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**EXPERIMENT DATA REPORT FOR SEMISCALE MOD-1
TEST S-06-5
(LOFT COUNTERPART TEST)**

VICENTE ESPARZA

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June 1977

EG&G Idaho, Inc.

IDAHO NATIONAL ENGINEERING LABORATORY

ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

IDAHO OPERATIONS OFFICE UNDER CONTRACT EY-76-C-07-1570

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EXPERIMENT DATA REPORT FOR SEMISCALE MOD-1

TEST S-06-5

(LOFT COUNTERPART TEST)

Approved:

D. J. Olson, Manager
Semiscale Program

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Water Reactor Research

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EXPERIMENT DATA REPORT FOR SEMISCALE MOD-1

TEST S-06-5

(LOFT COUNTERPART TEST)

by

Vicente Esparza
Kenneth E. Sackett

EG&G IDAHO, INC.

June 1977

PREPARED FOR THE
U.S. NUCLEAR REGULATORY COMMISSION
AND
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
IDAHO OPERATIONS OFFICE
UNDER CONTRACT NO. EY-76-C-07-1570

ABSTRACT

Recorded test data are presented for Test S-06-5 of the Semiscale Mod-1 LOFT counterpart test series. These tests are among several Semiscale Mod-1 experiments conducted to investigate the thermal and hydraulic phenomena accompanying a hypothesized loss-of-coolant accident in a pressurized water reactor (PWR) system.

Test S-06-5 was conducted from initial conditions of 2272 psia and 536°F to investigate the response of the Semiscale Mod-1 system to a depressurization and reflood transient following a simulated double-ended offset shear of the broken loop cold leg piping. During the test, cooling water was injected into the cold legs of the intact and broken loops to simulate emergency core coolant injection in a PWR.

The purpose of Test S-06-5 was to assess the influence of the break nozzle geometry on core thermal and system response and on the subcooled and low quality mass flow rates at the break locations.

The purpose of this report is to make available the uninterpreted data from Test S-06-5 for future data analysis and test results reporting activities. The data, presented in the form of graphs in engineering units, have been analyzed only to the extent necessary to assure that they are reasonable and consistent.

SUMMARY

Test S-06-5 was performed as part of the Semiscale Mod-1 portion of the Semiscale Program conducted by EG&G Idaho, Inc. for the United States Government. This test, which was part of the LOFT counterpart test series (Test Series 6), was performed to investigate the effects of break nozzle geometry on the Semiscale Mod-1 system response and on the subcooled and low quality mass flow rates at the break locations. The test objective specific to Test S-06-5 was to provide data which can be used to determine whether break nozzle geometry affects system response and if so, to evaluate that effect. Hardware configuration and test parameters were selected to yield a system response that simulates the response of a pressurized water reactor (PWR) to a hypothesized loss-of-coolant accident (LOCA) with subsequent refill and reflood.

Test S-06-5 utilized the Semiscale Mod-1 system equipped with a pressure vessel with a 40-rod electrically heated core; and intact loop with pump, steam generator, and pressurizer; a broken loop with simulated pump, simulated steam generator, and rupture assemblies; and a pressure suppression system with header, pressure suppression tank, and heated steam supply system. High and low pressure coolant injection pumps and a coolant injection accumulator were provided for each system loop. For Test S-06-5, four heater rods were intentionally unpowered to simulate the effects of control rod guide tubes and the power in three heater rods was increased to produce a slightly peaked profile. The break nozzle used was similar to that used in the LOFT tests.

The test was conducted from initial conditions of 2272 psia and 536°F (at the intact loop cold leg vessel inlet) with a simulated full size (200%) double-ended offset shear of the cold leg broken loop piping at an initial core power level of 1.44 MW, and an initial core inlet flow rate of 141 gpm. The instantaneous offset shear of the broken loop cold leg piping was simulated by simultaneous (within 10 msec) actuation of the rupture assemblies. After initiation of blowdown, power to the heated core was reduced to simulate the predicted heat flux response of nuclear fuel rods during a LOCA. Blowdown was accompanied by simulated emergency core coolant injected into the cold legs of the intact and broken loops and the vessel upper plenum.

Test S-06-5 was generally conducted as specified. Conditions which did not conform to the specified test configuration were considered acceptable for analysis purposes within the test objectives. The instrumentation used generally functioned as intended. Of 220 measurements taken, 219 produced usable data.

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EXPERIMENT DATA REPORT FOR SEMISCALE MOD-1

TEST S-06-5

(LOFT COUNTERPART TEST)

I. INTRODUCTION

The Semiscale Mod-1 experiments represent the current phase of the Semiscale Program conducted by EG&G Idaho, Inc. for the United States Government. The program, which is sponsored by the Nuclear Regulatory Commission through the Energy Research and Development Administration, is part of the overall program designed to investigate the response of a pressurized water reactor system to a hypothesized loss-of-coolant accident (LOCA). The underlying objectives of the Semiscale program are to quantify the physical processes controlling system behavior during a LOCA and to provide an experimental data base for assessing reactor safety evaluation models. The Semiscale Mod-1 program has the further objective of providing support to other experimental programs in the form of instrumentation assessment, optimization of test series, selection of test parameters, and evaluation of test results.

Test S-06-5 was conducted February 18, 1977, in the Semiscale Mod-1 system as part of the LOFT counterpart test series (Test Series 6) which was designed to obtain thermal-hydraulic response data from blowdown, refill, and reflood transients in a simulated nuclear reactor core. Test S-06-5 was conducted specifically to study the effects of break nozzle geometry on Semiscale Mod-1 system response.

The purpose of this report is to present the test data in an uninterpreted but readily usable form for use by the nuclear community in advance of detailed analysis and interpretation. Section II briefly describes the system configuration, procedures, initial test conditions, and events that are applicable to Test S-06-5; Section III presents the data graphs and provides comments and supporting information necessary for interpretation of the data. A description of the overall Semiscale Program and test series, a more detailed description of the Semiscale Mod-1 system, and a description of the measurement and data processing techniques and uncertainties can be found in Reference 1.

II. SYSTEM, PROCEDURES, CONDITIONS, AND EVENTS FOR TEST S-06-5

The following system configuration, procedures, initial test conditions, and events are specific to Test S-06-5 as indicated.

1. SYSTEM CONFIGURATION AND TEST PROCEDURES

The Semiscale Mod-1 system used for this test consisted of a pressure vessel with internals, including a 40-rod core with 36 electrically heated rods; an intact loop with steam generator, pump, and pressurizer; a broken loop with simulated steam generator, simulated pump, and two rupture assemblies; coolant injection accumulators for the intact loop, the broken loop, and the vessel upper plenum; high and low pressure injection pumps for each of the system loops; and a pressure suppression system with a suppression tank, header, and heated steam supply system. The Semiscale Mod-1 experimental system configuration is described further in Reference 1. Figures 1 and 2 provide the system configuration for Test S-06-5.

The break nozzle used in Test S-06-5 was similar in design to one used in the LOFT tests. This nozzle is shown in Figure 3[a].

For Test S-06-5, 33 rods of the 40-rod electrically heated core were operated at a peak power density of approximately 11.5 kW/ft, three rods (Rods D-4, E-4, and E-5) were operated at a peak power density of 12.1 kW/ft to yield a slightly peaked power profile, and four rods (Rods C-3, D-5, F-3, and F-6) were unpowered to simulate the effect of control rod guide tubes. The resulting total core power was approximately 1.44 MW.

In preparation for the test, the accumulators were filled with treated demineralized water, drained to the specified initial levels, and pressurized with nitrogen to 600 psig. The system was filled with treated demineralized water and vented at strategic points to assure a liquid full system. Prior to warmup the system was pressurized to check for leakage, system instrumentation was checked, and transducer readings were initialized. Warmup to initial test conditions was accomplished with the heaters in the vessel core. Heatup of the broken loop piping was accomplished with bypass lines which served to allow circulation through the broken loop. During warmup, the purification and sampling systems were valved into the primary system to maintain water chemistry requirements and to provide a water sample at system conditions for subsequent analysis. At 100-°F temperature intervals during warmup, detector readings were sampled to allow the integrity of the measurement instrumentation and the operability of the data acquisition system to be checked.

[a] The Semiscale Mod-1 system normally utilizes a break nozzle of the converging-diverging type referred to as a Henry nozzle.

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

Prior to the initial core power level being established, the pressure suppression system was pressurized to 35 psia with saturated steam from the steam supply system. After the core power was increased to 1.44 MW, initial test conditions were held for 10 minutes to establish equilibrium in the system. At the end of this period all auxiliary systems including the bypass lines were isolated to prevent blowdown through those systems.

The system was successfully subjected to simulated double-ended cold leg break through two rupture assemblies and two blowdown nozzles, each having a break area of 0.00262 ft^2 . Pressure to operate the rupture assemblies and initiate blowdown was taken from an accumulator system filled with water and pressurized to 2250 psig with gaseous

Fig. 2 Semiscale Mod-1 system for cold leg break configuration -- schematic.

Fig. 3 Geometric details -- LOFT nozzle simulation.

nitrogen. Immediately (within 0.02 sec) after initiation of blowdown, the lines to the accumulator were again isolated. The effluent from the primary system was ejected into the pressure suppression system which was vented to maintain a constant pressure of 35 psia. At blowdown, power to the primary coolant circulation pump was reduced and the pump was allowed to coast down to a speed of 1515 rpm which was maintained for the duration of the test. During the blowdown transient, power to the electrically heated core was automatically controlled to simulate the thermal response of nuclear heated fuel rods.

For Test S-06-5, the coolant injection systems were arranged to discharge into both system loops at the cold leg injection points (Spool 14 and Spool 42) and into the vessel upper plenum at a point 13.5 in. above the cold leg centerline. The high pressure coolant injection pumps were started immediately after initiation of blowdown (0 sec) and continued to the end of the test (300 sec). Low pressure coolant injection was initiated 27 sec after blowdown at a system pressure of 150 psig and continued until test termination (300 sec). Coolant injection from the intact loop accumulator started 17 sec after blowdown, and nitrogen discharge began 74 sec after rupture and was terminated 100 sec after blowdown. The broken loop accumulator began injection 3.6 sec after blowdown and continued to exhaustion (70 sec).

2. INITIAL TEST CONDITIONS AND SEQUENCE OF EVENTS

Conditions in the Semiscale Mod-1 system at initiation of blowdown are given in Tables I and II; the primary system water chemistry prior to blowdown is given in Table III; and the sequence of events relative to rupture is given in Table IV.

TABLE I
CONDITIONS AT BLOWDOWN INITIATION

	Test S-06-5	
	Measured ^[a]	Specified
Core power (MW) ^[b]	1.44	1.43 $\pm$ 0.01
Intact loop cold leg fluid temperature (°F) ^[b]	536	544 $\pm$ 2
Intact loop hot leg to cold leg temperature differential (°F) ^[b]	70	66 $\pm$ 1
Pressurizer pressure (psia) ^[b]	2272	2263 $\pm$ 25
Pressurizer water level (in.) ^[c]	26.3 ^[d]	27.1
Steam generator feedwater temperatures (°F) ^[e]	440	435 $\pm$ 10
Steam generator liquid level (from bottom of tube sheet) (in.) ^[e]	117	116 $\pm$ 2
Fluid temperature in broken loop ^[b] (pump side) (°F)	578	Not Specified
Fluid temperature in broken loop ^[b] (vessel side) (°F)	537	Not Specified
Intact loop cold leg flow (gpm) ^[e]	141	[f]
Pressure suppression tank water level (in.) ^[e]	47.5	47.4 $\pm$ 0.5
Pressure suppression tank pressure (psia) ^[c]	35	35
Pressure suppression tank water temperature (°F) ^[b]	62	Ambient

[a] Those measured conditions which did not meet the specified initial conditions were considered acceptable for analysis purposes within the test objectives.

[b] These initial conditions are taken from a digital listing of the test parameters at blowdown initiation.

[c] Pressurizer water level measured down from inside of top head. Level was specified in terms of differential pressure in the liquid level measuring system.

[d] Level shown corresponds to a pressurizer system volume of 0.57 ft³ (including surge line).

[e] Measured initial conditions are taken from process instrumentation read just prior to blowdown.

[f] Flow is not specified, since it must be adjusted to achieve the required differential temperature across the core.

TABLE II
PRIMARY COOLANT TEMPERATURE DISTRIBUTION PRIOR TO RUPTURE^[a]

	<u>Test S-06-5</u>	
	<u>Detector</u>	<u>Temperature (°F)</u>
Vessel lower plenum (upper portion above filler block)	TFV-LP-7	544
Intact loop hot leg (near vessel)	RBU-2	609
Intact loop cold leg (near pump inlet)	TFU-10	539
Intact loop cold leg (near vessel)	RBU-14A	542
Broken loop cold leg (near nozzle)	TFB-23	540
Broken loop hot leg (near vessel)	TFB-30	606
Broken loop cold leg (near nozzle)	TFB-42	596

[a] Data taken from final digital scan 211 sec before blowdown.

TABLE III
WATER CHEMISTRY PRIOR TO BLOWDOWN^[a]

	<u>Test S-06-5</u>
pH	11.00
Conductivity (μ mho/cm)	260
Lithium (ppm)	6.6
Chlorides (ppm)	<0.1
Fluorides (ppm)	<0.5
Oxygen (ppm)	0.3
Total Gas (cc/l)	157.5
Suspended solids (ppm)	0.84

[a] Water sample taken at a system pressure of about 2250 psia and a system temperature of about 540°F (cold leg).

TABLE IV
SEQUENCE OF EVENTS DURING TEST^[a]

Event	Time Relative To Rupture Test S-06-5
Core power level established (min)	-10
Bypass lines valved out of system (sec)	-2.5
Blowdown initiated (sec)	0
Pump power reduced (sec)	0
High pressure injection system pumps started (sec) ^[b]	0 ^[c]
ECC accumulators valved in (sec) ^[b]	0
Steam generator feedwater and discharge valves closed (sec)	1.0
Core power decay transient started (sec)	2.6
Low pressure injection system pumps started (sec) ^[b]	27 ^[c]
Core power tripped off (sec) ^[d]	300

[a] A time-controlled sequencer was used to control critical events during the test.

[b] Injection from ECC accumulators and high and low pressure injection system pumps does not start until system pressure drops below accumulator or pump pressure, respectively.

[c] Time intact loop turbine flowmeters FTU-HPIS and FTU-LPIS in lines leading from high and low pressure injection systems, respectively, indicated flow.

[d] Core power tripped manually at termination of test.

III. DATA PRESENTATION

The data from Semiscale Mod-1 Test S-06-5 are presented with brief comment. Processing analysis has been performed only to the extent necessary to obtain appropriate engineering units and to assure that the data are reasonable and consistent. In all cases, in converting transducer output to engineering units, a homogeneous fluid was assumed. Further interpretation and analysis should consider that sudden decompression processes such as those occurring during blowdown may have subjected the measurement devices to nonhomogeneous fluid conditions.

The performance of the system during Test S-06-5 was monitored by 220 detectors. The data obtained were recorded on both digital and analog data acquisition systems. The digital system was used to process the data presented in this report. The digital data were recorded at a sample rate of 57.5 points per sec. Long term plots (-20 to 300 sec) were compressed at a 20 to 1 ratio giving an effective sample rate of 2.875 points per sec. Short term plots (-6 to 42 sec) were compressed at a 3 to 1 ratio giving an effective sample rate of 19.17 points per sec. The analog system was used to provide better resolution capability (needed as input to various data analysis codes) and to provide redundancy.

The data are presented, in some instances, in the form of composite graphs to facilitate comparison of the values of given variables at several locations. The scales selected for the graphs do not reflect the obtainable resolution of the data. (The data processing techniques are described further in Reference 1.)

Figures 4 through 9 and Table V provide supporting information for interpretation of the data graphs shown in Figures 10 through 349, and provide relative locations of all detectors used during Test S-06-5. Table V groups the measurements according to measurement type; identifies the specific measurement location and the range of the detector and actual recording range of the data acquisition system; provides brief comments regarding the data; and references the measurements and comments to the corresponding figure. Figures 10 through 349 present all the blowdown and reflood data obtained. Time zero on the graphs is the time of rupture initiation. Appendix A provides information explaining posttest data processing for data conversion into engineering units and data adjustments.

Fig. 7 Semiscale Mod-1 pressure vessel -- isometric showing instrumentation.

Test S-06-5
INEL-A-2715

Fig. 9 Semiscale Mod-1 heated core -- plan view.

TABLE V
DATA PRESENTATION FOR SEMISCALE MOD-1 TEST S-06-5

Measurement	Location and Comments ^[a]	Range ^[a]		Figure ^[a]	Measurement Comments ^[b]
		Detector	Data Acquisition System		
FLUID TEMPERATURE					
Chromel-Alumel thermocouples unless specified otherwise.					
<u>Intact Loop</u>					
TFU-1	Hot leg, Spool 1, 31 in. from vessel center.	0 to 2300°F	0 to 591°F	10, 11	
RBU-2	Hot leg, Spool 2, 46 in. from vessel center (platinum resistance bulb).	0 to 1000°F	0 to 1000°F	10, 11	
TFU-10	Cold leg, Spool 10, 144 in. from vessel center.			12, 12	
RBU-14A	Cold leg, Spool 14, 43 in. from vessel center, upstream of cold leg injection port (platinum resistance bulb).	0 to 1000°F	0 to 1000°F	12, 13	
TFU-14B	Cold leg, Spool 14, 39 in. from vessel center, downstream of cold leg injection port.			12, 13	
TFU-15	Cold leg, Spool 15, 16 in. from vessel center.			12, 13	
<u>Broken Loop</u>					
TFB-20	Cold leg, Spool 20, 21 in. from vessel center.	0 to 2300°F	0 to 1017°F	14, 15	
TFB-23	Cold leg, Spool 23, 91 in. from vessel center, upstream of vessel-side nozzle.			14, 15	
TFB-30	Hot leg, Spool 30, 16 in. from vessel center.			16, 17	
TFB-37	Cold leg, Spool 37, 276 in. from vessel center along hot leg, discharge of simulated steam generator.			16, 17	
TFB-42	Cold leg, Spool 42, 414 in. from vessel center along hot leg, upstream of pump-side nozzle.			16, 17	
<u>Inlet Annulus</u>					
	4 in. below cold leg centerline, 0.2 in. from vessel wall, Type J iron-constantan thermocouples.	0 to 1400°F	0 to 803°F		
TFV-ANN-4A	0°.			18, 19	
TFV-ANN-4M	180°.			18, 19	
<u>DOWNCOMER ANNULUS</u>					
	Centered in annulus, Type J iron-constantan thermocouples.	0 to 1400°F	0 to 803°F		
TFV-ANN-35A	35 in. below cold leg centerline, 0°.			20, 21	
TFV-ANN-70A	70 in. below cold leg centerline, 0°.			20, 21	
TFV-ANN-115A	115 in. below cold leg centerline, 0°.			20, 21	
TFV-ANN-156A	156 in. below cold leg centerline, 0°. (Type K Chromel-Alumel).	0 to 2300°F	0 to 591°F	20, 21	
<u>Upper Plenum</u>					
TFV-UP-13	In upper plenum, 13.5 in. above cold leg centerline at 180°.	0 to 2300°F	0 to 1017°F	22, 23	
<u>Lower Plenum</u>					
	On fluid temperature port, 1 in. from vessel center, 45°.	0 to 2300°F	0 to 1017°F		
TFV-LP-2	2.0 in. above top of lower plenum filler.			24, 25	
TFV-LP-4	4.0 in. above top of lower plenum filler.			24, 25	
TFV-LP-7	7.0 in. above top of lower plenum filler.			24, 25	
<u>Core</u>					
TFV-CORE-IN	In core flow mixer box, 150 in. below cold leg centerline (a part of FDV-CORE-IN).	0 to 2300°F	0 to 1017°F	26, 27	

TABLE V (continued)

Measurement	Location and Comments [a]	Range [a]		Figure [a]	Measurement Comments [b]
		Detector	Data Acquisition System		
<u>Core Grid Spacers</u>					
<u>Grid Spacer 5</u>	55 in. below cold leg centerline, 21.5 in. above top of heated length.	0 to 2300°F	0 to 2382°F		
TFG-5CD-45	Thermocouple in space defined by Columns C and D, Rows 4 and 5.			28, 29	
<u>Grid Spacer 6</u>	76 in. Below cold leg centerline, 1/2 in. above top of heated length.				
TFG-6AB-45	Thermocouple in space defined by Columns A and B, Rows 4 and 5.			30, 31	
TFG-6CD-45	Thermocouple in space defined by Columns C and D, Rows 4 and 5.			30, 31	
TFG-6DE-23	Thermocouples in space defined by Columns D and E, Rows 2 and 3, and 6 and 7.			30, 31	
TFG-6DE-67				30, 31	
<u>Grid Spacer 10</u>	143 in. below cold leg centerline at bottom of heated length.				
TFG-10AB-45	Thermocouple in space defined by Columns A and B, Rows 4 and 5.				Thermocouple failed.
TFG-10CD-45	Thermocouple in space defined by Columns C and D, Rows 4 and 5.			32, 33	
TFG-10EF-45	Thermocouple in space defined by Columns E and F, Rows 4 and 5.			32, 33	
TFG-10GH-45	Thermocouple in space defined by Columns G and H, Rows 4 and 5.			32, 33	
<u>Core Barrel Insulation Gap</u>					
TFV-CIG-70A	70 in. below cold leg centerline, 0°.	0 to 1400°F	0 to 803°F	34, 35	
<u>ECC System</u>					
TFU-ECC-14	In ECC line leading to intact loop Spool 14.	0 to 2300°F	0 to 591°F	36, 37	
TFB-ECC-42	In ECC line leading to broken loop Spool 42.			38, 39	
<u>Steam Generator</u>					
TFU-SGFW	In feedwater line leading to steam generator.	0 to 2300°F	0 to 591°F	40, 41	
TFU-SGSD	In steam dome, 129.5 in. from bottom of tube sheet.			40, 41	
TFU-SG3	Secondary side, 48 in. above bottom of tube sheet.			42, 43	
TFU-SG4	Secondary side, 96 in. above bottom of tube sheet.			42, 43	
<u>Pressurizer</u>					
TFU-PRIZE	In surge line, near pressurizer exit, between turbine flowmeter and pressurizer.	0 to 2300°F	0 to 1017°F	44, 45	
<u>Pressure Suppression System</u>					
TF-PSS-33	33 in. from bottom of tank.			46, 47	
TF-PSS-130	130 in. from bottom of tank.			46, 47	
<u>MATERIAL TEMPERATURE</u>					
	Chromel-Alumel thermocouples unless specified otherwise				
<u>Intact Loop</u>					
TMU-1T16	Hot leg, Spool 1, top, 1/16 in. from pipe ID, 29 in. from vessel center.	0 to 2300°F	0 to 591°F	48, 49	
TMU-15T16	Cold leg, Spool 15, top, 1/16 in. from pipe ID, 17 in. from vessel center.		0 to 1017°F	48, 49	
<u>Broken Loop</u>					
TMB-20B16	Cold leg, Spool 20, bottom, 1/16 in. from pipe ID, 21 in. from vessel center.	0 to 2300°F	0 to 591°F	50, 51	

TABLE V (continued)

Measurement	Location and Comments ^[a]	Range ^[a]		Figure ^[a]	Measurement Comments ^[b]
		Detector	Data Acquisition System		
Vessel Filler	Type J iron-constantan.	0 to 1400°F	0 to 803°F		
TMV-FI-15A	15 in. below cold leg centerline, 1/16 in. from filler ID, 0°.			52, 53	
TMV-FI-35A	35 in. below cold leg centerline 1/16 in. from filler ID, 0°.			52, 53	
TMV-FI-115A	115 in. below cold leg centerline, 1/16 in. from filler ID, 0°.			52, 53	
Vessel Filler Insulator	Outer surface of insulator, Type J iron-constantan thermocouples.	0 to 1400°F	0 to 803°F		
TIV-FO-35A	35 in. below cold leg centerline, 0°.			54, 55	
TIV-FO-35M	35 in. below cold leg centerline, 180°.			54, 55	
TIV-FO-70A	70 in. below cold leg centerline, 0°.			54, 55	
TIV-FO-115A	115 in. below cold leg centerline, 0°.			54, 55	
Core Barrel	Type J iron-constantan thermocouples.	0 to 1400°F	0 to 803°F		
TMV-CI-35A	35 in. below cold leg centerline, 1/16 in. from core barrel I.D., 0°.			54, 55	
TMV-CO-115A	115 in. below cold leg centerline, 1/16 in. from core barrel OD, 0°.			58, 59	
CORE HEATER CLADDING TEMPERATURES	Chromel-Alumel thermocouples.				
High Power Heaters		0 to 2300°F	0 to 2382°F		
TH-D4-14 TH-D4-29	Heater at Column D, Row 5. Thermocouples 14 in. (270°) and 29 in. (315°) above bottom of core.			60, 61	
TH-E4-09 TH-E4-27 TH-E4-55	Heater at Column E, Row 4. Thermocouples 9 in. (180°), 27 in. (90°), and 55 in. (0°) above bottom of core.			62, 63	
Low Power Heaters		0 to 2300°F	0 to 2382°F		
TH-A4-09 TH-A4-29 TH-A4-39	Heater at Column A, Row 4. Thermocouples 9 in. (105°), 29 in. (240°) and 39 in. (300°) above bottom core.			64, 65	
TH-A5-29 TH-A5-45	Heater at Column A, Row 5. Thermocouples 29 in. (180°) and 45 in. (255°) above bottom of core.			66, 67	
TH-B3-32	Heater at Column B, Row 3. Thermocouple 32 in. (135°) above bottom of core.			68, 69	
TH-B5-29 TH-B5-33	Heater at Column B, Row 5. Thermocouples 29 in. (150°) and 33 in. (45°) above bottom of core.			70, 71	
TH-B6-29	Heater at Column B, Row 6. Thermocouple 29 in. (45°) above bottom of core.			72, 73	
TH-C2-38	Heater at Column C, Row 2. Thermocouple 38 in. (225°) above bottom of core.			74, 75	
TH-C4-26 TH-C4-53	Heater at Column C, Row 4. Thermocouples 26 in. (75°) and 53 in. (300°) above bottom of core.			76, 77	
TH-C5-28	Heater at Column C, Row 5. Thermocouple 28 in. (315°) above bottom of core.			78, 79	
TH-C6-32	Heater at Column C, Row 6. Thermocouple 32 in. (225°) above bottom of core.			80, 81	
TH-C7-07	Heater at Column C, Row 7. Thermocouples 7 in. (345°) above bottom of core.			82, 83	

TABLE V (continued)

Range [a]					
Measurement	Location and Comments [a]	Detector	Data Acquisition System	Figure [a]	Measurement Comments [b]
Low Power Heaters (continued)					
TH-D1-21	Heater at Column C, Row 1. Thermo-couple 21 in. (330°) above bottom of core.			84, 85	
TH-D2-14 TH-D2-61	Heater at Column D, Row 2. Thermo-couple 14 in. (0°) and 61 in. (270°) above bottom of core.			86, 87	
TH-D3-29 TH-D3-39	Heater at Column D, Row 3. Thermo-couples 29 in. (150°) and 39 in. (210°) above bottom of core.			88, 89	
TH-D6-15 TH-D6-25	Heater at Column D, Row 6. Thermo-couples 15 in. (90°) and 25 in. (225°) above bottom of core.			90, 91	
TH-D7-20	Heater at Column D, Row 7. Thermo-couple 20 in. (60°) above bottom of core.			92, 93	
TH-D8-57	Heater at Column D, Row 8. Thermo-couple 57 in. (15°) above bottom of core.			94, 95	
TH-E1-33	Heater at Column E, Row 1. Thermo-couple 33 in. (60°) above bottom of core.			96, 97	
TH-E2-33	Heater at Column E, Row 2. Thermo-couple 33 in. (315°) above bottom of core.			98, 99	
TH-E3-05 TH-E3-20 TH-E3-24	Heater at Column E, Row 3. Thermo-couples 5 in. (15°), 20 in. (165°), and 24 in. (75°) above bottom of core.			100, 101	
TH-E6-08 TH-E6-28 TH-E6-37	Heater at Column E, Row 6. Thermo-couples 8 in. (150°), 28 in. (285°), and 37 in. (330°) above bottom of core.			102, 103	
TH-E7-44	Heater at Column E, Row 7. Thermo-couple 44 in. (195°) above bottom of core.			104, 105	
TH-E8-14 TH-E8-29 TH-E8-45	Heater at Column E, Row 8. Thermo-couples 14 in. (150°), 29 in. (225°), and 45 in. (300°) above bottom of core.			106, 107	
TH-F2-07 TH-F2-22 TH-F2-25	Heater at Column F, Row 2. Thermo-couples 7 in. (255°), 22 in. (105°), and 25 in. (0°) above bottom of core.			108, 109	
TH-F3-22	Heater at Column F, Row 3. Thermo-couple 22 in. (105°) above bottom of core.			110, 111	
TH-F4-14 TH-F4-29 TH-F4-44	Heater at Column F, Row 4. Thermo-couples 14 in. (90°), 29 in. (165°), and 44 in. (210°) above bottom of core.			112, 113	
TH-F5-20 TH-F5-26 TH-F5-33 TH-F5-53	Heater at Column F, Row 5. Thermo-couples 20 in. (255°), 26 in. (165°), 33 in. (315°), and 53 in. (30°) above bottom of core.			114, 116	
TH-G3-13	Heater at Column G, Row 3. Thermo-couple 13 in. (150°) above bottom of core.			116, 117	
TH-G4-29 TH-G4-33 TH-G4-38	Heater at Column G, Row 4. Thermo-couples 29 in. (300°), 33 in. (225°), and 38 in. (30°) above bottom of core.			118, 119 118, 119 120, 121	
TH-G5-14 TH-G5-24	Heater at Column G, Row 5. Thermo-couples 14 in. (45°) and 24 in. (330°) above bottom of core.			122, 123	
TH-H5-32	Heater at Column H, Row 5. Thermo-couple 32 in. (45°) above bottom of core.			124, 125	

TABLE V (continued)

Measurement	Location and Comments ^[a]	Range ^[a]		Figure ^[a]	Measurement Comments ^[b]
		Detector	Data Acquisition System		
PRESSURE					
<u>Intact Loop</u>					
		0 to 3000 psi			
PU-13	Cold leg, Spool 13, 54 in. from vessel center.		0 to 4565 psia	126, 127	
PU-15L	Cold leg, Spool 15, 16 in. from vessel center, to atmosphere (low range).	0 to 500 psi	0 to 557 psia	128, 129	Detector saturated to t = 18 sec.
<u>Broken Loop</u>					
		0 to 3000 psi			
PB-21	Cold leg, Spool 21, 49 in. from vessel center.		0 to 4742 psia	130, 131	
PB-23	Cold leg, Spool 23, 92 in. from vessel center, upstream of nozzle (tee off DP tap).		0 to 4373 psia	130, 131	
PB-CN1	Cold leg, Spool 23, vessel-side nozzle, nozzle throat 96 in. from vessel center along cold leg, 45°.	0 to 2500 psi	0 to 3111 psia	134, 135	
PB-CN2	Cold leg, Spool 23, vessel-side nozzle, nozzle throat, 96 in. from vessel center along cold leg, 315°.		0 to 4513 psia	134, 135	
PB-CN3	Cold leg, Spool 23, vessel-side nozzle at beginning of nozzle divergent section, 97 in. from vessel center along cold leg, 0°.		0 to 4687 psia	134, 135	
PB-24	Cold leg, Spool 24, 103 in. from vessel center downstream of nozzle.		0 to 4844 psia	130, 131	
PB-42	Cold leg, Spool 42, 415 in. from vessel center along hot leg, upstream of pump-side nozzle (tee off DP tap).		0 to 4768 psia	132, 133	
PB-HN1	Pump-side nozzle, nozzle throat, 419 in. from vessel center along hot leg (tee off DP tap).		0 to 4574 psia	136, 137	
PB-43	Cold leg, Spool 43, 426 in. from vessel center along hot leg, upstream of rupture discs.		0 to 4617 psia	132, 133	
<u>Vessel</u>					
PV-UP+10	In upper plenum, 10 in. above cold leg centerline, mounted on standoff, 30°.	0 to 3000 psi	0 to 4900 psia	138, 139	
PV LP-166	In upper part of lower plenum, 166 in. below cold leg centerline, mounted on standoff, 225°.		0 to 2492 psia	138, 139	
<u>ECC System</u>					
		0 to 1000 psi			
PU-ACC	In intact loop accumulator.		0 to 1214 psia	140, 141	
PB-ACC	In broken loop accumulator.		0 to 1252 psia	142, 143	
<u>Steam Generator</u>					
PU-SGSD	Secondary side steam dome.	0 to 3000 psi	0 to 2000 psia	144, 145	
<u>Pressurizer</u>					
PU-PRIZE	Pressurizer steam dome.	0 to 2500 psi	0 to 3200 psia	146, 147	
<u>Pressure Suppression System</u>					
P-PSS	Suppression tank level.	0 to 2500 psi	0 to 3200 psia	148, 149	

TABLE V (continued)

Range ^[a]					
Measurement	Location and Comments ^[a]	Detector	Data Acquisition System	Figure ^[a]	Measurement Comments ^[b]
DIFFERENTIAL PRESSURE					
Elevation difference between transducer taps is zero unless otherwise specified.					
Intact Loop					
DPU-UP-3	Upper plenum 10.5 in. above cold leg centerline at 30° to hot leg, Spool 3, 62 in. from vessel center. Upper plenum tap is approximately 2 in. above Spool 3 tap.	+50 in. water	+2.4 psid	150, 151	
DPU-3-7	Across steam generator, hot leg Spool 3, 62 in. from vessel center to cold leg Spool 7, 231 in. from vessel center. Spool 3 tap is approximately 18 in. above Spool 7 tap.	+500 in. water	+25 psid	152, 153	
DPU-6-7	Across entire active steam generator assembly including orifice plates; hot leg Spool 6, 114 in. from vessel center to cold leg, Spool 7, 231 in. from vessel center. Spool 6 tap 21 in. above Spool 7 tap.	+500 in.	+25 psid	154, 155	
DPU-7-10	Steam generator outlet to pump inlet, cold leg Spool 7, 231 in. from vessel center, to cold leg Spool 10, 141 in. from vessel center.	+50 in. water	+5.0 psid	156, 157	
DPU-12-10	Pump outlet to pump inlet, cold leg Spool 12, 75 in. from vessel center, to cold leg Spool 10, 141 in. from vessel center. Spool 10 tap is 10 in. below Spool 12 tap.	+50 psi	+50 psid	158, 159	
DPU-12-10L	Pump outlet to pump inlet, cold leg Spool 12, 75 in. from vessel center, to cold leg Spool 10, 141 in. from vessel center. Spool 10 tap is 10 in. below Spool 12 tap (low range).	+100 in. water	+4.9 psid	160, 161	Data acquisition system saturated to t=7 sec.
DPU-12-15	Across cold leg injection point, cold leg Spool 12, 75 in. from vessel center, to cold leg Spool 15, 16 in. from vessel center.	+100 in. water	+4.9 psid	162, 163	
DPU-15-1	Cold leg to hot leg; cold leg Spool 15, 16 in. from vessel center to hot leg Spool 1, 31 in. from vessel center. Spool 15 tap is 8.5 in. below Spool 1 tap.	+500 in. water	+25 psid	164, 165	
DPU-15-1L	Cold leg to hot leg, cold leg Spool 15, 16 in. from vessel center to hot leg Spool 1, 31 in. from vessel center. Spool 15 tap is 8.5 in. below Spool 1 tap (low range).	+100 in. water	+2.4 psid	166, 167	Data acquisition system saturated from t=65 to t=95 sec.
DPU-15-1ANN	Cold leg Spool 15, 16 in. from vessel center, to inlet annulus, 9 in. below cold leg centerline at 225°. Spool 15 tap is 9 in. above inlet annulus tap.	+100 in. water	+4.8 psid	168, 169	
DPU-PRESLL	Pressurizer water level. Elevation difference between taps is 53 in. Lower tap is 3.5 in. above pressurizer exit.	+50 in. water	+2.5 psid	170, 171	
Broken Loop					
DPB-UP-30	Vessel upper plenum, 10.5 in. above cold leg centerline at 30°, to hot leg Spool 30, 18 in. from vessel center. Upper plenum tap is 2 in. above Spool 30 tap.	+100 in. water	+4.8 psid	172, 173	
DPB-21-1ANN	Cold leg Spool 21, 49 in. from vessel center, to vessel inlet annulus, 9 in. below cold leg centerline at 225°. Inlet annulus tap is 9 in. below Spool 21 tap.	+100 in. water	+4.8 psid	174, 175	
DPB-21-23	Cold leg Spool 21, 49 in. from vessel center, to cold leg Spool 23, 92 in. from vessel center.	+800 in. water	+38 psid	176, 177	
DPB-23-CN1	Cold leg Spool 23, 92 in. from vessel center, to vessel-side nozzle throat, 96 in. from vessel center.	+1500 psi	+2008 psid	178, 179	
NPR-CN1-CN4	Vessel-side nozzle, nozzle throat, 96 in. from vessel center, to nozzle divergent section, 101 in. from vessel center.	+1500 psi	+2007 psid	182, 183	

TABLE V (continued)

Measurement	Location and Comments ^[a]	Range ^[a]		Figure ^[a]	Measurement Comments ^[b]
		Detector	Data Acquisition System		
Broken Loop (continued)					
DPB-23-24	Across vessel-side nozzle, Spool 23, 92 in. from vessel center, to Spool 24, 104 in. from vessel center.	±1000 psi	±1353 psid	180, 181	
DPB-30-36L	Across entire simulated steam generator assembly, hot leg Spool 30, 18 in. from vessel center, to cold leg Spool 36 lower tap, 242 in. from vessel center. Spool 30 tap is 19 in. below Spool 36 lower tap.	±500 psi	±500 psid	184, 185	
DPB-30-38	Across entire simulated steam generator assembly and instrument spool downstream of simulated steam generator; hot leg Spool 30, 18 in. from vessel center, to cold leg Spool 38, 305 in. from vessel center along hot leg. Spool 30 tap is 40 in. above Spool 38 tap.	±100 psi	±129 psid	186, 187	
DPB-32U-36L	Across entire simulated steam generator orifice assembly, hot leg Spool 32 upper tap, 73 in. from vessel center, to Spool 36 lower tap, 242 in. from vessel center. Spool 32 upper tap is 16 in. above Spool 36 lower tap.	±500 psi	±500 psid	188, 189	
DPB-36L-42	Spool 36 lower tap, 242 in. from vessel center along hot leg, to Spool 42 upstream of pump-side nozzle, 415 in. from vessel center along hot leg. Spool 36 lower tap is 20 in. above Spool 42 tap.	±100 psi	±100 psid	190, 191	Data acquisition system saturated from t=0 to t=30 sec.
DPB-38-40	Across simulated pump, cold leg Spool 38, 305 in. from vessel center along hot leg, to cold leg Spool 40, 365 in. from vessel center along hot leg.	±1000 psi	±1353 psid	192, 193	
DPB-40-42	Across elbow leading to spool upstream of pump-side nozzle. Cold leg Spool 40, 365 in. from vessel center along hot leg, to Spool 42, 415 in. from vessel center along hot leg. Spool 40 tap is 40 in. below Spool 42 tap.	±50 in. water	±2.36 psid	194, 195	Physical conditions exceeded detector measurement capability from t=0 to t=1 sec and, from t=24 to t=35 sec.
DPB-42-43				196, 197	DPB-42-43 was created by subtracting PB-43 from PB-42.
DPB-42-HN1	Spool 42 upstream of pump-side nozzle, 415 in. from vessel center along hot leg, to nozzle throat, 419 in. from vessel center along hot leg.	±500 psi	±503 psid	198, 199	
DPB-HN1-HN4	Pump-side nozzle, nozzle throat, 419 in. from vessel center along hot leg, to nozzle divergent section, 424 in. from vessel center along hot leg.	±1000 psi	±1339 psid	200, 201	
DPB-HN4-43	Pump-side nozzle, nozzle divergent section, 424 in. from vessel center along hot leg to downstream Spool 43, 427 in. from vessel center along hot leg.	±50 psi	±50 psid	202, 203	Data acquisition system saturated from t=0 to t=20 sec.
Vessel					
DPV-UP-1ANN	Upper plenum, 10.5 in. above cold leg centerline at 30° to inlet annulus, 9 in. below cold leg centerline at 225°. Elevation difference between taps is 19 in.	±300 in. water	±14.7 psid	204, 205	Data acquisition system saturated at t=70 sec.
DPV-0-9GQ	Inlet annulus cold leg centerline at 225°, to inlet annulus centerline at 225°. Elevation difference between taps is 9 in.	±50 in. water	±2.5 psid	206, 207	
DPV-9-26GQ	Inlet annulus, 9 in. below cold leg centerline at 225°, to downcomer gap, 26 in. below cold leg centerline at 225°. Elevation difference between taps is 17 in.	±50 in. water	±2.5 psid	208, 209	
DPV-9-166GQ	Inlet annulus, 9 in. below cold leg centerline at 225°, to lower plenum, 166 in. below cold leg centerline at 225°. Elevation difference between taps is 157 in.	±300 in. water	±14.6 psid	210, 211	

TABLE V (continued)

Measurement	Location and Comments ^[a]	Range ^[a]		Figure ^[a]	Measurement Comments ^[b]
		Detector	Data Acquisition System		
<u>Vessel (continued)</u>					
DPV-26-55QM	Across part of downcomer, 26 in. (225°), to 55 in. (180°), below cold leg centerline. Elevation difference between taps is 29 in.	+50 in. water	+2.8 psid	212, 213	
DPV-55-110MM	Across part of downcomer, 55 in. (180°), to 110 in. (180°), below cold leg centerline. Elevation difference between taps is 55 in.	+100 in. water	+4.9 psid	214, 215	
DPV-110-156MQ	Across part of downcomer, 110 in. (180°), to 156 in. (225°), below cold leg centerline. Elevation difference between taps is 46 in.	+100 in. water	+4.9 psid	216, 217	
DPV-166-173QQ	Across part of lower plenum, 166 in. (225°), to 173 in. (225°), below cold leg centerline. Elevation difference between taps is 7 in.	+20 in. water	+1.0 psid	218, 219	
DPV-166Q-UP	Lower plenum, 166 in. below cold leg centerline at 225°, to upper plenum, 10.5 in. above cold leg centerline at 30°. Elevation difference between taps is 177 in.	+300 in. water	+14.7 psid	220, 221	
DPU-UP-3	Vessel upper plenum, 10.5 in. above cold leg centerline at 30°, to intact loop hot leg Spool 3, 62 in. from vessel center. Upper plenum tap is ~2 in. above Spool 3 tap.	+50 in. water	+2.4 psid	150, 151	
DPB-21-IANN	Cold leg Spool 21, 49 in. from vessel center, to vessel inlet annulus, 9 in. below cold leg centerline at 225°. Inlet annulus tap is 9 in. below Spool 21 tap.	+100 in. water	+4.8 psid	174, 175	
<u>ECC SYSTEM</u>					
DPU-ACC-TB	Top to bottom of intact loop accumulator. Elevation difference between taps is 108 in.	+300 in. water	+15 psid	222, 223	
DPB-ACC-TB	Top to bottom of broken loop accumulator tank. Elevation difference between taps is 84 in.	+50 in. water	+2.5 psid	224, 225	
<u>Steam Generator</u>					
DPU-SG-SEC	Secondary side, differential pressure taps at 45 in. and 126 in. above bottom of tube sheet. Elevation difference between taps is 81 in.	+100 in. water	+9.8 psid	226, 227	
DPU-SG-DISC	Across venturi tube, 66 in. downstream from steam generator discharge.	+500 in. water	+24.5 psid	228, 229	
VOLUMETRIC FLOW RATE	Turbine flowmeter, bidirectional.				Data acquisition system range may exceed rated detector range; however, turbine response is linear to flow rates well beyond the rated range.
<u>Intact Loop</u>					
FTU-1	Hot leg, Spool 1, 18 in. from vessel center.	+20 to +400 gpm	+1200 gpm	230, 231	
FTU-9	Cold leg, Spool 9, 154 in. from vessel center.	+80 to +800 gpm	+1200 gpm	230, 231	
FTU-13	Cold leg, Spool 13, 64 in. from vessel center.	+20 to +800 gpm	+1200 gpm	232, 233	Detector saturated from t=65 to t=70 sec.
FTU-15	Cold leg, Spool 15, 29 in. from vessel center.	+20 to +800 gpm	+1000 gpm	232, 233	
<u>Broken Loop</u>					
FTB-21	Cold leg, Spool 21, 58 in. from vessel center; 3-in. pipe.	+20 to +400 gpm	+1200 gpm	234, 235	
FTB-30	Hot leg, Spool 30, 25 in. from vessel center; 3-in. pipe.	+20 to +400 gpm	+800 gpm	236, 237	
FTB-37	Cold leg, Spool 37, 290 in. from vessel center along hot leg; 2-in. pipe.	+20 to +800 gpm	+800 gpm	236, 237	

TABLE V (continued)

Measurement	Location and Comments ^[a]	Range ^[a]		Figure ^[a]	Measurement Comments ^[b]
		Detector	Data Acquisition System		
<u>Core</u>					
FTV-CORE-IN	Entrance to core, ~158 in. below cold leg centerline.	+20 to +200 gpm	+900 gpm	238, 239	
<u>ECC System</u>					
FTU-HPIS	In line immediately after HPIS pump for intact loop, 1/2-in. line.	+0.75 to +7.5 gpm	+2 gpm	240, 241	Noise signals prior to t=0 sec. Data between t=2 and t=29 sec is 60 cycle noise pickup except for data transients greater or smaller than the approximate 0.3 gpm noise signal. Data acquisition system saturated intermittently from t=190 to t=300 sec.
FTB-HPIS	In line immediately after HPIS pump for broken loop, 1/2-in. line.	+0.75 to +7.5 gpm	+2 gpm	242, 243	
FTU-LPIS	In line leading from LPIS pump for broken loop, 1/2-in. line.	+0.75 to +7.5 gpm	+10 gpm	244, 245	Data acquisition system saturated at t=28 sec.
FTB-LPIS	In line leading from LPIS pump broken loop; 3/4-in. line.	+0.75 to +7.5 gpm	+4 gpm	246, 247	
FTU-ACC	In line leading from intact loop accumulator; 1-in. line.	+5 to +50 gpm	+75 gpm	248, 249	Data acquisition system saturated from t=40 to t=50 sec.
FTB-ACC	In line leading from broken loop accumulator; 1-in. line.	+2 to +20 gpm	+25 gpm	250, 251	
<u>Pressurizer</u>					
FTU-PRIZE	Surge line.	+2 to +20 gpm	+100 gpm	252, 253	Data acquisition system saturated from t=40 to t=50 sec.
<u>FLUID VELOCITY</u>					
	Turbine flowmeter, bidirectional.				
<u>Downcomer</u>					
FTV-40A	40 in. below cold leg centerline, 0°.	+2.5 to 50 ft/sec	+50 ft/sec	254, 255	
FTV-40M	40 in. below cold leg centerline, 180°.	+2.5 to 50 ft/sec	+50 ft/sec	254, 255	
<u>MOMENTUM FLUX</u>					
	Drag disc, bidirectional.				Drag disc data may exhibit significant temperature dependence.
<u>Intact Loop</u>					
FDU-1	Hot leg, Spool 1, 29 in. from vessel center; target size 0.875 in.	+200 to +11,500 lbm/ft-sec ²	+17,800 lbm/ft-sec ²	256, 257	
FDU-5	Hot leg, Spool 5, 100 in. from vessel center; target size 1.0 in.	+1 to +2000 lbm/ft-sec ²	+4090 lbm/ft-sec ²	258, 259	
FDU-10	Cold leg, Spool 10, 137 in. from vessel center; target size 0.875 in.	+200 to +104,000 lbm/ft-sec ²	+23,750 lbm/ft-sec ²	260, 261	
FDU-13	Cold leg, Spool 13, 54 in. from vessel center; target size 0.875 in.	+200 to +14,800 lbm/ft-sec ²	+19,170 lbm/ft-sec ²	262, 263	
FDU-15	Cold leg, Spool 15, 19 in. from vessel center; target size 0.875 in.	+200 to +14,500 lbm/ft-sec ²	+20,700 lbm/ft-sec ²	264, 265	
<u>Broken Loop</u>					
FDB-21	Cold leg, Spool 21, 53 in. from vessel center, 3-in. pipe; target size 0.050 in.	+200 to +70,500 lbm/ft-sec ²	+444,327 lbm/ft-sec ²	266, 267	
FDB-23	Cold leg, Spool 23, 93 in. from vessel center, upstream of vessel side nozzle, 2-in. pipe; target size 0.406 in.	+200 to +121,000 lbm/ft-sec ²	+127,657 lbm/ft-sec ²	268, 269	

TABLE V (continued)

Measurement	Location and Comments ^[a]	Range ^[a]		Figure ^[a]	Measurement Comments ^[b]
		Detector	Data Acquisition System		
Broken Loop (continued)					
FDB-30	Hot leg, Spool 30, 21 in. from vessel center, 3-in. pipe; target size 0.656 in.	± 200 to $\pm 60,000$ lbm/ft-sec ²	$\pm 49,750$ lbm/ft-sec ²	270, 271	
FDB-37	Cold leg, Spool 37, 284 in. from vessel center along hot leg, steam generator outlet, vertical pipe, 2-in. pipe; target size 0.406 in.	± 200 to $\pm 121,000$ lbm/ft-sec ²	$\pm 203,221$ lbm/ft-sec ²	272, 273	
FDB-42	Cold leg, Spool 42, 416 in. from vessel center along hot leg, upstream of pump-side nozzle, downstream of injection point, 2-in. pipe; target size 0.406 in.	± 200 to $\pm 116,000$ lbm/ft-sec ²	$\pm 101,780$ lbm/ft-sec ²	274, 275	
Vessel					
FDV-CORE-IN	In core flow mixer box 150 in. below cold leg centerline; target size 1.0 in.	± 150 to ± 450 lbm/ft-sec ²	± 1100 lbm/ft-sec ²	276, 277	
DENSITY					
Intact Loop					
		0.1 to 100 lbm/ft ³	0 to 100 lbm/ft ³		
GU-1VR	Hot leg, Spool 1, 24 in. from vessel center, vertical.			278, 279	
GU-1HZ	Hot leg, Spool 1, 26 in. from vessel center, horizontal.			278, 279	
GU-5VR	Hot leg, Spool 5, 96 in. from vessel center, vertical.			280, 281	
GU-10VR	Cold leg, Spool 10, 141 in. from vessel center, vertical.			280, 281	
GU-13VR	Cold leg, Spool 13, 59 in. from vessel center, vertical.			282, 283	
GU-15VR	Cold leg, Spool 15, 23 in. from vessel center, vertical.			284, 285	
GU-15HZ	Cold leg, Spool 15, 20 in. from vessel center, horizontal.			284, 285	Data values above 62.4 lbm/ft ³ do not reflect actual system density and were the result of detector photomultiplier tube nonlinearity.
Broken Loop					
		0.1 to 100 lbm/ft ³	0 to 100 lbm/ft ³		
GB-21T GB-21B GB-21C	Cold leg, Spool 21, 49 in. from vessel center. T (top) ranges 270 to 360°. B (bottom) ranges 30 to 330°. C, mathematical composite of T and B.			286, 287 286, 287 288, 289	
GB-23VR	Cold leg, Spool 23, 92 in. from vessel center, vertical.			290, 291	
GB-30T GB-30B GB-30C	Hot leg, Spool 30, 18 in. from vessel center. T (top) ranges 270 to 360°. B (bottom) ranges 30 to 330°. C, mathematical composite of T and B.			292, 293 292, 293 294, 295	
GB-42VR	Cold leg, Spool 42, 415 in. from vessel center along hot leg, vertical.			296, 297	
Vessel					
		0.1 to 100 lbm/ft ³	0 to 100 lbm/ft ³		
GV-COR-150HZ	Core flow mixer box, 152 in. below cold leg centerline, horizontal, 0 to 180°.			298, 299	Data values above 62.4 lbm/ft ³ do not reflect actual system density and were the result of the detector photomultiplier tube nonlinearity.
GVLP-165HZ	Upper part of lower plenum, 165 in. below cold leg centerline, 1.724 in. below downcomer exit, horizontal, 0 to 180°.			300, 301	
GVLP-172HZ	Lower plenum, 172 in. below cold leg centerline, 8.729 in. below downcomer exit, horizontal, 90 to 270°.			300, 301	
Pressurizer					
GU-PRIZE	Surge line.	0.1 to 100 lbm/ft ³	0 to 100 lbm/ft ³	302, 303	

TABLE V (continued)

Range [a]					
Measurement	Location and Comments [a]	Detector	Data Acquisition System	Figure [a]	Measurement Comments [b]
MASS FLOW RATE	Mass flow rate obtained by combining density (gamma attenuation technique) with volumetric flow rate (turbine flowmeter) or momentum flux (drag disc).	Range for mass flow is determined from range of individual detectors used in calculation.			
Intact Loop					
FDU-1, GU-1VR FTU-1, GU-1VR	Hot leg, Spool 1.			304, 305 306, 307	
FDU-5, GU-5VR	Hot leg, Spool 5.			308, 309	The drag disc transducer saturated prior to t=0 sec.
FTU-9, GU-1NVR	Cold leg, Spool 9.			310, 311	
FDU-10, GU-10VR	Cold leg, Spool 10.			312, 313	
FDU-13, GU-13VR FTU-13, GU-13VR	Cold leg, Spool 13.			314, 315 316, 317	Nonlinearity in the density detector system caused density data near 62.4 lbm/ft ³ to be greater than 62.4 lbm/ft ³ .
FDU-15, GU-15VR FTU-15, GU-15VR	Cold leg, Spool 15.			318, 319 320, 321	
Broken Loop					
FDB-21, GB-21C FTB-21, GB-21C	Cold leg, Spool 21.			322, 323 324, 325	Flow prior to t=0 sec should be zero. Flow indicated by FDB-21 prior to t=0 is not representative of system physical conditions. Data after t=0 sec appear not to be offset.
FDB-23, GB-23VR	Cold leg, Spool 23.			326, 327	
FDB-30, GB-30C FTB-30, GB-30C	Hot leg, Spool 30.			328, 329 330, 331	
FDB-42, GB-42VR	Cold leg, Spool 42.			332, 333	
Vessel					
FDV-CORE-IN, GV-COR-150HZ	Entrance to core.			334, 335	
FTV CORE IN, GV-COR-150HZ	Entrance to core			336, 337	
Pressurizer					
FTU-PRIZC GU-PRIZC	Pressurizer surge line.			338, 339	
CORE CHARACTERISTICS					
PWRCOR T-1	Core power.		1000 kW	340, 341	
PWRCOR T-2	Core power.		1600 kW	340, 341	
VOLTCOR-T	Core voltage.		0 to 200 Vdc	342, 343	
AMPCOR-T	Core current.		0 to 10,000 A	344, 345	
PUMP CHARACTERISTICS					
PUMPU-CUR	Pump current.		0 to 25 A	346, 347	
PUMPU-RPM	Pump speed.		0 to 3600 rpm	348, 349	

[a] Statements at the beginning of a measurement category regarding location and comments, range, and figure apply to all subsequent measurements within the given category unless specified otherwise.

[b] Detectors which were subjected to overrange conditions during portions of the test were capable of withstanding these conditions without change in operating or measuring characteristics when the physical conditions were again within the detector range.

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Fig. 10 Fluid temperature in intact loop hot leg (RBU-2, TFU-1), from -20 to 300 sec.

Fig. 11 Fluid temperature in intact loop hot leg (RBU-2, TFU-1), from -6 to 42 sec.

Fig. 12 Fluid temperature in intact loop cold leg (TFU-10, RBU-14A, TFU-14B, TFU-15), from -20 to 300 sec.

Fig. 13 Fluid temperature in intact loop cold leg (TFU-10, RBU-14A, TFU-14B, TFU-15), from -6 to 42 sec.

Fig. 14 Fluid temperature in broken loop, vessel side (TFB-20 and TFB-23), from -20 to 300 sec.

Fig. 15 Fluid temperature in broken loop, vessel side (TFB-20 and TFB-23), from -6 to 42 sec.

Fig. 16 Fluid temperature in broken loop, pump side (TFB-30, TFB-37, TFB-42), from -20 to 300 sec.

Fig. 17 Fluid temperature in broken loop, pump side (TFB-30, TFB-37, TFB-42), from -6 to 42 sec.

Fig. 18 Fluid temperature in downcomer annulus (TFV-ANN-4A, TFV-ANN-4M), from -20 to 300 sec.

Fig. 19 Fluid temperature in downcomer annulus (TFV-ANN-4A, TFV-ANN-4M), from -6 to 42 sec.

Fig. 20 Fluid temperature in downcomer annulus (TFV-ANN-35A, TFV-ANN-70A, TFV-ANN-115A, TFV-ANN-156A), from -20 to 300 sec.

Fig. 21 Fluid temperature in downcomer annulus (TFV-ANN-35A, TFV-ANN-70A, TFV-ANN-115A, TFV-ANN-156A), from -6 to 42 sec.

Fig. 22 Fluid temperature in upper plenum (TFV-UP+13), from -20 to 300 sec.

Fig. 23 Fluid temperature in upper plenum (TFV-UP+13), from -6 to 42 sec.

Fig. 24 Fluid temperature in lower plenum (TFV-LP-2, TFV-LP-4, TFV-LP-7), from -20 to 300 sec.

Fig. 25 Fluid temperature in lower plenum (TFV-LP-2, TFV-LP-4, TFV-LP-7), from -6 to 42 sec.

Fig. 26 Fluid temperature in core inlet (TFV-CORE-IN), from -20 to 300 sec.

Fig. 27 Fluid temperature in core inlet (TFV-CORE-IN), from -6 to 42 sec.

Fig. 28 Fluid temperature in core, Grid Spacer 5 (TFG-5CD-45), from -20 to 300 sec.

Fig. 29 Fluid temperature in core, Grid Spacer 5 (TFG-5CD-45), from -6 to 42 sec.

Fig. 30 Fluid temperature in core, Grid Spacer 6 (TFG-6AB-45, TFG-6CD-45, TFG-6DE-23, TFG-6DE-67), from -20 to 300 sec.

Fig. 31 Fluid temperature in core, Grid Spacer 6 (TFG-6AB-45, TFG-6CD-45, TFG-6DE-23, TFG-6DE-67), from -6 to 42 sec.

Fig. 32 Fluid temperature in core, Grid Spacer 10 (TFG-10CD-45, TFG-10EF-45, TFG-10GH-45), from -20 to 300 sec.

Fig. 33 Fluid temperature in core, Grid Spacer 10 (TFG-10CD-45, TFG-10EF-45, TFG-10GH-45), from -6 to 42 sec.

Fig. 34 Fluid temperature in core barrel insulation gap (TFV-CIG-70A), from -20 to 300 sec.

Fig. 35 Fluid temperature in core barrel insulation gap (TFV-CIG-70A), from -6 to 42 sec.

Fig. 36 Fluid temperature in intact loop coolant injection line (TFU-ECC-14), from -20 to 300 sec.

Fig. 37 Fluid temperature in intact loop coolant injection line (TFU-ECC-14), from -6 to 42 sec.

Fig. 38 Fluid temperature in broken loop coolant injection line (TFB-ECC-42), from -20 to 300 sec.

Fig. 39 Fluid temperature in broken loop coolant injection line (TFB-ECC-42), from -6 to 42 sec.

Fig. 40 Fluid temperature in steam generator feedwater line (TFU-SGFW, TFU-SGSD), from -20 to 300 sec.

Fig. 41 Fluid temperature in steam generator feedwater line (TFU-SGFW, TFU-SGSD), from -6 to 42 sec.

Fig. 42 Fluid temperature in steam generator secondary (TFU-SG3, TFU-SG4), from -20 to 300 sec.

Fig. 43 Fluid temperature in steam generator secondary (TFU-SG3, TFU-SG4), from -6 to 42 sec.

Fig. 44 Fluid temperature in pressurizer surge line (TFU-PRIZE), from -20 to 300 sec.

Fig. 45 Fluid temperature in pressurizer surge line (TFU-PRIZE), from -6 to 42 sec.

Fig. 46 Fluid temperature in pressure suppression tank (TF-PSS-33 and TF-PSS-130), from -20 to 300 sec.

Fig. 47 Fluid temperature in pressure suppression tank (TF-PSS-33 and TF-PSS-130), from -6 to 42 sec.

Fig. 48 Material temperature in intact loop (TMU-1T16 and TMU-15T16), from -20 to 300 sec.

Fig. 49 Material temperature in intact loop (TMU-1T16 and TMU-15T16), from -6 to 42 sec.

Fig. 50 Material temperature in broken loop (TMB-20B16), from -20 to 300 sec.

Fig. 51 Material temperature in broken loop (TMB-20B16), from -6 to 42 sec.

Fig. 52 Material temperature in vessel filler (TMV-FI-15A, TMV-FI-35A, TMV-FI-115A), from -20 to 300 sec.

Fig. 53 Material temperature in vessel filler (TMV-FI-15A, TMV-FI-35A, TMV-FI-115A), from -6 to 42 sec.

Fig. 54 Material temperature in vessel filler insulator (TIV-FO-35A, TIV-FO-35M, TIV-FO-70A, and TIV-FO-115A), from -20 to 300 sec.

Fig. 55 Material temperature in vessel filler insulator (TIV-FO-35A, TIV-FO-35M, TIV-FO-70A, and TIV-FO-115A), from -6 to 42 sec.

Fig. 56 Material temperature in core barrel inner diameter (TMV-CI-35A), from -20 to 300 sec.

Fig. 57 Material temperature in core barrel inner diameter (TMV-CI-35A), from -6 to 42 sec.

Fig. 58 Material temperature in core barrel (TMV-CO-115A), from -20 to 300 sec.

Fig. 59 Material temperature in core barrel (TMV-CO-115A), from -6 to 42 sec.

Fig. 60 Core heater temperature, Rod D-4 (TH-D4-14 and TH-D4-29), from -20 to 300 sec.

Fig. 61 Core heater temperature, Rod D-4 (TH-D4-14 and TH-D4-29), from -6 to 42 sec.

Fig. 62 Core heater temperature, Rod E-4 (TH-E4-09, TH-E4-28, TH-E4-55), from -20 to 300 sec.

Fig. 63 Core heater temperature, Rod E-4 (TH-E4-09, TH-E4-28, TH-E4-55), from -6 to 42 sec.

Fig. 64 Core heater temperature, Rod A-4 (TH-A4-09, TH-A4-29, TH-A4-39), from -20 to 300 sec.

Fig. 65 Core heater temperature, Rod A-4 (TH-A4-09, TH-A4-29, TH-A4-39), from -6 to 42 sec.

Fig. 66 Core heater temperature, Rod A-5 (TH-A5-29 and TH-A5-45), from -20 to 300 sec.

Fig. 67 Core heater temperature, Rod A-5 (TH-A5-29 and TH-A5-45), from -6 to 42 sec.

Fig. 68 Core heater temperature, Rod B-3 (TH-B3-32), from -20 to 300 sec.

Fig. 69 Core heater temperature, Rod B-3 (TH-B3-32), from -6 to 42 sec.

Fig. 70 Core heater temperature, Rod B-5 (TH-B5-29 and TH-B5-33), from -20 to 300 sec.

Fig. 71 Core heater temperature, Rod B-5 (TH-B5-29 and TH-B5-33), from -6 to 42 sec.

Fig. 72 Core heater temperature, Rod B-6 (TH-B6-29), from -20 to 300 sec.

Fig. 73 Core heater temperature, Rod B-6 (TH-B6-29), from -6 to 42 sec.

Fig. 74 Core heater temperature, Rod C-2 (TH-C2-38), from -20 to 300 sec.

Fig. 75 Core heater temperature, Rod C-2 (TH-C2-38), from -6 to 42 sec.

Fig. 76 Core heater temperature, Rod C-4 (TH-C4-26 and TH-C4-53), from -20 to 300 sec.

Fig. 77 Core heater temperature, Rod C-4 (TH-C4-26 and TH-C4-53), from -6 to 42 sec.

Fig. 78 Core heater temperature, Rod C-5 (TH-C5-28), from -20 to 300 sec.

Fig. 79 Core heater temperature, Rod C-5 (TH-C5-28), from -6 to 42 sec.

Fig. 80 Core heater temperature, Rod C-6 (TH-C6-32), from -20 to 300 sec.

Fig. 81 Core heater temperature, Rod C-6 (TH-C6-32), from -6 to 42 sec.

Fig. 82 Core heater temperature, Rod C-7 (TH-C7-07), from -20 to 300 sec.

Fig. 83 Core heater temperature, Rod C-7 (TH-C7-07), from -6 to 42 sec.

Fig. 84 Core heater temperature, Rod D-1 (TH-D1-21), from -20 to 300 sec.

Fig. 85 Core heater temperature, Rod D-1 (TH-D1-21), from -6 to 42 sec.

Fig. 86 Core heater temperature, Rod D-2 (TH-D2-14 and TH-D2-61), from -20 to 300 sec.

Fig. 87 Core heater temperature, Rod D-2 (TH-D2-14 and TH-D2-61), from -6 to 42 sec.

Fig. 88 Core heater temperature, Rod D-3 (TH-D3-29 and TH-D3-39), from -20 to 300 sec.

Fig. 89 Core heater temperature, Rod D-3 (TH-D3-29 and TH-D3-39), from -6 to 42 sec.

Fig. 90 Core heater temperature, Rod D-6 (TH-D6-15 and TH-D6-25), from -20 to 300 sec.

Fig. 91 Core heater temperature, Rod D-6 (TH-D6-15 and TH-D6-25), from -6 to 42 sec.

Fig. 92 Core heater temperature, Rod D-7 (TH-D7-20), from -20 to 300 sec.

Fig. 93 Core heater temperature, Rod D-7 (TH-D7-20), from -6 to 42 sec.

Fig. 94 Core heater temperature, Rod D-8 (TH-D8-57), from -20 to 300 sec.

Fig. 95 Core heater temperature, Rod D-8 (TH-D8-57), from -6 to 42 sec.

Fig. 96 Core heater temperature, Rod E-1 (TH-E1-33), from -20 to 300 sec.

Fig. 97 Core heater temperature, Rod E-1 (TH-E1-33), from -6 to 42 sec.

Fig. 98 Core heater temperature, Rod E-2 (TH-E2-33), from -20 to 300 sec.

Fig. 99 Core heater temperature, Rod E-2 (TH-E2-33), from -6 to 42 sec.

Fig. 100 Core heater temperature, Rod E-3 (TH-E3-05, TH-E3-20, TH-E3-24), from -20 to 300 sec.

Fig. 101 Core heater temperature, Rod E-3 (TH-E3-05, TH-E3-20, TH-E3-24), from -6 to 42 sec.

Fig. 102 Core heater temperature, Rod E-6 (TH-E6-08, TH-E6-28, TH-E6-37), from -20 to 300 sec.

Fig. 103 Core heater temperature, Rod E-6 (TH-E6-08, TH-E6-28, TH-E6-37), from -6 to 42 sec.

Fig. 104 Core heater temperature, Rod E-7 (TH-E7-44), from -20 to 300 sec.

Fig. 105 Core heater temperature, Rod E-7 (TH-E7-44), from -6 to 42 sec.

Fig. 106 Core heater temperature, Rod E-8 (TH-E8-14, TH-E8-29, TH-E8-45), from -20 to 300 sec.

Fig. 107 Core heater temperature, Rod E-8 (TH-E8-14, TH-E8-29, TH-E8-45), from -6 to 42 sec.

Fig. 108 Core heater temperature, Rod F-2 (TH-F2-07, TH-F2-22, TH-F2-25), from -20 to 300 sec.

Fig. 109 Core heater temperature, Rod F-2 (TH-F2-07, TH-F2-22, TH-F2-25), from -6 to 42 sec.

Fig. 110 Core heater temperature, Rod F-3 (TH-F3-22), from -20 to 300 sec.

Fig. 111 Core heater temperature, Rod F-3 (TH-F3-22), from -6 to 42 sec.

Fig. 112 Core heater temperature, Rod F-4 (TH-F4-14, TH-F4-29, TH-F4-44), from -20 to 300 sec.

Fig. 113 Core heater temperature, Rod F-4 (TH-F4-14, TH-F4-29, TH-F4-44), from -6 to 42 sec.

Fig. 114 Core heater temperature, Rod F-5 (TH-F5-20, TH-F5-26, TH-F5-33, TH-F5-53), from -20 to 300 sec.

Fig. 115 Core heater temperature, Rod F-5 (TH-F5-20, TH-F5-26, TH-F5-33, TH-F5-53), from -6 to 42 sec.

Fig. 116 Core heater temperature, Rod G-3 (TH-G3-13), from -20 to 300 sec.

Fig. 117 Core heater temperature, Rod G-3 (TH-G3-13), from -6 to 42 sec.

Fig. 118 Core heater temperature, Rod G-4 (TH-G4-29, TH-G4-33), from -20 to 300 sec.

Fig. 119 Core heater temperature, Rod G-4 (TH-G4-29, TH-G4-33), from -6 to 42 sec.

Fig. 120 Core heater temperature, Rod G-4 (TH-G4-38), from -20 to 300 sec.

Fig. 121 Core heater temperature, Rod G-4 (TH-G4-38), from -6 to 42 sec.

Fig. 122 Core heater temperature, Rod G-5 (TH-G5-14 and TH-G5-24), from -20 to 300 sec.

Fig. 123 Core heater temperature, Rod G-5 (TH-G5-14 and TH-G5-24), from -6 to 42 sec.

Fig. 124 Core heater temperature, Rod H-5 (TH-H5-32), from -20 to 300 sec.

Fig. 125 Core heater temperature, Rod H-5 (TH-H5-32), from -6 to 42 sec.

Fig. 126 Pressure in intact loop, Spool 13 (PU-13), from -20 to 300 sec.

Fig. 127 Pressure in intact loop, Spool 13 (PU-13), from -6 to 42 sec.

Fig. 128 Pressure in intact loop, Spool 15, low range (PU-15L), from -20 to 300 sec.

Fig. 129 Pressure in intact loop, Spool 15, low range (PU-15L), from -6 to 42 sec.

Fig. 130 Pressure in broken loop, Spool 23 (PB-21, PB-23, PB-24), from -20 to 300 sec.

Fig. 131 Pressure in broken loop, Spool 23 (PB-21, PB-23, PB-24), from -6 to 42 sec.

Fig. 132 Pressure in broken loop, near break (PB-42 and PB-43), from -20 to 300 sec.

Fig. 133 Pressure in broken loop, near break (PB-42 and PB-43), from -6 to 42 sec.

Fig. 134 Pressure in broken loop, vessel-side nozzle (PB-CN1, PB-CN2, PB-CN3), from -20 to 300 sec.

Fig. 135 Pressure in broken loop, vessel-side nozzle (PB-CN1, PB-CN2, PB-CN3), from -6 to 42 sec.

Fig. 136 Pressure in broken loop, pump-side nozzle (PB-HN1), from -20 to 300 sec.

Fig. 137 Pressure in broken loop, pump-side nozzle (PB-HN1), from -6 to 42 sec.

Fig. 138 Pressure in vessel (PV-UP+10 and PV-LP-166), from -20 to 300 sec.

Fig. 139 Pressure in vessel (PV-UP+10 and PV-LP-166), from -6 to 42 sec.

Fig. 140 Pressure in intact loop accumulator (PU-ACC), from -20 to 300 sec.

Fig. 141 Pressure in intact loop accumulator (PU-ACC), from -6 to 42 sec.

Fig. 142 Pressure in broken loop accumulator (PB-ACC), from -20 to 300 sec.

Fig. 143 Pressure in broken loop accumulator (PB-ACC), from -6 to 42 sec.

Fig. 144 Pressure in steam generator, secondary side (PU-SGSD), from -20 to 300 sec.

Fig. 145 Pressure in steam generator, secondary side (PU-SGSD), from -6 to 42 sec.

Fig. 146 Pressure in pressurizer (PU-PRIZE), from -20 to 300 sec.

Fig. 147 Pressure in pressurizer (PU-PRIZE), from -6 to 42 sec.

Fig. 148 Pressure in pressure suppression tank (P-PSS), from -20 to 300 sec.

Fig. 149 Pressure in pressure suppression tank (P-PSS), from -6 to 42 sec.

Fig. 150 Differential pressure in intact loop (DPU-UP-3), from -20 to 300 sec.

Fig. 151 Differential pressure in intact loop (DPU-UP-3), from -6 to 42 sec.

Fig. 152 Differential pressure in intact loop (DPU-3-7), from -20 to 300 sec.

Fig. 153 Differential pressure in intact loop (DPU-3-7), from -6 to 42 sec.

Fig. 154 Differential pressure in intact loop (DPU-6-7), from -20 to 300 sec.

Fig. 155 Differential pressure in intact loop (DPU-6-7), from -6 to 42 sec.

Fig. 156 Differential pressure in intact loop (DPU-7-10), from -20 to 300 sec.

Fig. 157 Differential pressure in intact loop (DPU-7-10), from -6 to 42 sec.

Fig. 158 Differential pressure in intact loop (DPU-12-10), from -20 to 300 sec.

Fig. 159 Differential pressure in intact loop (DPU-12-10), from -6 to 42 sec.

Fig. 160 Differential pressure in intact loop, low range (DPU-12-10L), from -20 to 300 sec.

Fig. 161 Differential pressure in intact loop, low range (DPU-12-10L), from -6 to 42 sec.

Fig. 162 Differential pressure in intact loop (DPU-12-15), from -20 to 300 sec.

Fig. 163 Differential pressure in intact loop (DPU-12-15), from -6 to 42 sec.

Fig. 164 Differential pressure in intact loop (DPU-15-1), from -20 to 300 sec.

Fig. 165 Differential pressure in intact loop (DPU-15-1), from -6 to 42 sec.

Fig. 166 Differential pressure in intact loop, low range (DPU-15-1L), from -20 to 300 sec.

Fig. 167 Differential pressure in intact loop, low range (DPU-15-1L), from -6 to 42 sec.

Fig. 168 Differential pressure in intact loop (DPU-15-IANN), from -20 to 300 sec.

Fig. 169 Differential pressure in intact loop (DPU-15-IANN), from -6 to 42 sec.

Fig. 170 Differential pressure in intact loop (DPU-PRESLL), from -20 to 300 sec.

Fig. 171 Differential pressure in intact loop (DPU-PRESLL), from -6 to 42 sec.

Fig. 172 Differential pressure in broken loop (DPB-UP-30), from -20 to 300 sec.

Fig. 173 Differential pressure in broken loop (DPB-UP-30), from -6 to 42 sec.

Fig. 174 Differential pressure in broken loop (DPB-21-IANN), from -20 to 300 sec.

Fig. 175 Differential pressure in broken loop (DPB-21-IANN), from -6 to 42 sec.

Fig. 176 Differential pressure in broken loop (DPB-21-23), from -20 to 300 sec.

Fig. 177 Differential pressure in broken loop (DPB-21-23), from -6 to 42 sec.

Fig. 178 Differential pressure in broken loop (DPB-23-CN1), from -20 to 300 sec.

Fig. 179 Differential pressure in broken loop (DPB-23-CN1), from -6 to 42 sec.

Fig. 180 Differential pressure in broken loop (DPB-23-24), from -20 to 300 sec.

Fig. 181 Differential pressure in broken loop (DPB-23-24), from -6 to 42 sec.

Fig. 182 Differential pressure in broken loop (DPB-CN1-CN4), from -20 to 300 sec.

Fig. 183 Differential pressure in broken loop (DPB-CN1-CN4), from -6 to 42 sec.

Fig. 184 Differential pressure in broken loop (DPB-30-36L), from -20 to 300 sec.

Fig. 185 Differential pressure in broken loop (DPB-30-36L), from -6 to 42 sec.

Fig. 186 Differential pressure in broken loop (DPB-30-38), from -20 to 300 sec.

Fig. 187 Differential pressure in broken loop (DPB-30-38), from -6 to 42 sec.

Fig. 188 Differential pressure in broken loop (DPB-32U-36L), from -20 to 300 sec.

Fig. 189 Differential pressure in broken loop (DPB-32U-36L), from -6 to 42 sec.

Fig. 190 Differential pressure in broken loop (DPB-36L-42), from -20 to 300 sec.

Fig. 191 Differential pressure in broken loop (DPB-36L-42), from -6 to 42 sec.

Fig. 192 Differential pressure in broken loop (DPB-38-40), from -20 to 300 sec.

Fig. 193 Differential pressure in broken loop (DPB-38-40), from -6 to 42 sec.

Fig. 194 Differential pressure in broken loop (DPB-40-42), from -20 to 300 sec.

Fig. 195 Differential pressure in broken loop (DPB-40-42), from -6 to 42 sec.

Fig. 196 Differential pressure in broken loop (DPB-42-43), from -20 to 300 sec.

Fig. 197 Differential pressure in broken loop (DPB-42-43), from -6 to 42 sec.

Fig. 198 Differential pressure in broken loop (DPB-42-HN1), from -20 to 300 sec.

Fig. 199 Differential pressure in broken loop (DPB-42-HN1), from -6 to 42 sec.

Fig. 200 Differential pressure in broken loop (DPB-HN1-HN4), from -20 to 300 sec.

Fig. 201 Differential pressure in broken loop (DPB-HN1-HN4), from -6 to 42 sec.

Fig. 202 Differential pressure in broken loop (DPB-HN4-43), from -20 to 300 sec.

Fig. 203 Differential pressure in broken loop (DPB-HN4-43), from -6 to 42 sec.

Fig. 204 Differential pressure in vessel (DPV-UP-IANN), from -20 to 300 sec.

Fig. 205 Differential pressure in vessel (DPV-UP-IANN), from -6 to 42 sec.

Fig. 206 Differential pressure in vessel (DPV-O-9GQ), from -20 to 300 sec.

Fig. 207 Differential pressure in vessel (DPV-O-9GQ), from -6 to 42 sec.

Fig. 208 Differential pressure in vessel (DPV-9-260Q), from -20 to 300 sec.

Fig. 209 Differential pressure in vessel (DPV-9-260Q), from -6 to 42 sec.

Fig. 210 Differential pressure in vessel (DPV-9-166QQ), from -20 to 300 sec.

Fig. 211 Differential pressure in vessel (DPV-9-166QQ), from -6 to 42 sec.

Fig. 212 Differential pressure in vessel (DPV-26-55QM), from -20 to 300 sec.

Fig. 213 Differential pressure in vessel (DPV-26-55QM), from -6 to 42 sec.

Fig. 214 Differential pressure in vessel (DPV-55-110MM), from -20 to 300 sec.

Fig. 215 Differential pressure in vessel (DPV-55-110MM), from -6 to 42 sec.

Fig. 216 Differential pressure in vessel (DPV-110-156MQ), from -20 to 300 sec.

Fig. 217 Differential pressure in vessel (DPV-110-156MQ), from -6 to 42 sec.

Fig. 218 Differential pressure in vessel (DPV-166-173QQ), from -20 to 300 sec.

Fig. 219 Differential pressure in vessel (DPV-166-173QQ), from -6 to 42 sec.

Fig. 220 Differential pressure in vessel (DPV-166Q-UP), from -20 to 300 sec.

Fig. 221 Differential pressure in vessel (DPV-166Q-UP), from -6 to 42 sec.

Fig. 222 Differential pressure in intact loop accumulator (DPU-ACC-TB), from -20 to 300 sec.

Fig. 223 Differential pressure in intact loop accumulator (DPU-ACC-TB), from -6 to 42 sec.

Fig. 224 Differential pressure in broken loop accumulator (DPB-ACC-TB), from -20 to 300 sec.

Fig. 225 Differential pressure in broken loop accumulator (DPB-ACC-TB), from -6 to 42 sec.

Fig. 226 Differential pressure in steam generator secondary (DPU-SG-SEC), from -20 to 300 sec.

Fig. 227 Differential pressure in steam generator secondary (DPU-SG-SEC), from -6 to 42 sec.

Fig. 228 Differential pressure across steam generator outlet orifice (DPU-SG-DISC), from -20 to 300 sec.

Fig. 229 Differential pressure across steam generator outlet orifice (DPU-SG-DISC), from -6 to 42 sec.

Fig. 230 Volumetric flow in intact loop (FTU-1 and FTU-9), from -20 to 300 sec.

Fig. 231 Volumetric flow in intact loop (FTU-1 and FTU-9), from -6 to 42 sec.

Fig. 232 Volumetric flow in intact loop (FTU-13, FTU-15), from -20 to 300 sec.

Fig. 233 Volumetric flow in intact loop (FTU-13, FTU-15), from -6 to 42 sec.

Fig. 234 Volumetric flow in broken loop (FTB-21), from -20 to 300 sec.

Fig. 235 Volumetric flow in broken loop (FTB-21), from -6 to 42 sec.

Fig. 236 Volumetric flow in broken loop (FTB-30 and FTB-37), from -20 to 300 sec.

Fig. 237 Volumetric flow in broken loop (FTB-30 and FTB-37), from -6 to 42 sec.

Fig. 238 Volumetric flow in core entrance (FTV-CORE-IN), from -20 to 300 sec.

Fig. 239 Volumetric flow in core entrance (FTV-CORE-IN), from -6 to 42 sec.

Fig. 240 Volumetric flow in intact loop high pressure injection line (FTU-HPIS), from -20 to 300 sec.

Fig. 241 Volumetric flow in intact loop high pressure injection line (FTU-HPIS), from -6 to 42 sec.

Fig. 242 Volumetric flow in broken loop high pressure injection line (FTB-HPIS), from -20 to 300 sec.

Fig. 243 Volumetric flow in broken loop high pressure injection line (FTB-HPIS), from -6 to 42 sec.

Fig. 244 Volumetric flow in intact loop low pressure injection line (FTU-LPIS), from -20 to 300 sec.

Fig. 245 Volumetric flow in intact loop low pressure injection line (FTU-LPIS), from -6 to 42 sec.

Fig. 246 Volumetric flow in broken loop low pressure injection line (FTB-LPIS), from -20 to 300 sec.

Fig. 247 Volumetric flow in broken loop low pressure injection line (FTB-LPIS), from -6 to 42 sec.

Fig. 248 Volumetric flow in intact loop accumulator discharge line (FTU-ACC), from -20 to 300 sec.

Fig. 249 Volumetric flow in intact loop accumulator discharge line (FTU-ACC), from -6 to 42 sec.

Fig. 250 Volumetric flow in broken loop accumulator discharge line (FTB-ACC), from -20 to 300 sec.

Fig. 251 Volumetric flow in broken loop accumulator discharge line (FTB-ACC), from -6 to 42 sec.

Fig. 252 Volumetric flow from pressurizer (FTU-PRIZE), from -20 to 300 sec.

Fig. 253 Volumetric flow from pressurizer (FTU-PRIZE), from -6 to 42 sec.

Fig. 254 Fluid velocity in vessel (FTV-40A, FTV-40M), from -20 to 300 sec.

Fig. 255 Fluid velocity in vessel (FTV-40A, FTV-40M), from -6 to 42 sec.

Fig. 256 Momentum flux in intact loop (FDU-1), from -20 to 300 sec.

Fig. 257 Momentum flux in intact loop (FDU-1), from -6 to 42 sec.

Fig. 258 Momentum flux in intact loop (FDU-5), from -20 to 300 sec.

Fig. 259 Momentum flux in intact loop (FDU-5), from -6 to 42 sec.

Fig. 260 Momentum flux in intact loop (FDU-10), from -20 to 300 sec.

Fig. 261 Momentum flux in intact loop (FDU-10), from -6 to 42 sec.

Fig. 262 Momentum flux in intact loop (FDU-13), from -20 to 300 sec.

Fig. 263 Momentum flux in intact loop (FDU-13), from -6 to 42 sec.

Fig. 264 Momentum flux in intact loop (FDU-15), from -20 to 300 sec.

Fig. 265 Momentum flux in intact loop (FDU-15), from -6 to 42 sec.

Fig. 266 Momentum flux in broken loop (FDB-21), from -20 to 300 sec.

Fig. 267 Momentum flux in broken loop (FDB-21), from -6 to 42 sec.

Fig. 268 Momentum flux in broken loop (FDB-23), from -20 to 300 sec.

Fig. 269 Momentum flux in broken loop (FDB-23), from -6 to 42 sec.

Fig. 270 Momentum flux in broken loop (FDB-30), from -20 to 300 sec.

Fig. 271 Momentum flux in broken loop (FDB-30), from -6 to 42 sec.

Fig. 272 Momentum flux in broken loop (FDB-37), from -20 to 300 sec.

Fig. 273 Momentum flux in broken loop (FDB-37), from -6 to 42 sec.

Fig. 274 Momentum flux in broken loop (FDB-42), from -20 to 300 sec.

Fig. 275 Momentum flux in broken loop (FDB-42), from -6 to 42 sec.

Fig. 276 Momentum flux in core entrance (FDV-CORE-IN), from -20 to 300 sec.

Fig. 277 Momentum flux in core entrance (FDV-CORE-IN), from -6 to 42 sec.

Fig. 278 Density in intact loop (GU-1VR and GU-1HZ), from -20 to 300 sec.

Fig. 279 Density in intact loop (GU-1VR and GU-1HZ), from -6 to 42 sec.

Fig. 280 Density in intact loop (GU-5VR and GU-10VR), from -20 to 300 sec.

Fig. 281 Density in intact loop (GU-5VR and GU-10VR), from -6 to 42 sec.

Fig. 282 Density in intact loop (GU-13VR), from -20 to 300 sec.

Fig. 283 Density in intact loop (GU-13VR), from -6 to 42 sec.

Fig. 284 Density in intact loop (GU-15VR and GU-15HZ), from -20 to 300 sec.

Fig. 285 Density in intact loop (GU-15VR and GU-15HZ), from -6 to 42 sec.

Fig. 286 Density in broken loop (GB-21B, GB-21T), from -20 to 300 sec.

Fig. 287 Density in broken loop (GB-21B, GB-21T), from -6 to 42 sec.

Fig. 288 Density in broken loop (GB-21C), from -20 to 300 sec.

Fig. 289 Density in broken loop (GB-21C), from -6 to 42 sec.

Fig. 290 Density in broken loop (GB-23VR), from -20 to 300 sec.

Fig. 291 Density in broken loop (GB-23VR), from -6 to 42 sec.

Fig. 292 Density in broken loop (GB-30B, GB-30T), from -20 to 300 sec.

Fig. 293 Density in broken loop (GB-30B, GB-30T), from -6 to 42 sec.

Fig. 294 Density in broken loop (GB-30C), from -20 to 300 sec.

Fig. 295 Density in broken loop (GB-30C), from -6 to 42 sec.

Fig. 296 Density in broken loop (GB-42VR), from -20 to 300 sec.

Fig. 297 Density in broken loop (GB-42VR), from -6 to 42 sec.

Fig. 298 Density in vessel (GV-COR-150HZ), from -20 to 300 sec.

Fig. 299 Density in vessel (GV-COR-150HZ), from -6 to 42 sec.

Fig. 300 Density in vessel (GVLP-165HZ and GVLP-172HZ), from -20 to 300 sec.

Fig. 301 Density in vessel (GVLP-165HZ and GVLP-172HZ), from -6 to 42 sec.

Fig. 302 Density in pressurizer (GU-PRIZE), from -20 to 300 sec.

Fig. 303 Density in pressurizer (GU-PRIZE), from -6 to 42 sec.

Fig. 304 Mass flow in intact loop (FDU-1 and GU-1VR), from -20 to 300 sec.

Fig. 305 Mass flow in intact loop (FDU-1 and GU-1VR), from -6 to 42 sec.

Fig. 306 Mass flow in intact loop (FTU-1 and GU-1VR), from -20 to 300 sec.

Fig. 307 Mass flow in intact loop (FTU-1 and GU-1VR), from -6 to 42 sec.

Fig. 308 Mass flow in intact loop (FDU-5 and GU-5VR), from -20 to 300 sec.

Fig. 309 Mass flow in intact loop (FDU-5 and GU-5VR), from -6 to 42 sec.

Fig. 310 Mass flow in intact loop (FTU-9 and GU-10VR), from -20 to 300 sec.

Fig. 311 Mass flow in intact loop (FTU-9 and GU-10VR), from -6 to 42 sec.

Fig. 312 Mass flow in intact loop (FDU-10 and GU-10VR), from -20 to 300 sec.

Fig. 313 Mass flow in intact loop (FDU-10 and GU-10VR), from -6 to 42 sec.

Fig. 314 Mass flow in intact loop (FDU-13 and GU-13VR), from -20 to 300 sec.

Fig. 315 Mass flow in intact loop (FDU-13 and GU-13VR), from -6 to 42 sec.

Fig. 316 Mass flow in intact loop (FTU-13 and GU-13VR), from -20 to 300 sec.

Fig. 317 Mass flow in intact loop (FTU-13 and GU-13VR), from -6 to 42 sec.

Fig. 318 Mass flow in intact loop (FDU-15 and GU-15VR), from -20 to 300 sec.

Fig. 319 Mass flow in intact loop (FDU-15 and GU-15VR), from -6 to 42 sec.

Fig. 320 Mass flow in intact loop (FTU-15 and GU-15VR), from -20 to 300 sec.

Fig. 321 Mass flow in intact loop (FTU-15 and GU-15VR), from -6 to 42 sec.

Fig. 322 Mass flow in broken loop (FDB-21 and GB-21VR), from -20 to 300 sec.

Fig. 323 Mass flow in broken loop (FDB-21 and GB-21VR), from -6 to 42 sec.

Fig. 324 Mass flow in broken loop (FTB-21 and GB-21VR), from -20 to 300 sec.

Fig. 325 Mass flow in broken loop (FTB-21 and GB-21VR), from -6 to 42 sec.

Fig. 326 Mass flow in broken loop (FDB-23 and GB-23VR), from -20 to 300 sec.

Fig. 327 Mass flow in broken loop (FDB-23 and GB-23VR), from -6 to 42 sec.

Fig. 328 Mass flow in broken loop (FDB-30 and GB-30C), from -20 to 300 sec.

Fig. 329 Mass flow in broken loop (FDB-30 and GB-30C), from -6 to 42 sec.

Fig. 330 Mass flow in broken loop (FTB-30 and GB-30C), from -20 to 300 sec.

Fig. 331 Mass flow in broken loop (FTB-30 and GB-30C), from -6 to 42 sec.

Fig. 332 Mass flow in broken loop (FDB-42 and GB-42VR), from -20 to 300 sec.

Fig. 333 Mass flow in broken loop (FDB-42 and GB-42VR), from -6 to 42 sec.

Fig. 334 Mass flow in vessel (FDV-CORE-IN and GV-COR-150HZ), from -20 to 300 sec.

Fig. 335 Mass flow in vessel (FDV-CORE-IN and GV-COR-150HZ), from -6 to 42 sec.

Fig. 336 Mass flow in vessel (FTV-CORE-IN and GV-COR-150HZ), from -20 to 300 sec.

Fig. 337 Mass flow in vessel (FTV-CORE-IN and GV-COR-150HZ), from -6 to 42 sec.

Fig. 338 Mass flow in pressurizer surge line (FTU-PRIZE and GU-PRIZE), from -20 to 300 sec.

Fig. 339 Mass flow in pressurizer surge line (FTU-PRIZE and GU-PRIZE), from -6 to 42 sec.

Fig. 340 Core heater pin total power (PWRCOR T1 and PWRCOR T2), from -20 to 300 sec.

Fig. 341 Core heater pin total power (PWRCOR T1 and PWRCOR T2), from -6 to 42 sec.

Fig. 342 Core heater voltage (VOLT COR-T), from -20 to 300 sec.

Fig. 343 Core heater voltage (VOLT COR-T), from -6 to 42 sec.

Fig. 344 Core heater total current (AMPCOR-T), from -20 to 300 sec.

Fig. 345 Core heater total current (AMPCOR-T), from -6 to 42 sec.

Fig. 346 Primary pump speed (PUMPU-RPM), from -20 to 300 sec.

Fig. 347 Primary pump speed (PUMPU-RPM), from -6 to 42 sec.

Fig. 348 Primary pump current (PUMPU-CUR), from -20 to 300 sec.

Fig. 349 Primary pump current (PUMPU-CUR), from -6 to 42 sec.

IV. REFERENCE

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

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APPENDIX A

POSTTEST ADJUSTMENTS TO DATA FROM SEMISCALE MOD-1 TEST S-06-5

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APPENDIX A

POSTTEST ADJUSTMENTS TO DATA FROM SEMISCALE MOD-1 TEST S-06-5

Many of the transducers used in the Semiscale Mod-1 system exhibit significant sensitivity to one or more spurious inputs. Strain gage bridge circuits used in pressure transducers, differential pressure transducers, and drag discs are sensitive to changes in ambient temperature. Differential pressure cells are also sensitive to changes in system pressure. Photomultiplier tubes used as gamma ray detectors in the density transducers are sensitive to temperature changes, as well as to random variations in the locations of the radiation sources. Core power measurements depend on a calibrated resistor, which changes in value as a function of time and power level as it heats up.

Although the errors introduced into the data by spurious secondary inputs generally do not exceed the specified error ranges of the transducers, significant improvement in measurement accuracy can be achieved if the secondary sensitivity can be identified and removed. In the case of the drag discs, corrections are absolutely necessary since the signal due to temperature fluctuations can exceed that due to flow by several hundred percent. Since the exact values of the spurious inputs to which different transducers might be sensitive cannot often be easily predicted and are sometimes inconvenient to measure, secondary effects have been accounted for by correcting the data after the test rather than by using elaborate real time programs in the data acquisition system computer. The methods and results of the posttest data correction analysis for Test S-06-5 are presented in the following paragraphs and tables.

1. PRESSURE MEASUREMENTS

Corrections to pressure transducer measurements in the main system loop are based on data taken from the standard reference (Heise) gauge at Spool 4, taken 15 sec before initiation of blowdown and at 300 sec after initiation of blowdown. The pressure readings are adjusted to account for pressure variations around the main loop, using the readings of nearby differential pressure cells. A linear correction is then applied to the pressure data to match the data to the calculated reference data at the two specified time points.

Correction of the steam generator secondary pressure (PU-SGSD) measurement is done in the same manner as for the main loop pressures using a Heise gauge installed expressly for this purpose. The data from the pressure transducer for the pressure suppression system (P-PSS) are corrected to match the process instrumentation at preblowdown conditions.

Pressure measurement corrections are performed using the data acquisition system (DAS) computer using the following equation:

$$F'(t) = C_0 + C_1 [F(t)]$$

where

$F'(t)$ = corrected data

$F(t)$ = raw data

C_0 = offset

C_1 = scaling factor.

The exact values of C_0 and C_1 are given in Table A-I.

TABLE A-I

CONSTANTS FOR PRESSURE MEASUREMENT
CORRECTIONS (TEST S-06-5)

<u>Detector Identification</u>	<u>C_0</u>	<u>C_1</u>
PU-SGSD	-15.5	0.9839
PV-UP+10	-122.0	1.0425
PU-PRIZE	17.3	0.9922
PB-CM1	11.0	0.9910
PB-43	-31.6	1.0049
PB-42	-19.0	1.0073

2. DIFFERENTIAL PRESSURE MEASUREMENTS

Pressure sensitivity in the differential pressure cells in the main system loop is determined from the pretest system pressure check. Digital data are recorded for all measurements at ambient temperature, with no system flow, at pressures of ambient, 200, 500, 1000, 1500, 2000, and 2250 psig. The output of the differential pressure cells is plotted against system pressure, with the resulting plots used to describe the pressure response of the transducers.

The response of the differential pressure cells due to ambient temperature is determined from a digital data scan taken at 500°F and 1750 psig, with no system flow.

The measured transducer outputs are corrected for pressure and compared with the values calculated due only to the density difference between the water inside the loop (500°F) and outside the loop in the sense lines (80 to 100°F).

The difference between the measured pressure corrected value and the calculated value is the thermal drift. After the data scan at 500°F is made, no more opportunities exist to obtain data with the pump stopped and the system full of liquid; therefore, for lack of later data, the thermal drift calculated from the 500°F data is assumed to be constant throughout the test.

For some differential pressure measurements, the data scan at 500°F cannot be used as a reference for thermal drift; so other references are used. The liquid level measurements in the broken loop accumulator (DPB-ACC-TB) and pressurizer (DPU-PRESLL) are referenced to calculated values based on geometrical considerations at the time when gas flow from the respective vessel is first noted. The reading from the steam generator discharge venturi (DPU-SGDISC) is shifted to read zero after flow is stopped. The steam generator secondary liquid level measurement (DPU-SG-SEC) is shifted to match the output of the process instrumentation prior to blowdown.

In correcting differential pressure data for pressure sensitivity, the corrections are calculated for various times during the test by referring to nearby system pressure transducers. The thermal drift correction is then added to each pressure sensitivity correction and the combined value is added to the raw data using a computer program that linearly interpolates the corrections between the specified time points. The corrections are performed according to the following equations:

$$F'(t) = KF(t) + C_1 \text{ for } t < t_1 \text{ or when no } t_i \text{ are listed.}$$

For time points t , where $t_1 \leq t \leq t_n$

$$F'(t) = KF(t) + C_i + \frac{t-t_i}{t_{i+1}-t_i} (C_{i+1} - C_i) \text{ for } t_i \leq t \leq t_{i+1}$$

where i takes on value 1 to $n-1$

$$F'(t) = KF(t) + C_n \text{ for } t > t_n$$

where

t = time

$F'(t)$ = corrected data

$F(t)$ = raw data

K = scaling factor

C_i and t_i = corrections and time points.

The differential pressure data are initially corrected for errors in amplification and ambient offsets. The pressure sensitivity is then subtracted from these corrected data to arrive at the final values. Corrections were made using the following equations:

$$F'(t) = C_1 [F(t)] + C_0$$

$$F''(t) = F'(t) - P_1 [P(t)]$$

where

C_0 = ambient offset

C_1 = amplification factor

$F(t)$ = raw data

$F'(t)$ = first data correction

$P(t)$ = pressure data obtained from specified transducer

P_1 = pressure sensitivity

$F''(t)$ = Final result.

The values for C_0 , C_1 , and P_1 are given in Table A-II.

The differential pressure measurement DPB-ACC-TB was corrected using the following equation:

$$F'(t) = 0.16/6 F(t) + 0.962$$

where

$F(t)$ = raw data

$F'(t)$ = corrected data.

TABLE A-II
CONSTANTS FOR DIFFERENTIAL PRESSURE
MEASUREMENT CORRECTIONS (TEST S-06-5)

<u>Detector Identification</u>	<u>C₁</u>	<u>C₀</u>	<u>P(t) as obtained from Indicated Transducer</u>	<u>P₁</u>
DPB-23-24	-1.0	0		
DPB-HN1-43	1.0	1.808	PB-43	0.001033
DPU-9-166QQ	1.0	-0.323	PV-LP-166	0.000189
DPB-30-38	1.0	3.569	PB-42	0.002030
DPU-PRESLL	1.0	-0.095		
DPB-23-CN1	100	1.0		
DPU-ACC-TB	1.0	0.440		
DPU-SG-SEC	-1.0	-7.290		
DPU-SG-DISC	1.0	1.60		

3. MOMENTUM FLUX MEASUREMENTS

The temperature sensitivity of drag discs is determined from pretest warmup data taken at 200 and 500°F with no system flow. The temperature sensitivity is removed before the data are converted to momentum flux. The temperature of each transducer is taken from the signal of a nearby fluid or metal temperature thermocouple. Slight corrections for errors in setting the transducer output to zero at ambient conditions are also made at this time. Corrections are made using the following equation:

$$F'(t) = F(t) + D_0 - D_1 T(t)$$

where

F'(t) = corrected data

F(t) = raw data

T(t) = temperature data from the transducer used for temperature correction sensitivity

D_0 = ambient offset

D_1 = temperature sensitivity.

Values of the constants are given in Table A-III.

TABLE A-III

CONSTANTS FOR MOMENTUM FLUX
MEASUREMENT CORRECTIONS (TEST S-06-5)

<u>Detector Identification</u>	<u>D_0</u>	<u>D_1</u>	<u>$T(t)$[a]</u>
FDU-5	-0.09	-0.000221	TMU-1T16
FDU-10	-0.01	0.000224	TMU-1T16
FDU-13	0.27	0.000935	TMU-15T16
FDB-30	-0.150	-0.000800	TFB-30
FDB-21	-0.130	-0.000798	TMB-20B16
FDB-23	0.050	0.000561	TMB-20B16
FDB-37	-0.03	0.000440	TFB-37
FDB-42	-0.140	-0.000902	TFB-42
FDU-1	0.44	-0.000622	TMU-1T16
FDU-15	0.075	-0.001207	TMU-15T16

[a] $T(t)$ is the temperature data used for temperature sensitivity correction. The symbols listed identify the thermocouples from which the data were obtained.

4. DENSITY MEASUREMENTS

Density calculations are based on the voltage output of the photomultiplier tubes in the gamma-attenuation densitometer assemblies. The equation used for converting voltage to density is as follows:

$$\rho = (1/C) \ln \{D/[A F(t) + B]\}$$

where

- ρ = the density in lbm/ft³
- C = a constant based on the length of the gamma beam path
- D = a theoretical voltage for zero attenuation inside the vessel
- A = an amplification factor
- B = a biasing factor
- F(t) = the transducer voltage output.

Constants A and B are adjusted to match the final data to density values calculated from measured pressure and temperature values at the preblowdown and postdrain conditions, effectively giving the data an in-place calibration. The values of the constants for various transducers are given in Table A-IV.

The density measurement GVLP-172HZ uses an amplifier which precalculates the logarithm function, and hence has a simpler conversion formula:

$$\rho = 1.351 F(t) - 26.70$$

Some density measurements are obtained using a two-beam gamma densitometer which operates on the same basic principle of gamma attenuation as does the single-beam gamma densitometer. Each beam originates from the same gamma source and is allowed to pass through separate portions of the piping cross-sectional flow area to obtain an average density measurement in that particular region. The geometrical relationship of the gamma beam path through the piping and geometrically related variables used for processing of data from a two-beam gamma densitometer are shown in Figure A-1.

The average density measured by each individual gamma beam is obtained using the same equation as is used for the single-beam gamma densitometers:

$$\rho = (1/C) \ln \{D/[A F(t) + B]\}.$$

TABLE A-IV
 CONSTANTS FOR DENSITY MEASUREMENT
 CONVERSIONS TO ENGINEERING UNITS (TEST S-06-5)

<u>Detector Identification</u>	<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>
GV-COR-150HZ	1.000	0.005	0.014	1.87
GV-42VR	1.133	-0.618	0.006	5.14
GU-1VR	1.087	-0.247	0.0095	3.15
GU-1HZ	1.079	-0.487	0.0095	7.03
GU-5VR	1.116	-0.579	0.0095	5.49
GU-10VR	1.073	-0.447	0.0095	7.00
GU-13VR	1.270	-0.705	0.0095	2.74
GU-15VR	1.101	-0.674	0.0095	7.37
GU-15HZ	1.051	-0.107	0.0095	2.65
GU-23VR	0.964	0.321	0.0095	6.97
GU-PRIZE	1.074	-0.061	0.0095	0.96
GV-LP-165HZ	1.037	-0.239	0.024	6.92
GB-21-B	1.082	-0.584	0.008	8.12
GB-21-T	1.035	-0.175	0.0057	7.47
GB-30-B	0.935	0.201	0.008	7.92
GB-30-T	1.136	-0.904	0.0057	7.36

Values for the constants for the single-beam density measurements obtained with the two-beam gamma densitometers are presented in Table A-IV along with the constants for single-beam gamma densitometers.

In the Semiscale Mod-1 system, two-beam gamma densitometers provide added information which allows the calculation of a better average density than that obtained from a single beam. A mathematical model is used for processing the two-beam data to obtain the improved average density information. The processing method used is based on a

Fig. A-1 Geometry used for processing of density data obtained from two-beam gamma densitometers.

froth-water model coupled with information from the two individual gamma beams and related beam path and piping cross-sectional geometry. The resulting information is recorded and reported under the density measurement identification ending with a "C", for example, GB-21C.

The use of the froth-water model for obtaining average density from a two-beam gamma densitometer is based on observations indicating that flow regimes in the Semiscale Mod-1 system can be modeled by a layer of water on the bottom of the pipe with a degree of froth on the surface. For homogeneous flow conditions such as all froth or all liquid the model remains valid. At any point in time slug flow is also modeled. The froth-water model does not model annular or inverted annular flows very well. However, these flows are not expected to exist for significant portions of a Semiscale Mod-1 system blowdown in horizontal piping. Density gradients from the top to the bottom of the pipe may exist showing no distinct location change from water to froth. This flow is neither totally homogeneous nor stratified, but the froth-water model does provide an adequate approximation of the average density characteristic of this flow pattern.

The average density obtained by using the gamma beam geometry shown in Figure A-1 and by applying the froth-water model is given by

$$\bar{\rho} = \alpha_f \rho_1 + (1 - \alpha_f) \rho_w \quad \text{lbm/ft}^3$$

where

$\bar{\rho}$ = average cross-sectional density

ρ_1 = average density measured by the upper gamma beam (measures the froth density)

ρ_w = density of liquid water (at local system conditions)

α_f = $1 + (1/2\pi) (\sin\beta - \beta)$ = froth fraction.

The angle which β represents is shown in Figure A-1. Values for β are obtained as follows:

$$\beta = 2 \cos^{-1} (1 - 2h)$$

where

$$h = \frac{H}{D} = \cos^2 \theta \left(\frac{\rho_2 - \rho_1}{\rho_w - \rho_1} \right)$$

where

H = $\ell_w \cos \theta$ (ℓ_w , and θ are defined in Figure A-1)

D = piping inside diameter

ρ_2 = the average density measured by the lower gamma beam.

Average density is not calculated using the two-beam froth-water model when the angle θ is not favorable due to system hardware restrictions in positioning the source. The froth-water model requires separate density sampling in both the upper and lower portions of the piping cross section.

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