Lawrence Livermore Laboratory

MARK I 1/5-SCALE BOILING WATER REACTOR PRESSURE SUPPRESSION EXPERIMENT
QUICK-LOOK REPORT

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May 24, 1977

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MARK I 1/5-SCALE BOILING WATER REACTOR
PRESSURE SUPPRESSION EXPERIMENT
QUICK-LOOK REPORT
FOR TEST NUMBERS 2.1, 2.2, and 2.3
PERFORMED ON April 26, 1977

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1. INTRODUCTION

This report is intended as a "quick-look" report summarizing the experimental results obtained from pressure suppression experiment numbers 2.1, 2.2, and 2.3 that were performed on the Lawrence Livermore Laboratory's 1/5-scale boiling water reactor (BWR) Mark I pressure suppression experimental facility on April 26, 1977. Any analysis or conclusions contained herein are to be regarded as preliminary.

This report is divided into four sections as follows:

- (1) Introduction
- (2) Summary of Tests
- (3) Analysis of Experimental Data
- (4) Conclusions

Section 2 contains a brief description of the general nature of the tests and a summary of the actual tests that were performed on April 26, 1977, and are being reported herein. Sections 3 and 4 contain the preliminary analysis and any empirical conclusions that can be made at this stage of the project, respectively. Information regarding the Pressure Suppression Experiment Program, the test facility, key design parameters, scaling relationship studies, instrumentation, calibration, and data processing will be found in Quick-Look Report No. 1, dated March 16, 1977 (UCID-17446-1).

2. SUMMARY OF TESTS

2.1 INTRODUCTION

The tests conducted on the 1/5-scale BWR Mark I pressure suppression test facility simulate the three-dimensional transient conditions that are encountered in a wetwell pressure suppression system during a hypothetical loss-of-coolant accident (LOCA). Specifically, the nitrogen (N_2)-driven air clearing phase tests discussed here were performed to obtain the air/water-induced dynamic vertical load function and to determine the response of a 90° sector of a 360° torus structure.

2.2 AIR TEST SCHEDULE

The air clearing phase of the pressure suppression tests was begun on March 4, 1977. Table 2-1 contains a listing of the air pressure suppression test matrix (Revision A).^{*} It includes the actual date any given test was conducted as well as the number of the Quick-Look Report for that test.

2.3 INSTRUMENTATION AND ASSOCIATED ERROR

A summary of instrumentation used during testing and the expected accuracy is shown in Table 2-2. Both the manufacturer's accuracy specifications and the anticipated accuracy specifications are provided. The location and the type of instrumentation used in these tests are identified in Figures 2-1 through 2-8. The excess number of instrumentation ports on the facility allows for flexibility in the location of transducers from test to test.

^{*}Originally planned pressurization rates: 14.0, 18.6, 23.0, 26.0 psi/sec.
Revision A pressurization rates: 20.5, 27.3, 33.8, 38.2 psi/sec.

Table 2-1. Test Matrix for Air Tests (Revision A).

Test No.	Initial Wetwell Pressure kPa (psia)	Initial Drywell Pressure kPa (psia)	Initial Drywell Overpressure m H ₂ O (in)	Downcomer Submergence m (in)	Torus Water-Level m (in)	Initial ^{a/} Drywell Pressurization Rate kPa/s (psi/s)	Imposed Asymmetry	Measurement on 7.5° Sector	Remarks	Date of Test	Quick-Look Report No.
1.0 (a)	20.3 (2.95)	20.3 (2.95)	0	--	--	108 (15.6)	-	-	No water; without orifice	March 4, 1977	17446-1
1.0 (b)	20.3 (2.95)	20.3 (2.95)	0	--	--	121 (17.5)	-	-	No water; with orifice	March 8, 1977	
1.1	20.3 (2.95)	20.3 (2.95)	0	0.24 (9.6)	Nom.	188 (27.3)	-	-	Check out repeatability, 3-D effects	March 18, 1977	17446-2
1.2	20.3 (2.95)	20.3 (2.95)	0	0.24 (9.6)	Nom.	188 (27.3)	-	-		March 25, 1977	
1.3	20.3 (2.95)	20.3 (2.95)	0	0.24 (9.6)	Nom.	188 (27.3)	-	yes		March 30, 1977	
1.4	20.3 (2.95)	20.3 (2.95)	0	0.24 (9.6)	Nom.	141 (20.5)	-	-	Drywell pressurization rate		
1.5	20.3 (2.95)	20.3 (2.95)	0	0.24 (9.6)	Nom.	233 (33.8)	-	-			
1.6	20.3 (2.95)	20.3 (2.95)	0	0.24 (9.6)	Nom.	263 (38.2)	-	-			
2.1	20.3 (2.95)	()	0.12 (4.8)	0.24 (9.6)	Nom.	188 (27.3)	-	-	Drywell overpressure	April 26, 1977	17446-3
2.2	20.3 (2.95)	()	0.18 (7.2)	0.24 (9.6)	Nom.	188 (27.3)	-	-			
2.3	20.3 (2.95)	()	0.18 (7.2)	0.24 (9.6)	Nom.	188 (27.3)	-	yes			
2.4	20.3 (2.95)	20.3 (2.95)	0	0.24 (9.6)	Nom.	188 (27.3)	-	-	Repeatability		
2.5	20.3 (2.95)	20.3 (2.95)	0	0.340 (13.4)	0.10 (3.8)	188 (27.3)	-	-	Downcomer submergence		
2.6	20.3 (2.95)	20.3 (2.95)	0	0.15 (5.8)	-0.10 (-3.8)	188 (27.3)	-	-			
2.7	20.3 (2.95)	20.3 (2.95)	0	0.305 (12.0)	Nom.	188 (27.3)	-	-			
2.8	20.3 (2.95)	20.3 (2.95)	0	0.24 (9.6)	0.061 (2.4)	188 (27.3)	-	yes	Variation of mh		
3.1	20.3 (2.95)	20.3 (2.95)	0	0.24 (9.6)	Nom.	188 (27.3)	-	-			
3.2	20.3 (2.95)	20.3 (2.95)	0	0.24 (9.6)	Nom.	188 (27.3)	-	-			
3.3	20.3 (2.95)	20.3 (2.95)	0	0.24 (9.6)	Nom.	188 (27.3)	(yes) ^{b/}	-	Asymmetry		
3.4	20.3 (2.95)	20.3 (2.95)	0	0.24 (9.6)	Nom.	188 (27.3)	(yes) ^{b/}	-			
3.5	20.3 (2.95)	20.3 (2.95)	0	0.24 (9.6)	Nom.	188 (27.3)	-	yes	Repeatability		
3.6	20.3 (2.95)	20.3 (2.95)	0	0.24 (9.6)	Nom.	188 (27.3)	-	-	45° Sector		

^{a/} Initial drywell pressurization rates changed 17 March 1977 by L. Slegers for NRC-RSR.

^{b/} The degree of asymmetry to be specified in terms of degree of obstruction in drywell vent.

Table 2-2. Summary of Transducer Accuracy and Uncertainty Specifications for the 1/5-Scale Pressure Suppression Test.

Type	Transducers	Range	Transducer Response Time	Manufacturer's Transducer Accuracy (Laboratory Conditions)	Anticipated Transducer Accuracy (Test Conditions)	Expected Uncertainty
Pressure	71	0-69 kPa (0-10 psia)	25 μ s	41 Pa (0.006 psia)	690 Pa (0.1 psia)	3.4% of L_{max+}
	22	0-517 kPa (0-75 psia)	25 μ s	2.59 kPa (0.375 psia)	6.9 kPa (1 psia)	9.6% of L_{max+}
Differential Pressure	3 (annubar)	0-2.5 kPa (0-0.36 psia)	1.7 ms	250 Pa (0.036 psia)	25 Pa (0.0036 psia)	--
	1 (annubar)	0-69 kPa (0-10 psia)	1 ms	6.9 kPa (1 psia)	690 Pa (0.1 psia)	--
	3 (orifice)	0-25 kPa (0-3.6 psia)	1 ms	2.5 kPa (0.36 psia)	250 Pa (0.036 psia)	--
Temperature	38	280-611 K (500-1100°R)	10 ms	1.7 K (3°R)	3.4 K (6°R)	1.2%
Strain Gages	21	0.025 mm (± 1000 μ -in)	1 μ s	0.00025 mm (10 μ -in)	0.0005 mm (20 μ -in)	4% of ϵ_{max}
Load Cells	5	11,000 kg ($\pm 25,000$ lbm)	100 μ s	56.7 kg (125 lbm)	227 kg (500 lbm)	6.5% of L_{max+}
	2	45,000 kg ($\pm 100,000$ lbm)		227 kg (500 lbm)	907 kg (2000 lbm)	18% of L_{max+}
Pool Swell	40	--	1 μ s	--	3.2 mm (1/8 in)	0.5% of PS_{max}
Acceleration	8	25 g	1 ms	0.75 g	0.75 g	--
Displacement	10	10 mm (0.5 in)	1 ms	0.08 mm (0.003 in)	0.25 mm (0.01 in)	--
TOTAL	224					

L_{max+} - maximum expected downward load.

ϵ_{max} - maximum expected strain.

L_{max-} - maximum expected upward load.

PS_{max} - maximum expected pool swell.

Light ports and camera ports are included on the torus. Up to six high-speed cameras and two Storz lens television systems are used to view water pool dynamics. Pressures and temperatures are recorded in the drywell, air storage bottles and connecting lines in addition to the torus. Flow measurements in the connecting lines are made using orifice plates and Pitot-static tubes. Direct dynamic load measurement is provided by load cells in the torus and header supports.

2.4 TEST SUMMARY

Test numbers 2.1, 2.2, and 2.3 of the air clearing experiment series were conducted on the 26th of April, 1977. The primary objective of these tests was to determine the effects of drywell overpressure (downcomer fill level).

The same vent line orifices were used for all three tests. The initial conditions are listed in Table 2-3.

2.5 TEST EVALUATION AND TYPICAL RESULTS

The total number of transducers used in Tests 2.1, 2.2, and 2.3 was 177; the eight pool swell transducers are counted as one transducer because their output was sampled and recorded on a single channel. Records of each test were made with six Hycam cameras (1000 frames/sec) and a Storz lens television system. In addition to this, Tests 2.2 and 2.3 were also recorded with a Milliken camera. The Hycam camera fiducial failed to function during the tests. One pressure transducer, one thermocouple, and two displacement gauges also failed. A list of the 62 engineering plots selected from these experiments is given in Tables 2-5, 2-6, and 2-7 for Tests 2.1, 2.2, and 2.3, respectively. Locations of transducers (as listed in Tables 2-5 through 2-7) are shown pictorially in Figures 2-1 through 2-8.

INSTRUMENTATION LOCATIONS FOR FLOW MEASUREMENTS

LOCATION	TYPE OF XDCR	TRANSDUCER NO.	LOCATION	TYPE OF XDCR	TRANSDUCER NO.
1	P	91	12	T	37
2	T	35	13	P	
3	A	92	14	ΔP	96
4	T	36	15	A	97
5	P	93	16	T	38
6	ΔP		17	P	98
7	A		18	ΔP	99
8	T		19	A	100
9	P ΔP		20	T	39
10	ΔP		21	P	101
11	A	94	22	ΔP	102

P = Pressure
 T = Thermocouple
 A = Annubar, ΔP
 ΔP = Diff. Press.

Figure 2-1. Instrumentation Locations for Flow Measurements.

NRC-1

INSTRUMENTATION LOCATIONS FOR DRYWELL

Test No. 2.1, 2.2, and 2.3

Date April 26, 1977

LCCATION	TYPE OF XDCCR	TRANSDUCER NO.
1	P	
	T	
	T _W	
2	P	
	T	
	T _W	
3	P	73
	T	26
	T _W	
4	P	
	T	
	T _W	
5	P	
	T	200
	T _W	
6	P	74
	T	27
	T _W	
7	P	
	T	
	T _W	
8	P	
	T	
	T _W	
9	P	
	T	
	T _W	
10	P	
	T	
	T _W	

P = Pressure
T = Thermocouple, Fluid
T_W = Thermocouple, Wall

Figure 2-2. Instrumentation Locations for Drywell.

NRC-1

INSTRUMENTATION LOCATIONS FOR TORUS DISPLACEMENT

LOCATION	TYPE OF XDCR	TRANSDUCER NO.
1	D	1
2	D	2
3	D	3
4	D	4
5	D	5
6	D	6
7	D	7
8	D	8
9	D	9
10	D	10
11	D	11
12		
13		

D = Displacement

Figure 2-3. Instrumentation Locations for Torus Displacement.

NRC-1

INSTRUMENTATION LOCATIONS FOR TORUS AND RINGHEADER/DOWNCOMER 7.5° SECTOR

DOWNCOMER		
LOCATION	TYPE OF XDCR	TRANSDUCER NO.
LEFT	P	89
	T	33
	SB	17
	SA	
RIGHT	P	90
	T	34
	SB	18
	SA	
STRUT	P	
	T	
	SB	
	SA	

P = Pressure
 T = Thermocouple
 PS = Pool Swell
 SA = Strain, Axial
 SB = Strain, Bending

TORUS		
LOCATION	TYPE OF XDCR	TRANSDUCER NO.
0°	P	
5°	T	
18°	PS	
37°	PS	9
45°	P	75
85°	T	
90°	P	
128°	P	76
135°	T	
140°	P	
155°	P	77
160°	P	78
165°	P	79
175°	T	30
180°	P	80
195°	P	81
200°	P	82
205°	P	83
220°	P	84
235°	P	85
270°	P	
315°	P	86
323°	PS	10
342°	PS	
355°	T	202

RINGHEADER		
LOCATION	TYPE OF XDCR	TRANSDUCER NO.
0°	P	87
	T	31
	SB	16
	SA	
180°	P	88
	T	32
	SB	
	SA	

Figure 2-4. Instrumentation Locations for Torus and Ringheader/Downcomer 7.5° Sector.

INSTRUMENTATION LOCATIONS FOR VENT PIPE

LOCATION	TYPE OF XDCR	TRANSDUCER NO.
LEFT VENT PIPE	S _B	21
RIGHT VENT PIPE	S _B	22

S_B = Strain, Bending

Figure 2-5. Instrumentation Locations for Vent Pipe.

NRC-1

INSTRUMENTATION LOCATIONS FOR TORUS

LOCATION	TYPE OF XDCR	TRANSDUCER NO.																			
		SECTION																			
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
12°	P						29			42	7					56					
14°	T	1			4		7			10	20										
18°	PS					1	3														
37°	PS					2	4			5	6										
45°	P		NO				30			43	45										
73°	T		NO																		
78°	P																				
128°	P				17		31			44	8										
135°	T	2			5		8			11								13		14	
140°	P				18		32														
155°	P	2			19		33			46	47										
160°	P				20		34														
165°	P	3			21		35			48	9										
175°	T	3		11	6		9			12											
180°	P			11	22	13	36	14		49	10									57	
195°	P	5			23		37			50	11										
200°	P						38														
205°	P	6			25		39			52	51										
220°	P				26		40														
235°	P						41			54	53										
270°	P																				
315°	P									55	12										
323°	PS									7											
342°	PS									8											

P = Pressure
T = Thermocouple, Fluid
PS = Pool Swell

Figure 2-5. Instrumentation Locations for Torus.

NRC-1

INSTRUMENTATION LOCATIONS FOR RINGHEADER/DOWNCOMER

PLAN VIEW

SECTIONS

RINGHEADER									
LOCATION	TYPE OF XDCR	TRANSDUCER NO.							
		SECTION							
		1	2	3	4	5	6	7	8
0°	P	58		61		65			70
	T	15		16		20			25
	SB				7		11		
180°	P			62		66			
	T			17		21			

DOWNCOMER									
LOCATION	TYPE OF XDCR	TRANSDUCER NO.							
		SECTION							
		1	2	3	4	5	6	7	8
LEFT	P	59		63		67			71
	T			18		22			
	SB	1		4		8			13
RIGHT	P	60		64		68			72
	T			19		23			
	SB	2		5					14
STRUT	SA	3							

P = Pressure
 T = Thermocouple, Fluid
 SA = Strain, Axial
 SB = Strain, Bending

Figure 2-7. Instrumentation Locations for Ringheader/Downcomer.

NRC-1

INSTRUMENTATION LOCATIONS FOR TORUS LOADS, RINGHEADER LOADS, AND ACCELERATION

LOCATION	TYPE OF XDCR	TRANSDUCER NO.						
		SECTION						
		1	2	3	4	5	6	7
0°	A	1			3			7
	L							
90°	A				4			
	L				4A, 4B			
180°	A	2			5			8
	L	1	2	3		6	7	
270°	A				6			
	L				5A, 5B			

A = Accelerometer
L = Load Cell

SECTIONS

Figure 2-8. Instrumentation Locations for Torus Loads, Ringheader Loads, and Acceleration.

Table 2-3. Initial Test Conditions^{a/} for Tests 2.1, 2.2, and 2.3.

PARAMETER	TEST 2.1		TEST 2.2		TEST 2.3	
	PLANNED	ACTUAL	PLANNED	ACTUAL	PLANNED	ACTUAL
Pool Temperature	15.6°C (60°F)		15.2°C (59.4°F)		15.3°C (59.5°F)	
Nitrogen Supply:						
Bottle Number	2 and 7		2 and 7		2 and 7	
Total Volume	0.69 m ³ (24.4 ft ³)		0.69 m ³ (24.4 ft ³)		0.69 m ³ (24.4 ft ³)	
Initial Pressure	5929 kPa (860 psig)		5929 kPa (860 psig)		5929 kPa (860 psig)	
Supply Line Nozzle Diameter	4.859 cm (1.913 in)		4.859 cm (1.913 in)		4.859 cm (1.913 in)	
Vent Line Orifice Diameters:						
Left Hand Vent	24 cm (9.5 in)		24 cm (9.5 in)		24 cm (9.5 in)	
Right Hand Vent	24 cm (9.5 in)		24 cm (9.5 in)		24 cm (9.5 in)	
7.5° Vent	9.22 cm (3.63 in)		9.22 cm (3.63 in)		9.22 cm (3.63 in)	
Drywell Pressure	21.5 kPa (3.13 psia)	21.5 kPa (3.13 psia)	22.1 kPa (3.20 psia)	22.1 kPa (3.20 psia)	22.1 kPa (3.20 psia)	22.1 kPa (3.20 psia)
Wetwell Pressure	20.3 kPa (2.95 psia)	20.4 kPa (2.96 psia)	20.3 kPa (2.95 psia)	20.4 kPa (2.96 psia)	20.3 kPa (2.95 psia)	20.2 kPa (2.93 psia)
Drywell Pressurization Rate	188 kPa/s (27.3 psi/s)	182 kPa/s (26.4 psi/s)	188 kPa/s (27.3 psi/s)	168 kPa/s (24.3 psi/s)	188 kPa/s (27.3 psi/s)	182 kPa/s (26.4 psi/s)

a/ Test measurements were made in English units and converted to SI units, rounding off to the appropriate number of significant figures.

The decision was made to range torus pressure transducers to enhance the dynamic pressure signals during vent clearing. As a result, the transducers saturated before the final equilibrium pressures (e.g., Figure 2-11) were reached. The displacement measurements show that the torus movements are in the order of tens of mills or less (Figures 2-66 through 2-70).

2.6 ACCURACY OF DATA

The quality of data reported in Quick-Look Report No. 1 has been maintained in Tests 2.1, 2.2 and 2.3 (refer to Table 2-4).

Table 2-4. Estimated Measurement Uncertainties
for Tests 2.1, 2.2, and 2.3.

TYPE	UNCERTAINTY
Pressure	± 1.0 kPa (± 0.15 psia)
Temperature	$\pm 1.6^{\circ}\text{C}$ ($\pm 3^{\circ}\text{F}$)
Differential Pressure	$\pm 15\%$

Table 2-5. List of Selected Data Plots for Test 2.1.

PARAMETER	LOCATIONS	FIGURE	PAGE	TRANSDUCER NO.
Pressure	Drywell	2-9	2-19	P73
Ullage Pressure	7.5° Sector	2-10	2-20	P75
Pressure at 128°	7.5° Sector	2-11	2-21	P76
Pressure at 165°	7.5° Sector	2-12	2-22	P79
Pressure at 180°	7.5° Sector	2-13	2-23	P80
Ullage Pressure	90° Torus, Plane 9	2-14	2-24	P43
Pressure at 128°	90° Torus, Plane 9	2-15	2-25	P44
Pressure at 165°	90° Torus, Plane 9	2-16	2-26	P48
Pressure at 180°	90° Torus, Plane 9	2-17	2-27	P49
Pressure at 205°	90° Torus, Plane 9	2-18	2-28	P52
Load Cell at 90°	90° Torus, Plane 4	2-19	2-29	L4B
Load Cell at 270°	90° Torus, Plane 4	2-20	2-30	L5B
Load Cell at 180°	90° Torus, Plane 1	2-21	2-31	L1
Load Cell at 180°	Header Support, Plane 3	2-22	2-32	L3

Table 2-6. List of Selected Data Plots for Test 2.2.

PARAMETER	LOCATIONS	FIGURE	PAGE	TRANSDUCER NO.
Pressure	Drywell	2-23	2-33	P73
Ullage Pressure	7.5° Sector	2-24	2-34	P75
Pressure at 128°	7.5° Sector	2-25	2-35	P76
Pressure at 165°	7.5° Sector	2-26	2-36	P79
Pressure at 180°	7.5° Sector	2-27	2-37	P80
Ullage Pressure	90° Torus, Plane 9	2-28	2-38	P43
Pressure at 128°	90° Torus, Plane 9	2-29	2-39	P44
Pressure at 165°	90° Torus, Plane 9	2-30	2-40	P48
Pressure at 180°	90° Torus, Plane 9	2-31	2-41	P49
Pressure at 205°	90° Torus, Plane 9	2-32	2-42	P52
Load Cell at 90°	90° Torus, Plane 4	2-33	2-43	L4R
Load Cell at 270°	90° Torus, Plane 4	2-34	2-44	L5B
Load Cell at 180°	90° Torus, Plane 1	2-35	2-45	L1
Load Cell at 180°	Header Support, Plane 3	2-36	2-46	L3

Table 2-7. List of Selected Data Plots for Test 2.3.

PARAMETER	LOCATIONS	FIGURE	PAGE	TRANSDUCER NO.
Pressure	Drywell	2-37	2-47	P73
Orifice ΔP	7.5° Vent Line	2-38	2-48	P96
Temperature	7.5° Vent Line	2-39	2-49	T37
Orifice ΔP	90° Torus Right Vent	2-40	2-50	P99
Temperature	90° Torus Right Vent	2-41	2-51	T38
Pressure	90° Torus Right Vent	2-42	2-52	P98
Ullage Pressure, 45°	7.5° Sector	2-43	2-53	P75
Pressure at 128°	7.5° Sector	2-44	2-54	P76
Pressure at 165°	7.5° Sector	2-45	2-55	P79
Pressure at 180°	7.5° Sector	2-46	2-56	P80
Ullage Pressure, 45°	90° Torus, Plane 9	2-47	2-57	P43
Pressure at 180°	90° Torus, Plane 3	2-48	2-58	P111
Pressure at 180°	90° Torus, Plane 4	2-49	2-59	P22
Pressure at 180°	90° Torus, Plane 6	2-50	2-60	P36
Pressure at 180°	90° Torus, Plane 7	2-51	2-61	P14
Pressure at 180°	90° Torus, Plane 9	2-52	2-62	P49
Pressure at 180°	90° Torus, Plane 11	2-53	2-63	P10
Pressure at 180°	90° Torus, Plane 20	2-54	2-64	P57
Pressure at 128°	90° Torus, Plane 9	2-55	2-65	P44
Pressure at 165°	90° Torus, Plane 9	2-56	2-66	P48
Pressure at 205°	90° Torus, Plane 9	2-57	2-67	P52

Table 2-7. List of Selected Data Plots for Test 2.3 (Continued).

PARAMETER	LOCATIONS	FIGURE	PAGE	TRANSDUCER NO.
Pressure at 235°	90° Torus, Plane 9	2-58	2-68	P54
Load Cell at 90°	90° Torus, Plane 4	2-59	2-69	L4A
Load Cell at 270°	90° Torus, Plane 4	2-60	2-70	L5A
Load Cell at 180°	90° Torus, Plane 1	2-61	2-71	L1
Load Cell at 180°	Header Support, Plane 2	2-62	2-72	L2
Load Cell at 180°	Header Support, Plane 3	2-63	2-73	L3
Load Cell at 180°	Header Support, Plane 5	2-64	2-74	L6
Load Cell at 180°	Header Support, Plane 6	2-65	2-75	L7
Torus Displacement	Left End	2-66	2-76	D1
Torus Displacement	Right End	2-67	2-77	D10
Torus Displacement	Vertical	2-68	2-78	D3
Torus Displacement	Horizontal, Out	2-69	2-79	D4
Torus Displacement	Horizontal, In	2-70	2-80	D5

NRC TEST NO. 2.1

CHAN 31

ENC3-01
U05/17/77
20:13:57
3' 32
2.364E-03

CE TIME : 04/28/77Z
09.16.08
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ

SA RATE : 0
NCHANS : 15

PRESSURE, PSIA (P-73), DRY WELL, 3

Figure 2-9. Drywell Pressure, Test 2.1.

NRC TEST NO. 2.1

CHAN 11

CE TIME : 04/28/77Z

SA RATE :

0

LOFAU1-01

Z05/04/77

10:27:18

3492

2.864E-03

LO FREQ : 0.100007 HZ

NCHANS :

15

HI FREQ : 174 HZ

PRESSURE, PSIA (P-75), TORUS, 7.5 DEG., 45 DEG.

Figure 2-10. Ullage Pressure, 45°, 7.5° Sector, Test 2.1.

NRC TEST NO. 2.1

CHAN 12

LOFAU1-01
205/04/77
10:27:20
3492
2.864E-03

CE TIME : 04/28/77Z
09.16.08
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ
SA RATE : 0
NCHANS : 15

PRESSURE, PSIA (P-76), TORUS, 7.5 DEG., 128 DEG.

Figure 2-11. Pressure at 128°, 7.5° Sector, Test 2.1.

NRC TEST NO. 2.1

CHAN 15

LOFAU1-02
205/04/77
10:32:08
3492
2.864E-03

CE TIME : 04/28/77Z

SA RATE : 0

09.16.08

NCHANS : 15

LO FREQ : 0.100007 HZ

HI FREQ : 174 HZ

PRESSURE, PSIA (P-79), TORUS, 7.5 DEG., 165 DEG.

Figure 2-12. Pressure at 155°, 7.5° Sector, Test 2.1.

NRC TEST NO. 2.1

CHAN 16

CE TIME : 04/28/77Z

SA RATE :

0

09.16.08

NCHANS :

15

LO FREQ : 0.100007 HZ

HI FREQ : 174 HZ

LOFAU1-02

205/04/77

10:32:10

3492

2.864E-03

PRESSURE, PSIA (P-80), TORUS, 7.5 DEG., 180 DEG.

Figure 2-13. Pressure at 180°, 7.5° Sector, Test 2.1.

NRC TEST NO. 2.1

CHAN 43

LOFAU1-03
205/04/77
10:37:40
3492
2.864E-03

CE TIME : 04/28/77Z
09.16.08
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ

SA RATE : 0
NCHANS : 15

PRESSURE, PSIA (P-43), TORUS, 9-45 DEG.

Figure 2-14. Ullage Pressure at Plane 9, 45°, 90° Torus Sector, Test 2.1.

NRC TEST NO. 2.1

CHAN 44

CE TIME : 04/28/77Z

SA RATE : 0

LOFAU1-04

09.16.08

NCHANS : 15

205/04/77

LO FREQ : 0.100007 HZ

10:40:25

HI FREQ : 174 HZ

3492

2.864E-03

PRESSURE, PSIA (P-44), TORUS, 9-128 DEG.

Figure 2-15. Pressure at Plane 9, 128°, 90° Torus Sector, Test 2.1.

NRC TEST NO. 2.1

CHAN 48

CE TIME : 04/28/77
09.16.08
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ

SA RATE : 0
NCHANS : 15

LOFAL11-04
205/04/77
10:42:14
3492
2.864E-03

Figure 2-16. Pressure at Plane 9, 165°, 90° Torus Sector, Test 2.1.

LOFAU1-04
Z05/04/77
10:42:15
3492
2.864E-03

CE TIME : 04/28/77Z
09.16.08
LO FREQ : 0.100007 MZ
HI FREQ : 174 MZ

SA RATE : 0
NCHANS : 15

Figure 2-17. Pressure at Plane 9, 180°, 90° Torus Sector, Test 2.1.

LOFAUI-02
Z05/04/77
10:32:12
3492
2.864E-03

SA RATE : 0
NCHANS : 15

NRC TEST NO. 2.1

CHAN 12

CE TIME : 04/28/77Z

SA RATE : 0

0

09.16.08

NCHANS : 15

15

LO FREQ : 0.100007 HZ

HI FREQ : 174 HZ

ENC1-01

U05/17/77

20:11:41

3492

2.864E-03

Figure 2-19. Load at Plane 4, 90°, 90°
Torus Sector, Test 2.1.

NRC TEST NO. 2.1

CHAN 14

ENC1-01
U05/17/77
20:11:44
3492
2.864E-03

CE TIME : 04/28/77Z
09.16.08
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ

SA RATE : 0
NCHANS : 15

LOAD, LBS. (L-5B), TORUS TRUNION, 4-270 DEG.

Figure 2-20. Load at Plane 4, 270°, 90°
Torus Sector, Test 2.1.

NRC TEST NO. 2.1

CHAN 1

ENC1-01
U05/17/77
20:11:23
3492
2.864E-03

CE TIME : 04/28/77Z
09.16.08
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ

SA RATE : 0
NCHANS : 15

LOAD, LBS (L-1), TORUS SUPPORT, 1-180 DEG.

Figure 2-21. Load at Plane 1, 180°, 90°
Torus Sector, Test 2.1.

NRC TEST NO. 2.1

CHAN 3

ENC1-01
U05/17/77
20:11:25
3492
2.864E-03

CE TIME : 04/28/77Z
09.16.08
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ
SA RATE : 0
NCHANS : 15

LOAD, LBS (L-3), RINGHDR SUPPORT, 3-180 DEG.

Figure 2-22. Ringheader Load at Plane 3, 180°, 90° Torus Sector, Test 2.1.

NRC TEST NO. 2.2

CHAN 31

ENC3B-01
U05/17/77
21:32:10
3492
2.854E-03

CE TIME : 04/28/77Z
09.16.08
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ
SA RATE : 0
NCHANS : 15

Figure 2-23. Drywell Pressure, Test 2.2.

NRC TEST NO. 2.2

CHAN 11

LOFAU1-01
U05/02/77
13:39:44
3492
2.864E-03

CE TIME : 04/28/77Z

SA RATE : 0

09.16.08

NCHANS : 15

LO FREQ : 0.100007 HZ

HI FREQ : 174 HZ

Figure 2-24. Ullage Pressure, 45°,
7.5° Sector, Test 2.2.

NRC TEST NO. 2.2

CHAN 12

CE TIME : 04/28/77

SA RATE : 0

0

09.16.08

NCHANS : 15

15

LO FREQ : 0.100007 HZ

HI FREQ : 174 HZ

LOFAU1-01

U05/02/77

13:39:45

3492

2.864E-03

Figure 2-25. Pressure at 128°, 7.5° Sector, Test 2.2.

NRC TEST NO. 2.2

CHAN 15

CE TIME : 04/28/77Z

SA RATE :

0

09.16.08

NCHANS :

15

LO FREQ : 0.100007 HZ

HI FREQ : 174 HZ

LOFAU1-02

U05/02/77

13:40:39

3492

2.864E-03

PRESSURE, PSIA (P-79), TORUS, 7.5 DEG., 165 DEG.

Figure 2-26. Pressure at 165°, 7.5° Sector, Test 2.2.

NRC TEST NO. 2.2

CHAN 16

CE TIME : 04/28/77Z

SA RATE : 0

LOFAU1-02

09.16.08

NCHANS : 15

U05/02/77

LO FREQ : 0.100007 HZ

13:40:39

HI FREQ : 174 HZ

3492

2.864E-03

Figure 2-27. Pressure at 180°, 7.5°
Sector, Test 2.2.

NRC TEST NO. 2.2

CHAN 43

LOFAU1-03
U05/02/77
13:41:51
3.92
2.864E-03

CE TIME : 04/28/77Z
09.16.08
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ

SA RATE : 0
NCHANS : 15

PRESSURE, PSIA (P-43), TORUS, 9-45 DEG.

Figure 2-28. Ullage Pressure at Plane 9, 45°, 90° Torus Sector, Test 2.2.

NRC TEST NO. 2.2

CHAN 44

LOFAU1-04
U05/02/77
13:42:50
3492
2:064E-03

CE TIME : 04/28/77Z
09.16.08
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ

SA RATE : 0
NCHANS : 15

PRESSURE, PSIA (P-44), TORUS, 9-128 DEG.

Figure 2-29. Pressure at Plane 9, 128°, 90° Torus Sector, Test 2.2.

NRC TEST NO. 2.2

CHAN 48

LOFAU1-04
U05/02/77
13:42:56
3492
2.854E-03

CE TIME : 04/28/77Z
09.16.08
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ
SA RATE : 0
NCHANS : 15

Figure 2-30. Pressure at Plane 9, 165°, 90° Torus Sector, Test 2.2.

NRC TEST NO. 2.2

CHAN 49

LOFAU1-04
U05/02/77
13:42:57
3492
2.864E-03

CE TIME : 04/28/77Z
09.16.08
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ
SA RATE : 0
NCHANS : 15

Figure 2-31. Pressure at Plane 9, 180°, 90° Torus Sector, Test 2.2.

NRC TEST NO. 2.2

CHAN 22

CE TIME : 04/28/77Z
09.16.08
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ

SA RATE : 0
NCHANS : 15

LOFAU1-02
U05/02/77
13:40:44
3492
2.864E-03

Figure 2-32. Pressure at Plane 9, 205°, 90° Torus Sector, Test 2.2.

NRC TEST NO. 2.2

CHAN 12

CE TIME : 04/28/77Z
09.16.08
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ

SA RATE : 0
NCHANS : 15

ENC18-01
U05/17/77
21:22:51
3492
2.864E-03

Figure 2-33. Load at Plane 4, 90°, 90°
Torus Sector, Test 2.2.

NRC TEST NO. 2.2

CHAN 14

CE TIME : 04/28/77Z

SA RATE : 0

ENC18-01

U05/17/77

09.16.08

NCHANS : 15

21:22:54

LO FREQ : 0.100007 HZ

3492

HI FREQ : 174 HZ

2.864E-03

Figure 2-34. Load at Plane 4, 270°, 90°
Torus Sector, Test 2.2.

NRC TEST NO. 2.2

CHAN 1

ENC18-01
U05/17/77
21:22:38
3492
2.864E-03

CE TIME : 04/28/77Z

SA RATE : 0

09.16.08

NCHANS : 15

LO FREQ : 0.100007 HZ

HI FREQ : 174 HZ

LOAD, LBS (L-1), TORUS SUPPORT, 1-180 DEG.

Figure 2-35. Load at Plane 1, 180°, 90°
Torus Sector, Test 2.2.

NRC TEST NO. 2.2

CHAN 3

ENC18-01
U05/17/77
21:22:41
3492
2.864E-03

CE TIME : 04/28/77Z
09.16.08
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ

SA RATE : 0
NCHANS : 15

LOAD, LBS (L-3), RINGHDR SUPPORT, 3-180 DEG.

Figure 2-36. Ringheader Load at Plane 3, 180°,
90° Torus Sector, Test 2.2.

NRC TEST NO. 2.3

CHAN 31

ENC3C-01
205/18/77
17:21:14
3492
2.864E-03

CE TIME : 04/28/77Z
09.16.08
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ

SA RATE : 0
NCHANS : 15

Figure 2-37. Drywell Pressure, Test 2.3.

NRC TEST NO. 2.3

CHAN 53

CE TIME : 04/28/77

SA RATE : 0

LOFAU1-04

09.16.08

NCHANS : 15

R05/07/77

LO FREQ : 0.100007 HZ

09:48:40

HI FREQ : 174 HZ

3492

2.864E-03

DELTA PRESS., PSID (P-96), 7.5 DEG., ORIFICE, 14

Figure 2-38. Differential Pressure Across the Vent Line Orifice, 7.5° Sector, Test 2.3.

Figure 2-39. Upstream Nitrogen Temperature in Vent Line, 7.5° Sector, Test 2.3.

NRC TEST NO. 2.3

CHAN 55

CE TIME : 04/28/77

SA RATE :

0

09.16.08

NCHANS :

15

LO FREQ : 0.100007 HZ

HI FREQ : 174 HZ

LOFAU1-04

R05/07/77

09:48:43

3492

2.864E-03

DELTA PRESS , PSID (P-99), ORIFICE RT. VENT 18

Figure 2-40. Differential Pressure Across Right Vent Line Orifice, 90° Torus Sector, Test 2.3.

NRC TEST NO. 2.3

CHAN 40

LOFAU3-03
R05/07/77
11:48:08
3492
2.864E-03

CE TIME : 04/28/77Z
09.16.08
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ

SA RATE : 0
NCHANS : 15

Figure 2-41. Upstream Nitrogen Temperature in Right Vent Line, 90° Torus Sector, Test 2.3.

NRC TEST NO. 2.3

CHAN 59

CE TIME : 04/28/77
09.16.08
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ

SA RATE : 0
NCHANS : 15

LOFAU1-05
R05/07/77
09:48:56
3492
2.864E-03

Figure 2-42. Right Vent Line Pressure Upstream of Orifice, 90° Torus Sector, Test 2.3.

NRC TEST NO. 2.3

CHAN 11

LOFAUI-01
R05/07/77
09:46:29
3492
2.864E-03

CE TIME : 04/28/77Z
09.16.08
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ

SA RATE : 0
NCHANS : 15

Figure 2-43. Ullage Pressure, 45°, 7.5° Sector, Test 2.3.

NRC TEST NO. 2.3

CHAN 12

LOFAU1-01
R05/07/77
09:46:30
3492
2.864E-03

CE TIME : 04/28/77
09.16.08
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ

SA RATE : 0
NCHANS : 15

PRESSURE, PSIA (P-76), TORUS, 7.5 DEG., 128 DEG.

Figure 2-44. Pressure at 128°, 7.5° Sector, Test 2.3.

NRC TEST NO. 2.3

CHAN 15

CE TIME : 04/28/77
09.16.08
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ

SA RATE : 0
NCHANS : 15

LOFAU1-02
R05/07/77
09:47:09
3492
2.864E-03

Figure 2-45. Pressure at 165°, 7.5°
Sector, Test 2.3.

NRC TEST NO. 2.3

CHAN 16

CE TIME : 04/28/77
09:16:08
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ

SA RATE : 0
NCHANS : 15

LOFAU1-02
R05/07/77
09:47:10
3492
2.864E-03

Figure 2-46. Pressure at 180°, 7.5° Sector, Test 2.3.

NRC TEST NO. 2.3

CHAN 43

CE TIME : 04/28/77
09.16.08
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ

SA RATE : 0
NCHANS : 15

LOFAU1-03
R05/07/77
09:48:04
3492
2.864E-03

Figure 2-47. Ullage Pressure at Plane 9, 45°, 90° Torus Sector, Test 2.3.

NRC TEST NO. 2.3

CHAN 10

ENC1C-01
205/18/77
17:17:50
3492
2.864E-03

CE TIME : 04/28/77Z
09.16.08
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ

SA RATE : 0
NCHANS : 15

PRESSURE, PSIA (P-111), TORUS, 3-180 DEG.

Figure 2-48. Pressure at Plane 3, 180°, 90° Torus Sector, Test 2.3.

NRC TEST NO. 2.3

CHAN 32

LOFAU1-03
R05/07/77
09:47:56
3492
2.864E-03

CE TIME : 04/28/77Z
09.16.08
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ
SA RATE : 0
NCHANS : 15

Figure 2-49. Pressure at Plane 4, 180°,
90° Torus Sector, Test 2.3.

NRC TEST NO. 2.3

CHAN 26

LOFAU2-02
R05/07/77
10:35:30
3492
2.864E-03

CE TIME : 04/28/77Z
09.16.08
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ

SA RATE : 0
NCHANS : 15

Figure 2-50. Pressure at Plane 6, 180°,
90° Torus Sector, Test 2.3.

NRC TEST NO. 2.3

CHAN 8

LOFAU1-01
R05/07/77
09:46:26
3492
2.864E-03

CE TIME : 04/28/77
09.16.08
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ
SA RATE : 0
NCHANS : 15

Figure 2-51. Pressure at Plane 7, 180°, 90° Torus Sector, Test 2.3.

NRC TEST NO. 2.3

CHAN 49

LOFAU1-04
R05/07/77
09:48:34
3492
2.864E-03

CE TIME : 04/28/77
09.16.08
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ

SA RATE : 0
NCHANS : 15

PRESSURE, PSIA (P-49), TORJS, 9-180 DEG.

Figure 2-52. Pressure at Plane 9, 180°, 90° Torus Sector, Test 2.3.

NRC TEST NO. 2.3

CHAN 4

LOFAU1-01
R05/07/77
09:46:23
3492
2.864E-03

CE TIME : 04/28/77
09.16.08
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ

SA RATE : 0
NCHANS : 15

PRESSURE, PSIA (P-10), TORUS, 11-180 DEG.

Figure 2-53. Pressure at Plane 11, 180°,
90° Torus Sector, Test 2.3.

NRC TEST NO. 2.3

CHAN 27

CE TIME : 04/28/77
09.16.08
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ

SA. RATE : 0
NCHANS : 15

LOFAU1-02
R05/07/77
09:47:20
3492
2.864E-03

Figure 2-54. Pressure at Plane 20, 180°, 90° Torus Sector, Test 2.3.

NRC TEST NO. 2.3

CHAN 44

LOFAU1-04
R05/07/77
09:48:28
3492
2.864E-03

CE TIME : 04/28/77Z
09.16.08
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ

SA RATE : 0
NCHANS : 15

PRESSURE, PSIA (P-44), TORUS, 9-128 DEG.

Figure 2-55. Pressure at Plane 9, 128°, 90° Torus Sector, Test 2.3.

NRC TEST NO. 2.3

CHAN 48

CE TIME : 04/28/77
 09.16.08
 LO FREQ : 0.100007 HZ
 HI FREQ : 174 HZ
 SA RATE : 0
 NCHANS : 15

LOFAU1-04
 R05/07/77
 09:48:33
 3492
 2.854E-03

Figure 2-56. Pressure at Plane 9, 165°, 90° Torus Sector, Test 2.3.

NRC TEST NO. 2.3

CHAN 22

CE TIME : 04/28/77

SA RATE :

0

09.16.08

NCHANS :

15

LO FREQ : 0.100007 HZ

HI FREQ : 174 HZ

LOFAU1-02

R05/07/77

09:47:16

3492

2.864E-03

PRESSURE, PSIA (P-52), TORUS, 9-205 DEG.

Figure 2-57. Pressure at Plane 9, 205°, 90° Torus Sector, Test 2.3.

NRC TEST NO. 2.3

CHAN 24

CE TIME : 04/28/772
09.16.08
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ

SA RATE : 0
NCHANS : 15

LOFAU1-02
R05/07/77
09:47:17
3492
2.864E-03

Figure 2-58. Pressure at Plane 9, 235°, 90° Torus Sector, Test 2.3.

NRC TEST NO. 2.3

CHAN 11

ENCIC-01
Z05/18/77
17:17:51
3492
2.864E-03

CE TIME : 04/28/77Z

SA RATE : 0

09.16.08

NCHANS : 15

LO FREQ : 0.100007 HZ

HI FREQ : 174 HZ

LOAD, LBS. (L-4A), TORUS TRUNION, 4-90 DEG.

Figure 2-59. Load at Plane 4, 90°, 90°
Torus Sector, Test 2.3.

NRC TEST NO. 2.3

CHAN 13

ENC1C-01
Z05/18/77
17:17:54
3492
2.864E-03

CE TIME : 04/28/77Z SA RATE : 0
09.16.08 NCHANS : 15
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ

Figure 2-60. Load at Plane 4, 270°, 90°
Torus Sector, Test 2.3.

NRC TEST NO. 2.3

CHAN 1

ENCIC-01
Z05/18/77
17:17:24
3492
2.864E-03

CE TIME : 04/28/77Z
09.16.08
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ

SA RATE : 0
NCHANS : 15

Figure 2-61. Load at Plane 1, 180°, 90°
Torus Sector, Test 2.3.

NRC TEST NO. 2.3

CHAN 2

ENC1C-01
Z05/18/77
17:17:25
3492
2.864E-03

CE TIME : 04/28/77Z
09.16.08
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ
SA RATE : 0
NCHANS : 15

LOAD, LBS (L-2), RINGHDR SUPPORT, 2-180 DEG.

Figure 2-62. Ringheader Load at Plane 2, 180°, 90° Torus Sector, Test 2.3.

NRC TEST NO. 2.3

CHAN 3

ENCIC-01
205/18/77
17:17:42
3492
2.864E-03

CE TIME : 04/28/77
09.16.08

SA RATE : 0
NCHANS : 15

LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ

LOAD, LBS (L-3), RINGHDR SUPPORT, 3-180 DEG.

Figure 2-63. Ringheader Load at Plane 3, 180°, 90° Torus Sector, Test 2.3.

NRC TEST NO. 2.3

CHAN 15

ENCIC-02
Z05/18/77
17:18:09
3492
2.864E-03

CE TIME : 04/28/77Z SA RATE : 0
09.16.08 NCHANS : 15
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ

LOAD, LBS (L-6), RINGHDR SUPPORT, 5-180 DEG.

Figure 2-64. Ringheader Load at Plane 5, 180°, 90° Torus Sector, Test 2.3.

NRC TEST NO. 2.3.

CHAN 16

CE TIME : 04/28/77Z

SA RATE : 0

ENC2C-01

09.16.08

NCHANS : 15

205/18/77

LO FREQ : 0.100007 HZ

17:19:31

HI FREQ : 174 HZ

3492

2.864E-03

LOAD, LBS. (L-7), RINGHDR SUPPORT, 6-180 DEG.

Figure 2-65. Ringheader Load at Plane 6, 180°, 90° Torus Sector, Test 2.3.

NRC TEST NO. 2.3

CHAN 34

ENC3C-01
205/18/77
17:21:36
3492
2.864E-03

CE TIME : 04/28/77Z
09.16.08
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ

SA RATE : 0
NCHANS : 15

Figure 2-66. Torus Displacement, Left End, Test 2.3.

NRC TEST NO. 2.3

CHAN 36

ENC3C-01
Z05/18/77
17:21:39
3492
2.864E-03

CE TIME : 04/28/77
09.16.08
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ
SA RATE : 0
NCHANS : 15

Figure 2-67. Torus Displacement, Right End,
Test 2.3.

NRC TEST NO. 2.3

CHAN 25

CE TIME : 04/28/77Z

SA RATE : 0

ENC2C-01

09.16.08

NCHANS : 15

Z05/18/77

LO FREQ : 0.100007 HZ

17:19:51

HI FREQ : 174 HZ

3492
2.864E-03

Figure 2-68. Torus Displacement, Vertical, Test 2.3.

NRC TEST NO. 2.3

CHAN 22

ENC2C-01
205/18/77
17:19:48
3492
2.864E-03

CE TIME : 04/28/77Z SA RATE : 0
09.16.08 NCHANS : 15
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ

Figure 2-69. Torus Displacement, Horizontal, Outward, Test 2.3.

NRC TEST NO. 2.3

CHAN 37

ENC3C-01
Z05/18/77
17:21:39
3492
2.864E-03

CE TIME : 04/28/77Z

SA RATE : 0

09.16.08

NCHANS : 15

LO FREQ : 0.100007 HZ

HI FREQ : 174 HZ

Figure 2-70. Torus Displacement, Horizontal, Inward, Test 2.3.

3. ANALYSIS OF EXPERIMENTAL DATA

Tests 2.1, 2.2, and 2.3 were conducted to examine the effects of initial drywell overpressure. Initial drywell overpressure is obtained by evacuating the toroidal wetwell to a pressure slightly below that of the drywell before the start of a test. Because of the pressure difference between the drywell and toroidal wetwell, the water level inside the downcomers is displaced below the level of the water surface outside the downcomers. For all three tests, the water level outside the downcomers was maintained at the nominal elevation of 0.24 m (9.6 inches) above the exit of the downcomers. The water level inside the downcomers was maintained below the water level outside the downcomers by 0.12 m (4.7 inches), 0.18 m (6.9 inches), and 0.19 m (7.4 inches) for Tests 2.1, 2.2, and 2.3, respectively.

The mass of the water initially present inside the downcomers is reduced if drywell overpressure is present. Because of the reduced mass, it was anticipated that the peak downward and upward loads, which occur around the time of vent clearing, would also decrease. The reduction of loads could result from the shorter vent clearing times and possibly lower gas pressure inside the downcomers at vent clearing.

Table 3-1 relates the peak magnitude of the upward and downward loads as recorded with the load cells for the three tests. For comparison, values from Test 1.3 (Quick-Look Report No. 2, UCID-17446-2) are also shown. The peak magnitudes of the downward loads on the main load cells decrease if initial drywell overpressure is present. The peak uploads on the main load cells are less sensitive to initial drywell overpressure. The ringheader load cell data is essentially invariant to initial drywell overpressure.

The experimental drywell pressurization data is compared to desired values, which are based on information supplied by NRC for the full-scale Peachbottom plant*, in Figures 3-1, 3-2, and 3-3. The experimental data is shown as the computer-generated line; the desired values are indicated as circles. The desired values were calculated by use of dimensionless groups:

$$\frac{P}{\rho g L} \quad \text{and} \quad \frac{t^2 g}{L}$$

where

P = pressure
 ρ = water density
 g = gravitational constant
 L = characteristic length
 t = time.

The characteristic length for the test apparatus is 1/5 that of a full-scale Peachbottom plant so that the full-scale plant pressures and times supplied by NRC are divided by a factor of 5 and a factor of $\sqrt{5}$, respectively. The dimensionless groups are kept constant when applied to either the 1/5-scale LLL experimental facility or the full-scale Peachbottom plant.

The agreement between the experimental data and the desired values is excellent. The initial drywell pressurization rates tabulated in Table 3-1 varied somewhat more than expected. The pressurization rates for Tests 1.3 and 2.2 are 8 percent lower than the rates for Tests 2.1 and 2.3.

The initial drywell pressurization rates were determined by examination of experimental data. The rates for each test were assumed to approximate a constant slope established between the start of the pressure

*Curve of the drywell pressure history for the full-scale Peachbottom Plant to 2 seconds, transmitted by telecopier on March 8, 1977 from L. Slegers, NRC. The curve was generated on March 4, 1977 at 14.32.01 hours.

Table 3-1. Comparison of Load Cell Peak Magnitude Data.

	TEST 1.3	TEST 2.1	TEST 2.2	TEST 2.3
Initial Drywell Pressurization Rate	168 kPa/s (24.3 psi/s)	182 kPa/s (26.4 psi/s)	168 kPa/s (24.3 psi/s)	182 kPa/s (26.4 psi/s)
Initial Drywell Overpressure	0 mm H ₂ O (0 in H ₂ O)	119 mm H ₂ O (4.7 in H ₂ O)	175 mm H ₂ O (6.9 in H ₂ O)	188 mm H ₂ O (7.4 in H ₂ O)
Load Cell 4 (Main Outboard):				
Peak Download	66.7 kN (15000 lbf)	48.9 kN (11000 lbf)	37.4 kN (8400 lbf)	34.7 kN (7800 lbf)
Peak Upload	27000 kN (6000 lbf)	28000 kN (6400 lbf)	22000 kN (5000 lbf)	23000 kN (5100 lbf)
Load Cell 5 (Main Inboard):				
Peak Download	102 kN (23000 lbf)	71.2 kN (16000 lbf)	48.9 kN (11000 lbf)	44.5 kN (10000 lbf)
Peak Upload	53000 kN (12000 lbf)	41000 kN (9300 lbf)	43000 kN (9700 lbf)	42000 kN (9400 lbf)
Load Cell 1 (Stabilizing):				
Peak Download	26.7 kN (6000 lbf)	23.1 kN (5200 lbf)	18.2 kN (4100 lbf)	16.5 kN (3700 lbf)
Peak Upload	40000 kN (9000 lbf)	17000 kN (3900 lbf)	9800 kN (2200 lbf)	8000 kN (1800 lbf)
Load Cell 2 (Left Section Ringheader, Plane 2):				
Peak Download	1.8 kN (400 lbf)	1.8 kN (400 lbf)	2.1 kN (480 lbf)	2.5 kN (570 lbf)
Peak Upload	10.2 kN (2300 lbf)	11.1 kN (2500 lbf)	10.2 kN (2300 lbf)	10.2 kN (2300 lbf)

NOTE: The peak load of one load cell does not necessarily occur at the same time as the peak load on another load cell.

rise in the drywell and a time 0.089 seconds later. This method is consistent with that used by NRC on the Peachbottom plant where a constant slope was established between time zero and a time of 0.2 seconds.*

The nitrogen storage bottle volume and the initial pressure was identical for Tests 2.1, 2.2, and 2.3. Similar initial drywell pressurization rates were expected on these three tests. A graphical overlay of transducer P-73 data (Figures 3-1, 3-2, and 3-3) shows that the drywell pressure curves from the three tests are essentially congruent. The reasons why the experimental data for Test 2.2 indicates an initial drywell pressurization rate 8 percent below that obtained on Tests 2.1 and 2.3 is not clear. It may be that this difference is within the range of uncertainty that results from the calculation of the initial drywell pressurization rate.

The available volume in the drywell during Tests 2.1, 2.2, and 2.3 was 8.38 m^3 (296 ft^3) which is 15 percent lower than the 9.85 m^3 (348 ft^3) volume used in previous tests. This reduction of available volume was inadvertently caused during a water-filling operation in which 1.47 m^3 (52 ft^3) of water was placed in the drywell. This reduction in volume changed the shape of the drywell pressure-time curve only slightly. This seems to indicate that a change in drywell volume has an insignificant effect on drywell pressure-time history.

*The value $0.2/0.089 = \sqrt{5}$ which corresponds to the square root of the scale factor. The value of the initial drywell pressurization rate for Test 1.3 (reported in UCID-17446-2) was determined graphically and is slightly higher than the value indicated in Table 3-1.

NRC TEST NO. 2.1

CHAN 31

ENC3-01
U05/17/77
20:13:57
3-32
2.364E-03

CE TIME : 04/28/77Z
09.16.08
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ

SA RATE : 0
NCHANS : 15

PRESSURE, PSIA (P-73), DRY WELL, 3

Figure 3-1. Comparison of Experimental and Desired Values for Drywell Pressure, Test 2.1.

NRC TEST NO. 2.2

CHAN 31

CE TIME : 04/28/77

SA RATE :

0

ENC38-01

U05/17/77

21:32:10

3492

2.864E-03

09.16.08

NCHANS :

15

LO FREQ : 0.100007 HZ

HI FREQ : 174 HZ

PRESSURE, PSIA (P-73), DRY WELL, 3

Figure 3-2. Comparison of Experimental and Desired Values for Drywell Pressure, Test 2.2.

NRC TEST NO. 2.3

CHAN 31

CE TIME : 04/28/77Z
09.16.08
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ

SA RATE : 0
NCHANS : 15

ENC3C-01
205/18/77
17:21:14
3492
2.864E-03

Figure 3-3. Comparison of Experimental and Desired Values for Drywell Pressure, Test 2.3.

4. CONCLUSIONS

Results of Tests 2.1, 2.2, and 2.3 show that the peak download is reduced if initial drywell overpressure is present. This reduction in peak download was anticipated and results from the reduction of water in the downcomer and possibly from shorter vent clearing times and lower gas pressure inside the downcomers at vent clearing.

High speed motion pictures revealed that vent clearing in tests with initial drywell overpressure was more uniform than in tests with no initial drywell overpressure. The gas-liquid interface moved down to the downcomer exit in a generally horizontal orientation during all three tests. In the previous tests (notably 1.1, 1.2, and 1.3), the interface moved down to the downcomer exit such that the gas first left the downcomer in the region furthest from the vertical centerline of the toroidal wetwell. It should be noted that the initial water level was above the miter joint in the downcomers during tests without initial drywell overpressurization (Tests 1.1, 1.2, and 1.3). However, the initial water level was below these miter joints in the downcomers for all tests with initial drywell overpressure (Tests 2.1, 2.2, and 2.3).

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