Commonwealth Edison
One First National Plaza, Chicago, Illinois
Address Reply to: Post Office Box 767
Chicago, Illinois 60690

Transmittal contains
Attachment C

June 30, 1978

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Rec'd 7/8/78

Mr. George E. Lear, Chief
Operating Reactors - Branch 3
Division of Operating Reactors
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Subject: Dresden Station Units 2 and 3
Quad-Cities Station Units 1 and 2
Evaluation of the Consequence of a
Multiple Subsequent Relief Valve
Discharge on the Mark I Containments
NRC Docket Nos. 50-237/249 and 50-254/265

References (a): V. Stello, Jr. letter to Commonwealth Edison dated March 20, 1978

(b): R. L. Bolger letter to D. K. Davis dated November 1, 1978

Dear Mr. Lear:

Enclosed is Commonwealth Edison's evaluation of the potential for and consequence of multiple subsequent relief valve discharge on the torus and torus support systems on Dresden Units 2 & 3 and Quad-Cities Units 1 & 2. This evaluation provides the assessment requested in Reference (a). As described in Attachments A and B to this letter, transient analyses results for the subject plants indicate that only the low setpoint relief valve (setpoint - 1115 psig) will undergo a subsequent actuation. The remaining four valves do not undergo a subsequent actuation after the initial cold actuation. This result was described in Reference (b), at which time the commitment was made to reduce the setpoint of the lowest setpoint valve to 1115 psig. The factors developed to establish the response of the Dresden and Quad-Cities containments to a relief valve actuation are delineated in Attachment C.

Portions of Attachment C are marked "General Electric Company Proprietary Information" because it contains monticello ramshead test data. This Attachment contains test data from the monticello ramshead test report (NEDC-21581-P) which was transmitted to the NRC Staff on August 23, 1977. Therefore,

A025 5/1/60* see list

the affidavit which accompanied that transmittal is applicable to the information in Attachment C.

The results of this assessment satisfy the criteria defined in Reference (a) and indicate that the strength ratios for the torus shell and torus support system are, as required, less than 0.5. For this reason no corrective action is required.

One (1) signed original and nine (9) copies of this letter and Attachments (including Attachment C) are provided for your use. An additional fifty (50) copies of this transmittal without Attachment C are also provided. Transmittals with Attachment C are appropriately marked.

Please direct any additional questions on this subject to this office.

Very truly yours,

M. S. Turbak

M. S. Turbak
Nuclear Licensing Administrator
Boiling Water Reactors

attachments

DOCKET NO. 50-237/249/254/265
DATE: 9-21-78

NOTE TO NRC AND/OR LOCAL PUBLIC DOCUMENT ROOMS

The following item submitted with letter dated 6-30-78 from Commonwealth Edison of IL. is being withheld from public disclosure, pending review, in accordance with Section 2.790.

PROPRIETARY INFORMATION

Applicant's Evaluation of Potential fort Consequence of Multiple subsequent Relief valve discharge on the torus and torus support systems of subject facilitys

Roland Wood
O/6
Regulatory File Room

MARK I CONTAINMENT PROGRAM

MULTIPLE CONSECUTIVE S/RV ACTUATION EVALUATION

TASK 7.1.3

GENERIC STRUCTURAL MULTIPLIER DEVELOPMENT PROCEDURE

GENERAL ELECTRIC COMPANY
PROPRIETARY INFORMATION

LEGAL NOTICE

MARK I CONTAINMENT PROGRAM
MULTIPLE CONSECUTIVE S/RV ACTUATION EVALUATION
TASK 7.1.3

GENERIC STRUCTURAL MULTIPLIER DEVELOPMENT PROCEDURE

The following pages document the data base and methodology used in developing the recommended generic structural values to be used by the Utility/AE's in calculating column and shell loadings which result from the multiple consecutive S/RV actuation phenomenon. The generic values described were developed following the guidelines outlined in the NRC letter to the Mark I utilities requesting that this evaluation be performed on a plant unique basis.

Throughout the discussion which follows, references will be made to the Monticello, Hatch I, and Pilgrim S/RV tests. Data from these tests was used extensively in developing the structural and attenuation curves. The reports documenting this data base are identified in the reference section.

The continuing discussion will emphasize the development of the factors and attenuation curves derived to support the Utility/AE calculations. Each section will address a single factor or attenuation curve.

A. Torus Shell Structural Response Attenuation Curve

For the purpose of the shell stress analysis, the responses from the torus shell pressure transducers in Bay D at Monticello were evaluated as a function of the distance to the centerline of the discharge ramshead. The shell pressures were chosen as the evaluation parameter as it was the only test data reflecting the membrane stress in the torus shell. All of the strain gages in Bay D were on the outside surface of the torus shell and recorded extreme fiber stresses only. As the key Short Term Program criteria is margin on failure, i.e., bursting of the shell, the attenuation response of the membrane stress was required. As the strain gages measured both the membrane and shell bending stresses, only the pressure transducers could be relied upon to truly indicate the membrane attenuation on the shell. Pressure transducers P7, P8, P10, P14, P17 and P18 located along the bottom centerline of the torus bay were selected for the evaluation. The pressure transducers on the bottom of the torus were chosen as the maximum hydrodynamic pressures occur along the bottom of torus shell due to a ramshead S/RV discharge. Six pressure transducers were assessed to factor pressure distribution, skewness, and statistical variation into the analysis. The locations of the pressure transducers are shown in Figure 1.

The mean plus one standard deviation of the pressures was tabulated for each test and normalized with the corresponding value of Test No. 1 (Discharge in Bay D). The responses were evaluated for the following tests:

Discharge Bay	Test Number
D	1 (Reference Test)
A	4, 21
B	20, 24
C	2, 13, 17
E	22
F	6, 23, 27

The normalized values for each of the tests were then averaged for the cases where the nominal distance between the discharge bays and bay D, the instrumented bay, were the same, i.e., values from discharges in bays C and E were averaged as were the values from bays B and F. The data and steps performed in this calculation are shown in Table 1. The normalized average values as a function of distance from bay D were then plotted. These results are shown in Figure 2.

As a confirmation of the applicability of the torus shell attenuation curve, multiplier factors were determined from the curve and compared

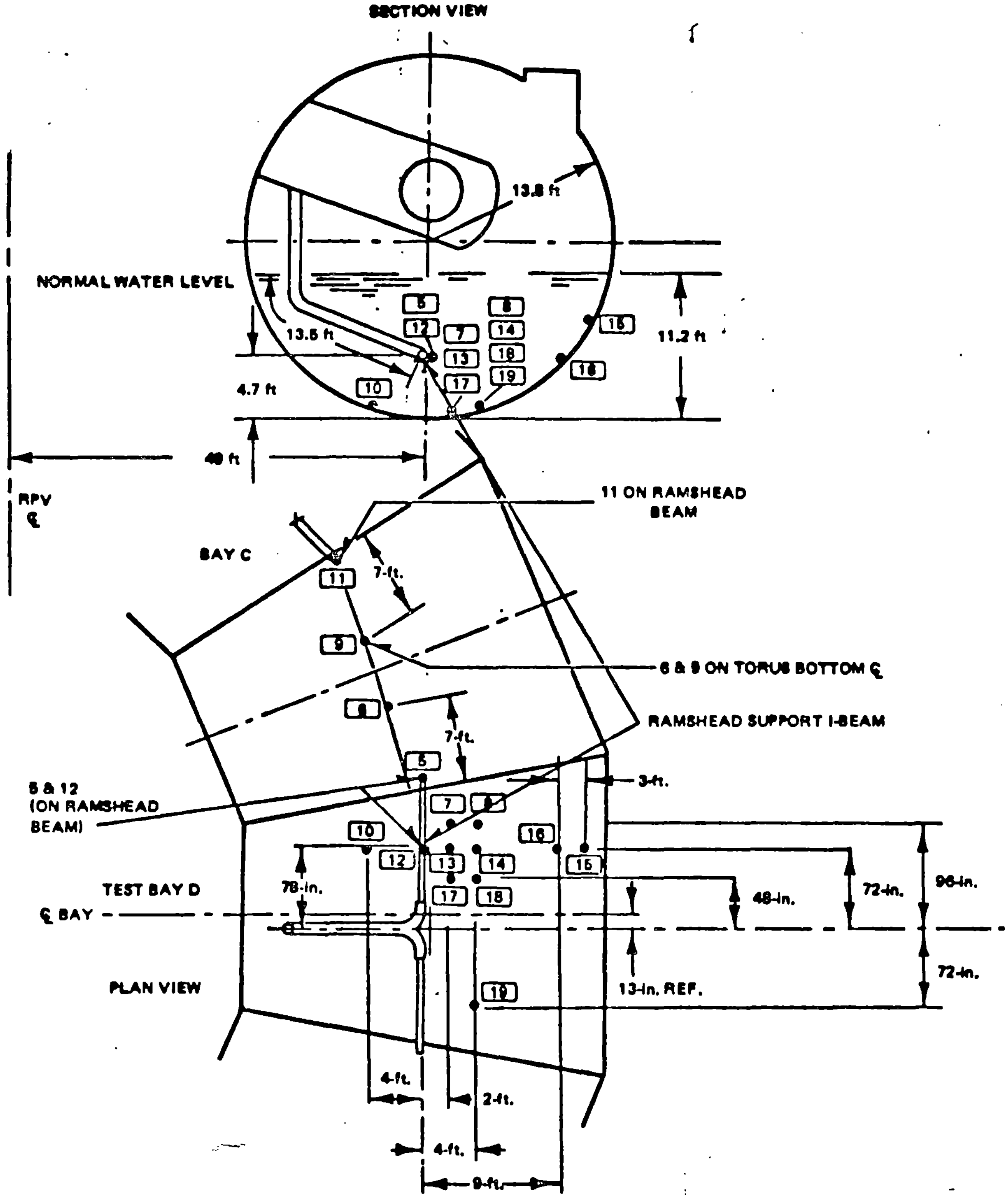


FIGURE 1) — Location of Pressure Transducers P5 through P19 in Torus Pool

		PRESSURES - PSID								
		TRANSDUCERS								
DISCHARGE BAY	TEST	7	8	10	14	17	18	$\bar{X}$	σ	$\bar{X}+\sigma$
A	4	1.4	1.2	2.9	1.5	1.0	1.5			
	21	1.3	1.8	3.0	–	1.0	1.0			
	AVE.	1.35	1.5	2.95	1.5	1.0	1.25	1.59	.69	2.28
B	20	1.0	1.1	1.7	0.8	0.9	1.0			
	24	–	1.4	3.2	–	1.0	1.6			
	AVE.	1.0	1.25	2.45	0.8	0.95	1.3	1.29	.60	1.89
C	2	4.2	3.6	5.3	3.0	1.3	2.0			
	13	4.3	5.1	6.2	3.0	2.3	2.6			
	17	5.1	3.8	5.7	2.0	2.0	2.0			
	AVE.	4.53	4.17	5.73	2.67	1.87	2.2	3.53	1.52	5.05
D	1	19.5	16.2	22.2	10.8	9.8	9.8	14.72	5.38	20.10
E	22	1.0	1.8	2.5	–	0.6	–	1.48	.85	2.33
F	6	2.0	1.3	2.3	2.0	0.9	2.0			
	23	–	1.7	1.8	1.1	1.0	1.0			
	27	1.5	1.9	2.1	–	1.0	1.2			
	AVE.	1.75	1.63	2.07	1.55	0.97	1.40	1.56	.37	1.93

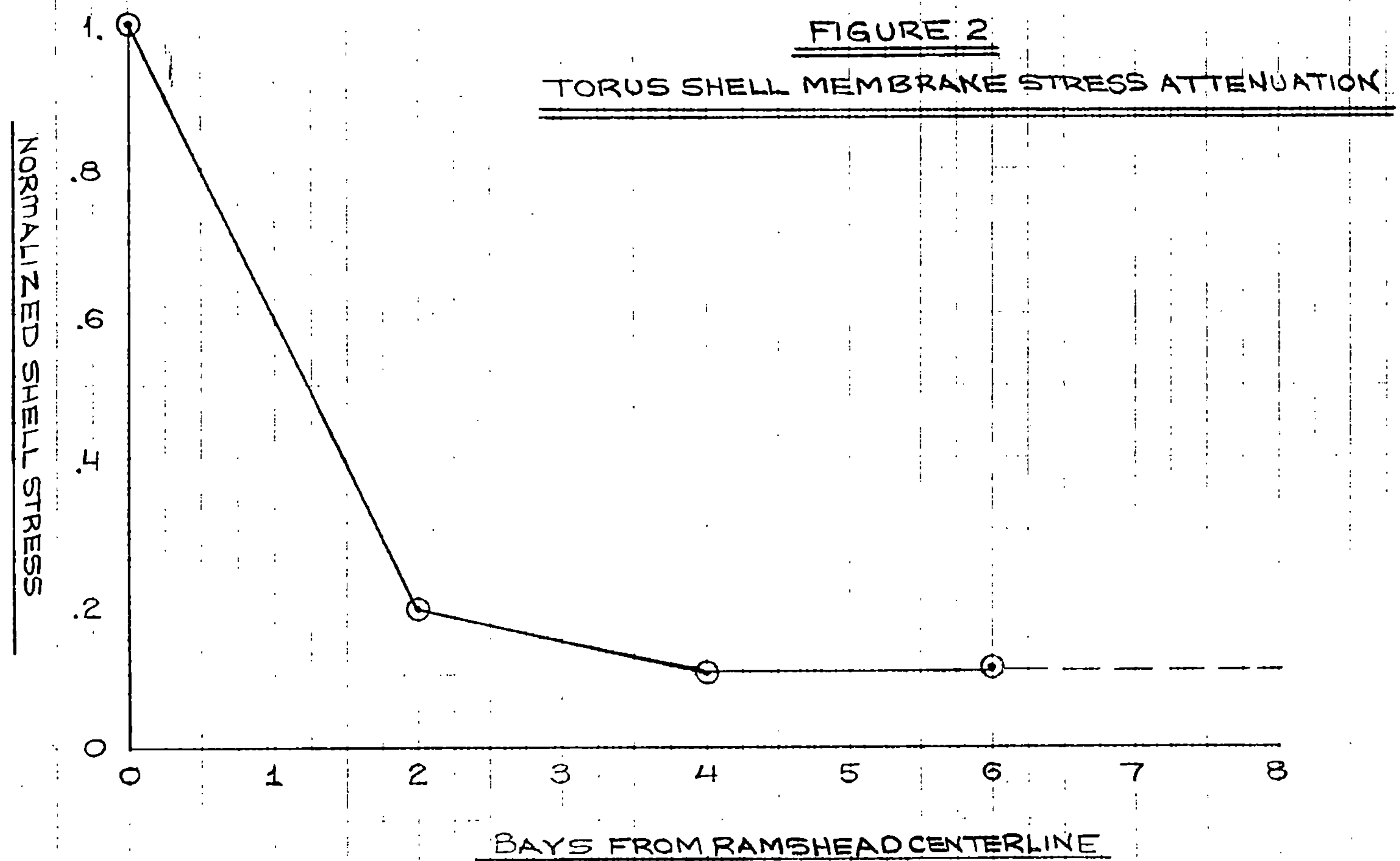
NORMALIZED TO TEST NO. 1 : A/D = 0.11
B/D = 0.09
C/D = 0.25
E/D = 0.12
F/D = 0.11

AVERAGING EQUIDISTANT DISCHARGES : $(C/D + E/D)_{AVE} = 0.19$
$(B/D + F/D)_{AVE} = 0.10$

TABLE 1) - SHELL ATTENUATION DATA AND CALCULATIONS

FIGURE 2

TORUS SHELL MEMBRANE STRESS ATTENUATION



to comparative multiplier factors derived from the shell stresses recorded during multiple valve actuation tests. The data, method, and results of this comparison are shown in Figure 3. The conclusion drawn from this comparison was that there was good correlation between the multiple valve discharge strain gage data and the pressure based attenuation curve. The small differences in the results were attributed to the fact that the gages measured both the membrane and shell bending stresses.

B) Torus Shell Reference Stress

The clean shell reference stress was determined using strain gage 18 located midbay, 45° up from the bottom, on the outside surface of bay D at Monticello. The maximum principal, extreme fiber, stress measured on SG18 during test No. 1 was 3400 psi. In bay C at Monticello, adjacent to bay D, strain gages were located at the bottom center of the bay both on the inside and outside surface of the shell. From these gages it was possible to establish a factor relating extreme fiber stress to membrane stress. This was done by plotting the outside fiber and membrane hoop stresses as a function of time and finding the outside fiber/membrane stress ratio at several points during the event history. See Figure 4. The mean of the outside fiber/membrane stress ratios was 1.17, indicating approximately 17% of the extreme fiber stress was due to bending of the shell. The same evaluation was performed on the longitudinal stresses and resulted in an outside fiber/membrane stress ratio of 1.26. See Figure 5. From this data an extreme fiber stress to membrane stress multiplier of .84 (1/1.17) was established.

During the Pilgrim SRV test there were strain gages located on the outside surface of the torus shell, midbay 45° up from bottom, SG18, and midbay on the bottom centerline, SG17. During the test, the maximum principal stress on SG18 was 3288 psi and on SG17 it was 4893 psi. By taking the ratio between the two principal stresses, a 1.49 shell stress factor is obtained when resolving stresses from 45° to the bottom centerline midbay.

The clean shell reference stress was derived from the Monticello SG18 stress, the outside fiber/membrane stress factor, and the 45° to bottom centerline factor as follows:

$$\sigma \text{ Ref. Clean Shell} = 3400 \text{ psi} \times .84 \times 1.49 = 4360 \text{ psi}$$

The σ Ref is the clean shell, midbay, bottom centerline reference stress for the Monticello Torus.

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RE STRAIN GAGE TEST DATA:

DISCHARGE BAYS	TEST	CLEAN SHELL MAX. PRINCIPAL STRESS SG 15	SG 18	SG 19	NORMALIZED TO TEST NO. 1 SG 15	SG 18	SG 19	CLEAN SHELL AVERAGE RATIOS
D	1	2433	3400	2281	1.0	1.0	1.0	
CDE	11	3609	4252	3743				
CDE	15	3403	5218	3441				
CDE	AVE.	3506	4735	3592	1.44	1.39	1.57	1.46
DFG	10	2519	4563	2480	1.04	1.34	1.09	1.16
CD	9	2660	4105	1795				
CD	18	4426	4443	3350				
CD	AVE.	3543	4274	2573	1.46	1.26	1.13	1.28

RE ATTENUATION CURVE, FIGURE 2:

1) BAY CDE DISCHARGE

CONTRIBUTION FROM BAY C (2 BAYS) = .19
CONTRIBUTION FROM BAY D (0 BAYS) = 1.00
CONTRIBUTION FROM BAY E (2 BAYS) = .19

TOTAL BAYS C,D,E = 1.38 → 1.46

2) BAY DFG DISCHARGE

CONTRIBUTION FROM BAY D (0 BAYS) = 1.0
CONTRIBUTION FROM BAY F (4 BAYS) = 0.11
CONTRIBUTION FROM BAY G (6 BAYS) = 0.10

TOTAL BAYS DFG = 1.21 → 1.16

3) BAY CD DISCHARGE

CONTRIBUTION FROM BAY C (2 BAYS) = .19
CONTRIBUTION FROM BAY D (0 BAYS) = 1.00

TOTAL BAYS CD = 1.19 → 1.28

FIGURE 3) STRAIN GAGE VS. PRESSURE DATA COMPARISON

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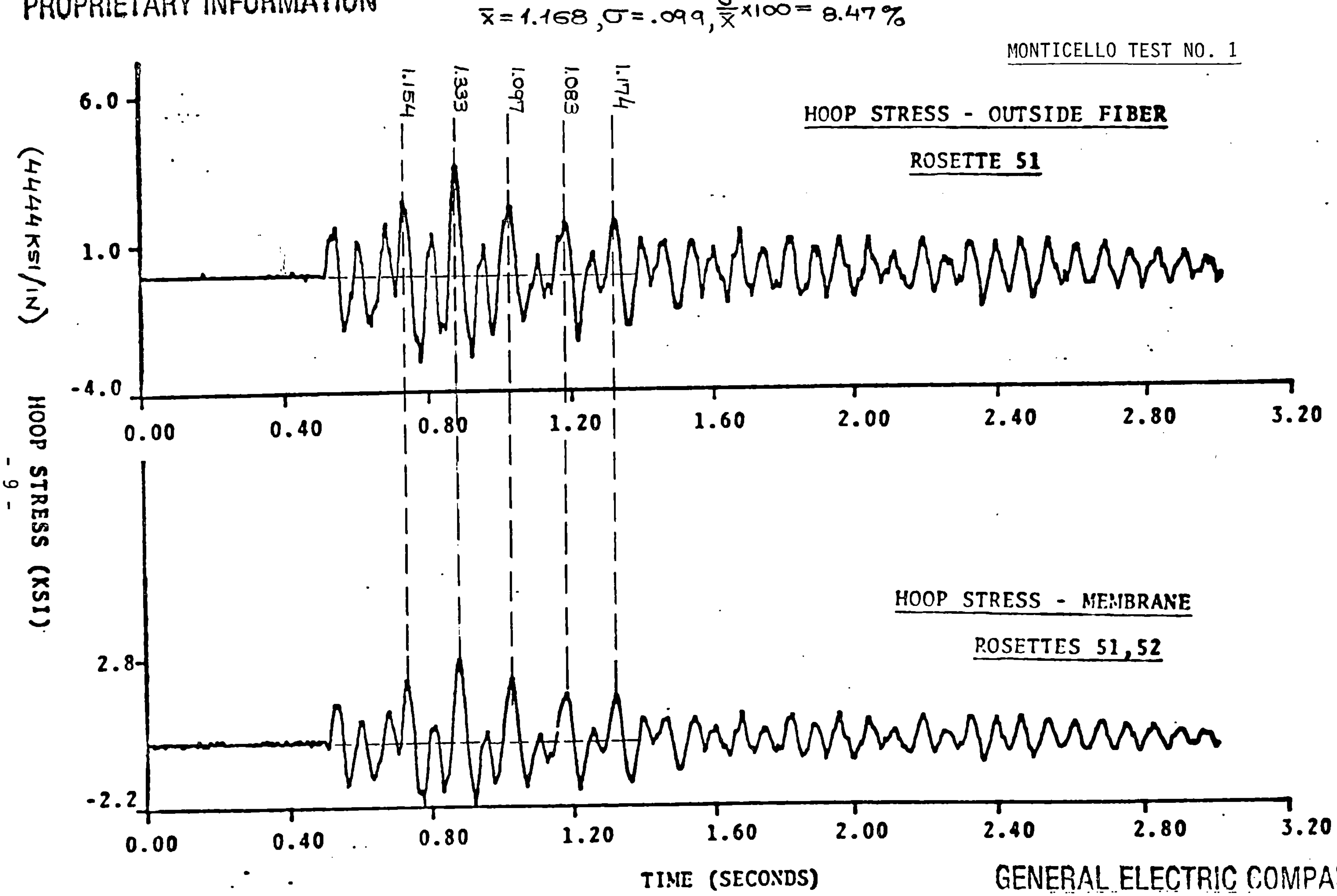

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FIGURE 4) OUTSIDE FIBER/MEMBRANE HOOP STRESS, TEST 1

$\bar{X} = 1.264$, $\sigma = .222$, $\frac{\sigma}{\bar{X}} \times 100 = 17.6\%$

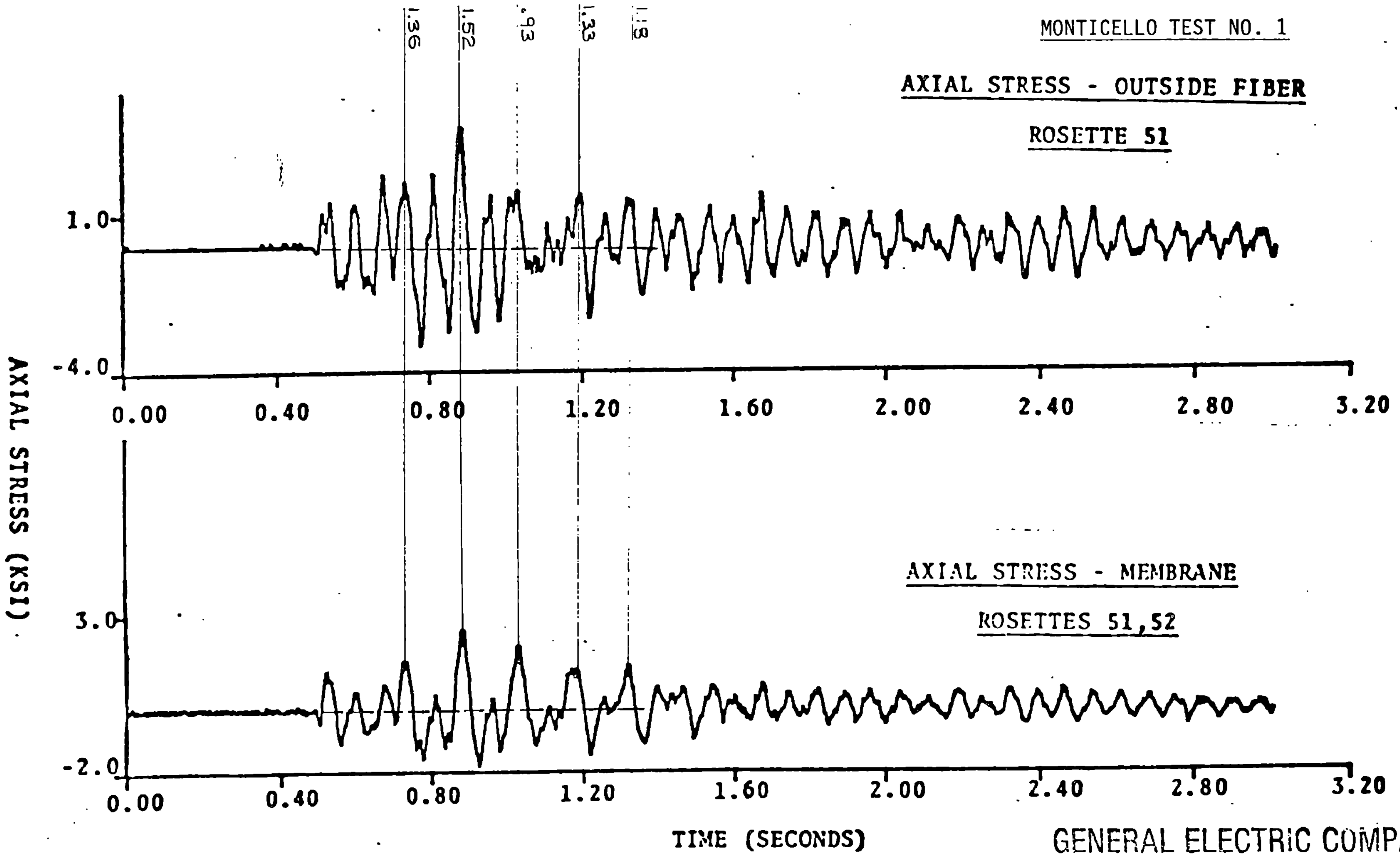

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FIGURE 5) OUTSIDE FIBER/MEMBRANE LONGITUDINAL STRESS

C) Torus Shell Consecutive Valve Actuation, "Hot Pop", Factor

The shell consecutive valve actuation factor, CVA, was obtained by evaluating the Monticello torus shell response for Tests No. 702, 703, and 1602. Test No. 1603 was omitted on the basis that it was not representative as a result of the earthquake tie clearance being taken up. The responses from the clean shell midspan bay D strain gages 15, 18 and 19 were used to calculate the CVA factor. The mean plus one standard deviation of the responses of each of the gages for the three tests were computed and normalized to the corresponding responses from Test No. 1. The normalized values were then averaged to obtain the CVA. See Table 2 for data and calculations. The torus shell CVA factor calculated by this method is 2.37.

D) Torus Support Column Response Attenuation Curve

The maximum downward column loads on Monticello column D4 were averaged for similar tests and then normalized to the column load from Test No. 1. The normalized values for discharges nominally equidistant from the instrumented column were then averaged as described in the previous shell stress section. Figure 6 shows the results of plotting these normalized column loads as a function of distance from column D4 to the centerline of the discharge ramshead.

Column D4 is an outside column located in bay D. During the tests, data from 3 strain gages, each separated by 90° circumferentially around the column, was recorded. In evaluating the column loads, only SG65 and SG67, located 180° apart, were used to eliminate the effect of column bending and to measure column axial load only. The data and the column attenuation load calculations are shown in Table 3.

Column load data was also available from the Hatch I S/RV test. At Hatch I, the S/RV ramsheads are located midbay and on the ring girders. Tests were run with discharges from both locations. Column load attenuation responses for both discharge locations were calculated as described above and the data points were plotted on Figure 6. Note the attenuation curve developed from Monticello data bounds the Hatch I data points and supports the use of the Monticello derived curve for analysis purposes.

The reference column load to which the column attenuation curve is to be applied for midbay discharges was obtained from Monticello column D4 during Test No. 1 and was equal to 196.7 kips compression. By comparing the column load responses from the two Hatch S/RV tests, a ring girder to midbay column load factor of .84 was determined. Applying this factor to the Monticello reference column load produced a ring girder column reference load equal to 196.7 X .84 = 165.3 kips compression.

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TEST NUMBER	MAX. PRINCIPAL STRESS SG 15	MAX. PRINCIPAL STRESS SG 18	MAX. PRINCIPAL STRESS SG 19
1	2433	3400	2281
702	4149	5957	3786
703	4344	6878	4610
1602	5944	9066	4512
	$\bar{X} = 4812$ $\sigma = 984$	$\bar{X} = 7300$ $\sigma = 1596$	$\bar{X} = 4302$ $\sigma = 450$
$\bar{X} + \sigma$ RATIO	5796 2.32	8896 2.62	4752 2.1
CVA = RATIO AVE. = 2.37			

TABLE 2) TORUS SHELL CVA CALCULATION

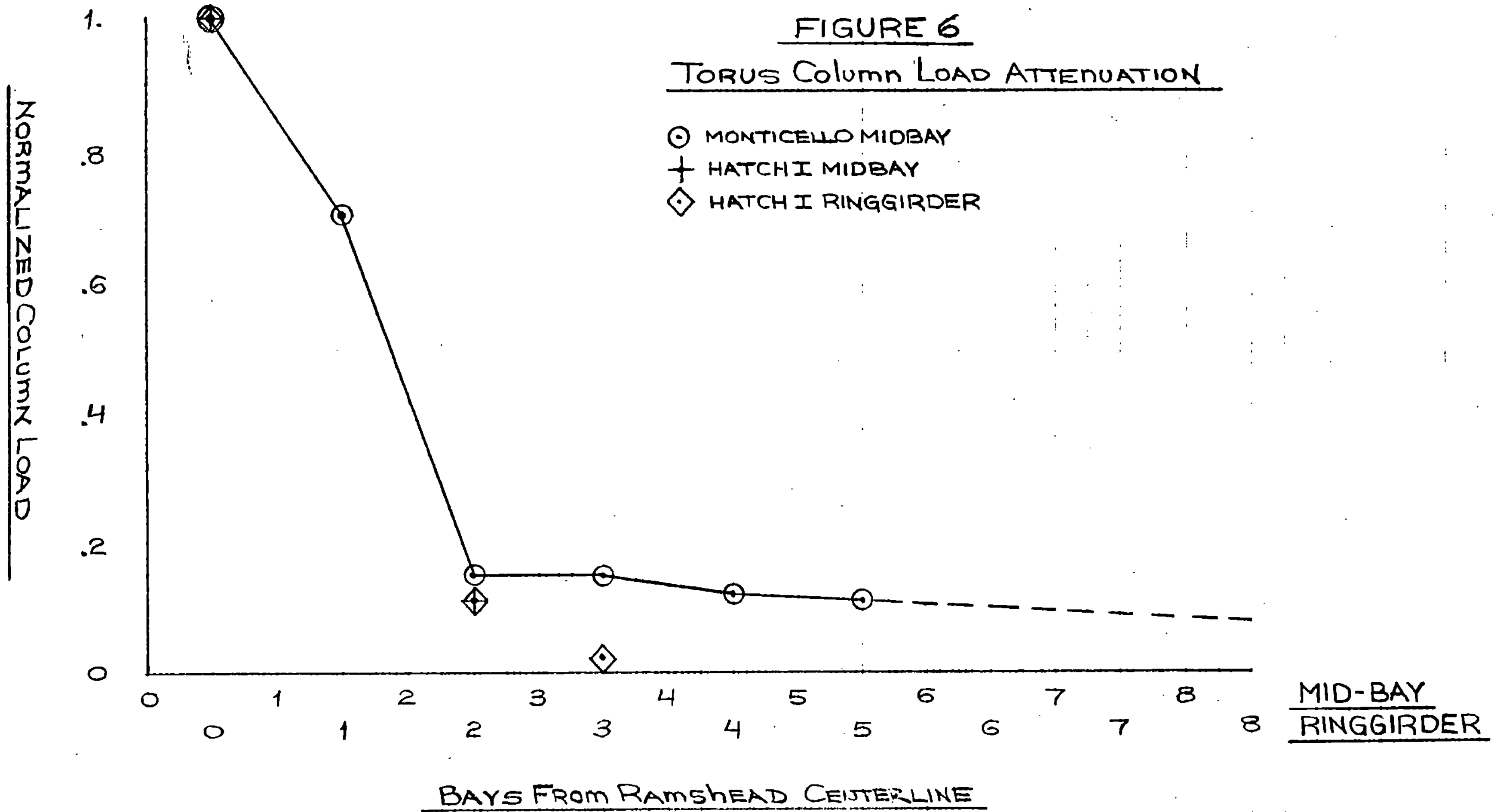


FIGURE 6

Torus Column Load Attenuation

DISCHARGE BAY	TEST NUMBER	COLUMN STRAINS μIN/IN			DISTANCE -BAYS-
		SG65	SG67	AVERAGE	
A	4	-23	3	-10	
	21	-28	-3	-16	
	AVE.			-13	5½
B	20	-15	-7	-11	
	24	-25	-23	-24	
	AVE.			-17.5	3½
C	2	-59	-52	-56	
	13	-109	-94	-102	
	17	-103	-92	-98	
	AVE.			-85.33	1½
D	1	-113	-128	-121	½
E	22	-14	-23	-19	2½
F	6	-20	-11	-16	4½
	23	-12	-13	-13	
	27	-17	-13	-15	
	AVE.			-14.67	

NORMALIZED TO TEST NO 1 (BAY D)

A/D = -13/-121 = .11
B/D = -17.5/-121 = .15
C/D = -85.33/-121 = .70
E/D = -19/-121 = .15
F/D = -14.67/-121 = .12

TABLE 3) TORUS SUPPORT COLUMN ATTENUATION CURVE DATA

The analysis of the Hatch S/RV test data used in this evaluation is enclosed in Attachment A.

E) Torus Support Column Consecutive Valve Actuation Factor

A procedure similar to that described above for the torus shell was applied to the column data. The maximum column compressive loads in column D4 (strain gages 65 and 67) were calculated for Tests 702, 703, and 1602. The mean plus one standard deviation of the maximum column loads for the 3 tests was then compared to the maximum compressive column load for Test No. 1. This procedure results in an overall CVA factor of 1.96 for the columns. The data and calculations for the column CVA factor are shown in Table 4.

STRAIN GAGE	COLUMN STRAINS μIN/IN TEST 702	TEST 703	TEST 1602
G5	-199	-210	-224
G7	-193	-223	-246
AVE.	-196	-216.5	-235

$\bar{X} = -215.833$

$\sigma = 19.5$

$\bar{X} - 1\sigma = -235.33$

$$\text{COLUMN CVA} = \frac{-235.33}{-120.5} = 1.96$$

TABLE 4) COLUMN CONSECUTIVE VALVE ACTUATION FACTOR

GENERAL ELECTRIC COMPANY
PROPRIETARY INFORMATION

References

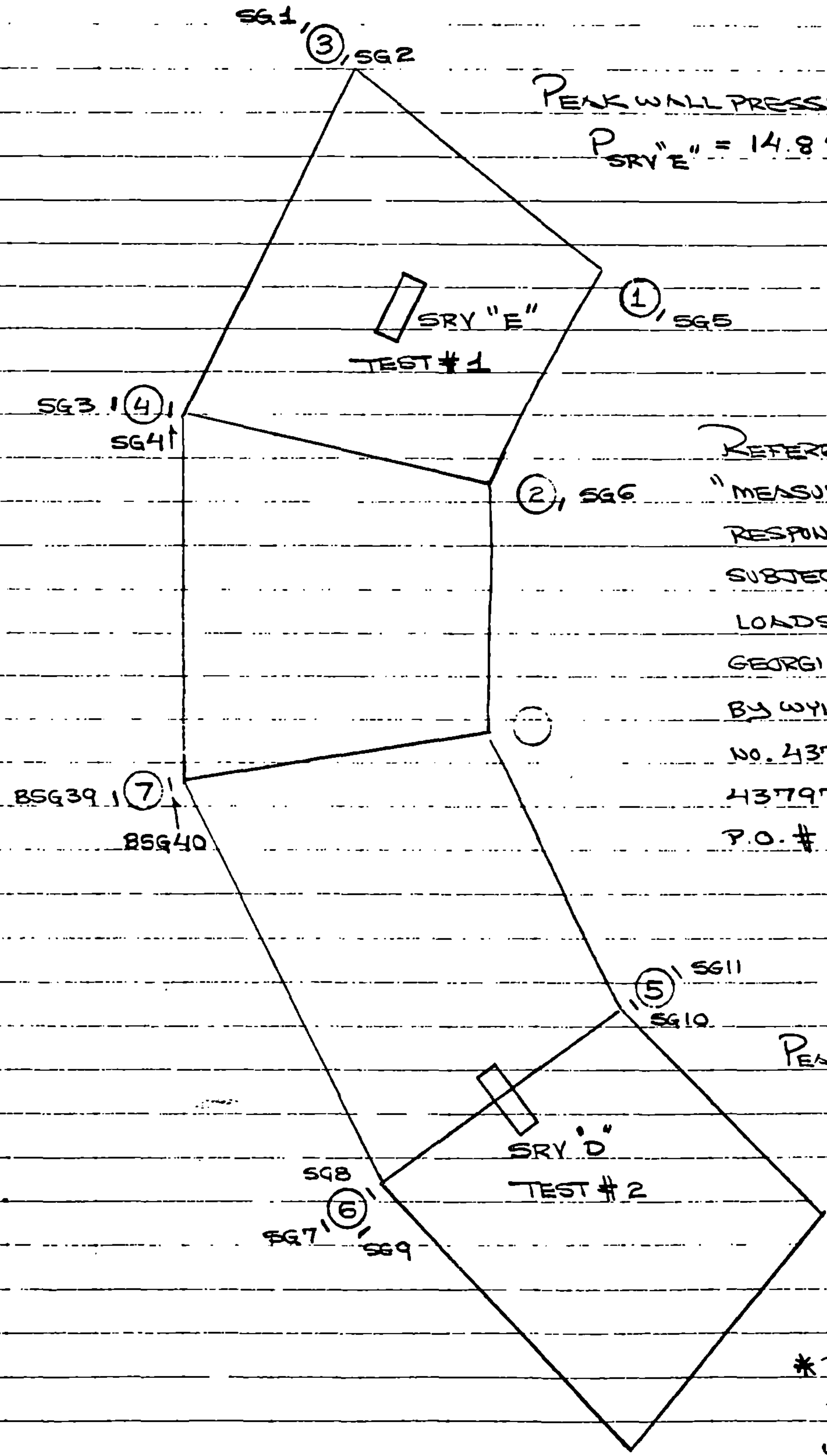
1) "Final Report, In-Plant Safety/Relief Valve Discharge Load Test - Monticello Plant", General Electric Co. Report NEDC-21581-P, Class III, August 1977.

2) "Preliminary Data From Pilgrim Unit 1 S/RV Test", Teledyne Engineering Services Technical Report No. TR-2682, August 19, 1977.

3) "Measurement of Structural Response of Mark I Torus Subjected to SRV Discharge Loads", Wyle Laboratories Report No. 43797-1, December 9, 1977, Prepared for Georgia Power Company (Hatch 1)

ATTACHMENT A - ANALYSIS OF HATCH 1 SRV TEST DATA

HATCH I SRV TEST INSTRUMENTATION



PEAK WALL PRESSURE*

$P_{SRV "E"}$ = 14.8 PSID

REFERENCE:

"MEASUREMENT OF STRUCTURAL RESPONSE OF MK I TORUS SUBJECTED TO SRV DISCHARGE LOADS", 12/9/77 PREPARED FOR GEORGIA POWER CO. (HATCH I) BY WYLE LABS. WYLE REPORT NO. 43797-1, WYLE JOB NO. 43797, GEORGIA POWER P.O. # PEH 10822

PEAK WALL PRESSURE*

$P_{SRV "D"}$ = 28.2 PSID

* RE JOHN NOSLER VIA PHONCON 5/19 : REF. OCT. 77 WORK DONE FOR NRC MTG.

MIDBAY RAMSHEAD DISCHARGE

TEST	SG					
1	1	-1753	-2172	-2017	-1651	-1365
TIME	-	2205	2210	2215	2220	2225
	2	-2510	-3405	-3673	-3499	-3125
AVERAGE		-2131	-2788	-2845	-2575	-2245
1	3	-1711	-2110	-1972	-1604	-1249
TIME	-	2205	2210	2215	2220	2225
	4	-2632	-3632	-3869	-3620	-3250
AVERAGE		-2172	-2871	-2921	-2610	-2250
1	7	-39	-202	-318	-323	-158
TIME	-	2205	2210	2215	2220	2225
	8	-77	-222	-336	-277	-94
AVERAGE		-58	-212	-327	-300	-126
1	10	+114	+279	+463	+540	+466
TIME	-	2205	2210	2215	2220	2225
	11	-78	-216	-419	-599	-708 max.
AVERAGE		+18	+32	+22	-30	-121

ATTENUATION - MIDBAY DISCHARGE

½ BAY -2883/-2883 = 1.0

2½ BAY -327/-2883 = .113

RINGGIRDER MIDBAY DISCHARGE

TEST	SG					
2	7	-1093	-1581	-1567	-1316	-1042
TIME	–	2130	2135	2140	2145	2150
	8	-1949	-2975	-3261	-3064	-2745
AVERAGE		-1521	-2278	-2414	-2190	-1894
2	10	-1569	-2468	-3009	-3198	-2931
TIME	–	2130	2135	2140	2145	2150
	11	-606	-715	-713	-711	-553
AVERAGE		-1088	-1592	-1861	-1955	-1742
2	3	-56	-139	-280	-316	-349
TIME	–	2130	2135	2140	2145	2150
	4	-49	-146	-266	-335	-414
AVERAGE		-53	-143	-273	-326	-382
2	1	+18	+33	-31	-120	-167
TIME	–	2130	2135	2140	2145	2150
	2	-24	-41	-86	-123	-116
AVERAGE		-3	-4	-59	-122	-142

ATTENUATION - RINGGIRDER DISCHARGE

0 BAYS	-2414/-2414	= 1.0
2 BAYS	-273/-2414	= .113
3 BAYS	-59/-2414	= .025

COMPARING OUTER COLUMN AXIAL LOADS FOR MIDBAY VERSUS RINGGIRDER RAMSHEAD DISCHARGE

MIDBAY DISCHARGE

$F_{COL\ 3} = -2845$ * 　　　　* UNITS IN PSI STRESS

$F_{COL\ 4} = -2921$

AVERAGE = -2883

RINGGIRDER DISCHARGE

$F_{COL\ 6} = -2414$

$$\frac{\text{RINGGIRDER}}{\text{MIDBAY}} \text{ FACTOR} = \frac{2414}{2883} = .84 \times 100 = 84\%$$