JAERI-M
8746

# AN ANALYSIS OF CSNI STANDARD PROBLEM NO. 8

March 1980

Shinobu SASAKI and Fumimasa ARAYA

日 本 原 子 力 研 究 所
Japan Atomic Energy Research Institute

# An Analysis of CSNI Standard Problem NO.8

Shinobu SASAKI and Fumimasa ARAYA

Division of Reactor Safety Evaluation,
Tokai Research Establishment, JAERI

(Received January 31, 1980)

The CSNI International Standard Problem (ISP8), based on the Semiscale S-06-3 Test, was analyzed in the course of verification work of the computer code ALARM-P1. In this report, described was the result of the initial trial, which had been submitted to the CSNI. Due to the limitations of ALARM-P1 capability, only the blowdown portion of the transient was calculated. Though the hydraulic behavior before ECCS injection agreed with the test data, the ALARM-P1 could not continue calculation after 26 seconds due to severe predicted instability following the ECCS injection. The prediction of surface temperature of the heater rods was also unsatisfactory. Several problems to be improved have been identified both in the analytical model and the input data.

Key Word: Committee on Safety of Nuclear Installations-Standard Problem, Blowdown, Refill, Reflood, Loft L2-3, Semiscale Test

# CSNI標準問題No.8の解析

日本原子力研究所東海研究所安全解析部
佐々木　忍・新谷　文将

（1980年1月31日受理）

計算コードALARM－P1を用いてセミスケールS－06－3実験の解析がおこなわれたのでここに報告する。本問題は，1979年度NEA国際標準問題No.8として選ばれたものである。

本報告は，入力データ作成後CSNIに送付した最初の計算結果をまとめたものである。使用されたコードの性格上，リフィルリフラッドphaseの解析は除外され，ブローダウンの解析が中心となった。結果として，ECC水の注入以前の水力挙動は概ね実験データと一致してはいるが，ヒータ表面温度はかなり低く予測された。ECC水注入後は,解析モデルに起因する急激な圧力変動のため，26秒以降計算が続行できなかった。データとの比較検討の結果，解析手法と入力データの双方にいくつかの問題点が明らかになり，次回の再解析で十分改善されるであろう。

# 目　　次

# CONTENTS

List of Figures

## List of Tables

## 1. Introduction

One of the 1-1/2 loop Mod-1 experiments(1)~(4),(6),(11)* investigating the system behaviors of a light water-cooled nuclear reactor during a postulated loss-of-coolant-accident was analyzed using the computer code ALARM-P1.

The object of a simulation and analysis is a third test of the Semiscale Test Group 6, which was selected as the CSNI (Committee on Safety of Nuclear Installations) Standard Problem NO.8. This experiment, using an active core simulator, covers three different categories of a blowdown, refill and reflood, and is intended to offer a counterpart to the LOFT nuclear test L2-3.

A lay-out of the Semiscale test facility is exhibited in the Figure 1. A full description of the system configuration can be found in the references.(2),(3),(4) The experiment S-06-3 simulates an instantaneous 200 % double-ended cold leg break from the incipient conditions of about a 65 % rated power (1.005 MW). Emergency core cooling (ECC) water from AIS, HPIS, and LPIS was injected only into the intact loop cold leg. A reactor core, consisting of thirty-six electrically heated and four unpowered rods, simulates the LOFT nuclear fuels.

The present ALARM-P1 analysis was restricted to the decompression process up to 40 seconds from the initiation of the accident. Therefore, no calculation of the refill-reflood portions was made. The results of this preliminary analysis indicate that the thermal hydraulic behaviors in the system were reasonablly simulated, but the core heater thermal response not.

Comparative analysis of the experimental data provided some valuable suggestions regarding corrections of the input data and/or refinement of

*) Numbers in brackets designate References.

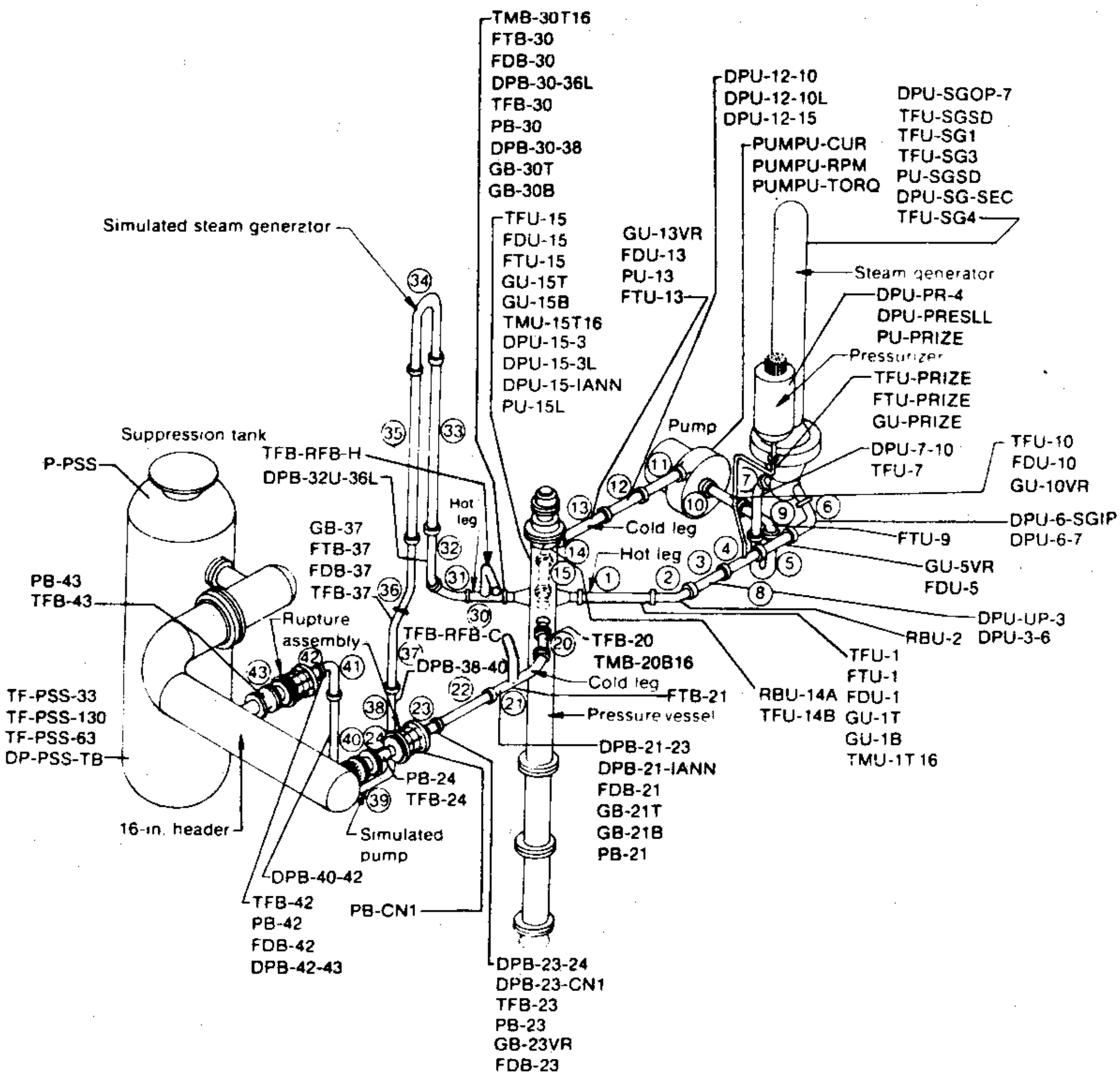


Fig. 1 Semiscale Mod-1 system and instrumentation for cold leg break configuration -- isometric.

the analytical model employed in ALARM-P1. The purpose of this report is to document the comparative analyses on the blowdown phase of the international standard problem 8 (ISP8) submitted to the CSNI.

## 2. System model and assumptions

The ALARM-P1 computational model for the Mod-1 facility is divided into 36 control volumes with 40 junctions as depicted in the Figure 2. The volume and junction geometrical data were picked out of the references.[(2),(3),(4)] A short description of this code is presented in the Table 1.

The core region was nodarized into five axially-stacked volume nodes according to the CSNI request. The upper-plenum and the upper-head was represented by a single combined compartment. The downcomer consists of two volumes: inlet annulus and downcomer annulus. The suppression tank and header were made up of one volume. In the Table 2 and 3, is listed an identification of each control volume and junction.

A bubble separation model, with a bubble density gradient and velocity of 0.8 and 0.914 m/s, respectively, was used in the pressurizer, steam generator secondary side, accumulator and the pressure suppression tank. The remaining control volumes were assumed to be in homogeneous fluid flow conditions.

HPIS (High Pressure Injection System), LPIS (Low Pressure Injection System) and feed water line were treated as fill junctions with time dependent data. On the other hand, the steam generator discharge valve was represented using a leak junction. The initial flow through the fill or leak junction was determined from the mass and energy balance.

the analytical model employed in ALARM-P1. The purpose of this report is to document the comparative analyses on the blowdown phase of the international standard problem 8 (ISP8) submitted to the CSNI.

## 2. System model and assumptions

The ALARM-P1 computational model for the Mod-1 facility is divided into 36 control volumes with 40 junctions as depicted in the Figure 2. The volume and junction geometrical data were picked out of the references.(2),(3),(4) A short description of this code is presented in the Table 1.

The core region was nodarized into five axially-stacked volume nodes according to the CSNI request. The upper-plenum and the upper-head was represented by a single combined compartment. The downcomer consists of two volumes: inlet annulus and downcomer annulus. The suppression tank and header were made up of one volume. In the Table 2 and 3, is listed an identification of each control volume and junction.

A bubble separation model, with a bubble density gradient and velocity of 0.8 and 0.914 m/s, respectively, was used in the pressurizer, steam generator secondary side, accumulator and the pressure suppression tank. The remaining control volumes were assumed to be in homogeneous fluid flow conditions.

HPIS (High Pressure Injection System), LPIS (Low Pressure Injection System) and feed water line were treated as fill junctions with time dependent data. On the other hand, the steam generator discharge valve was represented using a leak junction. The initial flow through the fill or leak junction was determined from the mass and energy balance.

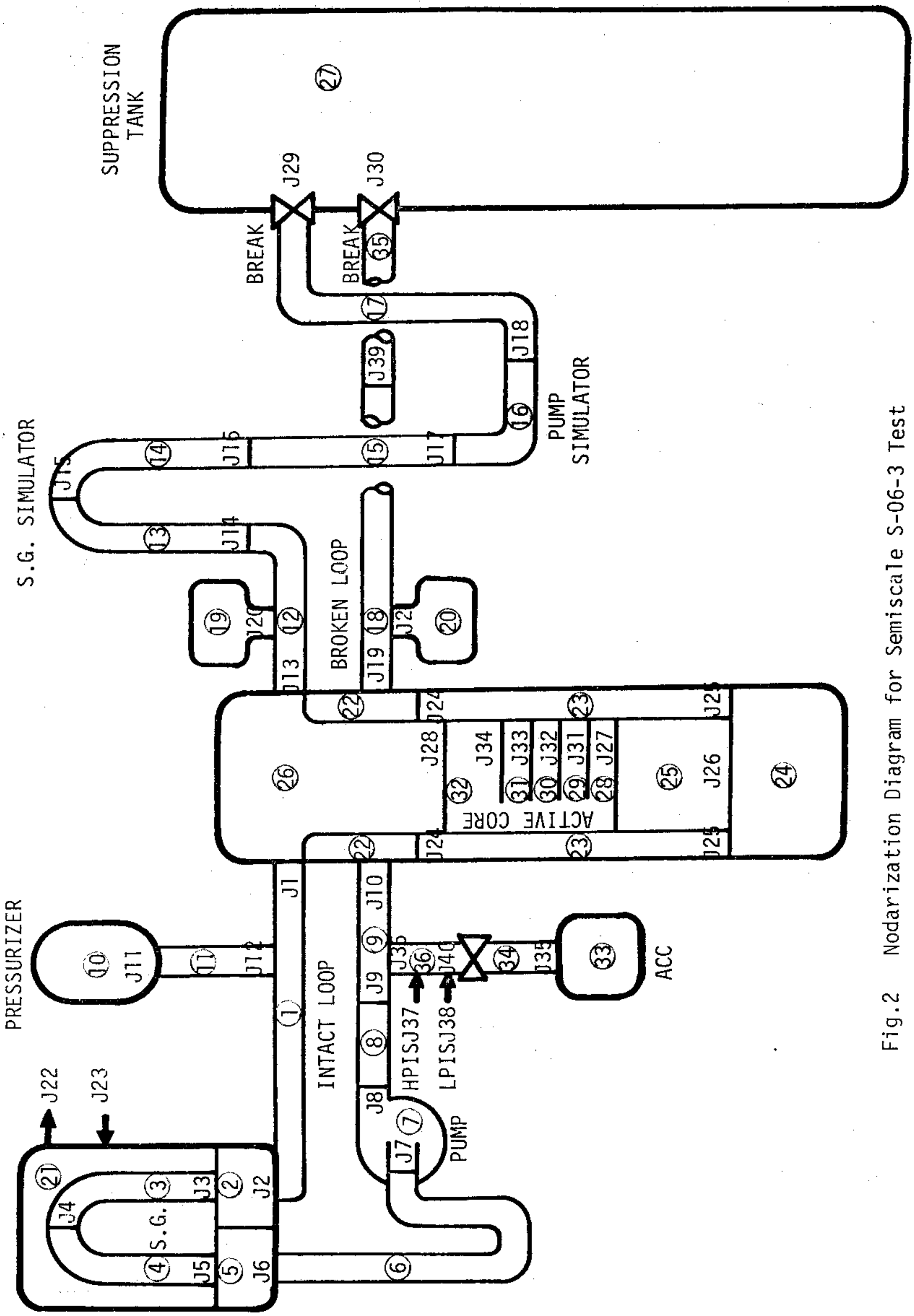


Fig.2 Nodarization Diagram for Semiscale S-06-3 Test

Seven heat slabs in all were used in the reactor core region and the intact loop steam generator U-tubes. In the present analysis, four hot fuel rods in the center were not simulated. Instead, the core was modelled with 40 low power rods, which was divided into five control volumes to predict the surface temperature of the elevation 8", 14", 28" and 39" above the bottom of the heated length of 66".
The initial power generation rates in the individual volumes were selected as follows:

| Volume NO. | Ratio |
|---|---|
| 28 | 0.1323 |
| 29 | 0.2307 |
| 30 | 0.2553 |
| 31 | 0.2086 |
| 32 | 0.1731 |

The critical flow model used at the break junctions is estimated by the Zaloudek and Moody correlation in the subcooled and the saturated region, respectively. The discharge coefficient of 0.6 was applied in common with two regions.

The pump is assumed to revolve at 1618 rpm as specified. The ALARM-P1 homologous curves equivalent to the RELAP-4 analytical model were given by input. The cavitation effects at the two-phase flow region and the frictional torque were neglected.
For the T-shaped connection (i.e., pressure vessel inlet and outlet, pressurizer surge line outlet and ECC entrance) momentum flux terms were optionally removed.
Break was simulated by a valve which was fully opened within 10 micro seconds. ALARM-P1 employs a forward explicit method in solving the differential equations without any automatic time step control.

Table 1 Basic Features of ALARM-P1 Code

| | |
|---|---|
| Used language | FORTRAN-IV (for FACOM 230 computer) |
| Range of Application | PWR-LOCA with large breaks (only blowdown phase) |
| Assumptions of governing equations and fluid state | (i) one dimensional fluid equation (mass, energy and momentum) and state equation<br>heat transfer equation<br>reactor kinetic equation (IREK)<br>(ii) lumped parameter (node and junction type)<br>(iii) homogeneous flow<br>(iv) thermal equilibrium |
| Solution technique | Fully explicit method except for Crank Nicolson model in the conduction equation solutions |
| Time step size | Specified by user |
| Friction factor | Single phase : Fanning smooth pipe<br>Two phase : Thom and Martinelli-Nelson |
| Phase separation model | Homogeneous or bubble rise model.<br>Bubble rise velocity and bubble density gradient is required as input data. |
| Slip model | None |
| Critical flow model | $x \leq 0.02$ : Zaloudek<br>$x \geq 0.02$ : Moody<br>Superheated : Murdock-Bauman<br>$C_D$ (contraction coeff. input) |
| Pump model | Single phase model by homologous law (non-cavitated) |
| Heat transfer coeff. | According to ANCR-1127 |
| Dryout correlation | B&W-2, Barnett, Modified Barnett |

In the present calculation, the time step widths were sellected as follows.

| | |
|---|---|
| $0.0 \le t \le 0.01$ (sec) | $\Delta t = 0.000005$ (sec) |
| $0.01 \le t \le 0.05$ (sec) | $\Delta t = 0.00001$ (sec) |
| $0.05 \le t \le 0.3$ (sec) | $\Delta t = 0.000025$ (sec) |
| $0.3 \le t \le 0.5$ (sec) | $\Delta t = 0.00005$ (sec) |
| $0.5 \le t \le 5.0$ (sec) | $\Delta t = 0.0001$ (sec) |
| $5.0 \le t \le 10.0$ (sec) | $\Delta t = 0.00025$ (sec) |
| $10.0 \le t \le 17.0$ (sec) | $\Delta t = 0.0005$ (sec) |
| $17.0 \le t \le 25.0$ (sec) | $\Delta t = 0.0001$ (sec) |
| $25.0 \le t \le 30.0$ (sec) | $\Delta t = 0.0002$ (sec) |
| $30.0 \le t \le 40.0$ (sec) | $\Delta t = 0.0004$ (sec) |

The junction inertia ($\ell/A$) and form loss coefficient for complicated configurations were estimated by hand calculations. Particularly, K-factor was determined so as to minimize the residual friction loss. The initial conditions used in this calculation are given in the Table 4. In addition, Appendix 1 shows the entire input data list.

## 3. Results and comparisons with experimental data

The calculated results by ALARM-P1 were compared with the Semiscale S-06-3 test data[1] in Figures 3 through 48. In these figures, the calculated results were denoted by "A".
Only key parameters requested by the CSNI were mentioned in this section.(Figures 44 to 48 are not the requested parameters.) The experimental data was retrieved from the Semiscale data tape recorded. Application of this tape was made through the LOFT plotter program[12],[13] by the introduction of the detector code names (i.e., function codes) similar to the LOFT function codes as listed in Appendix 2. In this section, a simple outline of the calculated results obtained using this code is given. The blowdown calculation was terminated at approximately

In the present calculation, the time step widths were sellected as follows.

| | |
|---|---|
| $0.0 \le t \le 0.01$ (sec) | $\Delta t = 0.000005$ (sec) |
| $0.01 \le t \le 0.05$ (sec) | $\Delta t = 0.00001$ (sec) |
| $0.05 \le t \le 0.3$ (sec) | $\Delta t = 0.000025$ (sec) |
| $0.3 \le t \le 0.5$ (sec) | $\Delta t = 0.00005$ (sec) |
| $0.5 \le t \le 5.0$ (sec) | $\Delta t = 0.0001$ (sec) |
| $5.0 \le t \le 10.0$ (sec) | $\Delta t = 0.00025$ (sec) |
| $10.0 \le t \le 17.0$ (sec) | $\Delta t = 0.0005$ (sec) |
| $17.0 \le t \le 25.0$ (sec) | $\Delta t = 0.0001$ (sec) |
| $25.0 \le t \le 30.0$ (sec) | $\Delta t = 0.0002$ (sec) |
| $30.0 \le t \le 40.0$ (sec) | $\Delta t = 0.0004$ (sec) |

The junction inertia ($\ell/A$) and form loss coefficient for complicated configurations were estimated by hand calculations. Particularly, K-factor was determined so as to minimize the residual friction loss. The initial conditions used in this calculation are given in the Table 4. In addition, Appendix 1 shows the entire input data list.

## 3. Results and comparisons with experimental data

The calculated results by ALARM-P1 were compared with the Semiscale S-06-3 test data[1] in Figures 3 through 48. In these figures, the calculated results were denoted by "A".
Only key parameters requested by the CSNI were mentioned in this section.(Figures 44 to 48 are not the requested parameters.) The experimental data was retrieved from the Semiscale data tape recorded. Application of this tape was made through the LOFT plotter program[12],[13] by the introduction of the detector code names (i.e., function codes) similar to the LOFT function codes as listed in Appendix 2. In this section, a simple outline of the calculated results obtained using this code is given. The blowdown calculation was terminated at approximately

Table 2 Geometrical Description of Semiscale S-06-3 Model Control Volumes

| Control volume | Description | Volume($m^3$) | Flow Area($m^2$) |
|---|---|---|---|
| 1 | Intact loop hot leg piping | 0.01082 | 0.00349 |
| 2 | Steam Generator inlet plenum | 0.00963 | 0.01984 |
| 3 | Steam generator U-tubes | 0.01140 | 0.00442 |
| 4 | Steam generator U-tubes | 0.01140 | 0.00442 |
| 5 | Steam generator outlet plenum | 0.00963 | 0.01984 |
| 6 | Pump suction leg | 0.01018 | 0.00349 |
| 7 | Primary coolant pump | 0.00408 | 0.00349 |
| 8 | Cold leg piping | 0.00425 | 0.00349 |
| 9 | Cold leg piping | 0.00425 | 0.00349 |
| 10 | Pressurizer | 0.02741 | 0.02400 |
| 11 | Pressurizer surge line | 0.00037 | 4.3E-5 |
| 12 | Broken loop hot leg piping | 0.00315 | 0.00349 |
| 13 | S.G. simulator | 0.00852 | 0.00374 |
| 14 | S.G. simulator | 0.00852 | 0.00374 |
| 15 | Outlet piping from S.G. simulator | 0.00252 | 0.00158 |
| 16 | Pump simulator | 0.00147 | 0.00198 |
| 17 | Break node | 0.00227 | 0.00145 |
| 18 | Broken loop cold leg | 0.00461 | 0.00349 |
| 19 | Reflood assist by-pass piping | 0.00538 | 0.00349 |
| 20 | Reflood assist by-pass piping | 0.00640 | 0.00349 |
| 21 | Secondary side of steam generator | 0.19820 | 0.04255 |
| 22 | Upper annular region of the vessel inlet region | 0.00504 | 0.00548 |
| 23 | Downcomer region | 0.02183 | 0.00534 |
| 24 | Lower plenum | 0.02161 | 0.00623 |
| 25 | Turbine flowmeter housing | 0.00371 | 0.00713 |
| 26 | Upper plenum | 0.02620 | 0.00713 |
| 27 | Pressure Suppression tank | 3.17549 | 0.70205 |

Table 2 (continued)

| Control volume | Description | Volume($m^3$) | Flow Area($m^2$) |
|---|---|---|---|
| 28 | Active core region | 0.00137 | 0.00492 |
| 29 | Active core region | 0.00137 | 0.00492 |
| 30 | Active core region | 0.00137 | 0.00492 |
| 31 | Active core region | 0.00137 | 0.00492 |
| 32 | Active core region | 0.00274 | 0.00492 |
| 33 | ECCS-accumulator | 0.00145 | 0.03812 |
| 34 | ECCS-injection line | 0.00244 | 0.00046 |
| 35 | Break node | 0.00161 | 0.00349 |
| 36 | ECCS-injection line | 0.00244 | 0.00046 |

Table 3 Junction Description of ALARM-P1 Model

| Junction | Volumes (From) | Volumes (To) | Flow Area (m²) | Form Loss Coefficients Forward | Form Loss Coefficients Reverse |
|---|---|---|---|---|---|
| 1 | 26 | 1 | 0.00183 | 0.0 | 0.0* |
| 2 | 1 | 2 | 0.00349 | 6.198 | 6.198 |
| 3 | 2 | 3 | 0.00442 | 0.0 | 0.0 |
| 4 | 3 | 4 | 0.00442 | 0.0 | 0.0 |
| 5 | 4 | 5 | 0.00442 | 0.0 | 0.0 |
| 6 | 5 | 6 | 0.00349 | 15.4395 | 15.4395 |
| 7 | 6 | 7 | 0.00349 | 5.30 | 4.86 |
| 8 | 7 | 8 | 0.00349 | 1.65 | 1.65 |
| 9 | 8 | 9 | 0.00349 | 0.467 | 7.32 |
| 10 | 9 | 22 | 0.00183 | 0.658 | 1.466 |
| 11 | 10 | 11 | 4.3E-5 | 10.8 | 10.8 |
| 12 | 11 | 1 | 4.3E-5 | 0.0 | 0.0 |
| 13 | 26 | 12 | 0.00183 | 0.677 | 1.2144 |
| 14 | 12 | 13 | 0.00024 | 1.41181 | 1.41146 |
| 15 | 13 | 14 | 0.00349 | 285.435 | 285.435 |
| 16 | 14 | 15 | 0.00024 | 1.40405 | 1.41583 |
| 17 | 15 | 16 | 0.00024 | 0.844137 | 1.54353 |
| 18 | 16 | 17 | 0.00024 | 12.8823 | 12.438 |
| 19 | 22 | 18 | 0.00183 | 0.677051 | 1.21442 |
| 20 | 19 | 12 | 0.00349 | 0.0 | 0.0 |
| 21 | 20 | 18 | 0.00349 | 0.0 | 0.0 |
| 22 | 21 | 0 | 0.00203 | 0.0 | 0.0 |
| 23 | 0 | 21 | 0.00113 | 0.0 | 0.0 |
| 24 | 22 | 23 | 0.00534 | 3.9706E-2 | 2.2542E-3 |
| 25 | 23 | 24 | 0.00534 | 4.6518E-2 | 0.1465 |
| 26 | 24 | 25 | 0.00713 | 19.569 | 19.569 |
| 27 | 25 | 28 | 0.00492 | 10.5898 | 10.5898 |
| 28 | 32 | 26 | 0.00492 | 7.2754 | 7.2754 |
| 29 | 17 | 27 | 0.00024 | 1.00777 | 1.13360 |
| 30 | 35 | 27 | 0.00024 | 1.38245 | 1.15464 |
| 31 | 28 | 29 | 0.00492 | 0.0 | 0.0 |
| 32 | 29 | 30 | 0.00492 | 0.0 | 0.0 |
| 33 | 30 | 31 | 0.00492 | 0.0 | 0.0 |

Table 3 (continued)

| Junction | Volumes (From) | Volumes (To) | Flow Area (m²) | Form Loss Coefficients Forward | Form Loss Coefficients Reverse |
|---|---|---|---|---|---|
| 34 | 31 | 32 | 0.00492 | 0.0 | 0.0 |
| 35 | 33 | 34 | 0.00046 | 71.095 | 1.0E-6 |
| 36 | 36 | 9 | 0.00046 | 71.095 | 1.0E-6 |
| 37 | 0 | 36 | 0.00015 | 0.0 | 0.0 |
| 38 | 0 | 36 | 0.00028 | 0.0 | 0.0 |
| 39 | 18 | 35 | 0.00349 | 1.0E-10 | 1.0E-10 |
| 40 | 34 | 36 | 0.00046 | 142.19 | 1.0E-6 |

*) "0.0" denotes automatic calculation option incorporated in ALARM-P1 code

## Table 4 Initial Conditions

**Pressure** ($kg/cm^2$)

| | |
|---|---|
| Upper-plenum | 160.8298 |
| Pressurizer | 160.7948 |
| Steam Generator Secondary | Sat. at 284 °C |
| Accumulator | 45 |
| Pressure suppression | 2.48 |

**Fluid Temperature** (°C)

| | |
|---|---|
| Core inlet fluid temperature | 290.889 |
| Core outlet fluid temperature | 326.444 |
| Broken loop cold leg | 288.80 |
| Broken loop hot leg | 322.96 |
| Broken loop hot leg break node | 316.97 |
| Accumulator tank | 27.778 |
| Pressure suppression | 16.1 |
| Feed water supply system | 204.8 |
| HPIS, LPIS | 27.778 |
| Reflood bypass line: Hot leg side | 315.85 |
| Reflood bypass line: Cold leg side | 288.85 |

**ECC Injection**

| | |
|---|---|
| Accumulator: | |
| Water volume | 0.08 ($m^3$) |
| Gas volume | 0.058 ($m^3$) |
| Initiation pressure | 42.19 ($kg/cm^2$) |
| HPIS: | |
| Injection initiation | 126.58 ($kg/cm^2$) |
| Injection rate | 0.0149 (kg/s)($0.0 \leq t \leq 30.0$) |
| | 0.0817 (kg/s)(30801 $\leq t \leq 50.0$) |
| LPIS: | |
| Injection initiation | 17.58 ($kg/cm^2$) |
| Injection rate | 0.299 (kg/s)($0 \leq t \leq 50.0$) |

(t : time after tripping)

**Others**

| | |
|---|---|
| Core power | 1.0058 (MW) |
| Core flow rate | 4.899 (kg/s) |
| Primary pump speed | 1618.9 (rpm) |
| Pressurizer liquid level | 0.625 (m) |
| Steam generator liquid level | 2.9 (m) |

Table 5 Parameters Requested for ISP8 Comparison

| Required Parameters | Location |
|---|---|
| (1) Pressures (kPa) | |
| PU-PRIZE | Pressurizer pressure |
| PB-42 | Upstream of break nozzle (pump side) |
| PB-23 | Upstream of break nozzle (reactor vessel side) |
| PV-UP+10 | Upper plenum |
| PU-ACC | Intact loop accumulator |
| PU-SGSD | Steam generator secondary side |
| (2) Differential pressures (kPa) | |
| DPU-12-10 | Across pump |
| DPU-7-10 | Across pump suction |
| DPB-32-36L | Across simulated steam generator |
| DPB-38-40 | Across simulated pump |
| DPV-LP-UP | Across core |
| (3) Flow rates (KG/s, ℓ/s) | |
| FTV-COREIN | Core inlet flow |
| FDB-42, GB-42VR | Break nozzle flow (pump side) |
| FDB-23, GB-23VR | Break nozzle flow (reactor vessel side) |
| FTU-15 | Intact loop cold leg flow |
| FTU-PRIZE | Pressurizer surge line flow |
| FTU-LPIS | Intact loop LPIS flow |
| FTU-HPIS | Intact loop HPIS flow |
| FTU-ACC | Intact loop accumulator flow |
| FDU-10, GU-10 | Mass flow rate in spool 10 |
| (4) Fluid density (kg/m$^3$) | |
| GB-42VR | Break volume density (pump side) |
| GB-23VR | Break volume density (reactor vessel side) |
| GU-15C | Intact loop cold leg density |
| GU-10 | Pump inlet density |
| GVCOR-150HZ | Core inlet density |
| GV161-192D | Lower plenum density |
| (5) Fluid temperature (°K) | |
| TFU-PRIZE | Pressurizer surge line fluid temperature |
| TFB-23 | Fluid temperature upstream of break |
| TFV-UP+13 | Fluid temperature in upper plenum |

Table 5 (continued)

| Required Parameters | Location |
|---|---|
| (6) Metal temperatures (°K) | |
| Rod surface temperatures on average rod (7.59 kW/ft) | Elevations of 8", 14", 28", and 39" above bottom of heated length |
| (7) Quality and heat transfer coefficient MW/m *K) | |
| | Same elevations in core corresponding to the thermocouples for the heater rod temperatures |
| (8) Mass Inventory (kg) | |
| FDB-23, FDB-42 | Integrated mass leaving the system through break junctions |

26 seconds into the transient due to the mass depletion in the core inlet volume (mixer housing).

### 3.1 Break flow and system pressure

The break flow through the cold leg at the initial period of blowdown significantly disagrees with the experimentally observed data as seen in the Figure 3, though the reported mass flow rate data may contain some extent of errors due to inaccurate measurements of momentum flux and fluid density. On examination, the major discrepancy is attributable to the treatment of the discharge coefficient applied to both the subcooled and the saturated regions. The present ALARM-P1 is modelled so as to use the same discharge coefficient irrespective of the two distinguished regions, which was 0.6 in the present calculation. Consequently, the Zaloudek critical flow at the subcooled or low quality phase (< 0.02) underpredicted the test data, while the choked flow at the Moody's region is in better agreement.
On the other hand, the vessel side break flow (JW 29) in the Figure 4 was predicted pretty well because the fluid in the hot leg line flashed immediately after the rupture and the Zaloudek correlation had an insignificant effect on the flow through the valve. Thus, an improvement at the subcooled or low quality phase (< 0.02) could evidently be made if a multiplier other than 0.6 was used to Zaloudek correlation.
As can be seen in Figures 5 and 6, the overall decompression transient up to the ECC injection agreed reasonably with the S-06-3 measured data. The pressure profiles in both the broken loop cold leg and hot leg were almost correctly predicted. A slight pressure difference in the Figure might come from the resistance factor across the pump simulator (see Fig.8). Differential pressure across the steam generator simulator

was not far from agreement (see Figure 9). As indicated in the Figure 7, the upper-plenum pressure representative of the whole system pressure was estimated somewhat low, which resulted in the initiation of the accumulator flow earlier than observed (see Figure 13). After the start of ECC injection, the rapid depressurization in the calculation produced untraceable disagreement with the experimental data. For example, the measured temperature in the upper-plenum, as seen in the Figure 33, was in the superheated state unlike the calculated result. This problem is of particular importance in order to analyze the effect of ECCS. In the current model, an assumed instantaneous mixing of two different fluids causes an unphysically severe transient, and is the principal factor unabling the continuation of the calculations. In the lower-plenum calculation shown in the Figure 34, more control volumes should have been employed because the fluid temperature and flow were significantly different between lower and upper parts of the lower-plenum.

## 3.2 ECCS behaviors

As mentioned above, the initiation time of the accumulator injection was predicted slightly earlier (see Figures 10, 13). Moreover, the injection flow (volumetric) was overpredicted condsiderably from the measured data. This was mainly due to the fact that the system pressure was calculated to drop faster than that in the experiment.
In the Figure 10, the disagreement of the initial state prior to injection is unknown. ALARM-input data was taken from the reference (7). After the initiation of the coolant inflow, the incompatibility of the decompression rate between the two is possibly ascribable to overrating of gas volume input data. This value in the tank was input in accordance with the initial condition in the same reference. In addition the

calculated temperature in the accumulator line (see Figure 44) seemed unreasonable. On investigation, an error was found in the program which was solely responsible for such a temperature behavior.

The small differences in the temperature before injection may be improved by considering heat transfer between the structure and the fluid. At all events, the control volume in this surge line had better be removed from the model shown in the Figure 2. The behaviors of HPIS and LPIS were given in the Figures 11 and 12.

### 3.3 Rod surface temperature in low power heater

The surface temperature response in the average channels was calculated much lower than the experimental data. Temperature traces in Figures 14 to 17 were measured at elevations 8", 14", 28" and 39", respectively above the bottom of the core.

In the calculation, the heat transfer area and slab volume in the reactor core were determined for fourty heater rods. In reality, heater rods were thirty six and the others unheated. This data should be corrected at the re-analyses. The predicted time of DNB at all elevations was slightly earlier as compared with the data. These figures indicate that the surface temperature increase tends to be arrested when heat transfer falls into the pool film boiling mode.

The current correlation in this mode is based on the Berenson's, which is insensitive to local flow conditions of the core inlet or outlet because it is represented as a simple function of the bulk pressure and $\Delta T_{sat}$ · ($h = F(p)(\Delta T)^{\frac{4}{3}}$ ). Accordingly, the heat transfer coefficients became stable in the pool film boiling mode as seen in Figs.35~38, and they were presumably too large resulting in the predicted low temperature. As used in the RELAP/MOD5,[14] the modified Bromley correlation may predict a lower coefficient than the Berenson model.

Rewetting phenomena were calculated during blowdown at the elevations 8" and 39", and at all elevations at the initiation of the accumulator injection while no rewetting was observed in the experiment. The reason of such unrealistic rewetting is now under examination.

## 3.4 Core flow

Although the core flow traces the test data to a considerable degree till the emergency cooling is initiated, the inflow of the accumulator liquid into the cold leg piping produced the drastic fluctuations (see Figure 18). The direction of the computed flow was predominantly downward. As seen in this figure, the ECC mixing model has a great influence on the core flow characteristics.
After 8 seconds did dissimilarity of the core flow directions make a significant difference in the density of core inlet volume (see Figure 19).

## 3.5 Temperature and density in the break volume

The temperature and density transient in the broken loop are shown in the Figures 20 to 22. The prediction of the pump side break density compares well to the data, while improvements should be directed to the cold leg density. The influence of ECCS is visible since 22 seconds.

## 3.6 Intact loop features

The comparisons of the intact loop characteristics are given in the Figures 23 to 31. The great fluctuations due to condensation effects by the ECC injection were manifestly demonstrated. With the exception of this problem, the calculated results were generally close to the experimental data. The predictions of the pressurizer and steam generator secondary system are necessary to be improved (see Figures 27 to 30). Probably the one ascribes to input data such as the K-factor, ℓ/A and bubble rise data while the other to the timing of a trip action in the fill/leak systems.

## 4. Conclusions

Based on the calculation results obtained, the following conclusions were reached. Only the blowdown portion of the S-06-3 Test was evaluated due to the inability of this code to calculate the refill/reflood behaviors. The prediction of the fluid pressure, density and the temperature up to the ECC injection was reasonably satisfactory. The overall system behavior after the ECC injection was far from satisfaction unabling the further continuation of the computation.
The surface temperature was much underpredicted. The cause of this underprediction should be carefully examined. Through the present analysis, the following several problems to be improved were found. These informations acquired are expected to serve the betterment of the present results or the future code assessment study.

(A) Input data

1. Corrections to provide more exact representation for all the junction configuration such as inertia and formloss coefficients (In particular, the inlet and outlet of the pressurizer, steam generator and the pressure vessel).
2. Nodarization

   Removal of ECC surge line. Two or more control volumes for the lower plenum, two channel model for the downcomer.

experimental data. The predictions of the pressurizer and steam generator secondary system are necessary to be improved (see Figures 27 to 30). Probably the one ascribes to input data such as the K-factor, $\ell$/A and bubble rise data while the other to the timing of a trip action in the fill/leak systems.

## 4. Conclusions

Based on the calculation results obtained, the following conclusions were reached. Only the blowdown portion of the S-06-3 Test was evaluated due to the inability of this code to calculate the refill/reflood behaviors. The prediction of the fluid pressure, density and the temperature up to the ECC injection was reasonably satisfactory. The overall system behavior after the ECC injection was far from satisfaction unabling the further continuation of the computation.
The surface temperature was much underpredicted. The cause of this underprediction should be carefully examined. Through the present analysis, the following several problems to be improved were found. These informations acquired are expected to serve the betterment of the present results or the future code assessment study.

(A) Input data

1. Corrections to provide more exact representation for all the junction configuration such as inertia and formloss coefficients (In particular, the inlet and outlet of the pressurizer, steam generator and the pressure vessel).
2. Nodarization
   Removal of ECC surge line. Two or more control volumes for the lower plenum, two channel model for the downcomer.

3. ECCS

   Examination of the accumulator gas volume shown in the reference.

4. Core

   Correction of the heat transfer data in the core by reducing four heater pins' area and volume.

5. Steam generator

   A more reasonable data set about fill/leak trip data in the steam generator secondary side.

6. Time Step

   A smaller size after the accumulator injection.

(B) Analytical models in the code

1. The treatment of the contraction coefficients in the critical flows
2. Heat transfer correlation and mode selection to make the quantitative investigations between Bromley and Berenson model in the pool film boiling.
3. Modification of the junction enthalpy routine.
4. Check of numerical values in two-phase friction multiplier given in block data (In particular, in Martinelli-Nelson region).
5. Modification of the pump model so as to give a more reasonable revolution during blowdown.
6. Condensation effects due to mixing during the emergency cooling water injections

## 5. References

(1) B.L. Collins, et al., "Experiment Data Report for Semiscale Mod-1 Test S-06-3 (LOFT Counterpart Test)", NUREG/CR-0251, TREE-1123, July, 1978

3. ECCS

   Examination of the accumulator gas volume shown in the reference.

4. Core

   Correction of the heat transfer data in the core by reducing four heater pins' area and volume.

5. Steam generator

   A more reasonable data set about fill/leak trip data in the steam generator secondary side.

6. Time Step

   A smaller size after the accumulator injection.

(B) Analytical models in the code

1. The treatment of the contraction coefficients in the critical flows
2. Heat transfer correlation and mode selection to make the quantitative investigations between Bromley and Berenson model in the pool film boiling.
3. Modification of the junction enthalpy routine.
4. Check of numerical values in two-phase friction multiplier given in block data (In particular, in Martinelli-Nelson region).
5. Modification of the pump model so as to give a more reasonable revolution during blowdown.
6. Condensation effects due to mixing during the emergency cooling water injections

## 5. References

(1) B.L. Collins, et al., "Experiment Data Report for Semiscale Mod-1 Test S-06-3 (LOFT Counterpart Test)", NUREG/CR-0251, TREE-1123, July, 1978

(2) L.J. Ball, et al., "Semiscale Program Description", TREE-NUREG-1210, May, 1978

(3) W.D. Laning, "System Design Description for the 1-1/2-Loop Mod-1 Semiscale System" (SDD1), June, 1975

(4) E.M. Feldman, D.J. Olson, "Semiscale Mod-1 Program and System Description for the Blowdown Heat Transfer Tests (TEST SERIES 2)", ANCR-1230, August, 1975

(5) L.E. Phillips, letter to International Standard Problem Participants, "Reference for Standard Problem NO.8 (Semiscale Test S-06-3)", May 8, 1978

(6) Appendix 6 Experimental Operating Specifications Tests S-06-1 through S-06-5 LOFT Counterpart Tests in the Mod-1 System (Test Series 6) Semiscale Program, Feburary, 1977

(7) D.J. Olson, letter to R.E. Tiller, "Transmittal of Initial Conditions-Semiscale Mod-1 Test S-06-3 (Regulatory Standard Problem 8)", DJO-222-77, November 28, 1977

(8) D.J. Olson, letter to R.E. Tiller, "Test S-06-3 (Standard Problem 8) PSS Prenure", DJO-4-78

(9) D.J. Olson, letter to R.E. Tiller, "Transmittal of Additional Requested Conditions-Semiscale Mod-1 Test S-06-3 (Regulatory Standard Problem 8), DJO-35-78, March 28, 1978

(10) L.E. Phillips to International Standard Problem Participants, "Additional Informations-CSNI Standard Problem NO.8" (Semiscale Test S-06-3), December 21, 1978

(11) P.M. Lang to P.E. Litteneker, "Transmittal of Mod-1 Experimental Operating Specification", PML-32-74, January 31, 1974

(12) K. Soda, et al., "LFTPLT7-LOFT Plotter Program", JAERI-M 7695, April 27, 1978

(13) K. Soda, et al., "Editting System of LOFT Data Tape", JAERI-memo 7861, September, 1978

(14) "RELAP4/MOD5 — A Computer Program for Transient Thermal-Hydraulic Analysis of Nuclear Reactors and Related Systems user's manual", Volume 1, ANCR-NUREG-1335, September 1976

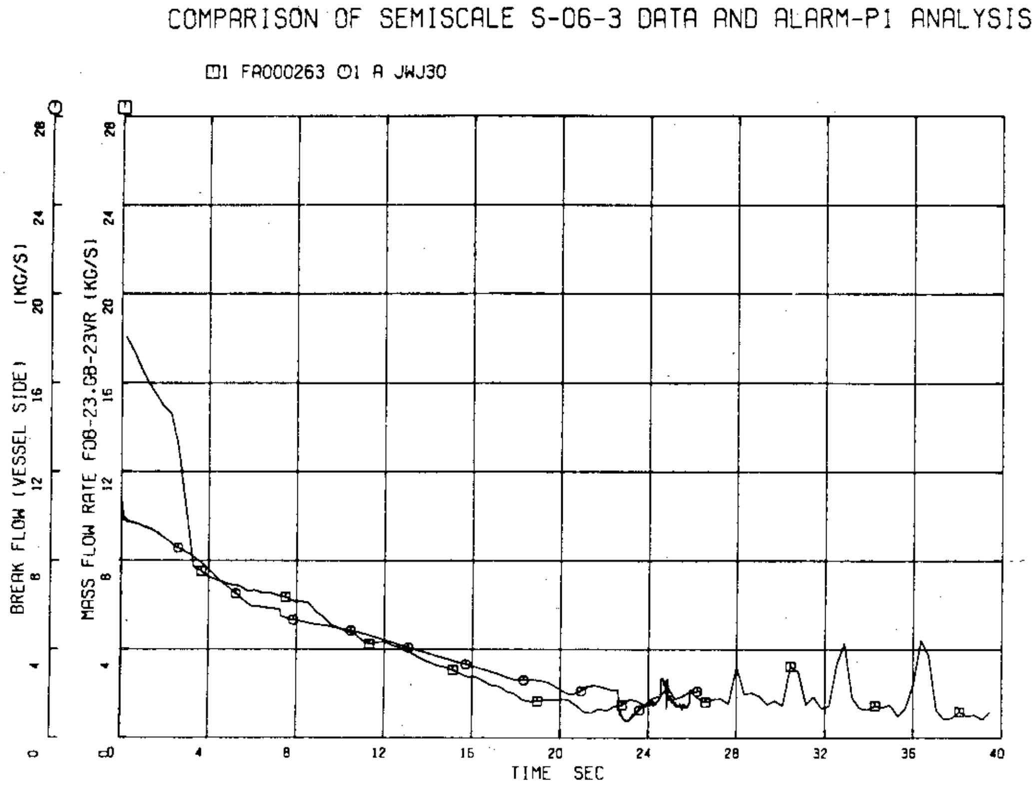


Fig.3 Mass Flow Rate at Break Nozzle — Reactor Vessel Side (FDB-23, GB-23VR)

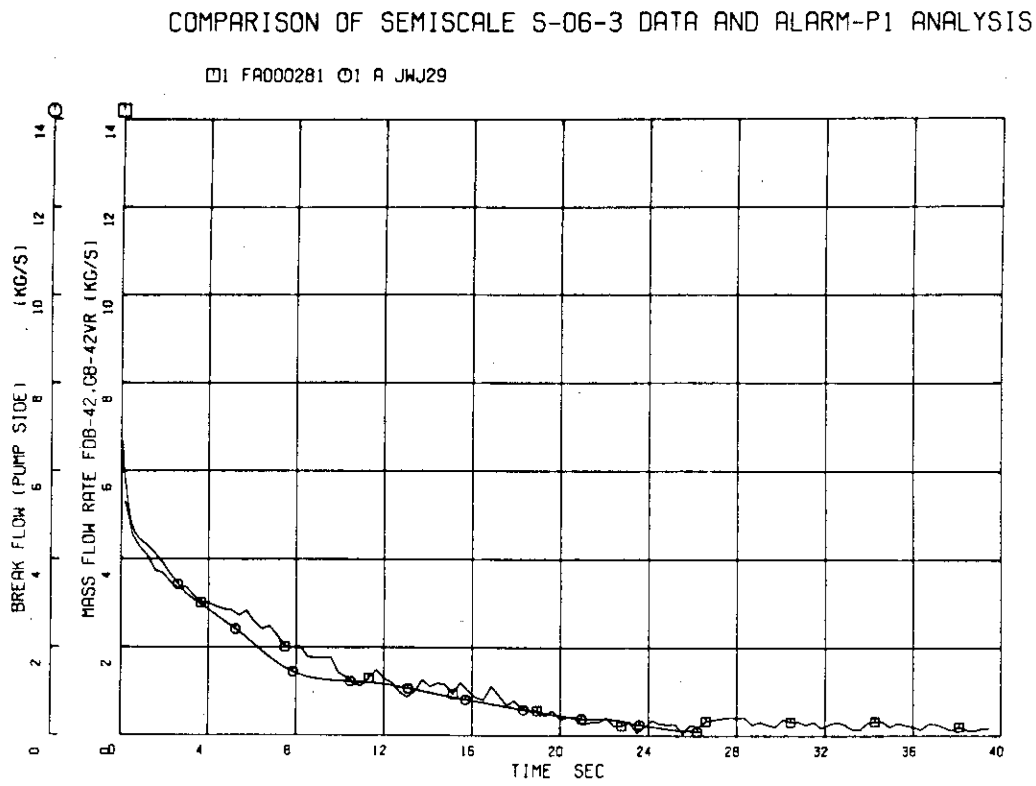


Fig.4 Mass Flow Rate at Break Nozzle — Pump Side (FDB-42, GB-42VR)

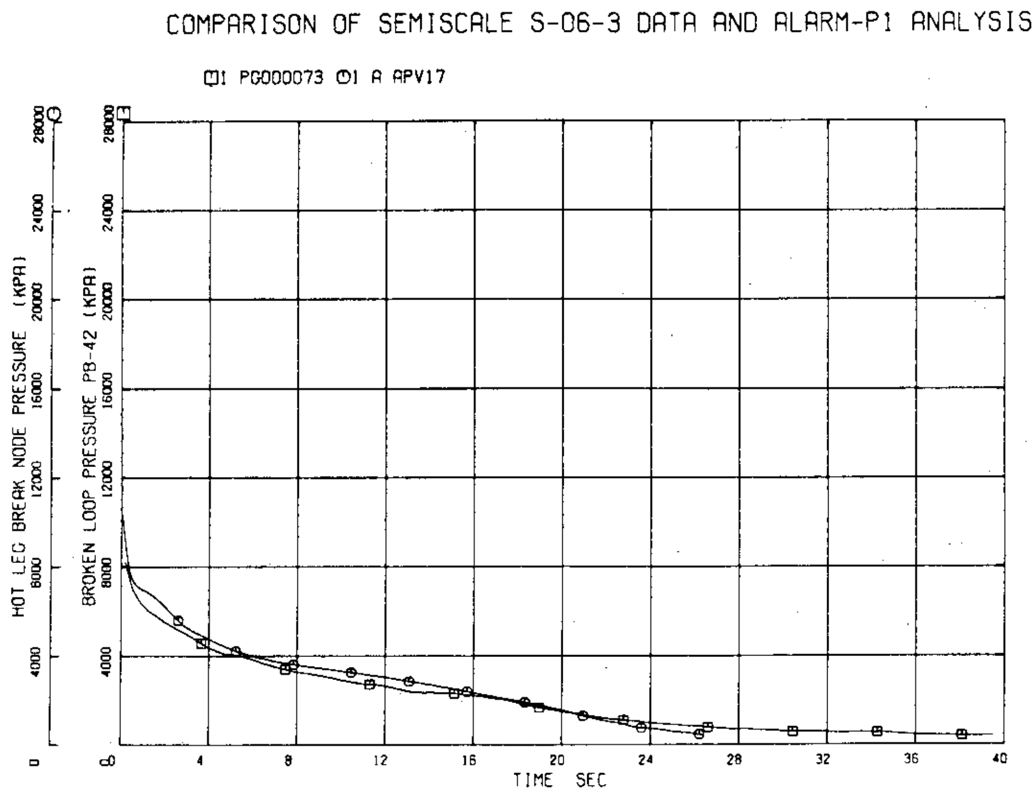


Fig.5 Pressure History Upstream of Break Nozzle — Pump Side (PB-42)

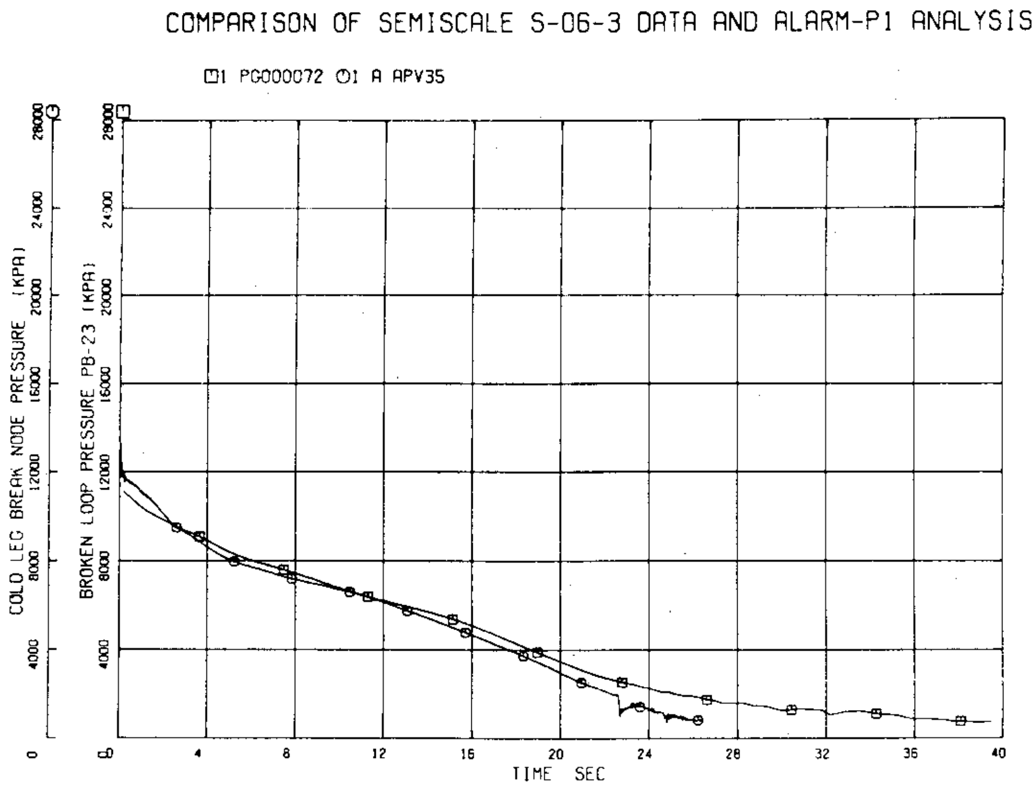


Fig.6 Pressure History upstream of Break Nozzle — Reactor Vessel Side (PB-23)

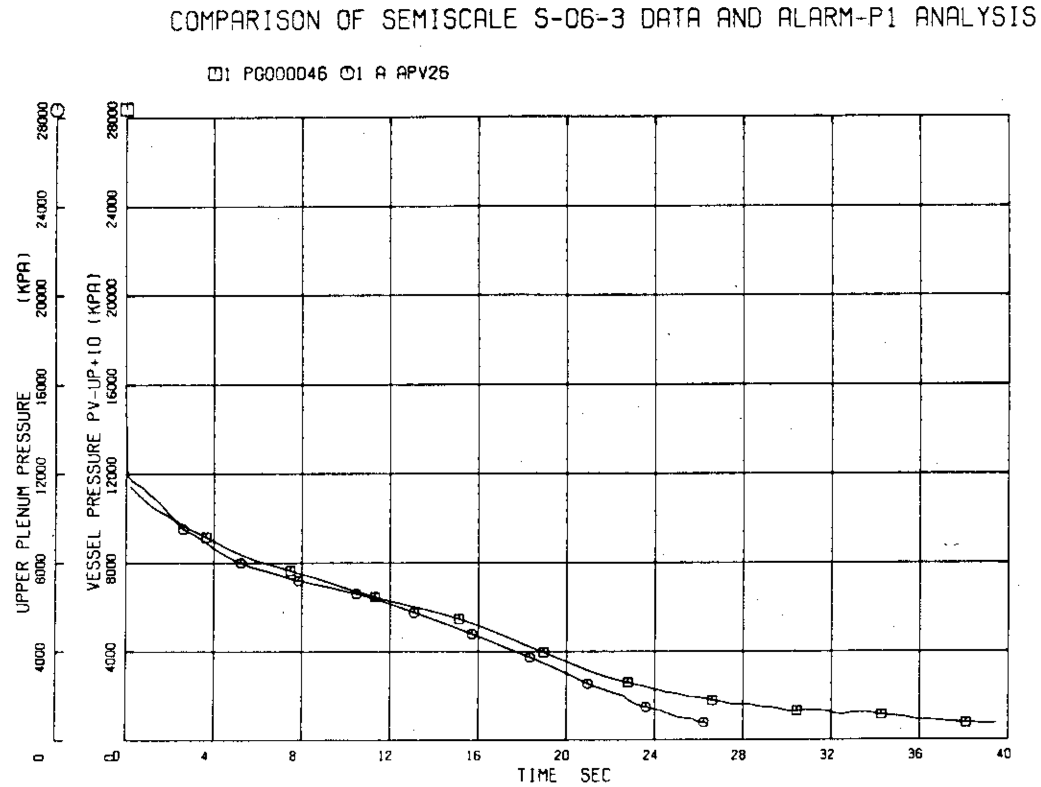


Fig.7 Upper Plenum Pressure History (PV-UP+10)

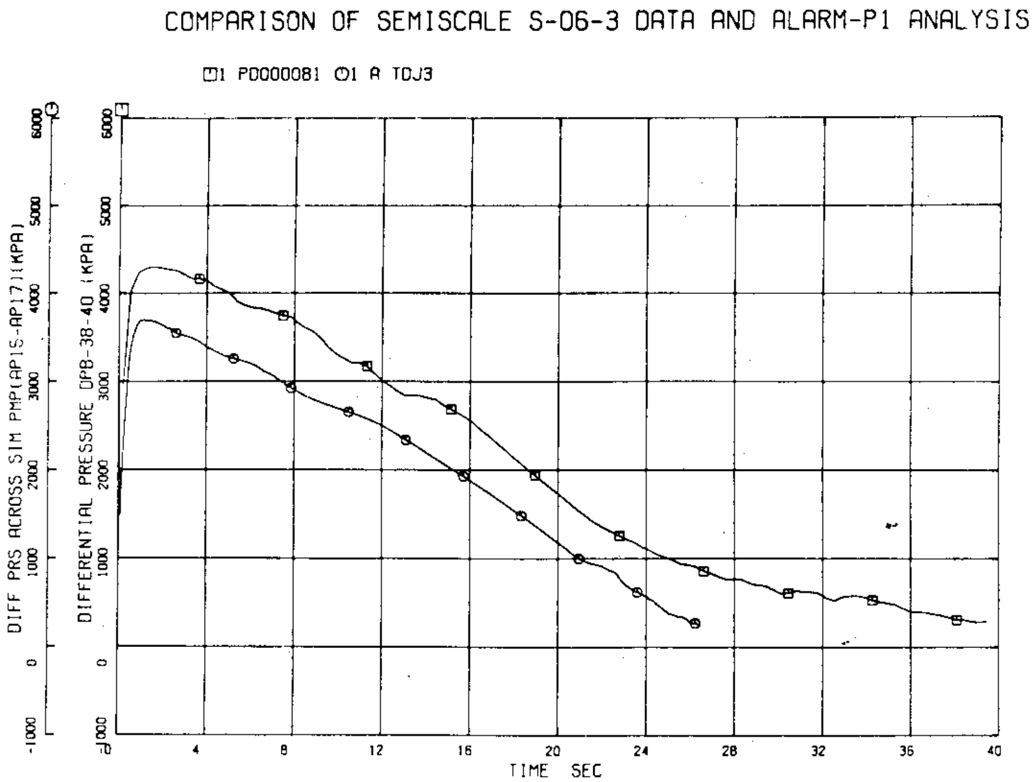


Fig.8 Differential Pressure Across the Simulated Pump (DPB-38-40)

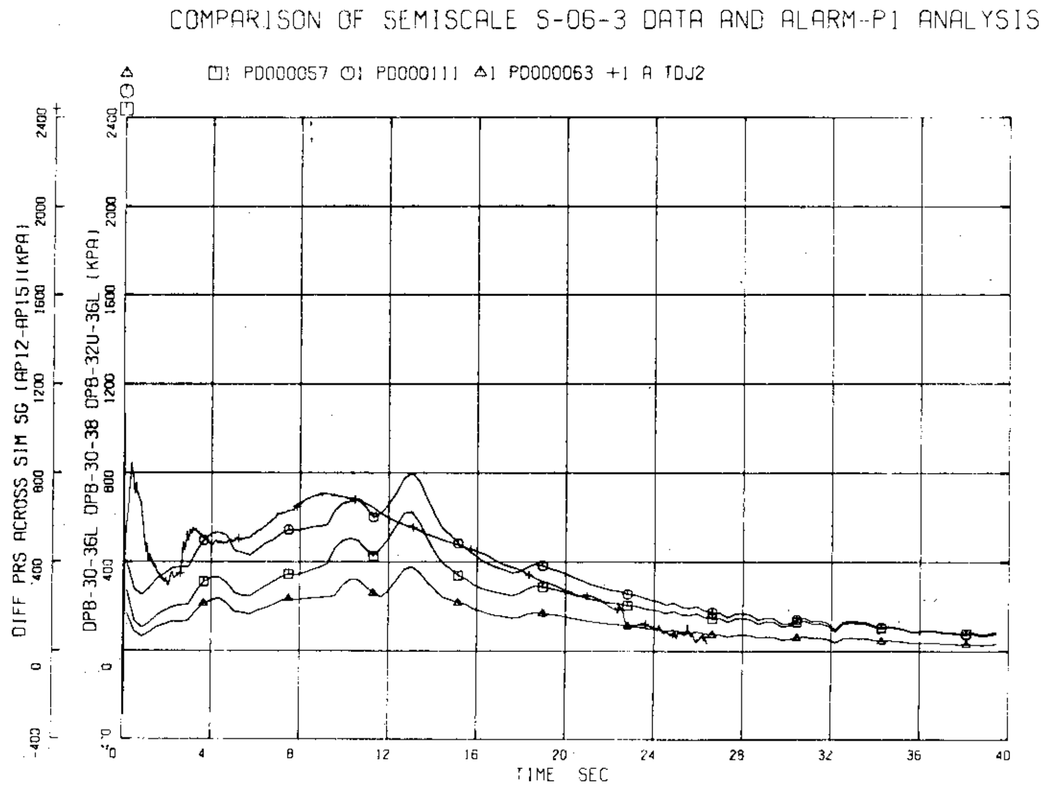


Fig.9 Differential Pressure Across the Simulated Steam Generator (DPB-32U-36L)

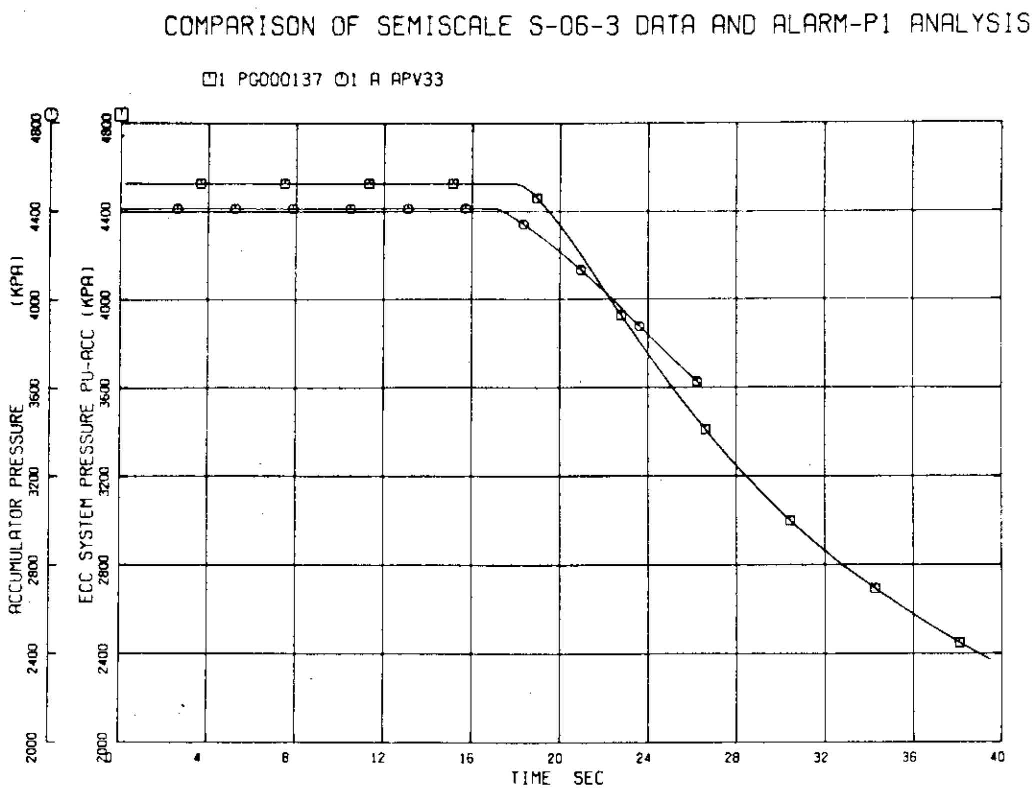


Fig.10 Intact Loop Accumulator Pressure History (PU-ACC)

COMPARISON OF SEMISCALE S-06-3 DATA AND ALARM-P1 ANALYSIS

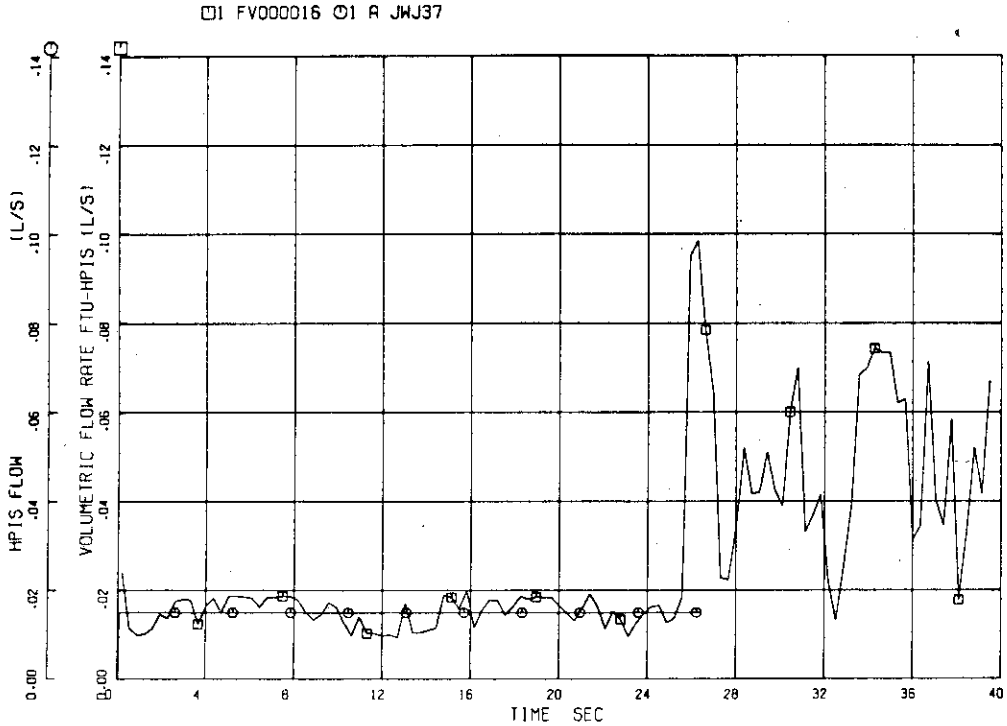


Fig.11 Volumetric Flow Rate in Intact Loop HPIS (FTU-HPIS)

COMPARISON OF SEMISCALE S-06-3 DATA AND ALARM-P1 ANALYSIS

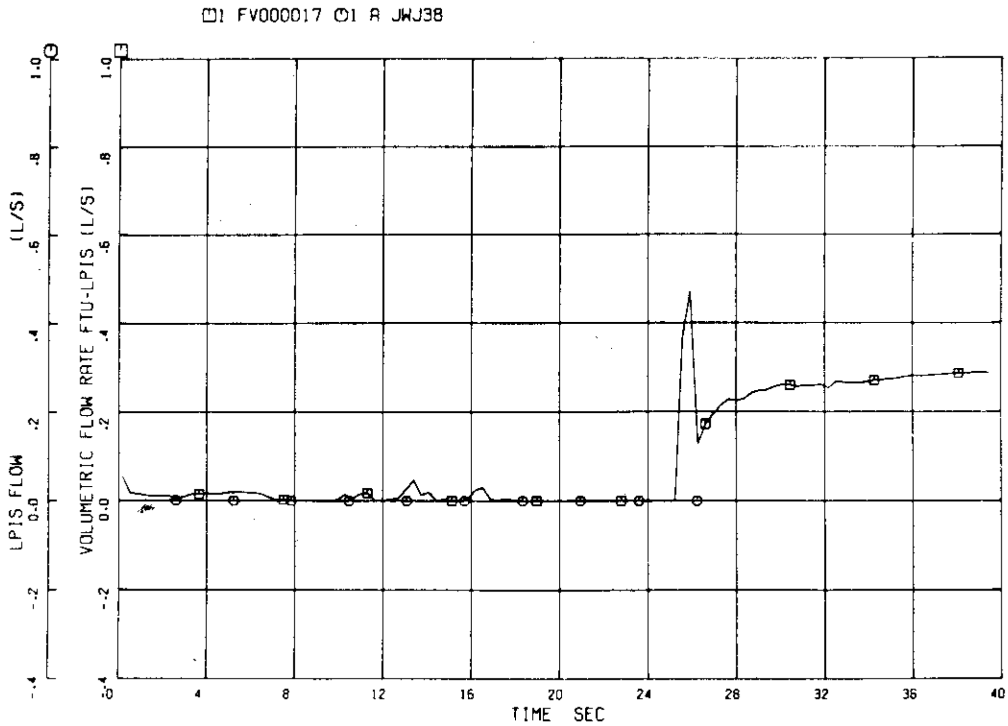


Fig.12 Volumetric Flow Rate in Intact Loop LPIS (FTU-LPIS)

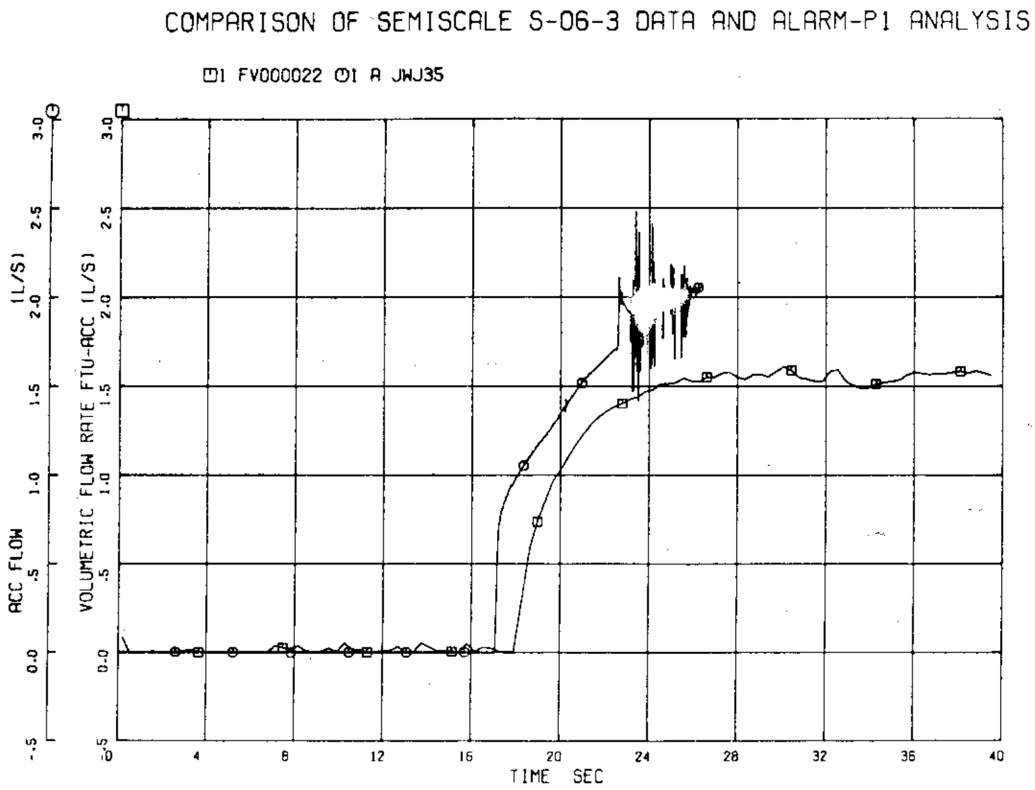


Fig.13 Volumetric Flow Rate in Accumulator Tank (FTU-ACC)

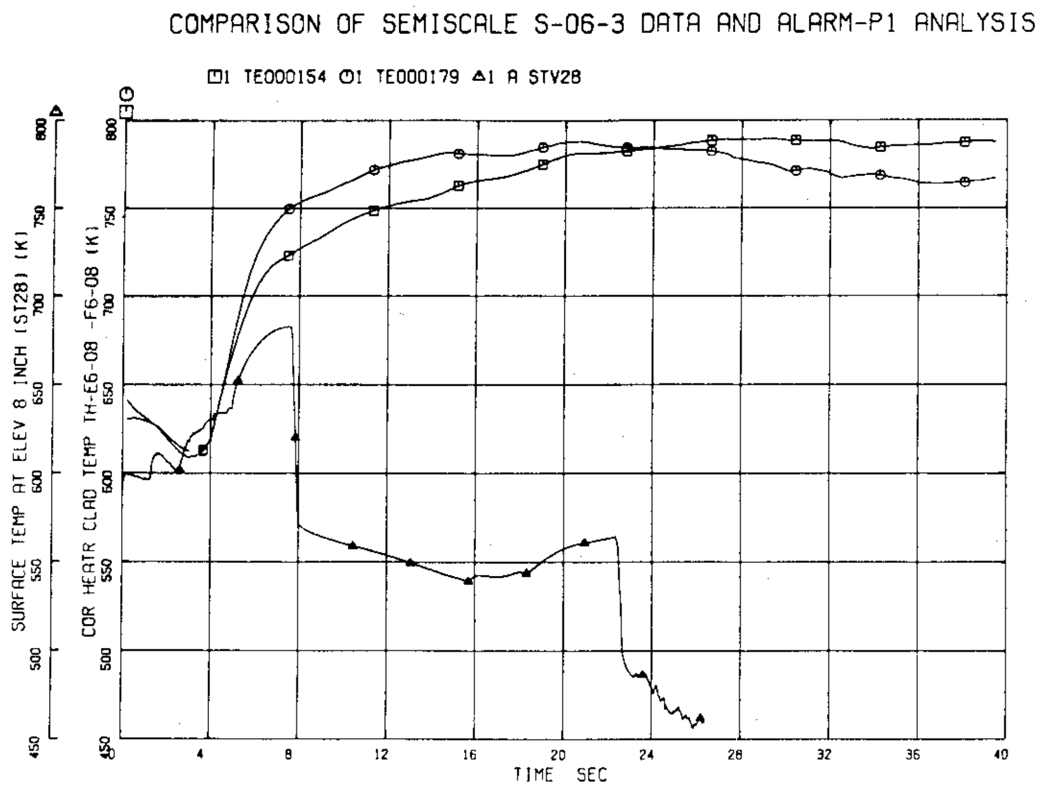


Fig.14 Surface Temperature History on Average Rods (Elevation of 8" above Bottom of Heated Length)

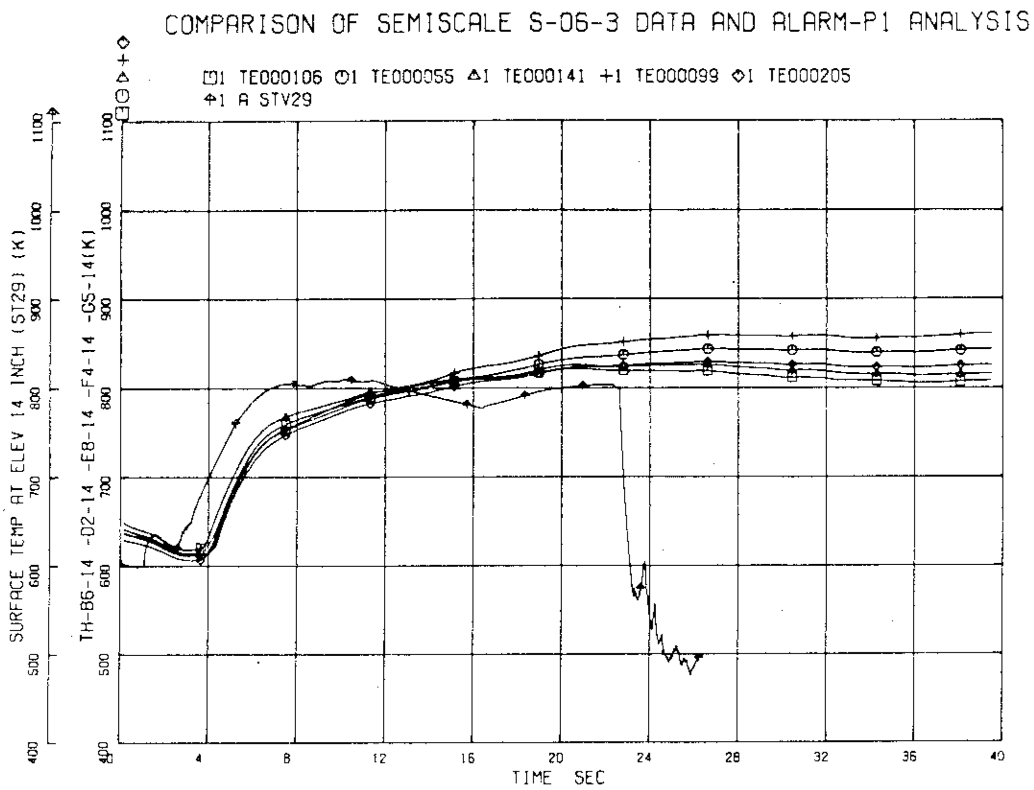


Fig.15 Surface Temperature History on Average Rods (Elevation of 14" above Bottom of Heated Length)

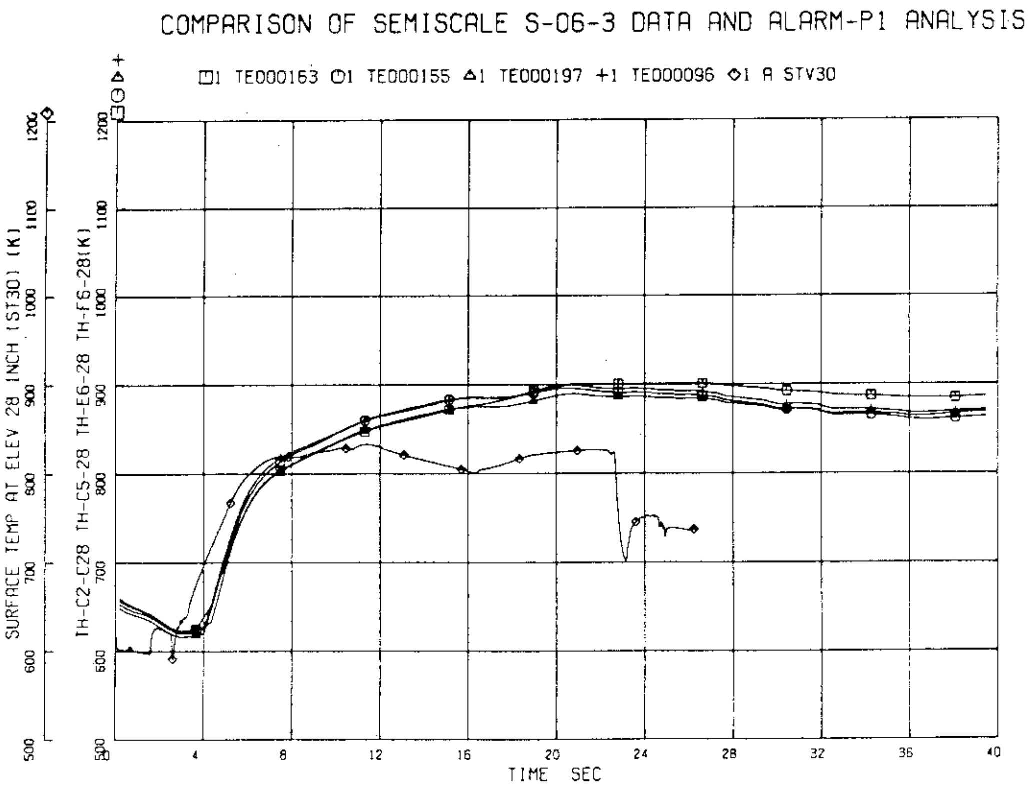


Fig.16 Surface Temperature History on Average Rods (Elevation of 28" above Bottom of Heated Length)

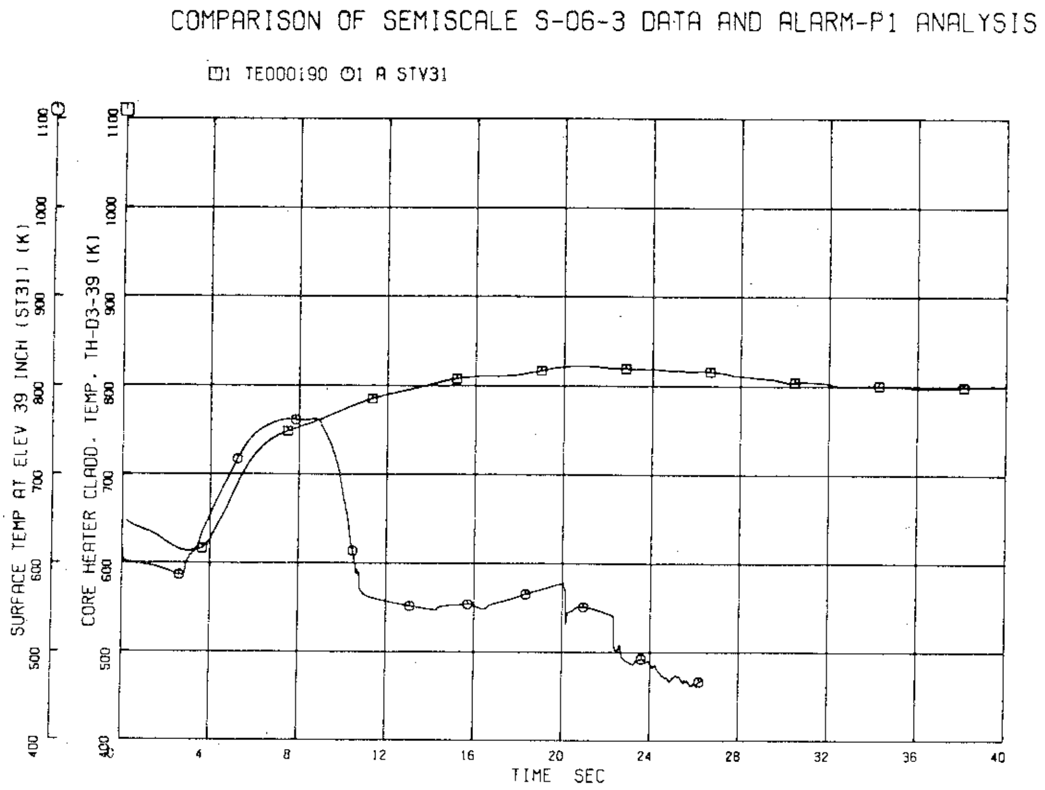


Fig.17 Surface Temperature History on Average Rods (Elevation of 39" above Bottom of Heated Length)

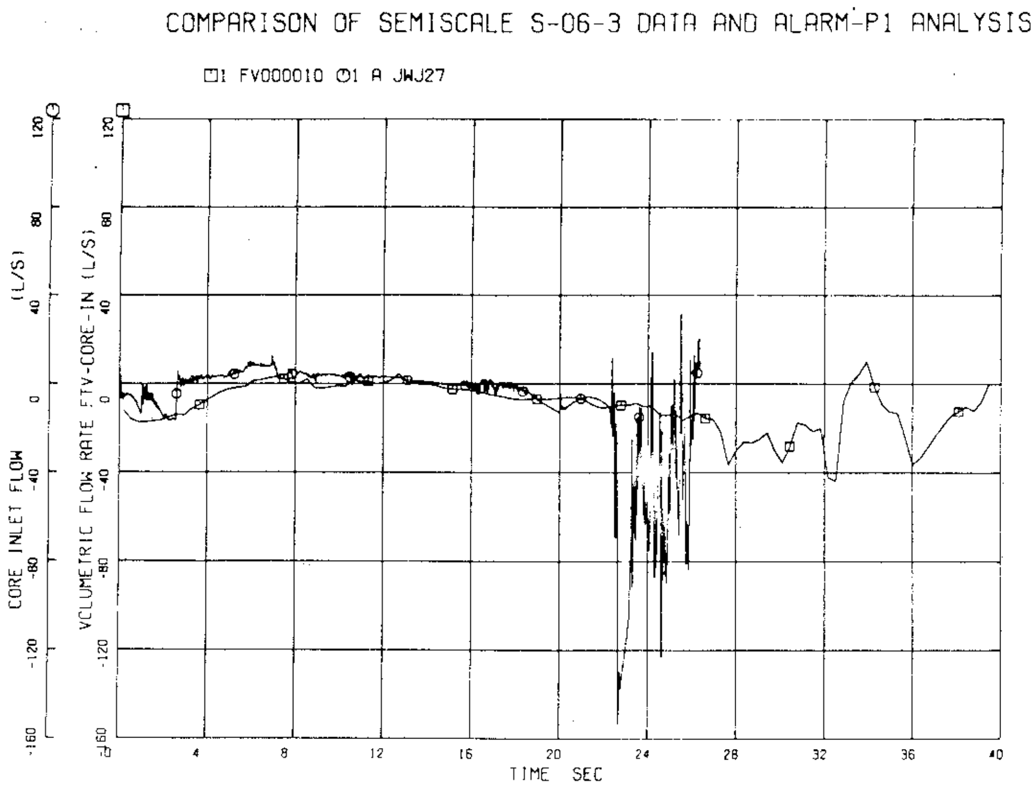


Fig.18 Volumetric Flow Rate at Core Inlet (FTV-COREIN)

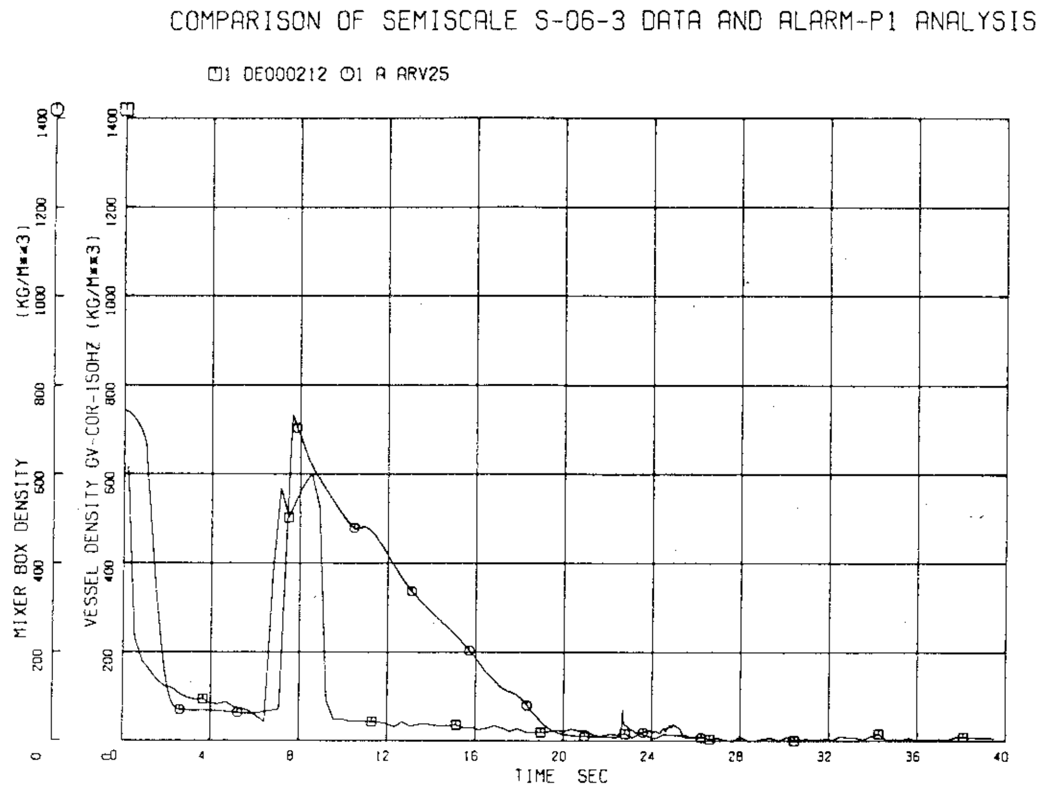


Fig.19 Density History at Core Inlet (GVCOR-150HZ)

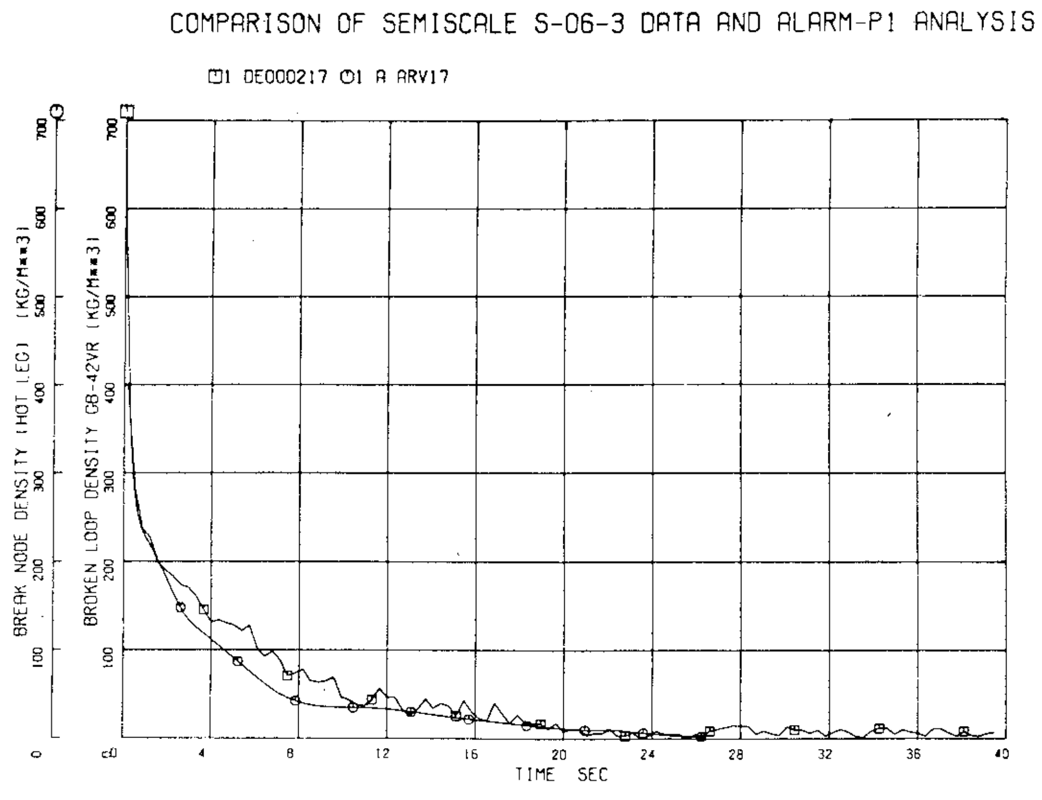


Fig.20 Density History in Break Volume — Pump Side (GB-42VR)

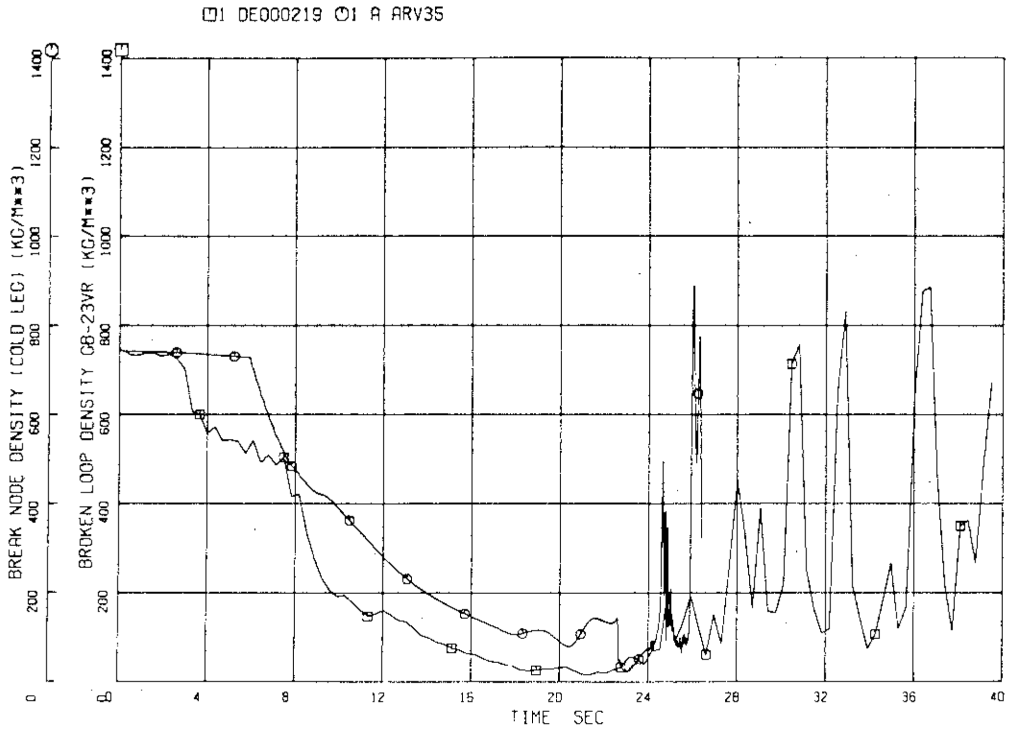


Fig.21 Density History in Break Volume — Reactor Vessel Side (GB-23VR)

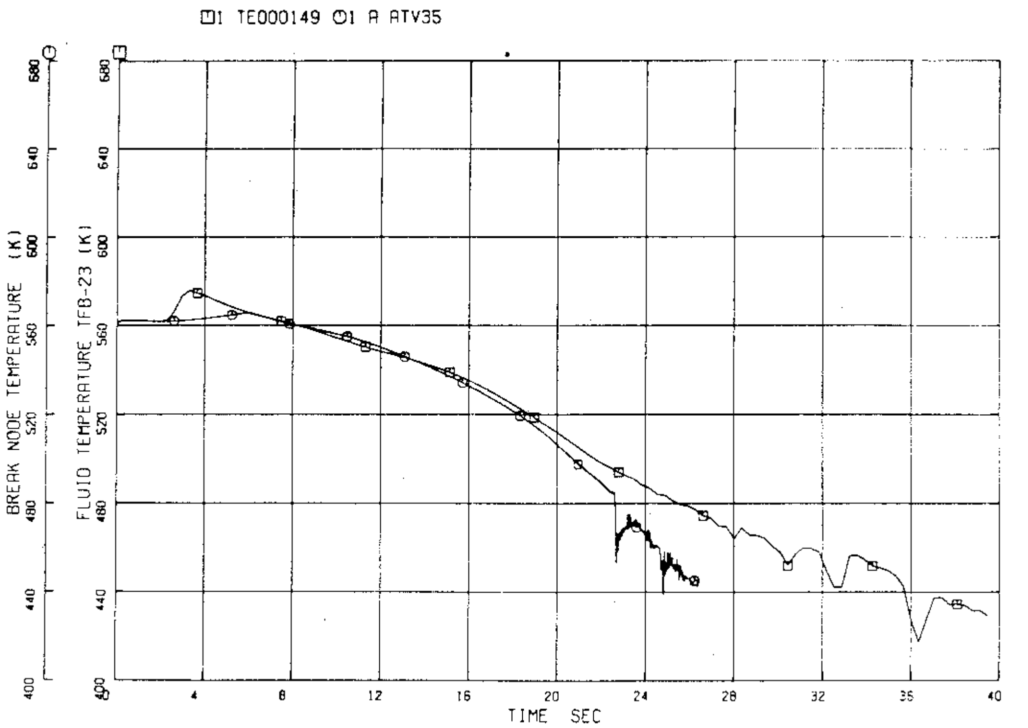


Fig.22 Fluid Temperature History Upstream of Break (TFB-23)

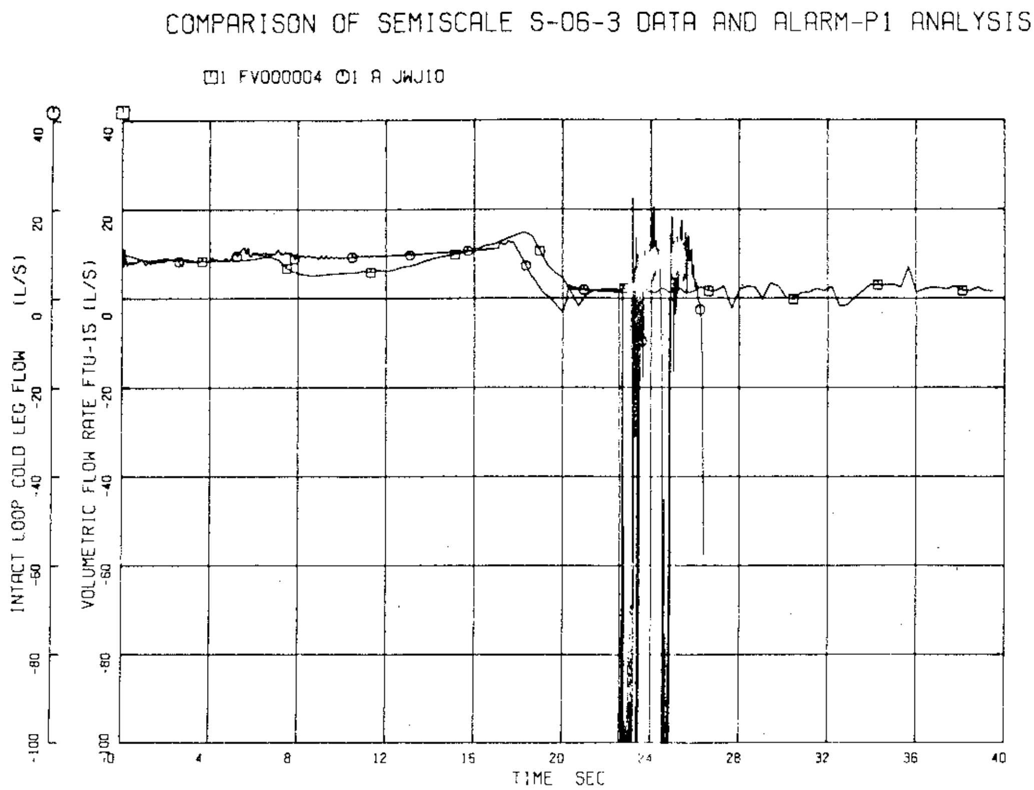


Fig.23 Volumetric Flow Rate in Intact Loop Cold Leg (FTU-15)

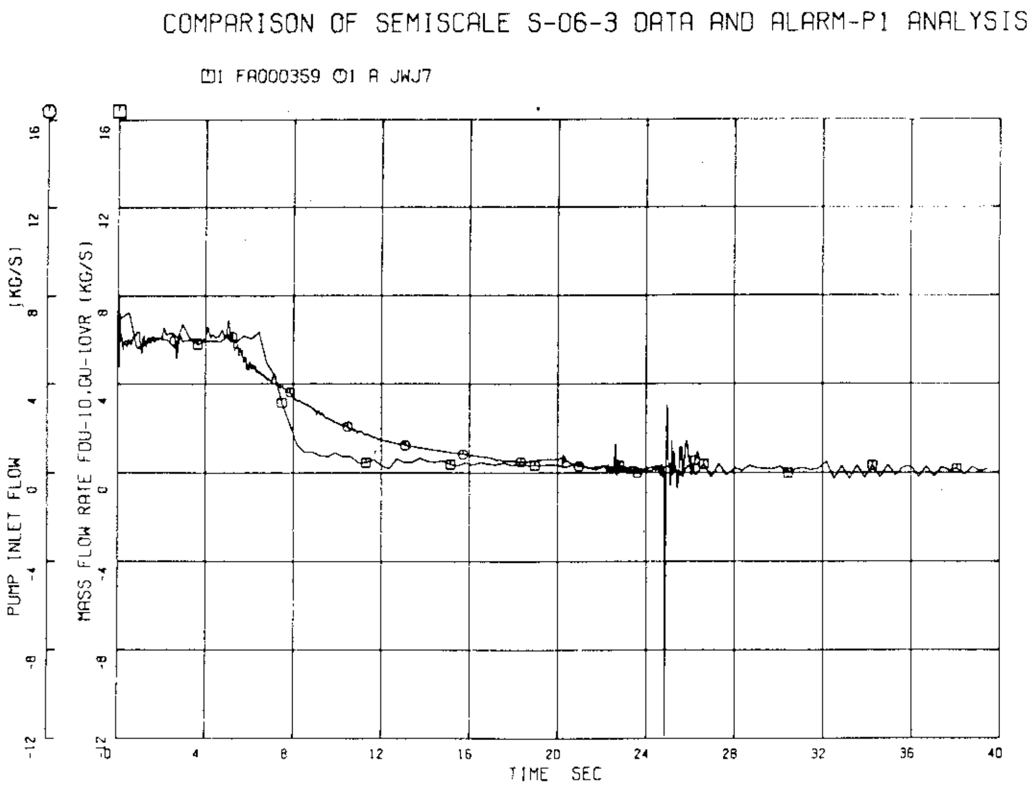


Fig.24 Mass Flow Rate in Spool 10 (FDU-10, GU-10VR)

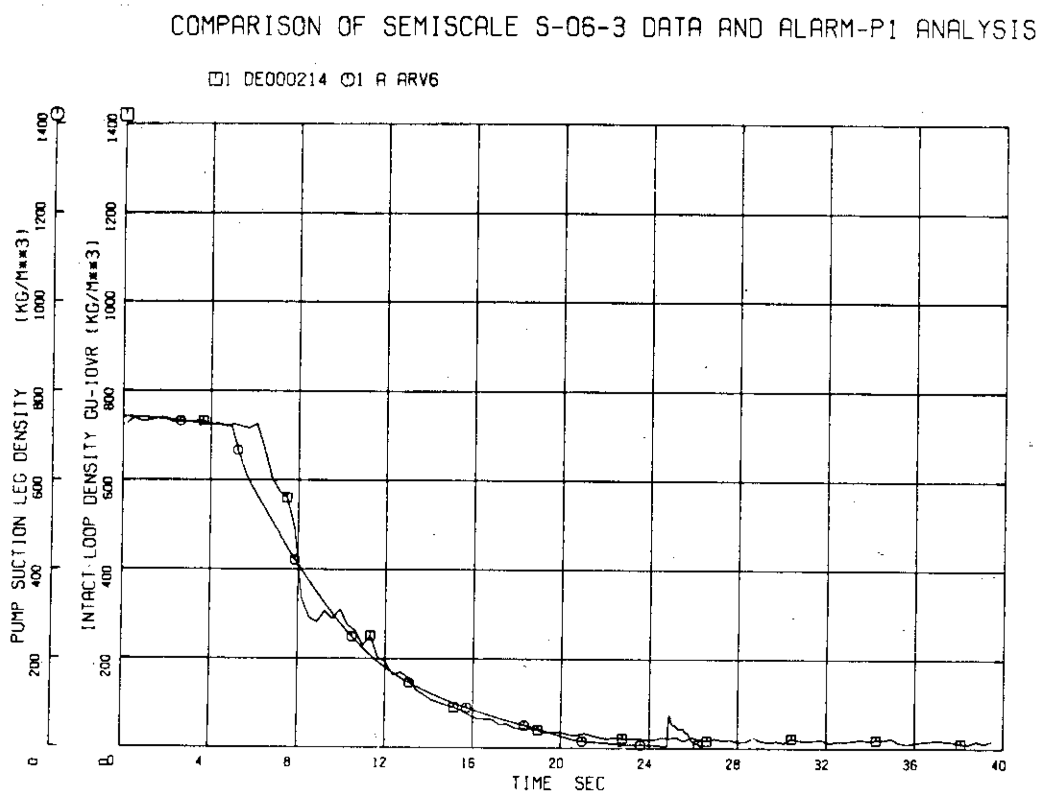


Fig.25 Density History at Pump Inlet (GU-10VR)

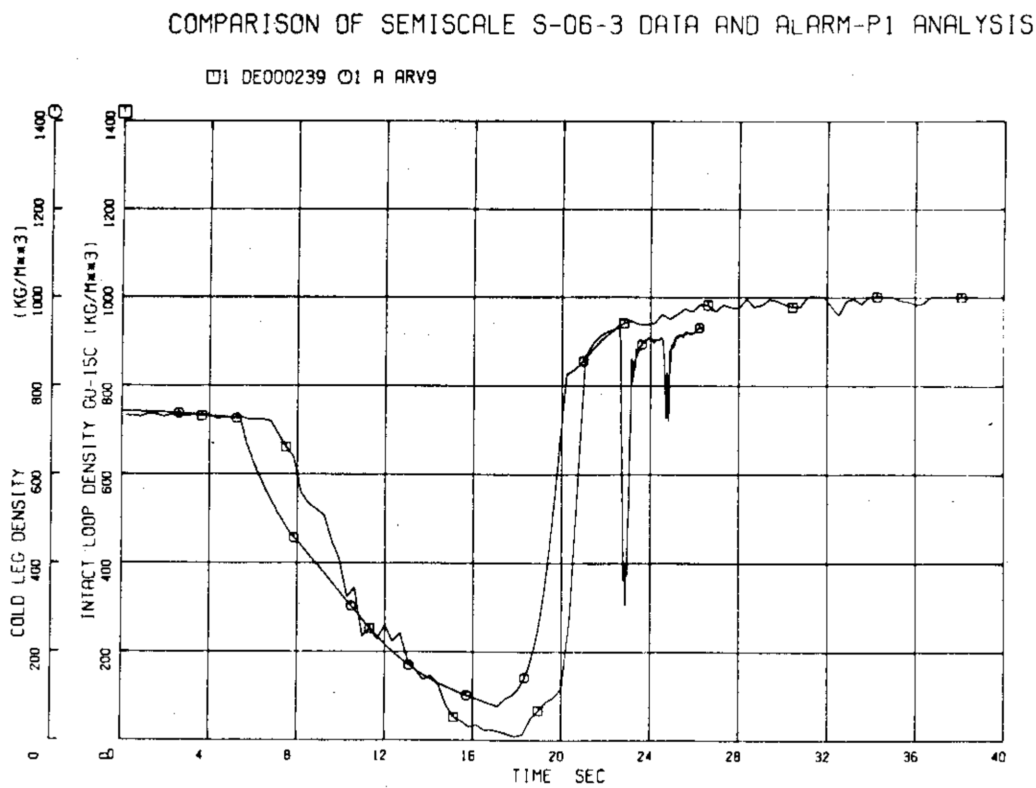


Fig.26 Density History in Intact Loop Cold Leg (GU-15C)

COMPARISON OF SEMISCALE S-06-3 DATA AND ALARM-P1 ANALYSIS

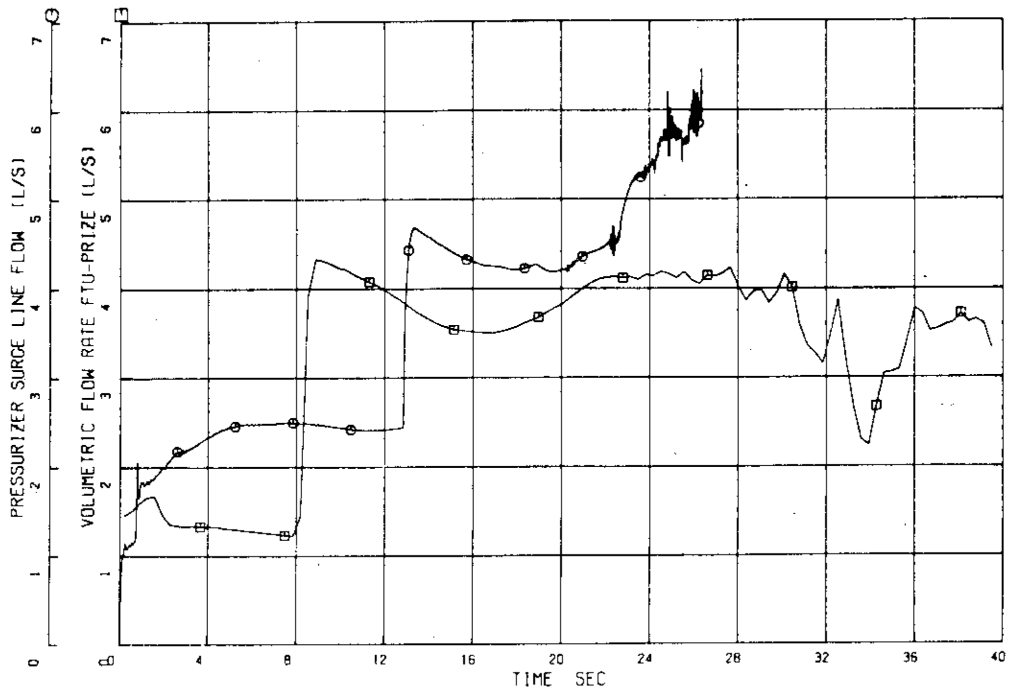


Fig.27 Volumetric Flow Rate in Pressurizer Surge Line Outlet (FTU-PRIZE)

COMPARISON OF SEMISCALE S-06-3 DATA AND ALARM-P1 ANALYSIS

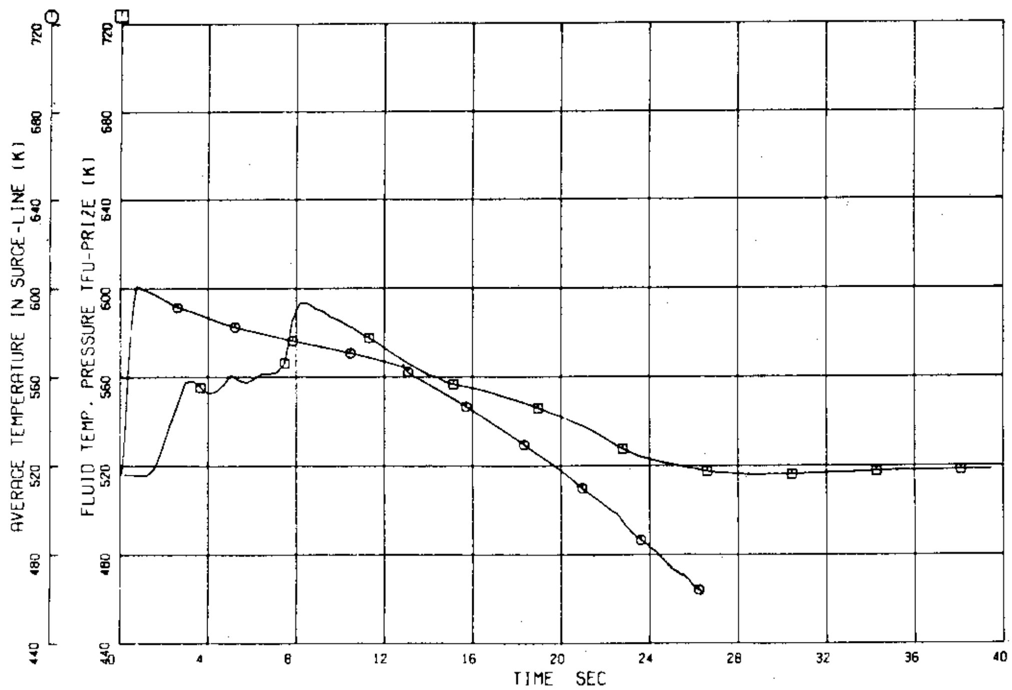


Fig.28 Fluid Temperature History in Pressurizer Surge Line (TFU-PRIZE)

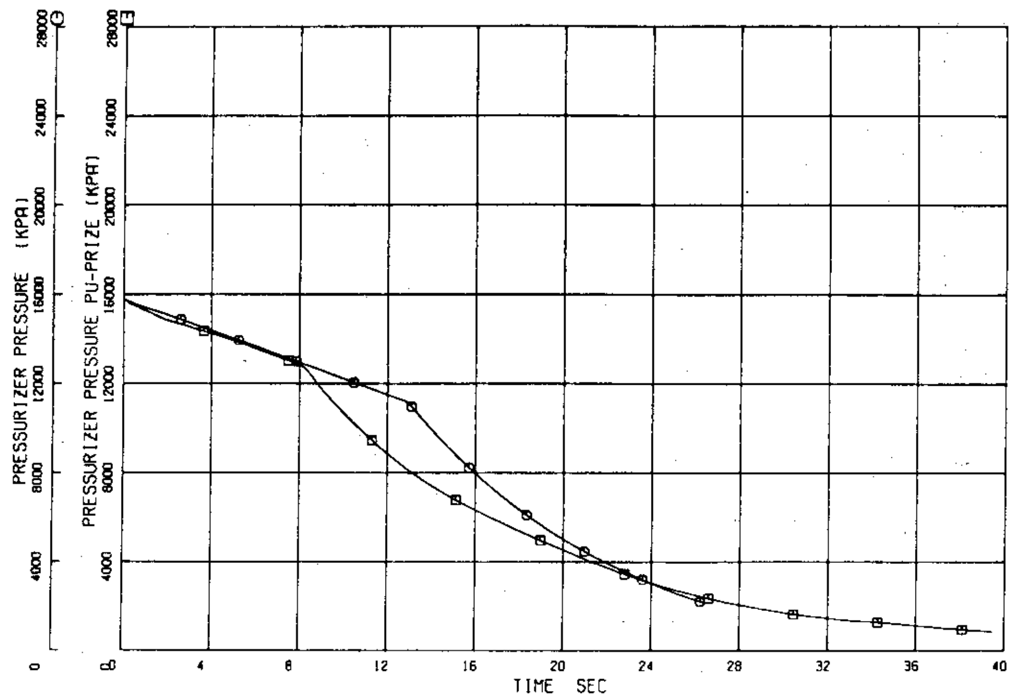


Fig.29 Pressurizer Pressure History (PU-PRIZE)

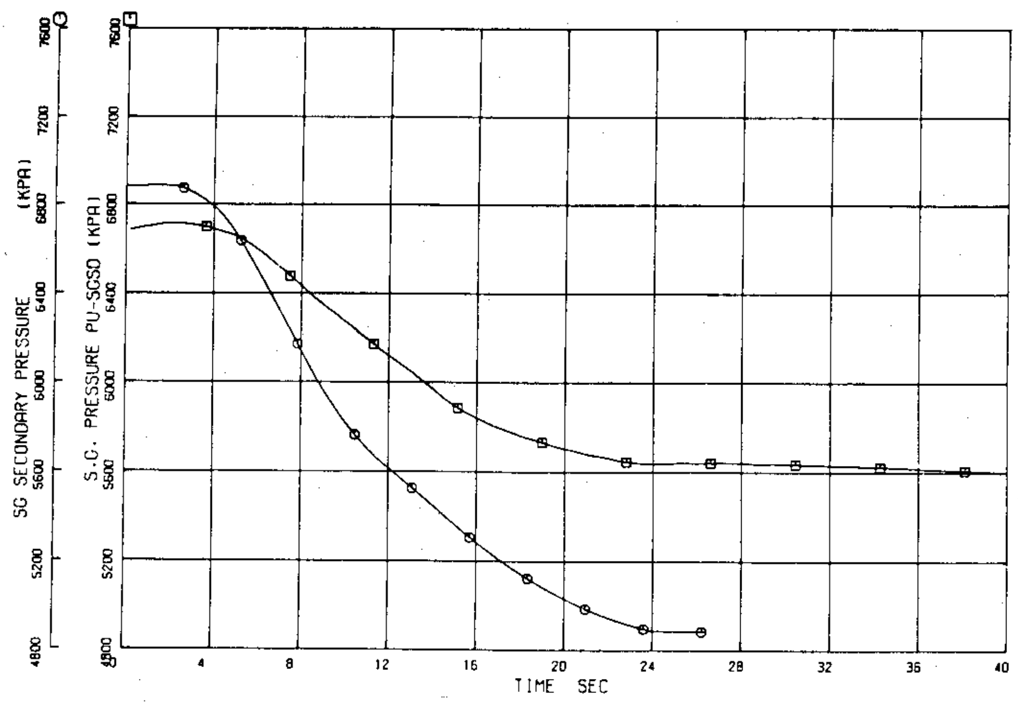


Fig.30 Pressure History in the Steam Generator Secondary System (PU-SGSD)

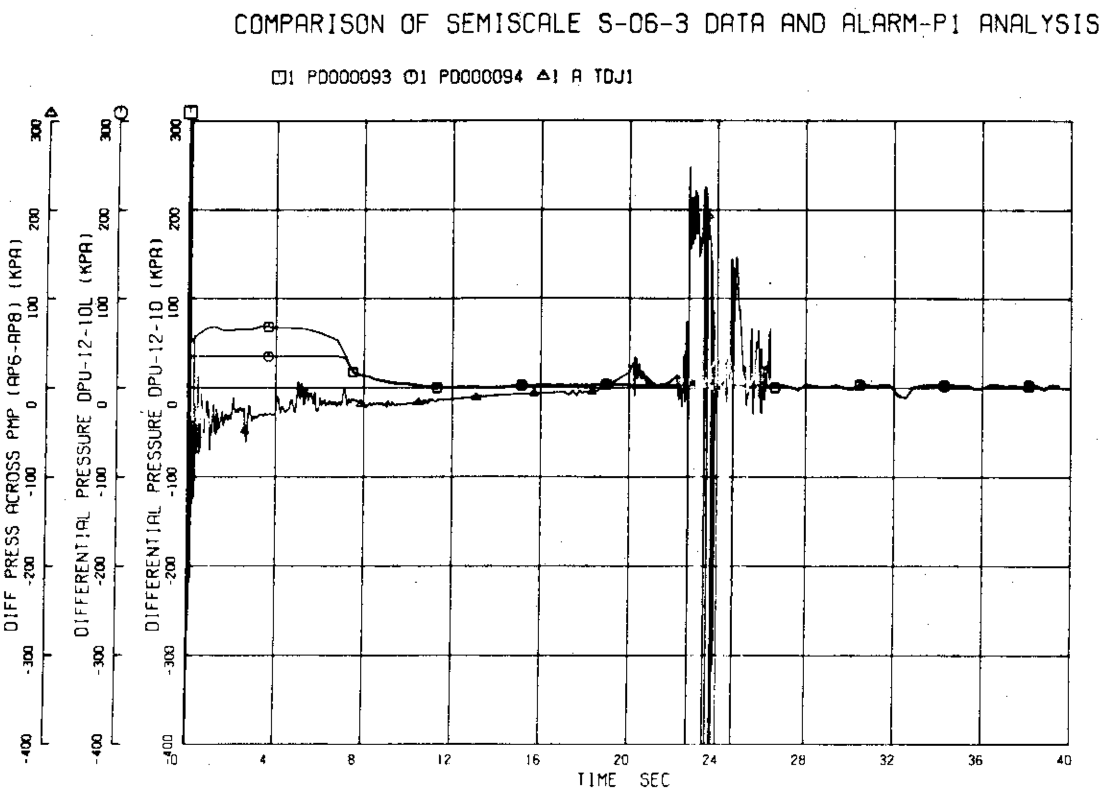


Fig.31 Differential Pressure Across Pump (DPU-12-10)

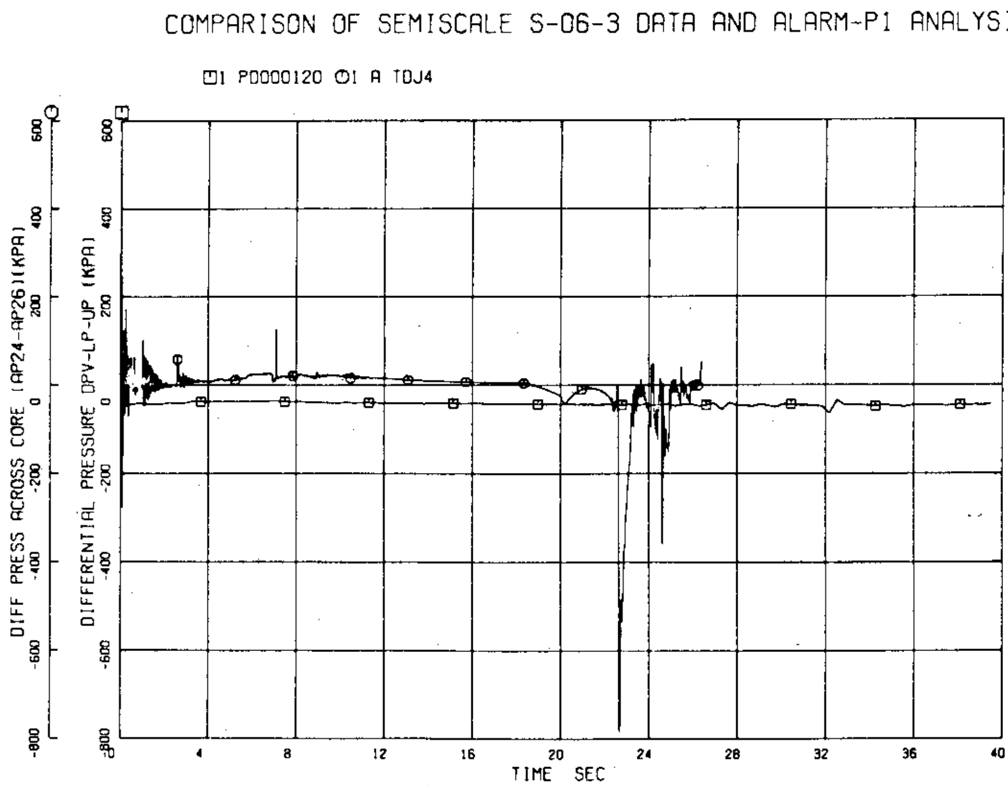


Fig.32 Differential Pressure Across Core (DPV-LP-UP)

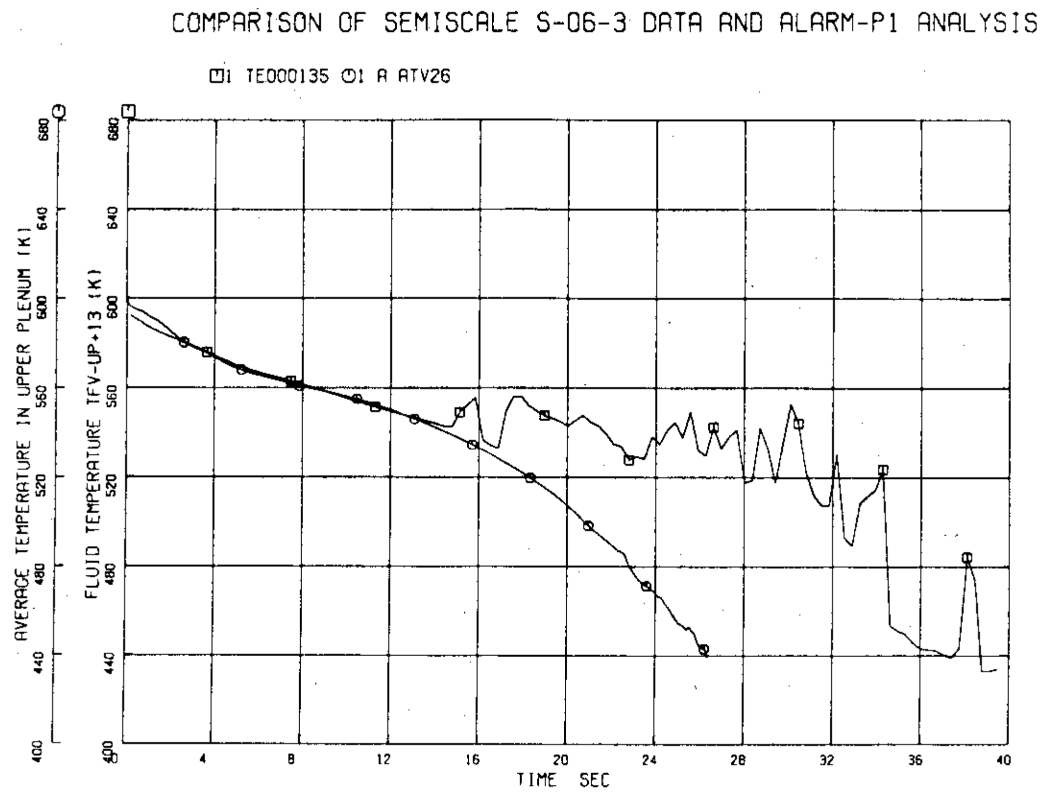


Fig.33 Fluid Temperature History in Upper Plenum (TFV-UP+13)

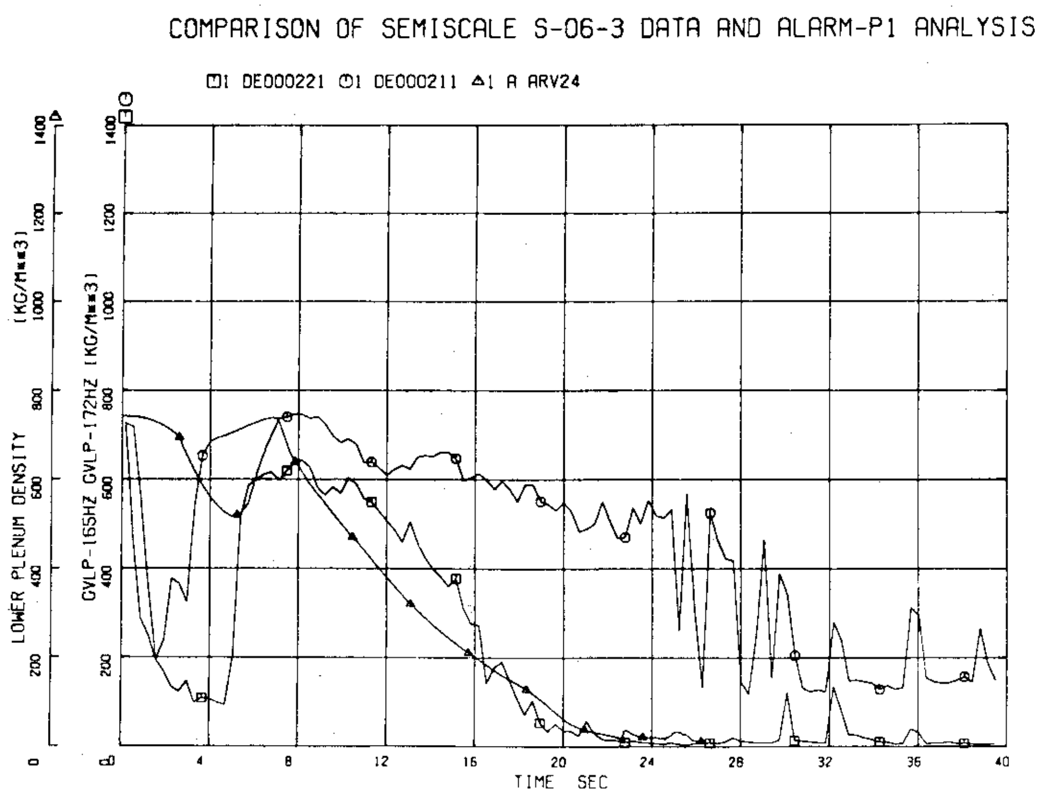


Fig.34 Density History in Lower Plenum (GV161/192D)

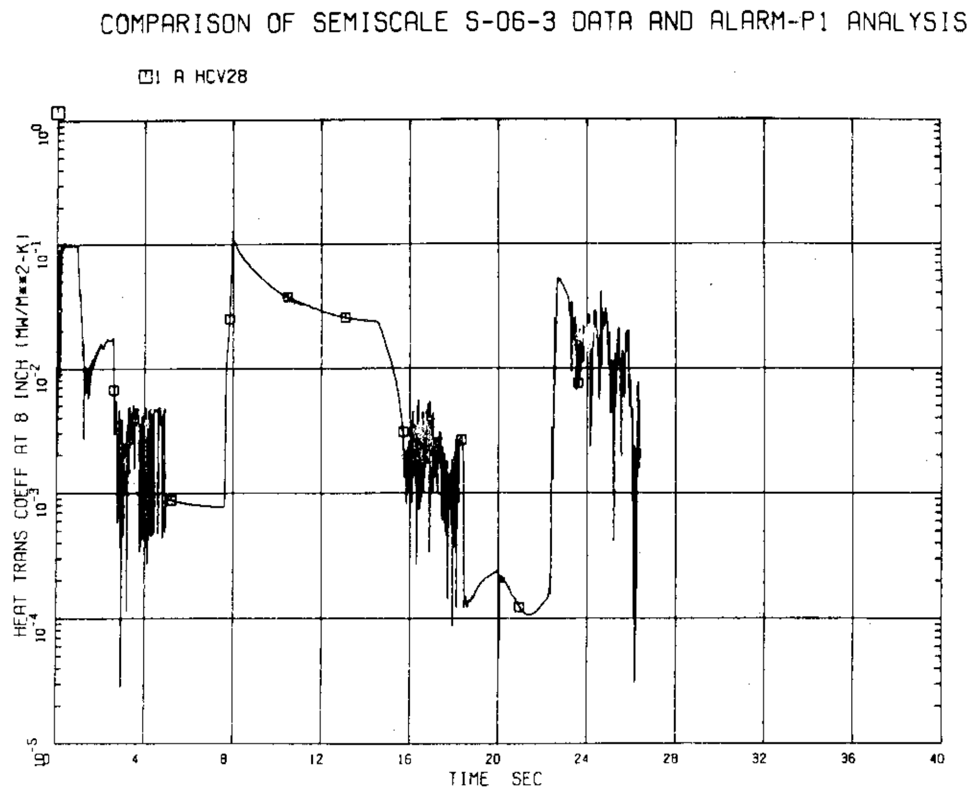


Fig.35 Heat Transfer Coefficient History (Elevation of 8" above Bottom of Core)

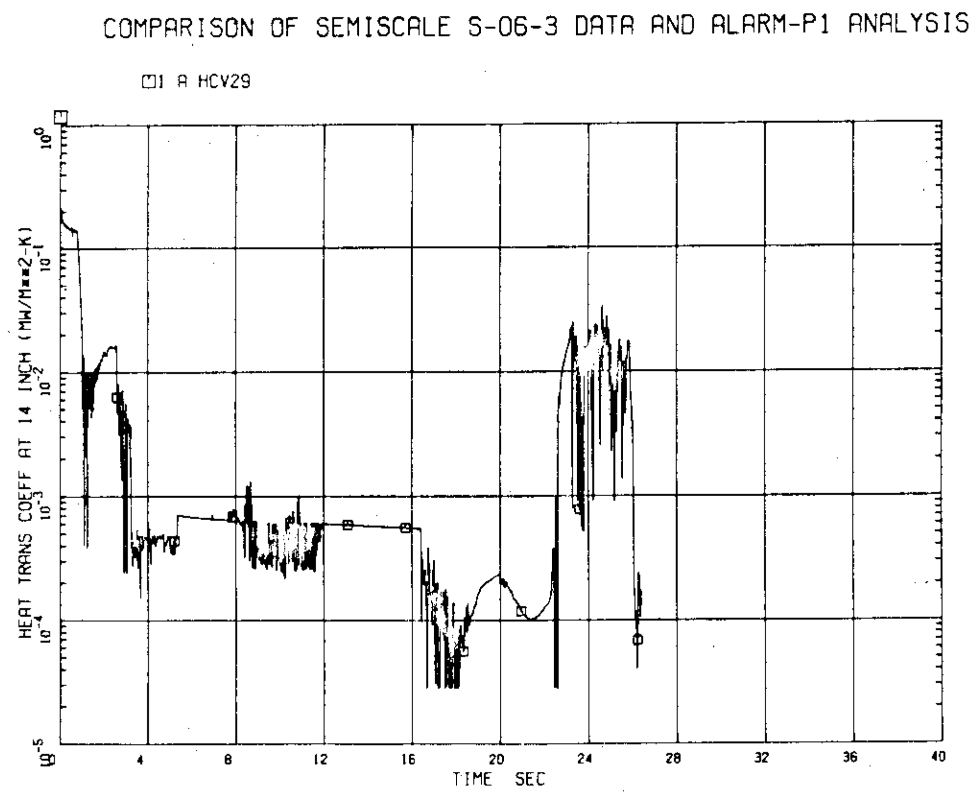


Fig.36 Heat Transfer Coefficient History (Elevation of 14" above Bottom of Core)

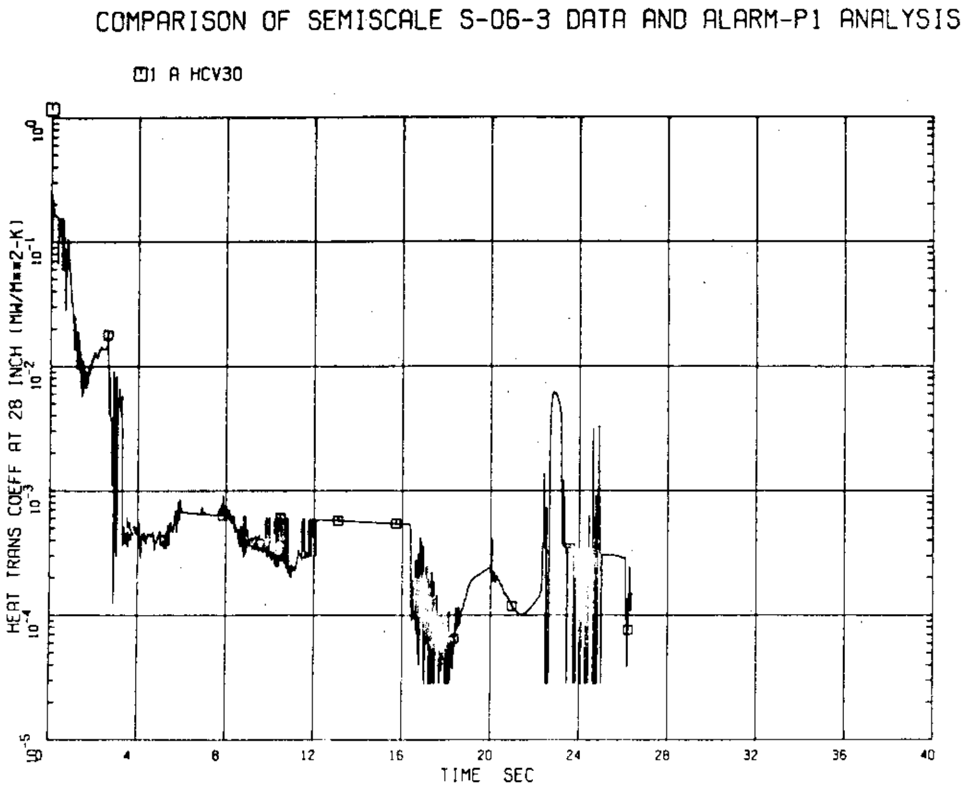


Fig.37 Heat Transfer Coefficient History (Elevation of 28" above Bottom of Core)

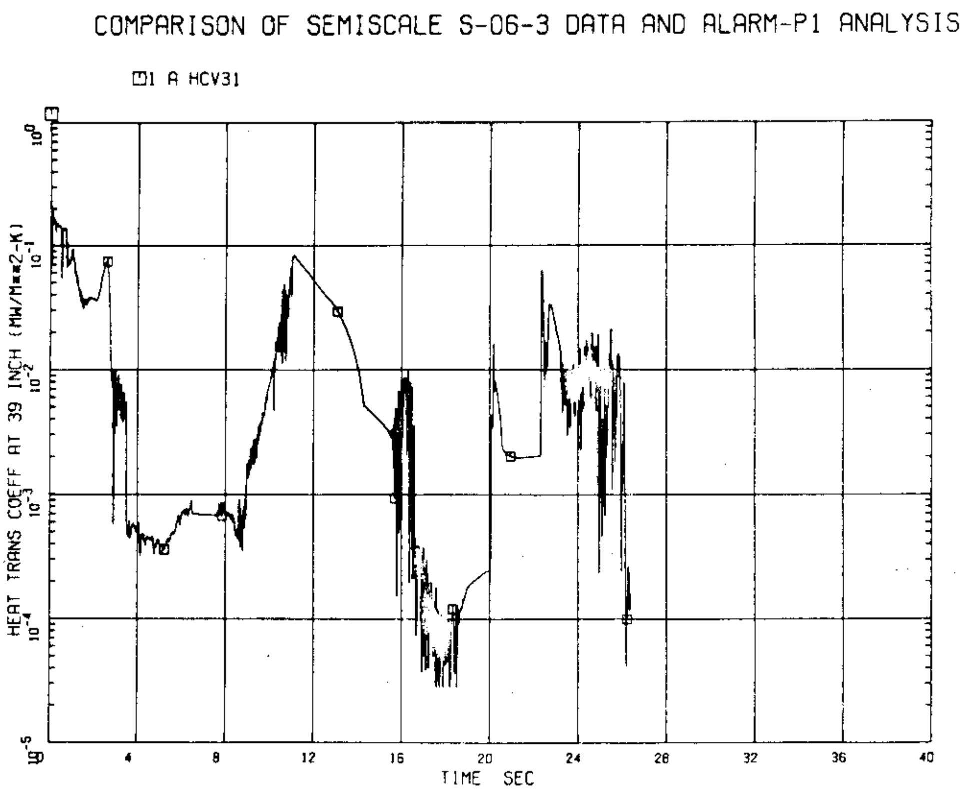


Fig.38 Heat Transfer Coefficient History (Elevation of 39" above Bottom of Core)

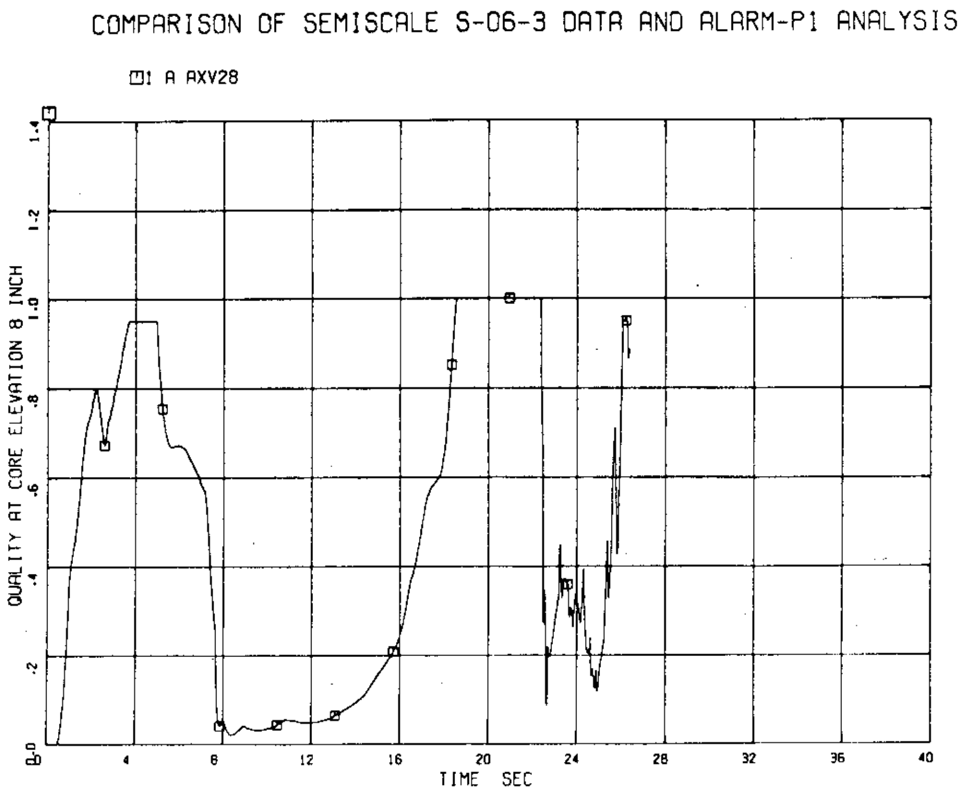


Fig.39 Fluid Quality History (Elevation of 8" above Bottom of Core)

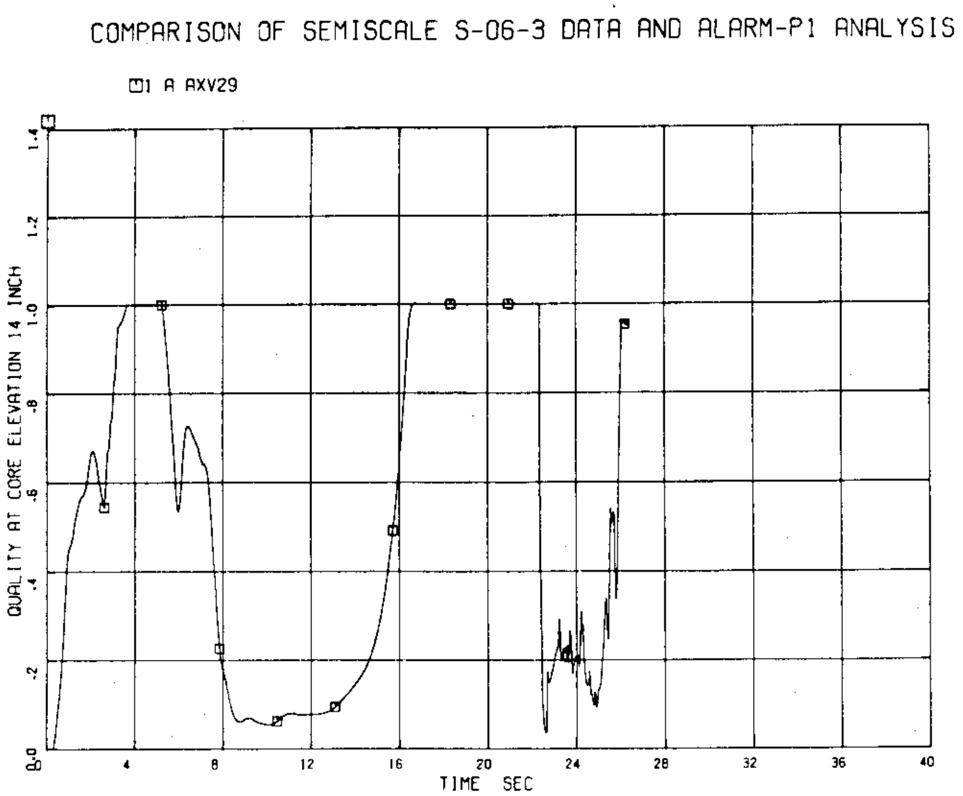


Fig.40 Fluid Quality History (Elevation of 14" above Bottom of Core)

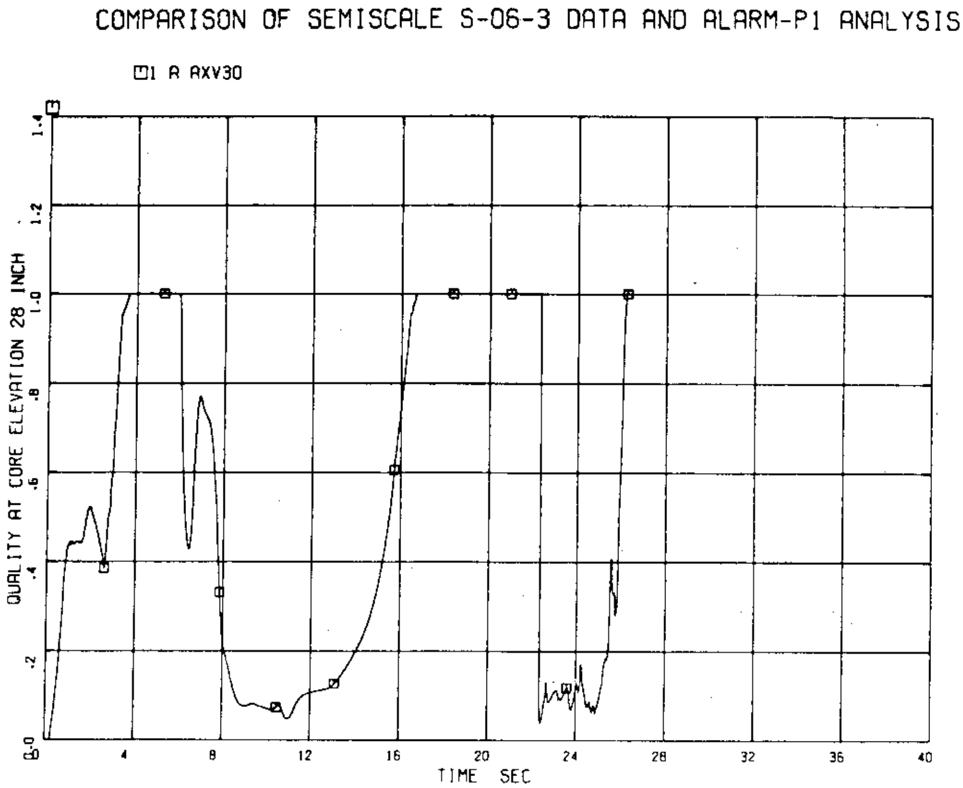


Fig.41 Fluid Quality History (Elevation of 28" above bottom of Core)

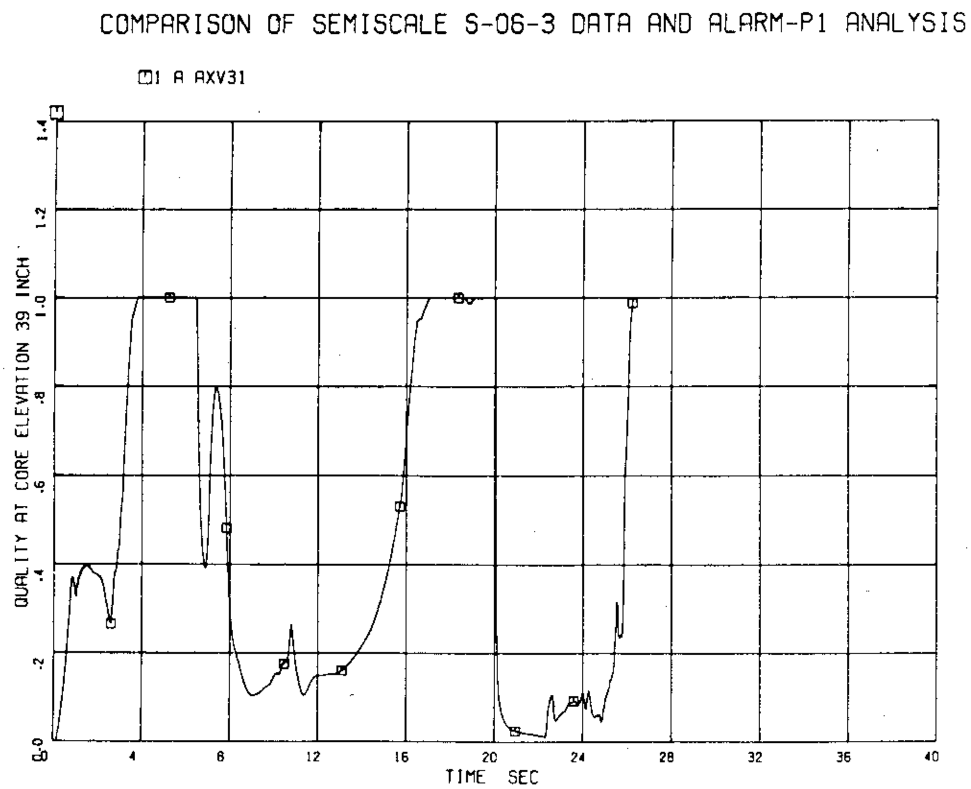


Fig.42 Fluid Quality History (Elevation of 39" above Bottom of Core)

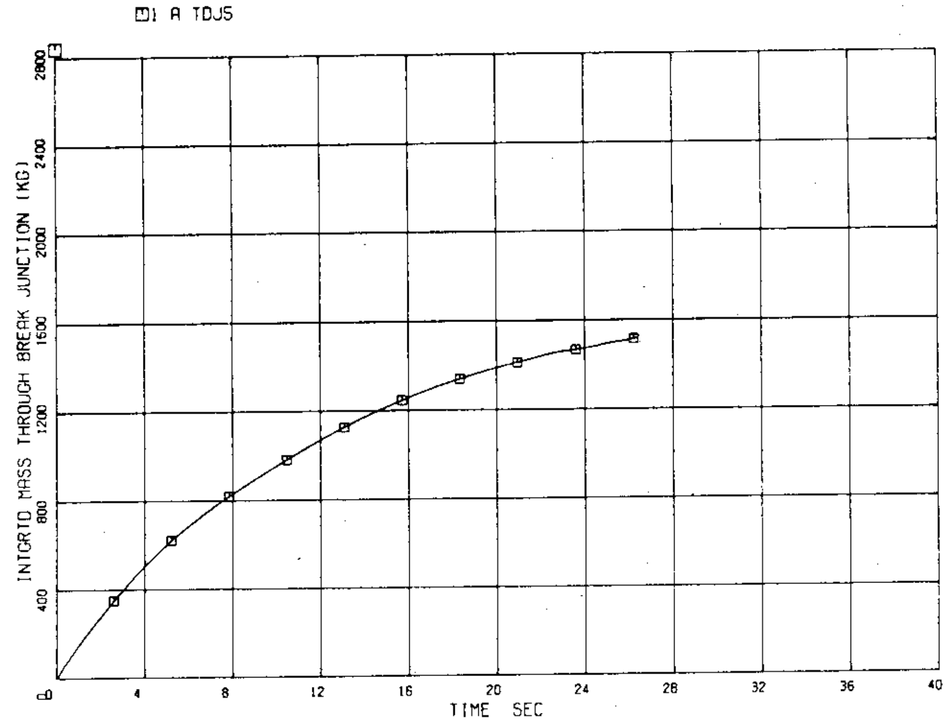


Fig.43 System Mass Inventory History (FDB-23, FDB-42)

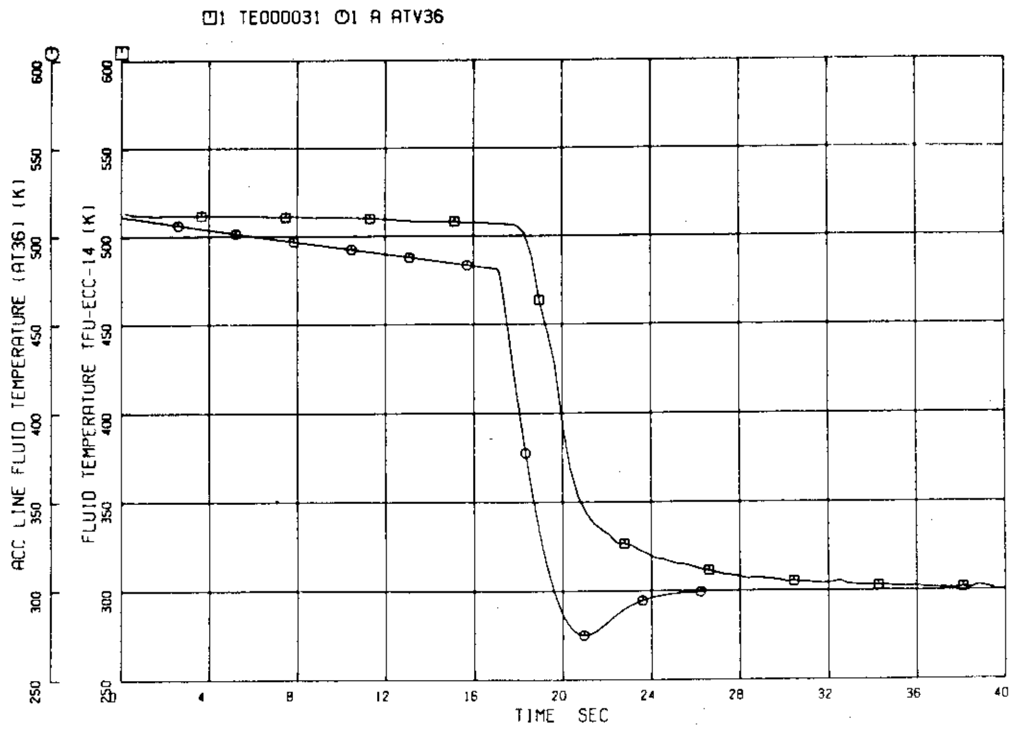


Fig.44 Fluid Temperature History in Accumulator Line (TFU-ECC-14)

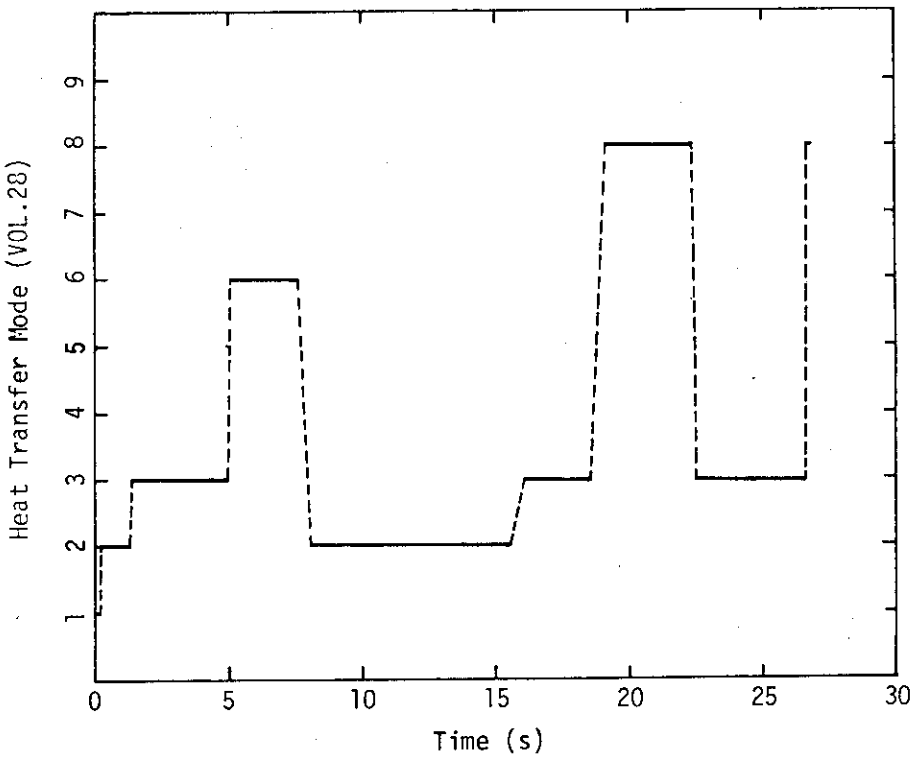


Fig.45 Heat Transfer Mode (Elevation of 8" above Bottom of Core)

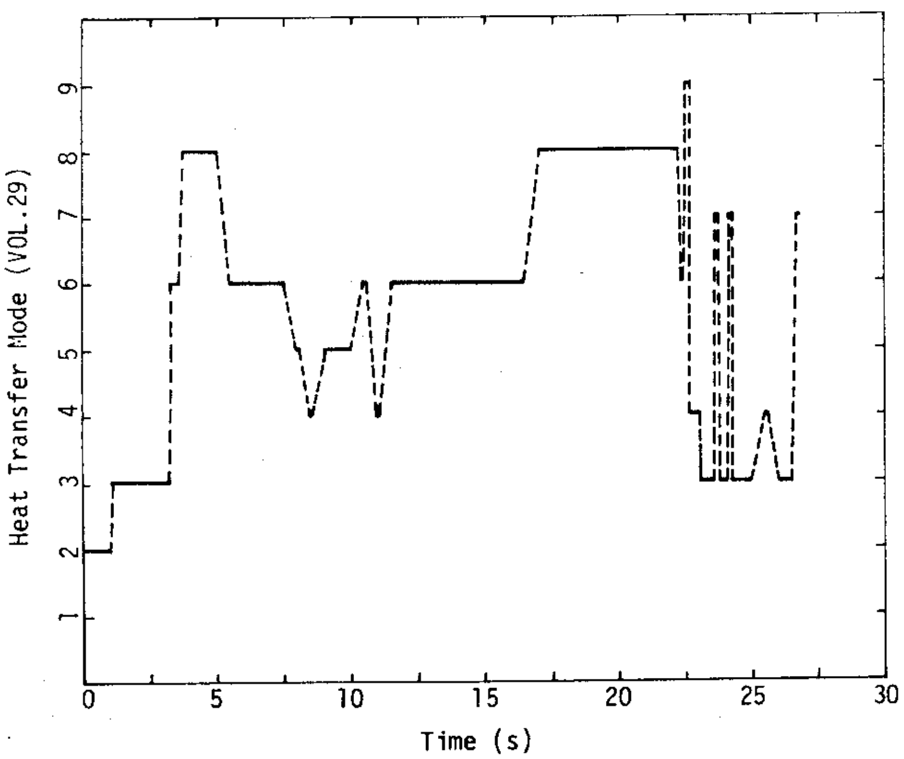


Fig.46 Heat Transfer Mode (Elevation of 14" above Bottom of Core)

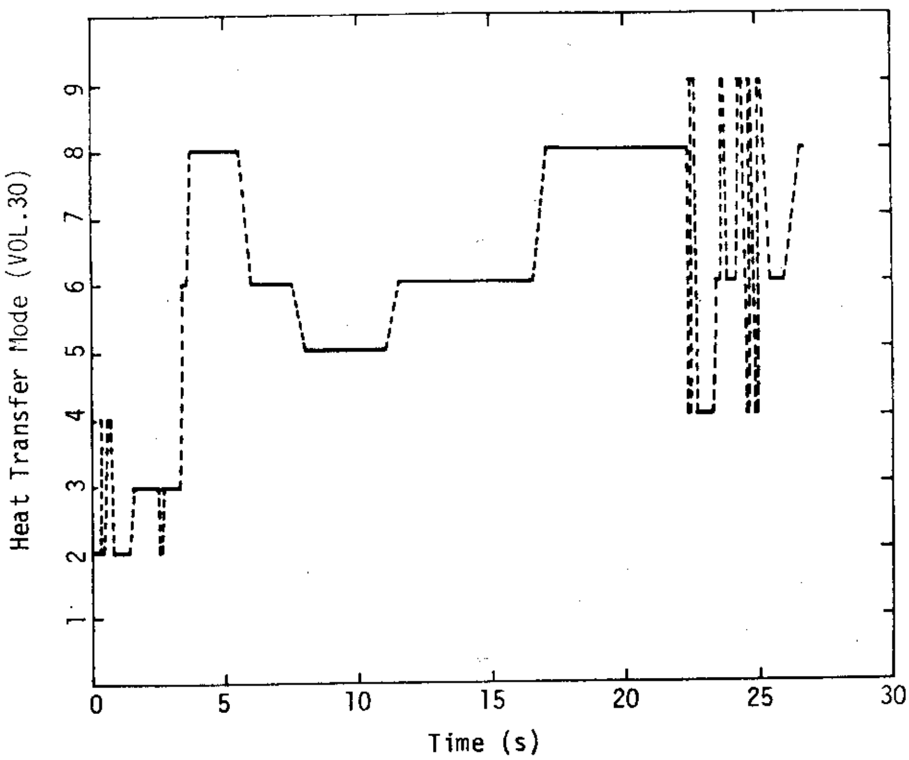


Fig.47 Heat Transfer Mode (Elevation of 28" above Bottom of Core)

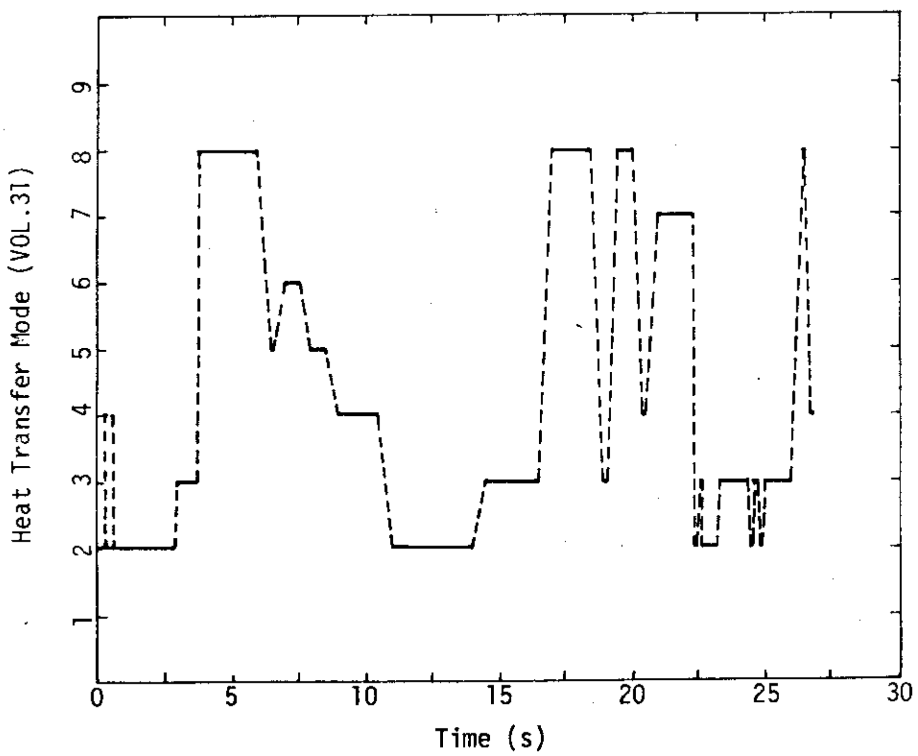


Fig.48 Heat Transfer Mode (Elevation of 39" above Bottom of Core)

## Appendix 1

### List of Input-data

```
/*                                                                              ISP80000
/*      AN ANALYSIS OF SEMISCALE S-06-3 TEST BY ALARM-P1 CODE                   ISP80010
/*                                                                              ISP80020
     ALARM-P1 PREDICTION OF CSNI STANDARD PROBLEM NO.8                          ISP80030
/*                                                                              ISP80040
/*   PROBLEM DIMENSION                                                          ISP80050
/*                                                                              ISP80060
   -3   18   12    10   36   3    40   1   1   3   1    3                      ISP80070
    7    5    2     4    0        1.0058                                        ISP80080
/*                                                                              ISP80090
/*   EDIT VARIABLE                                                              ISP80100
/*                                                                              ISP80110
JW   J29 JW   J30 AP   N10 AP   N17 AP   N35 AP   N21 AP   N26 ST   N28 ST   N29 ISP80120
ST   N30 ST   N31 JW   J7  AT   N11 AT   N18 AT   N26 WM   N27 TM   N27 HC   N28 ISP80130
/*                                                                              ISP80140
/*   TIME STEP SIZE                                                             ISP80150
/*                                                                              ISP80160
    100     20    1   2000       0.000005       0.01                            ISP80170
    100     10    1   1000       0.00001        0.05                            ISP80180
    100      4    1    400       0.000025       0.1                             ISP80190
    100      4    1    400       0.000025       0.3                             ISP80200
    100     20    1    200       0.00005        0.5                             ISP80210
    100     10    1    100       0.0001         5.0                             ISP80220
    100     20    1     40       0.00025       10.0                             ISP80230
    100     10    1     20       0.0005        17.0                             ISP80240
    200     10    1     40       0.00025       22.0                             ISP80250
    100     10    1    100       0.0001        24.5                             ISP80260
    100     50    1    200       0.0001        25.0                             ISP80270
    100     10    1    100       0.0002        50.0                             ISP80280
/*                                                                              ISP80290
/*   TRIP CONTROL                                                               ISP80300
/*                                                                              ISP80310
      1      1    0      0      40.0            0.0     / END OF PROBLEM        ISP80320
     21      1    0      0       0.0            0.0     / STEAM OUTLET J22      ISP80330
      3      1    0      0       0.0            0.0     /  POWER                ISP80340
      4      1    0      0     100.0            0.0     / PUMP TRIP             ISP80350
     51      1    0      0       0.0            0.0     / FEED WATER     J23    ISP80360
     52     -4   36      0     126.5823E4       0.0     / HPIS   J37            ISP80370
     53     -4   36      0      17.5809E4       0.0     / LPIS   J38            ISP80380
      6      1    0      0       0.00001        0.0     / BREAK                 ISP80390
      7      1    0      0       0.00001        0.0     / BREAK                 ISP80400
      8     -4   36      0      43.1941E4       0.0     / ACC VALVE      J40    ISP80410
/*                                                                              ISP80420
/*   VOLUME DATA                                                                ISP80430
/*                                                                              ISP80440
/* **********  VOL.1  INTACT LOOP HOT LEG  **********                           ISP80450
     0   0    160.7718E4       326.444  -1.0    0.01082    0.3086735            ISP80460
      0.3086735        0.00349     0.0667     0.1825625     3.17                ISP80470
/*                                                                              ISP80480
/* **********  VOL.2  SG INLET PLENUM  **********                               ISP80490
     0   0    160.6312E4       326.444  -1.0     0.00963   0.48514              ISP80500
       0.48514         0.01984     0.1590      0.491236      0.0                ISP80510
```

```
/*                                                                                          ISP80520
/* **********  VOL.3  SG U-TUBE  **********                                                 ISP80530
       0   0     160.4933E4        -343.52    -1.0      0.01140      2.629916            ISP80540
     2.629916            0.00442      0.0102        0.976376         0.0                 ISP80550
/*                                                                                          ISP80560
/* **********  VOL.4  SG U-TUBE  **********                                                 ISP80570
       0   0     160.4606E4        -320.14    -1.0      0.01140      2.629916            ISP80580
     2.629916            0.00442      0.0102        0.976376         0.0                 ISP80590
/*                                                                                          ISP80600
/* **********  VOL.5  SG OUTLET PLENUM  **********                                          ISP80610
       0   0     160.5583E4        290.889    -1.0      0.00963      0.48514             ISP80620
     0.48514             0.01984      0.1590        0.491236         0.0                 ISP80630
/*                                                                                          ISP80640
/* **********  VOL.6  PUMP SUCTION LEG  **********                                          ISP80650
       0   0     160.3786E4        290.889    -1.0      0.01018      1.543812            ISP80660
     1.543812            0.00349      0.0667       -1.052576         0.0                 ISP80670
/*                                                                                          ISP80680
/* **********  VOL.7  ACTIVE PUMP  **********                                               ISP80690
       0   1     160.6698E4        290.889    -1.0      0.00408      0.2809875           ISP80700
     0.2809875           0.00349      0.0667       -0.24765          0.0                 ISP80710
           169.53                                                                         ISP80720
/*                                                                                          ISP80730
/* **********  VOL.8  INTACT LOOP COLD LEG NEAR PUMP  **********                            ISP80740
       0   0     161.0171E4        290.889    -1.0      0.00425      0.066675            ISP80750
     0.066675            0.00349      0.0667       -0.0333375        1.25                ISP80760
/*                                                                                          ISP80770
/* **********  VOL.9  INTACT LOOP COLD LEG  **********                                      ISP80780
       0   0     161.0078E4        290.889    -1.0      0.00425      0.066675            ISP80790
     0.066675            0.00349      0.0667       -0.0333375        1.25                ISP80800
/*                                                                                          ISP80810
/* **********  VOL.10 PRESSURIZER  **********                                               ISP80820
       3   0     160.6254E4         -1.0       0.0      0.02741      1.143               ISP80830
     0.62547             0.02466      0.0           1.86055          0.0                 ISP80840
/*                                                                                          ISP80850
/* **********  VOL.11 PRESSURIZER SURGE LINE  **********                                    ISP80860
       0   0     160.7034E4        242.850    -1.0      0.00037      1.6113125           ISP80870
     1.6113125           4.3E-5       0.0           0.2492375        4.0                 ISP80880
/*                                                                                          ISP80890
/* **********  VOL.12  BROKEN LOOP HOT LEG  **********                                      ISP80900
       0   0     160.8332E4        322.960    -1.0      0.00315      0.2190115           ISP80910
     0.2190115           0.00349      0.0667        0.1825625        1.00646             ISP80920
/*                                                                                          ISP80930
/* **********  VOL.13  SG SIMULATOR  **********                                             ISP80940
       0   0     160.7478E4        -349.762 -1.0        0.00852      2.6099135           ISP80950
     2.6099135           0.00374      0.0690        0.401574         2.57658             ISP80960
/*                                                                                          ISP80970
/* **********  VOL.14  SG SIMULATOR  **********                                             ISP80980
       0   0     160.7478E4        -346.519 -1.0        0.00852      2.6099135           ISP80990
     2.6099135           0.00374      0.0690        0.401574         2.57658             ISP81000
/*                                                                                          ISP81010
/* **********  VOL.15  PUMP SUCTION LEG  **********                                         ISP81020
       0   0     160.7948E4        317.800    -1.0      0.00252      1.417574            ISP81030
     1.417574            0.00158      0.0449       -1.016            1.40081             ISP81040
/*                                                                                          ISP81050
```

```
/* ********** VOL.16 PUMP SIMULATOR **********                                          ISP81060
     0  0   160.8552E4       317.000  -1.0    0.00147    0.2301875                      ISP81070
     0.2301875         0.00198   0.0502    -1.2461875    0.768382                       ISP81080
/*                                                                                       ISP81090
/* ********** VOL.17 HOT LEG BREAK NODE **********                                      ISP81100
     0  0   160.8077E4       316.970  -1.0    0.00227    1.4954250                      ISP81110
     1.4954250         0.00145   0.0429    -1.2461875    1.50799                        ISP81120
/*                                                                                       ISP81130
/* ********** VOL.18 BROKEN LOOP COLD LEG **********                                    ISP81140
     0  0   161.0465E4       290.720  -1.0    0.00461    0.066675                       ISP81150
     0.066675          0.00349   0.0667    -0.0333375    1.44331                        ISP81160
/*                                                                                       ISP81170
/* ********** VOL.19 HOT LEG SIDE REFLOOD BYPASS LINE **********                        ISP81180
     0  0   160.8141E4       315.850  -1.0    0.00538    0.552323                       ISP81190
     0.552323          0.00349   0.0667     0.1825625    0.0                            ISP81200
/*                                                                                       ISP81210
/* ********** VOL.20 COLD LEG SIDE REFLOOD BYPASS LINE **********                       ISP81220
     0  0   161.0177E4       288.850  -1.0    0.00640    0.768223                       ISP81230
     0.768223          0.00349   0.0667    -0.0333375    0.0                            ISP81240
/*                                                                                       ISP81250
/* ********** VOL.21 SG SECONDARY SYSTEM **********                                     ISP81260
     1  0     0.0            284.650   0.0287 0.19820    4.6580                         ISP81270
     2.90              0.04255   0.0        0.976376     0.0                            ISP81280
/*                                                                                       ISP81290
/* ********** VOL.22 PRESSURE VESSEL INLET PLENUM **********                            ISP81300
     0  0   161.0066E4       290.889  -1.0    0.00504    0.45847                        ISP81310
     0.45847           0.00548   0.0412    -0.2667       0.0                            ISP81320
/*                                                                                       ISP81330
/* ********** VOL.23 DOWNCOMER ANNULUS **********                                       ISP81340
     0  0   161.1592E4       290.889  -1.0    0.02183    3.880612                       ISP81350
     3.880612          0.00534   0.0214    -4.147312     3.9                            ISP81360
/*                                                                                       ISP81370
/* ********** VOL.24 LOWER PLENUM **********                                            ISP81380
     0  0   161.3225E4       290.889  -1.0    0.02161    0.731774                       ISP81390
     0.731774          0.00623   0.0       -4.879086     1.0                            ISP81400
/*                                                                                       ISP81410
/* ********** VOL.25 MIXER HOUSING **********                                           ISP81420
     0  0   161.2122E4       290.889  -1.0    0.00371    0.520446                       ISP81430
     0.520446          0.00713   0.0       -4.147312     0.0                            ISP81440
/*                                                                                       ISP81450
/* ********** VOL.26 UPPER PLENUM **********                                            ISP81460
     1  0   160.8298E4       326.444  -1.0    0.02620    2.972816                       ISP81470
     2.972816          0.00713   0.0       -1.950466     2.5                            ISP81480
/*                                                                                       ISP81490
/* ********** VOL.27 PRESSURE SUPPRESSION SYSTEM **********                             ISP81500
     1  0     2.4820E4        16.350   0.0    3.17549    4.5225462                      ISP81510
     1.21              0.70205   0.9454    -2.5654       0.0                            ISP81520
/*                                                                                       ISP81530
/* ********** VOL.28 CORE REGION #1 **********                                          ISP81540
     0  0   161.1054E4      -311.09   -1.0    0.00137    0.2794                         ISP81550
     0.2794            0.00492   0.0113    -3.626866     0.0                            ISP81560
/*                                                                                       ISP81570
/* ********** VOL.29 CORE REGION #2 **********                                          ISP81580
     0  0   161.0817E4      -319.99   -1.0    0.00137    0.2794                         ISP81590
```

```
      0.2794          0.00492    0.0113    -3.347466      0.0        ISP81600
/*                                                                   ISP81610
/* **********  VOL.30  CORE REGION #3  **********                     ISP81620
    0   0    161.0582E4       -331.90   -1.0    0.00137    0.2794    ISP81630
      0.2794          0.00492    0.0113    -3.068066      0.0        ISP81640
/*                                                                   ISP81650
/* **********  VOL.31  CORE REGION #4  **********                     ISP81660
    0   0    161.0352E4       -343.28   -1.0    0.00137    0.2794    ISP81670
      0.2794          0.00492    0.0113    -2.788666      0.0        ISP81680
/*                                                                   ISP81690
/* **********  VOL.32  CORE REGION #5  **********                     ISP81700
    0   0    161.0018E4       -352.64   -1.0    0.00274    0.5588    ISP81710
      0.5588          0.00492    0.0113    -2.509266      0.0        ISP81720
/*                                                                   ISP81730
/* **********  VOL.33  ACCUMULATOR TANK  **********                   ISP81740
    3   0     45.0070E4        27.778   0.0    0.1145     3.0036     ISP81750
      1.3007          0.03812    0.2203     0.9877425     0.0        ISP81760
/*                                                                   ISP81770
/* **********  VOL.34  ACCUMULATOR LINE  **********                   ISP81780
    0   0     45.0070E4        27.778   -1.0    0.00244    0.0243    ISP81790
      0.02430         0.00046    0.0243     1.0301175     5.31       ISP81800
/*                                                                   ISP81810
/* **********  VOL.35  COLD LEG BREAK NODE  **********                ISP81820
    0   0    161.0465E4       288.800   -1.0    0.00161    0.066675  ISP81830
      0.066675        0.00349    0.0667    -0.0333375     0.601748   ISP81840
/*                                                                   ISP81850
/* **********  VOL.36  ACCUMULATOR LINE  **********                   ISP81860
    0   0    160.9655E4       238.850   -1.0    0.00244    1.02108   ISP81870
      1.02108         0.00046    0.0243     0.0333375     5.31       ISP81880
/*                                                                   ISP81890
/*    BUBBLE RISE PARAMETER                                          ISP81900
/*                                                                   ISP81910
      0.0      0.9144                                                ISP81920
      0.0      3.048                                                 ISP81930
      0.8      0.9144                                                ISP81940
/*                                                                   ISP81950
/*    PUMP  DESCRIPTION DATA AND CURVE DATA                          ISP81960
/*                                                                   ISP81970
      6   5    9    10    13    12    13    11    2                  ISP81980
        0.0      1.0E-5     997.856     58.522     0*0114     372.8  ISP81990
         4.8111        1.6139         0.0                            ISP82000
/*                                                                   ISP82010
/*    HEAD                                                           ISP82020
/*                                                                   ISP82030
      -1.0     1.5      -0.8     1.275    -0.6     1.375    -0.4     1.375 ISP82040
       0.0     1.2       1.0     1.0                                 ISP82050
/*                                                                   ISP82060
      -1.0     0.175    -0.5     0.65      0.0     0.975     0.5     1.35  ISP82070
       1.0     1.95                                                  ISP82080
/*                                                                   ISP82090
      -1.0     0.175    -0.75  -0.15    -0.55   -0.3     -0.275   -0.4   ISP82100
       0.0    -0.35      0.30  -0.20     0.50    0.0      0.80     0.545 ISP82110
       1.0     1.0                                                   ISP82120
/*                                                                   ISP82130
```

```
     -1.0     1.50      -0.80    1.15      -0.60    0.95       -0.40      0.83   ISP82140
     -0.2     0.775      0.0     0.725      0.20    0.725       0.40      0.80   ISP82150
      0.6     1.025      1.0     1.95                                            ISP82160
/*                                                                               ISP82170
/*   TORQUE                                                                      ISP82180
/*                                                                               ISP82190
     -1.0     0.62      -0.80    0.68      -0.60    0.53       -0.40      0.46   ISP82200
     -0.20    0.49       0.0     0.54       0.20    0.59        0.40      0.65   ISP82210
      0.60    0.77       0.80    0.95       0.90    0.98        0.95      0.96   ISP82220
      1.0     0.87                                                               ISP82230
/*                                                                               ISP82240
     -1.0    -1.44      -0.80   -1.25      -0.60   -1.08       -0.40     -0.92   ISP82250
     -0.20   -0.77       0.0    -0.63       0.20   -0.51        0.40     -0.39   ISP82260
      0.60   -0.29       0.80   -0.20       0.90   -0.16        1.0      -0.13   ISP82270
/*                                                                               ISP82280
     -1.0    -1.44      -0.80   -1.12      -0.60   -0.79       -0.40     -0.52   ISP82290
     -0.20   -0.31       0.0    -0.15       0.20    0.02        0.40      0.22   ISP82300
      0.60    0.46       0.80    0.71       0.90    0.81        0.95      0.85   ISP82310
      1.0     0.87                                                               ISP82320
/*                                                                               ISP82330
     -1.0     0.62      -0.80    0.53      -0.60    0.46       -0.40      0.42   ISP82340
     -0.2     0.39       0.0     0.36       0.20    0.32        0.40      0.27   ISP82350
      0.6     0.18       0.80    0.05       1.0    -0.13                         ISP82360
/*                                                                               ISP82370
      0.0     0.0        1.0E8   0.0                                             ISP82380
/*                                                                               ISP82390
/*   JUNCTION DATA                                                               ISP82400
/*                                                                               ISP82410
/*   *****  JUN.1    UPPER PLENUM TO HOT LEG   *****                             ISP82420
     26   1    0    0   2   1       4.899     0.00183    0.2159           0.0    ISP82430
      1.0E-6   1.0E-6 0  0.85      1.0                                           ISP82440
/*   *****  JUN.2    SG INLET   *****                                            ISP82450
      1   2    0    0   0   1       4.899     0.00349    0.491236         0.0    ISP82460
        0.0      0.0  0  0.85      1.0                                           ISP82470
/*   *****  JUN.3    INLET PLENUM TO U-TUBE    *****                             ISP82480
      2   3    0    0   0   1       4.899     0.00442    0.976376         0.0    ISP82490
        0.0      0.0  0  0.85      1.0                                           ISP82500
/*   *****  JUN.4    TOP OF U-TUBE   *****                                       ISP82510
      3   4    0    0   0   1       4.899     0.00442    3.531108         0.0    ISP82520
        0.0      0.0  0  0.85      1.0                                           ISP82530
/*   *****  JUN.5    U-TUBE TO OUTLET PLENUM   *****                             ISP82540
      4   5    0    0   0   1       4.899     0.00442    0.976376         0.0    ISP82550
        0.0      0.0  0  0.85      1.0                                           ISP82560
/*   *****  JUN.6    SG OUTLET   *****                                           ISP82570
      5   6    0    0   0   1       4.899     0.00349    0.491236         0.0    ISP82580
        0.0      0.0  0  0.85      1.0                                           ISP82590
/*   *****  JUN.7    PUMP INLET   *****                                          ISP82600
      6   7   -1    0   0   1       4.899     0.00349   -0.24765          0.0    ISP82610
        5.30     4.86 0  0.85      1.0                                           ISP82620
/*   *****  JUN.8    PUMP OUTLET   *****                                         ISP82630
      7   8    1    0   0   1       4.899     0.00349    0.0              0.0    ISP82640
        1.65     1.65 0  0.85     -1.0                                           ISP82650
/*   *****  JUN.9    WITHIN COLD LEG   *****                                     ISP82660
      8   9    0    0   0   1       4.899     0.00349    0.0              0.0    ISP82670
```

```
          0.0       0.0  0  0.85    -1.0                                              ISP82680
/*     *****  JUN.10  VESSEL INLET *****                                              ISP82690
        9  22    0    0   2   1     4.899     0.00183    0.0          0.0             ISP82700
        1.0E-6    1.0E-6 0  0.85    -1.0                                              ISP82710
/*     *****  JUN.11  PRESSURIZER OUTLET  *****                                       ISP82720
       10  11    0    0   0   1     0.0       4.3E-5     1.86055      0.0             ISP82730
          10.8      10.8  0  0.85    0.6                                              ISP82740
/*     *****  JUN.12  SURGE LINE OUTLET  *****                                        ISP82750
       11   1    0    0   2   1     0.0       4.3E-5     0.2492375    0.0             ISP82760
          0.0       0.0  0  0.85    0.6                                               ISP82770
/*     *****  JUN.13  VESSEL TO HOT LEG  *****                                        ISP82780
       26  12    0    0   2   1     0.0       0.00183    0.2159       747.499         ISP82790
        0.677051 1.2144 0  0.85     1.0                                               ISP82800
/*     *****  JUN.14  SG SIMULATOR INLET  *****                                       ISP82810
       12  13    0    0   0   1     0.0       0.00024    0.401574    1012.61          ISP82820
          1.41181 1.41146 0  0.85     1.0                                             ISP82830
/*     *****  JUN.15  TOP OF SG SIMULATOR  *****                                      ISP82840
       13  14    0    0   0   1     0.0       0.00349    2.9448125 1030.44            ISP82850
         285.435 285.435 0  0.85     1.0                                              ISP82860
/*     *****  JUN.16  SG SIMULATOR OUTLET  *****                                      ISP82870
       14  15    0    0   0   1     0.0       0.00024    0.401574    1387.54          ISP82880
          1.40405 1.41583 0  0.85     1.0                                             ISP82890
/*     *****  JUN.17  PUMP SIMULATOR INLET  *****                                     ISP82900
       15  16    0    0   0   1     0.0       0.00024   -1.016        827.54          ISP82910
          0.844137 1.54353 0  0.85     1.0                                            ISP82920
/*     *****  JUN.18  PUMP SIMULATOR OUTLET  *****                                    ISP82930
       16  17    0    0   0   1     0.0       0.00024   -1.21285     2018.77          ISP82940
          12.8823 12.438 0  0.85     1.0                                              ISP82950
/*     *****  JUN.19  VESSEL EXIT  *****                                              ISP82960
       22  18    0    0   2   1     0.0       0.00183    0.0          574.74          ISP82970
        0.677051 1.21442 0  0.85    -1.0                                              ISP82980
/*     *****  JUN.20  REFLOOD BYPASS EXIT (HOT LEG)  *****                            ISP82990
       19  12    0    0   0   1     0.0       0.00349    0.2492375    0.0             ISP83000
          0.0       0.0  0  0.85    1.0                                               ISP83010
/*     *****  JUN.21  REFLOOD BYPASS EXIT (COLD LEG) *****                            ISP83020
       20  18    0    0   0   1     0.0       0.00349    0.0333375    0.0             ISP83030
          0.0       0.0  0  0.85    1.0                                               ISP83040
/*     *****  JUN.22  STEAM OUTLET  *****                                             ISP83050
       21   0    1    0   2   1     0.5296    0.00203    5.345176     0.0             ISP83060
          0.0       0.0  0  0.85    0.6                                               ISP83070
/*     *****  JUN.23  FEED WATER INLET  *****                                         ISP83080
        0  21    1    0   2   1     0.5296    0.00113    3.9307262    0.0             ISP83090
          0.0       0.0  0  0.85    0.6                                               ISP83100
/*     *****  JUN.24  DOWNCOMER ANNULUS INLET  *****                                  ISP83110
       22  23    0    0   2   1     4.899     0.00534   -0.2667       0.0             ISP83120
          0.0       0.0  0  0.85    -1.0                                              ISP83130
/*     *****  JUN.25  DOWNCOMER TO LOWER PLENUM  ******                               ISP83140
       23  24    0    0   2   1     4.899     0.00534   -4.147312     0.0             ISP83150
          0.0       0.0  0  0.85    -1.0                                              ISP83160
/*     *****  JUN.26  LOWER PLENUM TO MIXER BOX  ******                               ISP83170
       24  25    0    0   2   1     4.899     0.00713   -4.147312     0.0             ISP83180
          0.0       0.0  0  0.85    -1.0                                              ISP83190
/*     *****  JUN.27  CORE INLET  *****                                               ISP83200
       25  28    0    0   2   1     4.899     0.00492   -3.626866     0.0             ISP83210
```

```
         0.0       0.0  0  0.85    -1.0                                                    ISP83220
/*     *****  JUN.28  CORE OUTLET *****                                                    ISP83230
      32  26     0    0    2    1      4.899      0.00492   -1.950466        0.0           ISP83240
         0.0       0.0  0  0.85    -1.0                                                    ISP83250
/*     *****  JUN.29  BREAK PLANE *****                                                    ISP83260
      17  27     0    1    0    1      0.0        0.00024    0.2159        978.25          ISP83270
         1.00777 1.13360 0  0.85     0.6                                                   ISP83280
/*     *****  JUN.30  BREAK PLANE *****                                                    ISP83290
      35  27     0    2    0    1      0.0        0.00024    0.0           318.823         ISP83300
         1.38245 1.15464 0  0.85     0.6                                                   ISP83310
/*     *****  JUN.31  WITHIN CORE REGION  *****                                            ISP83320
      28  29     0    0    0    1      4.899      0.00492   -3.347466        0.0           ISP83330
         0.0       0.0  0  0.85    -1.0                                                    ISP83340
/*     *****  JUN.32  WITHIN CORE REGION  *****                                            ISP83350
      29  30     0    0    0    1      4.899      0.00492   -3.068066        0.0           ISP83360
         0.0       0.0  0  0.85    -1.0                                                    ISP83370
/*     *****  JUN.33  WITHIN CORE REGION  *****                                            ISP83380
      30  31     0    0    0    1      4.899      0.00492   -2.788666        0.0           ISP83390
         0.0       0.0  0  0.85    -1.0                                                    ISP83400
/*     *****  JUN.34  WITHIN CORE REGION  *****                                            ISP83410
      31  32     0    0    0    1      4.899      0.00492   -2.509266        0.0           ISP83420
         0.0       0.0  0  0.85    -1.0                                                    ISP83430
/*     *****  JUN.35  ACC EXIT  *****                                                      ISP83440
      33  34     0    0    0    1      0.0        0.00046    1.0301175       0.0           ISP83450
         0.0       0.0  0  0.85    -1.0                                                    ISP83460
/*     *****  JUN.36  ECC INJECTION POINT  *****                                           ISP83470
      36   9     0    0    2    1      0.0        0.00046    0.0333375       0.0           ISP83480
       284.38     1.E6 0   0.85    -1.0                                                    ISP83490
/*     *****  JUN.37  HPIS   *****                                                         ISP83500
       0  36     2    0    2    1      0.0        0.00015    0.1111111       0.0           ISP83510
         0.0       0.0  0  0.85     1.0                                                    ISP83520
/*     *****  JUN.38  LPIS   *****                                                         ISP83530
       0  36     3    0    2    1      0.0        0.00028    0.1111111       0.0           ISP83540
         0.0       0.0  0  0.85     1.0                                                    ISP83550
/*     *****  JUN.39  COLD LEG BREAK NODE ENTRANCE *****                                   ISP83560
      18  35     0    0    0    1      0.0        0.00349    0.0           292.636         ISP83570
         1.0E-10 1.0E-10 0  0.85     1.0                                                   ISP83580
/*     *****  JUN.40  WITHIN ACC LINE  **********                                          ISP83590
      34  36     0    3    0    1      0.0        0.00046    1.0301175       0.0           ISP83600
         0.0       0.0  0  0.85    -1.0                                                    ISP83610
/*                                                                                         ISP83620
/*    CHECK VALVE DATA                                                                     ISP83630
/*                                                                                         ISP83640
      -6        0.0      0.0      0.0       0.0          /  BREAK VALVE (J29)              ISP83650
      -7        0.0      0.0      0.0       0.0          /  BREAK VALVE (J30)              ISP83660
      -8        0.0      0.0      0.0       0.0          /  ACC LINE    (J40)              ISP83670
/*                                                                                         ISP83680
/*                                                                                         ISP83690
/*    LEAK DATA                                                                            ISP83700
/*          AT JUNCTION 22  OF SG SECONDARY SIDE                                           ISP83710
/*                                                                                         ISP83720
/*     1    12      1.0338E4    0.85  1.0                                                  ISP83730
       2     6      1.0338E4    0.6   0.85                                                 ISP83740
  0.0 0.5296 8.0 0.5296 12.0 0.2354 24.0 0.0471 24.001 0.0 50.0 0.0                        ISP83750
```

```
                                                                          ISP83760
/*                                                                        ISP83770
/*   FILL DATA                                                            ISP83780
/*       AT JUNCTION 23 OF SG SECONDARY SIDE     FEED WATER               ISP83790
/*                                                                        ISP83800
     6     0    61.1814E4    204.8                                        ISP83810
 0.0 0.5296 8.0 0.5296 12.0 0.2354 24.0 0.0471 24.001 0.0 50.0 0.0        ISP83820
/*      HPIS     (JUNCTION 37)                                            ISP83830
/*                                                                        ISP83840
     4     0       7.0338E4      27.778                                   ISP83850
      0.0   0.0149    30.0   0.0149    30.001   0.0817    50.0   0.0817   ISP83860
/*                                                                        ISP83870
/*      LPIS     (JUNCTION 38)                                            ISP83880
/*                                                                        ISP83890
     2     0       7.0338E4      27.778                                   ISP83900
      0.0   0.299    50.0   0.299                                         ISP83910
/*                                                                        ISP83920
/*   KINETICS CONSTANT DATA                                               ISP83930
/*                                                                        ISP83940
     1     0      0.0       0.0                                           ISP83950
     30                                                                   ISP83960
      0.0     1.0     1.23    1.0     1.64    0.795   2.05    0.597       ISP83970
      2.18    0.579   2.51    0.579   2.59    0.597   2.86    0.795       ISP83980
      3.27    1.0     5.05    1.0     5.45    0.795   6.00    0.597       ISP83990
      6.68    0.398   7.36    0.216   7.64    0.199  11.05    0.199       ISP84000
     11.45    0.138  12.00    0.121  15.27    0.121  15.82    0.086       ISP84010
     16.91    0.086  17.45    0.147  18.00    0.156  19.36    0.156       ISP84020
     20.18    0.061  20.72    0.052  26.45    0.022  36.00    0.022       ISP84030
     39.55    0.038  42.00    0.038                                       ISP84040
/*                                                                        ISP84050
/*   HEAT SLAB DATA                                                       ISP84060
/*                                                                        ISP84070
     3   21   1    3.09632 3.85116   6.2100E-3   0.0   0.0    / U-TUBE1   ISP84080
     4   21   1    3.09632 3.85116   6.2100E-3   0.0   0.0    / U-TUBE2   ISP84090
     0   28   2    0.0     0.3763    1.0085E-3   0.0   0.0    / CORE #1   ISP84100
     0   29   2    0.0     0.3763    1.0085E-3   0.0   0.0    / CORE #2   ISP84110
     0   30   2    0.0     0.3763    1.0085E-3   0.0   0.0    / CORE #3   ISP84120
     0   31   2    0.0     0.3763    1.0085E-3   0.0   0.0    / CORE #4   ISP84130
     0   32   2    0.0     0.7526    2.0170E-3   0.0   0.0    / CORE #5   ISP84140
/*                                                                        ISP84150
/*   CORE SECTION DATA                                                    ISP84160
/*                                                                        ISP84170
     3      0.2794      0.0113      0.1323                                ISP84180
     4      0.2794      0.0113      0.2307                                ISP84190
     5      0.2794      0.0113      0.2553                                ISP84200
     6      0.2794      0.0113      0.2086                                ISP84210
     7      0.5588      0.0113      0.1731                                ISP84220
/*                                                                        ISP84230
/*   SLAB  GEOMETRY DATA                                                  ISP84240
/*                                                                        ISP84250
/*   *****  GEOMETRY INDEX 1  *****                                       ISP84260
     2    1    0    1    2   12.446E-4    1.0    5.1054E-3  / INCONEL600ISP84270
/*   *****  GEOMETRY INDEX 2  *****                                       ISP84280
     2    4    0    2    2    8.890E-4    0.0    0.0        / B.N.      ISP84290
          0         3    2   21.830E-4    1.0               / CONSTANTANISP84290
```

```
          0         2     2   12,960E-4     0.0                     / B.N.      ISP84300
          0         4     2    9.910E-4     0.0                     / ST        ISP84310
/*                                                                              ISP84320
/*    MATERIAL THERMAL PROPERTY DATA                                            ISP84330
/*                                                                              ISP84340
/*    THERMAL CONDUCTIVITY OF INCONEL-600                                       ISP84350
/*                                                                              ISP84360
      5                                                                         ISP84370
      37.8      3.5133E-3     148.9      3.9597E-3       315.6       4.6087E-3  ISP84380
     593.3      5.6420E-3    1000.0      7.1553E-3                              ISP84390
/*                                                                              ISP84400
/*    HEAT CAPACITY OF INCONEL-600                                              ISP84410
/*                                                                              ISP84420
      5                                                                         ISP84430
      37.8  916.024          204.4       979.463         315.6  1021.595        ISP84440
     426.7 1063.888         1000.0      1282.129                                ISP84450
/*                                                                              ISP84460
/*    GAP CONDUCTANCE DATA                                                      ISP84470
/*                                                                              ISP84480
      2                                                                         ISP84490
      0.0    0.0     1000    0.0                                                ISP84500
/*                                                                              ISP84510
/*    THERMAL CONDUCTIVITY OF BORON-NITRIDE                                     ISP84520
/*                                                                              ISP84530
      22                                                                        ISP84540
      50.0      0.5995E-2     100.0      0.5966E-2       150.0       0.5936E-2  ISP84550
     200.0      0.5907E-2     250.0      0.5877E-2       300.0       0.5848E-2  ISP84560
     350.0      0.5819E-2     400.0      0.5789E-2       450.0       0.5760E-2  ISP84570
     500.0      0.5731E-2     550.0      0.5701E-2       600.0       0.5672E-2  ISP84580
     650.0      0.5643E-2     700.0      0.5613E-2       750.0       0.5584E-2  ISP84590
     800.0      0.5555E-2     850.0      0.5525E-2       900.0       0.5496E-2  ISP84600
     950.0      0.5467E-2    1000.0      0.5437E-2      1050.0       0.5408E-2  ISP84610
    1100.0      0.5379E-2                                                       ISP84620
/*                                                                              ISP84630
/*    HEAT CAPACITY OF BORON-NITRIDE                                            ISP84640
/*                                                                              ISP84650
      22                                                                        ISP84660
      50.0      0.4625E3      100.0      0.5279E3        150.0       0.5874E3   ISP84670
     200.0      0.6413E3      250.0      0.6899E3        300.0       0.7335E3   ISP84680
     350.0      0.7726E3      400.0      0.8074E3        450.0       0.8382E3   ISP84690
     500.0      0.8654E3      550.0      0.8895E3        600.0       0.9105E3   ISP84700
     650.0      0.9289E3      700.0      0.9451E3        750.0       0.9593E3   ISP84710
     800.0      0.9718E3      850.0      0.9831E3        900.0       0.9935E3   ISP84720
     950.0      0.1003E4     1000.0      0.1013E4       1050.0       0.1022E4   ISP84730
    1100.0      0.1032E4                                                        ISP84740
/*                                                                              ISP84750
/*    GAP CONDUCTANCE                                                           ISP84760
      2                                                                         ISP84770
      0.0       0.0          1000.0      0.0                                    ISP84780
/*                                                                              ISP84790
/*    THERMAL CONDUCTIVITY OF CONSTANTAN                                        ISP84800
/*                                                                              ISP84810
      22                                                                        ISP84820
      50.0      0.6138E-2     100.0      0.6336E-2       150.0       0.6535E-2  ISP84830
```

```
   200.0    0.6733E-2     250.0   0.6931E-2     300.0    0.7129E-2  ISP84840
   350.0    0.7328E-2     400.0   0.7526E-2     450.0    0.7724E-2  ISP84850
   500.0    0.7923E-2     550.0   0.8121E-2     600.0    0.8319E-2  ISP84860
   650.0    0.8517E-2     700.0   0.8716E-2     750.0    0.8914E-2  ISP84870
   800.0    0.9112E-2     850.0   0.9311E-2     900.0    0.9509E-2  ISP84880
   950.0    0.9707E-2    1000.0   0.9905E-2    1050.0    0.1010E-1  ISP84890
  1100.0    0.1030E-1                                               ISP84900
/*                                                                  ISP84910
/*     HEAT CAPACITY OF CONSTANTAN                                  ISP84920
       22                                                           ISP84930
    50.0    0.8771E3      100.0   0.8945E3      150.0    0.9120E3   ISP84940
   200.0    0.9294E3      250.0   0.9469E3      300.0    0.9643E3   ISP84950
   350.0    0.9818E3      400.0   0.9992E3      450.0    0.1017E4   ISP84960
   500.0    0.1034E4      550.0   0.1052E4      600.0    0.1069E4   ISP84970
   650.0    0.1086E4      700.0   0.1104E4      750.0    0.1121E4   ISP84980
   800.0    0.1139E4      850.0   0.1156E4      900.0    0.1174E4   ISP84990
   950.0    0.1191E4     1000.0   0.1209E4     1050.0    0.1226E4   ISP85000
  1100.0    0.1244E4                                                ISP85010
/*                                                                  ISP85020
/*     GAP CONDUCTANCE DATA                                         ISP85030
       2                                                            ISP85040
     0.0    0.0          1000.0   0.0                               ISP85050
/*                                                                  ISP85060
/*     THERMAL CONDUCTIVITY OF STAINLESS STEEL                      ISP85070
/*                                                                  ISP85080
       22                                                           ISP85090
    50.0    0.3287E-2     100.0   0.3446E-2     150.0    0.3604E-2  ISP85100
   200.0    0.3763E-2     250.0   0.3921E-2     300.0    0.4079E-2  ISP85110
   350.0    0.4238E-2     400.0   0.4396E-2     450.0    0.4555E-2  ISP85120
   500.0    0.4713E-2     550.0   0.4872E-2     600.0    0.5030E-2  ISP85130
   650.0    0.5189E-2     700.0   0.5347E-2     750.0    0.5505E-2  ISP85140
   800.0    0.5664E-2     850.0   0.5822E-2     900.0    0.5981E-2  ISP85150
   950.0    0.6139E-2    1000.0   0.6298E-2    1050.0    0.6456E-2  ISP85160
  1100.0    0.6614E-2                                               ISP85170
/*                                                                  ISP85180
/*     HEAT CAPACITY OF STAINLESS STEEL                             ISP85190
/*                                                                  ISP85200
       22                                                           ISP85210
    50.0    0.9204E3      100.0   0.9350E3      150.0    0.9495E3   ISP85220
   200.0    0.9640E3      250.0   0.9783E3      300.0    0.9926E3   ISP85230
   350.0    0.1007E4      400.0   0.1021E4      450.0    0.1035E4   ISP85240
   500.0    0.1049E4      550.0   0.1062E4      600.0    0.1076E4   ISP85250
   650.0    0.1090E4      700.0   0.1103E4      750.0    0.1117E4   ISP85260
   800.0    0.1130E4      850.0   0.1143E4      900.0    0.1156E4   ISP85270
   950.0    0.1170E4     1000.0   0.1182E4     1050.0    0.1195E4   ISP85280
  1100.0    0.1208E4                                                ISP85290
/*                                                                  ISP85300
/*     GAP CONDUCTANCE DATA                                         ISP85310
/*                                                                  ISP85320
       2                                                            ISP85330
     0.0    0.0          1000.0   0.0                               ISP85340
/*                                                                  ISP85350
/*     END  OF DATA                                                 ISP85360
/*                                                                  ISP85370
```

```
/***********************************************************************
/*    INDIVIDUAL PARAMETERS CORRESPONDING TO MEASUREMENT DATA          *
/*     PRESSURE                                                        *
/*            PU-PRIZE            ----------      AP 10                *
/*            PB-42               ----------      AP 17                *
/*            PB-43               ----------      AP 35                *
/*            PV-UP+10            ----------      AP 26                *
/*            PU-ACC              ----------      AP 33                *
/*            PU-SGSD             ----------      AP 21                *
/*     DIFFERENTIAL PRESSURE                                           *
/*            DPU-10-12           ----------   AP 10- AP 12            *
/*            DPU-7-10            ----------   AP 7 - AP 10            *
/*            DPB-32-36L          ----------   AP 12- AP 15            *
/*            DPB-38-40           ----------   AP 15- AP 17            *
/*            DPV-LP-UP           ----------   AP 24- AP 26            *
/*     FLOW RATE                                                       *
/*            FTV-COREIN (V)      ----------   JW 27                   *
/*            FTU-15     (V)      ----------   JW 10                   *
/*            FTU-PRIZE  (V)      ----------   JW 12                   *
/*            FTU-LPIS   (V)      ----------   JW 38                   *
/*            FTU-HPIS   (V)      ----------   JW 37                   *
/*            FTU-ACC    (V)      ----------   JW 35                   *
/*            FTU-10,GU-10        ----------   JW 7                    *
/*            FDB-42,GB-42R       ----------   JW 29                   *
/*            FDR-23,GB-23R       ----------   JW 30                   *
/*     FLUID DENSITY                                                   *
/*            GB-42VR             ----------   AR 17                   *
/*            GB-23VR             ----------   AR 35                   *
/*            GU-15C              ----------   AR 9                    *
/*            GU-10               ----------   AR 6                    *
/*            GVCOR-150HZ         ----------   AR 25                   *
/*            GV161/192D          ----------   AR 24                   *
/*     FLUID TEMPERATURE                                               *
/*            TFU-PRIZE           ----------   AT 11                   *
/*            TFB-23              ----------   AT 35                   *
/*            TFV-UP+23           ----------   AT 26                   *
/*                                                                     *
/***********************************************************************
/*
```

## Appendix 2

Table 6 List of the Semiscale Function Code

| Measurement | Function Code | Location and Comments |
|---|---|---|
| FLUID TEMPERATURE | | Chromel-Alumel thermocouples unless specified otherwise. |
| Intact Loop | | |
| TFU-1 | TE000150 | Hot leg, Spool 1, 54 cm from vessel center. |
| RBU-2 | TE000023 | Hot leg, Spool 2, 117 cm from vessel center (platinum resistance bulb). |
| TFU-7 | TE000069 | Cold leg, Spool 7, 624 cm from vessel center. |
| TFU-10 | TE000152 | Cold leg, Spool 10, 367 cm from vessel center. |
| RBU-14A | TE000024 | Cold leg, Spool 14, 109 cm from vessel center, upstream of cold leg injection port (platinum resistance bulb). |
| TFU-14B | TE000162 | Cold leg, Spool 14, 99 cm from vessel center, downstream of cold leg injection port. |
| TFU-15 | TE000168 | Cold leg, Spool 15, 54 cm from vessel center. |
| Broken Loop | | |
| TFB-20 | TE000159 | Cold leg, Spool 20, 52 cm from vessel center. |
| TFB-23 | TE000149 | Cold leg, Spool 23, 232 cm from vessel center, upstream of vessel-side nozzle. |
| TFB-24 | TE000201 | Cold leg, Spool 24, 264 cm from vessel center, downstream from vessel-side nozzle. |
| TFB-30 | TE000148 | Hot leg, Spool 30, 40 cm from vessel center. |
| TFB-37 | TE000161 | Cold leg, Spool 37, 703 cm from vessel center along hot leg, discharge of simulated steam generator. |
| TFB-42 | TE000151 | Cold leg, Spool 42, 1054 cm from vessel center along hot leg, upsteam of pump-side nozzle. |
| TFB-43 | TE000200 | Cold leg, Spool 43, 1086 cm from vessel center along hot leg. |
| TFB-RFB-C | TE000145 | Reflood bypass, near end cap, cold leg side. |
| TFB-RFB-H | TE000166 | REflood bypass, near end cap, hot leg side. |
| Inlet Annulus | | 10 cm below cold leg centerline, 0.5 cm from vessel wall, Type iron-constantan thermocouples. |
| TFV-ANN-4A | TE000202 | 0°. |
| TFV-ANN-4M | TE000191 | 180°. |

| Measurement | Function Code | Location and Comments |
|---|---|---|
| Downcomer Annulus | | Centered in annulus, Type J iron-constantan thermocouples. |
| TFV-ANN-15T | TE000180 | 38 cm below cold leg centerline, 270°. |
| TFV-ANN-35A | TE000176 | 89 cm below cold leg centerline, 0°. |
| TFV-ANN-35T | TE000181 | 89 cm below cold leg centerline, 270°. |
| TFV-ANN-70A | TE000178 | 178 cm below cold leg centerline, 0°. |
| TFV-ANN-115A | TE000177 | 292 cm below cold leg centerline, 0°. |
| TFV-ANN-115M | TE000182 | 292 cm below cold leg centerline, 180°. |
| TFV-ANN-156A | TE000184 | 396 cm below cold leg centerline, 0°. |
| Upper Plenum | | |
| TFV-UP+13 | TE000135 | In upper plenum, 34 cm above cold leg centerline at 180°. |
| Lower Plenum | | On fluid thermocouple rack, 2.54 cm from vessel center, 45°. |
| TFV-LP-8 | TE000186 | 19 cm from bottom of vessel. |
| TFV-LP-15 | TE000187 | 37 cm from bottom of vessel. |
| TFV-LP-22 | TE000188 | 55 cm from bottom of vessel. |
| Core | | |
| TFV-CORE-IN | TE000196 | In core flow mixer box, 381 cm below cold leg centerline (a part of FDV-CORE-IN). |
| Core Grid Spacers | | |
| Grid Spacer 5 | | 140 cm below cold leg centerline, 54.6 cm above top of heated length. |
| TFG-5CD-45 | TE000050 | Thermocouple in space defined by Columns C and D, Rows 4 and 5. |
| Grid Spacer 6 | | 193 cm below cold leg centerline, 1.3 cm above top of heated length. |
| TFG-6CD-45 | TE000158 | Thermocouple in space defined by Columns C and D, Rows 4 and 5. |
| TFG-6DE-67 | TE000130 | Thermocouple in space defined by Columns D and E, Rows 6 and 7. |
| Grid Spacer 10 | | 363 cm below cold leg centerline at bottom of heated length. |
| TFG-10AB-45 | TE000033 | Thermocouple in space defined by Columns A and B, Rows 4 and 5. |
| TFG-10GH-45 | TE000103 | Thermocouple in space defined by Columns G and H, Rows 4 and 5. |

| Measurement | Function Code | Location and Comments |
|---|---|---|
| ECC System<br>TFU-ECC-14 | TE000031 | In ECC line leading to intact loop spool 14. |
| Steam Generator<br>TFU-SGFW | TE000167 | In feedwater line leading to steam generator. |
| TFU-SGSD | TE000028 | In steam dome, 329 cm above bottom of tube sheet. |
| TFU-SG1 | TE000124 | Secondary side, 30 cm above bottom of tube sheet. |
| TFU-SG3 | TE000077 | Secondary side, 122 cm above bottom of tube sheet. |
| TFU-SG4 | TE000027 | Secondary side, 244 cm above bottom of tube sheet. |
| Pressurizer<br>TFU-PRISE | TE000080 | In surge line, near pressurizer exit, between turbine flowmeter and pressurizer. |
| Pressure Suppression System<br>TF-PSS-33 | TE000082 | 84 cm from bottom of tank. |
| TF-PSS-63 | TE000107 | 160 cm from bottom of tank. |
| TF-PSS-130 | TE000085 | 330 cm from bottom of tank. |
| MATERIAL TEMPERATURE | | Chromel-Alumel thermocouples unless specified otherwise. |
| Intact Loop<br>TMU-1T16 | TE000110 | Hot leg, Spool 1, top, 1.6 mm from pipe ID, 54 cm from vessel center. |
| TMU-15T16 | TE000142 | Cold leg, Spool 15, top, 1.6 mm from pipe ID, 54 cm from vessel center. |
| Broken Loop<br>TMB-20B16 | TE000157 | Cold leg, Spool 20, bottom, 1.6 mm from pipe ID, 52 cm from vessel center. |
| TMB-30B16 | TE000087 | Hot leg, Spool 30, bottom, 1.6 mm from pipe ID, 40 cm from vessel center. |
| Vessel Filler | | Type J iron-constantan |
| TMV-FI-115A | TE000122 | 292 cm below cold leg centerline, 1.6 mm from filler ID, 0°. |
| Core Barrel | | Type J iron-constantan thermocouples. |
| TMV-CI-35A | TE000192 | 89 cm below cold leg centerline, 1.6 mm from core barrel ID, 0°. |

| Measurement | Function Code | Location and Comments |
|---|---|---|
| CORE HEATER CLADDING TEMPERATURE | | Chromel-Alumel thermocouples. |
| High Power Heaters | | |
| TH-D4-14<br>TH-D4-29 | TE000194<br>TE000193 | Heater at Column D, Row 4. Thermocouples 36 cm (270°) and 74 cm (315°) above bottom of core. |
| TH-D5-09<br>TH-D5-29<br>TH-D5-39 | TE000052<br>TE000102<br>TE000037 | Heater at Column D, Row 5. Thermocouples 23 cm (45°), 74 cm (225°) and 99 cm (135°) above bottom of core. |
| TH-E4-09<br>TH-E4-27<br>TH-E4-55 | TE000054<br>TE000169<br>TE000170 | Heater at Column E, Row 4. Thermocouples 23 cm (180°), 69 cm (90°) and 140 cm (0°) above bottom of core. |
| TH-E5-21 | TE000164 | Heater at Column E, Row 5. Thermocouple 53 cm (180°) above bottom of core. |
| Low Power Heaters | | |
| TH-A4-09<br>TH-A4-29 | TE000172<br>TE000128 | Heater at Column A, Row 4. Thermocouples 23 cm (105°) and 74 cm (240°) above bottom of core. |
| TH-A5-29<br>TH-A5-45 | TE000147<br>TE000160 | Heater at Column A, Row 5. Thermocouples 74 cm (180°) and 114 cm (255°) above bottom of core. |
| TH-B3-32 | TE000171 | Heater at Column B, Row 3. Thermocouple 81 cm (135°) above bottom of core. |
| TH-B5-29<br>TH-B5-33 | TE000098<br>TE000140 | Heater at Column B, Row 5. Thermocouples 74 cm (150°) and 85 cm (45°) above bottom of core. |
| TH-B6-14<br>TH-B6-29 | TE000106<br>TE000104 | Heater at Column B, Row 6. Thermocouples 36 cm (0°) and 74 cm (45°) above bottom of core. |
| TH-C2-28<br>TH-C2-38 | TE000163<br>TE000199 | Heater at Column C, Row 2. Thermocouples 71 cm (135°) and 97 cm (225°) above bottom of core. |
| TH-C3-60 | TE000032 | Heater at Column C, Row 3. Thermocouple 152 cm (135°) above bottom of core. |
| TH-C4-20<br>TH-C4-26 | TE000066<br>TE000203 | Heater at Column C, Row 4. Thermocouples 51 cm (150°) and 66 cm (75°) above bottom of core. |
| TH-C5-28 | TE000155 | Heater at Column C, Row 5. Thermocouple 71 cm (315°) above bottom of core. |
| TH-C6-32<br>TH-C6-53 | TE000079<br>TE000070 | Heater at Column C, Row 6. Thermocouples 81 cm (225°) and 135 cm (270°) above bottom of core. |

| Measurement | Function Code | Location and Comments |
|---|---|---|
| Low Power Heaters (continued) | | |
| TH-C7-07<br>TH-C7-15 | TE000097<br>TE000143 | Heater at Column C, Row 7. Thermocouples 18 cm (345°) and 38 cm (255°) above bottom of core. |
| TH-D1-21 | TE000146 | Heater at Column D, Row 1. Thermocouple 53 cm (330°) above bottom of core. |
| TH-D2-14<br>TH-D2-61 | TE000055<br>TE000053 | Heater at Column D, Row 2. Thermocouples 36 cm (0°) and 155 cm (270°) above bottom of core. |
| TH-D3-29<br>TH-D3-33<br>TH-D3-39 | TE000034<br>TE000165<br>TE000190 | Heater at Column D, Row 3. Thermocouples 74 cm (150°), 84 cm (45°) and 99 cm (210°) above bottom of core. |
| TH-D7-20 | TE000189 | Heater at Column D, Row 7. Thermocouple 51 cm (60°) above bottom of core. |
| TH-D8-57 | TE000132 | Heater at Column D, Row 8. Thermocouple 145 cm (15°) above bottom of core. |
| TH-E1-33 | TE000195 | Heater at Column E, Row 1. Thermocouple 84 cm (60°) above bottom of core. |
| TH-E2-20<br>TH-E2-33 | TE000129<br>TE000026 | Heater at Column E, Row 2. Thermocouples 51 cm (210°) and 84 cm (315°) above bottom of core. |
| TH-E3-24 | TE000116 | Heater at Column E, Row 3. Thermocouple 61 cm (75°) above bottom of core. |
| TH-E6-08<br>TH-E6-28<br>TH-E6-37 | TE000154<br>TE000197<br>TE000153 | Heater at Column E, Row 6. Thermocouples 20 cm (150°), 71 cm (285°) and 94 cm (330°) above bottom of core. |
| TH-E7-13<br>TH-E7-44 | TE000101<br>TE000035 | Heater at Column E, Row 7. Thermocouples 33 cm (45°) and 112 cm (195°) above bottom of core. |
| TH-E8-14<br>TH-E8-29<br>TH-E8-45 | TE000141<br>TE000144<br>TE000173 | Heater at Column E, Row 8. Thermocouples 36 cm (150°), 74 cm (225°) and 114 cm (300°) above bottom of core. |
| TH-F2-07<br>TH-F2-22<br>TH-F2-25 | TE000138<br>TE000084<br>TE000095 | Heater at Column F, Row 2. Thermocouples 18 cm (255°), 56 cm (105°) and 64 cm (0°) above bottom of core. |
| TH-F3-06<br>TH-F3-22<br>TH-F3-25 | TE000036<br>TE000183<br>TE000185 | Heater at Column F, Row 3. Thermocouples 15 cm (315°), 56 cm (105°) and 64 cm (30°) above bottom of core. |
| TH-F4-14<br>TH-F4-29<br>TH-F4-44 | TE000099<br>TE000156<br>TE000136 | Heater at Column F, Row 4. Thermocouples 36 cm (90°), 74 cm (165°) and 112 cm (210°) above bottom of core. |
| TH-F5-20<br>TH-F5-26 | TE000175<br>TE000126 | Heater at Column F, Row 5. Thermocouples 51 cm (255°) and 66 cm (165°) above bottom of core. |

| Measurement | Function Code | Location and Comments |
|---|---|---|
| Low Power Heaters (continued) | | |
| TH-F6-08<br>TH-F6-28 | TE000179<br>TE000096 | Heater at Column F, Row 6. Thermocouples 20 cm (60°) and 71 cm (210°) above bottom of core. |
| TH-G3-13 | TE000059 | Heater at Column G, Row 3. Thermocouples 33 cm (150°) above bottom of core. |
| TH-G4-29<br>TH-G4-33<br>TH-G4-38 | TE000198<br>TE000174<br>TE000139 | Heater at Column G, Row 4. Thermocouples 74 cm (300°), 84 cm (225°) and 97 cm (30°) above bottom of core. |
| TH-G5-14<br>TH-G5-24 | TE000205<br>TE000204 | Heater at Column G, Row 5. Thermocouples 36 cm (45°) and 61 cm (330°) above bottom of core. |
| TH-H5-32 | TE000133 | Heater at Column H, Row 5. Thermocouple 81 cm (45°) above bottom of core. |
| PRESSURE | | |
| Intact Loop | | |
| PU-13 | PG000042 | Cold leg, Spool 13, 138 cm from vessel center. |
| PU-15L | PG000040 | Cold leg, Spool, 15, 55 cm from vessel center, to atmosphere (low range). |
| Broken Loop | | |
| PB-21 | PG000065 | Cold leg, Spool 21, 112 cm from vessel center. |
| PB-23 | PG000072 | Cold leg, Spool 23, 235 cm from vessel center, upstream of nozzle (tee off DP tap). |
| PB-24 | PG000076 | Cold leg, Spool 24, 264 cm from vessel center, downstream of nozzle. |
| PB-30 | PG000051 | Hot leg, Spool 30, 45 cm from vessel center (tee off DP tap). |
| PB-42 | PG000073 | Cold leg, Spool 42, 1057 cm from vessel center along hot leg, upstream of pump-side nozzle (tee off DP tap). |
| PB-43 | PG000105 | Cold leg, Spool 43, 1086 cm from vessel center along hot leg, upstream of rupture discs. |
| PB-CN1 | PG000062 | Vessel-side nozzle, nozzle throat 245 cm from vessel center (tee off DP tap). |
| Vessel | | |
| PV-UP+10 | PG000046 | In upper plenum, 25 cm above cold leg centerline, mounted on standoff, 30°. |
| PV-LP-180 | PG000119 | In upper part of lowerplenum, 457 cm below cold leg centerline, mounted on standoff, 225°. |

| Measurement | Function Code | Location and Comments |
|---|---|---|
| ECC System<br>PU-ACC | PG000137 | In intact loop accumulator. |
| Steam Generator<br>PU-SGSD | PG000043 | Secondary side steam dome. |
| Pressurizer<br>PU-PRIZE | PG000056 | Pressurizer steam dome. |
| Pressure Suppression System<br>P-PSS | PG000091 | Suppression tank top. |
| DIFFERENTIAL PRESSURE | | Elevation difference between transducer taps is zero unless otherwise specified. |
| Intact Loop<br>DPU-UP-3 | PD000049 | Upper plenum 26.7 cm above cold leg centerline at 30° to hot leg, Spool 3, 158 cm from vessel center. Upper plenum tap is approximately 5 cm above Spool 3 tap. |
| DPU-3-6 | PD000045 | Hot leg Spool 3, 158 cm from vessel center to hot leg Spool 6, 290 cm from vessel center. |
| DPU-6-SGIP | PD000089 | Hot leg, Spool 6, 290 cm from vessel center to steam generator inlet plenum 368 cm from vessel center. Spool 6 tap is 41 cm below SGIP tap. |
| DPU-6-7 | DP000047 | Across steam generator, hot leg Spool 6, 290 cm from vessel center to cold leg. Spool 7, 587 cm from vessel center. Spool 6 tap is 48 cm above Spool 7 tap. |
| DPU-SGOP-7 | PD000088 | From steam generator outlet plenum 683 cm from vessel center along cold leg to cold leg Spool 7, 587 cm from vessel center, including orifice. Spool 7 tap is 89 cm below SGOP tap. |
| DPU-7-10 | PD000109 | Steam generator outlet to pump inlet, cold leg Spool 7, 587 cm from vessel center, to cold leg Spool 10, 359 cm from vessel center. |
| DPU-12-10 | PD000093 | Pump outlet to pump inlet, cold leg Spool 12, 192 cm from vessel center, to cold leg Spool 10, 359 cm from vessel center. Spool 10 tap is 25 cm below Spool 12 tap. |
| DPU-12-10L | PD000094 | Pump outlet to pump inlet, cold leg Spool 12, 192 cm from vessel center, to cold leg Spool 10, 359 cm from vessel center. Spool 10 tap is 25 cm below Spool 12 tap (low range). |
| DPU-12-15 | PD000048 | Cold leg Spool 12, 192 cm from vessel center, to cold leg Spool 15, 55 cm from vessel center. |

| Measurement | Function Code | Location and Comments |
|---|---|---|
| Intact Loop (continued) | | |
| DPU-15-3 | PD000074 | Cold leg to hot leg; cold leg Spool 15, 55 cm from vessel center, to hot leg Spool 3, 158 cm from vessel center. Spool 15 tap is 22 cm below Spool 3 tap. |
| DPU-15-3L | PD000075 | Cold leg to hot leg, cold leg Spool 15, 55 cm from vessel center, to hot leg Spool 3, 158 cm from vessel center. Spool 15 tap is 22 cm below Spool 3 tap (low range). |
| DPU-15-IANN | PD000108 | Cold leg Spool 15, 55 cm from vessel center, to inlet annulus, 23 cm below cold leg centerline at 225°. Spool 15 tap is 23 cm above inlet annulus tap. |
| DPU-PRESLL | PD000058 | Pressurizer water level. Elevation difference between taps is 135 cm. Lower tap is 9 cm above pressurizer exit. |
| DPU-PR-4 | PD000100 | Pressurizer bottom to Spool 4. Elevation difference between taps is 157 cm. Spool 4 tap is 140 cm below pressurizer exit. |
| Broken Loop | | |
| DPB-21-IANN | PD000092 | Cold leg Spool 21, 112 cm from vessel center, to vessel inlet annulus, 23 cm below cold leg centerline at 225°. Inlet annulus tap is 23 cm below Spool 21 tap. |
| DPB-21-23 | PD000067 | Cold leg, Spool 21, 112 cm from vessel center, to cold leg 23, 235 cm from vessel center. |
| DPB-23-CNI | PD000078 | Cold leg, Spool 23, 235 cm from vessel center to vessel-side nozzle throat, 245 cm from vessel center. |
| DPB-23-24 | PD000068 | Across vessel-side nozzle, Spool 23, 235 cm from vessel center to Spool 24, 264 cm from vessel center. |
| DPB-30-36L | PD000057 | Across entire simulated steam generator assembly, hot leg Spool 30, 45 cm from vessel center, to cold leg Spool 36 lower tap, 617 cm from vessel center. Spool 30 tap is 48 cm below Spool 36 lower tap. |
| DPB-30-38 | PD000111 | Across entire simulated steam generator assembly and instrument spool down-stream of simulated steam generator; hot leg Spool 30, 45 cm from vessel center to cold leg, Spool 38, 776 cm from vessel center along hot leg. Spool 30 tap is 102 cm above Spool 38 tap. |

| Measurement | Function Code | Location and Comments |
|---|---|---|
| Broken Loop (continued) | | |
| DPB-32U-36L | PD000063 | Across simulated steam generator orifice assembly, hot leg Spool 32 upper tap, 189 cm from vessel center, to Spool 36 lower tap, 617 cm from vessel center. Spool 32 upper tap is 41 cm above Spool 36 lower tap. |
| DPB-38-40 | PD000081 | Across simulated pump, cold leg Spool 38, 776 cm from vessel center along hot leg, to cold leg Spool 40, 929 cm from vessel center along hot leg. |
| DPB-40-42 | PD000086 | Across elbow leading to spool up-stream of pump-side nozzle. Cold leg Spool 40, 929 cm from vessel center along hot leg, to Spool 42, 1057 cm from vessel center along hot leg. Spool 40 tap is 102 cm below Spool 42 tap. |
| DPB-42-43 | PD000090 | Across pump-side nozzle cold leg Spool 42, 1057 cm from vessel center along hot leg, to cold leg, Spool 43 1086 cm from vessel center along hot leg. |
| Vessel | | |
| DPV-UP-IANN | PD000115 | Upper plenum, 27 cm above cold leg centerline at 30° to inlet annulus, 23 cm below cold leg centerline at 225°. Elevation difference between taps is 48 cm. |
| DPV-0-9GQ | PD000044 | Inlet annulus cold leg centerline at 90°, to 23 cm below cold leg centerline at 225°. Elevation difference between taps is 23 cm. |
| DPV-9-26QQ | PD000117 | Inlet annulus, 23 cm below cold leg centerline at 225°, to downcomer gap, 66 cm below cold leg centerline at 225°. Elevation difference between taps is 43 cm. |
| DPV-9-180QQ | PD000112 | Inlet annulus, 23 cm below cold leg centerline at 225°, to lower plenum, 457 cm below cold leg centerline at 225°. Elevation difference between taps is 434 cm. |
| DPV-26-55QM | PD000118 | Across part of downcomer, 66 cm (225°), to 140 cm (180°), below cold leg centerline. Elevation difference between taps is 74 cm. |
| DPV-55-110MM | PD000121 | Across part of downcomer, 140 cm (180°), to 279 cm (180°), below cold leg centerline. Elevation difference between taps is 140 cm. |
| DPV-110-15MQ | PD000127 | Across part of downcomer, 279 cm (180°), to 396 cm (225°), below cold leg centerline. Elevation difference between taps is 117 cm. |

| Measurement | Function Code | Location and Comments |
|---|---|---|
| Vessel (continued) | | |
| DPV-156-173QQ | PD000113 | Across part of lower plenum, 396 cm (225°), to 439 cm (225°), below cold leg centerline. Elevation difference between taps is 43 cm. |
| DPV-166-192QT | PD000114 | Across lower plenum, 422 cm (225°) to 488 cm (270°), below cold leg centerline. Elevation difference between taps is 66 cm. |
| DPV-173-180QQ | PD000123 | Across part of lower plenum, 439 cm (225°) to 457 cm (225°), below cold leg centerline. Elevation difference between taps is 18 cm. |
| DPV-LP-UP | PD000120 | Lower plenum, 457 cm below cold leg centerline at 225° to upper plenum, 27 cm above cold leg centerline at 30°. Elevation difference between taps is 485 cm. |
| ECC System | | |
| DPU-ACC-TB | PD000030 | Top to bottom of intact loop accumulator. Elevation difference between taps is 274 cm. |
| Steam Generator | | |
| DPU-SGFW | PD000018 | In steam generator feedwater line. |
| DPU-SG-SEC | PD000060 | Secondary side, differential pressure taps at 114 cm and 320 cm above bottom of tube sheet. Elevation difference between taps is 206 cm. |
| DPU-SG-DISC | PD000029 | Across venturi tube, 168 cm downstream from steam generator discharge. |
| Pressure Suppression System | | |
| DP-PSS-TB | PD000125 | Top to bottom of pressure suppression tank. Elevation difference between taps is 338 cm. |
| VOLUMETRIC FLOW RATE | | Turbine flowmeter, bidirectional. |
| Intact Loop | | 3-in. Schedule 160 pipe. |
| FTU-1 | FV000001 | Hot leg, Spool 1, 42 cm from vessel center. |
| FTU-9 | FV000002 | Cold leg, Spool 9, 393 cm from vessel center. |
| FTU-13 | FV000003 | Cold leg, Spool 13, 163 cm from vessel center. |
| FTU-15 | FV000004 | Cold leg, Spool 15, 42 cm from vessel center. |
| Broken Loop | | Schedule 160 pipe. |
| FTB-21 | FV000006 | Cold leg, Spool 21, 146 cm from vessel center; 3-in. pipe. |
| FTB-30 | FV000007 | Hot leg, Spool 30, 63 cm from vessel center; 3-in. pipe. |

| Measurement | Function Code | Location and Comments |
|---|---|---|
| Broken Loop (continued) | | |
| FTB-37 | FV000005 | Cold leg, Spool 37, 739 cm from vessel center along hot leg; 2-in. pipe. |
| Core | | |
| FTV-CORE-IN | FV000010 | Entrance to core, 401 cm below cold leg centerline. |
| ECC System | | |
| FTU-HPIS | FV000016 | In line immediately after HPIS pump for intact loop, 1/2-in. line. |
| FTU-LPIS | FV000017 | In line leading from LPIS pump for intact loop, 1/2-in. line. |
| FTU-ACC | FV000022 | In line leading from intact loop accumulator, 1-in. line. |
| Pressurizer | | 1-1/2-in. turbine |
| FTU-PRIZE | FV000020 | Surge line. |
| FLUID VELOCITY | | Turbine flowmeter, bidirectional. |
| Downcomer | | |
| FTV-40A | VE000008 | 102 cm below cold leg centerline, 0°. |
| FTV-40M | VE000009 | 102 cm below cold leg centerline, 180°. |
| MOMENTUM FLUX | | Drag disc, bidirectional. |
| Intact Loop | | 3-in. pipe. |
| FDU-1 | MF000131 | Hot leg, Spool 1, 60 cm from vessel center; target size 2.22 cm. |
| FDU-5 | MF000011 | Hot leg, Spool 5, 256 cm from vessel center; target size 2.54 cm. |
| FDU-10 | MF000038 | Cold leg, Spool 10, 349 cm from vessel center; target size 2.22 cm. |
| FDU-13 | MF000039 | Cold leg, Spool 13, 138 cm from vessel center; target size 2.22 cm. |
| FDU-15 | MF000134 | Cold leg, Spool 15, 60 cm from vessel center; target size 2.22 cm. |
| Broken Loop | | |
| FDB-21 | MF000061 | Cold leg, Spool 21, 134 cm from vessel center, 3-in. pipe; target size 1.67 cm. |
| FDB-23 | MF000064 | Cold leg, Spool 23, 238 cm from vessel center, upstream of vessel side nozzle, 2-in. pipe; target size 1.03 cm. |
| FDB-30 | MF000041 | Hot leg, Spool 30, 52 cm from vessel center, 3-in. pipe; target size 1.03 cm. |

| Measurement | Function Code | Location and Comments |
|---|---|---|
| Broken Loop (continued) | | |
| FDB-37 | MF000083 | Cold leg, Spool 37, 725 cm from vessel center along hot leg, steam generator outlet, vertical pipe, 2-in. pipe; target size 1.03 cm. |
| FDB-42 | MF000071 | Cold leg, Spool 42, 1057 cm from vessel center along hot leg, upstream of pump-side nozzle, downstream of injection point, 2-in. pipe; target size 1.03 cm. |
| Vessel | | |
| FDV-CORE-IN | MF000019 | In core flow mixer box, 381 cm below cold leg centerline; target size 2.54 cm. |
| DENSITY | | |
| Intact Loop | | |
| GU-1T<br>GU-1B<br>GU-1C | DE000233<br>DE000232<br>DE000238 | Hot leg, Spool 1, 77 cm from vessel center. T (top) ranges 270 to 360°. B (bottom) ranges 30 to 330°. C is a mathematical composite of T and B. |
| GU-5VR | DE000213 | Hot leg, Spool 5, 246 cm from vessel center, vertical. |
| GU-10VR | DE000214 | Cold leg, Spool 10, 359 cm from vessel center, vertical. |
| GU-13VR | DE000215 | Cold leg, Spool 13, 142 cm from vessel center, vertical. |
| GU-15T<br>GU-15B<br>GU-15C | DE000235<br>DE000234<br>DE000239 | Cold leg, Spool 15, 77 cm from vessel center. T (top) ranges 270 to 360°. B (bottom) ranges 30 to 330°. C is a mathematical composite of T and B. |
| Broken Loop | | |
| GB-21T<br>GB-21B<br>GB-21C | DE000229<br>DE000228<br>DE000236 | Cold leg, Spool 21, 123 cm from vessel center. T (top) ranges 270 to 360°. B (bottom) ranges 30 to 330°. C is a mathematical composite of T and B. |
| GB-23VR | DE000219 | Cold leg, Spool 23, 235 cm from vessel center, vertical. |
| GB-30T<br>GB-30B<br>GB-30C | DE000231<br>DE000230<br>DE000237 | Hot leg, Spool 30, 49 cm from vessel center. T (top) ranges 270 to 360°. B (bottom) ranges 30 to 330°. C is a mathematical composite of T and B. |
| GB-37 | DE000218 | Cold leg, Spool 37, 709 cm from vessel center along hot leg, across vertical pipe, simulated steam generator discharge. |
| GB-42VR | DE000217 | Cold leg, Spool 42, 1057 cm from vessel center along hot leg, vertical. |

| Measurement | Function Code | Location and Comments |
|---|---|---|
| Vessel | | |
| GV-COR-150HZ | DE000212 | Core flow mixer box, 386 cm below cold leg centerline, horizontal, 0 to 180°. |
| GV-161/192D | DE000207 | Lower plenum, 409 cm below cold leg centerline (270°) to 488 cm below cold leg centerline (90°), 79 cm vertical, 82 cm diagonal. |
| GVLP-165HZ | DE000221 | Upper part of lower plenum, 419 cm below cold leg centerline, 4.379 cm below downcomer exit, horizontal 0 to 180°. |
| GVLP-172HZ | DE000211 | Lower plenum, 437 cm below cold leg centerline, 22 cm below downcomer exit, horizontal, 90 to 270°. |
| Pressurizer | | |
| GU-PRIZE | DE000224 | Surge line. |
| CORE CHARACTERISTICS | | |
| PWRCOR T-1 | PP000012 | Core power. |
| PWRCOR T-2 | PP000013 | Core power. |
| VOLTCOR-T | V0000015 | Core voltage. |
| AMPCOR-T | CT000014 | Core current. |
| PUMP CHARACTERISTICS | | |
| PUMPU-CUR | CT000021 | Pump current. |
| PUMPU-RPM | SR000025 | Pump speed. |
| MASS FLOW RATE | | Mass flow rate obtained by combining density (gamma attenuation technique) with volumetric flow rate (turbine flowmeter) or momentum flux (drag disc). |
| Intact Loop | | |
| FDU-1, GU-1C<br>FTU-1, GU-1C | FA000347<br>FA000287 | Hot Leg, Spool 1. |
| FDU-5, GU-5VR | FA000353 | Hot Leg, Spool 5. |
| FTU-9, GU-10VR | FA000293 | Cold Leg, Spool 9. |
| FDU-10, GU-10VR | FA000359 | Cold Leg, Spool 10. |
| FDU-13, GU-13VR<br>FTU-13, GU-13VR | FA000245<br>FA000299 | Cold Leg, Spool 13. |
| FDU-15, GU-15C<br>FTU-15, GU-15C | FA000251<br>FA000305 | Cold Leg, Spool 15. |
| Broken Loop | | |
| FDB-21, GB-21C<br>FTB-21, GB-21C | FA000257<br>FA000311 | Cold Leg, Spool 21. |

| Measurement | Function Code | Location and Comments |
|---|---|---|
| Broken Loop (continued) | | |
| FDB-23, GB-23VR | FA000263 | Cold Leg, Spool 23. |
| FDB-30, GB-30C<br>FTB-30, GB-30C | FA000269<br>FA000317 | Hot Leg, Spool 30. |
| FDB-37, GB-37<br>FTB-37, GB-37 | FA000275<br>FA000323 | Hot Leg, Spool 37. |
| FDB-42, GB-42VR | FA000281 | Hot Leg, Spool 42. |
| Vessel | | |
| FDV-CORE-IN<br>GV-COR-150HZ | FA000341 | Entrance to Core. |
| FTV-CORE-IN<br>GV-COR-150HZ | FA000329 | Entrance to Core. |
| Pressurizer | | |
| FTU-PRIZE<br>GU-PRIZE | FA000335 | Pressurizer Surge Line. |
| INTEGRATED FLOW RATE | | |
| Intact Loop | | |
| FD01IFLO<br>FT01IFLO | IF000348<br>IF000288 | Hot Leg, Spool 1. |
| FD05IFLO | IF000354 | Hot Leg, Spool 5. |
| FT09IFLO | IF000294 | Cold Leg, Spool 9. |
| FD13IFLO<br>FT13IFLO | IF000246<br>IF000300 | Cold Leg, Spool 13. |
| FD15IFLO<br>FT15IFLO | IF000252<br>IF000306 | Cold Leg, Spool 15. |
| Broken Loop | | |
| FD21IFLO<br>FT21IFLO | IF000258<br>IF000312 | Cold Leg, Spool 21. |
| FD23IFLO | IF000264 | Cold Leg, Spool 23. |
| FD30IFLO<br>FT30IFLO | IF000270<br>IF000318 | Hot Leg, Spool 30. |
| FD37IFLO<br>FT37IFLO | IF000276<br>IF000324 | Hot Leg, Spool 37. |
| FD42IFLO | IF000282 | Hot Leg, Spool 42. |
| Vessel | | |
| FDCOIFLO | IF000342 | Entrance to Core. |
| FTCOIFLO | IF000330 | Entrance to Core. |
| Pressurizer | | |
| FTPZIFLO | IF000336 | Pressurizer Surge Line. |

| Measurement | Function Code | Location and Comments |
|---|---|---|
| MOMENTUM FLUX | | |
| Intact Loop | | |
| FD01R*V2 | MF000349 | Hot Leg, Spool 1. |
| FT01R*V2 | MF000289 | |
| FD05R*V2 | MF000355 | Hot Leg, Spool 5. |
| FT09R*V2 | MF000295 | Cold Leg, Spool 9. |
| FD10R*V2 | MF000241 | Cold Leg, Spool 10. |
| FD13R*V2 | MF000247 | Cold Leg, Spool 13. |
| FT13R*V2 | MF000301 | |
| FD15R*V2 | MF000253 | Cold Leg, Spool 15. |
| FT15R*V2 | MF000307 | |
| Broken Loop | | |
| FD21R*V2 | MF000259 | Cold Leg, Spool 21. |
| FT21R*V2 | MF000313 | |
| FD23R*V2 | MF000265 | Cold Leg, Spool 23. |
| FD30R*V2 | MF000271 | Hot Leg, Spool 30. |
| FT30R*V2 | MF000319 | |
| FD37R*V2 | MF000277 | Hot Leg, Spool 37. |
| FT37R*V2 | MF000325 | |
| FD42R*V2 | MF000283 | Hot Leg, Spool 42. |
| Vessel | | |
| FDCOR*V2 | MF000343 | Entrance to Core. |
| FTCOR*V2 | MF000331 | Entrance to Core. |
| Pressurizer | | |
| FTPZR*V2 | MF000337 | Pressurizer Surge Line. |
| VOLUMETRIC FLOW RATE | | |
| Intact Loop | | |
| FD01GPM | FV000350 | Hot Leg. Spool 1. |
| FT01GPM | FV000290 | |
| FD05GPM | FV000356 | Hot Leg, Spool 5. |
| FT09GPM | FV000296 | Cold Leg, Spool 9. |
| FD10GPM | FV000242 | Cold Leg, Spool 10. |
| FD13GPM | FV000248 | Cold Leg, Spool 13. |
| FT13GPM | FV000302 | |
| FD15GPM | FV000254 | Cold Leg, Spool 15. |
| FT15GPM | FV000308 | |
| Broken Loop | | |
| FD21GPM | FV000260 | Cold Leg, Spool 21. |
| FT21GPM | FV000314 | |

| Measurement | Function Code | Location and Comments |
|---|---|---|
| Broken Loop (continued) | | |
| FD23GPM | FV000266 | Cold Leg, Spool 23. |
| FD30GPM | FV000272 | Hot Leg, Spool 30. |
| FT30GPM | FV000320 | |
| FD37GPM | FV000278 | Hot Leg, Spool 37. |
| FT37GPM | FV000326 | |
| FD42GPM | FV000284 | Hot Leg, Spool 42. |
| Vessel | | |
| FDCOGPM | FV000344 | Entrance to Core. |
| FTCOGPM | FV000332 | |
| Pressurizer | | |
| FTPZGPM | FV000338 | Pressurizer Surge Line. |
| VELOCITY | | |
| Intact Loop | | |
| FD01VELO | VE000345 | Hot Leg, Spool 1. |
| FT01VELO | VE000285 | |
| FD05VELO | VE000351 | Hot Leg, Spool 5. |
| FT09VELO | VE000291 | Cold Leg, Spool 9. |
| D10VELOC | VE000357 | Cold Leg, Spool 10. |
| FD13VELO | VE000243 | Cold Leg, Spool 13. |
| FT13VELO | VE000297 | |
| FD15VELO | VE000249 | Cold Leg, Spool 15. |
| FT15VELO | VE000303 | |
| Broken Loop | | |
| FD21VELO | VE000255 | Cold Leg, Spool 21. |
| FT21VELO | VE000309 | |
| FD23VELO | VE000261 | Cold Leg, Spool 23. |
| FD30VELO | VE000267 | Hot Leg, Spool 30. |
| FT30VELO | VE000315 | |
| FD37VELO | VE000273 | Hot Leg, Spool 37. |
| FT37VELO | VE000321 | |
| FD42VELO | VE000279 | Hot Leg, Spool 42. |
| FDCOVELO | VE000339 | Entrance to Core. |
| FTCOVELO | VE000327 | |
| Pressurizer | | |
| FTPZVELO | VE000333 | Pressurizer Surge Line. |

| Measurement | Function Code | Location and Comments |
|---|---|---|
| MOMENTUM FLUX | | |
| Intact Loop | | |
| FD01MFLU | MF000346 | Hot Leg, Spool 1. |
| FT01MFLU | MF000286 | |
| FD05MFLU | MF000352 | Hot Leg, Spool 5. |
| FT09MFLU | MF000292 | Cold Leg, Spool 9. |
| D10MFLUX | MF000358 | Cold Leg, Spool 10. |
| FD13MFLU | MF000244 | Cold Leg, Spool 13. |
| FT13MFLU | MF000298 | |
| FD15MFLU | MF000250 | Cold Leg, Spool 15. |
| FT15MFLU | MF000304 | |
| Broken Loop | | |
| FD21MFLU | MF000256 | Cold Leg, Spool 21. |
| FT21MFLU | MF000310 | |
| FD23MFLU | MF000262 | Cold Leg, Spool 23. |
| FD30MFLU | MF000268 | Hot Leg, Spool 30. |
| FT30MFLU | MF000316 | |
| FD37MFLU | MF000274 | Hot Leg, Spool 37. |
| FT37MFLU | MF000322 | |
| FD42MFLU | MF000280 | Hot Leg, Spool 42. |
| Vessel | | |
| FDCOMFLU | MF000340 | Entrance to core. |
| FTCOMFLU | MF000328 | |
| Pressurizer | | |
| FTPZMFLU | MF000334 | Pressurizer Surge Line. |
| UNKNOWN DATA | | |
| BDV-23 | BD000209 | |