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INTERIM REPORT

ABSTRACT

The fourth nuclear powered small break experiment was successfully conducted on September 29, 1980, in the Loss-of-Fluid Test (LOFT) facility. The experiment, designated L3-5/L3-5A, consisted of two parts, each of which addressed specific reactor safety issues. The first part, L3-5, simulated a 4-in. pipe break (2.5%) in a commercial pressurized water reactor and is one of two LOFT experiments required to address the systems effects of primary coolant pump operation during a small break Loss-of-coolant accident. System mass inventory decreased to a minimum of 3350 ± 100 kg (7370 ± 220 lbm) (61% of initial mass) during L3-5. The second part, L3-5A, demonstrated steam generator efficacy and plant recovery using secondary system control when the pipe break and emergency core coolant system accumulator are isolated from the primary coolant system. The steam generator again became a heat sink, and the plant was returned to a safe shutdown condition using operator-controlled feed and bleed. Selected data are presented and comparison of selected pretest predictions are made.

SUMMARY

The preliminary evaluation has been completed of the results from nuclear Loss-of-Coolant Experiment (LOCE) L3-5/L3-5A. This experiment was successfully completed on September 29, 1980, in the Loss-of-Fluid Test (LOFT) facility and was the fourth nuclear experiment in the LOFT Small Break Test Series L3. The experiment simulated an offset shear break of a small (4-in.-diameter) pipe attached to the inlet primary coolant loop of a large pressurized water reactor (PWR) with the primary coolant pump manually tripped at break initiation.

LOFT LOCE L3-5/L3-5A consisted of two parts designated L3-5 and L3-5A. The objective of L3-5, together with a future LOFT experiment, LOCE L3-6, is to investigate the sensitivity of a small break loss-of-coolant accident to main coolant pump operation. L3-5 was conducted to measure primary system behavior during a controlled experiment with primary coolant pump trip at LOCE initiation. L3-5A was conducted to investigate plant recovery after isolating the break and regaining use of the steam generator as a heat sink.

The LOCE was initiated from operating conditions representative of a commercial PWR. At 4.8 s prior to break initiation, the reactor was scrammed manually. The primary coolant pumps were tripped within 1 s after break initiation and coasted down by 18 s. Natural circulation started at about the same time. The break was isolated and flow from the high-pressure injection system was terminated at approximately 2310 s (38 min 30 s) Primary system pressure increased to equal secondary system pressure by 2883 s (∿48 min). Both pressures continued to increase until operator-controlled secondary feed and bleed operations were initiated at 5011 s (1 h 24 min). The experiment terminated at 11 758 s (∿3 h 16 min).

The primary system mass inventory decreased to a minimum of 3350 ± 100 kg (7370 ± 220 lbm) (61% of initial mass) at approximately 1480 s (24 min), when high-pressure injection system flow equalled break flow. The reactor vessel liquid level experienced two minima: the first

during L3-5 at 2125 s (36 min), when the level dropped to 0.6 $\pm$ 0.4 m (2.0 $\pm$ 1.3 ft) above the core; and the second during L3-5A at approximately 5880 s (1 h 38 min), when the level dropped to 0.31 $\pm$ 0.15 m (1.0 $\pm$ 0.5 ft) above the top of the core. Mass redistribution caused the time difference between the system mass minimum and reactor vessel liquid level minimum in L3-5.

Reflux flow was detected during L3-5 between 400 and 600 s, (7 and 10 min) and in L3-5A for about 300 s (5 min) at the reinitiation of natural circulation.

Reestablishment of nataural circulation in L3-5A enabled the steam generator to again become a primary system heat sink. Subsequent operator-controlled feed and bleed operations effectively removed core decay heat and brought the plant to a safe shutdown condition.

Predictions of LOCE L3-5/L3-5A were made with RELAP5 and TRAC-PD2 codes. The codes predicted the major phenomena in the proper sequence.

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DEFINITIONS

Flow reversal - the inception of negative flow in a system component or at a particular location in the system.

Flow rereversal - the reinception of positive flow in system piping, in a component, or at a particular location in the system.

Forced circulation - circulation (flow) caused by the pumps in the loop.

Loop circulation - positive loop flow which proceeds from the heat source (the core) to the heat sink (the steam generator) and then returns to the heat source.

Natural circulation - circulation (flow) caused by density gradients, induced by heat generation in the core and sustained by concomitant heat removal.

Positive flow - flow in the direction that occurs during normal operation in piping, component, or loop.

Pump seal - the U-shaped piping on the inlet side of the primary coolant pumps.

Reflux flow - condensation in steam generator primary tubes with concomitant fallback of condensed liquid film into the intact loop hot leg and reactor vessel upper plenum.

Subcooled blowdown - the period during a loss-of-coolant transient when subcooled fluid is leaving the system through the break and system fluid is saturated only in the pressurizer and downstream of the break.

Mass flux-induced flow - flow in the loops induced by mass influx or efflux (for example, break- or ECCS-induced flow).

Subcooled break flow - the period during a loss-of-coolant transient when subcooled fluid is leaving the system from at least one location.

Submeter (or subcooling meter) - the calculated value, from measured parameters, of the fluid subcooling in the reactor vessel upper plenum. Positive values indicate the fluid is subcooled.

Time zero - time of predefined transient initiating event (for LOCEs, defined as break initiation).

QUICK-LOOK REPORT ON LOFT NUCLEAR EXPERIMENT L3-5/L3-5A

1. INTRODUCTION

Loss-of-Coolant Experiment (LOCE) L3-5/L3-5A, the fourth nuclear experiment in Small Break Test Series L3 scheduled for performance in the Loss-of-Fluid Test facility, was successfully completed on September 29, 1980. The experiments in Test Series L3 that have been completed are summarized in Table 1. LOCE L3-5/L3-5A simulated an offset shear of a small (4-in.-diameter) pipe connected to the cold leg of a four-loop large pressurized water reactor (PWR). A summary of the specified and measured system conditions immediately prior to LOCE L3-5/L3-5A blowdown initiation is given in Table 2. Identifiable significant events for LOCE L3-5/L3-5A are listed in Table 3. The LOFT system geometry and core configuration are shown in Appendix A. Additional details of the LOFT system are presented in Reference 11.

LOFT LOCE L3-5/L3-5A consisted of two parts designated as L3-5 and L3-5A. The programmatic objective of L3-5, together with a future LOFT experiment, LOCE L3-6, is to address the effects of continued main coolant pump operation during a small break loss-of-coolant accident (LOCA), as discussed in Reference 12. The programmatic objective of L3-5A is to evaluate plant recovery after isolating the break and regaining use of the steam generator as a system heat sink. The L3-5A objective was considered secondary to the L3-5 objective during planning and conduction of the experiment.

The test objectives, required to satisfy the programmatic objectives for each part are as follows:[9]

TABLE 1. LOFT TEST SERIES L3 EXPERIMENTS PERFORMED TO DATE

Experiment	Date Completed	Power Level (MW)	Core ΔT(K)	Description
L3-0[1,2]	05-31-79	0	0	Small break through power-operated relief valve, non-nuclear.
L3-1[3,4]	11-20-79	50	35	Small break in cold leg, break flow greater than or equal to HPIS flow.[a]
L3-2[5,6]	02-06-80	50	35	Small break in cold leg, HPIS flow greater than or equal to saturated break flow.[a]
L3-7[7,8]	06-20-80	50	35	Small break in cold leg, HPIS flow greater than or equal to saturated break flow.[a]
L3-5/ L3-5A[9,10]	09-29-80	50	35	Small break in intact loop cold leg, HPIS injection into downcomer, pumps tripped at LOCE initiation.

a. Primary flow at 78.8 kg/s (3.8×10^6 lbm/hr).

TABLE 2. INITIAL CONDITIONS FOR LOCE L3-5/L3-5A

Parameter	Specified Value[9,a]	Measured Value
Primary Coolant System		
Mass flow rate (kg/s)	479.0 ± 6	476.4 ± 6.2
(lbm/s)	3.8 ± 0.05	1050 ± 15
Hot leg pressure (MPa)	14.97 ± 0.1	14.86 ± 0.14
(psia)	2170.0 ± 15.0	2154 ± 20
Cold leg temperature (K)	556.8 ± 1.1	558 ± 1[b]
(°F)	542.5 ± 2.0	545 ± 2
Hot leg temperature (K)	--	576 ± 2
(°F)		577 ± 4
Boron concentration (ppm)	--	670 ± 5
Primary coolant pump injection flow (kg/s)	0.079 ± 0.016	0.094 ± 0.002
(gpm)	1.25 ± 0.25	0.210 ± 0.004
Reactor Vessel		
Power level (MW)	50 ± 1	49 ± 1
Maximum linear heat generation rate (kW/m)	--	53 ± 4
(kW/ft)		16.0 ± 1.1
Control rod position (above full-in position) (m)	1.37 ± 0.01	1.372 ± 0.01
(in.)	54.0 ± 0.5	54.0 ± 0.4
Steam Generator Secondary Side		
Water level (m)	0.25 ± 0.05	0.19 ± 0.04[b]
(in.)	10.0 ± 2.0	7.5 ± 1.2
Water temperature (K)	--	543 ± 1
(°F)		578 ± 2
Pressure (MPa)	--	5.58 ± 0.06
(psia)		809 ± 9
Mass flow rate (kg/s)	--	26.4 ± 1.0
(lb/s)		58 ± 3

TABLE 2. (continued)

Parameter	Specified Value[9,a]	Measured Value
Suppression Tank		
Liquid level (m)	1.27 ± 0.05	1.285 ± 0.015
(in.)	50.0 ± 2.0	506 ± 0.6
Gas volume (m^3)	--	55.4 ± 0.5
(ft^3)		1956 ± 18
Water temperature (K)	363.0 ± 12.0	356.5 ± 0.6
(°F)	193.0 ± 21.0	182 ± 1
Pressure (gas space)		
(MPa)	0.13 ± 0.03	0.113 ± 0.004
(psia)	19.0 ± 4.5	16.4 ± 0.6
Pressurizer		
Steam volume (m^3)	--	0.25 ± 0.06
(ft^3)		9 ± 2
Liquid volume (m^3)	--	0.68 ± 0.06
(ft^3)		24 ± 2
Water temperature (K)	--	614.9 ± 0.1
(°F)		647 ± 0.2
Pressure (MPa)	14.97 ± 0.21	14.88 ± 0.02
(psia)	2171 ± 30	2158 ± 3
Liquid level (m)	1.13 ± 0.18	1.25 ± 0.08
(in.)	44.5 ± 7.0	49 ± 3
HPIS		
Initiation pressure		
(MPa)	13.17 ± 0.19	13.2 ± 0.1
(psia)	1911.0 ± 27.0	1914 ± 15
Initial flow rate (L/s)	0.35 ± 0.10	0.28 ± 0.02
(gpm)	5.5 ± 1.5	4.4 ± 0.3

TABLE 2. (continued)

Parameter	Specified Value[3,a]	Measured Value
LPIS[d]		
Initiation pressure		
(MPa)	2.14 ± 0.19	--
(psia)	311.0 ± 27.0	

a. Listed values are specified in the Experiment Operating Specification (EOS). If no value is listed, that parameter is not specified by the EOS.

b. These values are out of the ranges specified by Reference 9.

c. Water level specified at 100% power relative to that at 0% power by the EOS.

d. LPIS - low-pressure injection system, flow did not initiate during the experiment.

TABLE 3. CHRONOLOGY OF EVENTS - EXPERIMENTAL DATA VERSUS PRETEST PREDICTIONS

Event	Time after LOCE Initiation (s) Measured Data	RELAP5[a] Prediction
L3-5		
Reactor scrammed	-4.8 ± 0.1	-2.0
Control rods reached bottom	-2.8 ± 0.1	0
LOCE initiation[b]	0	0
Primary coolant pumps tripped	0.8 ± 0.2	0
HPIS initiated	0.5 ± 0.2	4.5
First indication in core of natural loop circulation	17.0 ± 3.0	12.0
Primary coolant pumps coastdown completed	17.7 ± 0.2	c
Pressurizer emptied	22.2 ± 0.5	63.0
Upper plenum fluid reached saturation temperature (end of subcooled blowdown)	28.4 ± 0.4	35
Intact loop hot leg voiding initiated	30 ± 5	25
End of subcooled break flow	92.9 ± 0.2	100
Secondary coolant system auxiliary feed pump started (initial steam generator fill)	105 ± 5	58.0
Primary pressure less than secondary pressure	745 ± 20	528
Minimum primary system mass inventory reached	1 480 ± 100	c
Minimum reactor vessel liquid level reached	2 125 ± 180	c
Break isolated	2 309.1 ± 0.5	1 119.3
HPIS turned off	2 311.5 ± 0.5	1 119.3

TABLE 3. (continue

Event	Time After LOCE Initiation (s)	
	Measured Data	RELAP5[a] Prediction
L3-5A		
Secondary coolant system auxiliary feed pumps tripped (terminated initial steam generator fill)	1 800 ± 5	1 314.0
Primary and secondary pressure equilibrated	2 883 ± 10	1 314.0
Secondary coolant system steam and bleed initiated	5 011 ± 3	--
HPIS turned on	5 880.0 ± 0.5	--
Primary system fluid becomes subcooled	10 985 ± 0.5	--
LPIS injection initiated[d]	--	--
Experiment completed[e]	11 758 ± 20	--

a. RELAP5 calculation terminated at 3200 s.

b. LOCE initiation defined as when the break was initiated.

c. Not calculated by RELAP5.

d. LPIS flow did not initiate during the experiment.

e. End of experiment is defined as primary subcooling = 28 K (50°F).

1. For L3-5:

   a. To conduct a small break depressurization in the LOFT facility with a 16.19-mm (0.6374-in.) diameter break orifice in the intact loop cold leg between the primary pump and the reactor vessel, with primary coolant pump trip at rupture, with the high-pressure injection system (HPIS) injecting into the reactor vessel downcomer, and with the scaled accumulator isolated from the loop.

   b. To measure the primary system coolant inventory and system mass distribution as a function of time during the depressurization using available instrumentation.

2. For L3-5A:

   a. To reestablish the steam generator as a primary system heat sink by isolating the break, allowing the primary system pressure to increase to above the secondary system pressure, and using operator controlled secondary "feed and bleed" cooldown.

   b. To obtain flow and density measurements in the intact loop hot leg and fluid temperature difference data associated with the steam generator to investigate the primary coolant loop flow modes and steam generator heat transfer modes following reestablishment of the steam generator as a primary system heat sink.

   c. To reestablish primary coolant conditions to achieve complete LOFT facility recovery with the break isolated and the accumulator isolated.

This report presents a preliminary examination of plant performance (Section 2), followed by a summary of the results from LOFT LOCE L3-5/L3-5A (Section 3). Section 4 presents conclusions reached from the preliminary examination of results reported in Section 3. Data plots are presented in Section 5 to support the experiment chronology in Section 2 and the discussion of results in Section 3. The data plots presented include comparisons of measured and predicted data for LOCE L3-5/L3-5A. The predicted data include primary and secondary system pressures and break mass flow in the LOFT system during the blowdown phase of the transient calculated by EG&G Idaho, Inc.,[10] using the RELAP5[a,13] computer code and by Los Alamos Scientific Laboratory[14] (LASL) using the TRAC-PD2 computer code.[15]

a. The version of the code used was Cycle 160, an experimental version of the RELAP5/MOD1 Code. The source deck and update input data deck are stored under Idaho National Engineering Laboratory Configuration Control Numbers H011985B and H011785B, respectively.

2. PLANT EVALUATION

An evaluation of plant performance is presented. The discussion summarizes the initial experimental conditions, the identifiable significant events, and the instrumentation performance for LOCE L3-5/L3-5A. Data plots showing results of the evaluation are provided in Figures 1 through 14 in Section 5.

2.1 Initial Experimental Conditions

A summary of the specified and measured system conditions immediately prior to LOCE L3-5/L3-5A initiation is given in Table 2. All of the initial conditions were within specified limits except for cold leg temperature and secondary liquid level. These out of specification values did not adversely affect the experiment results.

2.2 Chronology of Events

Identifiable significant events for LOCE L3-5/L3-5A are listed in Table 3, where their times of occurrence are compared with the times predicted by the RELAP5 calculations. The primary system depressurization history is shown in Figure 1. The reactor was manually scrammed at -4.8 s. At the same time, feed flow to the steam generator was shut off and the main steam valve started to close. After the break was initiated, the intact loop primary coolant pumps were tripped and started to coast down.

Before the pump coastdown was completed, the HPIS started injecting coolant into the reactor vessel downcomer. Forced circulation then ended as the pumps coasted down, and single-phase natural circulation was established beginning at 17 s.

The pressurizer emptied at 22.2 s, followed by fluid saturation in the upper plenum at 28.4 s. Fluid saturation in the upper plenum corresponded to an increase in the velocity of the fluid exiting the core as two-phase natural circulation was initiated (Figure 2). The intact loop hot leg began voiding at 30 s (Figure 3), followed by the intact loop cold leg at 85 s (Figure 4).

The primary and secondary system pressures decreased at the same rate until 745 s (~12 min 30 s), at which time the break uncovered. Sufficient energy was then removed through the break without heat transfer to the steam generator, and the primary system depressurized more rapidly (Figure 5).

The minimum primary system mass inventory of 3350 ± 100 kg (7370 ± 200 lbm), or 61% of the initial mass, was reached at 1480 s (Figure 6). The reactor vessel liquid level experienced two minima: the first during L3-5 at 2125 s (36 min), when the liquid level was 0.6 ± 0.4 m (2.0 ± 1.3 ft) above the core; and the second during L3-5A at 5880 s (1 h 38 min), when the liquid level dropped to 0.31 ± 0.15 m (1.0 ± 0.5 ft) above of the core. The break was isolated at 2309 s (~38 min) followed by HPIS termination 2.5 s later, ending L3-5 and initiating L3-5A.

After the break was isolated, the primary pressure increased until operator-controlled steam generator secondary feed and bleed operations were initiated at 5011 s (1 h 24 min). The primary system continued to cool after HPIS flow to the intact loop cold leg was initiated at 5880 s (1 h 38 min). Liquid in the primary system subcooled at 10 985 s (3 h 3 min) and the experiment was completed at 11 758 s (3 h 15 min), when the primary system liquid was 28 K (50°F) subcooled.

2.3 Instrumentation Performance

The instrumentation used for LOCE L3-5/L3-5A was the same instrumentation used for LOCE L3-7[8], with a few additions. These additional measurements provided break mass flow rate and included density, pressure, and temperature upstream of the break and pressure, temperature, momentum flux, and velocity measurements downstream of the break.

There were 1041 instruments recorded for evaluation of the experimental results. Of the number examined at this time, 97% performed satisfactorily.

3. EXPERIMENTAL RESULTS FROM LOCE L3-5/L3-5A

The preliminary analysis presented in this section is based on data processed and available within approximately the first two weeks following the conduct of LOCE L3-5/L3-5A. In certain instances, this analysis reflects the current lack of confirmatory data or analysis. Analysis of LOCE L3-5/L3-5A data will continue in order to further refine these preliminary results and conclusions. The discussion in the following subsections treats the phenomena of each part of the experiment separately.

3.1 L3-5 Phenomena and Comparison with Predictions

The significant phenomena observed during L3-5 (that is, prior to isolating the break) are discussed in this section. In addition, the measured data are compared with preexperiment predictions.[10,14]

3.1.1 Primary System Mass Distribution

The integrated primary system mass inventory shown in Figure 6 was calculated using initial mass and integrating break flow and HPIS flow. The primary system mass inventory reached a minimum at 1480 s. This minimum occurred as HPIS flow exceeded the break flow as shown in Figure 7.

The break mass flow rate in Figure 7 is a combination of the following independent calculational methods:

1. From 0 to 40 s, measurements of fluid temperatures, pressures, and densities taken immediately upstream of the break orifice were input into a calibrated break flow model for the orifice in order to calculate break flow.

2. From 40 to 750 s, break flow was calculated from momentum flux and fluid velocity measured downstream of the break. These data overlay the data calculated using Method 3 between 90 and 750 s.

3. From 750 to 2309 s (break isolation), the break flow was determined from the mass increase in the blowdown suppression tank (BST). The relatively large fluctuations are mainly caused by the calculational technique of this method which involves differentiation of the BST liquid level.

The reactor vessel liquid level experienced a minimum below the level of the measurement shown in Figure 8 at 2125 s (36 min), when the level decreased to 0.6 ± 0.4 m (2.0 ± 1.3 ft) above the core. This level was determined by extrapolating from the times when the upper plenum thermocouples and liquid level conductivity probes dryed out and requenched. The reactor vessel liquid level minimum occurred 645 s (~11 min) after the primary system mass minimum occurred. This difference is due to to a mass redistribution within the system. Reactor vessel mass inventory was sufficient to keep the core cooled (Figure 9) throughout L3-5 and L3-5A.

3.1.2 Reflux Flow During L3-5.

Examination of the temperature difference from steam generator inlet to outlet (Figure 10) indicates reflux flow occurred between approximately 400 and 600 s (~7 and 10 min). This evidenced by the occurrence of fluid saturation in the steam generator inlet prior to the outlet, but departure from saturation, apparent superheating, in the outlet prior to the inlet.

3.1.3 Comparison with Predictions

The preexperiment predictions predicted the important phenomena during L3-5 in the proper sequence, as shown in Table 3. Figure 11 shows the primary pressure history overlayed with the predictions. The system depressurized more slowly than predicted. That is, RELAP5 and TRAC-PD2 predicted the primary system would depressurize to 2.15 MPa (312 psia) by 1119 s (~18 min 30 s) and 835 s (~14 min), respectively, versus 2309 s (~35 min 30 s) in the data. Potential causes of the difference between predicted and measured data include: (a) less than predicted heat transfer from primary to secondary due to the slower than predicted secondary depressurization (Figure 12) and (b) smaller than predicted break flow (Figure 13).

RELAP5 predicted reflux flow between 140 and 465 s (~2 and 8 min). As previously discussed, reflux flow was indicated in the data from 400 to 600 s (~7 to 10 min).

3.2 L3-5A Phenomena and Comparison with Predictions

When primary pressure decreased to 2.30 ± 0.21 MPa (3.19 ± 30 psig), the break was isolated and HPIS flow was terminated, ending L3-5 and initiating L3-5A. During L3-5A, the primary system pressure exceeded the secondary system pressure, reestablishing the steam generator as a heat sink. The plant was recovered with the steam generator using operator-controlled feed and bleed. This section describes the phenomena noted in L3-5A and compares these phenomena with the preexperiment predictions.[10,14]

3.2.1 Steam Generator Cooling Effectiveness and System Recovery

The primary system pressure increased after the break was isolated because environmental heat loses were insufficient to dissipate core decay heat.

The steam generator again became a primary system heat sink when primary and secondary pressures reequilibrated at 2883 s (~48 min). Evidence that natural circulation initiated at this time and persisted until the end of the experiment is: (a) the primary system repressurization rate decreased, (b) the secondary system depressurization reversed, and (c) primary and secondary system pressures paralleled until the system subcooled (Figure 5).

When the primary system went subcooled at 10 985 s (3 h 3 min), the natural circulation transitioned from two phase to single phase as evidenced by a temperature rise across the core (Figure 14) and steam generator (Figure 10).

Reestablishment of the steam generator as a heat sink, however, was not sufficient to depressurize the system with an isolated secondary. Therefore, at 5011 s (1 h 23 min), operator-controlled secondary feed and bleed operations were initiated to augment primary-to-secondary heat transfer. This operation was sufficient to remove decay heat and recover the plant.

3.2.2 Reflux Flow

As natural circulation was being reestablished, reflux flow was indicated for approximately 300 s (5 min) (Figure 10). Following this time, reflux flow is not clear from the measurements.

3.2.3 Comparison with Predictions

RELAP5 and TRAC-PD2 preexperiment predictions calculated the primary and secondary systems would repressurize after break closure.

RELAP5 calculated that primary and secondary pressures would equilibrate and remain thermally coupled throughout the rest of the transient. RELAP5 also predicted that natural circulation would reinitiate after primary and secondary system pressures reequilibrated. However, reflux flow was not predicted by RELAP5 to occur during this time frame.

4. CONCLUSIONS

The conduct of LOFT LOCE L3-5/L3-5A and the experimental data acquired concerning integral system response to the experiment are considered to have met the objectives defined by the Experiment Operating Specification[9] and discussed in Section 3. Conclusions based on the preliminary analysis and experiment assessment are as follows:

1. For L3-5:

    a. The measured primary system mass inventory reached a minimum of 3350 kg (7370 lbm) (61% of initial mass) at 1480 s (24 min), when HPIS flow exceeded break flow.

    b. Reactor vessel liquid level reached a minimum at 2125 s (36 min), 0.6 m (2.0 ft) above the core.

    c. Mass redistribution within the primary system caused the time difference between the two minima.

    d. Reflux flow occurred for about 200 s ($\sim$3 min).

    e. RELAP5 and TRAC-PD2 predicted the major phenomena in the proper sequence.

2. For L3-5A:

    a. The steam generator was reestablished as a primary system heat sink through reinstallation of natural circulation.

    b. Reflux flow was indicated from about 300 s (5 min) at the onset of natural circulation.

c. Steam generator feed and bleed was effective in removing core decay heat and bringing the plant to a safe shutdown condition.

d. RELAP5 and TRAC-PD2 predicted the repressurization of the primary and secondary systems.

5. DATA PRESENTATION

This section presents selected, preliminary data from LOCE L3-5/L3-5A. LOCE L3-5/L3-5A data are overlayed with data from LOCE L3-5/L3-5A pretest calculations using the RELAP5 and TRAC-PD2 computer codes. A listing of the data plots is presented in Table 4. Table 5 gives the nomenclature system used in instrumentation identification. A complete list of the LOFT instrumentation and data acquisition requirements for LOCE L3-5/L3-5A is given in Reference 9.

The maximum (2σ) uncertainties in the report data are:

1. Temperature - ± 3 K ($\pm 6^{o}$F)
2. Pressure - ± 0.21 MPa (± 30 psi)
3. Density - ± 0.043 Mg/m^3 (± 3 lb/ft^3)
4. Mass flow rate - ± 10% (integrated uncertainty)
5. Submeter - ± 5 K ($\pm 9^{o}$F)
6. Differential temperature [(TE-SG-1)-(TE-SG-2)] - ± 0.5 K ($\pm 1^{o}$F).

TABLE 4. LIST OF DATA PLOTS

Figure	Title	Measurement Identification	Page
1	Pressure in the primary system intact loop	PE-PC-006	22
2	Fluid velocity above the center fuel module	FE-5UP-001	23
3	Fluid density in the primary system intact loop hot leg	DE-PC-205	24
4	Fluid density in the primary system intact loop cold leg	DE-PC-115	25
5	Comparison of pressure in the primary system intact loop and in the steam generator	PE-PC-006 PE-SGS-001	26
6	System mass inventory		27
7	Comparison of break flow and HPIS flow	Break flow FT-P128-104	28
8	Reactor vessel liquid level relative to the top of the core		29
9	Fuel cladding thermocouple temperatures in the center fuel module	TE-5F9-011 TE-5F9-045 TE-5H7-026 TE-5H7-058	30
10	Temperature difference, steam generator inlet minus steam generator outlet	TE-SG-001 TE-SG-002	31
11	Comparison of reactor vessel upper plenum pressure data with RELAP5 and TRAC predictions	PE-1UP-001A	32
12	Comparison of steam generator pressure data with RELAP5 and TRAC predictions	PE-SGS-001	33
13	Comparison of break flow data with RELAP5 and TRAC predictions	Break flow	34
14	Temperature difference across the core	TE-3UP-001 TE-3LP-001	35

TABLE 5. NOMENCLATURE FOR LOFT INSTRUMENTATION

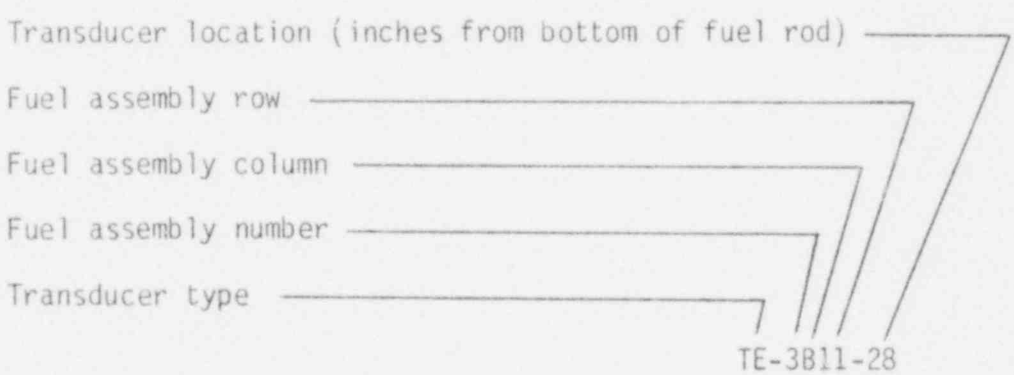
Designations for the Different Types of Transducers[a]

TE	- Temperature element	FE	- Coolant flow transducer
PE	- Pressure transducer	DE	- Densitometer
PdE	- Differential pressure transducer	DiE	- Displacement transducer
		ME	- Momentum flux transducer
LE	- Coolant level transducer	FT	- Flow rate transducer

Designations for the Different Systems, Except the Nuclear Core

PE	- Primary coolant intact loop	LP	- Lower plenum
BL	- Broken loop	ST	- Downcomer stalk
RV	- Reactor vessel	P120	- Emergency core cooling system
SV	- Suppression tank	P128	- Primary coolant addition and control
UP	- Upper plenum		

Designations for Nuclear Core Instrumentation



a. Includes only instruments discussed in this report.

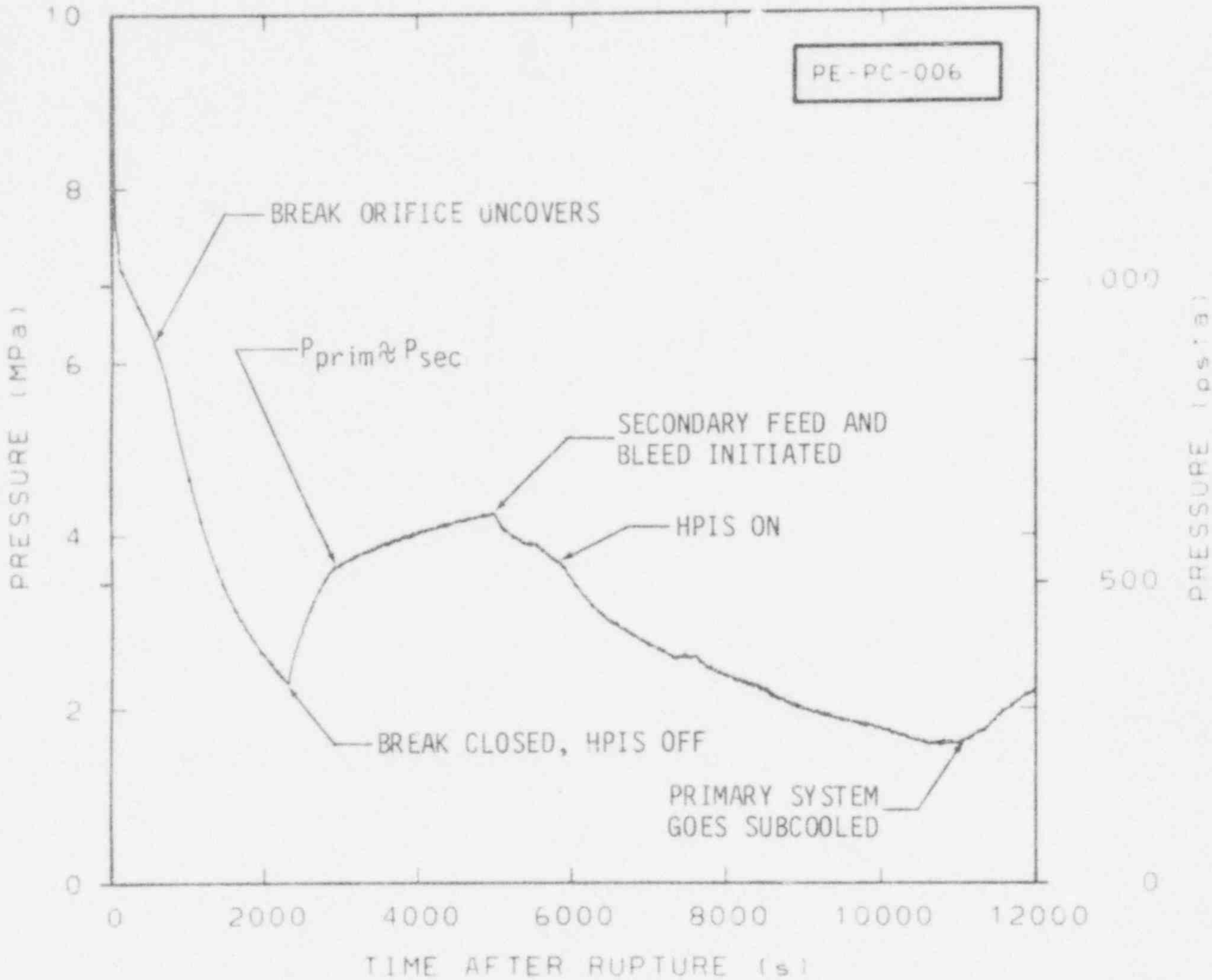


Figure 1. Pressure in the primary system intact loop.

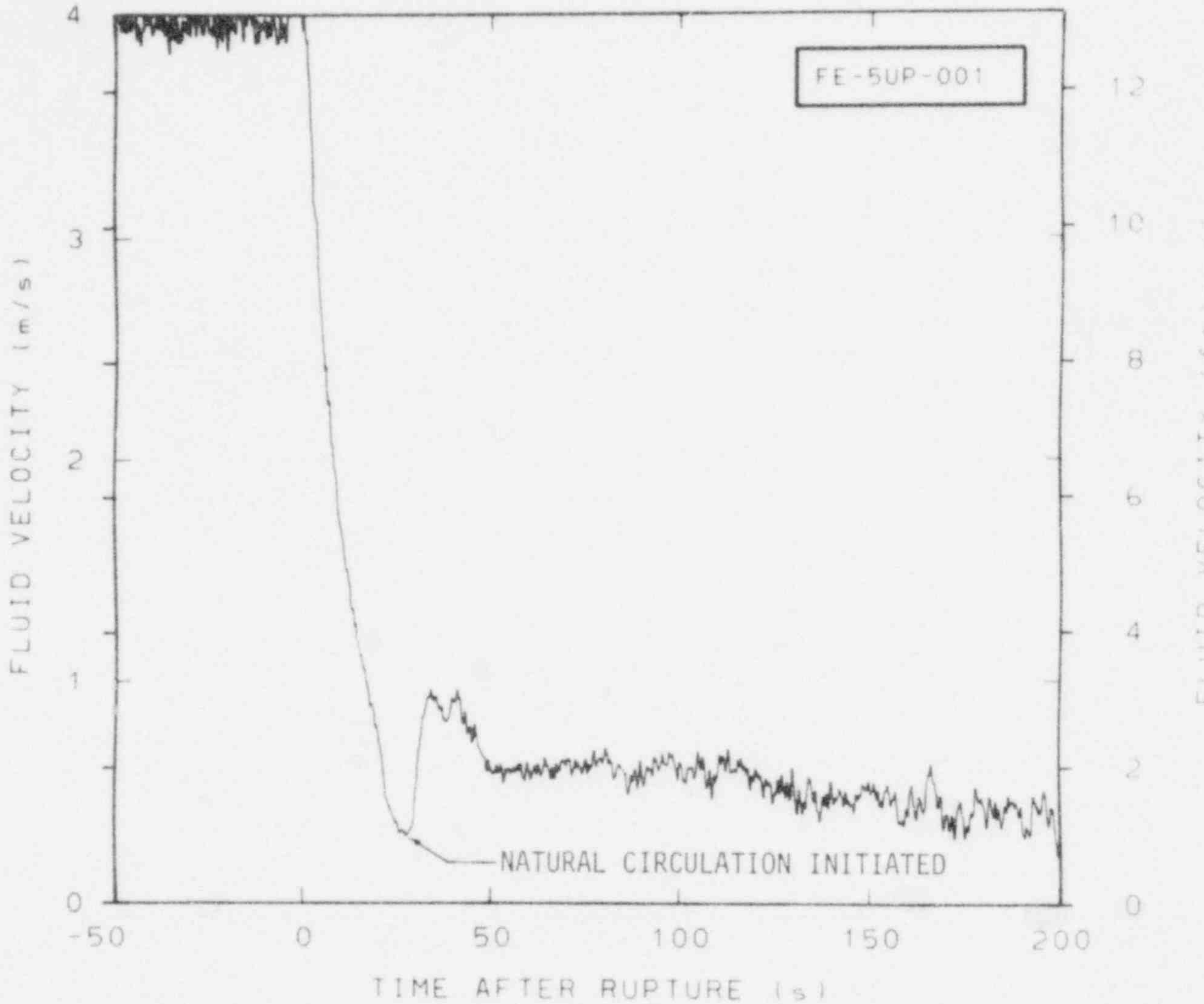


Figure 2. Fluid velocity above the center fuel module.

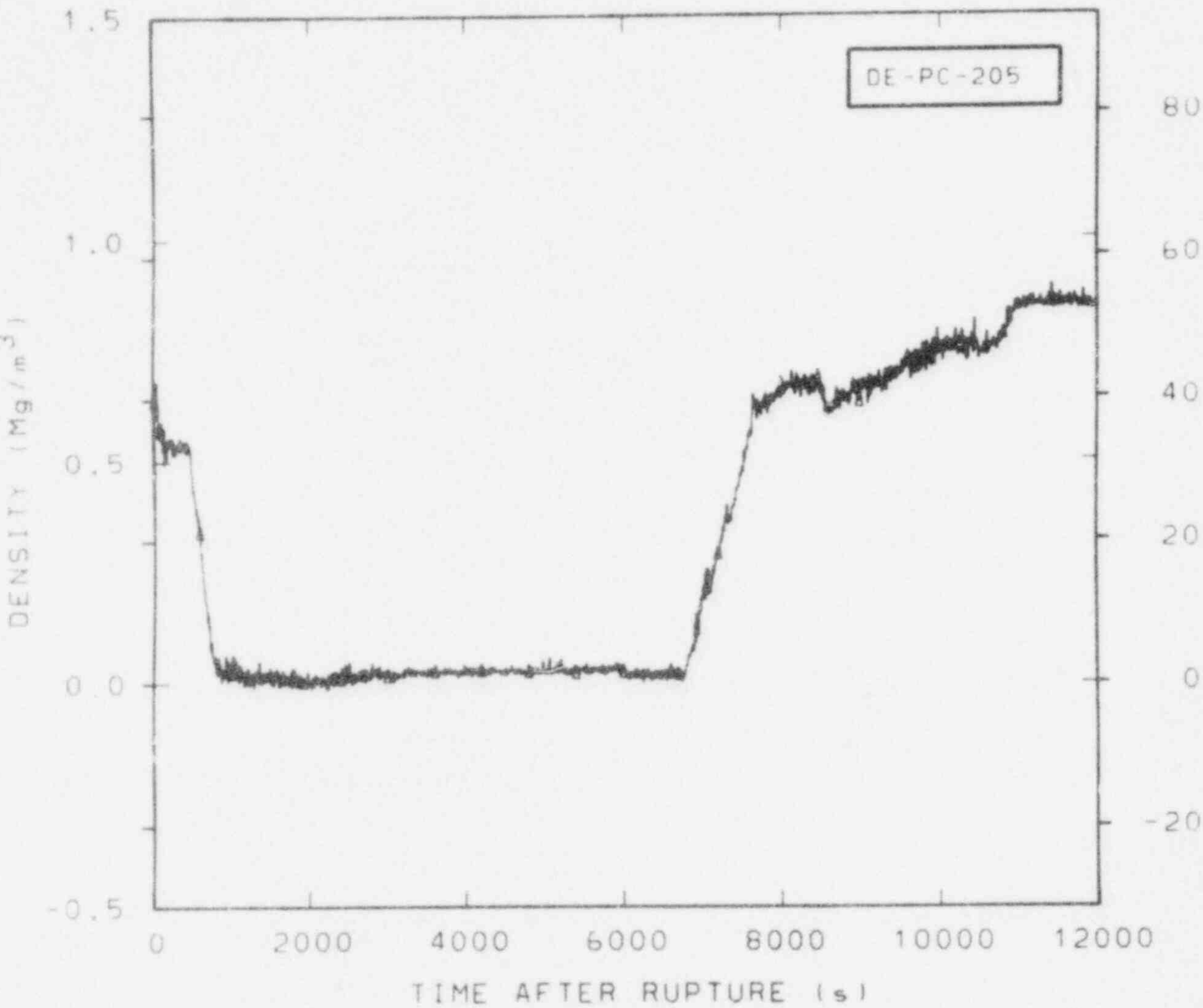


Figure 3. Fluid density in the primary system intact loop hot leg.

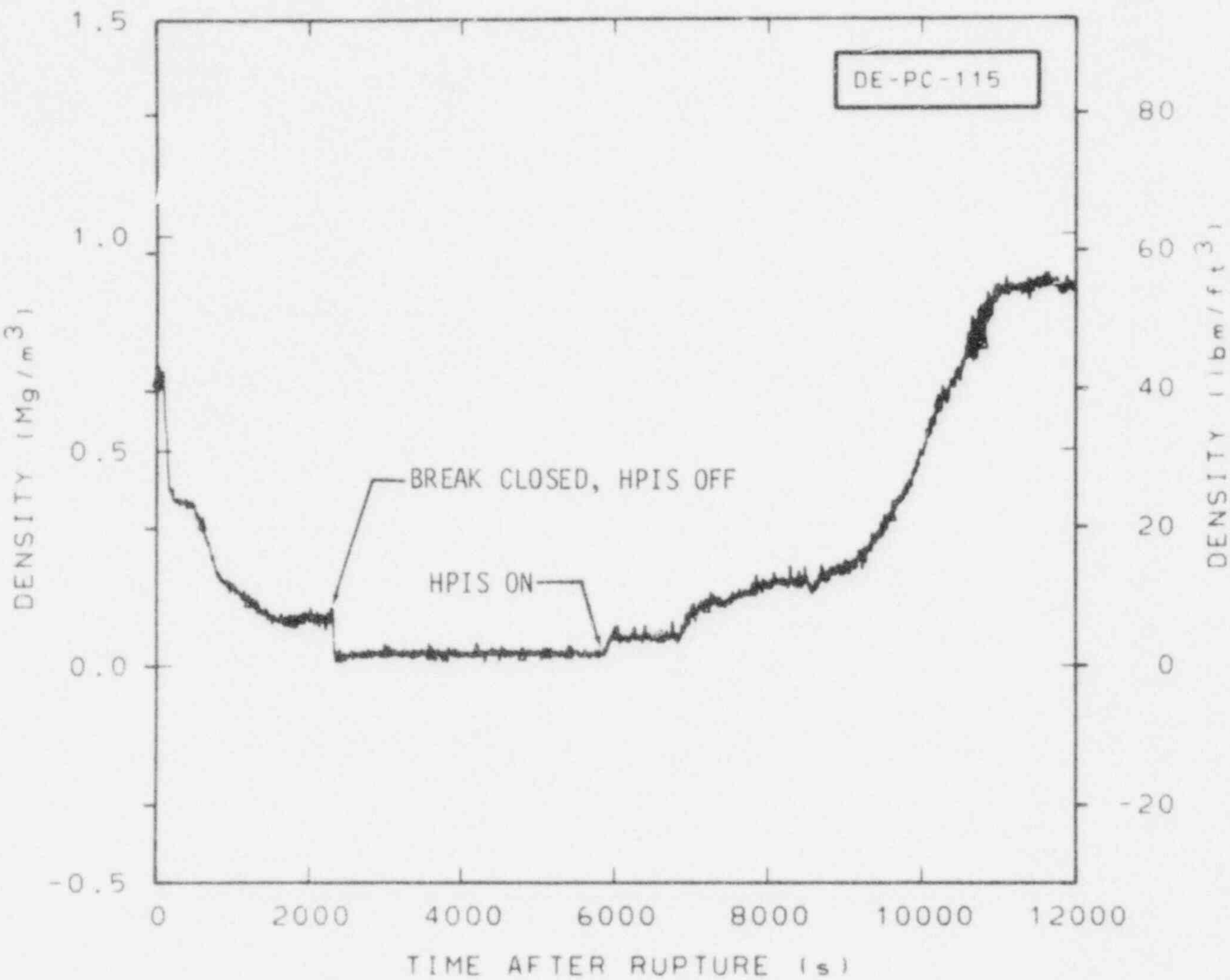


Figure 4. Fluid density in the primary system intact loop cold leg.

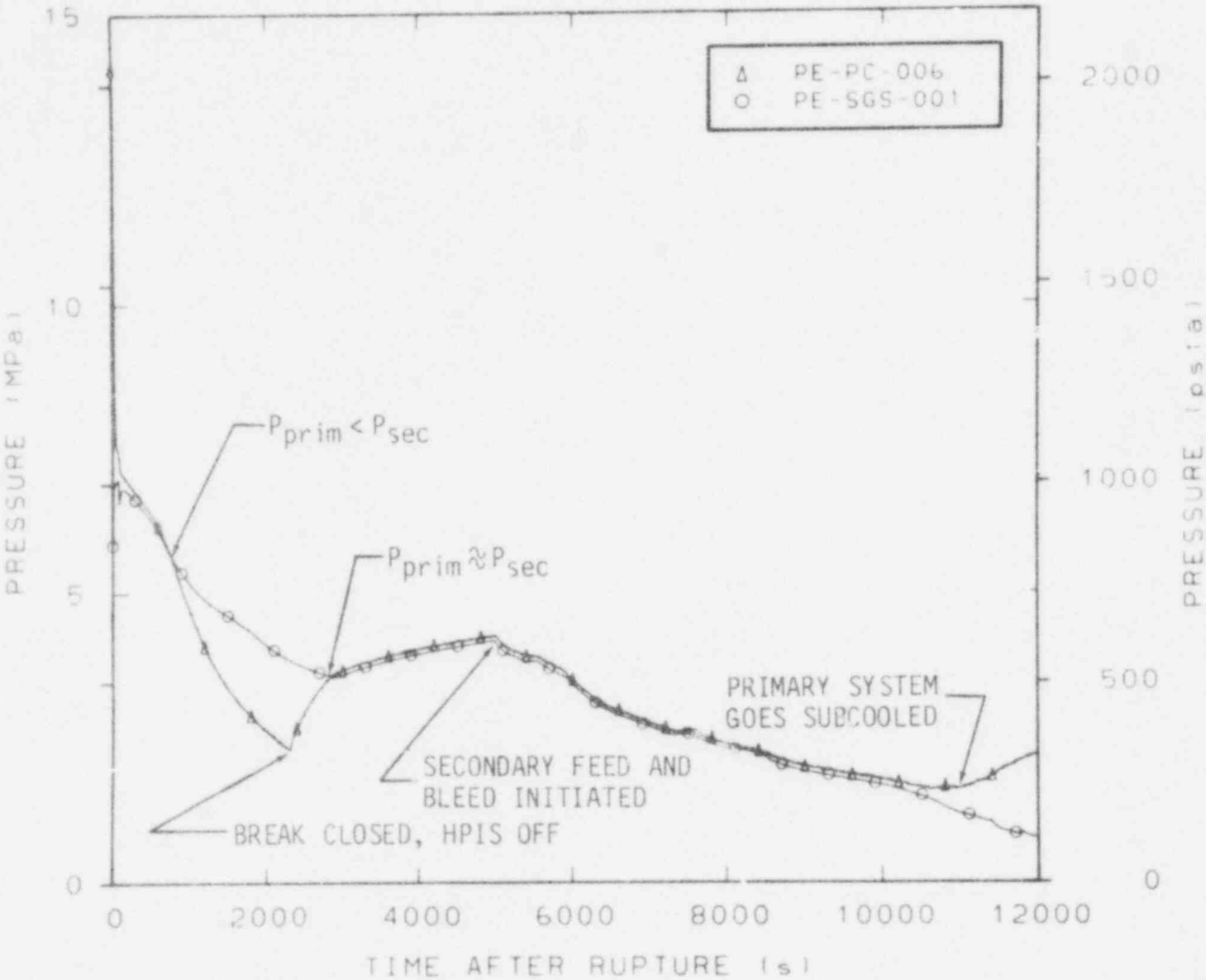


Figure 5. Comparison of pressure in the primary system intact loop and in the steam generator.

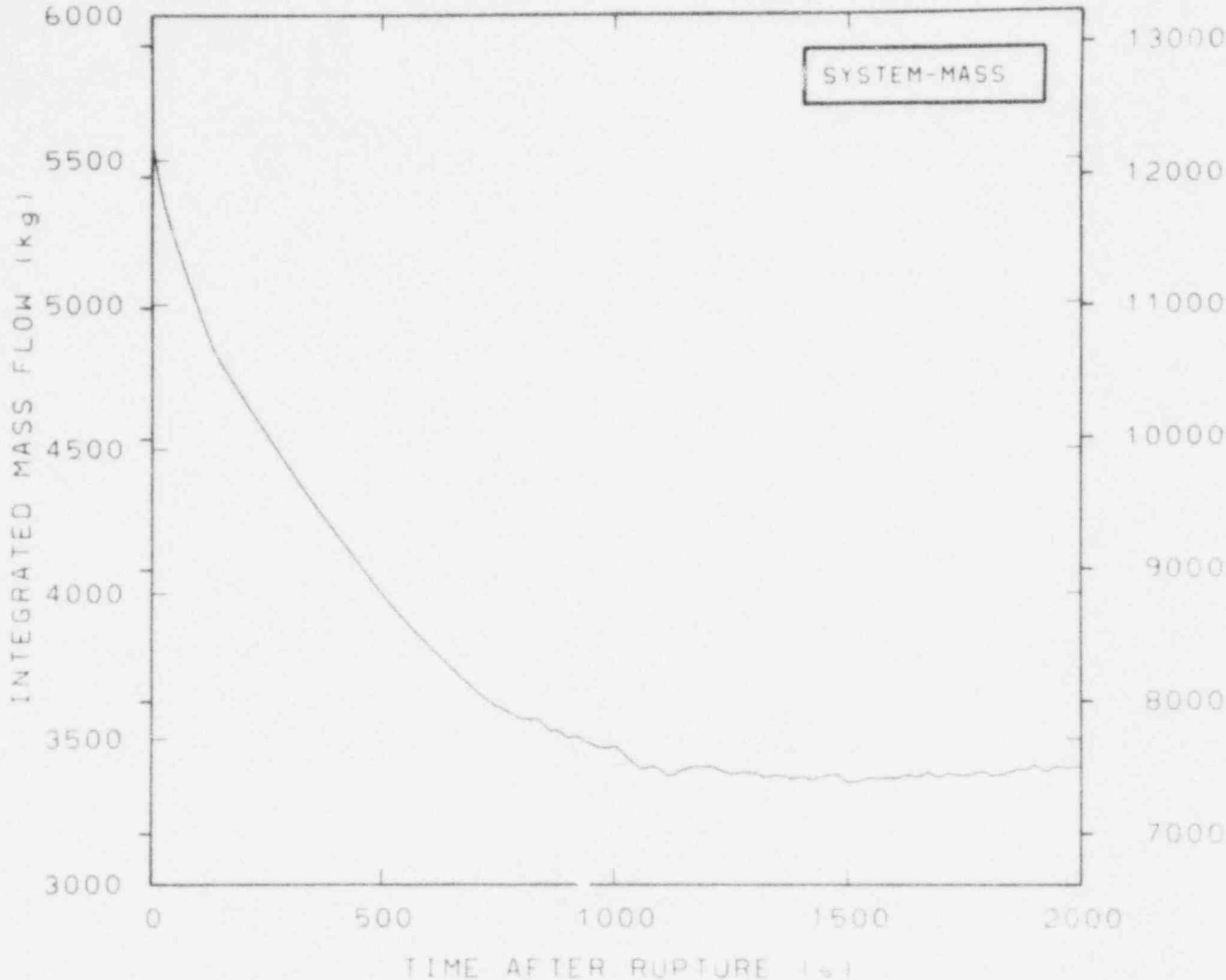


Figure 6. System mass inventory.

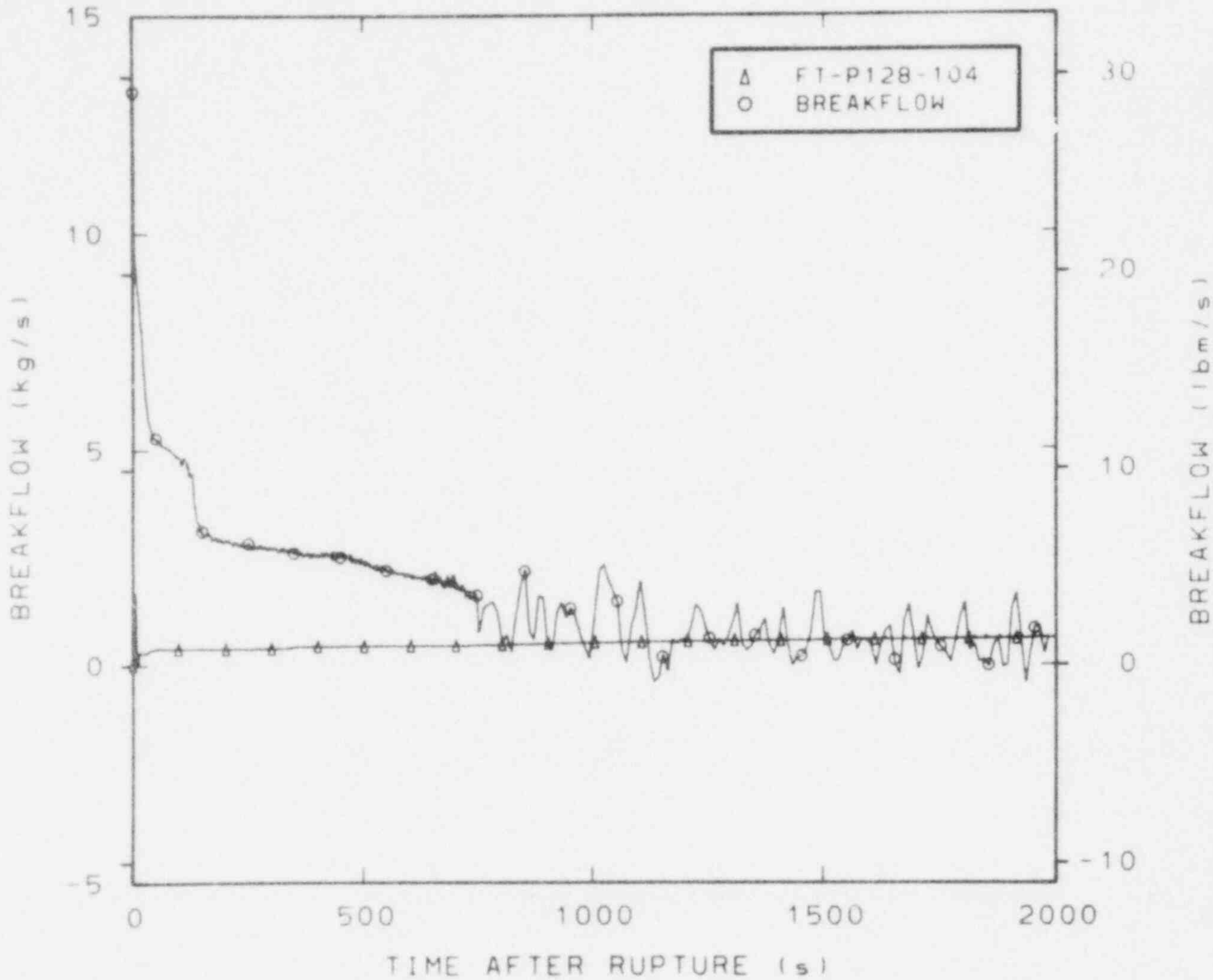


Figure 7. Comparison of break flow and HPIS flow.

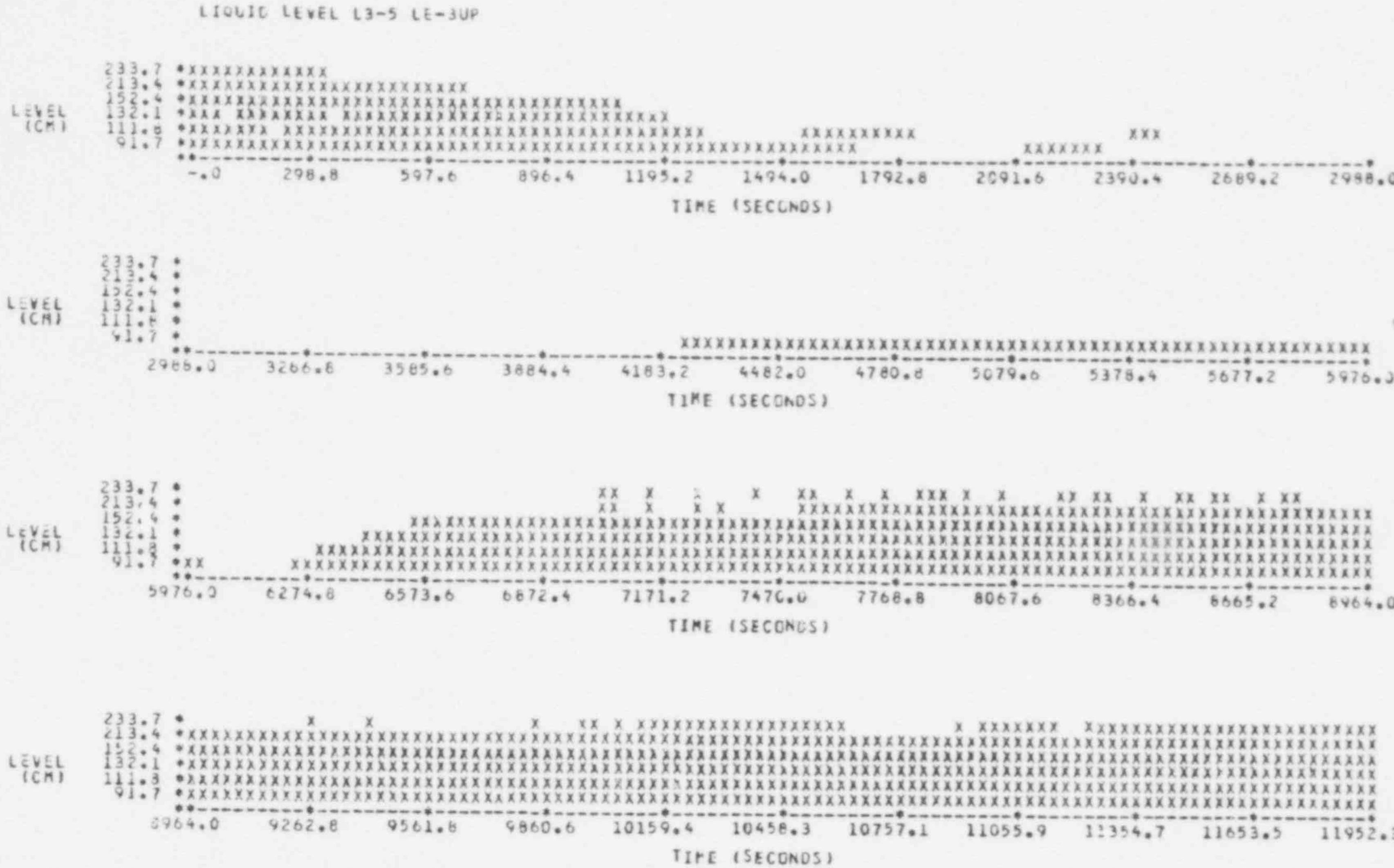


Figure 8. Reactor vessel liquid level relative to the top of the core.

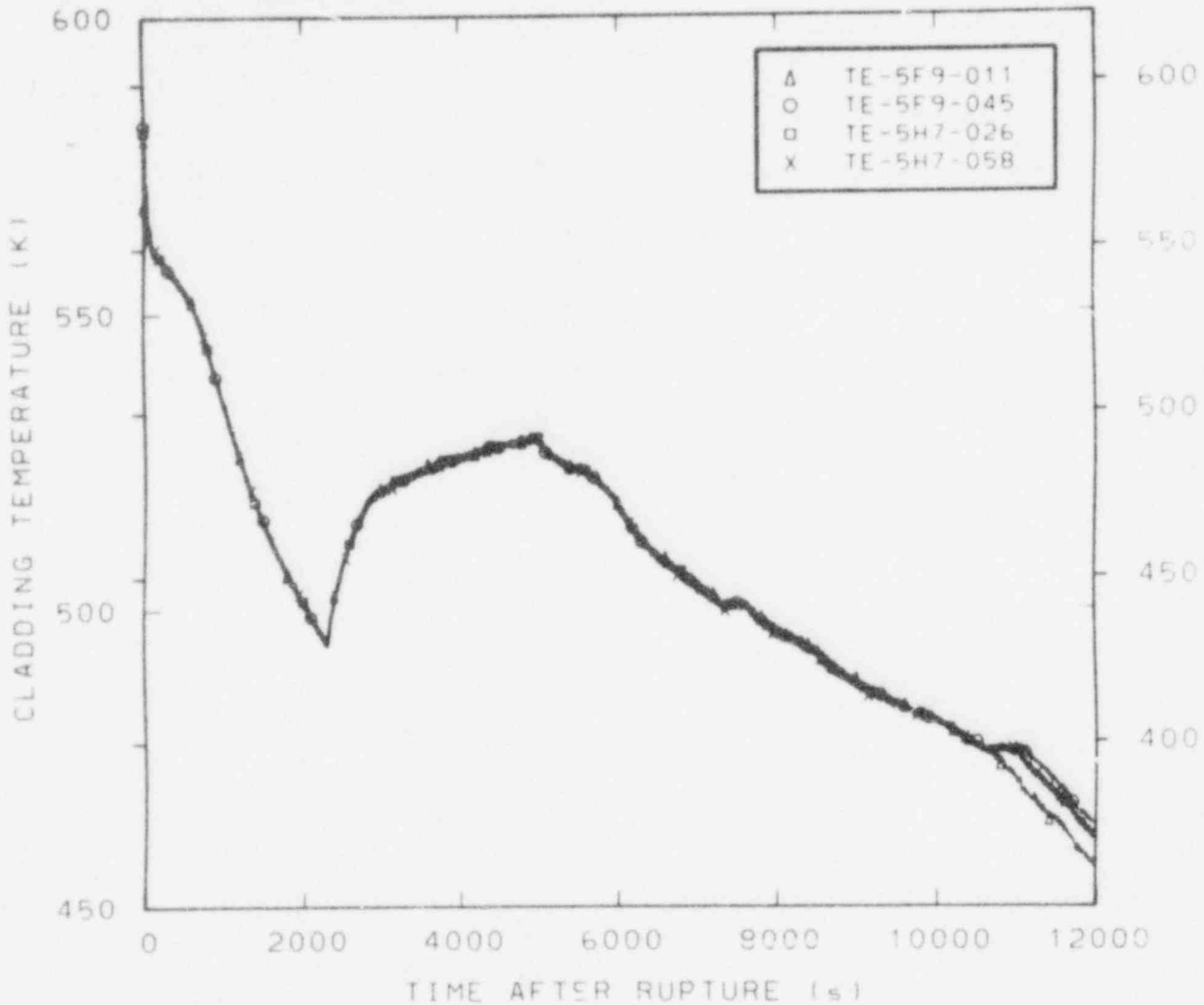


Figure 9. Fuel cladding thermocouple temperatures in the center fuel module.

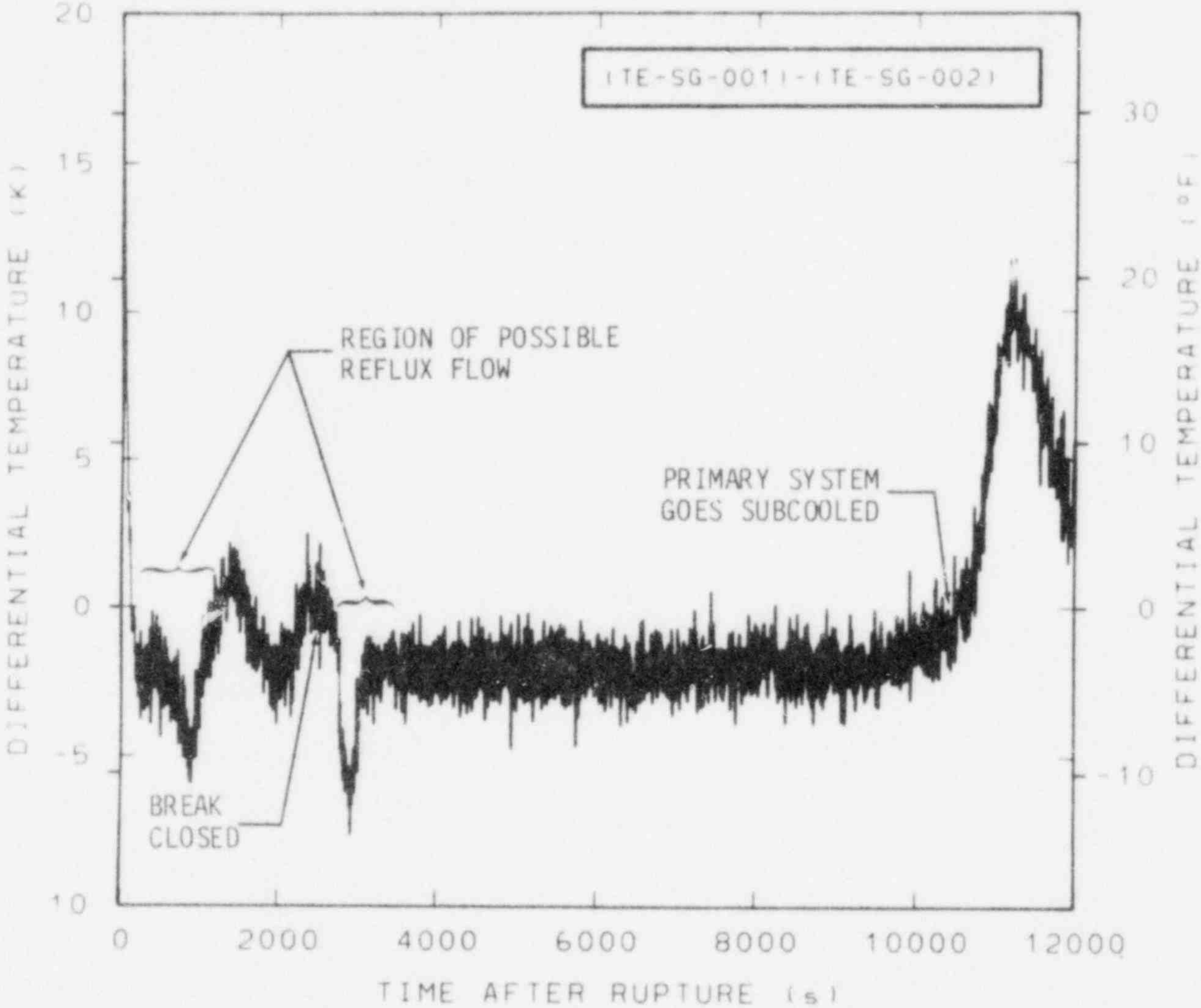


Figure 10. Temperature difference, steam generator inlet minus steam generator outlet.

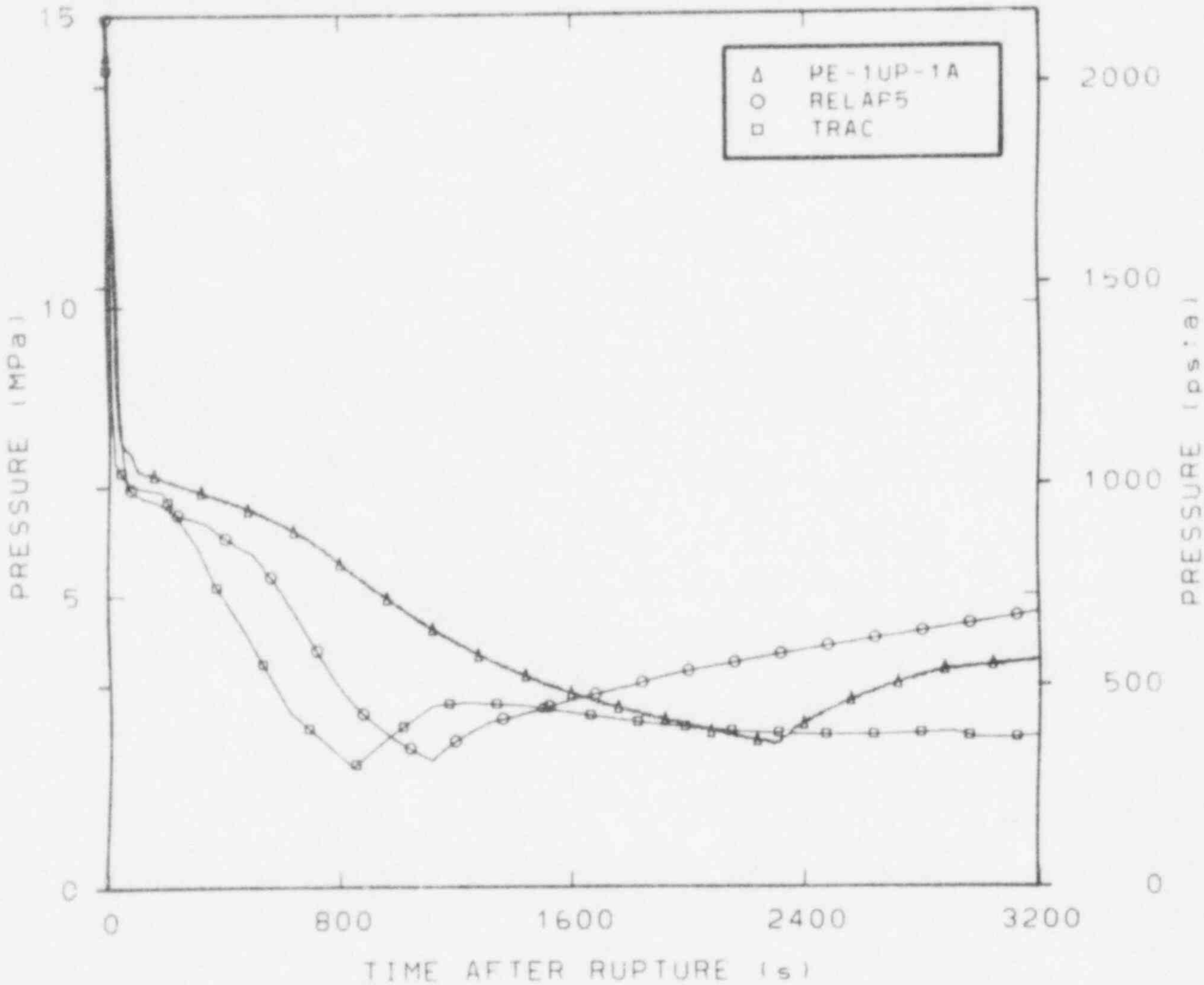


Figure 11. Comparison of reactor vessel upper plenum pressure data with RELAP5 and TRAC predictions.

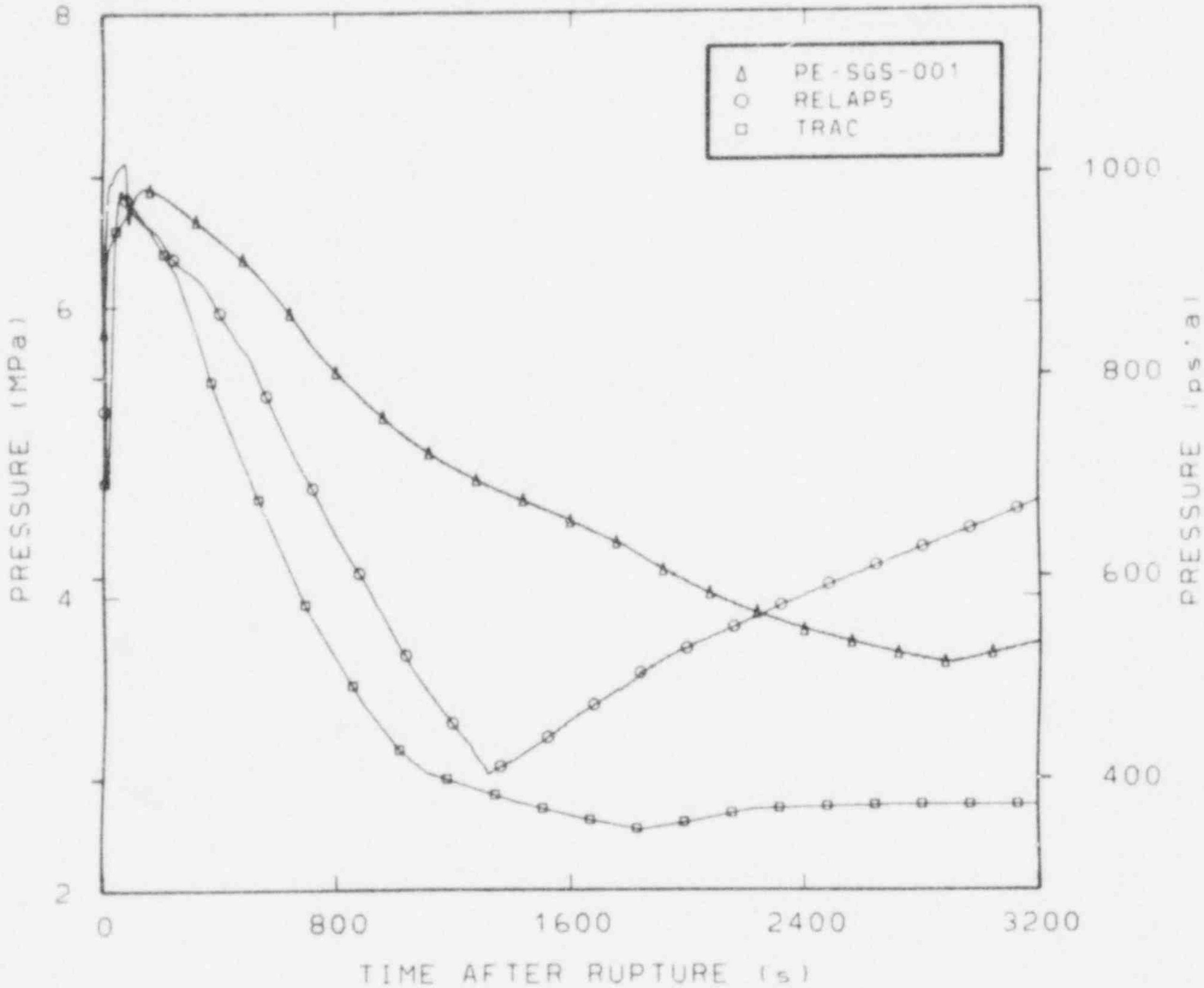


Figure 12. Comparison of steam generator pressure data with RELAP5 and TRAC predictions.

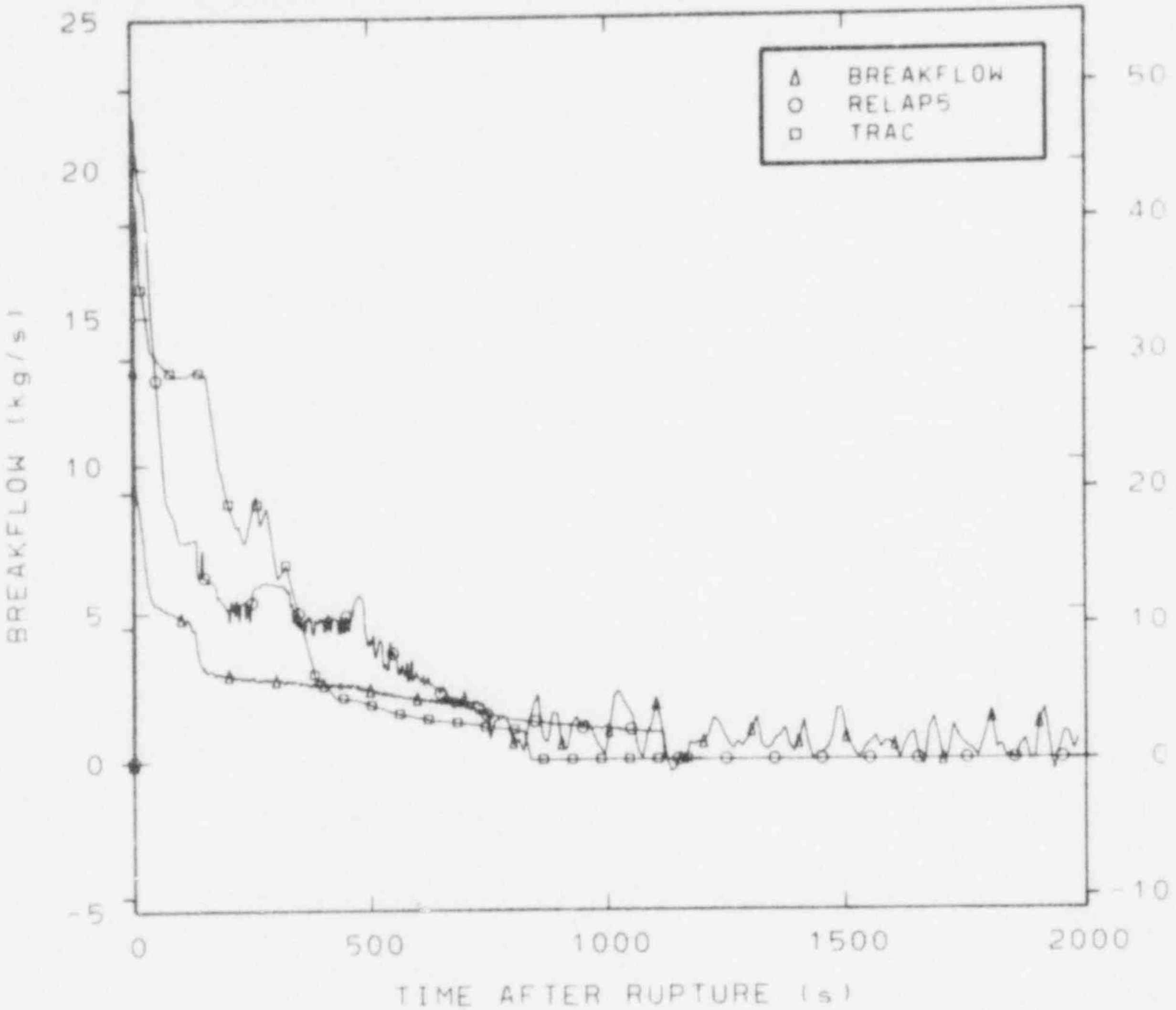


Figure 13. Comparison of break flow data with RELAP5 and TRAC predictions.

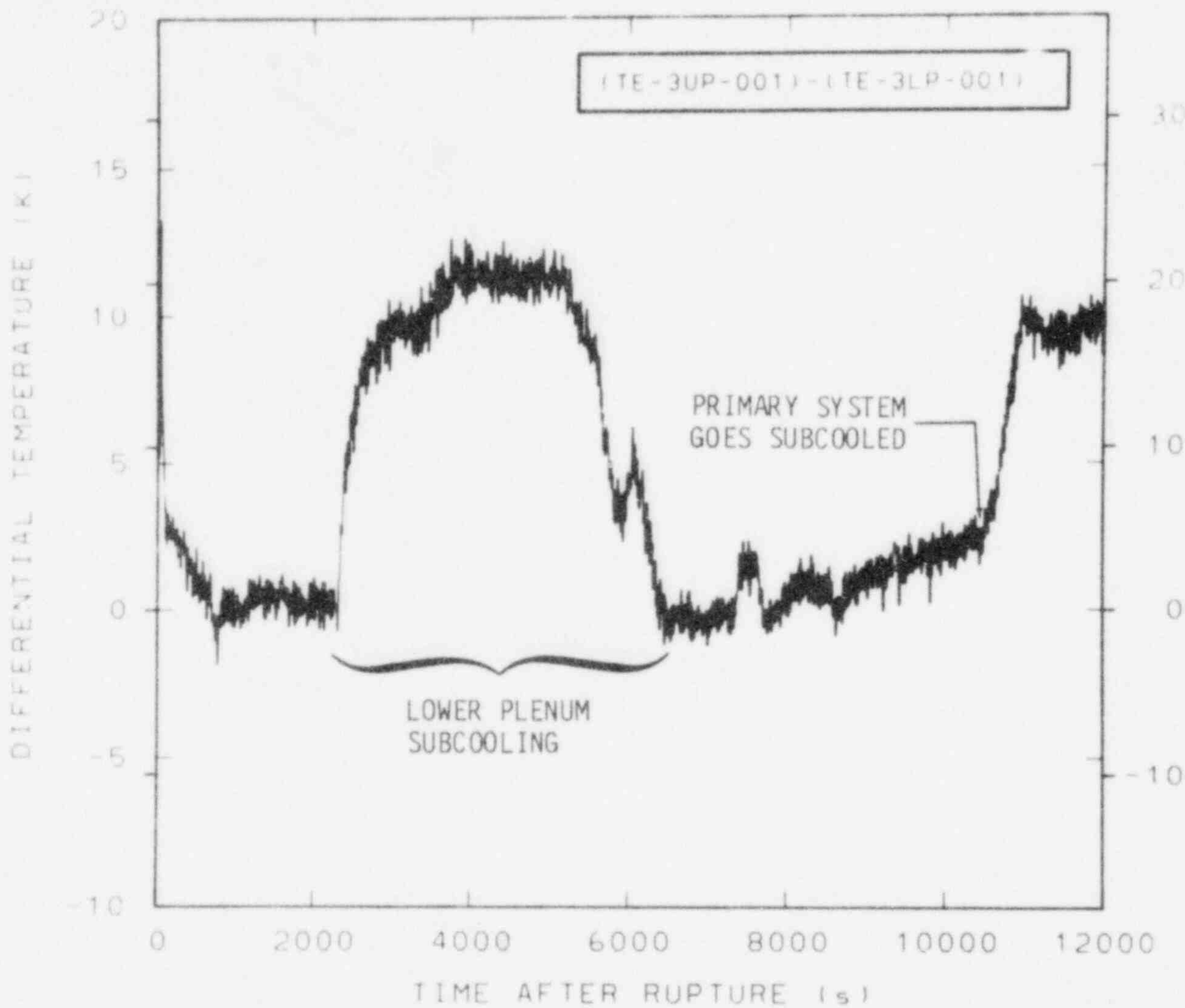


Figure 14. Temperature difference across the core.

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APPENDIX A

LOFT SYSTEM GEOMETRY AND CORE CONFIGURATION

APPENDIX A

LOFT SYSTEM GEOMETRY AND CORE CONFIGURATION

The LOFT system geometry is shown in Figure A-1, and a representation of the core configuration illustrating the instrumentation and position designations is shown in Figures A-2 and A-3, respectively. Two new spool pieces have been installed for LOCE L3-5/L3-5A which were not present in the previous experiments performed in Test Series L3. Figure A-4 shows the spool pieces and the small break orifice. Figure A-5 shows the LOFT steam generator geometry and instrument locations.

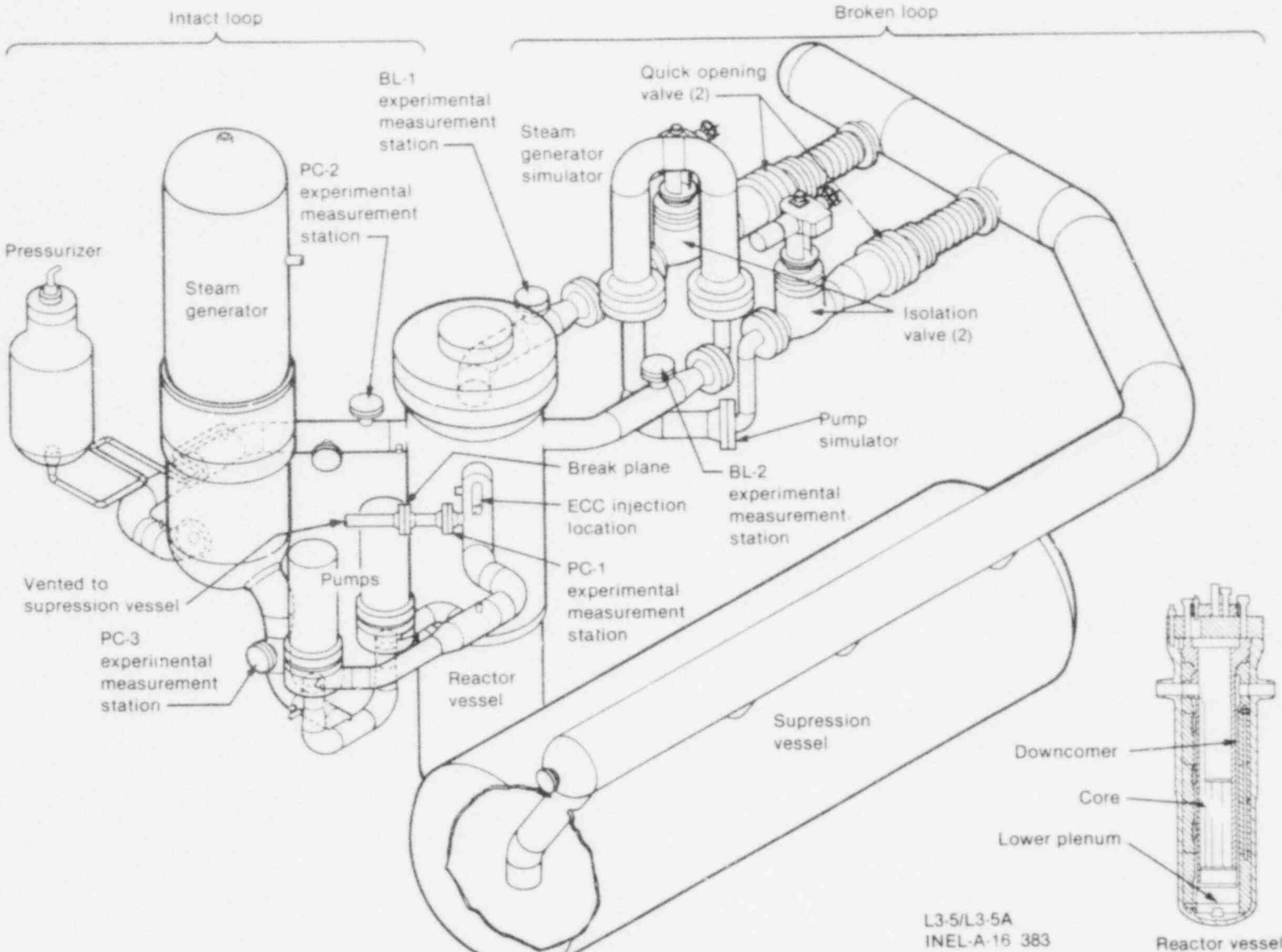

Figure A-1. Axonometric projection of LOFT system.

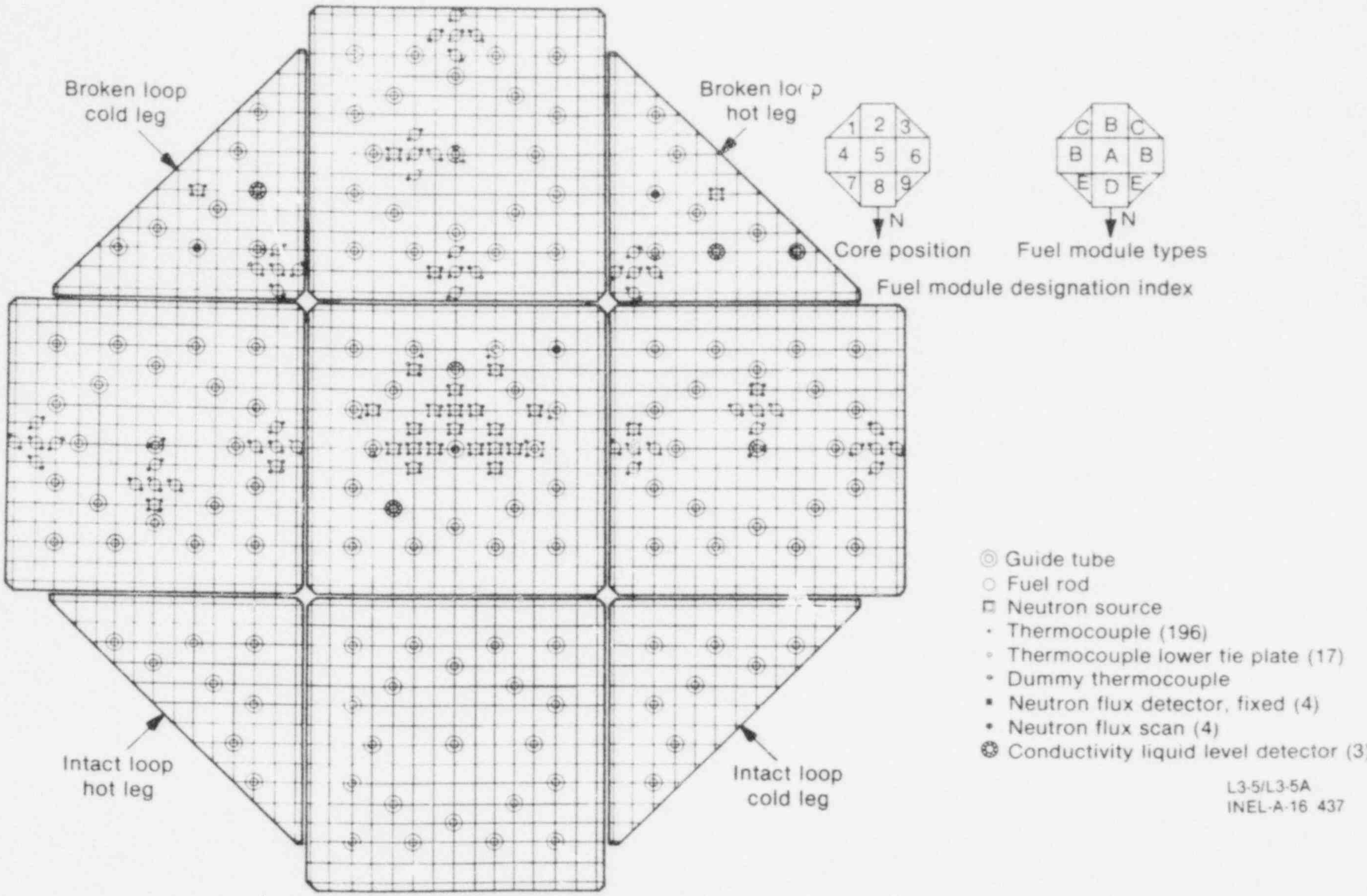

Figure A-2. LOFT core configuration and instrumentation.

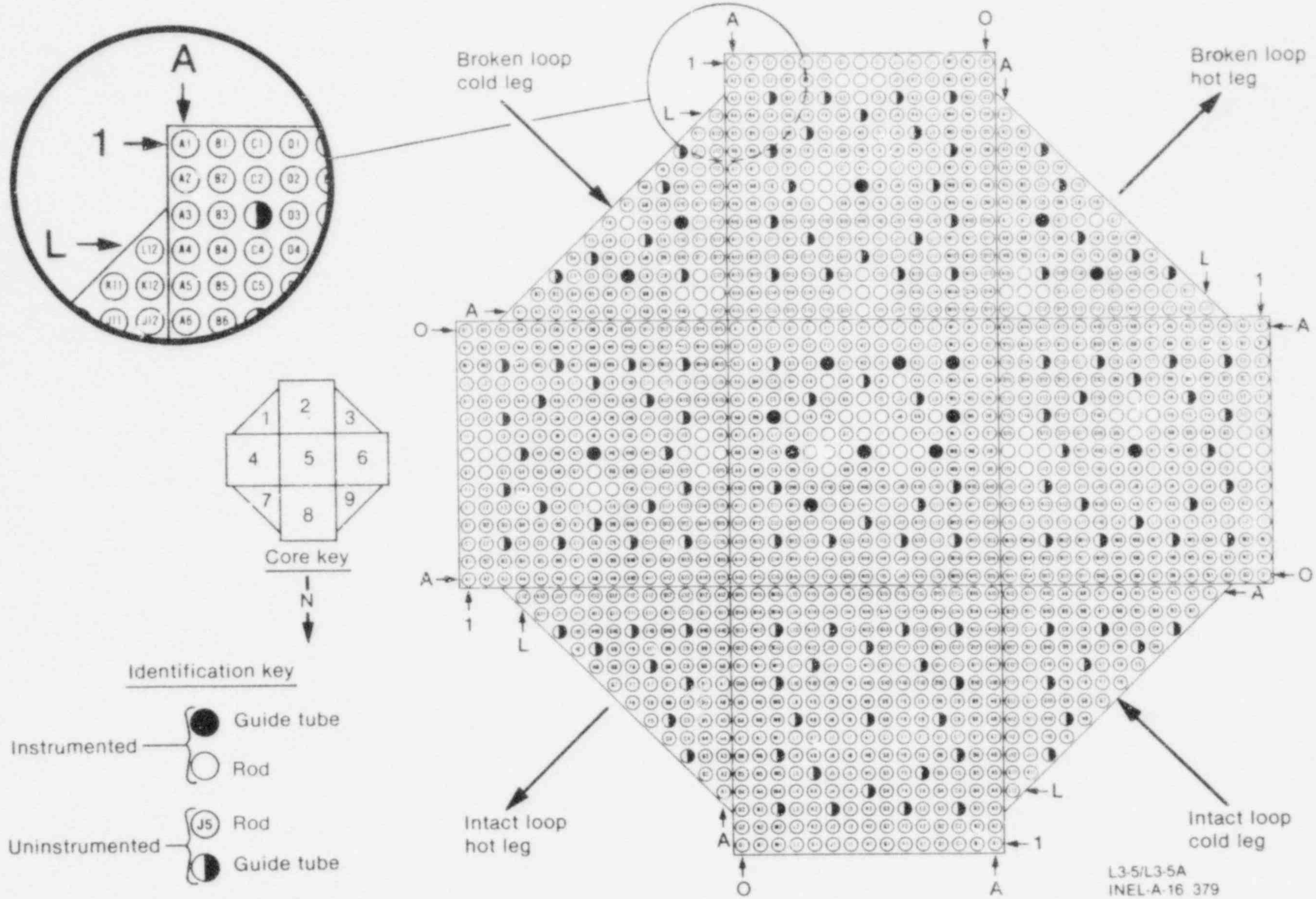

Figure A-3. LOFT core map showing position designations.

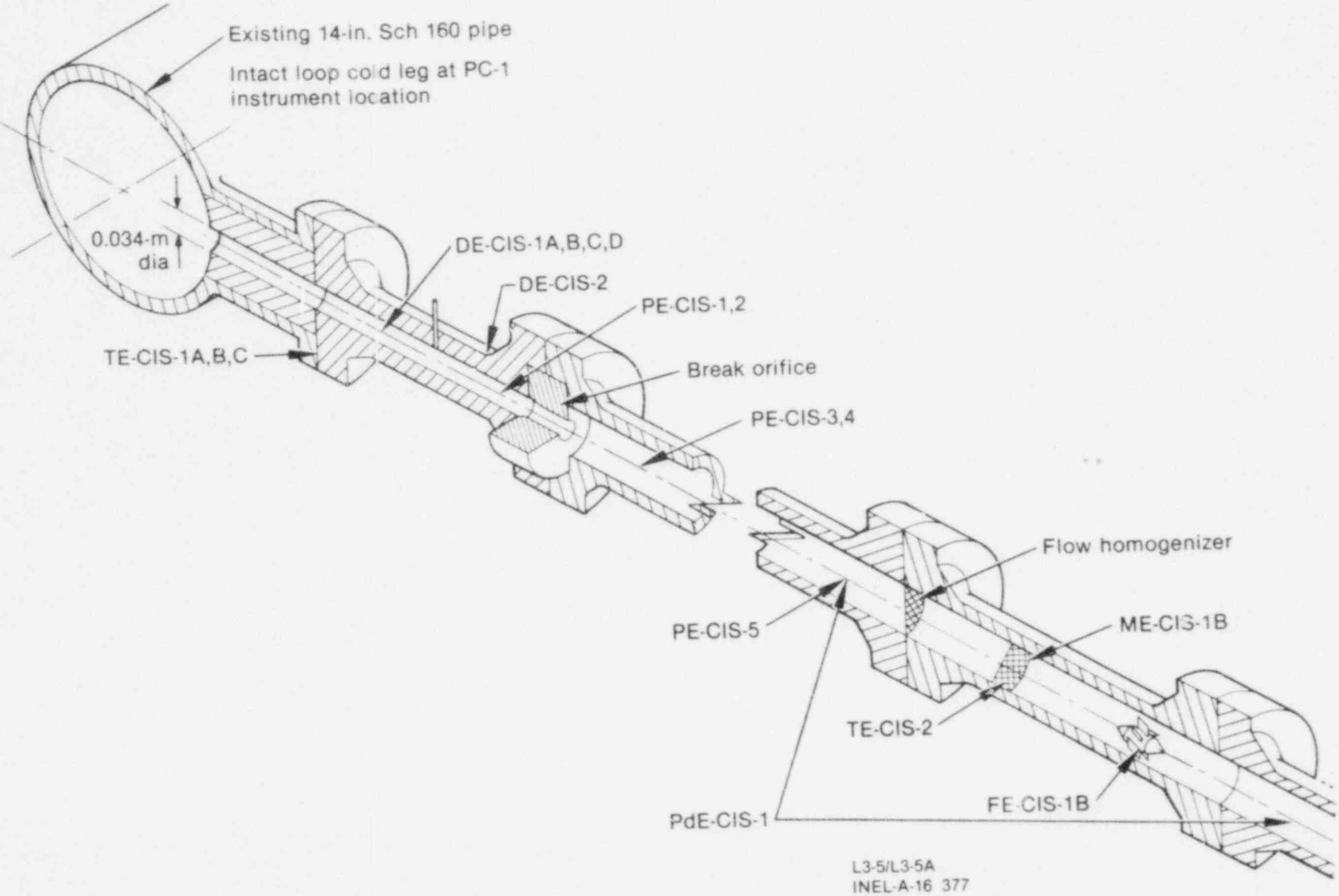

Figure A-4. LOFT spool pieces and small break orifice configuration.

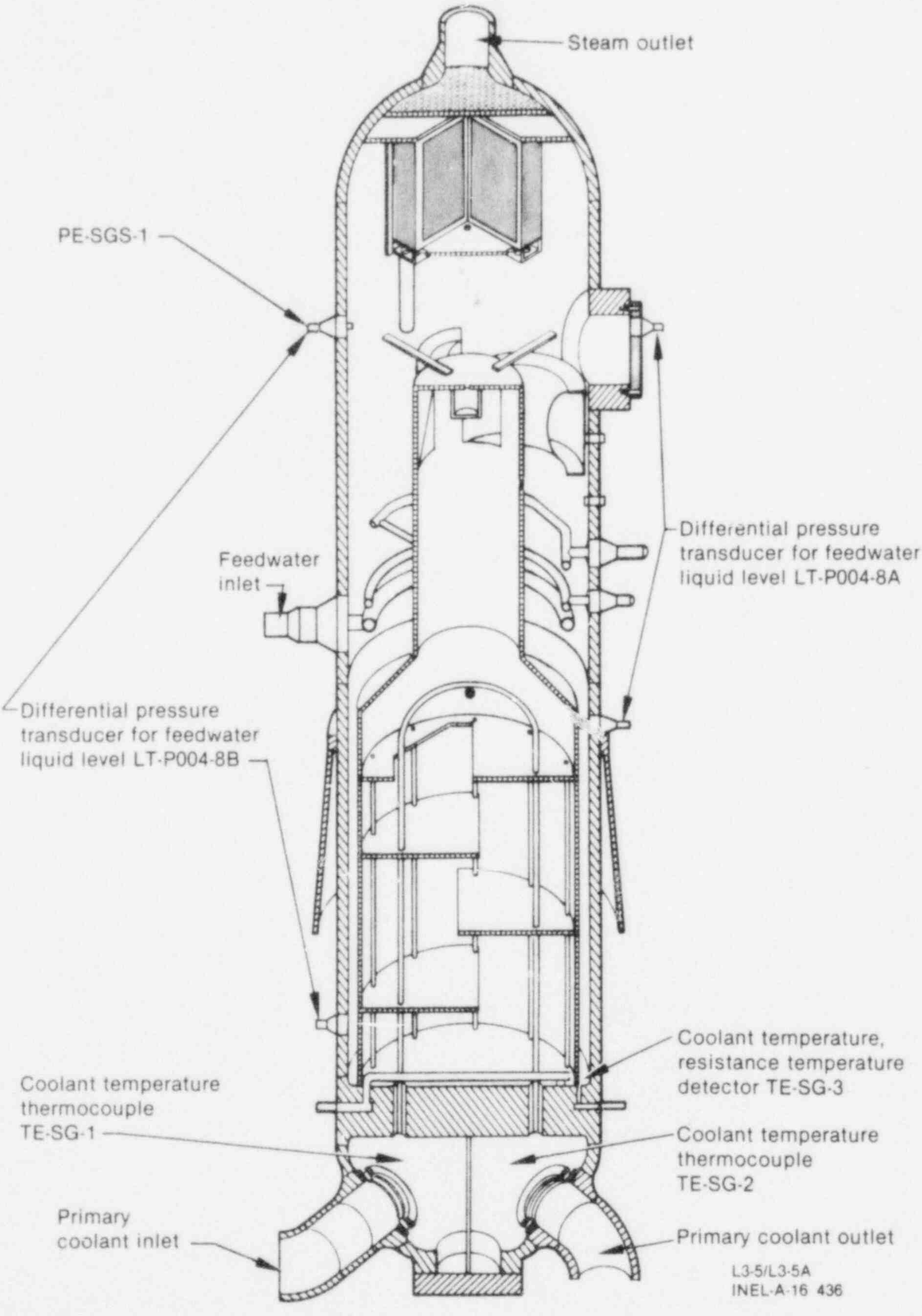

Figure A-5. LOFT steam generator and instrumentation.