165
1-74
ANCR-1147

OR-728

UC-78

EXPERIMENT DATA REPORT
FOR 1-1/2-LOOP SEMISCALE SYSTEM
ISOTHERMAL TEST 1014

E.M. Feldman
P.A. Pinson

Aerojet Nuclear Company

NATIONAL REACTOR TESTING STATION

Idaho Falls, Idaho. — 83401

MASTER

DATE PUBLISHED—MARCH 1974

PREPARED FOR THE

U. S. ATOMIC ENERGY COMMISSION

IDAHO OPERATIONS OFFICE UNDER CONTRACT AT(10-1)-1375

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.

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 22151
Price: Printed Copy \$5.45; Microfiche \$0.95

LEGAL NOTICE

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Atomic Energy 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.

ANCR-1147

Light-Water Reactor Technology
TID-4500

EXPERIMENT DATA REPORT FOR 1-1/2-LOOP SEMISCALE SYSTEM

ISOTHERMAL TEST 1014

by

E. M. Feldman

P. A. Pinson

AEROJET NUCLEAR COMPANY

Date Published - March 1974

NOTICE

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Atomic Energy 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.

PREPARED FOR THE U. S. ATOMIC ENERGY COMMISSION
IDAHO OPERATIONS OFFICE
UNDER CONTRACT NO. AT(10-1)-1375

MASTER

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

ABSTRACT

Recorded test data are presented for Test 1014 of the isothermal portion of the Semiscale Blowdown and Emergency Core Cooling (ECC) Project. The data represent the results of an isothermal test utilizing an enlarged downcomer gap (1.0 inch) to investigate system hydraulic response during blowdown without simulated ECC injection. The test was a single-ended break test in which only one of the rupture assemblies actuated. 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 correct. The intent of this report is to make available the uninterpreted data from Test 1014 for use by others and for support of subsequent interpretative reports and analyses.

SUMMARY

Test 1014 was performed in the isothermal portion of the Semiscale Blowdown and Emergency Core Cooling (ECC) Project conducted by Aerojet Nuclear Company for the Atomic Energy Commission. This decompression test in the isothermal series utilized an enlarged downcomer gap (1.0 inch) in the pressure vessel. The experimental system consisted of a pressure vessel with simulated reactor internals; an operating loop with pump, steam generator, and pressurizer; a blowdown loop with a simulated pump, a simulated steam generator, and rupture assemblies; and a pressure suppression system with header and pressure suppression tank.

Test 1014 was initiated from isothermal conditions of 2252 psig and 578°F by a simulated instantaneous cold leg pipe break in which only one of the rupture assemblies actuated. Test 1014 provided data for use in determining system hydraulic response during blowdown without simulated ECC injection.

In general, instrumentation used in Test 1014 functioned as intended and data loss was minimal. Of more than 150 measurements attempted during the test, more than 90% were accomplished. The data appear to be satisfactory for subsequent analysis.

CONTENTS

ABSTRACT	ii
SUMMARY	iii
I. INTRODUCTION	1
II. SYSTEM AND CONDITIONS FOR TEST 1014	3
1. SYSTEM CONFIGURATION	3
2. INITIAL TEST CONDITIONS	3
III. DATA PRESENTATION	5
IV. REFERENCE	52

FIGURES

1. 1-1/2-loop semiscale system and instrumentation -- isometric	6
2. 1-1/2-loop semiscale system and instrumentation -- schematic	7
3. Pressure vessel -- cross-sectional view showing instrumentation	8
4. Pressure vessel -- isometric showing instrumentation	9
5. Fluid temperatures in operating loop	15
6. Fluid temperatures in blowdown loop	15
7. Fluid temperatures in pressure suppression system	16
8. Fluid temperatures in lower plenum at thermocouple rack	16
9. Fluid temperatures in downcomer gap and outlet plenum	17
10. Metal temperatures in core barrel	17
11. Metal temperatures in downcomer filler	18
12. Metal temperatures in vessel wall 95 inches from vessel upper flange face	18
13. Metal temperatures in lower plenum vessel wall	19

14.	Metal temperatures in operating loop hot leg Spool 1	19
15.	Metal temperatures in operating loop cold leg Spool 19	20
16.	Metal temperatures in operating loop cold leg Spool 22	20
17.	Metal temperatures in blowdown loop	21
18.	Momentum flux from drag discs in operating loop hot leg	21
19.	Momentum flux from drag discs in operating loop cold leg	22
20.	Momentum flux from drag discs in blowdown loop	22
21.	Momentum flux from drag discs at core barrel inlet	23
22.	Volumetric flow rate from turbine meters in operating loop	23
23.	Volumetric flow rate from turbine meter in blowdown loop hot leg	24
24.	Volumetric flow rate from turbine meter at core barrel inlet	24
25.	Volumetric flow rate from turbine meter at pressurizer outlet	25
26.	Fluid velocity from turbine meters in downcomer gap	25
27.	Mass flow rate in operating loop hot leg Spool 1	26
28.	Mass flow rate in operating loop at pump discharge (Spool 19)	26
29.	Mass flow rate in operating loop cold leg Spool 22	27
30.	Mass flow rate in operating loop Spools 5 and 15	27
31.	Mass flow rate in blowdown loop Spool 70	28
32.	Mass flow rate in blowdown loop Spools 50 and 76	28
33.	Mass flow rate at core barrel inlet	29
34.	Fluid density in operating loop hot leg	29
35.	Fluid density at operating loop pump inlet and outlet	30
36.	Fluid density in operating loop cold leg	30

37.	Fluid density in blowdown loop	31
38.	Fluid density in vessel	31
39.	Fluid density in pressure suppression header	32
40.	Pressure in operating loop	32
41.	Pressure in blowdown loop	33
42.	Pressure in vessel	33
43.	Pressure in pressure suppression system	34
44.	Pressure at hot leg stub in outlet plenum (LOFT free field pressure transducer) . .	34
45.	Differential pressure across operating loop (DP-22-1)	35
46.	Differential pressure, operating loop hot leg (DP-1-5)	35
47.	Differential pressure across steam generator (DP-5-13)	36
48.	Differential pressure across pump suction orifice (DP-8-13)	36
49.	Differential pressure across operating loop pump inlet (DP-13-15)	37
50.	Differential pressure across operating loop pump (DP-19-15)	37
51.	Differential pressure across operating loop pump, low range (DP-19-15L)	38
52.	Differential pressure across operating loop cold leg (DP-19-22)	38
53.	Differential pressure between cold leg and lower plenum (DP-22-225)	39
54.	Differential pressure across core (DP-255-207)	39
55.	Differential pressure across upper portion of downcomer (DP-216-246)	40
56.	Differential pressure across middle portion of downcomer (DP-246-249)	40
57.	Differential pressure across lower portion of downcomer (DP-249-255)	41
58.	Differential pressure across lower plenum (DP-261-255)	41
59.	Differential pressure across vessel (DP-LOFT)	42

60.	Differential pressure between vessel upper plenum and blowdown loop hot leg (DP-207-70)	42
61.	Differential pressure between vessel inlet annulus and blowdown loop cold leg (DP-264-50)	43
62.	Differential pressure between inner disc cavities (DP-52-62)	43
63.	Differential pressure across blowdown loop hot leg nozzle (DP-76-61)	44
64.	Differential pressure between simulated pump and throat of blowdown loop hot leg nozzle (DP-76-HN2)	44
65.	Differential pressure across simulated pump (DP-96-76)	45
66.	Differential pressure across simulated steam generator (DP-70-96)	45
67.	Differential pressure across blowdown loop hot leg nozzle diverging section (DP6-HN2-HN4)	46
68.	Differential pressure across blowdown loop hot leg nozzle, Station 61 (DP-HN4-61)	46
69.	Differential pressure between vessel upper plenum and pressure suppression tank vapor chamber (DP-207-89)	47
70.	Differential pressure between pressure suppression header and pressure suppression tank vapor chamber (DP-81-89)	47
71.	Differential pressure between pressure suppression header and pressure suppression tank downcomer entrance (DP-81-85)	48
72.	Liquid level in pressure suppression tank	48
73.	Pump speed	49
74.	Pump power	49
75.	Pump torque	50
76.	Flow direction in downcomer gap	50
77.	Displacement of pressure suppression header	51

TABLES

I.	Conditions at Blowdown Initiation	4
II.	Water Chemistry Prior to Blowdown	4
III.	Data Presentation for Isothermal Test 1014	10

EXPERIMENT DATA REPORT FOR 1-1/2-LOOP SEMISCALE SYSTEM

ISOTHERMAL TEST 1014

I. INTRODUCTION

The isothermal blowdown test program is part of the Semiscale Blowdown and Emergency Core Cooling (ECC) Project conducted by Aerojet Nuclear Company. The project is part of an overall AEC-sponsored research and development program directed at (a) quantifying the physical processes controlling system behavior during a postulated loss-of-coolant accident (LOCA) in a pressurized water reactor (PWR), and (b) providing an experimental data base for assessing reactor safety evaluation models.

The 1-1/2-loop semiscale system in which the isothermal test program was conducted includes both an intact operating loop and a broken, or blowdown, loop. The operating loop simulates three unbroken loops of a PWR, and the blowdown loop simulates one broken loop of a PWR. Relative to previous experimental systems, the 1-1/2-loop semiscale system provides a source of more representative coupled-system response data from which to obtain a correspondingly more comprehensive understanding of the thermal and hydraulic processes during an LOCA.

Although major emphasis in the isothermal blowdown experiments was on ECC delivery, Test 1014 was conducted without simulated ECC injection. This test utilized an enlarged (1.0-inch) downcomer gap in the pressure vessel to provide data for comparison with that from other tests, which utilized a smaller downcomer gap (0.5 inch). Test 1014 provided information regarding the effects of the larger gap size and a single-ended cold leg break on general system hydraulic response. Blowdown occurred through one of two 100% break area nozzles in the system; the break nozzle was located in the blowdown loop on the simulated pump discharge side.

The test configuration and conditions for Test 1014 are summarized as follows:

- (1) Initial isothermal conditions were 2252 psig and 578°F
- (2) The downcomer gap size was 1.0 inch
- (3) The standard (long) lower plenum configuration ($L/D = 2.8:1$) was used with the thermal shield installed
- (4) One of two 100% break area nozzles was used.

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 and initial test conditions applicable to Test 1014. Section III presents the data graphs and provides comments and supporting information necessary for interpretation of the data. Reference 1 is recommended as an additional source of information regarding the isothermal experimental system and program; test conditions and procedures; instrument locations, nomenclature, and accuracies; and methods of obtaining and processing the data.

II. SYSTEM AND CONDITIONS FOR TEST 1014

The system configuration and initial test conditions that are specific to Test 1014 are presented.

1. SYSTEM CONFIGURATION

The 1-1/2-loop isothermal semiscale system used for Test 1014 consisted of a pressure vessel with internals; an operating loop with a steam generator, pump, and pressurizer; a blowdown loop with a simulated steam generator, a simulated pump, and two rupture assemblies; and a pressure suppression system with a suppression tank and a header.

For Test 1014 the standard lower plenum ($L/D = 2.8:1$) was used. This plenum consists of the standard (long) lower head and the downcomer filler extension. The lower plenum was thermally insulated with the thermal shield, which consists of the thermal sleeve and the bottom thermal liner plate. A vessel downcomer filler piece was used to provide a 1.0-inch downcomer gap. The system was subjected to a single-ended cold leg pipe break through use of one of two available rupture disc assemblies each employing a 100% break area nozzle. Decompression occurred through the hot leg nozzle and rupture disc assembly near the discharge side of the simulated pump.

The simulated ECC injection system was not used for this test.

2. INITIAL TEST CONDITIONS

Conditions in the semiscale system at initiation of blowdown and the primary system water chemistry prior to blowdown are given in Tables I and II, respectively.

TABLE I
CONDITIONS AT BLOWDOWN INITIATION

Conditions	Test 1014
Core outlet temperature (°F)	578
System flow rate (gpm)	172
System pressure at vessel outlet (psig)	2252
Pump differential pressure (psid)	38
Suppression tank water level (in.)	48
Suppression tank water temperature (°F)	193
Suppression tank pressure (psig)	16.7
Pressurizer water volume (ft ³)	0.63

TABLE II
WATER CHEMISTRY PRIOR TO BLOWDOWN

Conditions	Test 1014
pH	9.2
Chlorides (ppm)	0.08
Conductivity (μmhos)	33
Suspended solids (ppm)	1.8
H ₂ (cc/l)	0.04
O ₂ (cc/l)	42.9
N ₂ (cc/l)	168.1
CO ₂ (cc/l)	0.06
Ar (cc/l)	1.94
Total gas (cc/l)	213

III. DATA PRESENTATION

The data from semiscale isothermal Test 1014 are presented with brief comment. Processing and analysis have been performed only to the extent necessary to obtain appropriate engineering units and to assure that the data are reasonable and correct. 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 in the isothermal tests may have subjected the measurement devices to nonhomogeneous fluid conditions.

Figures 1 through 4 and Table III provide supporting information for interpretation of the data graphs shown in Figures 5 through 77. Figures 1 through 4 show the locations of all measurements in the isothermal system. Table III groups the measurements taken during Test 1014 according to measurement type; identifies the specific measurements, their locations, and the range over which the data are considered valid; provides brief comments regarding the data; and references the measurements and comments to the corresponding figure on which the data are presented. The data are presented, in many instances, in the form of composite graphs to facilitate comparison of a given variable at several locations during the test. Zero seconds on all graphs is the time of blowdown initiation.

Reference 1 provides more detailed information regarding the isothermal experimental system and program; test conditions and procedures; instrument locations, nomenclature, and accuracies; and methods of obtaining and processing the data.

Number Suffixes or Encircled Numbers Alone Identify System Locations (pipe spools, vessel ports, stations)

6

Fig. 3 Pressure vessel -- cross-sectional view showing instrumentation.

Encircled Letter Symbols Denote Measurement Types

Number Suffixes or Encircled Numbers Alone Identify System Locations (vessel ports, stations)

Degrees Indicate Clockwise Orientation Around Vessel as Viewed from Vessel Top with 0° at Centerline of Operating Loop Inlet Cold Leg Nozzle

Nozzles Receding from View Plane are Omitted for Clarity

Pressure Vessel Instruments not Installed in Ports are Shown on ANC-R-2188

View A-A
Long Lower Head
(standard)

View A-A
Short Lower Head

ANC-R-2281

PENETRATION CODE	SIZE (IN.)	ANGULAR LOCATION FROM COLD LEG (CLOCKWISE)	DISTANCE FROM TOP FACE OF VESSEL (IN.)	PRIMARY USAGE	VESSEL WALL PENETRATION DIAMETER (IN.)
200	3/4 NPT	150°	7.88		.750
201	3/4 NPT	30°	7.13		.750
202	1/2 NPT	0°	5.00		.703
203			9.88	DENSITY, SOURCE	.500
204	1/2 NPT	45°	11.88		.560
205	1/4 NPT	50°	14.88		.250
206	1/2 NPT	0°	25.38		.750
207	3/4 NPT	30°	28.38		.750
208	3/4 NPT	150°	28.38		.750
209			30.38	DENSITY, SOURCE	.500
210	1/4 NPT	50°	32.88		.250
211	1/2 NPT	45°	32.38		.560
212	1 NPT	135°	49.88		1.000
213	1/4 NPT	40°	47.88		.750
214	3/4 NPT	315°	55.62	DOWNCOMER SUPPORT	
215	3/4 NPT	75°	55.62	DOWNCOMER SUPPORT	
216	3/4-16-UNF	45°	49.88		.687
217	1/4 NPT	135°	81.859		.250
218	1/4 NPT	75°	81.859		.250
219	1/4 NPT	15°	81.859		.250
220	1/4 NPT	135°	105.859		.250
221	1/4 NPT	75°	105.859		.250
222	1/4 NPT	15°	105.859		.250
223	3/4 NPT	135°	109.989		.750
224	3/4 NPT	315°	109.989		.750
225	1-1/4 NPT	0°	109.989	DENSITY	1.438
226	1 NPT	45°	116.989	TURBINE PROBE	1.000
227	1 NPT	45°	121.297	FILL LINE	1.000
228	1-1/4 NPT	0°	122.370		1.500
229	1 NPT	315°	121.297		1.000
230	3/4-16-UNF	225°	7.13		.687
231			9.88	DENSITY	.5125
232	1/4 NPT	125°	14.88		.250
233	1/4 NPT	245°	14.38		.250
234	3/4-16-UNF	225°	28.38		.687
235			30.38	DENSITY	.5125
236	1/4 NPT	125°	32.38		.250
237	1/4 NPT	230°	32.88		.250
238	1/4 NPT	330°	47.88		.250
239	1 NPT	225°	47.88	ECC	1.000
240	1/4 NPT	165°	47.88		.250
241	1/4 NPT	270°	47.88		.250
242	3/4 NPT	270°	49.88		.750
243	3/4 NPT	195°	55.62	DOWNCOMER SUPPORT	
244	1/2 NPT	225°	59.562		.500
245	1/4 NPT	315°	81.859		.250
246	1/4 NPT	255°	81.859		.250
247	1/4 NPT	195°	81.859		.250
248	1/4 NPT	315°	105.859		.250
249	1/4 NPT	255°	105.859		.250
250	1/4 NPT	135°	105.859		.250
251	1-1/4 NPT	180°	110.010	DENSITY	1.438
252	1 NPT	315°	116.989	TURBINE PROBE	1.000
253	1 NPT	225°	119.234		1.000
254	1 NPT	135°	119.234	ECC	1.000
255	3/4 NPT	240°	121.297		.750
256	3/4 NPT	120°	122.672		.750
257	1/4 NPT	80°	47.88		.250
258	3/4-16-UNF		IN LOWER HEAD	PRESSURE TRANSDUCER	.687
259	1/2 NPT		IN LOWER HEAD	RESISTANCE BULB	.703
260	3/4 NPT		IN LOWER HEAD		.921
261	3/4 NPT		IN LOWER HEAD	DRAIN	.921
262	3/4 NPT		IN LOWER HEAD	AP PROBE	.921
263	1 NPT		IN LOWER HEAD	LEVEL TRANSDUCER	.921
264	1/4 NPT	45°	39.88		.840
265	1/2 NPT	45°	37.88		.540
266	1/2 NPT	299°	37.88		.840
267	1/4 NPT	259°	39.88		.540
268	1 NPT	0°	94.43		
269	1 NPT	90°	94.43		
270	1 NPT	180°	94.43		
271	1 NPT	0°	65.63		
272	1-1/4 NPT	180°	122.37		1.500
273	1-1/4 NPT	315°	7.88		1.500
274	1-1/4 NPT	315°	28.38		1.500
275			114.50		
276			IN LOWER HEAD	DENSITY	

Fig. 4 Pressure vessel -- isometric showing instrumentation.

TABLE III
DATA PRESENTATION FOR ISOTHERMAL TEST 1014

Measurement ^[a]	Location ^[b]	Range ^[c,d]	Figure ^[d]	Comment ^[d]
FLUID TEMPERATURE				
<u>Operating Loop</u>				
		33-650°F	5	Chromel-Alumel thermocouples; estimated accuracy to within $\pm 7^\circ\text{F}$.
TF-1	Hot leg, Spool 1			
TF-15	Pump suction, Spool 15			
TF-19	Pump discharge, Spool 19			
TF-22	Cold leg, Spool 22			
TF-40	Pressurizer outlet, Spool 40			
TS-3	Hot leg, Spool 3			TS-3 is a shielded thermocouple
TS-20	Cold leg, Spool 20			TS-20, a shielded thermocouple, failed during Test 1014
<u>Blowdown Loop</u>				
		33-650°F	6	
TF-50	Cold leg, Spool 50			
TF-51	Cold leg downstream of vessel-side nozzle			
TF-70	Hot leg, Spool 70			
TF-76	Cold leg, Spool 76			
TF-96	Simulated steam generator discharge, Spool 96			
<u>Pressure Suppression System</u>				
TF-83	Header near downcomer entrance (1 inch from ID of header on bottom)	33-350°F	7	TF-83 data conditioning system capability was exceeded above 350°F
TF-86-3	Suppression vessel, Station 86-3	33-300°F		
TF-86-4	Suppression vessel, Station 86-4	33-300°F		TF-86-4 failed during Test 1014
TF-88	Suppression vessel vapor chamber, 2 inches from tank wall	33-350°F		
RB-86-6	Suppression vessel water, Station 86-6	0-1000°F		RB-86-6 is a resistance bulb fluid temperature detector
<u>Lower Plenum (Vertical Thermocouple Rack)</u>				
		33-650°F	8	Nine thermocouples spaced at 2-inch intervals upward from ~1.75 inches above bottom of the lower head
TF-260-2	2-inch level from inside bottom of lower head			
TF-260-4	4-inch level from inside bottom of lower head			
TF-260-6	6-inch level from inside bottom of lower head			
TF-260-8	8-inch level from inside bottom of lower head			
TF-260-10	10-inch level from inside bottom of lower head			
TF-260-12	12-inch level from inside bottom of lower head			TF-260-12 failed during Test 1014
TF-260-14	14-inch level from inside bottom of lower head			
TF-260-16	16-inch level from inside bottom of lower head			
TF-260-18	18-inch level from inside bottom of lower head			TF-260-18 failed during Test 1014
TF-263	In lower plenum head, Station 263			TF-263 data are questionable and not presented
<u>Downcomer Gap</u>				
		33-650°F	9	
TF-47D-180	~48 inches, 180°, extending 1/8 inch into fluid from vessel wall side			
TF-48C-180	~48 inches, 180°, extending 1/8 inch into fluid from core barrel			
TF-48D-0	~48 inches, 0°, extending 1/8 inch into fluid from vessel wall side			
TF-78D-0	~78 inches, 0°			
TF-78D-180	~78 inches, 180°			
TF-95D-45	~95 inches, 45°			
TF-95D-225	~95 inches, 225°			
<u>Outlet Plenum</u>				
		33-650°F	9	
TF-211	32.4 inches, 45°			
METAL TEMPERATURE				
<u>Core Barrel</u>				
		33-650°F	10	Chromel-Alumel thermocouples; estimated accuracy to within $\pm 7^\circ\text{F}$
TM-47C-0	~47 inches, 0°, 1/8 inch from UU			
TM-47C-180	~47 inches, 180°, 1/8 inch from OD			
TM-62C-45	~62 inches, 45°, 1/8 inch from OD			
TM-77C-0	~77 inches, 0°, 1/8 inch from OD			
TM-77C-180	~77 inches, 180°, 1/8 inch from OD			
TM-94C-45	~95 inches, 45°, 1/8 inch from OD			
TM-94C-16-45	~95 inches, 45°, 1/16 inch from ID			
<u>Downcomer Filler</u>				
		33-650°F	11	
TM-48D-0	~48 inches, 0°, 1/16 inch from ID			
TM-48D-180	~48 inches, 180°, 1/16 inch from ID			
TM-63D-45	~63 inches, 45°, 1/16 inch from ID			
TM-63D-225	~63 inches, 225°, 1/8 inch from OD			TM-63D-225 failed during Test 1014
TM-78D-0	~78 inches, 0°, 1/16 inch from ID			

TABLE III (contd.)

Measurement [a]	Location [b]	Range [c,d]	Figure [d]	Comment [d]
TM-78D-180	~78 inches, 180°, 1/16 inch from ID			
TM-95D-45	~95 inches, 45°, 1/16 inch from ID			
TM-95D-225	~95 inches, 225°, 1/16 inch from ID			
TM-116D-45	~116 inches, 45°, 1/16 inch from ID			
TM-116D-225	~116 inches, 225°, 1/16 inch from ID			
TM-116D-0	~116 inches, 0°, 1/16 inch from ID			
<u>Vessel Wall</u>		33-650°F	12	
TM-95V-45	~95 inches, 45°, 1/2 inch from OD			
TM-95D-45	~95 inches, 45°, 1/16 inch from ID			
TM-95D-18-45	~95 inches, 45°, 0.176 inch from OD			
<u>Lower Plenum Vessel Wall</u>		33-650°F	13	
TM-LH-276	In lower plenum head			
TM-LP-IDL	4.9 inches below lower plenum upper Grayloc flange face, 270° from cold leg centerline, 1/16 inch from ID of filler piece			
TM-LP-IDU	5.0 inches above lower plenum upper Grayloc flange face, 270° from cold leg centerline, 1/16 inch from ID of filler piece			TM-LP-IDU failed during Tests 1014
TM-LP-VOD	On vessel OD 5.0 inches above lower plenum upper Grayloc flange face, 270° from cold leg centerline			
<u>Operating Loop</u>		33-650°F		
TM-1B	Hot leg, Spool 1, 1/8 inch from ID (bottom)		14	TM-1B system was not calibrated
TM-1I	Hot leg, Spool 1, 1/8 inch from ID (top)		14	
TM-19I	Cold leg, Spool 19, 1/8 inch ID (top)		15	
TM-19M	Cold leg, Spool 19, 1/4 inch from ID (top)		15	
TM-19S	Cold leg, Spool 19, outside surface (top)		15	
TM-19B	Cold leg, Spool 19, 1/8 inch from ID (bottom)			TM-19B data were not taken during Test 1014
TM-19H	Cold leg, Spool 19, 1/8 inch from ID (middle)		15	
TM-22B	Cold leg, Spool 22, 1/8 inch from ID (bottom)		16	
TM-22H	Cold leg, Spool 22, 1/8 inch from ID (middle)		16	
TM-22I	Cold leg, Spool 22, 1/8 inch from ID (top)			TM-22I failed during Test 1014
TM-22M	Cold leg, Spool 22, 1/4 inch from ID (top)		16	
TM-22S	Cold leg, Spool 22, outside surface (top)		16	
<u>Blowdown Loop</u>		33-650°F	17	
TM-96	Simulated pump suction, Spool 96, 1/16 inch from ID			
<u>MOMENTUM FLUX</u>				Obtained by drag discs which, through a strain gage network, measure force exerted by moving fluid stream. Fluid force is relatable to momentum flux through calibration curve.
<u>Operating Loop</u>		± 100 to $\pm 2.0 \times 10^4$ lb/ft-sec ²		
FD-1	Hot leg, Spool 1		18	
FD-5	Hot leg, Spool 5		18	
FD-15	Pump suction, Spool 15		19	
FD-19	Pump discharge, Spool 19		19	
FD-22	Cold leg, Spool 22		19	
<u>Blowdown Loop</u>			20	
FD-50	Cold leg, Spool 50	± 430 to $\pm 5.0 \times 10^4$ lb/ft-sec ²		
FD-70	Hot leg, Spool 70	± 500 to $\pm 6.0 \times 10^4$ lb/ft-sec ²		FD-70 failed during Test 1014
FD-76	Cold leg, Spool 76	± 500 to $\pm 6.0 \times 10^4$ lb/ft-sec ²		
<u>Pressure Suppression System</u>				
FD-83	Header near downcomer			Not reported; system was not calibrated.
<u>Core Barrel Inlet</u>				
FD-224	110 inches, 315° (target centered in gap)	± 140 to $\pm 3.0 \times 10^4$ lb/ft-sec ²	21	
<u>VOLUMETRIC FLOW RATE</u>				Obtained by turbine flowmeters
<u>Operating Loop</u>		± 40 to ± 800 gpm	22	
FT-1	Hot leg, Spool 1			
FT-19	Pump discharge, Spool 19			
FT-22	Cold leg, Spool 22			FT-22 failed at about 8 sec and appears to have recovered at about 30 sec after blowdown
<u>Blowdown Loop</u>				
FT-70	Hot leg, Spool 70	± 20 to ± 500 gpm	23	
<u>Core Barrel Inlet</u>				
FT-C-1	110 inches from upper vessel flange face	± 40 to ± 300 gpm	24	
<u>Pressurizer</u>				
FT-41	Outlet, Spool 41	± 8 to ± 200 gpm	25	FT-41 system was not calibrated

TABLE III (contd.)

Measurement [a]	Location [b]	Range [c,d]	Figure [d]	Comment [d]
FLUID VELOCITY				
<u>Vessel Downcomer Gap</u>		+1 to +10 ft/sec	26	
FT-239	47.88 inches, 225°			
FT-253	119.23 inches, 225°			
FT-270	94.43 inches, 180°			
MASS FLOW RATE				
<u>Operating Loop</u>		Momentum flux: +100 to $\pm 2.0 \times 10^4$ lb/ft-sec ² volumetric flow: +40 to +300 gpm density: 0.05 to 62.4 lbm/ft ³		Mass flow rate obtained by combining density (gamma attenuation technique) with volumetric flow rate (turbine flowmeters) or with momentum flux (drag disc)
FD-1 D-1V			27	
FT-1 D-1V	Hot leg, Spool 1		27	
FD-19 D-19V			28	
FT-19 D-19V	Pump discharge, Spool 19		28	
FD-22 D-22V			29	
FT-22 D-22V	Cold leg, Spool 22		29	
FD-5 D-5V	Hot leg, Spool 5		30	FT-22 failed at about 8 sec and appears to have recovered at about 30 sec after blowdown
FD-15 D-15V	Pump suction, Spool 15		30	
<u>Blowdown Loop</u>		Momentum flux: +500 to $\pm 5.0 \times 10^4$ lb/ft-sec ² volumetric flow: +40 to +300 gpm density: 0.05 to 62.4 lbm/ft ³		
FD-70 D-70V				FD-70 failed during Test 1014
FT-70 D-70V	Hot leg, Spool 70		31	
FD-50 D-50V	Cold leg, Spool 50		32	
FD-76 D-76V	Cold leg, Spool 76		32	
<u>Core Barrel Inlet</u>		Momentum flux: +140 to $\pm 3.0 \times 10^4$ lb/ft-sec ² volumetric flow: +40 to +300 gpm density: 0.5 to 62.4 lbm/ft ³		
FD-224 D-225H	D-225H: 110.0 inches, 0° FD-224: 110.0 inches, 315°		33	
FT-C-1 D-225H	FT-C-1: 110.0 inches		33	
DENSITY, FLUID				
		0.05 to 62.4 lbm/ft ³		Obtained by gamma attenuation technique (densitometer).
<u>Operating Loop</u>				
D-1V	Hot leg, Spool 1		34	
D-5V	Hot leg, Spool 5		34	
D-15V	Pump suction, Spool 15		35	
D-19V	Pump discharge, Spool 19		35	
D-22H				
D-22V	Cold leg, Spool 22		36	
<u>Blowdown Loop</u>				
D-50V	Cold leg, Spool 50		37	
D-70V	Hot leg, Spool 70			
D-76V	Cold leg, Spool 76			
<u>Vessel</u>			38	
D-225H	Core barrel inlet 110.0 inches, 0°			
D-228H	Lower plenum 122.4 inches, 0°			
D-275V	Lower plenum 114.5 inches, 315°			D-275V system was not calibrated. Gamma beam diagonally across lower plenum
<u>Pressure Suppression Header</u>			39	
D-83V	Near suppression tank downcomer			
PRESSURE				
<u>Operating Loop</u>		0-3000 psig	40	Obtained by Norwood strain gage type transducers accurate to within $\pm 1\%$ of full scale.
P-1	Hot leg, Spool 1			
P-15	Pump suction, Spool 15			
P-19	Pump discharge, Spool 19			
P-40	Pressurizer outlet, Spool 40			
<u>Blowdown Loop</u>		60-3000 psig	41	
P6-HN2	Simulated pump side, nozzle throat, Port 2			
P-50	Cold leg, Spool 50			
P-51	Cold leg, downstream of vessel-side nozzle, Station 51			

TABLE III (contd.)

Measurement ^[a]	Location ^[b]	Range ^[c,d]	Figure ^[d]	Comment ^[d]
P-61	Downstream of hot leg nozzle, Station 61			
P-62	Pump side, rupture assembly inner disc cavity, Spool 62			
P-70	Hot leg, Spool 70			
P-76	Cold leg, Spool 76			
<u>Vessel</u>		60-3000 psig	42	
P-207	Outlet plenum, 28.4 inches, 30°			
P-255	Lower plenum, 121.3 inches, 240°			
<u>Pressure Suppression System</u>			43	
P-53	Blowdown loop cold leg, Spool 53	0-1000 psig		
P-81	Pressure suppression header, Spool 81	0-200 psig		
P-89	Vapor chamber of pressure suppression vessel	0-200 psig		
<u>Outlet Plenum</u>		0-3000 psig	44	
P-LFF-HL (LOFT Pressure Transducer)	Hot leg stub in outlet plenum			
DIFFERENTIAL PRESSURE				Obtained by differential pressure transducers accurate to within $\pm 1\%$ of full range. Transducers zeroed under ambient liquid-full system conditions. Initial conditions shown in the data are the result of flow-induced pressure gradients and density changes from ambient to operating conditions.
<u>Operating Loop</u>				
DP 22-1	Across pressure vessel, operating loop cold leg to hot leg, Spool 22 to Spool 1	± 28.9 psid	45	
DP-1-5	Hot leg, Spool 1 to Spool 5	± 0.72 psid	46	
DP-5-13	Across steam generator, Spool 5 to Spool 13	± 28.9 psid	47	
DP-8-13	Pump suction orifice, Spool 8 to Spool 13	± 10.8 psid	48	
DP-13-15	Spool 13 to Spool 15	± 3.6 psid	49	
DP-19-15	Across pump, Spool 19 to Spool 15	± 50.0 psid	50	
DP-19-15L	Across pump, Spool 19 to Spool 15	± 3.6 psid	51	DP-19-15L detector capability exceeded for first 10 sec after start of blowdown
DP-19-22	Spool 19 to Spool 22	± 10.8 psid	52	
DP-22-255	Cold leg to lower plenum, Spool 22 to Station 255	± 10.8 psid	53	
<u>Vessel</u>				
DP-255-207	Vessel lower plenum to vessel upper plenum, Station 255 to Station 207	± 18.0 psid	54	
<u>Downcomer</u>				
DP-216-246	Station 216 to Station 246	± 1.8 psid	55	
DP-246-249	Station 246 to Station 249	± 1.8 psid	56	
DP-249-255	Station 249 to Station 255	± 0.72 psid	57	
<u>Lower Plenum</u>				
DP-261-255	Station 261 to Station 255	± 0.72	58	
<u>Core</u>				
DP-LOFT	Lower plenum to upper plenum of vessel	± 50.0	59	
<u>Blowdown Loop</u>				
DP-207-70	Vessel upper plenum to blowdown loop hot leg, Station 207 to Spool 70	± 3.6 psid	60	
DP-264-50	Vessel inlet annulus to blowdown loop cold leg, Station 264 to Spool 50	± 18.0 psid	61	
DP-52-62	Across rupture discs, Spool 52 to Spool 62	± 500.0 psid	62	
DP-76-61	Across hot leg nozzle, Spool 76 to Station 61	± 1000.0 psid	63	
DP-76-HN2	Spool 76 to hot leg nozzle downstream throat (Port 2)	± 500.0 psid	64	
DP-96-76	Across simulated pump, Spool 96 to Spool 76	± 100.0 psid	65	
DP-70-96	Across simulated steam generator, Spool 70 to Spool 96	± 100.0 psid	66	
DP5-HN2-HN4	Vessel side, downstream nozzle throat (Port 2) to downstream nozzle expansion section (Port 4)	± 1000.0 psid		DP5-HN2-HN4 data are below reliable range of the detector. Data are not presented
DP6-HN2-HN4	Simulated pump side, downstream nozzle throat (Port 2) to downstream nozzle expansion section (Port 4)	± 1000.0 psid	67	
DP-HN4-61	Across hot leg nozzle outlet, downstream nozzle expansion section (Port 4) to Station 61	± 18.0 psid	68	DP-HN4-61 detector capability exceeded during most of the first 30 sec after start of blowdown
<u>Pressure Suppression System</u>				
DP-207-89	Vessel upper plenum to vapor chamber of pressure suppression tank	± 500.0 psid	69	DP-207-89 detector capability exceeded during first 36 sec after start of blowdown
DP-81-89	Header to tank vapor chamber	± 50.0 psid	70	
DP-81-85	Header to downcomer entrance	± 10.8 psid	71	

TABLE III (contd.)

Measurement ^[a]	Location ^[b]	Range ^[c,d]	Figure ^[d]	Comment ^[d]
LIQUID LEVEL				
<u>Lower Plenum</u>	Port 259			Liquid level in lower plenum is indicated by density measurements D-228H and D-275V and by differential pressure measurement DP-261-255
LL-LFTA-259				System not calibrated, data not digitized.
LL-LFTD-259				
<u>Pressure Suppression System</u>				
LL-PSS	Suppression tank	3.64 psid	72	Obtained by differential pressure cell having one leg connected to a standpipe and the other leg attached to a port in the bottom of the pressure suppression tank
PUMP CHARACTERISTICS				
	Operating loop pump			
<u>Pump Speed</u>				
PS-RPM		--	73	
<u>Pump Power</u>				
PW-PMP		--	74	
<u>Pump Torque</u>				
T-PMP		--	75	
TIME OF BREAK				
				Data not presented; measurement established time of rupture as indicated by t=0 seconds on all data plots
<u>Blowdown Loop</u>				
BW-52	Cold leg, vessel side			
BW-62	Cold leg, simulated pump side			
FLOW DIRECTION				
<u>Downcomer Gap</u>				
S-271	65.6 inches, 0°, Station 271		76	S-271 data are questionable
DISPLACEMENT				
			77	System not calibrated, data useful only for relative motion indication.
<u>Pressure Suppression System</u>				
LDT-PSH	Header first elbow (horizontal deflection)			
LDT-PSV	Beneath suppression vessel (vessel vertical deflection)			

[a] Measurement nomenclature is defined in Reference 1.

[b] Measurement locations are shown in Figures 1 through 4.

[c] The range indicated is that over which the measurement is considered valid.

[d] Ranges, figure numbers, and comments apply to all measurements within a category unless indicated otherwise. The figure numbers correspond to the data plots presented.

Fig. 5 Fluid temperatures in operating loop.

Fig. 6 Fluid temperatures in blowdown loop.

Fig. 7 Fluid temperatures in pressure suppression system.

Fig. 8 Fluid temperatures in lower plenum at thermocouple rack.

Fig. 9 Fluid temperatures in downcomer gap and outlet plenum.

Fig. 10 Metal temperatures in core barrel.

Fig. 11 Metal temperatures in downcomer filler.

Fig. 12 Metal temperatures in vessel wall 95 inches from vessel upper flange face.

Fig. 13 Metal temperatures in lower plenum vessel wall.

Fig. 14 Metal temperatures in operating loop hot leg Spool 1.

Fig. 15 Metal temperatures in operating loop cold leg Spool 19.

Fig. 16 Metal temperatures in operating loop cold leg Spool 22.

Fig. 17 Metal temperatures in blowdown loop.

Fig. 18 Momentum flux from drag discs in operating loop hot leg.

Fig. 19 Momentum flux from drag discs in operating loop cold leg.

Fig. 20 Momentum flux from drag discs in blowdown loop.

Fig. 21 Momentum flux from drag discs at core barrel inlet.

Fig. 22 Volumetric flow rate from turbine meters in operating loop.

Fig. 23 Volumetric flow rate from turbine meter in blowdown loop hot leg.

Fig. 24 Volumetric flow rate from turbine meter at core barrel inlet.

Fig. 25 Volumetric flow rate from turbine meter at pressurizer outlet.

Fig. 26 Fluid velocity from turbine meters in downcomer gap.

Fig. 27 Mass flow rate in operating loop hot leg Spool 1.

Fig. 28 Mass flow rate in operating loop at pump discharge (Spool 19).

Fig. 29 Mass flow rate in operating loop cold leg Spool 22.

Fig. 30 Mass flow rate in operating loop Spools 5 and 15.

Fig. 31 Mass flow rate in blowdown loop Spool 70.

Fig. 32 Mass flow rate in blowdown loop Spools 50 and 76.

Fig. 33 Mass flow rate at core barrel inlet.

Fig. 34 Fluid density in operating loop hot leg.

Fig. 35 Fluid density at operating loop pump inlet and outlet.

Fig. 36 Fluid density in operating loop cold leg.

Fig. 37 Fluid density in blowdown loop.

Fig. 38 Fluid density in vessel.

Fig. 39 Fluid density in pressure suppression header.

Fig. 40 Pressure in operating loop.

Fig. 41 Pressure in blowdown loop.

Fig. 42 Pressure in vessel.

Fig. 43 Pressure in pressure suppression system.

Fig. 44 Pressure at hot leg stub in outlet plenum (LOFT free field pressure transducer).

Fig. 45 Differential pressure across operating loop (DP-22-1).

Fig. 46 Differential pressure, operating loop hot leg (DP-1-5).

Fig. 47 Differential pressure across steam generator (DP-5-13).

Fig. 48 Differential pressure across pump suction orifice (DP-8-13).

Fig. 49 Differential pressure across operating loop pump inlet (DP-13-15).

Fig. 50 Differential pressure across operating loop pump (DP-19-15).

Fig. 51 Differential pressure across operating loop pump, low range (DP-19-15L).

Fig. 52 Differential pressure across operating loop cold leg (DP-19-22).

Fig. 53 Differential pressure between cold leg and lower plenum (DP-22-255).

Fig. 54 Differential pressure across core (DP-255-207).

Fig. 55 Differential pressure across upper portion of downcomer (DP-216-246).

Fig. 56 Differential pressure across middle portion of downcomer (DP-246-249).

Fig. 57 Differential pressure across lower portion of downcomer (DP-249-255).

Fig. 58 Differential pressure across lower plenum (DP-261-255).

Fig. 59 Differential pressure across vessel (DP-LOFT).

Fig. 60 Differential pressure between vessel upper plenum and blowdown loop hot leg (DP-207-70).

Fig. 61 Differential pressure between vessel inlet annulus and blowdown loop cold leg (DP-264-50).

Fig. 62 Differential pressure between inner disc cavities (DP-52-62).

Fig. 63 Differential pressure across blowdown loop hot leg nozzle (DP-76-61).

Fig. 64 Differential pressure between simulated pump and throat of blowdown loop hot leg nozzle (DP-76-HN2).

Fig. 65 Differential pressure across simulated pump (DP-96-76).

Fig. 66 Differential pressure across simulated steam generator (DP-70-96).

Fig. 67 Differential pressure across blowdown loop hot leg nozzle diverging section (DP6-HN2-HN4).

Fig. 68 Differential pressure across blowdown loop hot leg nozzle, Station 61 (DP-HN4-61).

Fig. 69 Differential pressure between vessel upper plenum and pressure suppression tank vapor chamber (DP-207-89).

Fig. 70 Differential pressure between pressure suppression header and pressure suppression tank vapor chamber (DP-81-89).

Fig. 71 Differential pressure between pressure suppression header and pressure suppression tank downcomer entrance (DP-81-85).

Fig. 72 Liquid level in pressure suppression tank.

Fig. 73 Pump speed.

Fig. 74 Pump power.

Fig. 75 Pump torque.

Fig. 76 Flow direction in downcomer gap.

Fig. 77 Displacement of pressure suppression header.

IV. REFERENCE

1. R. S. Alder and P. A. Pinson, *1-1/2-Loop Semiscale Isothermal Test Program -- Program and System Description in Support of Experiment Data Reports*, ANCR-1143 (February 1974).