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EXPERIMENT DATA REPORT
FOR 1-1/2-LOOP SEMISCALE SYSTEM
ISOTHERMAL TEST 1009

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ANCR-1152

Light-Water Reactor Technology
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EXPERIMENT DATA REPORT FOR 1-1/2-LOOP SEMISCALE
SYSTEM ISOTHERMAL TEST 1009

by

E. M. Feldman

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ABSTRACT

Recorded test data are presented for Test 1009 of the isothermal portion of the Semiscale Blowdown and Emergency Core Cooling (ECC) Project. These data represent the results of the first isothermal test utilizing an enlarged downcomer gap (1.69 inches) in the pressure vessel to investigate general system hydraulic response with simulated ECC injection. The data, presented in the form of composite 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 1009 for use by others and for support of subsequent interpretive reports and analysis.

SUMMARY

Test 1009 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 utilized an enlarged downcomer gap (1.69 inches) with a 100% break area nozzle. 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 1009 was initiated from isothermal conditions of 2245 psig and 575°F by a simulated instantaneous large cold leg pipe break. Accumulators injected simulated ECC into the cold legs of the operating and blowdown loops.

In general, instrumentation used in Test 1009 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.

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

SYSTEM ISOTHERMAL TEST 1009

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 process 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.

The major emphasis in the isothermal blowdown experiments was on ECC delivery. Test 1009 was conducted with ECC injection and without a core barrel filler piece. The removal of the core barrel filler piece resulted in the largest possible downcomer gap (1.69 inches) relative to the other semiscale isothermal tests. Test 1009 provided data for determining system response to a variation in downcomer gap.

The test configuration and conditions for Test 1009 are as follows:

- (1) Initial isothermal conditions were 2245 psig and 575°F
- (2) An enlarged downcomer gap size of 1.69 inches was used
- (3) The standard (long) lower plenum configuration ($L/D = 2.8:1$) was used with the thermal shield installed
- (4) The 100% break area nozzles were used
- (5) ECC injection into the cold leg of the operating and blowdown loops was initiated at a primary system pressure of ~600 psig
 - (a) Operating loop accumulator injection flow was ~49 gpm average

- (b) Blowdown loop accumulator injection flow was ~ 10 gpm average.

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 that are applicable to Test 1009. 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 1009

The system configuration and initial test conditions that are specific to Test 1009 are presented.

1. SYSTEM CONFIGURATION

The 1-1/2-loop isothermal semiscale system used for Test 1009 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 tank and a header.

For Test 1009 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. The vessel downcomer filler piece was removed to provide a 1.69-inch downcomer gap for the test. The system was subjected to a double-ended offset cold leg break by means of two rupture disc assemblies each employing 100% break area nozzles.

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

<u>Conditions</u>	<u>Test 1009</u>
Core outlet temperature (°F)	575
System flow rate (gpm)	173
System pressure at vessel outlet (psig)	2245
Pump differential pressure (psid)	41
Suppression tank water level (in.)	47.5
Suppression tank water temperature (°F)	152
Suppression tank pressure	Atmospheric
Pressurizer water volume (ft ³)	0.52
Operating loop accumulator pressure (psig)	1120
Blowdown loop accumulator pressure (psig)	600

TABLE II

WATER CHEMISTRY PRIOR TO BLOWDOWN

<u>Conditions</u>	<u>Test 1009</u>
pH	8.3
Chlorides (ppm)	0.1
Conductivity (μmhos/cm)	20
Suspended solids (ppm)	2.1
H ₂ (cc/l)	0.5
O ₂ (cc/l)	19.2
N ₂ (cc/l)	90.9
CO ₂ (cc/l)	0.03
Total gas (cc/l)	111.0

3. EVENTS AND CONDITIONS FOLLOWING BLOWDOWN INITIATION

The sequence of events following blowdown initiation is presented in Table III. After coolant injection was terminated and blowdown was over, the lower plenum was found to contain 9.5 gal of water.

TABLE III

SEQUENCE OF EVENTS FOLLOWING BLOWDOWN INITIATION

Event	Time After Rupture (sec)
	Test 1009
Blowdown loop ECC injection from blowdown loop ECC accumulator starts	~13
Operating loop ECC injection from operating loop ECC accumulator starts	~16
Operating loop ECC injection from operating loop ECC accumulator stops	~54 [a]
Blowdown loop ECC injection from blowdown loop ECC accumulator stops	~52 [b]
Pressure suppression system spray starts	~88
Pressure suppression system spray stops	~208

[a] ECC water injection ended at ~54 sec after rupture; however, nitrogen gas used to pressurize the ECC continued to flow until ~85 sec.

[b] ECC water injection ended at ~52 sec after rupture; however, nitrogen gas used to pressurize the ECC continued to flow until ~78 sec.

III. DATA PRESENTATION

The data from semiscale isothermal Test 1009 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 nonhomogenous fluid conditions.

Figures 1 through 4 and Table IV provides supporting information for interpretation of the data graphs shown in Figures 5 through 79. Figures 1 through 4 show the locations of all measurements in the isothermal system. Table IV groups the measurements taken during Test 1009 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.

Encircled Letter Symbols Denote Measurement Types

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

Fig. 1 1-1/2-loop semiscale system and instrumentation -- isometric.

Fig. 2 1/1-2-loop semiscale system and instrumentation -- schematic.

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

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	5°	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	5°	32.88		.250
211	1/2 NPT	45°	32.88		.560
212	1 NPT	135°	43.08		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°	45.88		.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	.3125
232	1/4 NPT	125°	14.88		.250
233	1/4 NPT	245°	14.98		.250
234	3/4-16-UNF	225°	28.38		.687
235			30.38	DENSITY	.3125
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
259	1/2 NPT			IN LOWER HEAD	RESISTANCE BULB
260	3/4 NPT			IN LOWER HEAD	
261	3/4 NPT			IN LOWER HEAD	DRAIN
262	3/4 NPT			IN LOWER HEAD	AP PROBE
263	1 NPT			IN LOWER HEAD	LEVEL TRANSDUCER
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		.840
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	DENSITY	
276				IN LOWER HEAD	

Fig. 4 Pressure vessel -- isometric showing instrumentation.

TABLE IV
DATA PRESENTATION FOR ISOTHERMAL TEST 1009

TABLE IV DATA PRESENTATION FOR ISOTHERMAL TEST 1009				
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
<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>			7	
TF-86-3	Suppression Vessel, Station 86-3	33-300°F		
TF-88	Suppression vessel vapor chamber, 2 inches from tank wall	33-650°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	Eight 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-260-14	14-inch level from inside bottom of lower head			
TF-260-16	16-inch level from inside bottom of lower head			
TF-263	In lower plenum head, Station 263			TF-263 failed during Test 1009
<u>Downcomer Gap</u>		33-650°F		
TF-48C-180	~48 inches, 180°, extending 1/8 inch into fluid		9, 11	
TF-214	55.62 inches, 315°		9, 10	
TF-215	55.62 inches, 75°		9, 11	
TF-217	81.86 inches, 135°		9, 10	
TF-219	81.86 inches, 15°		9, 10	
TF-245	81.86 inches, 315°		9, 11	
TF-247	81.86 inches, 195°		9, 11	
TF-268	94.43 inches, 0°		9, 11	
TF-269	94.43 inches, 90°		9, 10	
<u>Outlet Plenum</u>		33-650°F		
TF-211	32.4 inches, 45°		9, 10	
<u>ECC System</u>		33-300°F	12	
TF-ECC-BLA	In line from blowdown loop ECC injection accumulator			
TF-ECC-OLA	In line from operating loop ECC injection accumulator			
METAL TEMPERATURE				
<u>Core Barrel</u>		33-650°F	13	Chromel-Alumel thermocouples; estimated accuracy to within $\pm 7^\circ\text{F}$ The thermocouples located in the core barrel were partially exposed to the local fluid and, therefore, may have been slightly influenced by temperature of the fluid. Data acquisition system for TM-47C-0 failed
TM-47C-0	~47 inches, 0°, 1/8 inch from OD			
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>Vessel Wall</u>		33-650°F	14	
TM-63V-45	~63 inches, 45°, 1/4 inch from ID			
TM-63V-225	~63 inches, 225°, 1/4 inch from ID			
TM-78V-0	~78 inches, 0°, 1/4 inch from ID			
TM-78V-90	~78 inches, 90°, 1/4 inch from ID			
TM-78V-180	~78 inches, 180°, 1/4 inch from OD			Data acquisition system for TM-78V-180 failed.

TABLE IV (contd.)

DATA PRESENTATION FOR ISOTHERMAL TEST 1009

TABLE IV (contd.)				
DATA PRESENTATION FOR ISOTHERMAL TEST 1009				
Measurement (a)	Location (b)	Range (c,d)	Figure (d)	Comment (d)
TM-95V-45	~95 inches 45° 1/2 inch from OD			
TM-95V-225	~95 inches, 225°, 1/4 inch from ID			
TM-95V-25-45	~95 inches, 45°, 1/4 inch from ID			
TM-116V-0	~116 inches, 0°, 1/4 inch from ID			
TM-116V-180	~116 inches, 180°, 1/4 inch from ID			
<u>Lower Plenum Vessel Wall</u>		33-650°F	15	
TM-LN-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-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)		16	No calibration step available for TM-1B
TM-1I	Hot leg, Spool 1, 1/8 inch from ID (top)		16	
TM-19B	Cold leg, Spool 19, 1/8 inch from ID (bottom)		17	
TM-19H	Cold leg, Spool 19, 1/8 inch from ID (middle)		17	
TM-19I	Cold leg, Spool 19, 1/8 inch ID (top)		17	
TM-19S	Cold leg, Spool 19, outside surface (top)		17	
TM-22B	Cold leg, Spool 22, 1/8 inch from ID (bottom)		18	
TM-22H	Cold leg, Spool 22, 1/8 inch from ID (middle)		18	
TM-22I	Cold leg, Spool 22, 1/8 inch from ID (top)		18	
TM-22S	Cold leg, Spool 22, outside surface (top)		18	
<u>Blowdown Loop</u>		33-650°F		
TM-96	Simulated pump suction, Spool 96, 1/16 inch from ID		19	
MOMENTUM FLUX				
<u>Operating Loop</u>		± 100 to $\pm 2.0 \times 10^4$ lb/ft-sec ²		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. The data as presented show magnitude only; direction can be determined from the mass flow rate data
FD-1	Hot leg, Spool 1		20	
FD-5	Hot leg, Spool 5		20	
FD-15	Pump suction, Spool 15		21	
FD-19	Pump discharge, Spool 19		21	
FD-22	Cold leg, Spool 22		21	
<u>Blowdown Loop</u>			22	
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-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	23	
VOLUMETRIC FLOW RATE				
<u>Operating Loop</u>		± 40 to ± 800 gpm	24	Obtained by turbine flowmeters
FT-1	Hot leg, Spool 1			
FT-19	Pump discharge, Spool 19			
FT-22	Cold leg, Spool 22			
<u>Blowdown Loop</u>				
FT-70	Hot leg, Spool 70	± 20 to ± 500 gpm	25	
<u>Core Barrel Inlet</u>				
FT-C-1	110 inches from upper vessel flange face	± 40 to ± 300 gpm	26	FT-C-1 electronic saturation occurs for flows greater than 350 gpm
<u>Pressurizer</u>				
FT-41	Outlet, Spool 41	± 8 to ± 200 gpm	27	
<u>ECC System</u>			28	
FT-ECC-OLA	In ECC line from operating loop ECC injection accumulator	± 4.0 to ± 50 gpm		For FT-ECC-OLA, at about 54 sec ECC water flow ends. Nitrogen gas used as a pressurizer continues to flow
FT-ECC-BLA	In ECC line from blowdown loop ECC injection accumulator	± 2.5 to ± 20 gpm		For FT-ECC-BLA, at about 52 sec ECC water flow ends. Nitrogen gas used as a pressurizer continues to flow

TABLE IV (contd.)

DATA PRESENTATION FOR ISOTHERMAL TEST 1009

TABLE IV (contd.)				
DATA PRESENTATION FOR ISOTHERMAL TEST 1009				
Measurement ^[a]	Location ^[b]	Range ^[c,d]	Figure ^[d]	Comment ^[d]
<u>Pressure Suppression System</u>				
FT-PSS	Pressure suppression System Spray water			FT-PSS was not used until after blowdown. Data were not digitized and are not presented
<u>FLUID VELOCITY</u>				
<u>Vessel Downcomer Gap</u>		± 1 to ± 10 ft/sec		Obtained by turbine flowmeters
FT-212	49.88 inches, 135°			FT-212 failed
FT-239	47.88 inches, 225°			FT-239 failed
FT-253	119.23 inches, 225°			FT-253 failed
FT-270	94.43 inches, 180°			FT-270 failed
<u>MASS FLOW RATE</u>				
<u>Operating Loop</u>		Momentum flux: ± 100 to $\pm 2.0 \times 10^4$ lb/ft-sec ² volumetric flow: ± 40 to ± 800 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			29	
FT-1 D-1V	Hot leg, Spool 1		29	
FD-19 D-19V			30	
FT-19 D-19V	Pump discharge, Spool 19		30	FT-19 D-19V a positive nonphysical spike occurs at about 55 sec
FD-22 D-22V			31	
FT-22 D-22V	Cold leg, Spool 22		31	
FD-5 D-5V	Hot leg, Spool 5		32	
FD-15 D-15V	Pump suction, Spool 15		32	
<u>Blowdown Loop</u>		Momentum flux: ± 500 to $\pm 6.0 \times 10^4$ lb/ft-sec ² or ± 40 to 4.0×10^4 lb/ft-sec ² volumetric flow: ± 40 to ± 300 gpm density: 0.05 to 62.4 lbm/ft ³		
FD-70 D-70V			33	
FT-70 D-70V	Hot leg, Spool 70		33	
FD-50 D-50V	Cold leg, Spool 50		34	
FD-76 D-76V	Cold leg, Spool 76		34	
<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°		35	
FT-C-1 D-225H	FT-C-1: 110.0 inches		35	
<u>DENSITY, FLUID</u>				
		0.05 to 62.4 lbm/ft ³		Obtained by gamma attenuation technique (densitometer).
<u>Operating Loop</u>				
D-1V	Hot leg, Spool 1		36	
D-5V	Hot leg, Spool 5		36	
D-15V	Pump suction, Spool 15		37	
D-19V	Pump discharge, Spool 19		37	
D-22H			38	
D-22V	Cold leg, Spool 22		38	
<u>Blowdown Loop</u>				
D-50V	Cold leg, Spool 50		39	
D-70V	Hot leg, Spool 70			
D-76V	Cold leg, Spool 76			
<u>Vessel</u>				
D-225H	Core barrel inlet 110.0 inches, 0°		40	D-225H data are questionable
D-228H	Lower plenum 122.4 inches, 0°			
D-275V	Lower plenum 114.5 inches, 315°			Gamma beam diagonally across lower plenum. D-275V system was not calibrated over its full range
<u>PRESSURE</u>				
		0-3000 psig	41	Obtained by Norwood strain gage type transducers accurate to within $\pm 1\%$ of full scale.
<u>Operating Loop</u>				
P-1	Hot leg, Spool 1			
P-15	Pump suction, Spool 15			
P-19	Pump discharge, Spool 19			
P-40	Pressurizer outlet, Spool 40			

TABLE IV (contd.)

DATA PRESENTATION FOR ISOTHERMAL TEST 1009

TABLE IV (contd.)				
DATA PRESENTATION FOR ISOTHERMAL TEST 1009				
Measurement [a]	Location [b]	Range [c,d]	Figure [d]	Comment [d]
<u>Blowdown Loop</u>		0-3000 psig	42	
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			
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>		0-3000 psig	43	
P-207	Outlet plenum, 28.4 inches, 30°			
P-255	Lower plenum, 121.3 inches, 240°			
<u>Pressure Suppression System</u>			44	The pressure suppression tank and header were vented to atmospheric pressure until 2 sec prior to blowdown. The 7 psig indicated at blowdown by the transducers in the pressure suppression system is not understood. No detectable zero shift or gain error could be identified nor could any physical explanation be given for this discrepancy. A regulated pressure steam injection control system was designed and connected to the pressure suppression system to provide a specified pressure history during blowdown. The pressure control system failed and manual override attempts resulted in the fluctuations in the pressure suppression system pressure during blowdown.
P-53	Blowdown loop cold leg, Spool 53	0-1000 psig		No calibration step available for P-53
P-80	Pressure suppression header between elbows	0-200 psig		
P-89	Vapor chamber of pressure suppression vessel	0-200 psig		
<u>Outlet Plenum</u>			45	
P-LFF-HL (LOFT Pressure Transducer)	Hot leg stub in outlet plenum			
<u>ECC Accumulator</u>		0-3000 psig	46	
P-ECC-BLA	Blowdown loop ECC accumulator			
P-ECC-OLA	Operating Loop ECC accumulator			
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		DP-22-1 failed
DP-1-5	Hot leg, Spool 1 to Spool 5	± 0.72 psid	47	
DP-5-13	Across steam generator, Spool 5 to Spool 13	± 28.9 psid	48	
DP-8-13	Pump suction orifice, Spool 8 to Spool 13	± 10.8 psid	49	
DP-13-15	Spool 13 to Spool 15	± 3.6 psid	50	
DP-19-15	Across pump, Spool 19 to Spool 15	± 50.0 psid	51	
DP-19-15L	Across pump, Spool 19 to Spool 15	± 3.6 psid	52	
DP-19-22	Spool 19 to Spool 22	± 10.8 psid	53	
NP-77-255	Cold leg to lower plenum, Spool 22 to Station 255	± 10.8 psid	54	
<u>Vessel</u>				
DP-255-207	Vessel lower plenum to vessel upper plenum, Station 255 to Station 207	± 18.0 psid	55	
<u>Downcomer</u>				
DP-216-246	Station 216 to Station 246	± 1.8 psid	56	
DP-246-249	Station 246 to Station 249	± 1.8 psid	57	
DP-249-255	Station 249 to Station 255	± 0.72 psid	58	
<u>Lower Plenum</u>				
DP-261-255	Station 261 to Station 255	± 0.72	59	
<u>Core</u>				
DP-LOFT	Lower plenum to upper plenum of vessel	± 50.0	60	
<u>Blowdown Loop</u>				
DP-207-70	Vessel upper plenum to blowdown loop hot leg, Station 207 to Spool 70	± 3.6 psid	61	
DP-264-50	Vessel inlet annulus to blowdown loop cold leg, Station 264 to Spool 50	± 18.0 psid	62	
DP-52-62	Across rupture discs, Spool 52 to Spool 62	± 500.0 psid	63	

TABLE IV (contd.)

DATA PRESENTATION FOR ISOTHERMAL TEST 1009

TABLE IV (contd.)				
DATA PRESENTATION FOR ISOTHERMAL TEST 1009				
Measurement [a]	Location [b]	Range [c,d]	Figure [d]	Comment [d]
DP-76-61	Across hot leg nozzle, Spool 76 to Station 61	± 1000.0 psid	64	
DP-76-HN2	Spool 76 to hot leg nozzle downstream throat (Port 2)	± 500.0 psid	65	
DP-96-76	Across simulated pump, Spool 96 to Spool 76	± 100.0 psid	66	
DP-70-96	Across simulated steam generator, Spool 70 to Spool 96	± 100.0 psid		
DP5-HN2-HN4	Vessel side, downstream nozzle throat (Port 2) to downstream nozzle expansion section (Port 4)	± 1000.0 psid	68	DP5-HN2-HN4 the cause of the magnitude difference between Test 1009 and other isothermal tests is not understood. A gain error during Test 1009 was suspected, but no gain error could be identified
DP6-HN2-HN4	Simulated pump side, downstream nozzle throat (Port 2) to downstream nozzle expansion section (Port 4)	± 1000.0 psid	69	
DP-HN4-61	Across hot leg nozzle outlet, downstream nozzle expansion section (Port 4) to Station 61	± 18.0 psid	70	
<u>Pressure Suppression System</u>				
DP-207-89	Vessel upper plenum to vapor chamber of pressure suppression tank	± 500.0 psid	71	For DP-207-89, electronic saturation occurs for about the first 17 sec
DP-81-89	Header to tank vapor chamber	± 50.0 psid	72	
DP-81-85	Header to downcomer exit	± 10.8 psid	73	
<u>LIQUID LEVEL</u>				
<u>Lower Plenum</u>				
LL-LFTA-259	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-LFTD-259				
<u>Pressure Suppression System</u>				
LL-PSS	Suppression tank	3.64 psid	74	System not calibrated, data not digitized.
<u>PUMP CHARACTERISTICS</u>				
<u>Operating loop pump</u>				
<u>Pump Speed</u>				
PS-RPM		--	75	
<u>Pump Power</u>				
PW-PMP		--	76	
<u>Pump Torque</u>				
T-PMP		--	77	
<u>TIME OF BREAK</u>				
				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			
<u>FLOW DIRECTION</u>				
<u>Downcomer Gap</u>				
S-271	65.6 inches, 0°, Station 271		78	S-271 data are questionable
<u>DISPLACEMENT</u>				
<u>Pressure Suppression System</u>				
LDT-PSH	Header first elbow (horizontal deflection)		79	System not calibrated, data useful only for relative motion indication.
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 Fluid temperatures in downcomer gap and outlet plenum (expansion of Figure 9 for TF-214, TF-217, TF-219, TF-269, and TF-211).

Fig. 11 Fluid temperatures in downcomer gap (expansion of Figure 9 for TF-48C-180, TF-215, TF-245, TF-247, and TF-268).

Fig. 12 Fluid temperatures in ECC lines from blowdown loop accumulator tank and operating loop accumulator tank.

Fig. 13 Metal temperatures in core barrel.

Fig. 14 Metal temperatures in vessel wall.

Fig. 15 Metal temperatures in lower plenum vessel wall.

Fig. 16 Metal temperatures in operating loop hot leg Spool 1.

Fig. 17 Metal temperatures in operating loop cold leg Spool 19.

Fig. 18 Metal temperatures in operating loop cold leg Spool 22.

Fig. 19 Metal temperatures in blowdown loop.

Fig. 20 Momentum flux from drag discs in operating loop hot leg.

Fig. 21 Momentum flux from drag discs in operating loop cold leg.

Fig. 22 Momentum flux from drag discs in blowdown loop.

Fig. 23 Momentum flux from drag discs at core barrel inlet.

Fig. 24 Volumetric flow rate from turbine meters in operating loop.

Fig. 25 Volumetric flow rate from turbine meter in blowdown loop hot leg.

Fig. 26 Volumetric flow rate from turbine meter at core barrel inlet.

Fig. 27 Volumetric flow rate from turbine meter at pressurizer outlet.

Fig. 28 Volumetric flow rate from ECC accumulator tanks in operating and blowdown loops (turbine meters).

Fig. 29 Mass flow rate in operating loop hot leg Spool 1.

Fig. 30 Mass flow rate in operating loop at pump discharge (Spool 19).

Fig. 31 Mass flow rate in operating loop cold leg Spool 22.

Fig. 32 Mass flow rate in operating loop Spools 5 and 15.

Fig. 33 Mass flow rate in blowdown loop Spool 70.

Fig. 34 Mass flow rate in blowdown loop Spools 50 and 76.

Fig. 35 Mass flow rate at core barrel inlet.

Fig. 36 Fluid density in operating loop hot leg.

Fig. 37 Fluid density at operating loop pump inlet and outlet.

Fig. 38 Fluid density in operating loop cold leg.

Fig. 39 Fluid density in blowdown loop.

Fig. 40 Fluid density in vessel.

Fig. 41 Pressure in operating loop.

Fig. 42 Pressure in blowdown loop.

Fig. 43 Pressure in vessel.

Fig. 44 Pressure in pressure suppression system.

Fig. 45 Pressure at hot leg stub in upper plenum (LOFT free field pressure transducer).

Fig. 46 Pressure of ECC in accumulators.

Fig. 47 Differential pressure, operating loop hot leg (DP-1-5).

Fig. 48 Differential pressure across steam generator (DP-5-13).

Fig. 49 Differential pressure across pump suction orifice (DP-8-13).

Fig. 50 Differential pressure across operating loop pump inlet (DP-13-15).

Fig. 51 Differential pressure across operating loop pump (DP-19-15).

Fig. 52 Differential pressure across operating loop pump, low range (DP-19-15L).

Fig. 53 Differential pressure across operating loop cold leg (DP-19-22).

Fig. 54 Differential pressure between cold leg and lower plenum (DP-22-255).

Fig. 55 Differential pressure across core (DP-255-207).

Fig. 56 Differential pressure across upper portion of downcomer (DP-216-246).

Fig. 57 Differential pressure across middle portion of downcomer (DP-246-249).

Fig. 58 Differential pressure across lower portion of downcomer (DP-249-255).

Fig. 59 Differential pressure across lower plenum (DP-261-255).

Fig. 60 Differential pressure across vessel (DP-LOFT).

Fig. 61 Differential pressure between vessel upper plenum and blowdown loop hot leg (DP-207-70).

Fig. 62 Differential pressure between vessel inlet annulus and blowdown loop cold leg (DP-264-50).

Fig. 63 Differential pressure between inner disc cavities (DP-52-62).

Fig. 64 Differential pressure across blowdown loop hot leg nozzle (DP-76-61).

Fig. 65 Differential pressure between simulated pump and throat of blow-down loop hot leg nozzle (DP-76-HN2).

Fig. 66 Differential pressure across simulated pump (DP-96-76).

Fig. 67 Differential pressure across simulated steam generator (DP-70-96).

Fig. 68 Differential pressure across blowdown loop cold leg nozzle diverging section (DP5-HN2-HN4).

Fig. 69 Differential pressure across blowdown loop hot leg nozzle diverging section (DP6-HN2-HN4).

Fig. 70 Differential pressure across blowdown loop hot leg nozzle, Station 61 (DP-HN4-61).

Fig. 71 Differential pressure between vessel upper plenum and pressure suppression tank vapor chamber (DP-207-89).

Fig. 72 Differential pressure between pressure suppression header and pressure suppression tank vapor chamber (DP-81-89).

Fig. 74 Liquid level in pressure suppression tank (LL-PSS).

Fig. 73 Differential pressure between pressure suppression header and pressure suppression tank downcomer entrance (DP-81-85).

Fig. 75 Pump speed (PS-RPM).

Fig. 76 Pump power (PW-PMP).

Fig. 77 Pump torque (T-PMP).

Fig. 78 Flow direction in downcomer gap (S-271).

Fig. 79 Displacement of pressure suppression system.

IV. REFERENCE

1. S. A. Naff 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).

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