Lawrence Livermore Laboratory

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

Compiled and Edited by William Lai and E. Kejka Collins

Edward W. McCauley and John H. Pitts
Principal Investigators

June 10, 1977

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MARK I 1/5-SCALE BOILING WATER REACTOR
PRESSURE SUPPRESSION EXPERIMENT
QUICK-LOOK REPORT
FOR TEST NUMBERS 2.4, 2.5, 2.6, 3.1, 3.2, and 3.5
PERFORMED ON May 3, 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 2.4, 2.5, 2.6, 3.1, 3.2, and 3.5 that were performed on the Lawrence Livermore Laboratory's 1/5-scale boiling water reactor (BWR) Mark I pressure suppression experimental facility on May 3, 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 May 3, 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 (N₂)-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 B).^{*} 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.

^{*}The originally planned pressurization rates were 14.0, 18.6, 23.0, 26.0 psi/sec. In revision A, pressurization rates were changed to 20.5, 27.3, 33.8, 38.2 psi/sec. In revision B, Tests 1.3.1, 2.9 through 2.11, 3.3(b) and 3.4(b) were added, and Test 3.6 was deleted from the test matrix.

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

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	QLR No. 1, UCID-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	QLR No. 2, UCID-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	
1.3.1	20.3 (2.95)	20.3 (2.95)	0	0.24 (9.6)	Nom.	188 (27.3)	-	yes	Drywell pressurization rate	April 26, 1977	QLR No. 4, UCID-17446-4
1.4	20.3 (2.95)	20.3 (2.95)	0	0.24 (9.6)	Nom.	141 (20.5)	-	yes			
1.5	20.3 (2.95)	20.3 (2.95)	0	0.24 (9.6)	Nom.	233 (33.8)	-	yes			
1.6	20.3 (2.95)	20.3 (2.95)	0	0.24 (9.6)	Nom.	263 (38.2)	-	yes			
2.1	20.3 (2.95)	()	0.12 (4.8)	0.24 (9.6)	Nom.	188 (27.3)	-	yes	Drywell overpressure	April 26, 1977	QLR No. 3, UCID-17446-3
2.2	20.3 (2.95)	()	0.18 (7.2)	0.24 (9.6)	Nom.	188 (27.3)	-	yes			
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)	-	yes	Repeatability	May 3, 1977	QLR No. 5, UCID-17446-5
2.5	20.3 (2.95)	20.3 (2.95)	0	0.340 (13.4)	0.10 (3.8)	188 (27.3)	-	yes			
2.6	20.3 (2.95)	20.3 (2.95)	0	0.15 (5.8)	-0.10 (-3.8)	188 (27.3)	-	yes			
2.7	20.3 (2.95)	20.3 (2.95)	0	0.305 (12.0)	Nom.	188 (27.3)	-	yes	Drywell pressurization rate with increased submergence	May 3, 1977	QLR No. 5, UCID-17446-5
2.8	20.3 (2.95)	20.3 (2.95)	0	0.24 (9.6)	0.061 (2.4)	188 (27.3)	-	yes			
2.9	20.3 (2.95)	20.3 (2.95)	0	0.305 (12.0)	Nom.	141 (20.5)	-	yes			
2.10	20.3 (2.95)	20.3 (2.95)	0	0.305 (12.0)	Nom.	233 (33.8)	-	yes	Variation of ah	May 3, 1977	QLR No. 5, UCID-17446-5
2.11	20.3 (2.95)	20.3 (2.95)	0	0.305 (12.0)	Nom.	263 (38.2)	-	yes			
3.1	20.3 (2.95)	20.3 (2.95)	0	0.24 (9.6)	Nom.	108 (27.3)	-	yes			
3.2	20.3 (2.95)	20.3 (2.95)	0	0.24 (9.6)	Nom.	188 (27.3)	-	yes	Asymmetry	May 3, 1977	QLR No. 5, UCID-17446-5
3.3 (a)	20.3 (2.95)	20.3 (2.95)	0	0.24 (9.6)	Nom.	188 (27.3)	(yes)b/	yes			
3.3 (b)	20.3 (2.95)	20.3 (2.95)	0	0.24 (9.6)	Nom.	188 (27.3)	(yes)b/	yes			
3.4 (a)	20.3 (2.95)	20.3 (2.95)	0	0.24 (9.6)	Nom.	188 (27.3)	(yes)b/	yes	Asymmetry	May 3, 1977	QLR No. 5, UCID-17446-5
3.4 (b)	20.3 (2.95)	20.3 (2.95)	0	0.24 (9.6)	Nom.	188 (27.3)	(yes)b/	yes			
3.5	20.3 (2.95)	20.3 (2.95)	0	0.24 (9.6)	Nom.	188 (27.3)	-	yes			

a/ Initial drywell pressurization rates changed 17 March 1977 by L. Siegers 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 (anrubar)	0-2.5 kPa (0-0.36 psia)	1.7 ms	250 Pa (0.036 psia)	25 Pa (0.0036 psia)	--
	1 (anrubar)	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 $^{\circ}$ R)	10 ms	1.7 K (3 $^{\circ}$ R)	3.4 K (6 $^{\circ}$ R)	1.2%
Strain Gages	21	0.025 mm ($\pm$ 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 2.4, 2.5, 2.6, 3.1, 3.2, and 3.5 of the air clearing experiment series were conducted on 3rd of May, 1977. There were three primary objectives for these tests:

- (1) Tests 2.4 and 3.5 were repeatability checks.
- (2) Tests 2.5 and 2.6 were conducted to determine the effect of downcomer submergence.
- (3) Tests 3.1 and 3.2 were conducted to determine the effect of the parameter $\dot{m}h$.

The same vent line orifices were used for Tests 2.4, 2.5, 2.6, and 3.5. Major changes were made in the vent line orifices to produce gross differences in $\dot{m}h$ for Tests 3.1 and 3.2. The initial conditions are listed in Table 2-3.

2.5 TEST EVALUATION AND TYPICAL RESULTS

The total number of transducers used in Test 2.4 was 221. The output from 40 pool swell transducers was recorded during Test 2.4. When the results indicated a malfunction which could not be field corrected, these transducers were disconnected, and only 181 transducers were used for the remainder of the series of tests. Records of each test were made with six Hycam cameras (1000 frames/sec) and a Storz lens television system. One displacement transducer failed. A list of the 63 engineering plots selected

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

LOCATION	TYPE OF XDCE	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	

F = 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

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	
	SA	19

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.

NRC-1

Date May 3, 1977

INSTRUMENTATION LOCATIONS FOR VENT PIPE

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

S_B = Strain, Bending

Figure 2-5. Instrumentation Locations for Vent Pipe.

Date May 3, 1977

NRC-1

INSTRUMENTATION LOCATIONS FOR TORUS

Figure 2-6. Instrumentation Locations for Torus.

LOCATION	TYPE OF XDCR	TRANSDUCER NO.																			
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
12°	P																				
14°	T																				
18°	PS																				
37°	PS																				
45°	P																				
73°	T																				
78°	P																				
128°	P																				
135°	T																				
140°	P																				
155°	P																				
160°	P																				
165°	P																				
175°	T																				
180°	P																				
195°	P																				
200°	P																				
205°	P																				
220°	P																				
235°	P																				
270°	P																				
315°	P																				
323°	PS																				
342°	PS																				

NRC-1

INSTRUMENTATION LOCATIONS FOR RINGHEADER/DOWNCOMER

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	12	
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		9			14
STRUT	SA	3							15

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		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 2.4, 2.5, 2.6, 3.1, 3.2, and 3.5.

PARAMETER	TEST 2.4		TEST 2.5		TEST 2.6		TEST 3.1		TEST 3.2		TEST 3.5	
	PLANNED	ACTUAL	PLANNED	ACTUAL	PLANNED	ACTUAL	PLANNED	ACTUAL	PLANNED	ACTUAL	PLANNED	ACTUAL
Pool Temperature	17.8°C (64.0°F)		17.8°C (64.0°F)		17.8°C (64.0°F)		17.8°C (64.0°F)		17.8°C (64.0°F)		15.0 59.0	
Nitrogen Supply:												
Bottle Number	2 and 7		2 and 7		2 and 7		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)		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)		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)		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)		27 cm (10.58 in)		None		24 cm (9.5 in)	
Right Hand Vent	24 cm (9.5 in)		24 cm (9.5 in)		24 cm (9.5 in)		27 cm (10.58 in)		None		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)		10.35 cm (4.08 in)		10.35 cm (4.08 in)		9.22 cm (3.63 in)	
Drywell Pressure	20.3 kPa (2.94 psia)	20.4 kPa (2.96 psia)	20.3 kPa (2.94 psia)	20.4 kPa (2.96 psia)	20.3 kPa (2.94 psia)	20.4 kPa (2.96 psia)	20.3 kPa (2.94 psia)	20.3 kPa (2.94 psia)	20.3 kPa (2.94 psia)	20.5 kPa (2.97 psia)	20.3 kPa (2.94 psia)	20.4 kPa (2.96 psia)
Wetwell Pressure	20.3 kPa (2.94 psia)	20.4 kPa (2.96 psia)	20.3 kPa (2.94 psia)	20.3 kPa (2.94 psia)	20.3 kPa (2.94 psia)	20.3 kPa (2.94 psia)	20.3 kPa (2.94 psia)	20.3 kPa (2.94 psia)	20.3 kPa (2.94 psia)	20.5 kPa (2.97 psia)	20.3 kPa (2.94 psia)	20.4 kPa (2.96 psia)
Drywell Pressurization Rate	188 kPa/s (27.3 psi/s)	167.5 kPa/s (24.5 psi/s)	188 kPa/s (27.3 psi/s)	197.2 kPa/s (28.6 psi/s)	188 kPa/s (27.3 psi/s)	182.7 kPa/s (26.5 psi/s)	188 kPa/s (27.3 psi/s)	189.6 kPa/s (27.5 psi/s)	188 kPa/s (27.3 psi/s)	160.0 kPa/s (23.2 psi/s)	188 kPa/s (27.3 psi/s)	168.2 kPa/s (24.4 psi/s)

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

from these experiments is given in Tables 2-5, 2-6, 2-7, 2-8, 2-9, and 2-10 for Tests 2.4, 2.5, 2.6, 3.1, 3.2, and 3.5, respectively. Locations of transducers (as listed in Tables 2-5 through 2-10) are shown pictorially in Figures 2-1 through 2-8.

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 mils or less.

2.6 ACCURACY OF DATA

The quality of data reported in Quick-Look Report No. 1, UCID-17446-1, has been maintained in this series of tests (refer to Table 2-4).

Table 2-4. Estimated Measurement Uncertainties for Tests 2.4, 2.5, 2.6, 3.1, 3.2, and 3.5.

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 2.4.

PARAMETER	LOCATIONS	FIGURE	PAGE	TRANSDUCER NO.
Pressure	Drywell	2-9	2-18	P73
Ullage Pressure	7.5° Sector	2-10	2-19	P75
Pressure at 180°	7.5° Sector	2-11	2-20	P80
Ullage Pressure	90° Torus, Plane 9	2-12	2-21	P43
Pressure at 180°	90° Torus, Plane 9	2-13	2-22	P49
Load Cell at 90°	90° Torus, Plane 4	2-14	2-23	L4A
Load Cell at 180°	90° Torus, Plane 1	2-15	2-24	L1
Load Cell at 270°	90° Torus, Plane 4	2-16	2-25	L5A
Load Cell at 180°	Header Support, Plane 5	2-17	2-26	L6

Table 2-6. List of Selected Data Plots for Test 2.5.

PARAMETER	LOCATIONS	FIGURE	PAGE	TRANSDUCER NO.
Pressure	Drywell	2-18	2-27	P73
Ullage Pressure	7.5° Sector	2-19	2-28	P75
Pressure at 180°	7.5° Sector	2-20	2-29	P80
Ullage Pressure	90° Torus, Plane 9	2-21	2-30	P43
Pressure at 180°	90° Torus, Plane 9	2-22	2-31	P49
Load Cell at 90°	90° Torus, Plane 4	2-23	2-32	L4A
Load Cell at 180°	90° Torus, Plane 1	2-24	2-33	L1
Load Cell at 270°	90° Torus, Plane 4	2-25	2-34	L5A
Load Cell at 180°	Header Support, Plane 5	2-26	2-35	L6

Table 2-7. List of Selected Data Plots for Test 2-6.

PARAMETER	LOCATIONS	FIGURE	PAGE	TRANSDUCER NO.
Pressure	Drywell	2-7	2-36	P73
Ullage Pressure	7.5° Sector	2-28	2-37	P75
Pressure at 180°	7.5° Sector	2-29	2-38	P80
Ullage Pressure	90° Torus, Plane 9	2-30	2-39	P43
Pressure at 180°	90° Torus, Plans 9	2-31	2-40	P49
Load Cell at 90°	90° Torus, Plane 4	2-32	2-41	L4A
Load Cell at 180°	90° Torus, Plane 1	2-33	2-42	L1
Load Cell at 270°	90° Torus, Plane 4	2-34	2-43	L5A
Load Cell at 180°	Header Support, Plane 5	2-35	2-44	L6

Table 2-8. List of Selected Data Plots for Test 3.1.

PARAMETER	LOCATIONS	FIGURE	PAGE	TRANSDUCER NO.
Pressure	Drywell	2-36	2-45	P73
Ullage Pressure	7.5° Sector	2-37	2-46	P75
Pressure at 180°	7.5° Sector	2-38	2-47	P80
Ullage Pressure	90° Torus, Plane 9	2-39	2-48	P43
Pressure at 180°	90° Torus, Plane 9	2-40	2-49	P49
Load Cell at 90°	90° Torus, Plane 4	2-41	2-50	L4A
Load Cell at 180°	90° Torus, Plane 1	2-42	2-51	L1
Load Cell at 270°	90° Torus, Plane 4	2-43	2-52	L5A
Load Cell at 180°	Header Support, Plane 5	2-44	2-53	L6

Table 2-9. List of Selected Data Plots for Test 3.2.

PARAMETER	LOCATIONS	FIGURE	PAGE	TRANSDUCER NO.
Pressure	Drywell	2-45	2-54	P73
Ullage Pressure	7.5° Sector	2-46	2-55	P75
Pressure at 180°	7.5° Sector	2-47	2-56	P80
Ullage Pressure	90° Torus, Plane 9	2-48	2-57	P43
Pressure at 180°	90° Torus, Plane 9	2-49	2-58	P49
Load Cell at 90°	90° Torus, Plane 4	2-50	2-59	L4A
Load Cell at 180°	90° Torus, Plane 1	2-51	2-60	L1
Load Cell at 270°	90° Torus, Plane 4	2-52	2-61	L5A
Load Cell at 180°	Header Support, Plane 5	2-53	2-62	L6

Table 2-10. List of Selected Data Plots for Test 3.5.

PARAMETER	LOCATIONS	FIGURE	PAGE	TRANSDUCER NO.
Pressure	Drywell	2-54	2-63	P73
Orifice ΔP	7.5° Vent Line	2-55	2-64	P96
Orifice ΔP	90° Torus Right Vent	2-56	2-65	P99
Pressure	90° Torus Right Vent	2-57	2-66	P98
Ullage Pressure, 45°	7.5° Sector	2-58	2-67	P75
Pressure at 180°	7.5° Sector	2-59	2-68	P80
Ullage Pressure, 45°	90° Torus, Plane 9	2-60	2-69	P43
Pressure at 180°	90° Torus, Plane 3	2-61	2-70	P111
Pressure at 180°	90° Torus, Plane 4	2-62	2-71	P22
Pressure at 180°	90° Torus, Plane 6	2-63	2-72	P36
Pressure at 180°	90° Torus, Plane 7	2-64	2-73	P14
Pressure at 180°	90° Torus, Plane 9	2-65	2-74	P49
Pressure at 180°	90° Torus, Plane 11	2-66	2-75	P10
Pressure at 180°	90° Torus, Plane 20	2-67	2-76	P57
Load Cell at 90°	90° Torus, Plane 4	2-68	2-77	L4A
Load Cell at 180°	90° Torus, Plane 1	2-69	2-78	L1
Load Cell at 270°	90° Torus, Plane 4	2-70	2-79	L5A
Load Cell at 180°	Header Support, Plane 5	2-71	2-80	L6

NRC TEST NO. 2.4

CE TIME : 05/18/77U

SA RATE :

0

09.15.48

NCHANS :

15

LO FREQ : 0.100007 HZ

HI FREQ : 174 HZ

CHAN 31

ENC3-01

205/20/77

15:02:04

3492

2.864E-03

Figure 2-9. Drywell Pressure, Test 2.4.

NRC TEST NO. 2.4

CHAN 11

CE TIME : 05/18/77U

SA RATE : 0

LOFAU1-01

R05/19/77

09.15.48

NCHANS : 15

17:03:56

LO FREQ : 0.100007 HZ

3492

HI FREQ : 174 HZ

2.864E-03

Figure 2-10. Ullage Pressure, 45°, 7.5° Sector, Test 2.4.

NRC TEST NO. 2.4

CHAN 16

LOFAU1-02
R05/19/77
17:05:29
3492
2.864E-03

CE TIME : 05/18/77U
09.15.48
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ
SA RATE : 0
NCHANS : 15

Figure 2-11. Pressure at 180°, 7.5° Sector, Test 2.4.

NRC TEST NO. 2.4

CHAN 43

LOFAU1-03
R05/19/77
17:11:23
3492
2.864E-03

CE TIME : 05/18/77U SA RATE : 0
09.15.48 NCHANS : 15
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ

Figure 2-12. Ullage Pressure at Plane 9, 45°, 90° Torus Sector, Test 2.4.

NRC TEST NO. 2.4

CHAN 49

CE TIME : 05/18/77U
09.15.48
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ

SA RATE : 0
NCHANS : 15

LOFAU1-04
R05/19/77
17:13:44
3492
2.864E-03

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

Figure 2-13. Pressure at Plane 9, 180°, 90° Torus Sector, Test 2.4.

NRC TEST NO. 2.4

CHAN 11

ENC1-01
205/20/77
15:00:52
3492
2.864E-03

CE TIME : 05/18/77U
09.15.48
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ

SA RATE : 0
NCHANS : 15

Figure 2-14. Load at Plane 4, 90°, 90° Torus Sector, Test 2.4.

NRC TEST NO. 2.4

CHAN 1

ENC1-01
Z05/20/77
15:00:39
3492
2.864E-03

CE TIME : 05/18/77U SA RATE : 0
09.15.48 NCHANS : 15
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ

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

Figure 2-15. Load at Plane 1, 180°, 90° Torus Sector, Test 2.4.

NRC TEST NO. 2.4

CHAN 13

ENC1-01
205/20/77
15:00:54
3492
2.864E-03

CE TIME : 05/18/77U
09.15.48
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ

SA RATE : 0
NCHANS : 15

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

Figure 2-16. Load at Plane 4, 270°, 90° Torus Sector, Test 2.4.

ENC1-02
Z05/20/77
15:01:03
3492
2.864E-03

09.15.48

NCHANS : 15

LO FREQ : 0.100007 HZ

HI FREQ : 174 HZ

2-26

ENC3-01
U05/20/77
20:40:18
3492
2.864E-03

SA RATE : 0
NCHANS : 15

NRC TEST NO. 2.5

CHAN 11

LOFAU1-01
Z05/20/77
17:57:36
3492
2.864E-03

CE TIME : 05/18/77U
09.15.48
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ

SA RATE : 0
NCHANS : 15

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

Figure 2-19. Ullage Pressure, 45°, 7.5° Sector, Test 2.5.

NRC TEST NO. 2.5

CHAN 16

LOFAU1-02
205/20/77
17:58:17
3492
2.864E-03

CE TIME : 05/18/77U
09.15.48
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ

SA RATE : 0
NCHANS : 15

Figure 2-20. Pressure at 180°, 7.5° Sector, Test 2.5.

NRC TEST NO. 2.5

CHAN 43

LOFAU1-03
205/20/77
18:00:06
3492
2.864E-03

CE TIME : 05/18/77U
09.15.48
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ

SA RATE : 0
NCHANS : 15

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

Figure 2-21. Ullage Pressure at Plane 9, 45°, 90° Torus Sector, Test 2.5.

NRC TEST NO. 2.5

CHAN 49

CE TIME : 05/18/77U
09.15.48
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ

SA RATE : 0
NCHANS : 15

LOFAU1-04
205/20/77
18:01:39
3492
2.864E-03

Figure 2-22. Pressure at Plane 9, 180°, 90° Torus Sector, Test 2.5.

NRC TEST NO. 2.5

CHAN 11

ENC1-01
005/20/77
20:36:10
3492
2.864E-03

CE TIME : 05/18/77U
09.15.48
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ

SA RATE : 0
NCHANS : 15

Figure 2-23. Load at Plane 4, 90°, 90° Torus Sector, Test 2.5.

NRC TEST NO. 2.5

CHAN 1

ENC1-01
005/20/77
20:35:51
3492
2.864E-03

CE TIME : 05/18/77U
09.15.48
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ

SA RATE : 0
NCHANS : 15

Figure 2-24. Load at Plane 1, 180°, 90° Torus Sector, Test 2.5.

NRC TEST NO. 2.5

CE TIME : 05/18/77U
 09.15.48
 LO FREQ : 0.100007 HZ
 HI FREQ : 174 HZ

SA RATE : 0
 NCHANS : 15

CHAN 13

ENC1-01
 U05/20/77
 20:36:15
 3492
 2.864E-03

Figure 2-25. Load at Plane 4, 270°, 90° Torus Sector, Test 2.5.

NRC TEST NO. 2.5

CHAN 15

CE TIME : 05/18/77U
09.15.48
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ

SA RATE : 0
NCHANS : 15

ENC1-02
U05/20/77
20:36:25
3492
2.864E-03

Figure 2-26. Load at Plane 5, 180°, Header Support, Test 2.5.

NRC TEST NO. 2.6

CHAN 31

ENC3-01
205/24/77
11:34:55
3492
2.864E-03

CE TIME : 05/19/77U
09.10.47
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ
SA RATE : 0
NCHANS : 15

Figure 2-27. Drywell Pressure, Test 2.6.

NRC TEST NO. 2.6

CHAN 11

LOFAU1-01
205/23/77
13:06:02
3492
2.864E-03

CE TIME : 05/19/77U

SA RATE : 0

09.10.47

NCHANS : 15

LO FREQ : 0.100007 HZ

HI FREQ : 174 HZ

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

Figure 2-28. Ullage Pressure, 45°, 7.5° Sector, Test 2.6.

NRC TEST NO. 2.6

CHAN 16

CE TIME : 05/19/77U
09.10.47
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ

SA RATE : 0
NCHANS : 15

LOFAU1-02
205/23/77
13:06:52
3492
2.864E-03

Figure 2-29. Pressure at 180°, 7.5° Sector, Test 2.6.

NRC TEST NO. 2.6

CHAN 43

LOFAU1-03
Z05/23/77
13:07:38
3492
2.864E-03

CE TIME : 05/19/77U SA RATE : 0
09.10.47 NCHANS : 15
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ

Figure 2-30. Ullage Pressure at Plane 9, 45°, 90° Torus Sector, Test 2.6.

NRC TEST NO. 2.6

CHAN 49

CE TIME : 05/19/77U
09.10.47
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ

SA RATE : 0
NCHANS : 15

LOFAU1-04
205/23/77
13:08:16
3492
2.864E-03

Figure 2-31. Pressure at Plane 9, 90° Torus Sector, Test 2.6.

NRC TEST NO. 2.6

CHAN 11

ENC1-01
205/24/77
11:32:52
3492
2.864E-03

CE TIME : 05/19/77U SA RATE : 0
09.10.47 NCHANS : 15
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ

Figure 2-32. Load at Plane 4, 90°, 90° Torus Sector, Test 2.6.

NRC TEST NO. 2.6

CHAN 1

ENC1-01
205/24/77
11:32:44
3492
2.864E-03

CE TIME : 05/19/77U SA RATE : 0
09.10.47 NCHANS : 15
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ

Figure 2-33. Load at Plane 1, 180°, 90° Torus Sector, Test 2.6.

NRC TEST NO. 2.6

CHAN 13

CE TIME : 05/19/77U

SA RATE :

0

09.10.47

NCHANS :

15

LO FREQ : 0.100007 HZ

HI FREQ : 174 HZ

ENC1-01

205/24/77

11:32:55

3492

2.864E-03

Figure 2-34. Load at Plane 4, 270°, 90° Torus Sector, Test 2.6.

NRC TEST NO. 2.6

CHAN 15

CE TIME : 05/19/77U

SA RATE :

0

09.10.47

NCHANS :

15

LO FREQ : 0.100007 HZ

HI FREQ : 174 HZ

ENC1-02
Z05/24/77

11:33:02

3492

2.864E-03

Figure 2-35. Load at Plane 5, 180°, Header Support, Test 2.6.

NRC TEST NO. 3.1

CHAN 31

CE TIME : 05/19/77U
09.10.47
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ

SA RATE : 0
NCHANS : 15

ENC3-01
R05/25/77
14:50:01
3492
2.864E-03

Figure 2-36. Drywell Pressure, Test 3.1.

NRC TEST NO. 3.1

CHAN 11

CE TIME : 05/19/77U
08.10.47
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ

SA RATE : 0
NCHANS : 15

LOFAU1-01
205/25/77
10:43:20
3492
2.864E-03

Figure 2-37. Ullage Pressure, 45°, 7.5° Sector, Test 3.1.

NRC TEST NO. 3.1

CHAN 16

LOFAU1-02
205/25/77
10:45:05
3492
2.864E-03

CE TIME : 05/19/77U SA RATE : 0
09.10.47 NCHANS : 15
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ

Figure 2-38. Pressure at 180°, 7.5° Sector, Test 3.1.

LOFAU1-03
Z05/25/77
10:58:00
3492
2.864E-03

```
SA RATE :      0
NCHANS :     15
```

NRC TEST NO. 3.1

CHAN 49

LOFAU1-04
205/25/77
11:00:10
3492
2.864E-03

CE TIME : 05/19/77U
09.10.47
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ
SA RATE : 0
NCHANS : 15

Figure 2-40. Pressure at Plane 9, 180°, 90° Torus Sector, Test 3.1.

NRC TEST NO. 3.1

CHAN 11

ENC1-01
R05/25/77
14:26:39
3492
2.864E-03

CE TIME : 05/19/77U
09.10.47
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ

SA RATE : 0
NCHANS : 15

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

Figure 2-41. Load at Plane 4, 90°, 90° Torus Sector, Test 3.1.

NRC TEST NO. 3.1

CHAN 1

ENC:-01
R05/25/77
14:26:27
3492
2.864E-03

CE TIME : 05/19/77U
09.10.47
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ

SA RATE : 0
NCHANS : 15

Figure 2-42. Load at Plane 1, 180°, 90° Torus Sector, Test 3.1.

NRC TEST NO. 3.1

CHAN 13

CE TIME : 05/19/77U
09.10.47
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ

SA RATE : 0
NCHANS : 15

ENC1-01
R05/25/77
14:26:42
3492
2.864E-03

Figure 2-43. Load at Plane 4, 270°, 90° Torus Sector, Test 3.1.

NRC TEST NO. 3.1

CHAN 15

ENC1-02
R05/25/77
14:26:50
3492
2.864E-03

CE TIME : 05/19/77U
09.10.47
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ
SA RATE : 0
NCHANS : 15

Figure 2-44. Load at Plane 5, 180°, Header Support, Test 3.1.

NRC TEST NO. 3.2

CHAN 31

ENC3-01
205/26/77
11:20:10
3492
2.864E-03

CE TIME : 05/25/772

SA RATE :

1

09.54.03

NCHANS :

15

LO FREQ : 0.100007 HZ

HI FREQ : 174 HZ

Figure 2-45. Drywell Pressure, Test 3.2.

NRC TEST NO. 3.2

CHAN 11

LGFAU1-01
U05/26/77
16:33:14
3492
2.864E-03

CE TIME : 05/25/772
09.54.03
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ

SA RATE : 1
NCHANS : 15

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

Figure 2-46. Ullage Pressure, 45°, 7.5° Sector, Test 3.2.

NRC TEST NO. 3.2

CHAN 16

LOFAU1-02
U05/26/77
16:34:15
3492
2.864E-03

CE TIME : 05/25/77Z
09.54.03
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ

SA RATE : 1
NCHANS : 15

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

Figure 2-47. Pressure at 180°, 7.5° Sector, Test 3.2.

NRC TEST NO. 3.2

CHAN 43

CE TIME : 05/25/77Z

SA RATE : 1

LOFAU1-03

09.54.03

NCHANS : 15

U05/26/77

LO FREQ : 0.100007 HZ

16:40:58

HI FREQ : 174 HZ

3492

2.864E-03

Figure 2-48. Ullage Pressure at Plane 9, 45°, 90° Torus Sector, Test 3.2.

NRC TEST NO. 3.2

CHAN 49

LOFAU1-04
U05/26/77
16:43:03
3492
2.864E-03

CE TIME : 05/25/77Z
09.54.03
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ
SA RATE : 1
NCHANS : 15

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

Figure 2-49. Pressure at Plane 9, 180°, 90° Torus Sector, Test 3.2.

NRC TEST NO. 3.2

CHAN 11

ENC1-01
Z05/26/77
11:17:07
3492
2.864E-03

CE TIME : 05/25/77Z

SA RATE :

1

09.54.03

NCHANS :

15

LO FREQ : 0.100007 HZ

HI FREQ : 174 HZ

Figure 2-50. Load at Plane 4, 90°, 90° Torus Sector, Test 3.2.

NRC TEST NO. 3.2

CHAN 1

ENC1-01
205/26/77
11:16:49
3492
2.864E-03

CE TIME : 05/25/77Z
09.54.03
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ

SA RATE : 1
NCHANS : 15

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

Figure 2-51. Load at Plane 1, 180°, 90° Torus Sector, Test 3.2.

NRC TEST NO. 3.2

CHAN 13

CE TIME : 05/25/77Z
09.54.03
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ

SA RATE : 1
NCHANS : 15

ENC1-01
205/26/77
11:17:08
3492
2.864E-03

Figure 2-52. Load at Plane 4, 270°, 90° Torus Sector, Test 3.2.

NRC TEST NO. 3.2

CHAN 15

ENC1-02
205/26/77
11:17:16
3492
2.864E-03

CE TIME : 05/25/77Z
09.54.03
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ

SA RATE : 1
NCHANS : 15

Figure 2-53. Load at Plane 5, 180°, Header Support, Test 3.2.

ENC3-01
U05/28/77
10:26:14
3492
2.864E-03

U05/28/77
10:26:14
3492
2.864E-03

NRC TEST NO. 3.5

CHAN 53

CE TIME : 05/25/77Z
09.54.03
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ

SA RATE : 1
NCHANS : 15

LOFAU1-04
005/28/77
13:40:35
3492
2.864E-03

Figure 2-55. Differential Pressure Across the Vent Line Orifice, 7.5° Sector, Test 3.5.

NRC TEST NO. 3.5

CHAN 55

CE TIME : 05/25/77Z

SA RATE :

1

09.54.03

NCHANS :

15

LO FREQ : 0.100007 HZ

HI FREQ : 174 HZ

LOFAU1-04

U05/28/77

13:40:37

3492

2.864E-03

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

Figure 2-56. Differential Pressure Across Right Vent Line Orifice, 90° Torus Sector, Test 3.5.

NRC TEST NO. 3.5

CHAN 59

LOFAU1-05
U05/28/77
13:40:47
3492
2.864E-03

CE TIME : 05/25/77Z
09.54.03
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ

SA RATE : 1
NCHANS : 15

PRESSURE, PSIA (P-98), RIGHT VENT PIPE, 17

Figure 2-57. Right Vent Line Pressure Upstream of Orifice, 90° Torus Sector, Test 3.5.

NRC TEST NO. 3.5

CHAN 11

LOFAU1-01
U05/28/77
13:37:56
3492
2.864E-03

CE TIME : 05/25/77Z
09.54.03
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ

SA RATE : 1
NCHANS : 15

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

Figure 2-58. Ullage Pressure at 45°, 7.5° Sector, Test 3.5.

NRC TEST NO. 3.5

CHAN 16

CE TIME : 05/25/77Z

SA RATE :

1

LOFAU1-02

U05/28/77

13:38:33

09.54.03

NCHANS :

15

3492

LO FREQ : 0.100007 HZ

2.864E-03

HI FREQ : 174 HZ

Figure 2-59. Pressure at 180°, 7.5° Sector, Test 3.5.

NRC TEST NO. 3.5

CHAN 43

LOFAU1-03
U05/28/77
13:39:36
3492
2.864E-03

CE TIME : 05/25/77Z SA RATE : 1
09.54.03 NCHANS : 15
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ

Figure 2-60. Ullage Pressure at Plane 9, 45°, 90° Torus Sector, Test 3.5.

ENC1-01
U05/28/77
10:24:44
3492
2.864E-03

SA RATE : 1
NCHANS : 15

NRC TEST NO. 3.5

CHAN 32

LOFAU1-03
U05/28/77
13:39:25
3492
2.864E-03

CE TIME : 05/25/77Z
09.54.03
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ
SA RATE : 1
NCHANS : 15

Figure 2-62. Pressure at Plane 4, 180°, 90° Torus Sector, Test 3.5.

NRC TEST NO. 3.5

CHAN 26

CE TIME : 05/25/77Z
 09.54.03
 LO FREQ : 0.100007 HZ
 HI FREQ : 174 HZ

SA RATE : 1
 NCHANS : 15

LOFAU2-02
 U05/28/77
 12:32:30
 3492
 2.864E-03

Figure 2-63. Pressure at Plane 6, 180°, 90° Torus Sector, Test 3.5.

LOFAUI-01
U05/28/77
13:37:54
3492
2.864E-03

09.54.03

NCHANS : 15

LO FREQ : 0.100007 HZ

HI FREQ : 174 HZ

LOGAU1-04
U05/28/77
13:40:31
3492
2.864E-03

```
CE TIME : 05/25/77Z      SA RATE : 1
              09.54.03    NCHANS : 15
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ
```

2-74

NRC TEST NO. 3.5

CHAN 4

LOFAU1-01
U05/28/77
13:37:50
3492
2.864E-03

CE TIME : 05/25/77Z
09.54.03
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ

SA RATE : 1
NCHANS : 15

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

Figure 2-66. Pressure at Plane 11, 180°, 90° Torus Sector, Test 3.5.

NRC TEST NO. 3.5

CHAN 27

LOFAU1-02
U05/28/77
13:38:46
3492
2.864E-03

CE TIME : 05/25/77Z SA RATE : 1
09.54.03 NCHANS : 15
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ

Figure 2-67. Pressure at Plane 20, 180°, 90° Torus Sector, Test 3.5.

NRC TEST NO. 3.5

CHAN 11

CE TIME : 05/25/77Z

SA RATE : 1

ENC1-01

U05/28/77

10:24:45

09.54.03

NCHANS : 15

3492

LO FREQ : 0.100007 HZ

2.864E-03

HI FREQ : 174 HZ

Figure 2-68. Load at Plane 4, 90°, 90° Torus Sector, Test 3.5.

NRC TEST NO. 3.5

CHAN 1

ENC1-01
U05/28/77
10:24:34
3492
2.864E-03

CE TIME : 05/25/77Z
09.54.03
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ

SA RATE : 1
NCHANS : 15

Figure 2-69. Load at Plane 1, 180°, 90° Torus Sector, Test 3.5.

NRC TEST NO. 3.5

CHAN 13

ENC1-01
U05/28/77
10:24:48
3492
2.854E-03

CE TIME : 05/25/77Z SA RATE : 1
09.54.03 NCHANS : 15
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ

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

Figure 2-70. Load at Plane 4, 270°, 90° Torus Sector, Test 3.5.

NRC TEST NO. 3.5

CHAN 15

ENC1-02
U05/28/77
10:24:56
3492
2.864E-03

CE TIME : 05/25/77Z
09.54.03
LO FREQ : 0.100007 HZ
HI FREQ : 174 HZ

SA RATE : 1
NCHANS : 15

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

Figure 2-71. Load at Plane 5, 180°, Header Support, Test 3.5.

3. ANALYSIS OF EXPERIMENTAL DATA

The planned and actual initial test conditions for Tests 2.4, 2.5, 2.6, 3.1, 3.2, and 3.5 are listed in Table 2-3. The actual initial pressurization rates that are listed in the table for each test were obtained by graphically determining the average slope of the drywell pressure curves (transducers P73 and P74) between the start of the pressure rise in the drywell and a time 0.89 seconds later. Drywell pressure curves for transducer P73 are shown in Figures 2-9, 2-18, 2-27, 2-36, 2-45, and 2-54. The actual (graphically-determined) pressurization rates for this series of tests deviates no more than approximately 10 percent from the planned values. Further analysis may show a smaller range of deviation.

Periodically, repeatability tests are performed to determine the dynamic response variability of transducers from test to test. Two such repeatability tests were conducted in this series of tests. The results from these nominally identical tests (Tests 2.4 and 3.5) are listed in Table 3-1. The comparable values for Tests 1.3 and 1.3.1 (previously reported in UCID-17446-2 and UCID-17446-4) are also listed. The initial conditions for Tests 1.3, 1.3.1, 2.4, and 3.5 were nominally identical.

Examination of the uncorrected data in Table 3-1 shows that, in general, the pressurization rates vary less than 10 percent from intended identical initial conditions. The peak upload for Test 3.5 (load cell 4) and the peak pressure at 180° for test 1.3 (7.5° torus sector) varied, from maximum to minimum, by more than 10 percent. That the larger differences do not occur consistently for any particular test or transducer suggests a random source. The source of the random influence might be electrical noise. A better estimate of dynamic measurement variations requires further analysis.

Table 3-1. Comparison of Uncorrected Peak Data from Repeatability Tests.

	TEST 1.3	TEST 1.3.1	TEST 2.4	TEST 3.5
Actual Initial Drywell Pressurization Rates	168 kPa/s (24.3 psi/s)	190 kPa/s (27.5 psi/s)	168 kPa/s (24.3 psi/s)	168 kPa/s (24.4 psi/s)
Load Cell 4 (Main Outboard):				
Peak Download	66.7 kN (15,000 lbf)	71.2 kN (16,000 lbf)	70.7 kN (15,900 lbf)	69.8 kN (15,700 lbf)
Peak Upload	26.2 kN (5,900 lbf)	27.1 kN (6,100 lbf)	26.7 kN (6,000 lbf)	30.2 kN (6,800 lbf)
Load Cell 5 (Main Inboard):				
Peak Download	102.3 kN (23,000 lbf)	106.8 kN (24,000 lbf)	102.3 kN (23,000 lbf)	99.6 kN (22,400 lbf)
Peak Upload	52.0 kN (11,700 lbf)	52.0 kN (11,700 lbf)	52.0 kN (11,700 lbf)	53.4 kN (12,000 lbf)
Peak Pressure at 180°:				
90° Torus, Plane 9	49.0 kPa (7.1 psia)	49.0 kPa (7.1 psia)	49.6 kPa (7.2 psia)	49.6 kPa (7.2 psia)
7.5° Torus	51.7 kPa (7.5 psia)	47.6 kPa (6.9 psia)	48.3 kPa (7.0 psia)	46.9 kPa (6.8 psia)

Tests 2.5 and 2.6 were conducted to determine the sensitivity of the dynamic load to downcomer submergence with nominal length downcomers. The water level inside the toroidal wetwells was raised 9.7 cm (3.8 in) above nominal* in Test 2.5 and lowered by 9.7 cm (3.8 in) below nominal in Test 2.6 prior to the start of the test. It was expected that Test 2.5 would yield higher peak loads and pressures at the bottom of the pool than those yielded by Test 2.4 or 2.6. Peak values for Tests 2.4, 2.5, and 2.6 are listed in Table 3-2. Test 2.4 represents the nominal submergence that has been used for this and the majority of other tests in this program. (Refer to Figures 2-9, 2-11, 2-13, 2-14, 2-16, 2-18, 2-20, 2-22, 2-23, 2-25, 2-27, 2-29, 2-31, 2-32, and 2-34.) The data in Table 3-2 shows the expected trend in spite of the variation in actual pressurization rates.

The peak loads from the main load cells (as listed in Table 3-2) are plotted against downcomer submergence in Figure 3-1. Included in this figure are results from the four nominal cases listed in Table 3-1 (i.e., Tests 1.3, 1.3.1, 2.4, and 3.5). The peak downloads measured on load cells 4A and 5A increase about 40 percent and 30 percent, respectively, as downcomer submergence is increased from 24.4 cm (9.6 in) to 34.0 cm (13.4 in). The peak downloads decrease about 35 percent for both load cells as downcomer submergence is decreased from 24.4 cm (9.6 in) to 14.7 cm (5.8 in) (compare Test 2.4 with Test 2.6).

The effect of the enthalpy flux parameter on the dynamic load has been a subject of much discussion. Experimental scaling studies at LLL have suggested that peak upload scaling between a prototype and a model can be accomplished equally well without the introduction of an orifice to artificially increase the vent loss coefficient, thereby controlling the enthalpy flux into the wetwell. Further, scaling studies also indicate that the presence of an orifice may distort peak download scaling, producing an underestimate of the download.

*Nominal submergence is 24.4 cm (9.6 in).

Table 3-2. Effect of Downcomer Submergence on Selected Peak Parameters.

	TEST 2.4	TEST 2.5	TEST 2.6
Water Level in Toroidal Wetwell	Nominal ---	+ 0.1 m (+ 3.8 in)	- 0.1 m (- 3.8 in)
Actual Initial Drywell Pressurization Rate	167.5 kPa/s (24.3 psi/s)	197 kPa/s (28.6 psi/s)	182.7 kPa/s (26.5 psi/s)
Load Cell 4 (Main Outboard):			
Peak Download	70.7 kN (15,900 lbf)	99.6 kN (22,400 lbf)	47.6 kN (10,700 lbf)
Peak Upload	26.7 kN (6,000 lbf)	34.7 kN (7,800 lbf)	21.8 kN (4,900 lbf)
Load Cell 5 (Main Inboard):			
Peak Download	102.3 kN (23,000 lbf)	131.7 kN (29,600 lbf)	66.7 kN (15,000 lbf)
Peak Upload	52.0 kN (11,700 lbf)	65.8 kN (14,800 lbf)	44.9 kN (10,100 lbf)
Peak Pressure at 180°:			
90° Torus, Plane 9	49.6 kPa (7.2 psia)	57.2 kPa (8.3 psia)	42.1 kPa (6.1 psia)
7.5° Torus	48.3 kPa (7.0 psia)	56.5 kPa (8.2 psia)	40.7 kPa (5.9 psia)
Downcomer Submergence	0.244 m (9.6 in)	0.340 m (13.4 in)	0.147 m (5.8 in)

Figure 3-1. Variation of Uncorrected Main Load Cell Data with Downcomer Submergence.

(▲ ≡ Load Cell 4 (outboard) peak download; △ ≡ Load Cell 4 (outboard) peak upload; ■ ≡ Load Cell 5 (inboard) peak download; □ ≡ Load Cell 5 (inboard) peak upload)

Tests 3.1 and 3.2 were conducted to examine the effects of vent line flow restriction and the resulting changes in enthalpy flux (or mass flux) entering the toroidal wetwell. The nominal-size orifice plates installed in the vent lines in previous tests were selected to correspond to Moody scaling.

Under Moody scaling, the vent pipe loss coefficient (or flow coefficient) in a full-scale plant should be multiplied by a factor of 5 for a 1/5-scale experiment. In Quick Look Report No. 1, UCID-17446-1, it was reported that the addition of a Moody-scaled orifice resulted in vent pipe loss coefficients of 21.0, 20.5, and 21.7 for the left 45° sector vent, right 45° sector vent, and 7.5° sector, respectively. The desired vent loss coefficient was 21.5 based on a calculated full-size BWR vent loss coefficient of 4.3. For the nominal tests, the scaled orifice diameters were 24 cm (9.5 in) in the left 45° and right 45° sector vent lines and 9.22 cm (3.63 in) in the 7.5° sector vent line.

Test 3.1 was conducted with orifices in the vent lines that were intermediate in size (between those for Moody scaling and no orifice). Specifically, orifice diameters of 26.88 cm (10.58 in) in the left and right 45° sectors and 10.35 cm (4.076 in) in the 7.5° sector were used. These sizes were selected to obtain a vent loss coefficient of $\frac{(21.5 + 4.3)}{2} = 12.9$. No flow tests were conducted to determine if this vent loss coefficient was obtained. Test 3.2 was conducted without orifice restrictions in any of the vent lines just as in the LLL scaling studies.

The selected peak parameters listed in Table 3-3 show the effect of $\dot{m}h$ (refer to Figures 2-9, 2-11, 2-13, 2-14, 2-16, 2-36, 2-38, 2-40, 2-41, 2-43, 2-45, 2-47, 2-49, 2-50, and 2-52). The uncorrected vertical load data in Table 3-3 does not show small changes in peak response in spite of the large change in the vent line loss coefficient. Specifically, load cells 4A and 5A indicate an increase in peak download of less than 15 percent and 5 percent, respectively, when compared to the nominal case (Test 1.3, 1.3.1, 2.4, or 3.5). The peak uploads measured on the main load cells also varied insignificantly.

Table 3.3. Effect of $\dot{m}h$ on Selected Peak Parameters.

	TEST 2.4	TEST 3.1	TEST 3.2
Actual Initial Drywell Pressurization Rate	167.5 kPa/s (24.3 psi/s)	189.6 kPa/s (27.5 psi/s)	160.0 kPa/s (23.2 psi/s)
Load Cell 4 (Main Outboard):			
Peak Download	70.7 kN (15,900 lbf)	71.6 kN (16,100 lbf)	64.5 kN (14,500 lbf)
Peak Upload	26.7 kN (6,000 lbf)	26.7 kN (6,000 lbf)	29.4 kN (6,600 lbf)
Load Cell 5 (Main Inboard):			
Peak Download	102.3 kN (23,000 lbf)	113.4 kN (25,500 lbf)	112.5 kN (25,300 lbf)
Peak Upload	52.0 kN (11,700 lbf)	52.0 kN (11,700 lbf)	56.9 kN (12,800 lbf)
Peak Pressure at 180°:			
7.5° Torus	48.3 kPa (7.0 psia)	48.3 kPa (7.0 psia)	47.6 kPa (6.9 psia)
90° Torus, Plane 9	49.6 kPa (7.2 psia)	48.3 kPa (7.0 psia)	47.6 kPa (6.9 psia)

The sensitivity of these loads to a change in vent loss coefficient is not as large as that in other variables that were examined (e.g., downcomer submergence and initial drywell pressurization rate). Further analysis of the data from Tests 3.1 and 3.2 is required to separate the effect of the initial drywell pressurization rate actually obtained on these tests. However, the effect of any adjustment due to differences in actual initial drywell pressurization rates between Tests 3.1 and 3.2 and the nominal case tests is expected to be small.

It should be noted that the effective drywell volume was reduced to 8.38 m^3 (296 ft^3) on Tests 2.3, 2.5, 2.6, and 3.1. This was 15 percent lower than the 9.85 m^3 (348 ft^3) present in Tests 1.1, 1.2, and 1.3. As mentioned in Quick-Look Report No. 3, UCID-17446-3, this reduction was caused by the inadvertent addition of 1.47 m^3 (52 ft^3) of water into the drywell during a water-filling operation. This water was removed for Tests 3.2 and 3.5 so that the available drywell volume was 9.85 m^3 (348 ft^3). The reduction of available drywell volume appears to have little effect on the drywell pressure-time history.

Test 3.5 pressure measurements, taken at the bottom and along the axis of the 90° torus, are shown in Figures 2-61 (plane 3) through Figure 2-67 (plane 20). The peak pressures, which were determined from these curves, are listed in Table 3-4 along with those from Test 1.3 (Quick-Look Report No. 2, UCID-17446-2). The peak pressure varies along the torus axis and tends to become greater as the axial spacing of downcomer pairs decreases (compare planes 3, 7, 9, and 11 which are planes containing two downcomers). Plane 7 is furthest from adjacent downcomer pairs and has the lowest peak pressure (6.9 psia for Test 3.5).

The measurements and data presented in this quick-look report, as in all others, is data just as it has been processed, and it is, therefore, uncorrected. Among the readily-identifiable corrections that should be applied to the data are the following:

- (1) The pressures should be corrected to standard conditions.

- (2) The force arising from torus acceleration should be removed from all load cell measurements.
- (3) The force arising from the movement of the torus due to continued pressurization should be removed from all load cell measurements.

Table 3-4. Variation of Peak Pressure at 180°
Along the Axis of the 90° Torus.

PLANE	TEST 1.3	TEST 3.5	NO. OF DOWNCOMERS
1	50.3 kPa (7.3 psia)	---	2
3	48.3 kPa (7.0 psia)	50.3 kPa (7.3 psia)	2
4	47.6 kPa (6.9 psia)	49.0 kPa (7.1 psia)	1
6	44.8 kPa (6.5 psia)	44.8 kPa (6.5 psia)	0
7	46.9 kPa (6.8 psia)	47.6 kPa (6.9 psia)	2
9	49.0 kPa (7.1 psia)	49.0 kPa (7.1 psia)	2
11	49.6 kPa (7.2 psia)	49.6 kPa (7.2 psia)	2
20	---	48.3 kPa (7.0 psia)	2

4. CONCLUSIONS

The preliminary results from Tests 2.4, 2.5, 2.6, 3.1, 3.2, and 3.5 indicate the following effects:

- (1) Dynamic measurements seem repeatable to less than 10 percent variation.
- (2) An increase of 30 percent to 40 percent in peak downloads, as measured by the main load cells, was observed when downcomer submergence was increased from 24.4 cm (9.6 in) to 34.0 cm (13.4 in). A decrease of about 35 percent in peak downloads was observed when downcomer submergence was decreased from 24.4 cm (9.6 in) to 14.7 cm (5.8 in).
- (3) The selected, uncorrected peak parameters show small effects due to the enthalpy flux parameter. In general, variations of 15 percent or less in the peak downloads and insignificant peak upload variation, as measured by the main load cells, were observed between those tests run with an orifice placed in each of the vent lines that represented Moody scaling and Tests 3.1 and 3.2. Test 3.1 had an orifice placed in each vent line that was larger in diameter than that used for Moody scaling. Test 3.2 had no orifices placed in the vent lines. The sensitivity of loads to changes in vent pipe resistance appear to be less than either changes in downcomer submergence or changes in the initial drywell pressurization rate.

(4) Significant pool pressure variations continue to be observed along the torus axis.

(5) The high quality of data has been maintained.

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