3007
3-9-77
- n.e. - 2/ +
40 copy to Collins

D-4 800

TRF-NUREG-1051
for U.S. Nuclear Regulatory Commission

MASTER

**EXPERIMENT DATA REPORT FOR SEMISCALE MOD-1
TEST S-05-2
(ALTERNATE ECC INJECTION TEST)**

EDGAR M. FELDMAN BRENT L. COLLINS
KENNETH E. SACKETT

February 1977

IDAHO NATIONAL ENGINEERING LABORATORY

ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

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

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

Printed in the United States of America
Available from
National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road
Springfield, Virginia 22161
Price: Printed Copy \$7.75; Microfiche \$3.00

"The NRC will make available data tapes and operational computer codes on research programs dealing with postulated loss-of-coolant accidents in light water reactors. Persons requesting this information must reimburse the NRC contractors for their expenses in preparing copies of the data tapes and the operational computer codes. Requests should be submitted to the Research Applications Branch, Office of Nuclear Regulatory Research, Nuclear Regulatory Commission, Washington, D.C. 20555."

NOTICE

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the Energy Research and Development Administration, nor the Nuclear Regulatory Commission, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

TREE-NUREG-1051

EXPERIMENT DATA REPORT FOR SEMISCALE MOD-1

TEST S-05-2

(ALTERNATE ECC INJECTION TEST)

Approved:

W. L. Headington, Manager
Semiscale Test Support Branch

D. J. Olson, Manager
Semiscale Program

NOTICE
This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Energy Research and Development Administration, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

TREE-NUREG-1051

Distributed Under Category:
NRC-2
Water Reactor Safety Research
Systems Engineering

EXPERIMENT DATA REPORT FOR SEMISCALE MOD-1

TEST S-05-2

(ALTERNATE ECC INJECTION TEST)

By

Edgar M. Feldman
Brent L. Collins
Kenneth E. Sackett

EG&G IDAHO, INC.

February 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-05-2 of the Semiscale Mod-1 alternate emergency core coolant (ECC) injection test series. This test is one of 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-05-2 was conducted from an initial cold leg fluid temperature of 545°F and an initial pressure of 2263 psia. A simulated double-ended offset shear cold leg break was used to investigate core and system response to a depressurization and reflood transient with ECC injection at the intact loop pump suction and broken loop cold leg. A reduced lower plenum volume was used for this test to more accurately represent the lower plenum of a PWR, based on system volume scaling. System flow was set to achieve a core fluid temperature differential of 65°F at a core power level of 1.44 MW. The flow resistance of the intact loop was based on core area scaling. An electrically heated core with a slightly peaked radial power profile was used in the pressure vessel to simulate the predicted surface heat flux of nuclear fuel rods during a loss-of-coolant accident.

The purpose of this report is to make available the uninterpreted data from Test S-05-2 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-05-2 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 was part of the alternate ECC injection test series performed to investigate the response of the Mod-1 system to alternate ECC injection locations. Hardware configuration and test parameters were selected to yield a system response that simulates the response of a pressurized water reactor to a hypothesized loss-of-coolant accident with subsequent refill and reflood. The test objective specific to Test S-05-2 was to determine the core and system response accompanying emergency core coolant injection at the intact loop pump suction.

Test S-05-2 utilized the Semiscale Mod-1 system, equipped with: a pressure vessel with internals; an intact loop with active 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 a heated steam supply system. High and low pressure coolant injection pumps and a coolant injection accumulator were provided for each system loop. The flow resistance of the intact loop was based on core area scaling and a reduced lower plenum volume was used to more accurately represent the lower plenum of a PWR.

The electrically heated core consisted of 40 heater rods with a maximum total power capacity of 1.6 MW. Of the 40 heater rods, four were intentionally unpowered to simulate unpowered regions of the core of a pressurized water reactor. To yield a slightly peaked radial power profile, the power level on heater Rods D-4, E-4, and E-5 was increased by 5% above the remaining 33 heater rods. The resulting total core power was about 1.44 MW.

The test was conducted from initial conditions of 2263 psia (at Spool 4 in the intact loop hot leg), 545°F (at the intact loop cold leg vessel inlet), and a core fluid differential temperature of 65°F with a core power level of 1.44 MW at a core inlet flow rate of 142 gpm. The test was initiated with a simulated full size (200%) double-ended offset shear of the cold leg broken loop piping. The instantaneous offset shear was simulated by simultaneous (within 10 msec) actuation of the rupture assemblies. After initiation of blowdown, power to the heated core was reduced in a manner to simulate the predicted heat flux response of nuclear fuel rods during a loss-of-coolant accident. Blowdown was accompanied by simulated emergency core coolant injection into the pump suction (Spool 8) of the intact loop and into the cold leg (Spool 42) of the broken loop.

Test S-05-2 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 219 measurements attempted, 214 produced usable data.

CONTENTS

ABSTRACT	ii
SUMMARY	iii
I. INTRODUCTION	1
II. SYSTEM, PROCEDURES, CONDITIONS, AND EVENTS FOR TEST S-05-2	3
1. SYSTEM CONFIGURATION AND TEST PROCEDURES	3
2. INITIAL TEST CONDITIONS AND SEQUENCE OF EVENTS	6
III. DATA PRESENTATION	10
IV. REFERENCE	181
APPENDIX A – POSTTEST ADJUSTMENTS TO DATA FROM SEMISCALE MOD-1 TEST S-05-2	183
1. PRESSURE MEASUREMENTS	185
2. DIFFERENTIAL PRESSURE MEASUREMENTS	186
3. MOMENTUM FLUX MEASUREMENTS (DRAG DISCS)	189
4. DENSITY MEASUREMENTS	191
5. CORE POWER MEASUREMENTS	192

FIGURES

1. Semiscale Mod-1 system for cold leg break configuration – schematic	4
2. Cross section of vessel with lower plenum filler	5
3. Semiscale Mod-1 system and instrumentation for cold leg break configuration – isometric	11
4. Semiscale Mod-1 system and instrumentation for cold leg break configuration – schematic	12

5.	Semiscale Mod-1 pressure vessel — cross section showing instrumentation	13
6.	Semiscale Mod-1 pressure vessel — isometric showing instrumentation	14
7.	Semiscale Mod-1 pressure vessel — penetrations and instrumentation	15
8.	Semiscale Mod-1 heated core — plan view	16
9.	Fluid temperature in intact loop hot leg (RBU-2), from -20 to 300 seconds	28
10.	Fluid temperature in intact loop hot leg (RBU-2), from -6 to 42 seconds	28
11.	Fluid temperature in intact loop cold leg (TSU-7, TFU-10, RBU-14A, TFU-14B), from -20 to 300 seconds	29
12.	Fluid temperature in intact loop cold leg (TSU-7, TFU-10, RBU-14A, TFU-14B), from -6 to 42 seconds	29
13.	Fluid temperature in broken loop, vessel side (TFB-20, TFB-23), from -20 to 300 seconds	30
14.	Fluid temperature in broken loop, vessel side (TFB-20, TFB-23), from -6 to 42 seconds	30
15.	Fluid temperature in broken loop, pump side (TFB-30, TFB-37, TFB-42), from -20 to 300 seconds	31
16.	Fluid temperature in broken loop, pump side (TFB-30, TFB-37, TFB-42), from -6 to 42 seconds	31
17.	Fluid temperature in downcomer annulus (TFV-ANN-4A, TFV-ANN-4M, TFV-ANN-35A), from -20 to 300 seconds	32
18.	Fluid temperature in downcomer annulus (TFV-ANN-4A, TFV-ANN-4M, TFV-ANN-35A), from -6 to 42 seconds	32
19.	Fluid temperature in downcomer annulus (TFV-ANN-70A, TFV-ANN-115A, TFV-ANN-156A), from -20 to 300 seconds	33
20.	Fluid temperature in downcomer annulus (TFV-ANN-70A, TFV-ANN-115A, TFV-ANN-156A), from -6 to 42 seconds	33

21.	Fluid temperature in upper plenum (TFV-UP+13), from -20 to 300 seconds	34
22.	Fluid temperature in upper plenum (TFV-UP+13), from -6 to 42 seconds	34
23.	Fluid temperature in lower plenum (TFV-LP-2, TFV-LP-4, TFV-LP-7), from -20 to 300 seconds	35
24.	Fluid temperature in lower plenum (TFV-LP-2, TFV-LP-4, TFV-LP-7), from -6 to 42 seconds	35
25.	Fluid temperature in core inlet (TFV-CORE-IN), from -20 to 300 seconds	36
26.	Fluid temperature in core inlet (TFV-CORE-IN), from -6 to 42 seconds	36
27.	Fluid temperature in core, barrel insulation gap (TFV-CIG-70A), -20 to 300 seconds	37
28.	Fluid temperature in core, barrel insulation gap (TFV-CIG-70A), -6 to 42 seconds	37
29.	Fluid temperature in filler insulation gap (TFV-FIG-156A), from -20 to 300 seconds	38
30.	Fluid temperature in filler insulation gap (TFV-FIG-156A), from -6 to 42 seconds	38
31.	Fluid temperature in intact loop ECC injection line (TFU-ECC-8C), from -20 to 300 seconds	39
32.	Fluid temperature in broken loop ECC injection line (TFB-ECC-42), from -20 to 300 seconds	40
33.	Fluid temperature in broken loop ECC injection line (TFB-ECC-42), from -6 to 42 seconds	40
34.	Fluid temperature in steam generator (TFU-SGFW, TFU-SGSD), from -20 to 300 seconds	41
35.	Fluid temperature in steam generator (TFU-SGFW, TFU-SGSD), from -6 to 42 seconds	41

36.	Fluid temperature in pressurizer surge line (TFU-PRIZE), from -20 to 300 seconds	42
37.	Fluid temperature in pressurizer surge line (TFU-PRIZE), from -6 to 42 seconds	42
38.	Fluid temperature in pressure suppression tank (TF-PSS-33, TF-PSS-130), from -20 to 300 seconds	43
39.	Fluid temperature in pressure suppression tank (TF-PSS-33, TF-PSS-130), from -6 to 42 seconds	43
40.	Material temperature in intact loop (TMU-1T16, TMU-15B16, TMU-15T16), from -20 to 300 seconds	44
41.	Material temperature in intact loop (TMU-1T16, TMU-15B16, TMU-15T16), from -6 to 42 seconds	44
42.	Material temperature in broken loop (TMB-30T16), from -20 to 300 seconds	45
43.	Material temperature in broken loop (TMB-30T16), from -6 to 42 seconds	45
44.	Material temperature in vessel filler (TMV-FI-4M, TMV-FI-15A, TMV-FI-35A), from -20 to 300 seconds	46
45.	Material temperature in vessel filler (TMV-FI-4M, TMV-FI-15A, TMV-FI-35A), from -6 to 42 seconds	46
46.	Material temperature in vessel filler insulator (TMV-FI-115A, TMV-FI-156A), from -20 to 300 seconds	47
47.	Material temperature in vessel filler insulator (TMV-FI-115A, TMV-FI-156A), from -6 to 42 seconds	47
48.	Material temperature in vessel filler (TMV-FO-156A), from -20 to 300 seconds	48
49.	Material temperature in vessel filler (TMV-FO-156A), from -6 to 42 seconds	48
50.	Material temperature in vessel filler insulator (TIV-FO-35A, TIV-FO-35M, TIV-FO-70A, TIV-FO-115A), from -20 to 300 seconds	49

51.	Material temperature in vessel filler insulator (TIV-FO-35A, TIV-FO-35M, TIV-FO-70A, TIV-FO-115A), from -6 to 42 seconds	49
52.	Material temperature in core barrel (TMV-CI-70A, TMV-CI-115A), from -20 to 300 seconds	50
53.	Material temperature in core barrel (TMV-CI-70A, TMV-CI-115A), from -6 to 42 seconds	50
54.	Material temperature in core barrel (TMV-CO-70A, TMV-CO-115A), from -20 to 300 seconds	51
55.	Material temperature in core barrel (TMV-CO-70A, TMV-CO-115A), from -6 to 42 seconds	51
56.	Material temperature on core housing filler (TMV-HF-115W, TMV-HF-127W, TMV-HF-138W), from -20 to 300 seconds	52
57.	Material temperature on core housing filler (TMV-HF-115W, TMV-HF-127W, TMV-HF-138W), from -6 to 42 seconds	52
58.	Core heater temperature, Rod D-4 (TH-D4-14, TH-D4-29), from -20 to 300 seconds	53
59.	Core heater temperature, Rod D-4 (TH-D4-14, TH-D4-29), from -6 to 42 seconds	53
60.	Core heater temperature, Rod D-5 (TH-D5-29), from -20, to 300 seconds	54
61.	Core heater temperature, Rod D-5 (TH-D5-29), from -6 to 42 seconds	54
62.	Core heater temperature, Rod E-4 (TH-E4-09, TH-E4-28G, TH-E4-28T, TH-E4-55), from -20 to 300 seconds	55
63.	Core heater temperature, Rod E-4 (TH-E4-09, TH-E4-28G, TH-E4-28T, TH-E4-55), from -6 to 42 seconds	55
64.	Core heater temperature, Rod E-5 (TH-E5-21, TH-E5-25), from -20 to 300 seconds	56
65.	Core heater temperature, Rod E-5 (TH-E5-21, TH-E5-25), from -6 to 42 seconds	56

66.	Core heater temperature, Rod A-4 (TH-A4-09, TH-A4-29, TH-A4-39), from -20 to 300 seconds	57
67.	Core heater temperature, Rod A-4 (TH-A4-09, TH-A4-29, TH-A4-39), from -6 to 42 seconds	57
68.	Core heater temperature, Rod A-5 (TH-A5-29, TH-A5-45), from -20 to 300 seconds	58
69.	Core heater temperature, Rod A-5 (TH-A5-29, TH-A5-45), from -6 to 42 seconds	58
70.	Core heater temperature, Rod B-3 (TH-B3-32), from -20 to 300 seconds	59
71.	Core heater temperature, Rod B-3 (TH-B3-32), from -6 to 42 seconds	59
72.	Core heater temperature, Rod B-5 (TH-B5-29, TH-B5-33), from -20 to 300 seconds	60
73.	Core heater temperature, Rod B-5 (TH-B5-29, TH-B5-33), from -6 to 42 seconds	60
74.	Core heater temperature, Rod B-6 (TH-B6-29), from -20 to 300 seconds	61
75.	Core heater temperature, Rod B-6 (TH-B6-29), from -6 to 42 seconds	61
76.	Core heater temperature, Rod C-2 (TH-C2-38), from -20 to 300 seconds	62
77.	Core heater temperature, Rod C-2 (TH-C2-38), from -6 to 42 seconds	62
78.	Core heater temperature, Rod C-4 (TH-C4-26, TH-C4-53), from -20 to 300 seconds	63
79.	Core heater temperature, Rod C-4 (TH-C4-26, TH-C4-53), from -6 to 42 seconds	63
80.	Core heater temperature, Rod C-5 (TH-C5-28), from -20 to 300 seconds	64

81.	Core heater temperature, Rod C-5 (TH-C5-28), from -6 to 42 seconds	64
82.	Core heater temperature, Rod C-6 (TH-C6-53), from -20 to 300 seconds	65
83.	Core heater temperature, Rod C-6 (TH-C6-53), from -6 to 42 seconds	65
84.	Core heater temperature, Rod C-7 (TH-C7-07, TH-C7-15), from -20 to 300 seconds	66
85.	Core heater temperature, Rod C-7 (TH-C7-07, TH-C7-15), from -6 to 42 seconds	66
86.	Core heater temperature, Rod D-1 (TH-D1-21), from -20 to 300 seconds	67
87.	Core heater temperature, Rod D-1 (TH-D1-21), from -6 to 42 seconds	67
88.	Core heater temperature, Rod D-2 (TH-D2-14, TH-D2-61), from -20 to 300 seconds	68
89.	Core heater temperature, Rod D-2 (TH-D2-14, TH-D2-61), from -6 to 42 seconds	68
90.	Core heater temperature, Rod D-3 (TH-D3-29, TH-D3-39), from -20 to 300 seconds	69
91.	Core heater temperature, Rod D-3 (TH-D3-29, TH-D3-39), from -6 to 42 seconds	69
92.	Core heater temperature, Rod D-6 (TH-D6-14, TH-D6-25), from -20 to 300 seconds	70
93.	Core heater temperature, Rod D-6 (TH-D6-14, TH-D6-25), from -6 to 42 seconds	70
94.	Core heater temperature, Rod D-7 (TH-D7-20), from -20 to 300 seconds	71
95.	Core heater temperature, Rod D-7 (TH-D7-20), from -6 to 42 seconds	71

96.	Core heater temperature, Rod D-8 (TH-D8-27, TH-D8-57), from -20 to 300 seconds	72
97.	Core heater temperature, Rod D-8 (TH-D8-27, TH-D8-57), from -6 to 42 seconds	72
98.	Core heater temperature, Rod E-1 (TH-E1-21, TH-E1-33), from -20 to 300 seconds	73
99.	Core heater temperature, Rod E-1 (TH-E1-21, TH-E1-33), from -6 to 42 seconds	73
100.	Core heater temperature, Rod E-2 (TH-E2-20, TH-E2-33), from -20 to 300 seconds	74
101.	Core heater temperature, Rod E-2 (TH-E2-20, TH-E2-33), from -6 to 42 seconds	74
102.	Core heater temperature, Rod E-3 (TH-E3-05, TH-E3-20, TH-E3-24), from -20 to 300 seconds	75
103.	Core heater temperature, Rod E-3 (TH-E3-05, TH-E3-20, TH-E3-24), from -6 to 42 seconds	75
104.	Core heater temperature, Rod E-6 (TH-E6-08, TH-E6-28, TH-E6-37), from -20 to 300 seconds	76
105.	Core heater temperature, Rod E-6 (TH-E6-08, TH-E6-28, TH-E6-37), from -6 to 42 seconds	76
106.	Core heater temperature, Rod E-7 (TH-E7-44), from -20 to 300 seconds	77
107.	Core heater temperature, Rod E-7 (TH-E7-44), from -6 to 42 seconds	77
108.	Core heater temperature, Rod E-8 (TH-E8-14, TH-E8-29, TH-E8-45), from -20 to 300 seconds	78
109.	Core heater temperature, Rod E-8 (TH-E8-14, TH-E8-29, TH-E8-45), from -6 to 42 seconds	78
110.	Core heater temperature, Rod F-2 (TH-F2-07, TH-F2-22, TH-F2-25), from -20 to 300 seconds	79

111. Core heater temperature, Rod F-2 (TH-F2-07, TH-F2-22, TH-F2-25), from -6 to 42 seconds	79
112. Core heater temperature, Rod F-4 (TH-F4-14, TH-F4-29, TH-F4-44), from -20 to 300 seconds	80
113. Core heater temperature, Rod F-4 (TH-F4-14, TH-F4-29, TH-F4-44), from -6 to 42 seconds	80
114. Core heater temperature, Rod F-5 (TH-F5-20, TH-F5-26, TH-F5-33, TH-F5-53), from -20 to 300 seconds	81
115. Core heater temperature, Rod F-5 (TH-F5-20, TH-F5-26, TH-F5-33, TH-F5-53), from -6 to 42 seconds	81
116. Core heater temperature, Rod G-3 (TH-G3-13), from -20 to 300 seconds	82
117. Core heater temperature, Rod G-3 (TH-G3-13), from -6 to 42 seconds	82
118. Core heater temperature, Rod G-4 (TH-G4-29, TH-G4-33, TH-G4-38), from -20 to 300 seconds	83
119. Core heater temperature, Rod G-4 (TH-G4-29, TH-G4-33, TH-G4-38), from -6 to 42 seconds	83
120. Core heater temperature, Rod G-5 (TH-G5-14, TH-G5-24), from -20 to 300 seconds	84
121. Core heater temperature, Rod G-5 (TH-G5-14, TH-G5-24), from -6 to 42 seconds	84
122. Core heater temperature, Rod H-5 (TH-H5-32), from -20 to 300 seconds	85
123. Core heater temperature, Rod H-5 (TH-H5-32), from -6 to 42 seconds	85
124. Pressure in intact loop, Spool 13 [PU-13(F)], from -20 to 300 seconds	86
125. Pressure in intact loop, Spool 13 [PU-13(F)], from -6 to 42 seconds	86

126. Pressure in intact loop, Spool 15 (PU-15L), from -20 to 300 seconds	87
127. Pressure in intact loop, Spool 15 (PU-15L), from -6 to 42 seconds	87
128. Pressure in broken loop, Spool 23 (PB-23), from -20 to 300 seconds	88
129. Pressure in broken loop, Spool 23 (PB-23), from -6 to 42 seconds	88
130. Pressure in broken loop, near break (PB-37, PB-42), from -20 to 300 seconds	89
131. Pressure in broken loop, near break (PB-37, PB-42), from -6 to 42 seconds	89
132. Pressure in broken loop, pump-side nozzle (PB-HN1), from -20 to 300 seconds	90
133. Pressure in broken loop, pump-side nozzle (PB-HN1), from -6 to 42 seconds	90
134. Pressure in broken loop, vessel-side nozzle (PB-CN1), from -20 to 300 seconds	91
135. Pressure in broken loop, vessel-side nozzle (PB-CN1), from -6 to 42 seconds	91
136. Pressure in vessel (PV-UP+10, PV-LP-166), from -20 to 300 seconds	92
137. Pressure in vessel (PV-UP+10, PV-LP-166), from -6 to 42 seconds	92
138. Pressure in accumulator (PU-ACC), from -20 to 300 seconds	93
139. Pressure in accumulator (PU-ACC), from -6 to 42 seconds	93
140. Pressure in steam generator, secondary side (PU-SGSD), from -20 to 300 seconds	94
141. Pressure in steam generator, secondary side (PU-SGSD), from -6 to 42 seconds	94

142. Pressure in pressurizer (PU-PRIZE), from -20 to 300 seconds	95
143. Pressure in pressurizer (PU-PRIZE), from -6 to 42 seconds	95
144. Pressure in pressure suppression tank (P-PSS), from -20 to 300 seconds	96
145. Pressure in pressure suppression tank (P-PSS), from -6 to 42 seconds	96
146. Differential pressure in intact loop (DPU-UP-3), from -20 to 300 seconds	97
147. Differential pressure in intact loop (DPU-UP-3), from -6 to 42 seconds	97
148. Differential pressure in intact loop (DPU-3-7), from -20 to 300 seconds	98
149. Differential pressure in intact loop (DPU-3-7), from -6 to 42 seconds	98
150. Differential pressure in intact loop (DPU-7-10), from -20 to 300 seconds	99
151. Differential pressure in intact loop (DPU-7-10), from -6 to 42 seconds	99
152. Differential pressure in intact loop (DPU-12-10), from -20 to 300 seconds	100
153. Differential pressure in intact loop (DPU-12-10), from -6 to 42 seconds	100
154. Differential pressure in intact loop, low range (DPU-12-10L), from -20 to 300 seconds	101
155. Differential pressure in intact loop, low range (DPU-12-10L), from -6 to 42 seconds	101
156. Differential pressure in intact loop, (DPU-12-15), from -20 to 300 seconds	102
157. Differential pressure in intact loop, (DPU-12-15), from -6 to 42 seconds	102

158. Differential pressure in intact loop, (DPU-15-1), from -20 to 300 seconds	103
159. Differential pressure in intact loop, (DPU-15-1), from -6 to 42 seconds	103
160. Differential pressure in intact loop (DPU-15-1L), from -20 to 300 seconds	104
161. Differential pressure in intact loop (DPU-15-1L), from -6 to 42 seconds	104
162. Differential pressure in intact loop (DPU-15-IANN), from -20 to 300 seconds	105
163. Differential pressure in intact loop (DPU-15-IANN), from -6 to 42 seconds	105
164. Differential pressure in intact loop (DPU-PRESLL), from -20 to 300 seconds	106
165. Differential pressure in intact loop (DPU-PRESLL), from -6 to 42 seconds	106
166. Differential pressure in intact loop (DPU-PR-4), from -20 to 300 seconds	107
167. Differential pressure in intact loop (DPU-PR-4), from -6 to 42 seconds	107
168. Differential pressure in broken loop (DPB-UP-30), from -20 to 300 seconds	108
169. Differential pressure in broken loop (DPB-UP-30), from -6 to 42 seconds	108
170. Differential pressure in broken loop (DPB-21-IANN), from -20 to 300 seconds	109
171. Differential pressure in broken loop (DPB-21-IANN), from -6 to 42 seconds	109
172. Differential pressure in broken loop (DPB-23-CN1), from -20 to 300 seconds	110

173. Differential pressure in broken loop (DPB-23-CN1), from -6 to 42 seconds	110
174. Differential pressure in broken loop (DPB-30-36L), from -20 to 300 seconds	111
175. Differential pressure in broken loop (DPB-30-36L), from -6 to 42 seconds	111
176. Differential pressure in broken loop (DPB-32U-36L), from -20 to 300 seconds	112
177. Differential pressure in broken loop (DPB-32U-36L), from -6 to 42 seconds	112
178. Differential pressure in broken loop (DPB-36L-37), from -20 to 300 seconds	113
179. Differential pressure in broken loop (DPB-36L-37), from -6 to 42 seconds	113
180. Differential pressure in broken loop (DPB-37-38), from -20 to 300 seconds	114
181. Differential pressure in broken loop (DPB-37-38), from -6 to 42 seconds	114
182. Differential pressure in broken loop (DPB-38-40), from -20 to 300 seconds	115
183. Differential pressure in broken loop (DPB-38-40), from -6 to 42 seconds	115
184. Differential pressure in broken loop (DPB-40-42), from -20 to 300 seconds	116
185. Differential pressure in broken loop (DPB-40-42), from -6 to 42 seconds	116
186. Differential pressure in vessel (DPV-UP-IANN), from -20 to 300 seconds	117
187. Differential pressure in vessel (DPV-UP-IANN), from -6 to 42 seconds	117

188. Differential pressure in vessel (DPV-0-9GQ), from -20 to 300 seconds	118
189. Differential pressure in vessel (DPV-0-9GQ), from -6 to 42 seconds	118
190. Differential pressure in vessel (DPV-9-26QQ), from -20 to 300 seconds	119
191. Differential pressure in vessel (DPV-9-26QQ), from -6 to 42 seconds	119
192. Differential pressure in vessel (DPV-9-166QQ), from -20 to 300 seconds	120
193. Differential pressure in vessel (DPV-9-166QQ), from -6 to 42 seconds	120
194. Differential pressure in vessel (DPV-26-55QM), from -20 300 seconds	121
195. Differential pressure in vessel (DPV-26-55QM), from -6 to 42 seconds	121
196. Differential pressure in vessel (DPV-55-110MM), from -20 to 300 seconds	122
197. Differential pressure in vessel (DPV-55-110MM), from -6 to 42 seconds	122
198. Differential pressure in vessel (DPV-110-156MQ), from -20 to 300 seconds	123
199. Differential pressure in vessel (DPV-110-156MQ), from -6 to 42 seconds	123
200. Differential pressure in vessel (DPV-166-173QQ), from -20 to 300 seconds	124
201. Differential pressure in vessel (DPV-166-173QQ), from -6 to 42 seconds	124
202. Differential pressure in vessel (DPV-166Q-UP), from -20 to 300 seconds	125

203. Differential pressure in vessel (DPV-166Q-UP), from -6 to 42 seconds	125
204. Differential pressure in vessel core (DPVC-89W-UP), from -20 to 300 seconds	126
205. Differential pressure in vessel core (DPVC-89W-UP), from -6 to 42 seconds	126
206. Differential pressure in vessel core (DPVC-89-106WQ), from -20 to 300 seconds	127
207. Differential pressure in vessel core (DPVC-89-106WQ), from -6 to 42 seconds	127
208. Differential pressure in vessel core (DPVC-106-122QJ), from -20 to 300 seconds	128
209. Differential pressure in vessel core (DPVC-106-122QJ), from -6 to 42 seconds	128
210. Differential pressure in vessel core (DPVC-122-140JD), from -20 to 300 seconds	129
211. Differential pressure in vessel core (DPVC-122-140JD), from -6 to 42 seconds	129
212. Differential pressure in vessel accumulator (DPU-ACC-TB), from -20 to 300 seconds	130
213. Differential pressure in vessel accumulator (DPU-ACC-TB), from -6 to 42 seconds	130
214. Differential pressure in steam generator secondary (DPU-SG-SEC), from -20 to 300 seconds	131
215. Differential pressure in steam generator secondary (DPU-SG-SEC), from -6 to 42 seconds	131
216. Differential pressure across steam generator outlet orifice (DPU-SG-DISC), from -20 to 300 seconds	132
217. Differential pressure across steam generator outlet orifice (DPU-SG-DISC), from -6 to 42 seconds	132

218. Volumetric flow in intact loop (FTU-1, FTU-9), from -20 to 300 seconds	133
219. Volumetric flow in intact loop (FTU-1, FTU-9), from -6 to 42 seconds	133
220. Volumetric flow in intact loop (FTU-13, FTU-15), from -20 to 300 seconds	134
221. Volumetric flow in intact loop (FTU-13, FTU-15), from -6 to 42 seconds	134
222. Volumetric flow in broken loop (FTB-21), from -20 to 300 seconds	135
223. Volumetric flow in broken loop (FTB-21), from -6 to 42 seconds	135
224. Volumetric flow in broken loop (FTB-30, FTB-37), from -20 to 300 seconds	136
225. Volumetric flow in broken loop (FTB-30, FTB-37), from -6 to 42 seconds	136
226. Volumetric flow in core entrance (FTV-CORE-IN), from -20 to 300 seconds	137
227. Volumetric flow in core entrance (FTV-CORE-IN), from -6 to 42 seconds	137
228. Volumetric flow in intact loop high pressure injection line (FTU-HPIS), from -20 to 300 seconds	138
229. Volumetric flow in intact loop high pressure injection line (FTU-HPIS), from -6 to 42 seconds	138
230. Volumetric flow in broken loop high pressure injection line (FTB-HPIS), from -20 to 300 seconds	139
231. Volumetric flow in broken loop high pressure injection line (FTB-HPIS), from -6 to 42 seconds	139
232. Volumetric flow in intact loop low pressure injection line (FTU-LPIS), from -20 to 300 seconds	140
233. Volumetric flow in intact loop low pressure injection line (FTU-LPIS), from -6 to 42 seconds	140

234. Volumetric flow in broken loop low pressure injection line (FTB-LPIS), from -20 to 300 seconds	141
235. Volumetric flow in broken loop low pressure injection line (FTB-LPIS), from -6 to 42 seconds	141
236. Volumetric flow in intact loop accumulator discharge line (FTU-ACC), from -20 to 300 seconds	142
237. Volumetric flow in intact loop accumulator discharge line (FTU-ACC), from -6 to 42 seconds	142
238. Volumetric flow in broken loop accumulator discharge line (FTB ACC), from 20 to 300 seconds	143
239. Volumetric flow in broken loop accumulator discharge line (FTB-ACC), from -6 to 42 seconds	143
240. Volumetric flow from pressurizer (FTU-PRIZE), from -20 to 300 seconds	144
241. Volumetric flow from pressurizer (FTU-PRIZE), from -6 to 42 seconds	144
242. Fluid velocity in vessel (FTV-40A, FTV-40M), from -20 to 300 seconds	145
243. Fluid velocity in vessel (FTV-40A, FTV-40M), from -6 to 42 seconds	145
244. Momentum flux in intact loop (FDU-1), from -20 to 300 seconds	146
245. Momentum flux in intact loop (FDU-1), from -6 to 42 seconds	146
246. Momentum flux in intact loop (FDU-5), from -20 to 300 seconds	147
247. Momentum flux in intact loop (FDU-5), from -6 to 42 seconds	147
248. Momentum flux in intact loop (FDU-10), from -6 to 42 seconds	148
249. Momentum flux in intact loop (FDU-13), from -6 to 42 seconds	148
250. Momentum flux in intact loop (FDU-15), from -6 to 42 seconds	149
251. Momentum flux in broken loop (FDB-21), from -6 to 42 seconds	149

252. Momentum flux in broken loop (FDB-30), from -6 to 42 seconds	150
253. Momentum flux in broken loop (FDB-37), from -6 to 42 seconds	150
254. Momentum flux in broken loop (FDB-42), from -20 to 300 seconds	151
255. Momentum flux in broken loop (FDB-42), from -6 to 42 seconds	151
256. Momentum flux in core entrance (FDV-CORE-IN), from -20 to 300 seconds	152
257. Momentum flux in core entrance (FDV-CORE-IN), from -6 to 42 seconds	152
258. Density in intact loop (GU-1VR, GU-1HZ), from -20 to 300 seconds	153
259. Density in intact loop (GU-1VR, GU-1HZ), from -6 to 42 seconds	153
260. Density in intact loop (GU-5VR, GU-10VR), from -20 to 300 seconds	154
261. Density in intact loop (GU-5VR, GU-10VR), from -6 to 42 seconds	154
262. Density in intact loop (GU-13VR), from -20 to 300 seconds	155
263. Density in intact loop (GU-13VR), from -6 to 42 seconds	155
264. Density in intact loop (GU-15VR, GU-15HZ), from -20 to 300 seconds	156
265. Density in intact loop (GU-15VR, GU-15HZ), from -6 to 42 seconds	156
266. Density in broken loop (GB-21VR, GB-23VR), from -20 to 300 seconds	157
267. Density in broken loop (GB-21VR, GB-23VR), from -6 to 42 seconds	157
268. Density in broken loop (GB-30VR), from -20 to 300 seconds	158
269. Density in broken loop (GB-30VR), from -6 to 42 seconds	158

270. Density in vessel (GV-COR-150HZ), from -20 to 300 seconds	159
271. Density in vessel (GV-COR-150HZ), from -6 to 42 seconds	159
272. Density in vessel (GVLP-165HZ, GVLP-172HZ), from -20 to 300 seconds	160
273. Density in vessel (GVLP-165HZ, GVLP-172HZ), from -6 to 42 seconds	160
274. Density in pressurizer (GU-PRIZE), from -20 to 300 seconds	161
275. Density in pressurizer (GU-PRIZE), from -6 to 42 seconds	161
276. Mass flow in intact loop (FDU-1, GU-1VR), from -20 to 300 seconds	162
277. Mass flow in intact loop (FDU-1, GU-1VR), from -6 to 42 seconds	162
278. Mass flow in intact loop (FTU-1, GU-1VR), from -20 to 300 seconds	163
279. Mass flow in intact loop (FTU-1, GU-1VR), from -6 to 42 seconds	163
280. Mass flow in intact loop (FDU-5, GU-5VR), from -20 to 300 seconds	164
281. Mass flow in intact loop (FDU-5, GU-5VR), from -6 to 42 seconds	164
282. Mass flow in intact loop (FTU-9, GU-10VR), from -20 to 300 seconds	165
283. Mass flow in intact loop (FTU-9, GU-10VR), from -6 to 42 seconds	165
284. Mass flow in intact loop (FDU-10, GU-10VR), from -6 to 42 seconds	166
285. Mass flow in intact loop (FDU-13, GU-13VR), from -6 to 42 seconds	166
286. Mass flow in intact loop (FTU-13, GU-13VR), from -20 to 300 seconds	167
287. Mass flow in intact loop (FTU-13, GU-13VR), from -6 to 42 seconds	167
288. Mass flow in intact loop (FDU-15, GU-15VR), from -6 to 42 seconds	168
289. Mass flow in intact loop (FTU-15, GU-15VR), from -20 to 300 seconds	169
290. Mass flow in intact loop (FTU-15, GU-15VR), from -6 to 42 seconds	169
291. Mass flow in broken loop (FDB-21, GB-21VR), from -6 to 42 seconds	170

292. Mass flow in broken loop (FTB-21, GB-21VR), from -20 to 300 seconds	171
293. Mass flow in broken loop (FTB-21, GB-21VR), from -6 to 42 seconds	171
294. Mass flow in broken loop (FDB-30, GB-30VR), from -6 to 42 seconds	172
295. Mass flow in broken loop (FTB-30, GB-30VR), from -20 to 300 seconds	173
296. Mass flow in broken loop (FTB-30, GB-30VR), from -6 to 42 seconds	173
297. Mass flow in vessel (FDV-CORE-IN, GV-COR-150HZ), from -20 to 300 seconds	174
298. Mass flow in vessel (FDV-CORE-IN, GV-COR-150HZ), from -6 to 42 seconds	174
299. Mass flow in vessel (FTV-CORE-IN, GV-COR-150HZ), from -20 to 300 seconds	175
300. Mass flow in vessel (FTV-CORE-IN, GV-COR-150HZ), from -6 to 42 seconds	175
301. Mass flow in pressurizer surge line (FTU-PRIZE, GU-PRIZE), from -6 to 42 seconds	176
302. Core heater pin total power (PWRCOR T-1, PWRCOR T-2), from -20 to 300 seconds	177
303. Core heater pin total power (PWRCOR T-1, PWRCOR T-2), from -6 to 42 seconds	177
304. Core heater voltage (VOLTCOR-T), from -20 to 300 seconds	178
305. Core heater voltage (VOLTCOR-T), from -6 to 42 seconds	178
306. Core heater total current (AMPCOR-T), from -20 to 300 seconds	179
307. Core heater total current (AMPCOR-T), from -6 to 42 seconds	179
308. Primary pump torque (PUMPU-TORQ), from -20 to 300 seconds	180
309. Primary pump torque (PUMPU-TORQ), from -6 to 42 seconds	180
310. Primary pump speed (PUMPU-CUR), from -20 to 300 seconds	181
311. Primary pump speed (PUMPU-CUR), from -6 to 42 seconds	181

TABLES

I.	Conditions at Blowdown Initiation	7
II.	Primary Coolant Temperature Distribution at Rupture	8
III.	Water Chemistry Prior to Blowdown	8
IV.	Sequence of Events During Test	9
V.	Data Presentation for Semiscale Mod-1 Test S-05-2	17
A-I.	Constants for Pressure Measurement Corrections, Test S-05-2	186
A-II.	Constants for Differential Pressure Measurement Corrections, Test S-05-2	188
A-III.	Constants for Momentum Flux Measurement Corrections, Test S-05-2	190
A-IV.	Constants for Density Measurements Conversions to Engineering Units, Test S-05-2	192

EXPERIMENT DATA REPORT FOR SEMISCALE MOD-1

TEST S-05-2

(ALTERNATE ECC INJECTION 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 project 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-05-2 was conducted on October 29, 1976, in the Semiscale Mod-1 system as part of the alternate ECC injection test series (Test Series 5), which was designed to obtain thermal-hydraulic response data from blowdown, refill, and reflood transients in a simulated nuclear reactor with a heated core in such a manner as to study the sensitivity of core and system to changes in emergency core coolant (ECC) injection location. For this test, the pressure vessel was equipped with a 40-electric-heater-rod heated core, of which 36 rods were active (Rods C-3, D-5, F-3, and F-6 were intentionally unpowered to simulate unpowered regions in the core of a pressurized water reactor). To yield a slightly peaked radial power profile, the power level on heater Rods D-4, E-4, and E-5 was increased by 5% above that used for tests with a flat radial power profile. At initial test conditions, heater Rods D-4, E-4, and E-5 were operated at a peak power density of about 12.1 kW/ft and the remaining 33 heater rods were operated at a peak power density of about 11.5 kW/ft. The resulting total core power was about 1.44 MW.

During the blowdown, the core heater power was adjusted to simulate the thermal response characteristics of nuclear-heated rods prior to departure from nucleate boiling. Blowdown was accompanied by simulated ECC injection into the pump suction (Spool 8) of the intact loop and into the cold leg (Spool 42) of the broken loop. At each ECC injection location, coolant was injected from an accumulator and high and low pressure injection pumps.

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-05-2; 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-05-2

The following system configuration, procedures, initial test conditions, and events are specific to Test S-05-2.

1. SYSTEM CONFIGURATION AND TEST PROCEDURES

The Semiscale Mod-1 system used for Test S-05-2 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 accumulator for the pressure vessel and both the intact and broken loops; high and low pressure injection pumps for both the intact and broken loops; and a pressure suppression system with a suppression tank, header, and a heated steam supply system. For this test, the volume of the lower plenum was reduced to 0.529 ft³ by the addition of a metal filler piece, and the flow resistance of the intact loop was based on core area scaling. System configuration information is provided in Reference 1. Figures 1 and 2 provide the system configuration for Test S-05-2.

In preparation for the test, the intact loop, broken loop, and vessel accumulators were filled with treated demineralized water, drained to the specified initial level, 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 systems to be checked.

Prior to establishing the initial core power level, the pressure suppression system was pressurized to 35 psia with saturated steam from the steam supply system. After the core power was increased to about 1.44 MW, initial test conditions were held for 17 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.

EGG-D-1073

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

Fig. 2 Cross section of vessel with lower plenum filler.

The system was successfully subjected to a simulated double-ended cold leg break through two rupture assemblies and two blowdown nozzles, each having a break area of 0.00262 ft². 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 nitrogen. Immediately (0.02 second) 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 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 1500 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-05-2, the coolant injection systems were arranged to discharge into both system loops at the cold leg injection points (Spool 8 and Spool 42). Coolant injection started immediately after initiation of blowdown with the manual activation of the intact and broken loop high pressure injection pumps. Coolant injection was initiated from the intact and broken loop accumulators after the system was depressurized to 600 psig. At approximately 150 psig, the low pressure injection pumps were also started. Coolant injection was continued until the test was terminated at 300 seconds after initiation of blowdown.

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

	Measured ^[a]	Specified
Core power (MW)	1.456	1.444 ± 0.03
Intact loop cold leg fluid temperature (°F)	545	544 ± 2
Hot leg to cold leg temperature differential (°F)	65	66 ± 1
Pressurizer pressure (psia)	2263	2263 ± 25
Pressurizer water level (in.) [b]	20.9[c]	20.7
Steam generator feedwater temperature (°F)	440	435 ± 10
Steam generator liquid level (from bottom of tube sheet) (in.)	116	116 ± 2
Fluid temperature in broken loop (pump side) (°F)	572	572 minimum
Fluid temperature in broken loop (vessel side) (°F)	539	Not Specified
Intact loop cold leg flow (gpm)	142	[d]
Pressure suppression tank water level (in.)	47.5	47 ± 1
Pressure suppression tank pressure (psia)	35.0	35.0
Pressure suppression tank water temperature (°F)	75	Ambient

[a] Measured initial conditions are taken from process instrumentation read just prior to blowdown. Those measured conditions which did not meet the specified initial conditions were considered acceptable for analysis purposes within the test objectives.

[b] Pressurizer water level measured from bottom hemispherical section.

[c] Level shown corresponds to a pressurizer system volume of 0.54 ft³ (including surge line).

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

TABLE II
PRIMARY COOLANT TEMPERATURE DISTRIBUTION AT RUPTURE[a]

	<u>Detector</u>	<u>Temperature (°F)</u>
Vessel lower plenum (upper portion)	TFV-LP-7	544
Intact loop hot leg (near vessel)	RBU-2	608
Intact loop cold leg (near pump inlet)	TFU-10	542
Intact loop cold leg (near vessel)	RBU-14A	541
Broken loop cold leg (near vessel)	TFB-20	543
Broken loop cold leg (near nozzle)	TFB-23	539
Broken loop hot leg (near vessel)	TFB-30	604
Broken loop cold leg (near nozzle)	TFB-42	598

[a] Data taken from final digital scan 209 seconds before rupture.

TABLE III
WATER CHEMISTRY PRIOR TO BLOWDOWN[a]

pH	9.35
Conductivity (μmhos/cm)	100.0
Lithium (ppm)	5.0
Chlorides (ppm)	1.6
Fluorides (ppm)	<0.4[b]
Oxygen (ppm)	0.023
Total gas (cc/l)	127.0
Suspended solids (ppm)	1.3

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

[b] Present analytical methods prevent accurate determination of fluorides at concentrations of less than 0.4 ppm.

TABLE IV
SEQUENCE OF EVENTS DURING TEST[a]

Event	Time Relative To Rupture
Established core power level (min)	-17
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
Steam generator feedwater and discharge valves closed (sec)	1
ECC accumulators valved in (sec)[b]	1
Low pressure injection system pumps started (sec)[b]	20
Core power tripped off (sec)[c]	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] Core power tripped manually at termination of test.

III. DATA PRESENTATION

The data from Semiscale Mod-1 Test S-05-2 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-05-2 was monitored by 219 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 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 many 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 3 through 8 and Table V provide supporting information for interpretation of the data graphs shown in Figures 9 through 311.

Figures 3 through 8 show the relative locations of all detectors used during Test S-05-2. 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. Appendix A provides information explaining posttest data processing for data conversion into engineering units and data adjustments. Figures 9 through 311 present all of the blowdown and reflood data obtained. Time zero on the graphs is the time of rupture initiation.

Fig. 3 Semiscale Mod-1 system and instrumentation for cold leg break configuration -- isometric.

Test S-05-2
EGG-A-1071

Fig. 6 Semiscale Mod-1 pressure vessel -- isometric showing instrumentation.

Test S-05-2
EGG-A-1079

Fig. 8 Semiscale Mod-1 heated core -- plan view.

TABLE V
DATA PRESENTATION FOR SEMISCALE MOD-1 TEST S-05-2

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>					
RBU-2	Hot leg, Spool 2, 46 in. from vessel center (platinum resistance bulb).	0 to 2300°F	0 to 591°F	9, 10	
TSU-7	Cold leg, Spool 7, 243 in. from vessel center (shielded).	0 to 1000°F	0 to 1000°F	11, 12	
TFU-10	Cold leg, Spool 10, 144 in. from vessel center.			11, 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	11, 12	
TFU-14B	Cold leg, Spool 14, 39 in. from vessel center, downstream of cold leg injection port.			11, 12	
<u>Broken Loop</u>					
TFB-20	Cold leg, Spool 20, 21 in. from vessel center.	0 to 2300°F	0 to 1017°F	13, 14	
TFB-23	Cold leg, Spool 23, 91 in. from vessel center, upstream of vessel-side nozzle.			13, 14	
TFB-30	Hot leg, Spool 30, 16 in. from vessel center.			15, 16	
TFB-37	Cold leg, Spool 37, 276 in. from vessel center along hot leg, discharge of simulated steam generator.			15, 16	
TFB-42	Cold leg, Spool 42, 414 in. from vessel center along hot leg, upstream of pump-side nozzle.			15, 16	
<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°.			17, 18	
TFV-ANN-4M	180°.			17, 18	
TFV-ANN-35A	35 in. below cold leg centerline, 0°.			17, 18	
<u>Downcomer Annulus</u>					
	Centered in annulus, Type J iron-constantan thermocouples.	0 to 1400°F	0 to 803°F		
TFV-ANN-70A	70 in. below cold leg centerline, 0°.			19, 20	
TFV-ANN-115A	115 in. below cold leg centerline, 0°.			19, 20	
TFV-ANN-156A	156 in. below cold leg centerline, 0°.		0 to 591°F	19, 20	
<u>Upper Plenum</u>					
		0 to 2300°F	0 to 1017°F		
TFV-UP-13	In upper plenum, 13.5 in. above cold leg centerline at 100°.			21, 22	
<u>Lower Plenum</u>					
	On fluid thermocouple rack, 1 in. from vessel center, 45°.	0 to 2300°F	0 to 1017°F		
TFV-LP-2	2.0 in. from top of lower plenum filler.			23, 24	
TFV-LP-4	4.0 in. from top of lower plenum filler.			23, 24	
TFV-LP-7	7.0 in. from top of lower plenum filler.			23, 24	
<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	25, 26	

TABLE V (continued)

Range ^[a]					
Measurement	Location and Comments ^[a]	Detector	Data Acquisition System	Figure ^[a]	Measurement Comments ^[b]
<u>Core Barrel Insulation Gap</u>					
TFV-CIG-70A	70 in. below cold leg centerline, 0°.	0 to 1400°F	0 to 803°F	27, 28	
<u>Vessel Filler Insulation Gap</u>					
TFV-FIG-156A	156 in. below cold leg centerline, 0°.	0 to 2300°F	0 to 1017°F	29, 30	
<u>ECC System</u>					
TFV-ECC-40	In ECC line leading to Spool 0.	0 to 2300°F	0 to 591°F	31	Long-term plot only.
TFB-ECC-42	In ECC line leading to Spool 42.			32, 33	
<u>Steam Generator</u>					
TFU-SGFW	In feedwater line leading to steam generator.	0 to 2300°F	0 to 591°F	34, 35	
TFU-SGSD	In steam dome, 129.5 in. from bottom of tube sheet.			34, 35	
<u>Pressurizer</u>					
TFU-PRIZE	In surge line, near pressurizer exit, between turbine flowmeter and pressurizer.	0 to 2300°F	0 to 1017°F	36, 37	
<u>Pressure Suppression System</u>					
TF-PSS-33	33 in. from bottom of tank.	0 to 2300°F	0 to 591°F	38, 39	
TF-PSS-130	130 in. from bottom of tank.			38, 39	
<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	40, 41	
TMU-15B16	Cold leg, Spool 15, bottom, 1/16 in. from pipe ID, 17 in. from vessel center.			40, 41	
TMU-15T16	Cold leg, Spool 15, top, 1/16 in. from pipe ID, 17 in. from vessel center.			40, 41	
<u>Broken Loop</u>					
TMU-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		Thermocouple failed.
TMU-30T16	Hot leg, Spool 30, top, 1/16 in. from pipe ID, 16 in. from vessel center.		0 to 1017°F	42, 43	
<u>Vessel Filler</u>					
Type J iron-constantan.					
TMV-FI-4M	4 in. below cold leg centerline, 1/16 in. from filler ID, 180°.	0 to 1400°F	0 to 803°F	44, 45	
TMV-FI-15A	15 in. below cold leg centerline, 1/16 in. from filler ID, 0°.			44, 45	
TMV-FI-35A	35 in. below cold leg centerline, 1/16 in. from filler ID, 0°.			44, 45	
TMV-FI-70A	70 in. below cold leg centerline, 1/16 in. from filler ID, 0°.				Thermocouple failed.
TMV-FI-115A	115 in. below cold leg centerline, 1/16 in. from filler ID, 0°.			46, 47	
TMV-FI-156	156 in. below cold leg centerline, 1/16 in. from filler ID, 0°.	0 to 2300°F	0 to 1017°F	46, 47	
TMV-FI-156A	156 in. below cold leg centerline, 0.65 in. from filler ID, 0°.	0 to 2300°F	0 to 1017°F	48, 49	

TABLE V (continued)

Measurement	Location and Comments ^[a]	Range ^[a]		Figure ^[a]	Measurement Comments ^[b]
		Detector	Data Acquisition System		
<u>Vessel Filler Insulator</u>	Outer surface of insulator, Type J iron-constantan thermocouples.	0 to 1400°F	0 to 803°F		
TIV-F0-35A	35 in. below cold leg centerline, 0°.			50, 51	
TIV-F0-35M	35 in. below cold leg centerline, 180°.			50, 51	
TIV-F0-70A	70 in. below cold leg centerline, 0°.			50, 51	
TIV-F0-115A	115 in. below cold leg centerline, 0°.			50, 51	
<u>Core Barrel</u>	Type J iron-constantan thermocouples.	0 to 1400°F	0 to 803°F		
TMV-CI-70A	70 in. below cold leg centerline, 1/16 in. from core barrel ID, 0°.			52, 53	
TMV-CI-115A	115 in. below cold leg centerline, 1/16 in. from core barrel ID, 0°.			52, 53	
TMV-CO-70A	70 in. below cold leg centerline, 1/16 in. from core barrel OD, 0°.			54, 55	
TMV-CO-115A	115 in. below cold leg centerline, 1/16 in. from core barrel OD, 0°.			54, 55	
<u>Core Housing Filler</u>		0 to 2300°F	0 to 1017°F		
TMV-HF-115W	On core housing filler, 115 in. below cold leg centerline, 0.20 in. from outer surface, 315°.			56, 57	
TMV-HF-127W	On core housing filler, 127 in. below cold leg centerline, 0.20 in. from outer surface, 315°.			56, 57	
TMV-HF-138W	On core housing filler, 138 in. below cold leg centerline, 0.20 in. from outer surface, 315°.			56, 57	
<u>CORE HEATER CLADDING TEMPERATURES</u>	Chromel-Alumel thermocouples.				
<u>High Power Heaters</u>		0 to 2300°F	0 to 2382°F		
TH-D4-14 TH-D4-29	Heater at Column D, Row 4. Thermocouples 14 in. (270°) and 29 in. (315°) above bottom of core.			58, 59	
TH-D5-29	Heater at Column D, Row 5. Thermocouple 29 in. (225°) above bottom of core.			60, 61	
TH-E4-09 TH-E4-28G TH-E4-28T TH-E4-55	Heater at Column E, Row 4. Thermocouples 9 in. (180°), 28 in. (90°), 28 in. (270°), and 55 in. (0°) above bottom of core.			62, 63	
TH-E5-21 TH-E5-25	Heater at Column E, Row 5. Thermocouples 21 in. (180°) and 25 in. (90°) above bottom of core.			64, 65	
<u>Low Power Heaters</u>		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 of core.			66, 67	
TH-A5-29 TH-A5-45	Heater at Column A, Row 5. Thermocouples 29 in. (180°) and 45 in. (255°) above bottom of core.			68, 69	
TH-B3-32	Heater at Column B, Row 3. Thermocouple 32 in. (135°) above bottom of core.			70, 71	
TH-B5-29 TH-B5-33	Heater at Column B, Row 5. Thermocouples 29 in. (150°) and 33 in. (45°) above bottom of core.			72, 73	
TH-B6-20	Heater at Column B, Row 6. Thermocouple 20 in. (45°) above bottom of core.			74, 75	

TABLE V (continued)

Measurement	Location and Comments ^[a]	Detector	Range ^[a]	Figure ^[a]	Measurement Comments ^[b]
			Data Acquisition System		
Low Power Heaters (continued)					
TH-C2-38	Heater at Column C, Row 2. Thermo- couple 38 in. (225°) above bottom of core.			76, 77	
TH-C4-26 TH-C4-53	Heater at Column C, Row 4. Thermo- couples 26 in. (75°) and 53 in. (300°) above bottom of core.			78, 79	
TH-C5-28	Heater at Column C, Row 5. Thermo- couple 28 in. (315°) above bottom of core.			80, 81	
TH-C6-53	Heater at Column C, Row 6. Thermo- couple 53 in. (270°) above bottom of core.			82, 83	
TH-C7-07 TH-C7-15	Heater at Column C, Row 7. Thermo- couples 7 in. (345°) and 15 in. (255°) above bottom of core.			84, 85	
TH-D1-21	Heater at Column D, Row 1. Thermo- couple 21 in. (330°) above bottom of core.			86, 87	
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.			88, 89	
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.			90, 91	
TH-D6-14 TH-D6-25	Heater at Column D, Row 6. Thermo- couples 14 in. (90°) and 25 in. (255°) above bottom of core.			92, 93	
TH-D7-20	Heater at Column D, Row 7. Thermo- couple 20 in. (60°) above bottom of core.			94, 95	
TH-D8-27 TH-D8-57	Heater at Column D, Row 8. Thermo- couples 27 in. (180°) and 57 in. (15°) above bottom of core.			96, 97	
TH-E1-21 TH-E1-33	Heater at Column E, Row 1. Thermo- couples 21 in. (285°) and 33 in. (60°) above bottom of core.			98, 99	
TH-E2-20 TH-E2-33	Heater at Column E, Row 2. Thermo- couples 20 in. (210°) and 33 in. (315°) above bottom of core.			100, 101	
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.			102, 103	
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. (300°) above bottom core.			104, 105	
TH-E7-44	Heater at Column E, Row 7. Thermo- couple 44 in. (195°) above bottom of core.			106, 107	
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.			108, 109	
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.			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, 115	
TH-G3-13	Heater at Column G, Row 3. Thermo- couple 13 in. (150°) above bottom of core.			116, 117	

TABLE V (continued)

Measurement	Location and Comments ^[a]	Range ^[a]		Figure ^[a]	Measurement Comments ^[b]
		Detector	Data Acquisition System		
<u>Low Power Heaters (continued)</u>					
TH-G4-29 TH-G4-33 TH-G4-38	Heater at Column G, Row 4. Thermocouples 29 in. (300°), 33 in. (225°), and 38 in. (30°) above bottom of core.			118, 119	
TH-G5-14 TH-G5-24	Heater at Column G, Row 5. Thermocouples 14 in. (45°) and 24 in. (330°) above bottom of core.			120, 121	
TH-H5-32	Heater at Column H, Row 5. Thermocouple 32 in. (45°) above bottom of core.			122, 123	
<u>PRESSURE</u>					
<u>Intact Loop</u>		0 to 3000 psi			
PU-13(F)	Cold leg, Spool 13, 54 in. from vessel center (flush mount).		0 to 4571 psia	124, 125	
PU-15L	Cold leg, Spool 15, 16 in. from vessel center (low range).	0 to 500 psi	0 to 553 psia	126, 127	
<u>Broken Loop</u>		0 to 3000 psi			
PB-23	Cold leg, Spool 23, 92 in. from vessel center, upstream of nozzle (tee off DP tap).		0 to 4364 psia	128, 129	
PB-37	Cold leg, Spool 37, 282 in. from vessel center along hot leg.		0 to 4402 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 4832 psia	130, 131	
PB-HN1	Pump-side nozzle, nozzle throat, 419 in. from vessel center along hot leg (tee off DP tap).		0 to 4666 psia	132, 133	
PB-CN1	Cold leg, Spool 23, vessel-side nozzle, nozzle throat, 96 in. from vessel center along cold leg, 45°.		0 to 2509 psia	134, 135	
<u>Vessel</u>					
PV-UP+10	In upper plenum, 10 in. above cold leg centerline, mounted on standoff, 30°.	0 to 2500 psi	0 to 3110 psia	136, 137	
PV-LP-166	In upper part of lower plenum, 166 in. below cold leg centerline, mounted on standoff, 225°.	0 to 3000 psi	0 to 2503 psia	136, 137	
<u>ECC System</u>		0 to 750 psi			
PU-ACC PB-ACC	In intact loop accumulator. In broken loop accumulator.		0 to 773 psia 0 to 746 psia	138, 139	Transducer failed.
<u>Steam Generator</u>					
PU-SGSD	Secondary side steam dome.	0 to 3000 psi	0 to 1811 psia	140, 141	
<u>Pressurizer</u>					
PU-PRIZE	Pressurizer steam dome.	0 to 2500 psi	0 to 3171 psia	142, 143	
<u>Pressure Suppression System</u>					
P-PSS	Suppression tank top.	0 to 250 psi	0 to 347 psia	144, 145	
<u>DIFFERENTIAL PRESSURE</u>					
	Elevation difference between transducer taps is zero unless otherwise specified.				

TABLE V (continued)

Measurement	Location and Comments ^[a]	Range ^[a]		Figure ^[a]	Measurement Comments ^[b]
		Detector	Data Acquisition System		
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	+2.5 psid	146, 147	
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 10 in. above Spool 7 tap.	+500 in. water	+25 psid	148, 149	
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	+2.5 psid	150, 151	
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	152, 153	
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	+5.0 psid	154, 155	Detector saturated intermittently prior to t=90 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	+5.0 psid	156, 157	
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	158, 159	
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	+5.0 psid	160, 161	Detector saturated intermittently prior to t=90 sec.
DPU-15-IANN	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	+5.0 psid	162, 163	
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	164, 165	
DPU-PR-4	Pressurizer top to Spool 4. Elevation difference between taps is 62 in. Spool 4 tap is 55 in. below pressurizer exit.	+1000 psi	+1357 psid	166, 167	
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	+2.5 psid	168, 169	
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	+5.0 psid	170, 171	
DPB-23-CN1	Cold leg Spool 23, 92 in. from vessel center to vessel-side nozzle throat, 96 in. from vessel center.	+1000 psi	+1336 psid	172, 173	
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	174, 175	

TABLE V (continued)

Measurement	Location and Comments [a]	Range [a]		Figure [a]	Measurement Comments [b]
		Detector	Data Acquisition System		
Broken Loop (continued)					
DPB-32U-36L	Across 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	176, 177	
DPB-36L-37	Across nozzle assembly, Spool 36 lower tap, 242 in. from vessel center along hot leg, to Spool 37, 282 in. from vessel center along hot leg. Spool 37 tap is 40 in. below Spool 36 lower tap.	+50 psi	+50 psid	178, 179	
DPB-37-38	Across turbine flowmeter and drag disc, cold leg Spool 37, 282 in. from vessel center along hot leg to cold leg Spool 38, 305 in. from vessel center along hot leg. Spool 37 tap is 23 in. above Spool 38 tap.	+50 in. water	+3.2 psid	180, 181	
DPB-38-40	Across simulated pump, cold leg Spool 30, 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	182, 183	
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	+2.5 psid	184, 185	Detector saturated from t=0 to t=1 sec and from t=23 to t=32 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	+15 psid	186, 187	
DPV-0-96Q	Inlet annulus cold leg centerline at 90° to 9 in. below cold leg centerline at 225°. Elevation difference between taps is 9 in.	+50 in. water	+2.5 psid	188, 189	
DPV-9-26QQ	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	190, 191	
DPV-9-166QQ	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	+14.4 psid	192, 193	
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	194, 195	
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	+5.0 psid	196, 197	
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	+5.0 psid	198, 199	
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	200, 201	
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	202, 203	

TABLE V (continued)

Measurement	Location and Comments ^[a]	Range ^[a]		Figure ^[a]	Measurement Comments ^[b]
		Detector	Data Acquisition System		
<u>Vessel (continued)</u>					
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	+2.5 psid	146, 147	
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	+5.0 psid	170, 171	
<u>Vessel Core</u>					
DPVC-89W-UP	Upper segment of active core region, 89 in. below cold leg centerline (315°), to upper plenum core tube, 10.5 in. above cold leg centerline (30°). Elevation difference between taps is 100 in.	+500 in. water	+25 psid	204, 205	
DPVC-89-106WQ	In active core region, upper segment, 89 in. below cold leg centerline (315°), to 106 in. below cold leg centerline (225°). Elevation difference between taps is 17 in.	+50 in. water	+2.5 psid	206, 207	
DPVC-106-122QJ	Across center segment of active core region, 106 in. below cold leg centerline (225°), to 122 in. below cold leg centerline (135°). Elevation difference between taps is 16 in.	+100 in. water	+5.0 psid	208, 209	
DPVC-122-140JU	In active core region, lower segment, 122 in. below cold leg centerline (135°), to 140 in. below cold leg centerline (45°). Elevation difference between taps is 18 in.	+100 in. water	+5.0 psid	210, 211	
<u>ECC SYSTEM</u>					
DPU-ACC-TD	Top to bottom of intact loop accumulator tank, elevation difference between taps is 108 in.	+100 in. water	+1.0 psid	212, 217	
DPB-ACC-TB	Top to bottom of broken loop accumulator tank, elevation difference between taps is 84 in.	+50 in. water	+5.2 psid		Detector failed.
<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	+1.7 psid	214, 215	
DPU-SG-DISC	Across venturi tube, 66 in. downstream from steam generator discharge.	+500 in. water	+25 psid	216, 217	
<u>VOLUMETRIC FLOW RATE</u>					
<u>Intact Loop</u>					
FTU-1	Hot leg, Spool 1, 18 in. from vessel center.	+20 to +400 gpm	+1200 gpm	218, 219	Data acquisition system saturated from t=26 to t=42 sec.
FTU-9	Cold leg, Spool 9, 154 in. from vessel center.	+80 to +800 gpm	+1200 gpm	218, 219	
FTU-13	Cold leg, Spool 13, 64 in. from vessel center.	+20 to +800 gpm	+1200 gpm	220, 221	
FTU-15	Cold leg, Spool 15, 29 in. from vessel center.	+20 to +800 gpm	+1000 gpm	220, 221	
<u>Broken Loop</u>					
Schedule 160 pipe.					
FTB-21	Cold leg, Spool 21, 58 in. from vessel center; 3-in. pipe.	+20 to +400 gpm	+1200 gpm	222, 223	
FTB-30	Hot leg, Spool 30, 25 in. from vessel center; 3-in. pipe.	+20 to +400 gpm	+800 gpm	224, 225	

TABLE V (continued)

Measurement	Location and Comments ^[a]	Range ^[a]		Figure ^[a]	Measurement Comments ^[b]
		Detector	Data Acquisition System		
Broken Loop (continued)					
FTB-37	Cold leg, Spool 37, 290 in. from vessel center along hot leg; 2-in. pipe.	+20 to +400 gpm	+800 gpm	224, 225	
Core					
FTV-CORE-IN	Entrance to core, ~158 in. below cold leg centerline.	+2 to +400 gpm	+900 gpm	226, 227	Data acquisition system saturated from t=31 to t=33 sec.
ECC System					
FTU-HPIS	In line immediately after HPIS pump for intact loop; 1/2-in. line.	+0.75 to +7.5 gpm	+2 gpm	228, 229	
FTB-HPIS	In line immediately after HPIS pump for broken loop; 1/2-in. line.	+0.75 to +7.5 gpm	+2 gpm	230, 231	Data acquisition system saturated from t=27 to t=31 sec.
FTU-LPIS	In line leading from LPIS pump for intact loop; 1/2-in. line.	+0.75 to +7.5 gpm	+10 gpm	232, 233	Data acquisition system saturated at t=0 and t=26 sec.
FTB-LPIS	In line leading from LPIS pump for broken loop; 3/4-in. line.	+0.75 to +7.5 gpm	+2 gpm	234, 235	
FTU-ACC	In line immediately after intact loop accumulator; 1-in. line.	+5 to +50 gpm	+75 gpm	236, 237	
FTB-ACC	In line immediately after broken loop accumulator; 1-in. line.	+2 to +20 gpm	+25 gpm	238, 239	
Pressurizer					
	1-1/2-in. turbine.				
FTU-PRIZE	Surge line.	+5 to +50 gpm	+80 gpm	240, 241	Data acquisition system saturated from t=26 to t=30 sec.
FLUID VELOCITY					
	Turbine flowmeter, bidirectional.				
Downcomer					
FTV-40A	40 in. below cold leg centerline, 0°.	+2.5 to 50 ft/sec	+50 ft/sec	242, 243	
FTV-40M	40 in. below cold leg centerline, 180°.	+2.5 to 50 ft/sec	+50 ft/sec	242, 243	
MOMENTUM FLUX					
	Drag disc, bidirectional.				Momentum flux reported only for -6 to 42 sec, except as noted. Drag disc data may exhibit significant temperature dependence. Drag disc data should be used only for short-term transient response.
Intact Loop					
	3-in. pipe.				
FDU-1	Hot leg, Spool 1, 29 in. from vessel center; target size 0.875 in.	+200 to +11,500 lbm/ft-sec ²	+23,750 lbm/ft-sec ²	244, 245	Long-term plot also presented.
FDU-5	Hot leg, Spool 5, 100 in. from vessel center; target size 1.0 in.	+1 to +2000 lbm/ft-sec ²	+4100 lbm/ft-sec ²	246, 247	Long-term plot also presented. Detector saturated prior to t=1 sec.
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	248	
FDU-13	Cold leg, Spool 13, 54 in. from vessel center; target size 0.875 in.	+200 to +14,800 lbm/ft-sec ²	+20,860 lbm/ft-sec ²	249	
FDU-15	Cold leg, Spool 15, 19 in. from vessel center; target size 0.875 in.	+200 to +14,500 lbm/ft-sec ²	+21,800 lbm/ft-sec ²	250	
Broken Loop					
FDB-21	Cold leg, Spool 21, 53 in. from vessel center, 3-in. pipe; target size 0.875 in.	+200 to +70,500 lbm/ft-sec ²	+27,150 lbm/ft-sec ²	251	
FDB-22	Cold leg, Spool 22, 92 in. from vessel center upstream of vessel-side nozzle, 2-in. pipe; target size 0.406 in.	+200 to +125,000 lbm/ft-sec ²	+134,560 lbm/ft-sec ²		Detector failed

TABLE V (continued)

Measurement	Location and Comments ^[a]	Range ^[a]		Figure ^[a]	Measurement Comments ^[b]
		Detector	Data Acquisition System		
<u>Broken Loop (continued)</u>					
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	$\pm 28,000$ lbm/ft-sec ²	252	
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 $\pm 21,000$ lbm/ft-sec ²	$\pm 247,200$ lbm/ft-sec ²	253	
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	$\pm 112,400$ lbm/ft-sec ²	254, 255	Long-term plot also presented.
<u>Vessel</u>					
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	± 1235 lbm/ft-sec ²	256, 257	Detector FDV-CORE-IN saturated at 500 lbm/ft-sec ² for forward flow measurements.
<u>DENSITY</u>					
<u>Intact Loop</u>					
		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.			258, 259	The positive spike occurring in the data at rupture is caused by mechanical vibration of the detector system and does not represent system density.
GU-1HZ	Hot leg, Spool 1, 26 in. from vessel center, horizontal.			258, 259	
GU-5VR	Hot leg, Spool 5, 96 in. from vessel center, vertical.			260, 261	
GU-10VR	Cold leg, Spool 10, 141 in. from vessel center, vertical.			260, 261	
GU-13VR	Cold leg, Spool 13, 59 in. from vessel center, vertical.			262, 263	
GU-15VR	Cold leg, Spool 15, 23 in. from vessel center, vertical.			264, 265	
GU-15HZ	Cold leg, Spool 15, 20 in. from vessel center, horizontal.			264, 265	
<u>Broken Loop</u>					
		0.1 to 100 lbm/ft ³	0 to 100 lbm/ft ³		
GB-21VR	Cold leg, Spool 21, 49 in. from vessel center, vertical.			266, 267	
GB-23VR	Cold leg, Spool 23, 92 in. from vessel center, vertical.			266, 267	
GB-30VR	Hot leg, Spool 30, 18 in. from vessel center, vertical.			268, 269	
GB-42VR	Cold leg, Spool 42, 415 in. from vessel center along hot leg, vertical.				Detector system failed.
<u>Vessel</u>					
		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°.			270, 271	
GVLP-165HZ	Upper part of lower plenum, 165 in. below cold leg centerline, 1.724 in. below downcomer exit, horizontal, 0 to 180°.			272, 273	
GVLP-172HZ	Lower plenum, 172 in. below cold leg centerline, 8.729 in. below downcomer exit, horizontal, 90 to 270°.			272, 273	

TABLE V (continued)

Measurement	Location and Comments ^[a]	Range ^[a]		Figure ^[a]	Measurement Comments ^[b]
		Detector	Data Acquisition System		
<u>Pressurizer</u>					
GU-PRIZE	Surge line.	0.1 to 100 lbm/ft ³	0 to 100 lbm/ft ³	274, 275	
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.			
<u>Intact Loop</u>					
FDU-1, GU-1VR FTU-1, GU-1VR	Hot leg, Spool 1.			276, 277 278, 279	
FDU-5, GU-5VR	Hot leg, Spool 5.			280, 281	Detector FDU-5 saturated until t=1 sec.
FTU-9, GU-10VR	Cold leg, Spool 9.			282, 283	
FDU-10, GU-10VR	Cold leg, Spool 10.			284	Short-term plot only.
FDU-13, GU-13VR FTU-13, GU-13VR	Cold leg, Spool 13.			285 286, 287	Short-term plot only.
FDU-15, GU-15VR FTU-15, GU-15VR	Cold leg, Spool 15.			288 289, 290	Short-term plot only.
<u>Broken Loop</u>					
FDB-21, GB-21VR FTB-21, GB-21VR	Cold leg, Spool 21			291 292, 293	Short-term plot only.
FDB-30, GB-30VR FTB-30, GB-30VR	Hot leg, Spool 30.			294 295, 296	Short-term plot only.
<u>Vessel</u>					
FDV-CORE-IN, GV-COR-160WZ	Entrance to core.			299, 300	
<u>Pressurizer</u>					
FTU-PRIZE GU-PRIZE	Pressurizer surge line.			301	Short-term plot only.
CORE CHARACTERISTICS					
PWRCOR T-1	Core power.		1600 kW	302, 303	
PWRCOR T-2	Core power.		1600 kW	302, 303	
VOLTCOR T	Core voltage.		0 to 200 Vdc	304, 305	
AMPCOR-T	Core current.		0 to 10,000 A	306, 307	
PUMP CHARACTERISTICS					
PUMPU-RPM	Pump speed.		0 to 3600 rpm	308, 309	
PUMPU-CUR	Pump current.		0 to 25 A	310, 311	

[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.

Fig. 9 Fluid temperature in intact loop hot leg (RBU-2), from -20 to 300 seconds.

Fig. 10 Fluid temperature in intact loop hot leg (RBU-2), from -6 to 42 seconds.

Fig. 11 Fluid temperature in intact loop cold leg (TSU-7, TFU-10, RBU-14A, TFU-14B), from -20 to 300 seconds.

Fig. 12 Fluid temperature in intact loop cold leg (TSU-7, TFU-10, RBU-14A, TFU-14B), from -6 to 42 seconds.

Fig. 13 Fluid temperature in broken loop, vessel side (TFB-20, TFB-23), from -20 to 300 seconds.

Fig. 14 Fluid temperature in broken loop, vessel side (TFB-20, TFB-23), from -6 to 42 seconds.

Fig. 15 Fluid temperature in broken loop, pump side (TFB-30, TFB-37, TFB-42), from -20 to 300 seconds.

Fig. 16 Fluid temperature in broken loop, pump side (TFB-30, TFB-37, TFB-42), from -6 to 42 seconds.

Fig. 17 Fluid temperature in downcomer annulus (TFV-ANN-4A, TFV-ANN-4M, TFV-ANN-35A); from -20 to 300 seconds.

Fig. 18 Fluid temperature in downcomer annulus (TFV-ANN-4A, TFV-ANN-4M, TFV-ANN-35A), from -6 to 42 seconds.

Fig. 19 Fluid temperature in downcomer annulus (TFV-ANN-70A, TFV-ANN-115A, TFV-ANN-156A), from -20 to 300 seconds.

Fig. 20 Fluid temperature in downcomer annulus (TFV-ANN-70A, TFV-ANN-115A, TFV-ANN-156A), from -6 to 42 seconds.

Fig. 21 Fluid temperature in upper plenum (TFV-UP+13), from -20 to 300 seconds.

Fig. 22 Fluid temperature in upper plenum (TFV-UP+13), from -6 to 42 seconds.

Fig. 23 Fluid temperature in lower plenum (TFV-LP-2, TFV-LP-4, TFV-LP-7), from -20 to 300 seconds.

Fig. 24 Fluid temperature in lower plenum (TFV-LP-2, TFV-LP-4, TFV-LP-7), from -6 to 42 seconds.

Fig. 25 Fluid temperature in core inlet (TFV-CORE-IN), from -20 to 300 seconds.

Fig. 26 Fluid temperature in core inlet (TFV-CORE-IN), from -6 to 42 seconds.

Fig. 27 Fluid temperature in core, barrel insulation gap (TFV-CIG-70A), -20 to 300 seconds.

Fig. 28 Fluid temperature in core, barrel insulation gap (TFV-CIG-70A), -6 to 42 seconds.

Fig. 29 Fluid temperature in filler insulation gap (TFV-FIG-156A), from -20 to 300 seconds.

Fig. 30 Fluid temperature in filler insulation gap (TFV-FIG-156A), from -6 to 42 seconds.

Fig. 31 Fluid temperature in intact loop ECC injection line (TFU-ECC-8C), from -20 to 300 seconds.

Fig. 32 Fluid temperature in broken loop ECC injection line (TFB-ECC-42), from -20 to 300 seconds.

Fig. 33 Fluid temperature in broken loop ECC injection line (TFB-ECC-42), from -6 to 42 seconds.

Fig. 34 Fluid temperature in steam generator (TFU-SGFW, TFU-SGSD); from -20 to 300 seconds.

Fig. 35 Fluid temperature in steam generator (TFU-SGFW, TFU-SGSD), from -6 to 42 seconds.

Fig. 36 Fluid temperature in pressurizer surge line (TFU-PRIZE), from -20 to 300 seconds.

Fig. 37 Fluid temperature in pressurizer surge line (TFU-PRIZE), from -6 to 42 seconds.

Fig. 38 Fluid temperature in pressure suppression tank (TF-PSS-33, TF-PSS-130), from -20 to 300 seconds.

Fig. 39 Fluid temperature in pressure suppression tank (TF-PSS-33, TF-PSS-130), from -6 to 42 seconds.

Fig. 40 Material temperature in intact loop (TMU-1T16, TMU-15B16, TMU-15T16), from -20 to 300 seconds.

Fig. 41 Material temperature in intact loop (TMU-1T16, TMU-15B16, TMU-15T16), from -6 to 42 seconds.

Fig. 42 Material temperature in broken loop (TMB-30T16), from -20 to 300 seconds.

Fig. 43 Material temperature in broken loop (TMB-30T16), from -6 to 42 seconds.

Fig. 44 Material temperature in vessel filler (TMV-FI-4M, TMV-FI-15A, TMV-FI-35A), from -20 to 300 seconds.

Fig. 45 Material temperature in vessel filler (TMV-FI-4M, TMV-FI-15A, TMV-FI-35A), from -6 to 42 seconds.

Fig. 46 Material temperature in vessel filler insulator (TMV-FI-115A, TMV-FI-156A), from -20 to 300 seconds.

Fig. 47 Material temperature in vessel filler insulator (TMV-FI-115A, TMV-FI-156A), from -6 to 42 seconds.

Fig. 48 Material temperature in vessel filler (TMV-F0-156A), from -20 to 300 seconds.

Fig. 49 Material temperature in vessel filler (TMV-F0-156A), from -6 to 42 seconds.

Fig. 50 Material temperature in vessel filler insulator (TIV-F0-35A, TIV-F0-35M, TIV-F0-70A, TIV-F0-115A), from -20 to 300 seconds.

Fig. 51 Material temperature in vessel filler insulator (TIV-F0-35A, TIV-F0-35M, TIV-F0-70A, TIV-F0-115A), from -6 to 42 seconds.

Fig. 52 Material temperature in core barrel (TMV-CI-70A, TMV-CI-115A), from -20 to 300 seconds.

Fig. 53 Material temperature in core barrel (TMV-CI-70A, TMV-CI-115A), from -6 to 42 seconds.

Fig. 54 Material temperature in core barrel (TMV-CO-70A, TMV-CO-115A), from -20 to 300 seconds.

Fig. 55 Material temperature in core barrel (TMV-CO-70A, TMV-CO-115A), from -6 to 42 seconds.

Fig. 56 Material temperature on core housing filler (TMV-HF-115W, TMV-HF-127W, TMV-HF-138W), from -20 to 300 seconds.

Fig. 57 Material temperature on core housing filler (TMV-HF-115W, TMV-HF-127W, TMV-HF-138W), from -6 to 42 seconds.

Fig. 58 Core heater temperature, Rod D-4 (TH-D4-14, TH-D4-29), from -20 to 300 seconds.

Fig. 59 Core heater temperature, Rod D-4 (TH-D4-14, TH-D4-29), from -6 to 42 seconds.

Fig. 60 Core heater temperature, Rod D-5 (TH-D5-29), from -20 to 300 seconds.

Fig. 61 Core heater temperature, Rod D-5 (TH-D5-29), from -6 to 42 seconds.

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

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

Fig. 64 Core heater temperature, Rod E-5 (TH-E5-21, TH-E5-25), from -20 to 300 seconds.

Fig. 65 Core heater temperature, Rod E-5 (TH-E5-21, TH-E5-25), from -6 to 42 seconds.

Fig. 66 Core heater temperature, Rod A-4 (TH-A4-09, TH-A4-29, TH-A4-39), from -20 to 300 seconds.

Fig. 67 Core heater temperature, Rod A-4 (TH-A4-09, TH-A4-29, TH-A4-39), from -6 to 42 seconds.

Fig. 68 Core heater temperature, Rod A-5 (TH-A5-29, TH-A5-45), from -20 to 300 seconds.

Fig. 69 Core heater temperature, Rod A-5 (TH-A5-29, TH-A5-45), from -6 to 42 seconds.

Fig. 70 Core heater temperature, Rod B-3 (TH-B3-32), from -20 to 300 seconds.

Fig. 71 Core heater temperature, Rod B-3 (TH-B3-32), from -6 to 42 seconds.

Fig. 72 Core heater temperature, Rod B-5 (TH-B5-29, TH-B5-33), from -20 to 300 seconds.

Fig. 73 Core heater temperature, Rod B-5 (TH-B5-29, TH-B5-33), from -6 to 42 seconds.

Fig. 74 Core heater temperature, Rod B-6 (TH-B6-29), from -20 to 300 seconds.

Fig. 75 Core heater temperature, Rod B-6 (TH-B6-29), from -6 to 42 seconds.

Fig. 76 Core heater temperature, Rod C-2 (TH-C2-38), from -20 to 300 seconds.

Fig. 77 Core heater temperature, Rod C-2 (TH-C2-38), from -6 to 42 seconds.

Fig. 78 Core heater temperature, Rod C-4 (TH-C4-26, TH-C4-53), from -20 to 300 seconds.

Fig. 79 Core heater temperature, Rod C-4 (TH-C4-26, TH-C4-53), from -6 to 42 seconds.

Fig. 80 Core heater temperature, Rod C-5 (TH-C5-28), from -20 to 300 seconds.

Fig. 81 Core heater temperature, Rod C-5 (TH-C5-28), from -6 to 42 seconds.

Fig. 82 Core heater temperature, Rod C-6 (TH-C6-53), from -20 to 300 seconds.

Fig. 83 Core heater temperature, Rod C-6 (TH-C6-53), from -6 to 42 seconds.

Fig. 84 Core heater temperature, Rod C-7 (TH-C7-07, TH-C7-15), from -20 to 300 seconds.

Fig. 85 Core heater temperature, Rod C-7 (TH-C7-07, TH-C7-15), from -6 to 42 seconds.

Fig. 86 Core heater temperature, Rod D-1 (TH-D1-21), from -20 to 300 seconds.

Fig. 87 Core heater temperature, Rod D-1 (TH-D1-21), from -6 to 42 seconds.

Fig. 88 Core heater temperature, Rod D-2 (TH-D2-14, TH-D2-61), from -20 to 300 seconds.

Fig. 89 Core heater temperature, Rod D-2 (TH-D2-14, TH-D2-61), from -6 to 42 seconds.

Fig. 90 Core heater temperature, Rod D-3 (TH-D3-29, TH-D3-39), from -20 to 300 seconds.

Fig. 91 Core heater temperature, Rod D-3 (TH-D3-29, TH-D3-39), from -6 to 42 seconds.

Fig. 92 Core heater temperature, Rod D-6 (TH-D6-14, TH-D6-25), from -20 to 300 seconds.

Fig. 93 Core heater temperature, Rod D-6 (TH-D6-14, TH-D6-25), from -6 to 42 seconds.

Fig. 94 Core heater temperature, Rod D-7 (TH-D7-20), from -20 to 300 seconds.

Fig. 95 Core heater temperature, Rod D-7 (TH-D7-20), from -6 to 42 seconds.

Fig. 96 Core heater temperature, Rod D-8 (TH-D8-27, TH-D8-57), from -20 to 300 seconds.

Fig. 97 Core heater temperature, Rod D-8 (TH-D8-27, TH-D8-57), from -6 to 42 seconds.

Fig. 98 Core heater temperature, Rod E-1 (TH-E1-21, TH-E1-33), from -20 to 300 seconds.

Fig. 99 Core heater temperature, Rod E-1 (TH-E1-21, TH-E1-33), from -6 to 42 seconds.

Fig. 100 Core heater temperature, Rod E-2 (TH-E2-20, TH-E2-33), from -20 to 300 seconds.

Fig. 101 Core heater temperature, Rod E-2 (TH-E2-20, TH-E2-33), from -6 to 42 seconds.

Fig. 102 Core heater temperature, Rod E-3 (TH-E3-05, TH-E3-20, TH-E3-24), from -20 to 300 seconds.

Fig. 103 Core heater temperature, Rod E-3 (TH-E3-05, TH-E3-20, TH-E3-24), from -6 to 42 seconds.

Fig. 104 Core heater temperature, Rod E-6 (TH-E6-08, TH-E6-28, TH-E6-37), from -20 to 300 seconds.

Fig. 105 Core heater temperature, Rod E-6 (TH-E6-08, TH-E6-28, TH-E6-37), from -6 to 42 seconds.

Fig. 106 Core heater temperature, Rod E-7 (TH-E7-44), from -20 to 300 seconds.

Fig. 107 Core heater temperature, Rod E-7 (TH-E7-44), from -6 to 42 seconds.

Fig. 108 Core heater temperature, Rod E-8 (TH-E8-14, TH-E8-29, TH-E8-45), from -20 to 300 seconds.

Fig. 109 Core heater temperature, Rod E-8 (TH-E8-14, TH-E8-29, TH-E8-45), from -6 to 42 seconds.

Fig. 110 Core heater temperature, Rod F-2 (TH-F2-07, TH-F2-22, TH-F2-25), from -20 to 300 seconds.

Fig. 111 Core heater temperature, Rod F-2 (TH-F2-07, TH-F2-22, TH-F2-25), from -6 to 42 seconds.

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

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

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

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

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

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

Fig. 118 Core heater temperature, Rod G-4 (TH-G4-29, TH-G4-33, TH-G4-38), from -20 to 300 seconds.

Fig. 119 Core heater temperature, Rod G-4 (TH-G4-29, TH-G4-33, TH-G4-38), from -6 to 42 seconds.

Fig. 120 Core heater temperature, Rod G-5 (TH-G5-14, TH-G5-24), from -20 to 300 seconds.

Fig. 121 Core heater temperature, Rod G-5 (TH-G5-14, TH-G5-24), from -6 to 42 seconds.

Fig. 122 Core heater temperature, Rod H-5 (TH-H5-32), from -20 to 300 seconds.

Fig. 123 Core heater temperature, Rod H-5 (TH-H5-32), from -6 to 42 seconds.

Fig. 124 Pressure in intact loop, Spool 13 [PU-13(F)], from -20 to 300 seconds.

Fig. 125 Pressure in intact loop, Spool 13 [PU-13(F)], from -6 to 42 seconds.

Fig. 126 Pressure in intact loop, Spool 15 (PU-15L), from -20 to 300 seconds.

Fig. 127 Pressure in intact loop, Spool 15 (PU-15L), from -6 to 42 seconds.

Fig. 128 Pressure in broken loop, Spool 23 (PB-23), from -20 to 300 seconds.

Fig. 129 Pressure in broken loop, Spool 23 (PB-23), from -6 to 42 seconds.

Fig. 130 Pressure in broken loop, near break (PB-37, PB-42), from -20 to 300 seconds.

Fig. 131 Pressure in broken loop, near break (PB-37, PB-42), from -6 to 42 seconds.

Fig. 132 Pressure in broken loop, pump-side nozzle (PB-HN1), from -20 to 300 seconds.

Fig. 133 Pressure in broken loop, pump-side nozzle (PB-HN1), from -6 to 42 seconds.

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

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

Fig. 136 Pressure in vessel (PV-UP+10, PV-LP-166), from -20 to 300 seconds.

Fig. 137 Pressure in vessel (PV-UP+10, PV-LP-166), from -6 to 42 seconds.

Fig. 138 Pressure in accumulator (PU-ACC), from -20 to 300 seconds.

Fig. 139 Pressure in accumulator (PU-ACC), from -6 to 42 seconds.

Fig. 140 Pressure in steam generator, secondary side (PU-SGSD), from -20 to 300 seconds.

Fig. 141 Pressure in steam generator, secondary side (PU-SGSD), from -6 to 42 seconds.

Fig. 142 Pressure in pressurizer (PU-PRIZE), from -20 to 300 seconds.

Fig. 143 Pressure in pressurizer (PU-PRIZE), from -6 to 42 seconds.

Fig. 144 Pressure in pressure suppression tank (P-PSS), from -20 to 300 seconds.

Fig. 145 Pressure in pressure suppression tank (P-PSS), from -6 to 42 seconds.

Fig. 146 Differential pressure in intact loop (DPU-UP-3), from -20 to 300 seconds.

Fig. 147 Differential pressure in intact loop (DPU-UP-3), from -6 to 42 seconds.

Fig. 148 Differential pressure in intact loop (DPU-3-7), from -20 to 300 seconds.

Fig. 149 Differential pressure in intact loop (DPU-3-7), from -6 to 42 seconds.

Fig. 150 Differential pressure in intact loop (DPU-7-10), from -20 to 300 seconds.

Fig. 151 Differential pressure in intact loop (DPU-7-10), from -6 to 42 seconds.

Fig. 152 Differential pressure in intact loop (DPU-12-10), from -20 to 300 seconds.

Fig. 153 Differential pressure in intact loop (DPU-12-10), from -6 to 42 seconds.

Fig. 154 Differential pressure in intact loop, low range (DPU-12-10L), from -20 to 300 seconds.

Fig. 155 Differential pressure in intact loop, low range (DPU-12-10L), from -6 to 42 seconds.

Fig. 156 Differential pressure in intact loop, (DPU-12-15), from -20 to 300 seconds.

Fig. 157 Differential pressure in intact loop, (DPU-12-15), from -6 to 42 seconds.

Fig. 158 Differential pressure in intact loop, (DPU-15-1), from -20 to 300 seconds.

Fig. 159 Differential pressure in intact loop, (DPU-15-1), from -6 to 42 seconds.

Fig. 160 Differential pressure in intact loop (DPU-15-1L), from -20 to 300 seconds.

Fig. 161 Differential pressure in intact loop (DPU-15-1L), from -6 to 42 seconds.

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

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

Fig. 164 Differential pressure in intact loop (DPU-PRESLL), from -20 to 300 seconds.

Fig. 165 Differential pressure in intact loop (DPU-PRESLL), from -6 to 42 seconds.

Fig. 166 Differential pressure in intact loop (DPU-PR-4), from -20 to 300 seconds.

Fig. 167 Differential pressure in intact loop (DPU-PR-4), from -6 to 42 seconds.

Fig. 168 Differential pressure in broken loop (DPB-UP-30), from -20 to 300 seconds.

Fig. 169 Differential pressure in broken loop (DPB-UP-30), from -6 to 42 seconds.

Fig. 170 Differential pressure in broken loop (DPB-21-IANN), from -20 to 300 seconds.

Fig. 171 Differential pressure in broken loop (DPB-21-IANN), from -6 to 42 seconds.

Fig. 172 Differential pressure in broken loop (DPB-23-CN1), from -20 to 300 seconds.

Fig. 173 Differential pressure in broken loop (DPB-23-CN1), from -6 to 42 seconds.

Fig. 174 Differential pressure in broken loop (DPB-30-36L), from -20 to 300 seconds.

Fig. 175 Differential pressure in broken loop (DPB-30-36L), from -6 to 42 seconds.

Fig. 176 Differential pressure in broken loop (DPB-32U-36L), from -20 to 300 seconds.

Fig. 177 Differential pressure in broken loop (DPB-32U-36L), from -6 to 42 seconds.

Fig. 178 Differential pressure in broken loop (DPB-36L-37), from -20 to 300 seconds.

Fig. 179 Differential pressure in broken loop (DPB-36L-37), from -6 to 42 seconds.

Fig. 180 Differential pressure in broken loop (DPB-37-38), from -20 to 300 seconds.

Fig. 181 Differential pressure in broken loop (DPB-37-38), from -6 to 42 seconds.

Fig. 182 Differential pressure in broken loop (DPB-38-40), from -20 to 300 seconds.

Fig. 183 Differential pressure in broken loop (DPB-38-40), from -6 to 42 seconds.

Fig. 184 Differential pressure in broken loop (DPB-40-42), from -20 to 300 seconds.

Fig. 185 Differential pressure in broken loop (DPB-40-42), from -6 to 42 seconds.

Fig. 186 Differential pressure in vessel (DPV-UP-IANN), from -20 to 300 seconds.

Fig. 187 Differential pressure in vessel (DPV-UP-IANN), from -6 to 42 seconds.

Fig. 188 Differential pressure in vessel (DPV-0-9GQ), from -20 to 300 seconds.

Fig. 189 Differential pressure in vessel (DPV-0-9GQ), from -6 to 42 seconds.

Fig. 190 Differential pressure in vessel (DPV-9-26QQ), from -20 to 300 seconds.

Fig. 191 Differential pressure in vessel (DPV-9-26QQ), from -6 to 42 seconds.

Fig. 192 Differential pressure in vessel (DPV-9-166QQ), from -20 to 300 seconds.

Fig. 193 Differential pressure in vessel (DPV-9-166QQ), from -6 to 42 seconds.

Fig. 194 Differential pressure in vessel (DPV-26-55QM), from -20 to 300 seconds.

Fig. 195 Differential pressure in vessel (DPV-26-55QM), from -6 to 42 seconds.

Fig. 196 Differential pressure in vessel (DPV-55-110MM), from -20 to 300 seconds.

Fig. 197 Differential pressure in vessel (DPV-55-110MM), from -6 to 42 seconds.

Fig. 198 Differential pressure in vessel (DPV-110-156MQ), from -20 to 300 seconds.

Fig. 199 Differential pressure in vessel (DPV-110-156MQ), from -6 to 42 seconds.

Fig. 200 Differential pressure in vessel (DPV-166-173QQ), from -20 to 300 seconds.

Fig. 201 Differential pressure in vessel (DPV-166-173QQ), from -6 to 42 seconds.

Fig. 202 Differential pressure in vessel (DPV-166Q-UP), from -20 to 300 seconds.

Fig. 203 Differential pressure in vessel (DPV-166Q-UP), from -6 to 42 seconds.

Fig. 204 Differential pressure in vessel core (DPVC-89W-UP), from -20 to 300 seconds.

Fig. 205 Differential pressure in vessel core (DPVC-89W-UP), from -6 to 42 seconds.

Fig. 206 Differential pressure in vessel core (DPVC-89-106WQ), from -20 to 300 seconds.

Fig. 207 Differential pressure in vessel core (DPVC-89-106WQ), from -6 to 42 seconds.

Fig. 208 Differential pressure in vessel core (DPVC-106-122QJ), from -20 to 300 seconds.

Fig. 209 Differential pressure in vessel core (DPVC-106-122QJ), from -6 to 42 seconds.

Fig. 210 Differential pressure in vessel core (DPVC-122-140JD), from -20 to 300 seconds.

Fig. 211 Differential pressure in vessel core (DPVC-122-140JD), from -6 to 42 seconds.

Fig. 212 Differential pressure in vessel accumulator (DPU-ACC-TB), from -20 to 300 seconds.

Fig. 213 Differential pressure in vessel accumulator (DPU-ACC-TB), from -6 to 42 seconds.

Fig. 214 Differential pressure in steam generator secondary (DPU-SG-SEC), from -20 to 300 seconds.

Fig. 215 Differential pressure in steam generator secondary (DPU-SG-SEC), from -6 to 42 seconds.

Fig. 216 Differential pressure across steam generator outlet orifice (DPU-SG-DISC), -20 to 300 seconds.

Fig. 217 Differential pressure across steam generator outlet orifice (DPU-SG-DISC), from -6 to 42 seconds.

Fig. 218 Volumetric flow in intact loop (FTU-1, FTU-9), from -20 to 300 seconds.

Fig. 219 Volumetric flow in intact loop (FTU-1, FTU-9), from -6 to 42 seconds.

Fig. 220 Volumetric flow in intact loop (FTU-13, FTU-15), from -20 to 300 seconds.

Fig. 221 Volumetric flow in intact loop (FTU-13, FTU-15), from -6 to 42 seconds.

Fig. 222 Volumetric flow in broken loop (FTB-21), from -20 to 300 seconds.

Fig. 223 Volumetric flow in broken loop (FTB-21), from -6 to 42 seconds.

Fig. 224 Volumetric flow in broken loop (FTB-30, FTB-37), from -20 to 300 seconds.

Fig. 225 Volumetric flow in broken loop (FTB-30, FTB-37), from -6 to 42 seconds.

Fig. 226 Volumetric flow in core entrance (FTV-CORE-IN), from -20 to 300 seconds.

Fig. 227 Volumetric flow in core entrance (FTV-CORE-IN), from -6 to 42 seconds.

Fig. 228 Volumetric flow in intact loop high pressure injection line (FTU-HPIS), from -20 to 300 seconds.

Fig. 229 Volumetric flow in intact loop high pressure injection line (FTU-HPIS), from -6 to 42 seconds.

Fig. 230 Volumetric flow in broken loop high pressure injection line (FTB-HPIS), from -20 to 300 seconds.

Fig. 231 Volumetric flow in broken loop high pressure injection line (FTB-HPIS), from -6 to 42 seconds.

Fig. 232 Volumetric flow in intact loop low pressure injection line (FTU-LPIS), from -20 to 300 seconds.

Fig. 233 Volumetric flow in intact loop low pressure injection line (FTU-LPIS), from -6 to 42 seconds.

Fig. 234 Volumetric flow in broken loop low pressure injection line (FTB-LPIS), from -20 to 300 seconds.

Fig. 235 Volumetric flow in broken loop low pressure injection line (FTB-LPIS), from -6 to 42 seconds.

Fig. 236 Volumetric flow in intact loop accumulator discharge line (FTU-ACC), from -20 to 300 seconds.

Fig. 237 Volumetric flow in intact loop accumulator discharge line (FTU-ACC), from -6 to 42 seconds.

Fig. 238 Volumetric flow in broken loop accumulator discharge line (FTB-ACC), from -20 to 300 seconds.

Fig. 239 Volumetric flow in broken loop accumulator discharge line (FTB-ACC), from -6 to 42 seconds.

Fig. 240 Volumetric flow from pressurizer (FTU-PRIZE), from -20 to 300 seconds.

Fig. 241 Volumetric flow from pressurizer (FTU-PRIZE), from -6 to 42 seconds.

Fig. 242 Fluid velocity in vessel (FTV-40A, FTV-40M), from -20 to 300 seconds.

Fig. 243 Fluid velocity in vessel (FTV-40A, FTV-40M), from -6 to 42 seconds.

Fig. 244 Momentum flux in intact loop (FDU-1), from -20 to 300 seconds.

Fig. 245 Momentum flux in intact loop (FDU-1), from -6 to 42 seconds.

Fig. 246 Momentum flux in intact loop (FDU-5), from -20 to 300 seconds.

Fig. 247 Momentum flux in intact loop (FDU-5), from -6 to 42 seconds.

Fig. 248 Momentum flux in intact loop (FDU-10), from -6 to 42 seconds.

Fig. 249 Momentum flux in intact loop (FDU-13), from -6 to 42 seconds.

Fig. 250 Momentum flux in intact loop (FDU-15), from -6 to 42 seconds.

Fig. 251 Momentum flux in broken loop (FDB-21), from -6 to 42 seconds.

Fig. 252 Momentum flux in broken loop (FDB-30), from -6 to 42 seconds.

Fig. 253 Momentum flux in broken loop (FDB-37), from -6 to 42 seconds.

Fig. 254 Momentum flux in broken loop (FDB-42), from -20 to 300 seconds.

Fig. 255 Momentum flux in broken loop (FDB-42), from -6 to 42 seconds.

Fig. 256 Momentum flux in core entrance (FDV-CORE-IN), from -20 to 300 seconds.

Fig. 257 Momentum flux in core entrance (FDV-CORE-IN), from -6 to 42 seconds.

Fig. 258 Density in intact loop (GU-1VR, GU-1HZ), from -20 to 300 seconds.

Fig. 259 Density in intact loop (GU-1VR, GU-1HZ), from -6 to 42 seconds.

Fig. 260 Density in intact loop (GU-5VR, GU-10VR), from -20 to 300 seconds.

Fig. 261 Density in intact loop (GU-5VR, GU-10VR), from -6 to 42 seconds.

Fig. 262 Density in intact loop (GU-13VR), from -20 to 300 seconds.

Fig. 263 Density in intact loop (GU-13VR), from -6 to 42 seconds.

Fig. 264 Density in intact loop (GU-15VR, GU-15HZ), from -20 to 300 seconds.

Fig. 265 Density in intact loop (GU-15VR, GU-15HZ), from -6 to 42 seconds.

Fig. 266 Density in broken loop (GB-21VR, GB-23VR), from -20 to 300 seconds.

Fig. 267 Density in broken loop (GB-21VR, GB-23VR), from -6 to 42 seconds.

Fig. 268 Density in broken loop (GB-30VR), from -20 to 300 seconds.

Fig. 269 Density in broken loop (GB-30VR), from -6 to 42 seconds.

Fig. 270 Density in vessel (GV-COR-150HZ), from -20 to 300 seconds.

Fig. 271 Density in vessel (GV-COR-150HZ), from -6 to 42 seconds.

Fig. 272 Density in vessel (GVLP-165HZ, GVLP-172HZ), from -20 to 300 seconds.

Fig. 273 Density in vessel (GVLP-165HZ, GVLP-172HZ), from -6 to 42 seconds.

Fig. 274 Density in pressurizer (GU-PRIZE), from -20 to 300 seconds.

Fig. 275 Density in pressurizer (GU-PRIZE), from -6 to 42 seconds.

Fig. 276 Mass flow in intact loop (FDU-1, GU-1VR), from -20 to 300 seconds.

Fig. 277 Mass flow in intact loop (FDU-1, GU-1VR), from -6 to 42 seconds.

Fig. 278 Mass flow in intact loop (FTU-1, GU-1VR), from -20 to 300 seconds.

Fig. 279 Mass flow in intact loop (FTU-1, GU-1VR), from -6 to 42 seconds.

Fig. 280 Mass flow in intact loop (FDU-5, GU-5VR), from -20 to 300 seconds.

Fig. 281 Mass flow in intact loop (FDU-5, GU-5VR), from -6 to 42 seconds.

Fig. 282 Mass flow in intact loop (FTU-9, GU-10VR), from -20 to 300 seconds.

Fig. 283 Mass flow in intact loop (FTU-9, GU-10VR), from -6 to 42 seconds.

Fig. 284 Mass flow in intact loop (FDU-10, GU-10VR), from -6 to 42 seconds.

Fig. 285 Mass flow in intact loop (FDU-13, GU-13VR), from -6 to 42 seconds.

Fig. 286 Mass flow in intact loop (FTU-13, GU-13VR), from -20 to 300 seconds.

Fig. 287 Mass flow in intact loop (FTU-13, GU-13VR), from -6 to 42 seconds.

Fig. 288 Mass flow in intact loop (FDU-15, GU-15VR), from -6 to 42 seconds.

Fig. 289 Mass flow in intact loop (FTU-15, GU-15VR), from -20 to 300 seconds.

Fig. 290 Mass flow in intact loop (FTU-15, GU-15VR), from -6 to 42 seconds.

Fig. 291 Mass flow in broken loop (FDB-21, GB-21VR), from -6 to 42 seconds.

Fig. 292 Mass flow in broken loop (FTB-21, GB-21VR), from -20 to 300 seconds.

Fig. 293 Mass flow in broken loop (FTB-21, GB-21VR), from -6 to 42 seconds.

Fig. 294 Mass flow in broken loop (FDB-30, GB-30VR), from -6 to 42 seconds.

Fig. 295 Mass flow in broken loop (FTB-30, GB-30VR), from -20 to 300 seconds.

Fig. 296 Mass flow in broken loop (FTB-30, GB-30VR), from -6 to 42 seconds.

Fig. 297 Mass flow in vessel (FDV-CORE-IN, GV-COR-150HZ), from -20 to 300 seconds.

Fig. 298 Mass flow in vessel (FDV-CORE-IN, GV-COR-150HZ), from -6 to 42 seconds.

Fig. 299 Mass flow in vessel (FTV-CORE-IN, GV-COR-150HZ), from -20 to 300 seconds.

Fig. 300 Mass flow in vessel (FTV-CORE-IN, GV-COR-150HZ), from -6 to 42 seconds.

Fig. 301 Mass flow in pressurizer surge line (FTU-PRIZE, GU-PRIZE), from -6 to 42 seconds.

Fig. 302 Core heater rod total power (PWRCOR T-1, PWRCOR T-2), from -20 to 300 seconds.

Fig. 303 Core heater rod total power (PWRCOR T-1, PWRCOR T-2), from -6 to 42 seconds.

Fig. 304 Core heater voltage (VOLT COR-T), from -20 to 300 seconds.

Fig. 305 Core heater voltage (VOLT COR-T), from -6 to 42 seconds.

Fig. 306 Core heater total current (AMPCOR-T), from -20 to 300 seconds.

Fig. 307 Core heater total current (AMPCOR-T), from -6 to 42 seconds.

Fig. 308 Primary pump speed (PUMPU-RPM), from -20 to 300 seconds.

Fig. 309 Primary pump speed (PUMPU-RPM), from -6 to 42 seconds.

Fig. 310 Primary pump torque (PUMPU-CUR), from -20 to 300 seconds.

Fig. 311 Primary pump torque (PUMPU-CUR), from -6 to 42 seconds.

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).

APPENDIX A

POSTTEST ADJUSTMENTS TO DATA FROM SEMISCALE MOD-1 TEST S-05-2

THIS PAGE
WAS INTENTIONALLY
LEFT BLANK

APPENDIX A

POSTTEST ADJUSTMENTS TO DATA FROM SEMISCALE MOD-1 TEST S-05-2

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-05-2 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 seconds before initiation of blowdown and at 300 seconds 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.

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 (see Table A-I)

C_1 = scaling factor (see Table A-I).

TABLE A-I

CONSTANTS FOR PRESSURE MEASUREMENT
CORRECTIONS (TEST S-05-2)

<u>Detector Identification</u>	<u>C_0</u>	<u>C_1</u>
PU-13(F)	-27.7	0.9865
PU-SGSD	32.0	1.1554
PV-UP+10	2.9	0.9967
PU-PRIZE	11.7	1.0008
PB-CN1	-26.0	0.9875
PB-23	-7.5	0.9903
PB-42	-12.6	0.9906
PB-HN1	11.8	0.9843
PB-37	10.2	0.9870
PV-LP-166	-6.0	0.9939

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 vessel accumulator (DPV-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 values 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 exact values of the constants are given in Table A-II.

TABLE A-II
 CONSTANTS FOR DIFFERENTIAL PRESSURE
 MEASUREMENT CORRECTIONS (TEST S-05-2)

Detector Identification	K	C_1	t_1	C_2	t_2	C_3	t_3
DPU-UP-3	1	0.013					
DPU-3-7	1	0.293	0	0.213	0.01	0.073	30
DPU-7-10	1	-0.027	0	-0.021	0.01	-0.007	30
DPU-12-10	1	0.523	0	0.443	0.01	0.293	30
DPU-12-10L	1	0.047	0	0.054	0.01	0.066	30
DPU-12-15	1	0.045					
DPU-15-1	1	0.393	0	0.313	0.01	0.193	30
DPU-15-1L	1	-0.027	0	0.013	0.01	0.033	30
DPU-15-IANN	1	0.053	0	0.038	0.01	0.011	30
DPU-PRESLL	1	-0.015	0	0.020	0.01	0.025	30
DPU-PR-4	1	-13.91	0	-12.51	0.01	-10.21	30
DPB-UP-30	1	0.033	0	0.025	0.01	0.012	30
DPB-21-IANN	1	-0.047	0	-0.027	0.01	0.013	30
DPB-23-CN1	-1	-2.395	0	-0.895	0.01	0.405	30
DPB-30-36L	1	4.865	0	2.965	0.01	0.165	30
DPB-32U-36L	1	4.071	0	2.371	0.01	1.729	30
DPB-36L-37	1	-0.236	0	-0.136	0.01	0.064	30

TABLE A-II(continued)

Detector Identification	K	C_1	t_1	C_2	t_2	C_3	t_3
DPB-37-38	1	0.023	0	0.023	0.01	-0.002	30
DPB-38-40	1	-7.010	0	-5.510	0.01	-3.210	30
DPB-40-42	1	-0.140	0	-0.117	0.01	-0.070	30
DPV-UP-IANN	1	-0.835	0	-0.865	0.01	-0.925	30
DPU-0-9GQ	1	-0.126	0	-0.086	0.01	-0.056	30
DPV-9-26QQ	1	0.035	0	0.026	0.01	0.010	30
DPV-9-166QQ	1	0.530	0	0.390	0.01	0.120	30
DPV-26-55QM	1	-0.125	0	-0.055	0.01	0.065	30
DPV-55-110MM	1	-0.051	0	-0.036	0.01	-0.011	30
DPU-110-156MQ	1	-1.009	0	-0.909	0.01	-0.709	30
DPV-166-173QQ	1	-0.026	0	-0.019	0.01	-0.008	30
DPU-LP-UP	1	0.053	0	0.050	0.01	0.043	30
DPVC-89W-UP	1	0.655	0	0.805	0.01	1.065	30
DPVC-89-106WG	1	0.083	0	0.095	0.01	0.123	30
DPVC-106-122QJ	1	0.144					
DPU-ACC-TB	-1	-0.800					
DPU-SGDISC	1	0.500					

3. MOMENTUM FLUX MEASUREMENTS (DRAG DISCS)

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 equations:

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

where

$F'(t)$ = corrected data

$F(t)$ = raw data

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

D_o = 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-05-2)

<u>Detector Identification</u>	<u>D₀</u>	<u>D₁</u>	<u>T(t)^[a]</u>				
FDV-CORE-IN	-0.06	0.0000483	TFV-LP-7				
FDU-10		0.0002471	TMU-1T16				
FDU-13	0.056	0.0009091	TMU-15B16				
FDB-21		-0.0006077	TMB-20B16				
FDB-42		-0.0007846	TFB-42				
FDU-1	0.05	-0.0005269	TMU-1T16				
FDU-15		-0.0013000	TMU-15B16				
FDU-5	-0.097	-0.0001148	TMU-1T16				
	<u>K</u>	<u>C₁</u>	<u>t₁</u>	<u>C₂</u>	<u>t₂</u>	<u>C₃</u>	<u>t₃</u>
FDB-30	1	0.464	0	0.427	20	0.416	42

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

The drag discs, FDB-30 and FDB-37, were partially filled with subcooled water during blowdown, giving them an unpredictable temperature response. However, corrections were performed to the data from FDB-30. The data from FDB-30 were set to zero prior to blowdown when no flow was present in the broken loop. The required data adjustment for zero flow was considered to be a result of detector temperature sensitivity and, in spite of the unpredictable temperature response, it was felt that for a short period of time following blowdown initiation a closer approximation to the real physical conditions being measured could be obtained by adjusting the data using fluid temperature data from TFB-30. Adjustments were made using the same time-based equations used for the differential pressure corrections described in Section A-II-2. Values of the constants are given in Table A-III.

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:

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

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:

$$\rho = -1.15 - 1.4488 \left[F(t) - 26 \right]$$

TABLE A-IV
 CONSTANTS FOR DENSITY MEASUREMENT
 CONVERSIONS TO ENGINEERING UNITS (TEST S-05-2)

<u>Detector Identification</u>	<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>
GV-COR-150HZ	0.9983	0.238	0.014	3.86
GB-30VR	1.1110	-0.6703	0.0095	6.45
GU-1VR	1.0758	-0.2401	0.0095	3.43
GU-1HZ	1.2449	-1.2683	0.0095	5.32
GU-5VR	1.1836	-1.0994	0.0095	6.07
GU-10VR	1.1726	-1.0729	0.0095	6.78
GU-13VR	1.2408	-0.6777	0.0095	2.88
GU-15VR	1.1162	-0.8011	0.0095	7.25
GU-15HZ	1.0447	-0.0578	0.0095	1.74
GB-21VR	1.0384	-0.1988	0.0095	6.34
GB-23VR	1.0847	-0.6098	0.006	7.56
GU-PRIZE	1.0476	-0.0664	0.0095	1.74
GVLP-165HZ	0.7226	2.1371	0.014	7.67

5. CORE POWER MEASUREMENTS

Corrections to core power readings are determined from the core voltage and core current readings, with a slight adjustment for the power lost in setting the core radial peaking factor. The adjustments are as follows:

$$\text{PWRCOR T-1: } F'(t) = 0.9864 F(t) - 1.34 = \left[(\text{volts}) \quad (\text{current}) \quad (0.974) \right]$$

$$\text{PWRCOR T-2: } F'(t) = 0.9917 F(t) + 4.39 = \left[(\text{volts}) \quad (\text{current}) \quad (0.974) \right]$$

where

$F'(t)$ = core power in kilowatts

$F(t)$ = the raw core power reading.

DISTRIBUTION RECORD FOR TREE-NUREG-1051

Internal Distribution

- 1 - Chicago Patent Group - ERDA
9800 South Cass Avenue
Argonne, Illinois 60439
- 2-4 - A. T. Morphew
Classification and Technical Information Officer
ERDA - ID
Idaho Falls, Idaho 83401
- 5 - R. J. Beers, ID
- 6 - P. E. Litteneker, ID
- 7 - R. E. Tiller, ID
- 8 - R. E. Wood, ID
- 9 - H. P. Pearson, Supervisor
Technical Information
- 10-19 - INEL Technical Library
- 20-39 - Authors
- 40-92 - Special Internal

External Distribution

- 93-94 - Saul Levine, Director
Office of Nuclear Regulatory Research, NRC
Washington, D.C. 20555
- 95-398 - Distribution under NRC-2, Water Reactor Safety Research
Systems Engineering