .010719R 2     0.0213E                                           LEVEL 10
 463 R 2    .010719R 2     0.0213E                                           LEVEL 10
 464 R 2 0.        R 2 562.0     E                                           LEVEL 10
 465 F   0.                                                                  LEVEL 10
 466 F   0.                                                                  LEVEL 10
 467 F   0.                                                                  LEVEL 10
 468 F   0.                                                                  LEVEL 10
 469 F   0.                                                                  LEVEL 10
 470 F   0.                                                                  LEVEL 10
 471 F   0.                                                                  LEVEL 10
 472 R 2 562.0     R 2 562.0                                                 LEVEL 10
 473 R 2 562.0     R 2 562.0                                                 LEVEL 10
 474 F   1.5596 E+7                                                          LEVEL 10
 475 R 4 .5134     E
 476 R 4 25.67     E
 477 F   .005                                                              LEVEL 11
 478 F   .005                                                              LEVEL 11
 479 F   .005                                                              LEVEL 11
 480 F   .005                                                              LEVEL 11
 481 F   .005                                                              LEVEL 11
 482 F   .005                                                              LEVEL 11
 483 R 2 .2758     R 2 1.                                                  LEVEL 11
 484 R 2 .38       R 2 1.                                                  LEVEL 11
 485 R 2 .2758     R 2 1.                                                  LEVEL 11
```

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                 1         2         3         4         5         6         7         8
CARD  12345678901234567890123456789012345678901234567890123456789012345678901234567890

486   F   0.                                                                LEVEL 11
487   R 2     0.1576R 2     0.0213E                                         LEVEL 11
488   R 2     0.1576R 2     0.0213E                                         LEVEL 11
489   R 2     0.1576R 2     0.0213E                                         LEVEL 11
490   R 2 596.4     R 2 555.4     E                                         LEVEL 11
491   F   0.                                                                LEVEL 11
492   F   0.                                                                LEVEL 11
493   F   0.                                                                LEVEL 11
494   F   0.                                                                LEVEL 11
495   F   0.                                                                LEVEL 11
496   F   0.                                                                LEVEL 11
497   F   0.                                                                LEVEL 11
498   F   596.4                                                             LEVEL 11
499   F   596.4                                                             LEVEL 11
500   F   1.5596 E+7                                                        LEVEL 11
501   R 4 .513      E
502   R 4 25.65     E
503   F   .005                                                              LEVEL 12
504   F   .005                                                              LEVEL 12
505   F   .005                                                              LEVEL 12
506   F   .005                                                              LEVEL 12
507   F   .005                                                              LEVEL 12
508   F   .005                                                              LEVEL 12
509   R 2 .2758     R 2 1.719                                               LEVEL 12
510   R 2 .38       R 2 1.                                                  LEVEL 12
511   R 2 .2758     R 2 0.0                                                 LEVEL 12
512   F   0.                                                                LEVEL 12
513   R 2     0.1576R 2     0.0213E                                         LEVEL 12
514   R 2     0.1576R 2     0.0213E                                         LEVEL 12
515   R 2     0.1576R 2     0.0213E                                         LEVEL 12
516   R 2 596.4     R 2 555.4     E                                         LEVEL 12
517   F   0.                                                                LEVEL 12
518   F   0.                                                                LEVEL 12
519   F   0.                                                                LEVEL 12
520   F   0.                                                                LEVEL 12
```

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                  1         2         3         4         5         6         7         8
CARD     12345678901234567890123456789012345678901234567890123456789012345678901234567890

 521     F   0.                                                           LEVEL 12
 522     F   0.                                                           LEVEL 12
 523     F   0.                                                           LEVEL 12
 524     F   596.4                                                        LEVEL 12
 525     F   596.4                                                        LEVEL 12
 526     F   1.5596 E+7                                                   LEVEL 12
 527     R 2 .63735     R 2 .356       E
 528     R 2 31.87      R 2 17.80      E
 529     F   .005                                                         LEVEL 13
 530     F   .005                                                         LEVEL 13
 531     F   .005                                                         LEVEL 13
 532     F   .005                                                         LEVEL 13
 533     F   .005                                                         LEVEL 13
 534     F   .005                                                         LEVEL 13
 535     R 2 .4947      R 2 .56        E
 536     R 2 .38        R 2 .56                                           LEVEL 13
 537     F   0.                                                           LEVEL 13
 538     R 2 .0155      R 2 0.0        E
 539     R 2     0.0750R 2     0.0107E                                    LEVEL 13
 540     R 2     0.0750R 2     0.0107E                                    LEVEL 13
 541     R 2     0.0750R 2     0.0107E                                    LEVEL 13
 542     F        596.4E                                                  LEVEL 13
 543     F   0.                                                           LEVEL 13
 544     F   0.                                                           LEVEL 13
 545     F   0.                                                           LEVEL 13
 546     F   0.                                                           LEVEL 13
 547     F   0.                                                           LEVEL 13
 548     F   0.                                                           LEVEL 13
 549     F   0.                                                           LEVEL 13
 550     F   596.4                                                        LEVEL 13
 551     F   596.4                                                        LEVEL 13
 552     F   1.5596 E+7                                                   LEVEL 13
 553     F   0.                                                             ROD DATA
 554     F   640.0
 555     F   0.                                                             ROD DATA
```

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              1         2         3         4         5         6         7         8
CARD  12345678901234567890123456789012345678901234567890123456789012345678901234567890

 556  F   640.0
 557  F   0.                                                                  ROD DATA
 558  F   640.0
 559  F   0.                                                                  ROD DATA
 560  F   640.0
 561  FILL                       7
 562               9             4           100             3
 563      .26           .01           0.           .05           497.0
 564        68.3 E+5
 565      0.            .05           .1           0.            1000.
 566      0.
 567  BREAK                      8
 568              13
 569       .26             2.0 E-3     .93           543.8          6.85 E+6
 570  PIPE                       9             0
 571               1             0             6            11             7
 572               0             0
 573    0.            0.            0.            0.            0.
 574    0.
 575  F   5.0000E-01E
 576  F   5.0000E-03E
 577  F   1.0000E-03E
 578  F   0.        E
 579  F   0.        E
 580  F   3.6000E-02E
 581  F            4E
 582  F   0.        E
 583  F   0.        E
 584  F   5.5440E+02E
 585  F   5.5440E+02E
 586  F   1.5596E+07E
 587  PIPE                      10             0
 588               1             0             7            12             7
 589               0             0
 590    0.            0.            0.            0.            0.
```

```
                 1         2         3         4         5         6         7         8
CARD    12345678901234567890123456789012345678901234567890123456789012345678901234567890

591       0.
592     F   5.0000E-01E
593     F   5.0000E-03E
594     F   1.0000E-03E
595     F   0.         E
596     F   0.         E
597     F   3.6000E-02E
598     F             4E
599     F   0.         E
600     F   0.         E
601     F   5.5440E+02E
602     F   5.5440E+02E
603     F   1.5596E+07E
604     FILL                      11
605                 11             1
606       .1            .001       0.            0.            562.0
607          1.5596E+7
608     FILL                      12
609                 12             1
610       .1            .001       0.            0.            596.4
611          1.5596E+7
612     VALVE                     13             0
613                  2             0            10            13             0
614                  0             0
615       0.            0.           0.            0.            0.
616       0.
617                  3           100             3            0              2
618       9.200000E-03  1.880000E-02  0.
619     F   5.0000E-01E
620     F   4.6000E-03E
621     F   9.2000E-03E
622     F   0.         E
623     F   0.         E
624     F   1.8800E-02E
625     F             4E
```

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              1         2         3         4         5         6         7         8
CARD 12345678901234567890123456789012345678901234567890123456789012345678901234567890

626  F   8.8100E-01E
627  F   1.8000E+00E
628  F   5.4430E+02E
629  F   5.4430E+02E
630  F   5.5600E+06E
631      0.              1.0000E+00     1.0000E-01  0.                1.0000E+03
632      0.         E
633  TEE                          30              0
634                1              1              7 0.                           0
635                0              1             36             37              0
636     3.324800E-02   1.112500E-02 0.             0.             2.945000E+02
637     2.950000E+02
638                0              1             31
639     1.215000E-02   5.500000E-04 0.             0.             2.945000E+02
640     2.950000E+02
641  F   4.8430E-01E
642  F   1.6922E-03E
643  F   3.4942E-03E
644  F   .0076     E
645  F   0.        E
646  F   6.6700E-02E
647  F            4E
648  F   0.        E
649  F   0.        E
650  F   5.5440E+02E
651  F   5.5440E+02E
652  F   1.5596E+07E
653  F   0.        E
654  F   5.5440E+02F
655  F   1.5000E+00E
656  F   6.9612E-04E
657  F   4.6408E-04E
658  F   3.3000E-01E
659  F   0.        E
660  F   2.4300E-02E
```

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              1         2         3         4         5         6         7         8
CARD 12345678901234567890123456789012345678901234567890123456789012345678901234567890

661  F            4E
662  F   0.         E
663  F   0.         E
664  F   5.5440E+02E
665  F   5.5440E+02E
666  F   1.5596E+07E
667  F   0.         E
668  F   5.5440E+02E
669  TEE                       31             0
670              1             1             7  0.                       0
671              0             2            31            32             0
672    1.215000E-02  5.500000E-04  0.            0.            2.945000E+02
673    2.950000E+02
674              0             1            35
675    1.215000E-02  5.500000E-04  0.            0.            2.945000E+02
676    2.950000E+02
677  F   1.5000E+00E
678  F   6.9612E-04E
679  F   4.6408E-04E
680  F   3.3000E-01E
681  F   0.         E
682  F   2.4300E-02E
683  F            4E
684  F   0.         E
685  F   0.         E
686  F   5.5440E+02E
687  F   5.5440E+02E
688  F   1.5596E+07E
689  F   0.         E
690  F   5.5440E+02E
691  F   1.5000E+00E
692  F   6.9612E-04E
693  F   4.6408E-04E
694      225.6         0.0       E
695  F   0.         E
```

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              1         2         3         4         5         6         7         8
CARD 12345678901234567890123456789012345678901234567890123456789012345678901234567890

696  F   2.4300E-02E
697  F           4E
698  F   0.        E
699  F   0.        E
700  F   5.5440E+02E
701  F   5.5440E+02E
702  F   1.5596E+07E
703  F   0.        E
704  F   5.5440E+02E
705  TEE                       32             0
706              1             1             7  0.                       0
707              0             2            32            33             0
708    1.215000E-02  5.500000E-04  0.            0.            2.945000E+02
709    2.950000E+02
710              0             1            34
711    1.215000E-02  5.500000E-04  0.            0.            2.945000E+02
712    2.950000E+02
713      1.5000E+00    3.0000E+00E
714      6.9612E-04    1.3922E-03E
715  F   4.6408E-04E
716  F   3.3000E-01E
717      0.            1.0000E+00    0.        E
718  F   2.4300E-02E
719  F           4E
720  F   0.        E
721  F   0.        E
722  F   5.5440E+02E
723  F   5.5440E+02E
724  F   1.5596E+07E
725  F   0.        E
726  F   5.5440E+02E
727  F   1.5000E+00E
728  F   6.9612E-04E
729  F   4.6408E-04E
730      34.5          0.0       E
```

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              1         2         3         4         5         6         7         8
CARD 12345678901234567890123456789012345678901234567890123456789012345678901234567890

731  F   0.        E
732  F   2.4300E-02E
733  F            4E
734  F   0.        E
735  F   0.        E
736  F   5.5440E+02E
737  F   5.5440E+02E
738  F   1.5596E+07E
739  F   0.        E
740  F   5.5440E+02E
741  FILL                      34
742              34             4          1000             6
743      1.5           6.9612E-04    0.0           0.0           300.
744      1.6000E+07E
745      0.0           0.0           30.4          0.0       S
746      30.5          .582          50.0          .582      S
747      50.1          .689          200.          .689      E
748  FILL                      35
749              35             4          1000             4
750      1.5           6.9612E-04    0.0           0.0           300.
751      1.6000E+07E
752      0.0           .03017        30.0          .03017    S
753      30.1          .26935        200.          .26935    E
754  VALVE                     36             0
755               2             0            33            38             7
756               0             0
757    0.            0.            0.            0.            0.
758    0.
759               2          2000             0             0             2
760    4.640800E-04  2.430000E-02  0.
761      1.5000E+00    1.5000E-01E
762      6.9612E-04    6.9612E-05E
763      4.6408E-04    0.            4.6408E-04E
764  F   3.3000E-01E
765  F   0.        E
```

```
                 1              2              3              4              5              6              7              8
CARD    12345678901234567890123456789012345678901234567890123456789012345678901234567890

 766    F   2.4300E-02E
 767    F            4E
 768    F   0.        E
 769    F   0.        E
 770        5.5440E+02     3.0000E+02E
 771        5.5440E+02     3.0000E+02E
 772        1.5596E+07     4.2382E+06E
 773    ACCUM                       33              0
 774                 3              38
 775        5.2680E-01     7.9140E-01     1.5000E-01E
 776        3.4600E-02     5.1900E-02     9.8363E-03E
 777    R 3 6.5575E-02R 1 4.6408E-04E
 778    F   0.        E
 779    F  -1.0000E+00E
 780    R 3 2.8895E-01R 1 2.4300E-02E
 781    F            4E
 782    R 1 1.0000E+00R 2 0.        E
 783    F   0.        E
 784    F   3.0000E+02E
 785    F   3.0000E+02E
 786    F   4.2382E+06E
 787    BREAK                      105             REPLACES PRIZER
 788                 8              0              0           0
 789         .004           9.1040E-05   0.0           588.          1.5596E+07
 790             1.0E-4           0.10     380.10          1000.
 791                4.0            .09            4.0          1.
 792                -1.
```

II. TRAC TRANSIENT RESTART INPUT DECK FOR SEMISCALE MOD-1 TEST S-06-3

```
                1         2         3         4         5         6         7         8
CARD    12345678901234567890123456789012345678901234567890123456789012345678901234567890

 1                  3             0
 2      S63 TRANS. USING TRAC VER 26.0
 3      S63TPD32   COR. PRIZER MASS
 4      USED WITH S63SPD3R1
 5                 -1  0.
 6                  0             1            21            21             1
 7         .100000E-02   .500000E-05   .100000E-02  0.
 8                 10             0            20             4             0
 9        0          1  0          2  0          3  0          4  0          5
10        0          7  0          8  0          9  0         10  0         11
11        0         12  0         13  0         30  0         31  0         32
12        0         33  0         34  0         35  0         36  0         37
13        0          6E 0          0  0          0  0          0  0          0
14                100             0   .100000E+01  0.
15                  0             0             0             0
16               1000             0  0.            0.
17                  0             0             0             0
18                900             0    0.0          0.
19                  0             0             0             0
20               2000            -1   .423800E+07  0.
21                 36             0             1             0
22      PIPE                      9             0
23                 18             1             6            11             7
24                 01             1
25        3.335000E-02  1.112520E-02  0.            0.            2.930000E+02
26        2.930000E+02
27      R 1 5.3486E-01R 2 4.0399E-01R 2 4.0747E-01R 2 7.2070E-03R 1 3.6417E-02
28      R 1 1.8208E-02R 1 9.1040E-03R 1 4.5520E-03R 1 2.2760E-03R 2 1.1380E-03
29      R 2 6.4756E-03R 1 1.2951E-02R 1 2.5903E-02E
30      R 1 1.8689E-03R 2 1.4116E-03R 2 7.0990E-04R 1 2.5906E-06R 1 2.0151E-06
```

```
                 1             2             3             4             5             6             7             8
CARD    12345678901234567890123456789012345678901234567890123456789012345678901234567890

  31    R 1 8.8202E-06R 1 4.4101E-06R 1 2.2050E-06R 1 1.1025E-06R 1 5.5126E-07
  32    R 2 2.7563E-07S
  33    R 1 1.7065E-06R 1 1.9942E-06R 1 4.9523E-06R 1 1.4434E-05E
  34        3.4942E-02S
  35    R 2 3.4942E-03R 2 1.4455E-03R 1 4.0190E-04R 1 3.1700E-04R 8 2.4218E-04
  36    R 1 2.8487E-04R 1 3.3103E-04R 1 4.3374E-04R 1 6.8072E-04E
  37    F   0.        E
  38    F   0.        E
  39    R 1 4.8260E-02R 2 6.6700E-02R 2 4.2900E-02R 1 2.2620E-02R 1 2.0090E-02
  40    R 8 1.7560E-02S
  41    R 1 1.9045E-02R 1 2.0530E-02R 1 2.3500E-02R 1 2.9440E-02E
  42    F            4E
  43    F   0.0000E+00E
  44    F   0.        E
  45    I 2 555.          562.      F   562.      E
  46    I 2 555.          562.      F   562.      E
  47    F   1.5610E+07E
  48    F   0.        E
  49    I 2 555.           562.     F   562.      E
  50    PIPE                      10            0
  51                34            3             7            12             7
  52                01            1
  53       3.335000E-02  1.112520E-02  0.            0.            2.930000E+02
  54       2.930000E+02
  55    R 1 5.1690E-01R 1 3.8570E-01R10 5.1530E-01R 2 6.4260E-01R 1 4.5840E-01
  56    R 2 4.0640E-01R 2 5.2780E-01R 2 3.2790E-01R 2 7.2070E-03R 1 3.6417E-02
  57    R 1 1.8208E-02R 1 9.1040E-03R 1 4.5520E-03R 1 2.2760E-03R 2 1.1380E-03
  58    R 2 6.4756E-03R 1 1.2951E-02R 1 2.5903E-02E
  59    R 1 1.8066E-03R 1 1.3479E-03R10 1.5843E-03R 2 9.2880E-04R 1 6.6261E-04
  60    R 2 7.4050E-04R 2 6.0175E-04R 2 4.9514E-04R 1 2.5906E-06R 1 2.0151E-06
  61    R 1 8.8202E-06R 1 4.4101E-06R 1 2.2050E-06R 1 1.1025E-06R 1 5.5126E-07
  62    R 2 2.7563E-07S
  63    R 1 1.7065E-06R 1 1.9942E-06R 1 4.9523E-06R 1 1.4434E-05E
  64    R 1 3.4942E-02R 2 3.4949E-03R 9 3.7378E-03R 3 1.4455E-03R 3 2.4475E-04
  65    R 3 1.1401E-03R 1 4.0190E-04R 1 3.1700E-04R 8 2.4218E-04S
```

```
               1         2         3         4         5         6         7         8
CARD  12345678901234567890123456789012345678901234567890123456789012345678901234567890

  66  R 1 2.8487E-04R 1 3.3103E-04R 1 4.3374E-04R 1 6.8072E-04E
  67  R 2 1.1000E+01R11 1.2500E+00R 1 1.3000E+00R 6 .05600E-02R15 0.        E
  68  R 1 0.         R 1 5.0000E-01R 5 1.0000E+00R 4-1.0000E+00R 1-5.0000E-01
  69  R 2-1.0000E+00R 2 0.         R 3 1.0000E+00R16 0.        E
  70  R 1 4.8260E-02R 2 6.6700E-02R 9 6.8990E-02R 3 4.2900E-02R 3 .38190E-02
  71  R 3 3.8100E-02R 1 2.2620E-02R 1 2.0090E-02R 8 1.7560E-02S
  72  R 1 1.9045E-02R 1 2.0530E-02R 1 2.3500E-02R 1 2.9440E-02E
  73  F            4E
  74  F   0.        E
  75  F   0.        E
  76  R14  596.     I 4 596.         591.       F   591.
  77  R14  596.     I 4 596.         591.       F   591.
  78  F   1.5610E+07E
  79  F   0.        E
  80  R14  596.     I 4 596.         591.       F    591.
  81  BREAK                     11
  82              11
  83          .13589   7.13949 E-5  1.000000E+00    396.7         2.420 E+05
  84  BREAK                     12
  85              12
  86          .13589   7.13949 E-5  1.000000E+00    396.7         2.420 E+05
  87  PRIZER                     5              0
  88              12             8
  89    8.000000E+03  1.576900E+07  1.000000E+05  1.000000E-01
  90      5.6340E-01R10 .0597         4.0000E-03E
  91      1.7664E-02R10 1.3587E-03    9.1040E-05E
  92  F   2.2760E-02E
  93  F   0.        E
  94  F  -1.0000E+00E
  95  F   1.7000E-01E
  96  F            4E
  97  R 2 1.0000E+00    .283       F   0.        E
  98  F   0.        E
  99  R 4 6.1840E+02F   558.      E
 100  F   6.1840E+02E
```

```
                1         2         3         4         5         6         7         8
CARD   12345678901234567890123456789012345678901234567890123456789012345678901234567890

101    F   1.5769E+07E
102    TEE                        1             0
103                 4             1             7  3.000000E-06             0
104                 0             6             1             2             0
105      3.335020E-02  1.112520E-02  0.            0.            2.950000E+02
106      2.950000E+02
107                 1             5             8
108      9.425000E-03  3.911600E-03  0.            0.            2.950000E+02
109      2.950000E+02
110    F   5.1480E-01E
111    F   1.7986E-03E
112    R 1 3.4942E-02R 6 3.4942E-03E
113    F   0.        E
114    R 6 0.        R 1 1.0000E+00E
115    F   6.6700E-02E
116    F           4E
117        9.0373E-14    9.3488E-14    9.3197E-14    9.2786E-14    9.2622E-14
118        9.2442E-14E
119    R 1 2.2299E-01R 3 2.2299E+00R 3 2.2281E+00E
120    F   5.9605E+02E
121    R 1 6.1855E+02R 5 6.1853E+02E
122    R 1 1.5617E+07R 5 1.5613E+07E
123    F   0.        E
124    F   5.9605E+02E
125        5.0000E-02    1.6720E+00    7.2000E-01    2.0300E-01    4.0000E-03E
126        1.7471E-04    7.1745E-05    3.0895E-05    7.0930E-04    9.1040E-05E
127    R 1 3.4942E-03R 3 4.2910E-05R 1 3.4940E-03R 1 2.2760E-02E
128    F   6.8000E-03E
129    F   1.0000E+00E
130    R 1 6.6700E-02R 3 7.3900E-03R 1 6.6700E-02R 1 1.7000E-01E
131    F           4E
132        9.6632E-14    9.6801E-14    9.6752E-14    7.8755E-14    7.5607E-14E
133    R 1 1.7329E-03R 3 1.4111E-01R 1 1.7329E-03R 1 2.6603E-04E
134    F   515.      E
135    R 1 6.1853E+02R 1 6.1850E+02R 1 6.1845E+02R 2 6.1843E+02E
```

```
                1                   2                   3                   4                   5                   6                   7                   8
CARD  12345678901234567890123456789012345678901234567890123456789012345678901234567890

136       1.5613E+07    1.5608E+07    1.5600E+07    1.5597E+07    1.5596E+07E
137   F   0.        E
138   F   515.      E
139   END
140           1.0E-5        2.0E-2             .01          .01
141           .01           .005                2.           .5
142           1.0E-5        2.0E-2             .10          .10
143           .10           .05                 2.           .5
144           1.0E-5        2.0E-2             1.0          1.0
145           1.0           2.0E-1              2.           .5
146           1.0E-5        2.0E-2             10.          10.
147           2.0           2.0E-1              2.           .5
148           1.0E-5        2.0E-2            36.          1.0
149           5.0           2.0E-1              5.           .5
150       -1.
```

III. TRAC TRANSIENT RESTART INPUT DECK WITH RENODED BROKEN-LOOP COLD LEG FOR SEMISCALE MOD-1 TEST S-06-3

```
                 1         2         3         4         5         6         7         8
CARD    12345678901234567890123456789012345678901234567890123456789012345678901234567890

   1              3             0
   2    S63 TRANS. USING TRAC VER 26.0
   3    S63NPD32
   4    USED WITH S63TPD3R2
   5             -1   0.
   6              0             1             21            21            1
   7       .100000E-02   .500000E-05   .100000E-02  0.
   8             10             0             20             4            0
   9      0       1  0          2  0           3  0          4  0         5
  10      0       7  0          8  0           9  0         10  0        11
  11      0      12  0         13  0          30  0         31  0        32
  12      0      33  0         34  0          35  0         36  0        37
  13      0      6E  0          0  0           0  0          0  0         0
  14             -1
  15
  16    PIPE                    9              0
  17              6             1              6            11            7
  18              3             1
  19      3.335000E-02  1.112520E-02  0.           0.            2.930000E+02
  20      2.930000E+02
  21        .53486        .40399        .40399        .40747        .40747
  22        .11       E
  23    F   -1.0      E
  24    F   -1.0      E
  25    R 5 0.0           .0339         0.0       E
  26    F   0.        E
  27        .04826        .0667         .0667         .0429         .0429
  28        .01756        .02944     E
  29    F            4E
  30        .1909         .0585         .02032        .01187        .007603
```

```
                  1         2         3         4         5         6         7         8
CARD     12345678901234567890123456789012345678901234567890123456789012345678901234567890

 31          .5        E
 32          .09688        .9974          .9516          2.275          2.275
 33          12.0      E
 34          402.2         396.8          393.6          395.7          395.8
 35          395.1     E
 36          407.1         407.1          407.0          406.9          406.2
 37          394.3     E
 38        3.12387E+05   3.12446E+05    3.12026E+05    3.10825E+05    3.04822E+05
 39        2.10433E+05E
 40      F 0.0
 41          464.4         470.2          467.4          461.3          438.5
 42          432.6     E
 43      END
 44              1.0E-5         2.0E-2         200.           1.0
 45              5.0            2.0E-1            5.             .5
 46          -1.
```

APPENDIX J

TRAC STEADY-STATE AND TRANSIENT INPUT DECKS FOR LOFT NONNUCLEAR EXPERIMENT L1-4

I. TRAC STEADY-STATE INPUT DECK FOR LOFT NONNUCLEAR EXPERIMENT L1-4

```
                1         2         3         4         5         6         7         8
CARD   12345678901234567890123456789012345678901234567890123456789012345678901234567890
```

CARD						
1	2	0	0			
2	LOFT TEST L1-4				(INITIAL INPUT)	
3	STEADY STATE					
4	-1	0.0				MCC 1
5	1	0	28	29	1	MCC 2
6	1.0E-03	1.0E-05	1.0E-04			MCC 3
7	10	50	20	3		MCC 4
8	1	2	3	4	5	IORDER
9	6	7	8	9	11	IORDER
10	12	13	14	15	16	IORDER
11	17	18	19	20	21	IORDER
12	22	23	24	25	27	IORDER
13	77	99	10E			IORDER
14	1	0	1.0			TRIPS
15						TRIPS
16	2	0	0.0			TRIPS
17						TRIPS
18	3	-1	424.01E4	0.0		TRIPS
19	27	0	1	0		TRIPS
20	TEE	1				CARD 1
21	4	1	7	0.0	0	CARD 2
22	0	4	1	3		CARD 3
23	1.420000E-01	3.650000E-02	0.0	0.0	2.950000E02	CARD 4
24	2.950000E2					CARD 5
25	0	3	2			CARD 6
26	2.330050E-02	8.696800E-03	0.0	0.0	2.950000E02	CARD 7
27	2.950000E2					CARD 8
28	R 2 666.75E-03	41.91E-02	66.01E-02E			DX 1
29	R 24233.39E-05	266.18E-04	4190.92E-05E			VOL 1
30	F 6342.53E-05E					FA 1

```
                1         2         3         4         5         6         7         8
CARD   12345678901234567890123456789012345678901234567890123456789012345678901234567890

  31   F         0.0E                                                        FRIC 1
  32   F         0.0E                                                        GRAV 1
  33   F     2.84E-1E                                                        HD 1
  34   F          +4E                                                        NFF 1
  35   F         0.0E                                                        ALP 1
  36   F   0.        E                                                       VM 1
  37   F    5.52E+02E                                                        TL 1
  38   F    5.52E+02E                                                        TV 1
  39   F   15.75E+06E                                                        P 1
  40   F         0.0E                                                        QPPP 1
  41   F    5.52E+02E                                                        TW 1
  42        2149.85E-3   2642.77E-03    2221.69E-3E                            DX 2
  43        3114.87E-6    3695.37E-6    5705.88E-6E                            VOL 2
  44   R 3 1449.29E-6    5732.12E-6E                                         FA 2
  45        1652.98E-4    5503.15E-6    4668.77E-6       0.0E+00E            FRIC 2
  46            1.00E0R 2        0.0       1.00E0E                           GRAV 2
  47   R 3 4295.68E-5    8543.04E-5E                                         HD 2
  48   R 2          +4R 2        +4E                                         NFF 2
  49   F         0.0E                                                        ALP 2
  50   F         0.0E                                                        VM 2
  51   F    5.52E+02E                                                        TL 2
  52   F    5.52E+02E                                                        TV 2
  53   F   15.75E+06E                                                        P 2
  54   F         0.0E                                                        QPPP 2
  55   F    5.52E+02E                                                        TW 2
  56   PIPE                    4                                             CARD  1
  57                 4         1         3         4         7              CARD  2
  58                 0         0                                             CARD  3
  59     1.505690E-01 3.761400E-02       0.0       0.0  2.950000E02          CARD  4
  60     2.950000E+02                                                        CARD  5
  61        10.16E-01    73.66E-02    35.56 E-02    53.34E-02E               DX
  62       4955.48E-05  4672.31E-05  2605.16E-05  433.26E-004E               VOL
  63   R 36342.53E-05R 28319.46E-05E                                         FA
  64   F         0.0E                                                        FRIC
  65   R 4       0.0   7071.07E-04E                                          GRAV
```

```
              1         2         3         4         5         6         7         8
CARD 12345678901234567890123456789012345678901234567890123456789012345678901234567890

 66  R 3   2.84E-01R 23254.64E-04E                                            HD
 67  R 2         +4R 2          +4           +4E                              NFF
 68  F          0.0E                                                          ALP
 69  F          0.0E                                                          VM
 70  F     5.54E+02E                                                          TL
 71  F     5.54E+02E                                                          TV
 72  F    15.75E+06E                                                          P
 73  F          0.0E                                                          QPPP
 74  F     5.54E+02E                                                          TW
 75  PRIZER                     2                                             CARD  1
 76               3             2                                             CARD  2
 77    0.000000E+00  1.565000E+07  1.378020E+05   1.167600E00                 CARD  3
 78     5307.32E-04R 2  58.38E-02E                                            DX
 79         0.30E00R 2    0.33E00E                                            VOL
 80  R 35652.63E-04   5732.12E-06E                                            FA
 81  R 3        0.0    4668.77E-6E                                            FRIC
 82  F     -1.00E00E                                                          GRAV
 83  R 3 848.36E-03   8543.04E-05E                                            HD
 84  R 3          4            +4E                                            NFF
 85         1.00E00R 2        0.0E                                            ALP
 86  F          0.0E                                                          VM
 87  F     6.19E+02E                                                          TL
 88  F     6.19E+02E                                                          TV
 89  F    15.75E+06E                                                          P
 90  STGEN                      3                                             CARD  1
 91             10             3             4             5            10   CARD  2
 92              1             0             0             1                  CARD  3
 93    5.105400E-03  1.244600E-03                                             CARD  4
 94              7            14            15                                CARD  5
 95          1.0000R 86419.85E-04        1.0000E                              DX 1
 96     3354.06E-04R 89698.57E-05   3354.06E-04E                              VOL 1
 97     8319.46E-05R 91511.71E-04   8319.46E-05E                              FA 1
 98      .00        R 9 0.0168       .00        E                             FRIC 1
 99     7071.07E-04R 4    1.00E00           0.0R 4  -1.00E00   -7071.07E-4E GRAV 1
100     3254.64E-04R 91021.08E-05   3254.64E-04E                              HD 1
```

```
                 1         2         3         4         5         6         7         8
CARD    12345678901234567890123456789012345678901234567890123456789012345678901234567890

 101                 4            +1R 7          1            +1             4E NFF 1
 102    F          0.0E                                                         ALP 1
 103    F          0.0E                                                         VM 1
 104    R 5   5.54E+02R 5   5.52E+02E                                           TL 1
 105    R 5   5.54E+02R 5   5.52E+02E                                           TV 1
 106    F    15.75E+06E                                                         P 1
 107    F       5.52E2E                                                         TW
 108    R 46419.85E-04R 31170.23E-03E                                           DX 2
 109        4008.61E-04R 37355.19E-04R 31157.07E-03E                            VOL 2
 110         8107.32E-6R 6    1.15E00    1824.15E-5E                            FA 2
 111    F          0.0E                                                         FRIC 2
 112    F      1.00E00E                                                         GRAV 2
 113          10.16E-2R 6 1210.06E-3      15.24E-2E                             HD 2
 114                +4R 6          4            +4E                             NFF 2
 115    R 4         0.0   2631.54E-4R 2        1.0E                             ALP 2
 116    F          0.0E                                                         VM 2
 117    F       5.52E2E                                                         TL 2
 118    F       5.52E2E                                                         TV 2
 119    F      66.50E5E                                                         P 2
 120                0.0  17.60000000R 6 3802.86E-2  17.60000000            0.0E WA 1
 121           22.000R 3 4729.93E-2R 3         0.0E                             WA 2
 122    TEE                        5                                            CARD  1
 123                  2            1            7           0.0             0  CARD  2
 124                  0            3            6             7                CARD  3
 125     1.420870E-1  3.572600E-2             0.0           0.0  2.950000E+2  CARD  4
 126     2.950000E+2                                                           CARD  5
 127                  0            2            5                              CARD  6
 128     1.420870E-1  3.572600E-2             0.0           0.0  2.950000E+2  CARD  7
 129     2.950000E+2                                                           CARD  8
 130         6.35E-1    167.64E-2     6.35E-1E                                 DX 1
 131      2746.75E-5   1124.88E-4   2746.75E-5E                                VOL 1
 132      3661.31E-5R 2 6342.49E-5   3.66131E-2E                               FA 1
 133    F          0.0E                                                        FRIC 1
 134    R 2   -1.00E0R 2    1.00E0E                                            GRAV 1
 135        215.91E-3R 2 2841.74E-4    215.91E-3E                              HD 1
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              1         2         3         4         5         6         7         8
CARD 12345678901234567890123456789012345678901234567890123456789012345678901234567890

136  F           +4E                                                         NFF 1
137  F          0.0E                                                         ALP 1
138  F          0.0E                                                         VM 1
139  F       5.52E2E                                                         TL 1
140  F       5.52E2E                                                         TV 1
141  F      15.75E6E                                                         P 1
142  F          0.0E                                                         QPPP 1
143  F       5.52E2E                                                         TW 1
144      131.41 E-2    124.46E-2E                                            DX 2
145       834.66E-4   9004.81E-5E                                            VOL 2
146  R 2 6342.49E-5   8319.46E-5E                                            FA 2
147  F          0.0E                                                         FRIC 2
148             0.0        1.00E0   7071.07E-4E                              GRAV 2
149  R 2 2841.74E-4   3254.64E-4E                                            HD 2
150  F           +4E                                                         NFF 2
151  F          0.0E                                                         ALP 2
152  F          0.0E                                                         VM 2
153  F       5.52E2E                                                         TL 2
154  F       5.52E2E                                                         TV 2
155  F      15.75E6E                                                         P 2
156  F          0.0E                                                         QPPP 2
157  F       5.52E2E                                                         TW 2
158  PUMP                      6                                             CARD  1
159              2             1             6             8             7  CARD  2
160              0             0             1             1             1  CARD  3
161              1             9                                            CARD  4
162    1.079550E-1   2.835930E-2           0.0           0.0    2.950000E2  CARD  5
163     2.950000E2                                                          CARD  6
164         941.54          500.          .315          614.       369.661  CARD  7
165     3.174380E2    3.68125000    2.311860E2    1.884960E2                CARD  8
166              0                                                          CARD  9
167              7            10            11            11            13  NDATA
168             10            14             6            12             8  NDATA
169              4             6             2             2             2  NDATA
170              2            11             7                              NDATA
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CARD	1 2 3 4 5 6 7 8 12345678901234567890123456789012345678901234567890123456789012345678901234567890					
171	-1.00E0	2.44E0	-0.80E0	2.03E0	-0.40E0	HSP1
172	1.60E0	-0.20E0	1.47E0	0.0	1.40E0	HSP1
173	0.40E0	1.30E0	1.00E0	1.00E0E		HSP1
174	-1.00E0	-1.00E0	-0.40E0	-0.88E0	-0.30E0	HSP2
175	-0.83E0	0.0	-0.68E0	0.20E0	-0.51E0	HSP2
176	0.40E0	-0.28E0	0.60E0	0.0	0.70E0	HSP2
177	0.18E0	0.80E0	0.40E0	1.00E0	1.00E0E	HSP2
178	-1.00E0	2.44E0	-0.83E0	2.00E0	-0.70E0	HSP3
179	1.70E0	-0.65E0	1.60E0	-0.45E0	1.32E0	HSP3
180	-0.17E0	1.10E0	0.0	0.93E0	0.50E0	HSP3
181	0.83E0	0.78E0	0.83E0	0.95E0	0.93E0	HSP3
182	1.00E0	1.00E0E				HSP3
183	-1.00E0	-1.00E0	-0.80E0	-0.60E0	-0.60E0	HSP4
184	-0.30E0	-0.44E0	-0.10E0	-0.23E0	0.10E0	HSP4
185	-0.05E0	0.23E0	3.90E-1	0.33E0	0.40E0	HSP4
186	0.27E0	0.62E0	0.48E00	0.90E0	0.83E0	HSP4
187	1.00E0	1.00E0E				HSP4
188	-1.00E0	3.61E0	-0.90E00	3.49E0	-0.80E0	HTP1
189	3.83E0	-0.60E0	4.62E00	-0.50E0	4.63E0	HTP1
190	-0.40E0	4.27E0	-0.20E00	2.82E0	0.0	HTP1
191	1.45E0	0.12E0	0.55E00	0.20E0	0.26E0	HTP1
192	0.40E0	0.25E0	0.90E00	0.22E0	1.00E0	HTP1
193	0.0E					HTP1
194	0.0	-0.68E0	0.10E0	-0.58E0	0.20E0	HTP2
195	-0.51E0	0.30E0	-0.49E0	0.40E0	-0.48E0	HTP2
196	0.60E0	-0.43E0	0.70E0	-0.37E0	0.80E0	HTP2
197	-0.26E0	0.90E0	-0.07E0	1.00E0	0.0E	HTP2
198	-1.00E0	3.61E0	-0.83E0	2.60E0	-0.70E0	HTP3
199	2.03E0	-0.65E0	1.85E0	-0.45E0	1.37E0	HTP3
200	-0.17E0	1.05E0	0.0	0.83E0	0.20E0	HTP3
201	0.76E0	0.40E0	0.73E0	0.50E0	0.76E0	HTP3
202	0.60E0	0.88E0	0.78E0	1.31E0	0.95E0	HTP3
203	2.08E0	1.00E0	2.46E0E			HTP3
204	0.0	0.24E0	3.99E-1	0.82E0	0.40E0	HTP4
205	0.77E0	0.62E0	1.58E0	0.90E0	2.18E0	HTP4

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                 1         2         3         4         5         6         7         8
CARD  12345678901234567890123456789012345678901234567890123456789012345678901234567890

206           1.00E0        2.46E0E                                         HTP4
207          -1.00E0        2.00E0       -0.80E0        1.40E0       -0.70E0  TSP1
208           1.20E0       -0.60E0        1.03E0       -0.40E0        0.80E0  TSP1
209          -0.20E0        0.66E0       -0.10E0        0.61E0           0.0  TSP1
210           0.60E0        0.10E0        0.61E0        0.20E0        0.63E0  TSP1
211           0.60E0        0.83E0        1.00E0        1.00E0E               TSP1
212          -1.00E0       -1.00E0       -0.30E0       -0.90E0       -0.20E0  TSP2
213          -0.87E0       -0.10E0       -0.81E0           0.0       -0.68E0  TSP2
214           0.40E0       -0.27E0        0.50E0        0.15E0        1.00E0  TSP2
215           1.00E0E                                                         TSP2
216          -1.00E0        2.00E0       -0.10E0        1.35E0        0.50E0  TSP3
217           0.83E0        1.00E0        0.34E0E                             TSP3
218          -1.00E0       -1.00E0       -0.30E0       -0.90E0       -0.10E0  TSP4
219          -0.52E0        0.40E0       -0.27E0        0.50E0           0.0  TSP4
220           1.00E0        0.34E0E                                           TSP4
221          -1.00E0           0.0        1.00E0           0.0E               TTP1
222          -1.00E0           0.0        1.00E0           0.0E               TTP2
223          -1.00E0           0.0        1.00E0           0.0E               TTP3
224          -1.00E0           0.0        1.00E0           0.0E               TTP4
225              0.0           0.0        0.10E0           0.0        0.15E0  HDM
226           0.05E0        0.24E0        0.80E0        0.30E0        0.96E0  HDM
227           0.40E0        0.98E0        0.60E0        0.97E0        0.80E0  HDM
228           0.90E0        0.90E0        0.80E0        0.96E0        0.50E0  HDM
229           1.00E0           0.0E                                           HDM
230       0.            0.            .1            0.            .15         TDM
231          0.48E-1        0.22E0       5.64E-1        0.80E0       5.64E-1  TDM
232           0.96E0       4.54E-1        1.00E0       0.76E-1E               TDM
233          0.0        188.496         4.00          157.08           9.00   SPTBL
234       131.95         19.00         94.25           29.00        68.07     SPTBL
235         31.50          63.36         46.50           78.54        64.00    SPTBL
236       62.83         69.00             48.17 E                             SPTBL
237   F   1352.13E-3E                                                         DX
238   F   4955.48E-5E                                                         VOL
239   F   3661.31E-5E                                                         FA
240   F          0.0E                                                         FRIC
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              1         2         3         4         5         6         7         8
CARD 12345678901234567890123456789012345678901234567890123456789012345678901234567890

241  F    +1.00E0E                                                        GRAV
242  F   215.91E-3E                                                       HD
243  F          4E                                                        NFF
244  F        0.0E                                                        ALP
245  F        0.0E                                                        VM
246  F     5.53E2E                                                        TL
247  F     5.53E2E                                                        TV
248  F    15.75E6E                                                        P
249  F        U.0E                                                        QPPP
250  F     5.53E2E                                                        TW
251  PUMP                     7                                           CARD  1
252               2           1             7             9            7  CARD  2
253               0           0             1             1            1  CARD  3
254               1           8                                           CARD  4
255     1.079550E-1 2.835930E-2           0.0           0.0  2.950000E2  CARD  5
256      2.950000E2                                                       CARD  6
257          941.54        500.          .315          614.     369.661  CARD  7
258     317.438       3.68125       231.186       170.693                 CARD  8
259               0                                                       CARD  9
260               7          10            11            11           13  NDATA
261              10          14             6            12            8  NDATA
262               4           6             2             2            2  NDATA
263               2          11             7                             NDATA
264        -1.00E0       2.44E0       -0.80E0        2.03E0      -0.40E0  HSP1
265         1.60E0      -0.20E0        1.47E0           0.0       1.40E0  HSP1
266         0.40E0       1.30E0        1.00E0       1.00E0E               HSP1
267        -1.00E0      -1.00E0       -0.40E0       -0.88E0      -0.30E0  HSP2
268        -0.83E0          0.0       -0.68E0        0.20E0      -0.51E0  HSP2
269         0.40E0      -0.28E0        0.60E0           0.0       0.70E0  HSP2
270         0.18E0       0.80E0        0.40E0        1.00E0      1.00E0E  HSP2
271        -1.00E0       2.44E0       -0.83E0        2.00E0      -0.70E0  HSP3
272         1.70E0      -0.65E0        1.60E0       -0.45E0       1.32E0  HSP3
273        -0.17E0       1.10E0           0.0        0.93E0       0.50E0  HSP3
274         0.83E0       0.78E0        0.83E0        0.95E0       0.93E0  HSP3
275         1.00E0       1.00E0E                                          HSP3
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CARD	1 2 3 4 5 6 7 8 12345678901234567890123456789012345678901234567890123456789012345678901234567890					
276	-1.00E0	-1.00E0	-0.80E0	-0.60E0	-0.60E0	HSP4
277	-0.30E0	-0.44E0	-0.10E0	-0.23E0	0.10E0	HSP4
278	-0.05E0	0.23E0	3.90E-1	0.33E0	0.40E0	HSP4
279	0.27E0	0.62E0	0.48E00	0.90E0	0.83E0	HSP4
280	1.00E0	1.00E0E				HSP4
281	-1.00E0	3.61E0	-0.90E00	3.49E0	-0.80E0	HTP1
282	3.83E0	-0.60E0	4.62E00	-0.50E0	4.63E0	HTP1
283	-0.40E0	4.27E0	-0.20E00	2.82E0	0.0	HTP1
284	1.45E0	0.12E0	0.55E00	0.20E0	0.26E0	HTP1
285	0.40E0	0.25E0	0.90E00	0.22E0	1.00E0	HTP1
286	0.0E					HTP1
287	0.0	-0.68E0	0.10E0	-0.58E0	0.20E0	HTP2
288	-0.51E0	0.30E0	-0.49E0	0.40E0	-0.48E0	HTP2
289	0.60E0	-0.43E0	0.70E0	-0.37E0	0.80E0	HTP2
290	-0.26E0	0.90E0	-0.07E0	1.00E0	0.0E	HTP2
291	-1.00E0	3.61E0	-0.83E0	2.60E0	-0.70E0	HTP3
292	2.03E0	-0.65E0	1.85E0	-0.45E0	1.37E0	HTP3
293	-0.17E0	1.05E0	0.0	0.83E0	0.20E0	HTP3
294	0.76E0	0.40E0	0.73E0	0.50E0	0.76E0	HTP3
295	0.60E0	0.88E0	0.78E0	1.31E0	0.95E0	HTP3
296	2.08E0	1.00E0	2.46E0E			HTP3
297	0.0	0.24E0	3.99E-1	0.82E0	0.40E0	HTP4
298	0.77E0	0.62E0	1.58E0	0.90E0	2.18E0	HTP4
299	1.00E0	2.46E0E				HTP4
300	-1.00E0	2.00E0	-0.80E0	1.40E0	-0.70E0	TSP1
301	1.20E0	-0.60E0	1.03E0	-0.40E0	0.80E0	TSP1
302	-0.20E0	0.66E0	-0.10E0	0.61E0	0.0	TSP1
303	0.60E0	0.10E0	0.61E0	0.20E0	0.63E0	TSP1
304	0.60E0	0.83E0	1.00E0	1.00E0E		TSP1
305	-1.00E0	-1.00E0	-0.30E0	-0.90E0	-0.20E0	TSP2
306	-0.87E0	-0.10E0	-0.81E0	0.0	-0.68E0	TSP2
307	0.40E0	-0.27E0	0.50E0	0.15E0	1.00E0	TSP2
308	1.00E0E					TSP2
309	-1.00E0	2.00E0	-0.10E0	1.35E0	0.50E0	TSP3
310	0.83E0	1.00E0	0.34E0E			TSP3

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              1         2         3         4         5         6         7         8
CARD 12345678901234567890123456789012345678901234567890123456789012345678901234567890
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CARD							
311		-1.00E0	-1.00E0	-0.30E0	-0.90E0	-0.10E0	TSP4
312		-0.52E0	0.40E0	-0.27E0	0.50E0	0.0	TSP4
313		1.00E0	0.34E0E				TSP4
314		-1.00E0	0.0	1.00E0	0.0E		TTP1
315		-1.00E0	0.0	1.00E0	0.0E		TTP2
316		-1.00E0	0.0	1.00E0	0.0E		TTP3
317		-1.00E0	0.0	1.00E0	0.0E		TTP4
318		0.0	0.0	0.10E0	0.0	0.15E0	HDM
319		0.05E0	0.24E0	0.80E0	0.30E0	0.96E0	HDM
320		0.40E0	0.98E0	0.60E0	0.97E0	0.80E0	HDM
321		0.90E0	0.90E0	0.80E0	0.96E0	0.50E0	HDM
322		1.00E0	0.0E				HDM
323		0.	0.	.1	0.	.15	TDM
324		0.48E-1	0.22E0	5.64E-1	0.80E0	5.64E-1	TDM
325		0.96E0	4.54E-1	1.00E0	0.76E-1E		TDM
326		0.0	1706.93E-01	4.00E0	142.42E0	9.00E0	SPTBL
327		118.33	19.00	78.54	28.00	54.45	SPTBL
328		46.50	78.54	64.00	62.83	69.00	SPTBL
329		40.32 E					SPTBL
330	F	1352.13E-3E					DX
331	F	4955.48E-5E					VOL
332	F	3661.31E-5E					FA
333	F	0.0E					FRIC
334	F	1.00E0E					GRAV
335	F	215.91-3E					HD
336	F	4E					NFF
337	F	0.0E					ALP
338	F	0.0E					VM
339	F	5.53E2E					TL
340	F	5.53E2E					TV
341	F	15.75E6E					P
342	F	0.0E					QPPP
343	F	5.53E2E					TW
344	TEE		8				CARD 1
345		2	1	7	0.0	0	CARD 2

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             1         2         3         4         5         6         7         8
CARD  12345678901234567890123456789012345678901234567890123456789012345678901234567890

346               0           2              9            10                 CARD  3
347     1.079550E-1  2.835930E-2            0.0           0.0   2.950000E2   CARD  4
348     2.950000E2                                                            CARD  5
349               0           1              8                                CARD  6
350     1.079550E-1  2.835930E-2            0.0           0.0   2.950000E2   CARD  7
351     2.950000E2                                                            CARD  8
352      130.81E-2     111.76E-2E                                             DX 1
353      4785.57E-5   6630.76E-5E                                             VOL 1
354   R 2 3661.31E-5  6342.49E-5E                                             FA 1
355   F         0.0E                                                          FRIC 1
356   F         0.0E                                                          GRAV 1
357   R 2  215.91E-3   .284174E+0E                                            HD 1
358   F         +4E                                                           NFF 1
359   F         0.0E                                                          ALP 1
360   F         0.0E                                                          VM 1
361   F       5.53E2E                                                         TL 1
362   F       5.53E2E                                                         TV 1
363   F      15.75E6E                                                         P 1
364   F         0.0E                                                          QPPP 1
365   F       5.53E2E                                                         TW 1
366        542.92E-3E                                                         DX 2
367       2543.94E-5E                                                         VOL 2
368   F    3661.31E-5E                                                        FA 2
369   F         0.0E                                                          FRIC 2
370   F         0.0E                                                          GRAV 2
371   F     215.91E-3E                                                        HD 2
372   F           4E                                                          NFF 2
373   F         0.0E                                                          ALP 2
374   F         0.0E                                                          VM 2
375   F       5.53E2E                                                         TL 2
376   F       5.53E2E                                                         TV 2
377   F      15.75E6E                                                         P 2
378   F         0.0E                                                          QPPP 2
379   F       5.53E2E                                                         TW 2
380   TEE                     9                                               CARD  1
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              1         2         3         4         5         6         7         8
CARD 12345678901234567890123456789012345678901234567890123456789012345678901234567890

381               2             1             7           0.0             0  CARD  2
382               0             3            10          11                  CARD  3
383     1.420870E-1   3.572600E-2           0.0           0.0      295.0     CARD  4
384         295.00                                                           CARD  5
385               0             1            22                              CARD  6
386     4.366260E-2   1.348740E-2           0.0           0.0       295.0    CARD  7
387      295.0                                                               CARD  8
388       116.84E-2R 2 7087.35E-4E                                           DX 1
389      7419.05E-5R 2 4474.09E-5E                                           VOL 1
390  F    6342.4E-5E                                                         FA 1
391  F        0.000E                                                         FRIC 1
392  F          0.0E                                                         GRAV 1
393  F   2841.74E-4E                                                         HD 1
394  F            4E                                                         NFF 1
395  F          0.0E                                                         ALP 1
396  F          0.0E                                                         VM 1
397  F     552.5   E                                                         TL 1
398  F     552.5   E                                                         TV 1
399  F      15.79E6E                                                         P 1
400  F          0.0E                                                         QPPP 1
401  F       552.00E                                                         TW 1
402           1.500E                                                         DX 2
403      8983.81E-6E                                                         VOL 2
404  F    598.92E-5E                                                         FA 2
405  F          0.0E                                                         FRIC 2
406  F          0.0E                                                         GRAV 2
407  F   8732.52E-5E                                                         HD 2
408  F            4E                                                         NFF 2
409  F          0.0E                                                         ALP 2
410  F          0.0E                                                         VM 2
411  F     552.5   E                                                         TL 2
412  F     552.5   E                                                         TV 2
413  F      15.79E6E                                                         P 2
414  F          0.0E                                                         QPPP 2
415  F       552.00E                                                         TW 2
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                    1         2         3         4         5         6         7         8
CARD       12345678901234567890123456789012345678901234567890123456789012345678901234567890

 416       VESSEL                    10                                            CARD  1
 417                   9             2             4             4                 CARD  2
 418                   9             2             1             0             0   CARD  3
 419                   0                                                           CARD  4
 420                   0             0             0             0                 CARD  5
 421            0.0E+00       0.0E+00       0.0E+00                                CARD  6
 422         0.007800E6    0.557668E3    0.016206E3    0.600000E0           0.0   CARD  7
 423         1.500000E0       0.0E+00                                              CARD  8
 424                   0             0             1                               CARD  9
 425                   0             0             0             0             0   CARD 10
 426                 0.0           0.0           0.0                               CARD 11
 427              0.38E0        0.76E0        1.52E0        2.28E0        3.04E0   Z
 428              3.80E0        4.56E0        5.32E0     59.02E-1E                 Z
 429           35.56E-2     46.99E-2E                                              RAD
 430         1570.80E-3    3141.59E-3    4712.39E-3   6283.19E-3E                  TH
 431                   8             5             3            13                 SOURCE
 432                   8             2             3             1                 SOURCE
 433                   8             7             3            11                 SOURCE
 434                   8             4             3            12                 SOURCE
 435       *                                                                       LEVEL 1
 436       F     1.99E-01E
 437       F     6.23E+01E
 438       F          0.0E                                                         CFZL-T
 439       F          0.0E                                                         CFZL-Z
 440       F          0.0E                                                         CFZL-R
 441       F          0.0E                                                         CFZV-T
 442       F          0.0E                                                         CFZV-Z
 443       F          0.0E                                                         CFZV-R
 444       R 4 9735.62E-4R 4        0.577E                                         VOL
 445       F       1.00E0E                                                         FA-T
 446       F       1.00E0E                                                         FA-Z
 447       R 4     1.00E0R 4          0.0E                                         FA-R
 448       R 4 3673.95E-4R 4 1757.43E-4E                                           HD-T
 449       R 4 3128.57E-4R 4  194.34E-3E                                           HD-Z
 450       R 4   45.23E-2R 4          0.0E                                         HD-R
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                1         2         3         4         5         6         7         8
CARD   12345678901234567890123456789012345678901234567890123456789012345678901234567890

 451   F   555.       E                                                   HSTN
 452   F           0.0E                                                   ALPN
 453   F           0.0E                                                   VVN-T
 454   F           0.0E                                                   VVN-Z
 455   F           0.0E                                                   VVN-R
 456   F           0.0E                                                   VLN-T
 457   F           0.0E                                                   VLN-Z
 458   F           0.0E                                                   VLN-R
 459   F        5.55E2E                                                   TVN
 460   F        5.55E2E                                                   TLN
 461   F       15.75E6E                                                   PN
 462   *                                                                  LEVEL 2
 463   F      1.99E-01E
 464   F      6.23E+01E
 465   F           0.0E                                                   CFZL-T
 466   F           0.0E                                                   CFZL-Z
 467   F           0.0E                                                   CFZL-R
 468   F           0.0E                                                   CFZV-T
 469   F           0.0E                                                   CFZV-Z
 470   F           0.0E                                                   CFZV-R
 471   R 4 9735.62E-4R 4       0.577E                                     VOL
 472   F        1.00E0E                                                   FA-T
 473   R 4    0.25   R 4        1.00E                                     FA-Z
 474   R 4      1.00E0R 4        0.0E                                     FA-R
 475   R 4 3673.95E-4R 4 1757.43E-4E                                      HD-T
 476   R 4 3128.57E-4R 4  194.34E-3E                                      HD-Z
 477   R 4   45.23E-2R 4        0.0E                                      HD-R
 478   F   555.       E                                                   HSTN
 479   F           0.0E                                                   ALPN
 480   F           0.0E                                                   VVN-T
 481   F           0.0E                                                   VVN-Z
 482   F           0.0E                                                   VVN-R
 483   F           0.0E                                                   VLN-T
 484   F           0.0E                                                   VLN-Z
 485   F           0.0E                                                   VLN-R
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               1         2         3         4         5         6         7         8
CARD  12345678901234567890123456789012345678901234567890123456789012345678901234567890

 486  F     5.55E2E                                                        TVN
 487  F     5.55E2E                                                        TLN
 488  F    15.75E6E                                                        PN
 489  *                                                                    LEVEL 3
 490  F   3.98E-01E
 491  F   1.25E+02E
 492  F        0.0E                                                       CFZL-T
 493  F        0.0E                                                       CFZL-Z
 494  F        0.0E                                                       CFZL-R
 495  F        0.0E                                                       CFZV-T
 496  F        0.0E                                                       CFZV-Z
 497  F        0.0E                                                       CFZV-R
 498  R 4 9735.62E-4R 4      0.577E                                        VOL
 499  R 4 7775.16E-4R 4     0.50E0E                                        FA-T
 500  R 4        1.0R 4   0.57700E                                        FA-Z
 501  F        0.0E                                                        FA-R
 502  R 4 2087.61E-4R 4 1063.06E-4E                                        HD-T
 503  R 4 1353.69E-4R 4 4574.89E-5E                                        HD-Z
 504  F        0.0E                                                        HD-R
 505  F   552.      E                                                      HSTN
 506  F        0.0E                                                        ALPN
 507  F        0.0E                                                        VVN-T
 508  F        0.0E                                                        VVN-Z
 509  F        0.0E                                                        VVN-R
 510  F        0.0E                                                        VLN-T
 511  F        0.0E                                                        VLN-Z
 512  F        0.0E                                                        VLN-R
 513  F     5.52E2E                                                        TVN
 514  F     5.52E2E                                                        TLN
 515  F    15.75E6E                                                        PN
 516  *                                                                    LEVEL 4
 517  F   3.98E-01E
 518  F   1.25E+02E
 519  F        0.0E                                                        CFZL-T
 520  F        0.0E                                                        CFZL-Z
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               1         2         3         4         5         6         7         8
CARD  12345678901234567890123456789012345678901234567890123456789012345678901234567890

 521  F          0.0E                                                       CFZL-R
 522  F          0.0E                                                       CFZV-T
 523  F          0.0E                                                       CFZV-Z
 524  F          0.0E                                                       CFZV-R
 525  R 4 9735.62E-4R 4       0.577E                                        VOL
 526  R 4      1.00E0R 4     0.50E0E                                        FA-T
 527  R 4      1.00E0R 4    0.577E0E                                        FA-Z
 528  F          0.0E                                                       FA-R
 529  R 4 4845.03E-4R 4 1063.06E-4E                                        HD-T
 530  R 4 3128.57E-4R 4 4574 89E-5E                                        HD-Z
 531  F          0.0E                                                       HD-R
 532  F   552.      E                                                       HSTN
 533  F          0.0E                                                       ALPN
 534  F          0.0E                                                       VVN-T
 535  F          0.0E                                                       VVN-Z
 536  F          0.0E                                                       VVN-R
 537  F          0.0E                                                       VLN-T
 538  F          0.0E                                                       VLN-Z
 539  F          0.0E                                                       VLN-R
 540  F       5.52E2E                                                       TVN
 541  F       5.52E2E                                                       TLN
 542  F      15.75E6E                                                       PN
 543  *                                                                     LEVEL 5
 544  F    3.98E-01E
 545  F    1.25E+02E
 546  F          0.0E                                                       CFZL-T
 547  F          0.0E                                                       CFZL-Z
 548  F          0.0E                                                       CFZL-R
 549  F          0.0E                                                       CFZV-T
 550  F          0.0E                                                       CFZV-Z
 551  F          0.0E                                                       CFZV-R
 552  R 4 9735.62E-4R 4       0.577E                                        VOL
 553  R 4      1.00E0R 4     0.50E0E                                        FA-T
 554  R 4      1.00E0R 4    0.577E0E                                        FA-Z
 555  F          0.0E                                                       FA-R
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                1         2         3         4         5         6         7         8
CARD   12345678901234567890123456789012345678901234567890123456789012345678901234567890

 556   R 4 4845.03E-4R 4 1063.06E-4E                                        HD-T
 557   R 4 3128.57E-4R 4 4574.89E-5E                                        HD-Z
 558   F          0.0E                                                      HD-R
 559   F   552.      E                                                      HSTN
 560   F          0.0E                                                      ALPN
 561   F          0.0E                                                      VVN-T
 562   F          0.0E                                                      VVN-Z
 563   F          0.0E                                                      VVN-R
 564   F          0.0E                                                      VLN-T
 565   F          0.0E                                                      VLN-Z
 566   F          0.0E                                                      VLN-R
 567   F       5.52E2E                                                      TVN
 568   F       5.52E2E                                                      TLN
 569   F      15.75E6E                                                      PN
 570   *                                                                    LEVEL 6
 571   F     3.98E-01E
 572   F     1.25E+02E
 573   F          0.0E                                                      CFZL-T
 574   F          0.0E                                                      CFZL-Z
 575   F          0.0E                                                      CFZL-R
 576   F          0.0E                                                      CFZV-T
 577   F          0.0E                                                      CFZV-Z
 578   F          0.0E                                                      CFZV-R
 579   R 4 9735.62E-4R 4       0.577E                                        VOL
 580   R 4      1.00E0R 4      0.50E0E                                       FA-T
 581   R 4    0.18400R 4    0.57700E                                        FA-Z
 582   F          0.0E                                                      FA-R
 583   R 4 4845.03E-4R 4 1063.06E-4E                                        HD-T
 584   R 4 3128.57E-4R 4 4574 89E-5E                                        HD-Z
 585   F          0.0E                                                      HD-R
 586   F   552.      E                                                      HSTN
 587   F          0.0E                                                      ALPN
 588   F          0.0E                                                      VVN-T
 589   F          0.0E                                                      VVN-Z
 590   F          0.0E                                                      VVN-R
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                 1         2         3         4         5         6         7         8
CARD    12345678901234567890123456789012345678901234567890123456789012345678901234567890

591     F         0.0E                                                         VLN-T
592     F         0.0E                                                         VLN-Z
593     F         0.0E                                                         VLN-R
594     F      5.52E2E                                                         TVN
595     F      5.52E2E                                                         TLN
596     F     15.75E6E                                                         PN
597     *                                                                      LEVEL 7
598     F    3.98E-01E
599     F    1.25E+02E
600     F         0.0E                                                         CFZL-T
601     F         0.0E                                                         CFZL-Z
602     F        0.00E                                                         CFZL-R
603     F         0.0E                                                         CFZV-T
604     F        0.00E                                                         CFZV-Z
605     F        0.00E                                                         CFZV-R
606     R 4 9735.62E-4R 4       0.577E                                         VOL
607     R 4     1.00E0R 4      0.50E0E                                         FA-T
608     R 4     0.1038R 4    0.57700E                                          FA-Z
609     F         0.0E                                                         FA-R
610     R 4 4845.03E-4R 4 1063.06E-4E                                          HD-T
611     R 4   30.48E-2R 4 4574.89E-5E                                          HD-Z
612     F         0.0E                                                         HD-R
613     R 4 552.      R 4     5.55E2E                                          HSTN
614     F         0.0E                                                         ALPN
615     F         0.0E                                                         VVN-T
616     F         0.0E                                                         VVN-Z
617     F         0.0E                                                         VVN-R
618     F         0.0E                                                         VLN-T
619     F         0.0E                                                         VLN-Z
620     F         0.0E                                                         VLN-R
621     R 4     5.52E2R 4     5.55E2E                                          TVN
622     R 4     5.52E2R 4     5.55E2E                                          TLN
623     F     15.75E6E                                                         PN
624     *                                                                      LEVEL 8
625     F    3.98E-01E
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CARD          1         2         3         4         5         6         7         8
     12345678901234567890123456789012345678901234567890123456789012345678901234567890

626  F     1.25E+02E
627  F          0.0E                                                         CFZL-T
628  F          0.0E                                                         CFZL-Z
629  F          0.0E                                                         CFZL-R
630  F          0.0E                                                         CFZV-T
631  F          0.0E                                                         CFZV-Z
632  F          0.0E                                                         CFZV-R
633  R 4 9735.62E-4R 4      0.577E                                           VOL
634  R 4     1.00E0R 4     0.50E0E                                           FA-T
635  R 4       1.00R 4      0.577E                                           FA-Z
636             0.0    1494.06E-4           0.0    1494.06E-4    1130.64E-4  FA-R
637             0.0    1130.64E-4           0.0E                             FA-R
638  R 4 4845.03E-4R 4 1063.06E-4E                                           HD-T
639  R 4 8669.01E-5R 4 4574.89E-5E                                           HD-Z
640             0.0       2.84E-1           0.0       2.84E-1       2.84E-1  HD-R
641             0.0       2.84E-1           0.0E                             HD-R
642  R 4 555.      R 4    5.55E02E                                           HSTN
643  F          0.0E                                                         ALPN
644  F          0.0E                                                         VVN-T
645  F          0.0E                                                         VVN-Z
646  F          0.0E                                                         VVN-R
647  F          0.0E                                                         VLN-T
648  F          0.0E                                                         VLN-Z
649  F          0.0E                                                         VLN-R
650  R 4     5.52E2R 4     5.55E2E                                           TVN
651  R 4     5.52E2R 4     5.55E2E                                           TLN
652  F      15.75E6E                                                         PN
653  *                                                                        LEVEL 9
654  F     3.04E-01E
655  F     9.56E+01E
656  F          0.0E                                                         CFZL-T
657  F          0.0E                                                         CFZL-Z
658  F          0.0E                                                         CFZL-R
659  F          0.0E                                                         CFZV-T
660  F          0.0E                                                         CFZV-Z
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                      1             2             3             4             5             6             7          8
CARD  12345678901234567890123456789012345678901234567890123456789012345678901234567890

661   F         0.0E                                                          CFZV-R
662   R 4 9735.62E-4R 4      0.577E                                           VOL
663   R 4     1.00E0R 4     0.50E0E                                           FA-T
664   F         0.0E                                                          FA-Z
665   F         0.0E                                                          FA-R
666   R 4 4845.03E-4R 4 1063.06E-4E                                           HD-T
667   F         0.0E                                                          HD-Z
668   F         0.0E                                                          HD-R
669   R 4 552.     R 4   552.0    E                                           HSTN
670   F         0.0E                                                          ALPN
671   F         0.0E                                                          VVN-T
672   F         0.0E                                                          VVN-Z
673   F         0.0E                                                          VVN-R
674   F         0.0E                                                          VLN-T
675   F         0.0E                                                          VLN-Z
676   F         0.0E                                                          VLN-R
677   R 4     5.52E2R 4     5.55E2E                                           TVN
678   R 4     5.52E2R 4     5.55E2E                                           TLN
679   F     15.75E6E                                                          PN
680   FILL                     13                                             CARD  1
681             14                                                            CARD  2
682         1.00E0        1.00E0           0.0           0.0        5.53E2    CARD  3
683       15.75E6                                                             CARD  4
684   BREAK                    14                                             CARD  1
685             15              0                                             CARD  2
686         1.00E0        1.00E0        1.00E0        5.53E2       66.50E5    CARD  3
687   TEE                      12                                             CARD  1
688              2              1             7           0.0             1   CARD  2
689              0              3            13            17                 CARD  3
690     0.142000E0  3.571240E-2            0.0           0.0   2.950000E2     CARD  4
691     2.950000E2                                                            CARD  5
692              0              1            77                               CARD  6
693        0.11115       3.57E-2           0.0           0.0         295.0    CARD  7
694          295.0                                                            CARD  8
695   F   5583.76E-4E                                                         DX 1
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               1         2         3         4         5         6         7         8
CARD  12345678901234567890123456789012345678901234567890123456789012345678901234567890

696   F      35.44E-3E                                                          VOL 1
697   R 3 6342.53E-5     1387.58E-5E                                            FA 1
698              0.0  2671.89E-3          44.38E-3            0.0E              FRIC 1
699   F          0.0E                                                           GRAV 1
700   R 3     2.84E-1    1329.18E-4E                                            HD 1
701   F            4E                                                           NFF 1
702   F          0.0E                                                           ALP 1
703   F          0.0E                                                           VM 1
704   F      5.55E2E                                                            TL 1
705   F      5.55E2E                                                            TV 1
706   F     15.75E6E                                                            P 1
707   F          0.0E                                                           QPPP 1
708   F      5.52E2E                                                            TW 1
709   F      7.9845E                                                            DX 2
710   F      0.3098E                                                            VOL 2
711   F     3.88E-2E                                                            FA 2
712   F          0.0E                                                           FRIC 2
713   F          1.0E                                                           GRAV 2
714   F      0.2223E                                                            HD 2
715   F            4E                                                           NFF 2
716   F          0.0E                                                           ALP 2
717   F          0.0E                                                           VM 2
718   F      5.55E2E                                                            TL 2
719   F      5.55E2E                                                            TV 2
720   F     15.75E6E                                                            P 2
721   F          0.0E                                                           QPPP 2
722   F      5.55E2E                                                            TW 2
723   PIPE                    16                                                CARD  1
724                 25         1             17             19             7    CARD  2
725                  0         1                                                CARD  3
726      0.958804E-1  0.159919E0            0.0            0.0   2.950000E2     CARD  4
727       2.950000E2                                                            CARD  5
728          1.27E-1  9925.54E-5    7444.15E-5R 2 4962.77E-5R 2 2481.39E-5      DX
729   R 6    1.27E-2R 2 2579.69E-5   5159.38E-5     7739.06E-5     1183.93E-4   DX
730      1851.91E-4R 3 2160.57E-4    2063.75E-4     3460.75E-4      46.99E-2E   DX
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                 1         2         3         4         5         6         7         8
CARD    12345678901234567890123456789012345678901234567890123456789012345678901234567890

731        1479.66E-6     9355.59E-7      701.67E-6R 2  467.78E-6R 2  233.89E-6  VOL
732     R 6 1062.32E-7R 2 6067.41E-7     1213.48E-6    1820.22E-6    2284.08E-6  VOL
733        4355.69E-6R 3 5081.64E-6     4853.93E-6    1798.07E-5    2441.41E-5E VOL
734        1387.58E-5R 6 9425.75E-6R 6 8364.71E-6R10 2351.98E-5R 3 5195.56E-5E FA
735     R 7        0.0R 7        1.6R 8        0.0R 4        0.20E              FRIC
736     F          0.0E                                                         GRAV
737        1329.18E-4R 6  109.55E-3R 6   10.32E-2R10  173.05E-3R 3   25.72E-2E HD
738     F            4E                                                         NFF
739     F          0.0E                                                         ALP
740     F          0.0E                                                         VM
741     R19     5.55E2R06      5.45E2E                                          TL
742     R19     5.55E2R06      5.45E2E                                          TV
743     F      15.75E6E                                                         P
744     F          0.0E                                                         QPPP
745     R19     5.55E2R06      5.45E2E                                          TW
746     TEE                         11                                          CARD  1
747                   2              1              7           0.0            0 CARD  2
748                   0             16             12            16             CARD  3
749        0.144514E0   0.758863E-1            0.0           0.0   2.950000E2 CARD  4
750        2.950000E2                                                           CARD  5
751                   0              1             99                           CARD  6
752            0.11115       3.57E-2            0.0           0.0         295.0 CARD  7
753              295.0                                                          CARD  8
754     R 3 5583.76E-4      525.78E-3     4674.87E-4      558.61E-3    1987.49E-3 DX 1
755     R 2 1077.21E-3     1987.49E-3     5102.86E-4     5462.91E-4    4862.83E-4 DX 1
756             2.54E-1     171.45E-3     1746.25E-4E                             DX 1
757     R 3   35.44E-3     4728.01E-6     3757.89E-6     4660.33E-6    1968.55E-4 VOL 1
758     R 2 1138.34E-4     1968.55E-4     4072.76E-6     4063.49E-6     317.15E-5 VOL 1
759        1611.49E-5     7091.63E-6     1107.57E-5E                             VOL 1
760     R 3 6342.53E-5      139.13E-4R 2 8364.71E-6     1914.12E-5R 2 1056.26E-4 FA 1
761        1914.12E-5     1056.26E-4R 2 8364.71E-6     6342.53E-5R 2 9462.37E-6 FA 1
762        6342.53E-5E                                                           FA 1
763               0.0     2671.89E-3R 3        0.0     2614.89E-5           0.0 FRIC 1
764          111.08E-2    3234.17E-5     2273.55E-5      111.08E-2R 3        0.0 FRIC 1
765        1302.49E-4     1700.00E-3            0.0E                             FRIC 1
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                 1         2         3         4         5         6         7         8
CARD    12345678901234567890123456789012345678901234567890123456789012345678901234567890

766     R 5       0.0R 3    1.00E0           0.0R 5    -1.00E0R 3        0.0E GRAV 1
767     R 3    2.84E-1    1330.96E-4R 2   10.32E-2    1756.41E-5R 2 3667.25E-4  HD 1
768         1756.41E-5R 3   10.32E-2         2.84E-1R 2 1197.61E-5       2.84E-1E HD 1
769     F           4E                                                           NFF 1
770     F         0.0E                                                           ALP 1
771     F         0.0E                                                           VM 1
772     F      5.55E2E                                                           TL 1
773     F      5.55E2E                                                           TV 1
774     F     15.75E6E                                                           P 1
775     F         0.0E                                                           QPPP 1
776     F      5.54E2E                                                           TW 1
777     F     7.54640E                                                           DX 2
778     F      0.2928E                                                           VOL 2
779     F      3.88E-2E                                                          FA 2
780     F         0.0E                                                           FRIC 2
781     F         1.0E                                                           GRAV 2
782     F       .2223E                                                           HD 2
783     F           4E                                                           NFF 2
784     F         0.0E                                                           ALP 2
785     F         0.0E                                                           VM 2
786     F      5.55E2E                                                           TL 2
787     F      5.55E2E                                                           TV 2
788     F     15.75E6E                                                           P 2
789     F         0.0E                                                           QPPP 2
790     F      5.55E2E                                                           TW 2
791     PIPE                     15                                              CARD  1
792                 25            1             16            18             7   CARD  2
793                  0            1                                              CARD  3
794         8331.79E-5    164.79E-3            0.0           0.0        2.95E2   CARD  4
795             2.95E2                                                           CARD  5
796           27.94E-2R 2 2118.36E-4R 4 1871.66E-4R 2 1496.06E-4    8413.75E-5   DX
797         5609.17E-5    2804.58E-5R 6    1.27E-2    2716.39E-5    5432.78E-5   DX
798     R 2 8149.17E-5R 3   19.05E-2E                                            DX
799         6860.64E-6R 2 1766.69E-6R 4 1567.35E-6R 2 1245.95E-6     703.79E-6   VOL
800         4691.93E-7    2345.97E-7R 6 1062.32E-7    1411.33E-6    2822.65E-6   VOL
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              1         2         3         4         5         6         7         8
CARD 12345678901234567890123456789012345678901234567890123456789012345678901234567890

801  R 2 4233.99E-6R 3 9897.61E-6E                                           VOL
802     6342.53E-5R18 8364.71E-6R 7 5195.56E-5E                             FA
803  R 3        0.0    4396.98E-5R 5        0.0    4396.98E-5R16        0.0E FRIC
804  R 3        0.0R 5     1.00E0    7071.07E-4R17        0.0E               GRAV
805        2.84E-01R18   10.32E-2R 7   25.72E-2E                             HD
806  F            4E                                                         NFF
807  F          0.0E                                                         ALP
808  F          0.0E                                                         VM
809  R13     5.55E2R12     5.45E2E                                          TL
810  R13     5.55E2R12     5.45E2E                                          TV
811  F      15.75E6E                                                         P
812  F          0.0E                                                         QPPP
813  R13     5.55E2R12     5.45E2E                                          TW
814  VALVE                     18                                            CARD  1
815              2             1            19            21             7 CARD  2
816              0             0                                            CARD  3
817      0.128600E0   0.277813E-1           0.0           0.0    2.950000E2 CARD  4
818      2.950000E2                                                          CARD  5
819              4             2             2                           2 CARD  6
820        5.273E-2      9.525E-2                                            CARD  7
821           1.5E0        2.00E0E                                           DX
822      3282.71E-5    6058.79E-5E                                           VOL
823      5195.56E-5    5272.92E-5    5855.64E-5E                             FA
824             1.0           1.0           1.0E                             FRIC
825  F          0.0E                                                         GRAV
826        25.72E-2    9524.99E-5     273.05E-3E                             HD
827  F            4E                                                         NFF
828             0.0        1.00E0E                                           ALP
829  F          0.0E                                                         VM
830           545.0         373.0E                                           TL
831           545.0         373.0E                                           TV
832         59.00E5        1.01E5E                                           P
833  F          0.0E                                                         QPPP
834           545.0         373.0E                                           TW
835             0.0       0.00001       1.75E-2        1.00E0E               VLTBL
```

```
               1         2         3         4         5         6         7         8
CARD  12345678901234567890123456789012345678901234567890123456789012345678901234567890

836   VALVE                    17                                               CARD  1
837            2                1          18          20                  7   CARD  2
838            0                0                                               CARD  3
839      0.128600E0  0.277813E-1          0.0         0.0      2.950000E2     CARD  4
840      2.950000E2                                                             CARD  5
841            4                2           2                          2       CARD  6
842      0.05272920  0.09525000                                                 CARD  7
843           1.500     2.00000E                                                DX
844      3282.71E-5  6058.79E-5E                                                VOL
845      5195.56E-5  5272.92E-5   5855.64E-5E                                   FA
846   F         1.0E                                                            FRIC
847   F         0.0E                                                            GRAV
848        25.72E-2  9524.99E-5    273.05E-3E                                   HD
849   F           4E                                                            NFF
850             0.0      1.00E0E                                                ALP
851   F         0.0E                                                            VM
852       545.0        374.0    E                                               TL
853       545.0        374.0    E                                               TV
854         15.75E6      1.01E5E                                                P
855   F         0.0E                                                            QPPP
856       545.0        374.0    E                                               TW
857             0.0    0.000001      1.75E-2      1.00E0E                       VLTBL
858   FILL                     99                                               CARD  1
859           99                1                                               CARD  2
860            2.50  0.226783E-2          0.0         0.0      0.297440E3     CARD  3
861          4.24E6                                                             CARD  4
862   FILL                     77                                               CARD  1
863           77                1                                               CARD  2
864            2.50  0.226783E-2          0.0         0.0      0.297440E3     CARD  3
865          4.24E6                                                             CARD  4
866   BREAK                    19                                               CARD  1
867           20                0                                               CARD  2
868      0.822325E0  0.605879E-1       1.00E0      3.73E2       101.33E3     CARD  3
869   BREAK                    20                                               CARD  1
870           21                0                                               CARD  2
```

```
                1             2             3             4             5             6             7             8
CARD   12345678901234567890123456789012345678901234567890123456789012345678901234567890

871               .2           .06           1.0         373.0        1.01E5  CARD  3
872    TEE                      21             0
873                1             0             7 -1.000000E+00             0
874                0             2            25            27             0
875      4.366260E-02  3.487400E-03  0.            0.            2.950000E+02
876      2.950000E+02
877                0             2            23
878      1.699260E-02  7.137400E-03  0.            0.            2.950000E+02
879      2.950000E+02
880    F   2.1844E+00E
881    F   5.2331E-02E
882    R 2 5.9890E-03R 1 5.5470E-02E
883    F   4.5000E-01E
884    F   0.        E
885    R 2 8.7330E-02R 1 2.6360E-01E
886    F            4E
887    F   0.        E
888    F   0.        E
889    F   5.5244E+02E
890    F   5.5244E+02E
891    F   1.5600E+07E
892    F   2.5000E+00E
893    F   2.2678E-03E
894    F   9.0713E-04E
895    F   0.        E
896    F   0.        E
897    F   3.3985E-02E
898    F            4E
899    F   0.        E
900    F   0.        E
901    F   5.5244E+02E
902    F   5.5244E+02E
903    F   1.5600E+07E
904    TEE                      22             0
905                1             0             7  1.000000E+00             0
```

```
               1         2         3         4         5         6         7         8
CARD  12345678901234567890123456789012345678901234567890123456789012345678901234567890

906                1             1            25            22             0
907     0.            0.            0.            0.            0.
908     0.
909                1             1            26
910     0.            0.            0.            0.            0.
911     0.
912   F   1.0000E+00E
913   F   5.9890E-03E
914   F   5.9890E-03E
915   F   0.        E
916   F   0.        E
917   F   8.7330E-02E
918   F            4E
919   F   0.        E
920   F   0.        E
921   F   5.5240E+02E
922   F   5.5240E+02E
923   F   1.5600E+07E
924   F   1.0000E+00E
925   F   5.9890E-03E
926   F   5.9890E-03E
927   F   0.        E
928   F   0.        E
929   F   8.7330E-02E
930   F            4E
931   F   0.        E
932   F   0.        E
933   F   5.5240E+02E
934   F   5.5240E+02E
935   F   1.5600E+07E
936   ACCUM                     23             0
937                3            24
938       8.8633E-01    1.2886E+00    2.2500E-02E
939       9.6000E-01    1.6760E+00    2.0000E-02E
940   R 3 1.2460E+00R 1 3.2852E-02E
```

```
                  1         2         3         4         5         6         7         8
CARD     12345678901234567890123456789012345678901234567890123456789012345678901234567890

 941     F    4.5000E-01E
 942     F   -1.0000E+00E
 943     R 3 1.2595E+00R 1 2.0452E-01E
 944     F            4E
 945     R 1 1.0000E+00R 2 0.          E
 946     F    0.        E
 947     F    3.0080E+02E
 948     F    3.0080E+02E
 949     F    4.1100E+06E
 950     FILL                    25              LPIS PUMP EQUIVALENT          CARD  1
 951                23            3                        11                  CARD  2
 952              1.50   8.983810E-3          0.0   0.421345E0    0.297440E3   CARD  3
 953            4.24E6                                                         CARD  4
 954          1.00E+04     7.72E+00      1.38E+05     7.40E+00S                FLTBL
 955          3.97E+05     6.68E+00      5.89E+05     5.98E+00S                FLTBL
 956          7.93E+05     5.19E+00      9.74E+05     4.41E+00S                FLTBL
 957          1.13E+06     3.43E+00      1.25E+06     2.47E+00S                FLTBL
 958          1.35E+06     1.39E+00      1.44E+06     0.00E+00S                FLTBL
 959          2.00E+07     0.00E+00E                                           FLTBL
 960     FILL                    24              HPIS PUMP EQUIVALENT          CARD  1
 961                26            2                         4                  CARD  2
 962              2.50  0.226783E-2           0.0          0.0    0.297440E3   CARD  3
 963            4.24E6                                                         CARD  4
 964               0.0          0.0          22.0          0.0S                FLTBL
 965           22.10E0     1.84E-01        1.00E3     1.84E-01E                FLTBL
 966     VALVE                   27             0
 967                 2            0            27           24             7
 968                 0            0
 969      4.366260E-02 3.487400E-03  0.           0.           2.950000E+02
 970      2.950000E+02
 971                 2            3             0            0             2
 972      5.989200E-02 8.732520E-01  0.
 973     F    1.0922E+00E
 974     F    2.6166E-02E
 975     R 2 5.5470E-02R 1 3.2852E-02E
```

```
               1         2         3         4         5         6         7         8
CARD  12345678901234567890123456789012345678901234567890123456789012345678901234567890

 976  F   4.5000E-01E
 977  F   0.         E
 978  R 2 2.6360E-01R 1 2.0452E-01E
 979  F            4E
 980  F   0.         E
 981  F   0.         E
 982      5.5250E+02    3.0567E+02E
 983      5.5250E+02    3.0567E+02E
 984      1.5600E+07    4.2400E+06E
 985          1.0E-4         0.100         100.0       1.0E+03
 986             5.0          0.10         5.0
 987  -1.
```

II. TRAC TRANSIENT INPUT DECK FOR LOFT NONNUCLEAR EXPERIMENT L1-4

```
                1         2         3         4         5         6         7         8
CARD   12345678901234567890123456789012345678901234567890123456789012345678901234567890

  1               2
  2    LOFT TEST L1-4                                                 (INITIAL INPUT)
  3       BLOWDOWN
  4              -1         0.0                                               MCC 1
  5               0          1             28             29             1   MCC 2
  6          2.0e-3     1.0e-5         1.0e-2                                 MCC 3
  7              10         50             10              3                  MCC 4
  8               1          2              3              4             5   IORDER
  9               6          7              8              9            11   IORDER
 10              12         13             14             15            16   IORDER
 11              17         18             19             20            21   IORDER
 12              22         23             24             25            27   IORDER
 13              77         99            10e                                IORDER
 14              -1
 15
 16    END
 17         1.0e-4        0.1           70.0                                 TIMSTP
 18            5.0       0.05            5.0                                 TIMSTP
 19    -1.                                                                   TIMSTP
 20    P
```

APPENDIX K

TRAC STEADY-STATE AND TRANSIENT INPUT DECKS FOR LOFT EXPERIMENT L2-2

I. TRAC STEADY-STATE INPUT DECK FOR LOFT EXPERIMENT L2-2

```
                1         2         3         4         5         6         7         8
CARD   12345678901234567890123456789012345678901234567890123456789012345678901234567890

   1                3                           1
   2    LOFT STEADY STATE TEST (INITIAL INPUT)
   3     L2-2 INCLUDING UPPER PLENUM BLOCKAGE
   4          GAP WIDTH = 0.0953 MM
   5              -1  0.
   6                1             0            27            28             1
   7      1.00000E-03  5.00000E-06  1.00000E-04  0.00000E+00
   8               10           100            20             7             1
   9                1             2             3             4             5
  10                6             7             8             9            10
  11               13            14            15            16            17
  12               18            19            20            21            22
  13               23            24            25            27            50
  14               77           99E
  15              333E
  16                1             0   .100000E+01  0.
  17                0             0             0             0
  18                2             0  0.            0.
  19                0             0             0             0
  20             3000            -1   .422000E+07  0.
  21               27             0             1             0
  22                4            -7   .230000E+00   .300000E+01
  23                2             0             1             0
  24              555             0  0.            0.
  25                0             0             0             0
  26              333             0          35.0           0.0
  27                0             0             0             0
  28             2000             0  0.            0.
  29                0             0             0             0
  30   TEE                        1             0
```

```
               1         2         3         4         5         6         7         8
CARD  12345678901234567890123456789012345678901234567890123456789012345678901234567890

  31               4             1             7  0.                       0
  32               0             4             1             3             0
  33    1.420000E-01  3.650000E-02  0.            0.            2.950000E+02
  34    2.950000E+02
  35               0             3             2
  36    2.330050E-02  8.696800E-03  0.            0.            2.950000E+02
  37    2.950000E+02
  38  R 2 6.6675E-01R 1 4.1910E-01R 1 6.6010E-01E
  39  R 2 4.2334E-02R 1 2.6618E-02R 1 4.1909E-02E
  40  F   6.3425E-02E
  41  F   0.        E
  42  F   0.        E
  43  F   2.8400E-01E
  44  F            4E
  45  F   0.        E
  46  F   0.        E
  47  F   5.5200E+02E
  48  F   5.5200E+02E
  49  F   1.5750E+07E
  50  F   0.        E
  51  F   5.5200E+02E
  52      2.1499E+00    2.6428E+00    2.2217E+00E
  53      3.1149E-03    3.6954E-03    5.7059E-03E
  54  R 3 1.4493E-03R 1 5.7321E-03E
  55      1.6530E-01    5.5032E-03    4.6688E-03    0.        E
  56  R 1 5.0000E-01R 2 0.        R 1 5.0000E-01E
  57  R 3 4.2957E-02R 1 8.5430E-02E
  58  F            4E
  59  F   0.        E
  60  F   0.        E
  61  F   5.5200E+02E
  62  F   5.5200E+02E
  63  F   1.5750E+07E
  64  F   0.        E
  65  F   5.5200E+02E
```

```
                 1         2         3         4         5         6         7         8
CARD    12345678901234567890123456789012345678901234567890123456789012345678901234567890

  66    PIPE                       4             0
  67                4             1             3             4             7
  68                0             0
  69      1.505690E-01  3.761400E-02  0.            0.            2.950000E+02
  70      2.950000E+02
  71        1.0160E+00    7.3660E-01    3.5560E-01    5.3340E-01E
  72        4.9555E-02    4.6723E-02    2.6052E-02    4.3326E-02E
  73        6.3430E-02    3.3300E-02    6.3430E-02    8.3190E-02    5.1600E-02E
  74    R 4 0.        R 1 2.5000E-02E
  75    F   0.        E
  76    R 3 2.8400E-01R 1 3.2546E-01R 1 2.5600E-01E
  77    F            4E
  78    F   0.        E
  79    F   0.        E
  80    F   5.5400E+02E
  81    F   5.5400E+02E
  82    F   1.5750E+07E
  83    F   0.        E
  84    F   5.5400E+02E
  85    STGEN                      3             0
  86               10             3             4             5            12
  87                1             0             0             1
  88      5.105400E-03  1.244600E-03
  89                7            14            15
  90    R 1 1.0000E+00R 8 6.4199E-01R 1 1.0000E+00E
  91    R 1 3.3541E-01R 8 9.7000E-02R 1 3.3541E-01E
  92    R 1 5.1605E-02R 9 1.5117E-01R 1 5.1605E-02E
  93    R 1 2.5000E-02R 9 0.        R 1 2.5000E-02E
  94    R 1 0.        R 4 1.0000E+00R 1 0.        R 4-1.0000E+00R 1 0.
  95    R 1 2.5600E-01R 9 1.0211E-02R 1 2.5600E-01E
  96    R 1          4R 9          1R 1          4E
  97    F   0.        E
  98    F   0.        E
  99    R 5 5.5400E+02R 5 5.5200E+02E
 100    R 5 5.5400E+02R 5 5.5200E+02E
```

```
                  1         2         3         4         5         6         7         8
CARD     12345678901234567890123456789012345678901234567890123456789012345678901234567890

101      F   1.5750E+07E
102      F   5.4600E+02E
103      R 4 6.4199E-01R 3 1.0502E+00E
104      R 1 4.7450E-01R 3 8.7060E-01R 3 1.1894E+00E
105      R 7 1.3560E+00R 1 1.8200E-02E
106      F   0.        E
107      F   1.0000E+00E
108      R 1 1.0200E-01R 6 3.5700E-02R 1 1.5240E-01E
109      F            4E
110      R 4 0.        R 1 2.6315E-01R 2 1.0000E+00E
111      F   0.        E
112      F   5.5800E+02E
113      F   5.5800E+02E
114      F   6.3340E+06E
115      R 1 0.        R 1 2.4040E+01R 6 4.4100E+01R 1 2.4040E+01R 1 0.        E
116      R 1 2.5780E+01R 3 4.7300E+01R 3 0.        E
117      TEE                        5             0
118                   2             1             7  0.                       0
119                   0             3             6             7             0
120        1.420870E-01  3.572600E-02  0.            0.            2.950000E+02
121        2.950000E+02
122                   0             2             5
123        1.420870E-01  3.572600E-02  0.            0.            2.950000E+02
124        2.950000E+02
125          6.3500E-01    1.6764E+00    6.3500E-01E
126          2.7468E-02    1.1249E-01    2.7468E-02E
127      R 1 3.6613E-02R 2 6.3425E-02R 1 3.6613E-02E
128      F   0.        E
129         -1.2380E-01   -1.0000E+00    1.0000E+00    1.2380E-01E
130      R 1 2.1591E-01R 2 2.8417E-01R 1 2.1591E-01E
131      F            4E
132      F   0.        E
133      F   0.        E
134      F   5.5200E+02E
135      F   5.5200E+02E
```

```
              1         2         3         4         5         6         7         8
CARD 12345678901234567890123456789012345678901234567890123456789012345678901234567890

 136 F   1.5750E+07E
 137 F   0.        E
 138 F   5.5200E+02E
 139     1.3141E+00    1.2446E+00E
 140     8.3466E-02    9.0048E-02E
 141 R 2 6.3425E-02R 1 5.1605E-02E
 142 F   0.        E
 143     0.            1.0000E+00    0.        E
 144 R 2 2.8417E-01R 1 2.5600E-01E
 145 F            4E
 146 F   0.        E
 147 F   0.        E
 148 F   5.5200E+02E
 149 F   5.5200E+02E
 150 F   1.5750E+07E
 151 F   0.        E
 152 F   5.5200E+02E
 153 PUMP                       6             0
 154             2             1             6             8             7
 155             0             0             1             1             1
 156             0             0
 157   1.079550E-01  2.835930E-02  0.            0.            2.950000E+02
 158   2.950000E+02
 159         941.54          500.          .315          614.       369.661 CARD 7
 160   3.174380E+02  3.681250E+00  2.311860E+02  1.370000E+02
 161             0
 162             7            10            11            11            13
 163            10            14             6            12             8
 164             4             6             2             2             2
 165             2            11             7
 166 R 1-1.0000E+00R 1 2.4400E+00R 1-8.0000E-01R 1 2.0300E+00R 1-4.0000E-01
 167 R 1 1.6000E+00R 1-2.0000E-01R 1 1.4700E+00R 1 0.        R 1 1.4000E+00
 168 R 1 4.0000E-01R 1 1.3000E+00R 2 1.0000E+00E
 169 R 2-1.0000E+00R 1-4.0000E-01R 1-8.8000E-01R 1-3.0000E-01R 1-8.3000E-01
 170 R 1 0.        R 1-6.8000E-01R 1 2.0000E-01R 1-5.1000E-01R 1 4.0000E-01
```

```
                1         2         3         4         5         6         7         8
CARD   12345678901234567890123456789012345678901234567890123456789012345678901234567890

171    R 1-2.8000E-01R 1 6.0000E-01R 1 0.        R 1 7.0000E-01R 1 1.8000E-01
172    R 1 8.0000E-01R 1 4.0000E-01R 2 1.0000E+00E
173    R 1-1.0000E+00R 1 2.4400E+00R 1-8.3000E-01R 1 2.0000E+00R 1-7.0000E-01
174    R 1 1.7000E+00R 1-6.5000E-01R 1 1.6000E+00R 1-4.5000E-01R 1 1.3200E+00
175    R 1-1.7000E-01R 1 1.1000E+00R 1 0.        R 1 9.3000E-01R 1 5.0000E-01
176    R 1 8.3000E-01R 1 7.8000E-01R 1 8.3000E-01R 1 9.5000E-01R 1 9.3000E-01
177    R 2 1.0000E+00E
178    R 2-1.0000E+00R 1-8.0000E-01R 2-6.0000E-01R 1-3.0000E-01R 1-4.4000E-01
179    R 1-1.0000E-01R 1-2.3000E-01R 1 1.0000E-01R 1-5.0000E-02R 1 2.3000E-01
180    R 1 3.9000E-01R 1 3.3000E-01R 1 4.0000E-01R 1 2.7000E-01R 1 6.2000E-01
181    R 1 4.8000E-01R 1 9.0000E-01R 1 8.3000E-01R 2 1.0000E+00E
182       -1.0000E+00    3.6100E+00   -9.0000E-01    3.4900E+00   -8.0000E-01
183        3.8300E+00   -6.0000E-01    4.6200E+00   -5.0000E-01    4.6300E+00
184       -4.0000E-01    4.2700E+00   -2.0000E-01    2.8200E+00    0.
185        1.4500E+00    1.2000E-01    5.5000E-01    2.0000E-01    2.6000E-01
186        4.0000E-01    2.5000E-01    9.0000E-01    2.2000E-01    1.0000E+00
187        0.        E
188        0.           -6.8000E-01    1.0000E-01   -5.8000E-01    2.0000E-01
189       -5.1000E-01    3.0000E-01   -4.9000E-01    4.0000E-01   -4.8000E-01
190        6.0000E-01   -4.3000E-01    7.0000E-01   -3.7000E-01    8.0000E-01
191       -2.6000E-01    9.0000E-01   -7.0000E-02    1.0000E+00    0.        E
192       -1.0000E+00    3.6100E+00   -8.3000E-01    2.6000E+00   -7.0000E-01
193        2.0300E+00   -6.5000E-01    1.8500E+00   -4.5000E-01    1.3700E+00
194       -1.7000E-01    1.0500E+00    0.            8.3000E-01    2.0000E-01
195        7.6000E-01    4.0000E-01    7.3000E-01    5.0000E-01    7.6000E-01
196        6.0000E-01    8.8000E-01    7.8000E-01    1.3100E+00    9.5000E-01
197        2.0800E+00    1.0000E+00    2.4600E+00E
198        0.            2.4000E-01    3.9900E-01    8.2000E-01    4.0000E-01
199        7.7000E-01    6.2000E-01    1.5800E+00    9.0000E-01    2.1800E+00
200        1.0000E+00    2.4600E+00E
201    R 1-1.0000E+00R 1 2.0000E+00R 1-8.0000E-01R 1 1.4000E+00R 1-7.0000E-01
202    R 1 1.2000E+00R 1-6.0000E-01R 1 1.0300E+00R 1-4.0000E-01R 1 8.0000E-01
203    R 1-2.0000E-01R 1 6.6000E-01R 1-1.0000E-01R 1 6.1000E-01R 1 0.
204    R 1 6.0000E-01R 1 1.0000E-01R 1 6.1000E-01R 1 2.0000E-01R 1 6.3000E-01
205    R 1 6.0000E-01R 1 8.3000E-01R 2 1.0000E+00E
```

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                1         2         3         4         5         6         7         8
CARD   12345678901234567890123456789012345678901234567890123456789012345678901234567890

206    R 2-1.0000E+00R 1-3.0000E-01R 1-9.0000E-01R 1-2.0000E-01R 1-8.7000E-01
207    R 1-1.0000E-01R 1-8.1000E-01R 1 0.         R 1-6.8000E-01R 1 4.0000E-01
208    R 1-2.7000E-01R 1 5.0000E-01R 1 1.5000E-01R 2 1.0000E+00E
209       -1.0000E+00     2.0000E+00    -1.0000E-01     1.3500E+00     5.0000E-01
210        8.3000E-01     1.0000E+00     3.4000E-01E
211    R 2-1.0000E+00R 1-3.0000E-01R 1-9.0000E-01R 1-1.0000E-01R 1-5.2000E-01
212    R 1 4.0000E-01R 1-2.7000E-01R 1 5.0000E-01R 1 0.         R 1 1.0000E+00
213    R 1 3.4000E-01E
214       -1.0000E+00     0.             1.0000E+00     0.         E
215       -1.0000E+00     0.             1.0000E+00     0.         E
216       -1.0000E+00     0.             1.0000E+00     0.         E
217       -1.0000E+00     0.             1.0000E+00     0.         E
218    R 2 0.         R 1 1.0000E-01R 1 0.         R 1 1.5000E-01R 1 5.0000E-02
219    R 1 2.4000E-01R 1 8.0000E-01R 1 3.0000E-01R 1 9.6000E-01R 1 4.0000E-01
220    R 1 9.8000E-01R 1 6.0000E-01R 1 9.7000E-01R 1 8.0000E-01R 2 9.0000E-01
221    R 1 8.0000E-01R 1 9.6000E-01R 1 5.0000E-01R 1 1.0000E+00R 1 0.         E
222    R 2 0.         R 1 1.0000E-01R 1 0.         R 1 1.5000E-01R 1 4.8000E-02
223    R 1 2.2000E-01R 1 5.6400E-01R 1 8.0000E-01R 1 5.6400E-01R 1 9.6000E-01
224    R 1 4.5400E-01R 1 1.0000E+00R 1 7.6000E-02E
225    F    1.3521E+00E
226    F    4.9555E-02E
227    F    3.6613E-02E
228    F    0.         E
229    R 1 1.2380E-01R 2 0.         E
230    F    2.1591E-01E
231    F             4E
232    F    0.         E
233    F    0.         E
234    F    5.5300E+02E
235    F    5.5300E+02E
236    F    1.5750E+07E
237    F    0.         E
238    F    5.5300E+02E
239    PUMP                     7              0
240                  2          1              7              9              7
```

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                 1         2         3         4         5         6         7         8
CARD    12345678901234567890123456789012345678901234567890123456789012345678901234567890

241                0             0             1             1             1
242                0             0
243      1.079550E-01  2.835930E-02  0.            0.            2.950000E+02
244      2.950000E+02
245           941.54          500.          .315          614.       369.661 CARD 7
246      3.174380E+02  3.681250E+00  2.311860E+02  1.370000E+02
247                0
248                7            10            11            11            13
249               10            14             6            12             8
250                4             6             2             2             2
251                2            11             7
252     R 1-1.0000E+00R 1 2.4400E+00R 1-8.0000E-01R 1 2.0300E+00R 1-4.0000E-01
253     R 1 1.6000E+00R 1-2.0000E-01R 1 1.4700E+00R 1 0.         R 1 1.4000E+00
254     R 1 4.0000E-01R 1 1.3000E+00R 2 1.0000E+00E
255     R 2-1.0000E+00R 1-4.0000E-01R 1-8.8000E-01R 1-3.0000E-01R 1-8.3000E-01
256     R 1 0.         R 1-6.8000E-01R 1 2.0000E-01R 1-5.1000E-01R 1 4.0000E-01
257     R 1-2.8000E-01R 1 6.0000E-01R 1 0.         R 1 7.0000E-01R 1 1.8000E-01
258     R 1 8.0000E-01R 1 4.0000E-01R 2 1.0000E+00E
259     R 1-1.0000E+00R 1 2.4400E+00R 1-8.3000E-01R 1 2.0000E+00R 1-7.0000E-01
260     R 1 1.7000E+00R 1-6.5000E-01R 1 1.6000E+00R 1-4.5000E-01R 1 1.3200E+00
261     R 1-1.7000E-01R 1 1.1000E+00R 1 0.         R 1 9.3000E-01R 1 5.0000E-01
262     R 1 8.3000E-01R 1 7.8000E-01R 1 8.3000E-01R 1 9.5000E-01R 1 9.3000E-01
263     R 2 1.0000E+00E
264     R 2-1.0000E+00R 1-8.0000E-01R 2-6.0000E-01R 1-3.0000E-01R 1-4.4000E-01
265     R 1-1.0000E-01R 1-2.3000E-01R 1 1.0000E-01R 1-5.0000E-02R 1 2.3000E-01
266     R 1 3.9000E-01R 1 3.3000E-01R 1 4.0000E-01R 1 2.7000E-01R 1 6.2000E-01
267     R 1 4.8000E-01R 1 9.0000E-01R 1 8.3000E-01R 2 1.0000E+00E
268       -1.0000E+00    3.6100E+00   -9.0000E-01    3.4900E+00   -8.0000E-01
269        3.8300E+00   -6.0000E-01    4.6200E+00   -5.0000E-01    4.6300E+00
270       -4.0000E-01    4.2700E+00   -2.0000E-01    2.8200E+00    0.
271        1.4500E+00    1.2000E-01    5.5000E-01    2.0000E-01    2.6000E-01
272        4.0000E-01    2.5000E-01    9.0000E-01    2.2000E-01    1.0000E+00
273        0.          E
274        0.           -6.8000E-01    1.0000E-01   -5.8000E-01    2.0000E-01
275       -5.1000E-01    3.0000E-01   -4.9000E-01    4.0000E-01   -4.8000E-01
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              1         2         3         4         5         6         7         8
CARD 12345678901234567890123456789012345678901234567890123456789012345678901234567890

276      6.0000E-01   -4.3000E-01    7.0000E-01   -3.7000E-01    8.0000E-01
277     -2.6000E-01    9.0000E-01   -7.0000E-02    1.0000E+00    0.        E
278     -1.0000E+00    3.6100E+00   -8.3000E-01    2.6000E+00   -7.0000E-01
279      2.0300E+00   -6.5000E-01    1.8500E+00   -4.5000E-01    1.3700E+00
280     -1.7000E-01    1.0500E+00    0.            8.3000E-01    2.0000E-01
281      7.6000E-01    4.0000E-01    7.3000E-01    5.0000E-01    7.6000E-01
282      6.0000E-01    8.8000E-01    7.8000E-01    1.3100E+00    9.5000E-01
283      2.0800E+00    1.0000E+00    2.4600E+00E
284      0.            2.4000E-01    3.9900E-01    8.2000E-01    4.0000E-01
285      7.7000E-01    6.2000E-01    1.5800E+00    9.0000E-01    2.1800E+00
286      1.0000E+00    2.4600E+00E
287  R 1-1.0000E+00R 1 2.0000E+00R 1-8.0000E-01R 1 1.4000E+00R 1-7.0000E-01
288  R 1 1.2000E+00R 1-6.0000E-01R 1 1.0300E+00R 1-4.0000E-01R 1 8.0000E-01
289  R 1-2.0000E-01R 1 6.6000E-01R 1-1.0000E-01R 1 6.1000E-01R 1 0.
290  R 1 6.0000E-01R 1 1.0000E-01R 1 6.1000E-01R 1 2.0000E-01R 1 6.3000E-01
291  R 1 6.0000E-01R 1 8.3000E-01R 2 1.0000E+00E
292  R 2-1.0000E+00R 1-3.0000E-01R 1-9.0000E-01R 1-2.0000E-01R 1-8.7000E-01
293  R 1-1.0000E-01R 1-8.1000E-01R 1 0.        R 1-6.8000E-01R 1 4.0000E-01
294  R 1-2.7000E-01R 1 5.0000E-01R 1 1.5000E-01R 2 1.0000E+00E
295     -1.0000E+00    2.0000E+00   -1.0000E-01    1.3500E+00    5.0000E-01
296      8.3000E-01    1.0000E+00    3.4000E-01E
297  R 2-1.0000E+00R 1-3.0000E-01R 1-9.0000E-01R 1-1.0000E-01R 1-5.2000E-01
298  R 1 4.0000E-01R 1-2.7000E-01R 1 5.0000E-01R 1 0.        R 1 1.0000E+00
299  R 1 3.4000E-01E
300     -1.0000E+00    0.            1.0000E+00    0.        E
301     -1.0000E+00    0.            1.0000E+00    0.        E
302     -1.0000E+00    0.            1.0000E+00    0.        E
303     -1.0000E+00    0.            1.0000E+00    0.        E
304  R 2 0.        R 1 1.0000E-01R 1 0.        R 1 1.5000E-01R 1 5.0000E-02
305  R 1 2.4000E-01R 1 8.0000E-01R 1 3.0000E-01R 1 9.6000E-01R 1 4.0000E-01
306  R 1 9.8000E-01R 1 6.0000E-01R 1 9.7000E-01R 1 8.0000E-01R 2 9.0000E-01
307  R 1 8.0000E-01R 1 9.6000E-01R 1 5.0000E-01R 1 1.0000E+00R 1 0.        E
308  R 2 0.        R 1 1.0000E-01R 1 0.        R 1 1.5000E-01R 1 4.8000E-02
309  R 1 2.2000E-01R 1 5.6400E-01R 1 8.0000E-01R 1 5.6400E-01R 1 9.6000E-01
310  R 1 4.5400E-01R 1 1.0000E+00R 1 7.6000E-02E
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                 1         2         3         4         5         6         7         8
CARD    12345678901234567890123456789012345678901234567890123456789012345678901234567890

 311    F   1.3521E+00E
 312    F   4.9555E-02E
 313    F   3.6613E-02E
 314    F   0.        E
 315    R 1 1.2380E-01R 2 0.         E
 316    F   2.1591E-01E
 317    F            4E
 318    F   0.        E
 319    F   0.        E
 320    F   5.5300E+02E
 321    F   5.5300E+02E
 322    F   1.5750E+07E
 323    F   0.        E
 324    F   5.5300E+02E
 325    TEE                        8             0
 326                 2             1             7  0.                        0
 327                 0             2             9            10              0
 328      1.079550E-01  2.835930E-02  0.            0.            2.950000E+02
 329      2.950000E+02
 330                 0             1             8
 331      1.079550E-01  2.835930E-02  0.            0.            2.950000E+02
 332      2.950000E+02
 333        1.3081E+00    1.1176E+00E
 334        4.7856E-02    6.6308E-02E
 335    R 2 3.6613E-02R 1 6.3425E-02E
 336    F   0.        E
 337    F   0.        E
 338    R 2 2.1591E-01R 1 2.8417E-01E
 339    F            4E
 340    F   0.        E
 341    F   0.        E
 342    F   5.5300E+02E
 343    F   5.5300E+02E
 344    F   1.5750E+07E
 345    F   0.        E
```

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                1         2         3         4         5         6         7         8
CARD  12345678901234567890123456789012345678901234567890123456789012345678901234567890

346   F   5.5300E+02E
347   F   5.4292E-01E
348   F   2.5439E-02E
349   F   3.6613E-02E
350   F   0.        E
351   F   0.        E
352   F   2.1591E-01E
353   F            4E
354   F   0.        E
355   F   0.        E
356   F   5.5300E+02E
357   F   5.5300E+02E
358   F   1.5750E+07E
359   F   0.        E
360   F   5.5300E+02E
361   TEE                        9             0
362                2             1             7  0.                       0
363                0             3            10            11             0
364     1.420870E-01  3.572600E-02  0.            0.            2.950000E+02
365     2.950000E+02
366                0             1            22
367     4.366260E-02  1.348740E-02  0.            0.            2.950000E+02
368     2.950000E+02
369   R 1 1.1684E+00R 2 7.0874E-01E
370   R 1 7.4191E-02R 2 4.4741E-02E
371   F   6.3424E-02E
372   F   0.        E
373   F   0.        E
374   F   2.8417E-01E
375   F            4E
376   F   0.        E
377   F   0.        E
378   F   5.5250E+02E
379   F   5.5250E+02E
380   F   1.5790E+07E
```

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                 1         2         3         4         5         6         7         8
CARD    12345678901234567890123456789012345678901234567890123456789012345678901234567890

 381    F   0.        E
 382    F   5.5200E+02E
 383    F   1.5000E+00E
 384    F   8.9838E-03E
 385    F   5.9892E-03E
 386    F   0.        E
 387    F   0.        E
 388    F   8.7325E-02E
 389    F            4E
 390    F   0.        E
 391    F   0.        E
 392    F   5.5250E+02E
 393    F   5.5250E+02E
 394    F   1.5790E+07E
 395    F   0.        E
 396    F   5.5200E+02E
 397    TEE                       16             0 BROKEN LOOP COLD LEG
 398                 1             1             7           0.0             0
 399                 1            28            13            19
 400      9.588040E-02  1.599190E-01  0.            0.            2.950000E+02
 401      2.950000E+02
 402                 0             1            77
 403      9.588040E-02  1.599190E-01  0.            0.            2.950000E+02
 404      2.950000E+02
 405    R 3 5.5837E-01R 1 1.2700E-01R 1 9.9255E-02R 1 7.4442E-02R 2 4.9628E-02
 406    R 2 2.4814E-02R 6 1.2700E-02R 2 2.5797E-02R 1 5.1594E-02R 1 7.7391E-02
 407    R 1 1.1839E-01R 1 1.8519E-01R 3 2.1606E-01R 1 2.0638E-01R 1 3.4608E-01
 408    R 1 4.6990E-01E
 409    R 3 3.5440E-02R 1 1.4797E-03R 1 9.3556E-04R 1 7.0167E-04R 2 4.6778E-04
 410    R 2 2.3389E-04R 6 1.0623E-04R 2 6.0674E-04R 1 1.2135E-03R 1 1.8202E-03
 411    R 1 2.2841E-03R 1 4.3557E-03R 3 5.0816E-03R 1 4.8539E-03R 1 1.7981E-02
 412    R 1 2.4414E-02E
 413    R 3 6.3425E-02R 1 1.3876E-02R 6 9.4258E-03R 6 8.3647E-03R10 2.3520E-02
 414    R 3 5.1956E-02E
 415    R 1 0.        R 1 2.6719E+00R 1 4.4380E-02R 7 0.        R 7 1.6000E+00
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                1         2         3         4         5         6         7         8
CARD    12345678901234567890123456789012345678901234567890123456789012345678901234567890

 416    R 8 0.         R 4 2.0000E-01E
 417    F   0.         E
 418    R 3 2.8400E-01R 1 1.3292E-01R 6 1.0955E-01R 6 1.0320E-01R10 1.7305E-01
 419    R 3 2.5720E-01E
 420    F             4E
 421    F   0.         E
 422    F   0.         E
 423    R 4 5.5500E+02R 1 5.5429E+02R 1 5.5358E+02R 1 5.5288E+02R 1 5.5217E+02
 424    R 1 5.5146E+02R 1 5.5075E+02R 1 5.5004E+02R 1 5.4933E+02R 1 5.4863E+02
 425    R 1 5.4792E+02R 1 5.4721E+02R 1 5.4650E+02R 1 5.4579E+02R 1 5.4508E+02
 426    R 1 5.4438E+02R 1 5.4367E+02R 1 5.4296E+02R 1 5.4225E+02R 1 5.4154E+02
 427    R 1 5.4083E+02R 1 5.4013E+02R 1 5.3942E+02R 1 5.3871E+02R 1 5.3800E+02E
 428    R 4 5.5500E+02R 1 5.5429E+02R 1 5.5358E+02R 1 5.5288E+02R 1 5.5217E+02
 429    R 1 5.5146E+02R 1 5.5075E+02R 1 5.5004E+02R 1 5.4933E+02R 1 5.4863E+02
 430    R 1 5.4792E+02R 1 5.4721E+02R 1 5.4650E+02R 1 5.4579E+02R 1 5.4508E+02
 431    R 1 5.4438E+02R 1 5.4367E+02R 1 5.4296E+02R 1 5.4225E+02R 1 5.4154E+02
 432    R 1 5.4083E+02R 1 5.4013E+02R 1 5.3942E+02R 1 5.3871E+02R 1 5.3800E+02E
 433    F   1.5750E+07E
 434    F   0.         E
 435    R 3 5.5500E+02R 1 5.4350E+02R 1 5.4327E+02R 1 5.4304E+02R 1 5.4281E+02
 436    R 1 5.4258E+02R 1 5.4235E+02R 1 5.4212E+02R 1 5.4190E+02R 1 5.4167E+02
 437    R 1 5.4144E+02R 1 5.4121E+02R 1 5.4098E+02R 1 5.4075E+02R 1 5.4052E+02
 438    R 1 5.4029E+02R 1 5.4006E+02R 1 5.3983E+02R 1 5.3960E+02R 1 5.3937E+02
 439    R 1 5.3915E+02R 1 5.3892E+02R 1 5.3869E+02R 1 5.3846E+02R 1 5.3823E+02
 440    R 1 5.3800E+02E
 441    F   7.9845E+00E
 442    F   3.0980E-01E
 443    F   3.8800E-02E
 444    F   0.0000E+00E
 445    F   1.0000E+00E
 446    F   2.2230E-01E
 447    F             4E
 448    F   0.0000E+00E
 449    F   0.0000E+00E
 450    F   5.5500E+02E
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               1         2         3         4         5         6         7         8
CARD  12345678901234567890123456789012345678901234567890123456789012345678901234567890

451   F   5.5500E+02E
452   F   1.5750E+07E
453   F   0.0000E+00E
454   F   5.5500E+02E
455   TEE                       15             0 BROKEN LOOP HOT LEG
456                1             1             7           0.0             0
457                1            41            12            18
458     8.331790E-02 1.647900E-01  0.            0.            2.950000E+02
459     2.950000E+02
460                0             1            99
461     8.331790E-02 1.647900E-01  0.            0.            2.950000E+02
462     2.950000E+02
463   R 3 5.5838E-01R 1 5.2578E-01R 1 4.6749E-01R 1 5.5861E-01R 1 1.9875E+00
464   R 2 1.0772E+00R 1 1.9875E+00R 1 5.1029E-01R 1 5.4629E-01R 1 4.8628E-01
465   R 1 2.5400E-01R 1 1.7145E-01R 1 3.0000E-01R 1 2.7940E-01R 2 2.1184E-01
466   R 4 1.8717E-01R 2 1.4961E-01R 1 8.4138E-02R 1 5.6092E-02R 1 2.8046E-02
467   R 6 1.2700E-02R 1 2.7164E-02R 1 5.4328E-02R 2 8.1492E-02R 3 1.9050E-01E
468   R 3 3.5440E-02R 1 4.7280E-03R 1 3.7579E-03R 1 4.6603E-03R 1 1.9686E-01
469   R 2 1.1383E-01R 1 1.9686E-01R 1 4.0728E-03R 1 4.0635E-03R 1 3.1715E-03
470   R 1 2.7500E-02R 1 1.8500E-02R 1 1.8900E-02R 1 6.8606E-03R 2 1.7667E-03
471   R 4 1.5674E-03R 2 1.2460E-03R 1 7.0379E-04R 1 4.6919E-04R 1 2.3460E-04
472   R 6 1.0623E-04R 1 1.4113E-03R 1 2.8227E-03R 2 4.2340E-03R 3 9.8976E-03E
473   R 3 6.3425E-02R 1 1.3913E-02R 3 8.3647E-03R 3 1.9141E-02R 3 8.3647E-03
474   R 1 6.3425E-02R 2 9.4624E-03R 1 6.3425E-02R18 8.3647E-03R 7 5.1956E-02E
475   R 1 0.        R 4 2.6400E-01R 1 0.        R 1 7.7200E-03R 3 1.4000E-02
476   R 1 1.9300E-02R 3 0.        R 1 1.4000E-01R 1 1.7000E-01R 1 1.1200E-01
477   R 2 0.        R 1 4.3970E-02R 5 0.        R 1 4.3970E-02R 3 0.
478   R 7 2.2000E+00R 6 0.        E
479   R 5 0.        R 3 1.0000E+00R 1 0.        R 5-1.0000E+00R 5 0.
480   R 5 1.0000E+00R 1 7.0711E-01R17 0.        E
481   R 3 2.8400E-01R 1 1.3300E-01R 3 1.0300E-01R 3 1.7500E-02R 3 1.0300E-01
482   R 1 2.8400E-01R 2 1.1900E-02R 1 2.8400E-01R18 1.0320E-01R 7 2.57[illegible]0E-01E
483   F            4E
484   F   0.        E
485   F   0.        E
```

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                 1         2         3         4         5         6         7         8
CARD    12345678901234567890123456789012345678901234567890123456789012345678901234567890

 486    R 1  5.6100E+02R 1  5.6033E+02R 1  5.5967E+02R 1  5.5900E+02R 1  5.5833E+02
 487    R 1  5.5767E+02R 1  5.5700E+02R 1  5.5633E+02R 1  5.5567E+02R 1  5.5500E+02
 488    R 1  5.5433E+02R 1  5.5367E+02R 1  5.5300E+02R 1  5.5233E+02R 1  5.5167E+02
 489    R 2  5.5100E+02R 1  5.5067E+02R 1  5.5033E+02R 1  5.5000E+02R 1  5.4967E+02
 490    R 1  5.4933E+02R 1  5.4900E+02R 1  5.4867E+02R 1  5.4833E+02R 1  5.4800E+02
 491    R 1  5.4767E+02R 1  5.4733E+02R 1  5.4700E+02R 1  5.4667E+02R 1  5.4633E+02
 492    R 1  5.4600E+02R 1  5.4567E+02R 1  5.4533E+02R 1  5.4500E+02R 1  5.4467E+02
 493    R 1  5.4433E+02R 1  5.4400E+02R 1  5.4367E+02R 1  5.4333E+02R 1  5.4300E+02E
 494    R 1  5.6100E+02R 1  5.6033E+02R 1  5.5967E+02R 1  5.5900E+02R 1  5.5833E+02
 495    R 1  5.5767E+02R 1  5.5700E+02R 1  5.5633E+02R 1  5.5567E+02R 1  5.5500E+02
 496    R 1  5.5433E+02R 1  5.5367E+02R 1  5.5300E+02R 1  5.5233E+02R 1  5.5167E+02
 497    R 2  5.5100E+02R 1  5.5067E+02R 1  5.5033E+02R 1  5.5000E+02R 1  5.4967E+02
 498    R 1  5.4933E+02R 1  5.4900E+02R 1  5.4867E+02R 1  5.4833E+02R 1  5.4800E+02
 499    R 1  5.4767E+02R 1  5.4733E+02R 1  5.4700E+02R 1  5.4667E+02R 1  5.4633E+02
 500    R 1  5.4600E+02R 1  5.4567E+02R 1  5.4533E+02R 1  5.4500E+02R 1  5.4467E+02
 501    R 1  5.4433E+02R 1  5.4400E+02R 1  5.4367E+02R 1  5.4333E+02R 1  5.4300E+02E
 502    F    1.5750E+07E
 503    F    0.         E
 504    R 1  5.6100E+02R 1  5.6033E+02R 1  5.5967E+02R 1  5.5900E+02R 1  5.5833E+02
 505    R 1  5.5767E+02R 1  5.5700E+02R 1  5.5633E+02R 1  5.5567E+02R 1  5.5500E+02
 506    R 1  5.5433E+02R 1  5.5367E+02R 1  5.5300E+02R 1  5.5233E+02R 1  5.5167E+02
 507    R 2  5.5100E+02R 1  5.5067E+02R 1  5.5033E+02R 1  5.5000E+02R 1  5.4967E+02
 508    R 1  5.4933E+02R 1  5.4900E+02R 1  5.4867E+02R 1  5.4833E+02R 1  5.4800E+02
 509    R 1  5.4767E+02R 1  5.4733E+02R 1  5.4700E+02R 1  5.4667E+02R 1  5.4633E+02
 510    R 1  5.4600E+02R 1  5.4567E+02R 1  5.4533E+02R 1  5.4500E+02R 1  5.4467E+02
 511    R 1  5.4433E+02R 1  5.4400E+02R 1  5.4367E+02R 1  5.4333E+02R 1  5.4300E+02E
 512    F    7.5464E+00E
 513    F    2.9280E-01E
 514    F    3.8800E-02E
 515    F    0.0000E+00E
 516    F    1.0000E+00E
 517    F    2.2230E-01E
 518    F             4E
 519    F    0.0000E+00E
 520    F    0.0000E+00E
```

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              1         2         3         4         5         6         7         8
CARD 12345678901234567890123456789012345678901234567890123456789012345678901234567890

521  F   5.6100E+02E
522  F   5.6100E+02E
523  F   1.5750E+07E
524  F   0.0000E+00E
525  F   5.6100E+02E
526  PRIZER                     2             0
527              3             2
528    0.            0.            1.000000E+00 0.
529      5.3073E-01    1.1500E+00    2.0000E-01E
530      3.4000E-01    6.1000E-01    1.0000E-02E
531  R 3 5.6526E-01R 1 5.7321E-03E
532  R 3 0.        R 1 4.6688E-03E
533  F  -1.0000E+00E
534  R 3 8.4836E-01R 1 8.5430E-02E
535  F            4E
536  R 1 1.0000E+00R 2 0.        E
537  F   0.        E
538  F   6.1900E+02E
539  F   6.1900E+02E
540  F   1.5500E+07E
541  VALVE                     18             0
542              2             1            19            21             7
543              0             0
544    1.286000E-01  2.778130E-02  0.           0.            2.950000E+02
545    2.950000E+02
546              4             2             2             0             2
547    5.273000E-02  9.525000E-02  0.
548      1.5000E+00    2.0000E+00E
549      7.7930E-02    1.1700E-01E
550      5.1956E-02    5.2729E-02    5.8556E-02E
551  F   5.0000E-02E
552  F   0.        E
553      2.5720E-01    9.5250E-02    2.7305E-01E
554  F            4E
555      0.            1.0000E+00E
```

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              1         2         3         4         5         6         7         8
CARD 12345678901234567890123456789012345678901234567890123456789012345678901234567890

556  F   0.        E
557      5.3800E+02    3.7300E+02E
558      5.3800E+02    3.7300E+02E
559      1.5500E+07    1.0100E+05E
560  F   0.        E
561      5.6100E+02    3.7300E+02E
562      0.            1.0000E-05    1.7500E-02    1.0000E+00E
563  VALVE                     17             0
564              2             1            18            20             7
565              0             0
566    1.286000E-01  2.778130E-02  0.            0.            2.950000E+02
567    2.950000E+02
568              4             2             2             0             2
569    5.272920E-02  9.525000E-02  0.
570      1.5000E+00    2.0000E+00E
571      7.7930E-02    1.1700E-01E
572      5.1956E-02    5.2729E-02    5.8556E-02E
573  F   5.0000E-02E
574  F   0.        E
575      2.5720E-01    9.5250E-02    2.7305E-01E
576  F            4E
577      0.            1.0000E+00E
578  F   0.        E
579      5.4300E+02    3.7400E+02E
580      5.4300E+02    3.7400E+02E
581      1.5500E+07    1.0100E+05E
582  F   0.        E
583      5.8000E+02    3.7400E+02E
584      0.            1.0000E-06    1.7500E-02    1.0000E+00E
585  TEE                       21             0 HPIS INJECTION TEE
586              1             0             7 -1.000000E+00             0
587              0             2            25            27             0
588    4.366260E-02  3.487400E-03  0.            0.            2.950000E+02
589    2.950000E+02
590              0             2            23
```

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              1         2         3         4         5         6         7         8
CARD 12345678901234567890123456789012345678901234567890123456789012345678901234567890

591    1.699260E-02  7.137400E-03  0.            0.            2.950000E+02
592    2.950000E+02
593  F   2.1844E+00E
594  F   5.2331E-02E
595  R 2 5.9890E-03R 1 5.5470E-02E
596  F   4.5000E-01E
597  F   0.        E
598  R 2 8.7330E-02R 1 2.6360E-01E
599  F            4E
600  F   0.        E
601  F   0.        E
602  F   5.5244E+02E
603  F   5.5244E+02E
604  F   1.5600E+07E
605  F   2.5000E+00E
606  F   2.2678E-03E
607  F   9.0713E-04E
608  F   0.        E
609  F   0.        E
610  F   3.3985E-02E
611  F            4E
612  F   0.        E
613  F   0.        E
614  F   5.5244E+02E
615  F   5.5244E+02E
616  F   1.5600E+07E
617  TEE                       22             0 LPIS INJECTION TEE
618               1             0             7  1.000000E+00             0
619               1             1            25            22             0
620    0.            0.            0.            0.            0.
621    0.
622               1             1            26
623    0.            0.            0.            0.            0.
624    0.
625  F   1.0000E+00E
```

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                1         2         3         4         5         6         7         8
CARD   12345678901234567890123456789012345678901234567890123456789012345678901234567890

626    F   5.9890E-03E
627    F   5.9890E-03E
628    F   0.        E
629    F   0.        E
630    F   8.7330E-02E
631    F            4E
632    F   0.        E
633    F   0.        E
634    F   5.5240E+02E
635    F   5.5240E+02E
636    F   1.5600E+07E
637    F   1.0000E+00E
638    F   5.9890E-03E
639    F   5.9890E-03E
640    F   0.        E
641    F   0.        E
642    F   8.7330E-02E
643    F            4E
644    F   0.        E
645    F   0.        E
646    F   5.5240E+02E
647    F   5.5240E+02E
648    F   1.5600E+07E
649    ACCUM                       23              0
650                  3             24
651         8.8633E-01     1.2886E+00     2.2500E-02E
652         9.6000E-01     1.6760E+00     2.0000E-02E
653    R 3 1.2460E+00R 1 3.2852E-02E
654    F   4.5000E-01E
655    F  -1.0000E+00E
656    R 3 1.2595E+00R 1 2.0452E-01E
657    F            4E
658    R 1 1.0000E+00R 2 0.        E
659    F   0.        E
660    F   3.0080E+02E
```

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                  1         2         3         4         5         6         7         8
CARD     12345678901234567890123456789012345678901234567890123456789012345678901234567890

661      F   3.0080E+02E
662      F   4.1100E+06E
663      FILL                      24               LPIS FILL
664                26             3                          13
665              1.50   8.983810E-3           0.0    0.421345E0    0.297440E3
666            4.24E6
667               0.1          1.21         8.5E4          1.17         4.3E5
668              1.02         7.7E5         0.840        9.47E5         0.730
669            11.2E5         0.591        11.9E5         0.529        12.6E5
670             0.449        13.3E5         0.361        13.9E5         0.255
671            14.6E5         0.120        15.2E5           0.0       100.0E6
672             0.000E
673      FILL                      25               HPIS FILL
674                23             4             4             2
675              2.50   0.226783E-2           0.0           0.0    0.297440E3
676            4.24E6
677            0.00E0       1.74           1.00E3    1.74      E
678      VALVE                     27             0
679                 2             0            27            24             7
680                 0             0
681        4.366260E-02  3.487400E-03  0.            0.            2.950000E+02
682        2.950000E+02
683                 2          3000             0             0             2
684        5.989200E-02  8.732520E-01  0.
685      F   1.0922E+00E
686      F   2.6166E-02E
687      R 2 5.5470E-02R 1 3.2852E-02E
688      F   4.5000E-01E
689      F   0.        E
690      R 2 2.6360E-01R 1 2.0452E-01E
691      F            4E
692      F   0.        E
693      F   0.        E
694          5.5250E+02    3.0567E+02E
695          5.5250E+02    3.0567E+02E
```

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              1         2         3         4         5         6         7         8
CARD 12345678901234567890123456789012345678901234567890123456789012345678901234567890

696      1.5600E+07    4.2400E+06E
697  BREAK                     20
698              21             1             8             3
699             1.0            .1           1.0         410.0         1.0E5
700             0.0        1.05E5           1.0        2.0E5S
701            20.0        3.00E5          30.0        2.8E5S
702            50.0        2.80E5          70.0        3.5E5S
703            90.0        3.30E5         150.0        3.2E5E
704  BREAK                     19
705              20             1             8             3
706             1.0            .1           1.0         410.0         1.0E5
707             0.0        1.05E5           1.0        2.0E5S
708            20.0        3.00E5          30.0        2.8E5S
709            50.0        2.80E5          70.0        3.5E5S
710            90.0        3.30E5         150.0        3.2E5E
711  BREAK                     14
712              80             0
713          1.00E0        1.00E0        1.00E0        5.59E2       60.00E5
714  VALVE                     50             0
715               2             0            15            80             0
716               0             0
717    0.            0.            0.            0.            0.
718    0.
719               3             2             2             0             2
720    1.820000E-02  1.500000E-01  0.
721  F   1.0000E+00E
722  F   1.8200E-02E
723  F   1.8200E-02E
724  F   0.        E
725  F   0.        E
726  F   1.5240E-01E
727  F            4E
728  F   9.2000E-01E
729  F   1.6800E+01E
730  F   5.5700E+02E
```

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              1             2         3         4         5         6         7         8
CARD 12345678901234567890123456789012345678901234567890123456789012345678901234567890

731  F   5.5700E+02E
732  F   6.8240E+06E
733      0.            1.0000E+00    1.0000E+01    0.        E
734  FILL                      13
735              14
736          1.00E0        1.00E0           0.0      1.07E-02        5.45E2
737          6.36E6
738  VESSEL                    10                                            CARD 1
739              12             4             4             4                CARD 2
740              12             2             3             8             3 CARD 3
741               3                                                          CARD 4
742                                                        16                CARD 5
743         4.0E+00       5.0E+01       1.0E-03                              CARD 6
744          7800.0         558.0          16.2           0.7        1.0E03 CARD 7
745           1.336           0.7                                            CARD 8
746              10            19             7           555                CARD 9
747             333             1             1             1            50 CARD 10
748         24.88E6                                                          CARD 11
749            .632          .732         1.379         1.684         1.912 Z
750           2.141         2.598         3.055         3.500         4.846 Z
751           5.130         5.900E                                          Z
752           0.105         0.231         0.329         0.470E              RADIUS
753           1.571         3.142         4.712         6.283E              THETA
754              11            15             3            11                SOURCE
755              11            12             3            12                SOURCE
756              11            13             3            13                SOURCE
757              11            10             3             1                SOURCE
758           0.955         0.960         0.965         0.975         0.990 RDPWR
759           1.016         1.060R 3      0.000E                            RDPWR
760  R 4     1.4312R 4     1.1191R 4     0.7295E                            CPOWR
761               1             4             5             9E              IDROD
762  R 2     1.0640R 1     1.1510R 1     0.5922E                            RPKF
763           0.652         1.227         1.504         1.516         0.912 ZPOWR
764           0.178E                                                        ZPOWR
765  R 4      40.50R 4      152.7R 4      131.8E                            RDX
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                 1         2         3         4         5         6         7         8
CARD    12345678901234567890123456789012345678901234567890123456789012345678901234567890

766              0.0     7.7449E-4   1.5489E-3     2.3235E-3     3.0979E-3 RADRD
767        3.8725E-3    4.64690E-3  4.74220E-3     5.0508E-3     5.3594E-3 RADRD
768     R 6        1           3R 2         2E                             MATRD
769              0.0      24.80E6          0.1      1.736E6S               PWTB
770              1.0      1.495E6          2.0      1.438E6S               PWTB
771              5.0      1.339E6         10.0      1.240E6S               PWTB
772             15.0      1.166E6         20.0      1.116E6S               PWTB
773             50.0      9.424E5         75.0      8.680E5S               PWTB
774            100.0      8.184E5        125.0      7.936E5S               PWTB
775            150.0      7.688E5        200.0      7.192E5S               PWTB
776            300.0      6.448E5        400.0      5.952E5S               PWTB
777            500.0      5.456E5        600.0      5.208E5S               PWTB
778           1000.0      4.464E5E                                         PWTB
779     F             0E                                                   NFAX
780     F           0.0E                                                   FPUO2
781     F          0.93E                                                   FTD
782          9.8101E-01   0.0000E+00  1.0103E-02  1.7830E-03    0.0000E+00  GMIX
783          7.0991E-03   0.0000E+00S           S           S               GMIX
784          9.8101E-01   0.0000E+00  1.0103E-02  1.7830E-03    0.0000E+00  GMIX
785          7.0991E-03   0.0000E+00S           S           S               GMIX
786          9.8101E-01   0.0000E+00  1.0103E-02  1.7830E-03    0.0000E+00  GMIX
787          7.0991E-03   0.0000E+00S           S           S               GMIX
788          9.8101E-01   0.0000E+00  1.0103E-02  1.7830E-03    0.0000E+00  GMIX
789          7.0991E-03   0.0000E+00S           S           S               GMIX
790          9.8101E-01   0.0000E+00  1.0103E-02  1.7830E-03    0.0000E+00  GMIX
791          7.0991E-03   0.0000E+00S           S           S               GMIX
792          9.8101E-01   0.0000E+00  1.0103E-02  1.7830E-03    0.0000E+00  GMIX
793          7.0991E-03   0.0000E+00S           S           S               GMIX
794          9.8101E-01   0.0000E+00  1.0103E-02  1.7830E-03    0.0000E+00  GMIX
795          7.0991E-03   0.0000E+00S           S           S               GMIX
796          9.8101E-01   0.0000E+00  1.0103E-02  1.7830E-03    0.0000E+00  GMIX
797          7.0991E-03   0.0000E+00S           S           S               GMIX
798          9.8101E-01   0.0000E+00  1.0103E-02  1.7830E-03    0.0000E+00  GMIX
799          7.0991E-03   0.0000E+00S           S           S               GMIX
800          9.8101E-01   0.0000E+00  1.0103E-02  1.7830E-03    0.0000E+00  GMIX
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               1         2         3         4         5         6         7         8
CARD  12345678901234567890123456789012345678901234567890123456789012345678901234567890

801        7.0991E-03     0.0000E+00S                S               S                GMIX
802        9.8101E-01     0.0000E+00     1.0103E-02      1.7830E-03      0.0000E+00   GMIX
803        7.0991E-03     0.0000E+00S                S               S                GMIX
804        9.8101E-01     0.0000E+00     1.0103E-02      1.7830E-03      0.0000E+00   GMIX
805        7.0991E-03     0.0000E+00E                                                 GMIX
806   F           1.0E                                                              GMILES
807   F        3.13E5E                                                              PGAPT
808   F           0.0E                                                              PLVOL
809   F           0.0E                                                              PSLEN
810   F           0.0E                                                              CLENN
811   R 4      0.0087R 4      0.0333R 4      0.0431R 4       0.344E                LEVEL 1
812   R 4        1.36R 4        .519R 4        .672R 4       53.66E
813   F           0.0E
814   F           0.0E
815   F           0.0E
816   F           0.0E
817   F           0.0E
818   F           0.0E
819   F           1.0E
820   F           1.0E
821   F           1.0E
822   F           1.0E
823   F           0.1E
824   F           0.1E
825   F           0.1E
826   F         553.0E
827   F           0.0E
828   F           0.0E
829   F           0.0E
830   F           0.0E
831   F           0.0E
832   F           0.0E
833   F           0.0E
834   F         553.0E
835   F         553.0E
```

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              1         2         3         4         5         6         7         8
CARD 12345678901234567890123456789012345678901234567890123456789012345678901234567890

836  F     155.8E05E
837  R12        0.0R 4     0.0956E                                         LEVEL 2
838  R12        0.0R 4      1.491E
839  F           .0E
840  F          0.0E
841  F          0.0E
842  F          0.0E
843  F          0.0E
844  F          0.0E
845  F          1.0E
846  F          1.0E
847  R12       .409R 4       .401E
848  F          1.0E
849  F           .1E
850  F           .1E
851  F           .1E
852  F        553.0E
853  F          0.0E
854  F          0.0E
855  F          0.0E
856  F          0.0E
857  F          0.0E
858  F          0.0E
859  F          0.0E
860  F        553.0E
861  F        553.0E
862  F     155.8E05E
863  R 4     0.1526R 4     0.5868R 4     0.7606R 4     0.9407E             LEVEL 3
864  R 4      23.81R 4      91.54R 4     118.65R 4     146.75E
865  F          0.0E
866  F          0.0E
867  F          0.0E
868  F          0.0E
869  F          0.0E
870  F          0.0E
```

```
                 1         2         3         4         5         6         7         8
CARD    12345678901234567890123456789012345678901234567890123456789012345678901234567890

871     R12        .932R 4      0.375E
872     R12          .9R 4       .362E
873     R12       0.481R 4       .401E
874     F            .9E
875     R12      1.22E-2R 4     0.100E
876     R12      1.22E-2R 4     0.100E
877     R12      1.22E-2R 4     0.100E
878     F         553.0E
879     F           0.0E
880     F           0.0E
881     F           0.0E
882     F           0.0E
883     F           0.0E
884     F           0.0E
885     F           0.0E
886     F         553.0E
887     F         553.0E
888     F     155.8E05E
889     R12         0.0R 4     0.4435E                                       LEVEL 4
890     R12         0.0R 4      69.19E
891     F           0.0E
892     F           0.0E
893     F           0.0E
894     F           0.0E
895     F           0.0E
896     F            .0E
897     R12        .518R 4       .375E
898     R12       0.251R 4       .362E
899     R12       0.481R 4       .401E
900     F          .251E
901     R12      1.22E-2R 4     0.100E
902     R12      1.22E-2R 4     0.100E
903     R12      1.22E-2R 4     0.100E
904     F         553.0E
905     F           0.0E
```

```
                 1         2         3         4         5         6         7         8
CARD    12345678901234567890123456789012345678901234567890123456789012345678901234567890

906     F         0.0E
907     F         0.0E
908     F         0.0E
909     F         0.0E
910     F         0.0E
911     F         0.0E
912     F       553.0E
913     F       553.0E
914     F    155.8E05E
915     R12       0.0R 4     0.3315E                                         LEVEL 5
916     R12       0.0R 4       51.71E
917     F         0.0E
918     F         0.0E
919     F         0.0E
920     F         0.0E
921     F         0.0E
922     F          .0E
923     R12       .518R 4        .375E
924     R12      0.251R 4        .362E
925     R12      0.481R 4        .401E
926     F         .251E
927     R12    1.22E-2R 4       0.100E
928     R12    1.22E-2R 4       0.100E
929     R12    1.22E-2R 4       0.100E
930     F       553.0E
931     F         0.0E
932     F         0.0E
933     F         0.0E
934     F         0.0E
935     F         0.0E
936     F         0.0E
937     F         0.0E
938     F       553.0E
939     F       553.0E
940     F    155.8E05E
```

```
                1         2         3         4         5         6         7         8
CARD   12345678901234567890123456789012345678901234567890123456789012345678901234567890

 941   R12          .0R 4     0.3330E                                       LEVEL 6
 942   R12         0.0R 4      51.95F
 943   F           0.0E
 944   F           0.0E
 945   F           0.0E
 946   F           0.0E
 947   F           0.0E
 948   F            .0E
 949   R12        .518R 4       .375E
 950   R12       0.251R 4       .362E
 951   R12       0.481R 4       .401E
 952   F          .251E
 953   R12     1.22E-2R 4      0.100E
 954   R12     1.22E-2R 4      0.100E
 955   R12     1.22E-2R 4      0.100E
 956   F         553.0E
 957   F           0.0E
 958   F           0.0E
 959   F           0.0E
 960   F           0.0E
 961   F           0.0E
 962   F           0.0E
 963   F           0.0E
 964   F         553.0E
 965   F         553.0E
 966   F     155.8E05E
 967   R12         0.0R 4     0.6645E                                       LEVEL 7
 968   R12         0.0R 4     103.66E
 969   F           0.0E
 970   F           0.0E
 971   F           0.0E
 972   F           0.0E
 973   F           0.0E
 974   F            .0E
 975   R12        .518R 4       .375E
```

```
                     1         2         3         4         5         6         7         8
CARD      12345678901234567890123456789012345678901234567890123456789012345678901234567890

 976      R12       0.251R 4        .362E
 977      R12       0.481R 4        .401E
 978      F          .251E
 979      R12     1.22E-2R 4       0.100E
 980      R12     1.22E-2R 4       0.100E
 981      R12     1.22E-2R 4       0.100E
 982      F         553.0E
 983      F           0.0E
 984      F           0.0E
 985      F           0.0E
 986      F           0.0E
 987      F           0.0E
 988      F           0.0E
 989      F           0.0E
 990      F         553.0E
 991      F         553.0E
 992      F     155.8E05E
 993      R12         0.0R 4       0.6645E                                      LEVEL 8
 994      R12         0.0R 4       103.66E
 995      F           0.0E
 996      F           0.0E
 997      F           0.0E
 998      F           0.0E
 999      F           0.0E
1000      F            .0E
1001      R12        .518R 4        .375E
1002      R12       0.251R 4        .362E
1003      R12       0.481R 4        .401E
1004      F          .251E
1005      R12     1.22E-2R 4       0.100E
1006      R12     1.22E-2R 4       0.100E
1007      R12     1.22E-2R 4       0.100E
1008      F         553.0E
1009      F           0.0E
1010      F           0.0E
```

```
               1         2         3         4         5         6         7         8
CARD  12345678901234567890123456789012345678901234567890123456789012345678901234567890

1011  F          0.0E
1012  F          0.0E
1013  F          0.0E
1014  F          0.0E
1015  F          0.0E
1016  F        553.0E
1017  F        553.0E
1018  F     155.8E05E
1019  R 4     0.7208R 4     2.7708R 4     3.5916R 4     1.2243E             LEVEL 9
1020  R 4      24.76R 4      95.12R 4     123.31R 4     190.99E
1021  F          0.0E
1022  R 4        0.0R 4        1.2R 4        0.5R 4        0.0E
1023  F          0.0E
1024  F          0.0E
1025  R 4        0.0R 4        1.2R 4        0.5R 4        0.0E
1026  F          0.0E
1027  R12      0.951R 4       .375E
1028  R12      0.366R 4       .362E
1029  R 4       0.85R 8      0.366R 4     0.4010E
1030  F       0.3660E
1031  R12    1.22E-2R 4      0.100E
1032  R12    1.22E-2R 4      0.100E
1033  R12    1.22E-2R 4      0.100E
1034  F        553.0E
1035  F          0.0E
1036  F          0.0E
1037  F          0.0E
1038  F          0.0E
1039  F          0.0E
1040  F          0.0E
1041  F          0.0E
1042  F        553.0E
1043  F        553.0E
1044  F     155.8E05E
1045  R 4     0.6641R 4     2.5528R 4     3.3090R 4     1.2228E             LEVEL 10
```

```
                1         2         3         4         5         6         7         8
CARD  12345678901234567890123456789012345678901234567890123456789012345678901234567890

1046  R 4       15.99R 4      61.50R 4      79.71R 4     190.76E
1047  F          0.0E
1048  F          0.0E
1049  F          0.0E
1050  F          0.0E
1051  F          0.0E
1052  F          0.0E
1053  R12      0.951R 4        .375E
1054  R 4        1.0R 8         0.0R 4      .3620E
1055  R 4       0.85R 4         0.0R 4       .250R 4       .401E
1056  F       0.0000E
1057  R12    1.22E-2R 4      0.100E
1058  R12    1.22E-2R 4      0.100E
1059  R12    1.22E-2R 4      0.100E
1060  F        580.0E
1061  F          0.0E
1062  F          0.0E
1063  F          0.0E
1064  F          0.0E
1065  F          0.0E
1066  F          0.0E
1067  F          0.0E
1068  F        580.0E
1069  F        580.0E
1070  F     155.8E05E
1071  R 4      .3948R 4     1.5176R 4     1.9672R 4     1.6500E             LEVEL 11
1072  R 4       9.51R 4      36.56R 4      47.39R 4     257.40E
1073  F          0.0E
1074  F          0.0E
1075  F          0.0E
1076  F          0.0E
1077  F          0.0E
1078  F          0.0E
1079  R12      0.951R 4        1.25E
1080  R12      0.366R 4        .362E
```

```
                 1         2         3         4         5         6         7         8
CARD  12345678901234567890123456789012345678901234567890123456789012345678901234567890

1081  R12       0.365R 4      .000E
1082  F        0.3660E
1083  R12     1.22E-2R 4     0.100E
1084  R12     1.22E-2R 4     0.100E
1085  R12     1.22E-2R 4     0.100E
1086  F          553.0E
1087  F            0.0E
1088  F            0.0E
1089  F            0.0E
1090  F            0.0E
1091  F            0.0E
1092  F            0.0E
1093  F            0.0E
1094  F          553.0E
1095  F          553.0E
1096  F     155.8E05E
1097  R 4      0.5227R 4     2.0093R 4     2.6046R 4         0.0E                LEVEL 12
1098  R 4       12.59R 4      48.40R 4      62.74R 4         0.0E
1099  F            0.0E
1100  F            0.0E
1101  F            0.0E
1102  F            0.0E
1103  F            0.0E
1104  F            0.0E
1105  R12       0.951R 4      .000E
1106  R12       0.366R 4      .362E
1107  R12       0.365R 4      .401E
1108  F        0.3660E
1109  R12     1.22E-2R 4     0.100E
1110  R12     1.22E-2R 4     0.100E
1111  R12     1.22E-2R 4     0.100E
1112  F          553.0E
1113  F            0.0E
1114  F            0.0E
1115  F            0.0E
```

```
                1         2         3         4         5         6         7         8
CARD  12345678901234567890123456789012345678901234567890123456789012345678901234567890

1116  F          0.0E
1117  F          0.0E
1118  F          0.0E
1119  F          0.0E
1120  F        553.0E
1121  F        553.0E
1122  F      155.8E05E
1123  F       0.0   E                                                        ROD 1
1124  F      553.0  E                                                        ROD 1
1125  F       0.0   E                                                        ROD 2
1126  F      553.0  E                                                        ROD 2
1127  F       0.0   E                                                        ROD 3
1128  F      553.0  E                                                        ROD 3
1129  F       0.0   E                                                        ROD 4
1130  F      553.0  E                                                        ROD 4
1131  F       0.0   E                                                        ROD 5
1132  F      553.0  E                                                        ROD 5
1133  F       0.0   E                                                        ROD 6
1134  F      553.0  E                                                        ROD 6
1135  F       0.0   E                                                        ROD 7
1136  F      553.0  E                                                        ROD 7
1137  F       0.0   E                                                        ROD 8
1138  F      553.0  E                                                        ROD 8
1139  F       0.0   E                                                        ROD 9
1140  F      553.0  E                                                        ROD 9
1141  F       0.0   E                                                        ROD 10
1142  F      553.0  E                                                        ROD 10
1143  F       0.0   E                                                        ROD 11
1144  F      553.0  E                                                        ROD 11
1145  F       0.0   E                                                        ROD 12
1146  F      553.0  E                                                        ROD 12
1147  F       0.0   E                                                        ROD 13
1148  F      553.0  E                                                        ROD 13
1149  F       0.0   E                                                        ROD 14
1150  F      553.0  E                                                        ROD 14
```

```
               1         2         3         4         5         6         7         8
CARD  12345678901234567890123456789012345678901234567890123456789012345678901234567890

1151  F       0.0   E                                                        ROD 15
1152  F      553.0  E                                                        ROD 15
1153  F       0.0   E                                                        ROD 16
1154  F      553.0  E                                                        ROD 16
1155  FILL                      99
1156              99             1
1157             2.5   2.26783E-03           0.0           0.0   2.97440E+02
1158       1.575E+07
1159  FILL                      77
1160              77             1
1161             2.5   2.26783E-03           0.0           0.0   2.97440E+02
1162       1.575E+07
1163          1.0E-5         0.100         60.0        1000.0
1164            5.0           0.10        5.0       5.0
1165  -1.
```

II. TRAC TRANSIENT INPUT DECK INCLUDING THE BLOWDOWN, REFILL, AND REFLOOD FOR LOFT EXPERIMENT L2-2

```
                  1         2         3         4         5         6         7         8
CARD     12345678901234567890123456789012345678901234567890123456789012345678901234567890

   1                  2                           1
   2     LOFT TEST L2-2 TRANSIENT
   3     ILOEGE TMIN CORRELATION
   4                -1  0.
   5                  0             1            27            28             1
   6        1.00000E-03   5.00000E-06   1.00000E-04   0.00000E+00
   7                 10           100            20             7             1
   8                  1             2             3             4             5
   9                  6             7             8             9            10
  10                 13            14            15            16            17
  11                 18            19            20            21            22
  12                 23            24            25            27            50
  13                 77            99E
  14               333E
  15                 -1
  16
  17     END
  18             1.0E-5         0.005          1.0
  19                5.0          0.01          5.0       5.0
  20             1.0E-5         0.005         10.0
  21                5.0          0.10          5.0       5.0
  22             1.0E-5         0.020        100.0
  23                5.0          0.10          5.0       5.0
  24     -1.
```

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