THE CLEVELAND ELECTRIC ILLUMINATING COMPANY
P.O. BOX 5000 ■ CLEVELAND, OHIO 44101 ■ TELEPHONE (216) 622-9800 ■ ILLUMINATING BLDG ■ 55 PUBLIC SQUARE
Serving The Best Location in the Nation

Dalwyn R. Davidson
VICE PRESIDENT
SYSTEM ENGINEERING AND CONSTRUCTION

June 7, 1982

Mr. A. Schwencer, Chief
Licensing Branch No. 2
Division of Licensing
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Dear Mr. Schwencer:

Perry Nuclear Power Plant
Docket Nos. 50-440; 50-441
Draft SER -
Structural Engineering Branch

Members of the Structural Engineering Branch requested additional information regarding Perry's Containment buckling analysis.

The subject information is attached to this letter.

Very truly yours,

Dalwyn R. Davidson

Dalwyn R. Davidson
Vice President
System Engineering and Construction

DRD: mb

cc: Jay Silberg, Esq.
John Stefano
Max Gildner

B001

BUCKLING ANALYSIS

At the meeting with the NRC in Bethesda on February 11, 1982, Newport News Industrial Corporation, Gilbert Associates, and Cleveland Electric Illuminating Company presented results of the containment vessel buckling evaluations to the Staff. As a result of this meeting the NRC requested that the vessel be evaluated against different criteria. The SEB position on Buckling Analysis of Steel Containment Vessel for Perry 1 and 2 was used for this evaluation.

A preliminary buckling analysis, Attachment No. 1, which used the NRC criteria and ASME Code Case N-284, indicated that the containment vessel design did not meet the new criteria including the proposed higher factors of safety.

Based upon the results of the preliminary analysis and recommendations of the staff the following action was proposed:

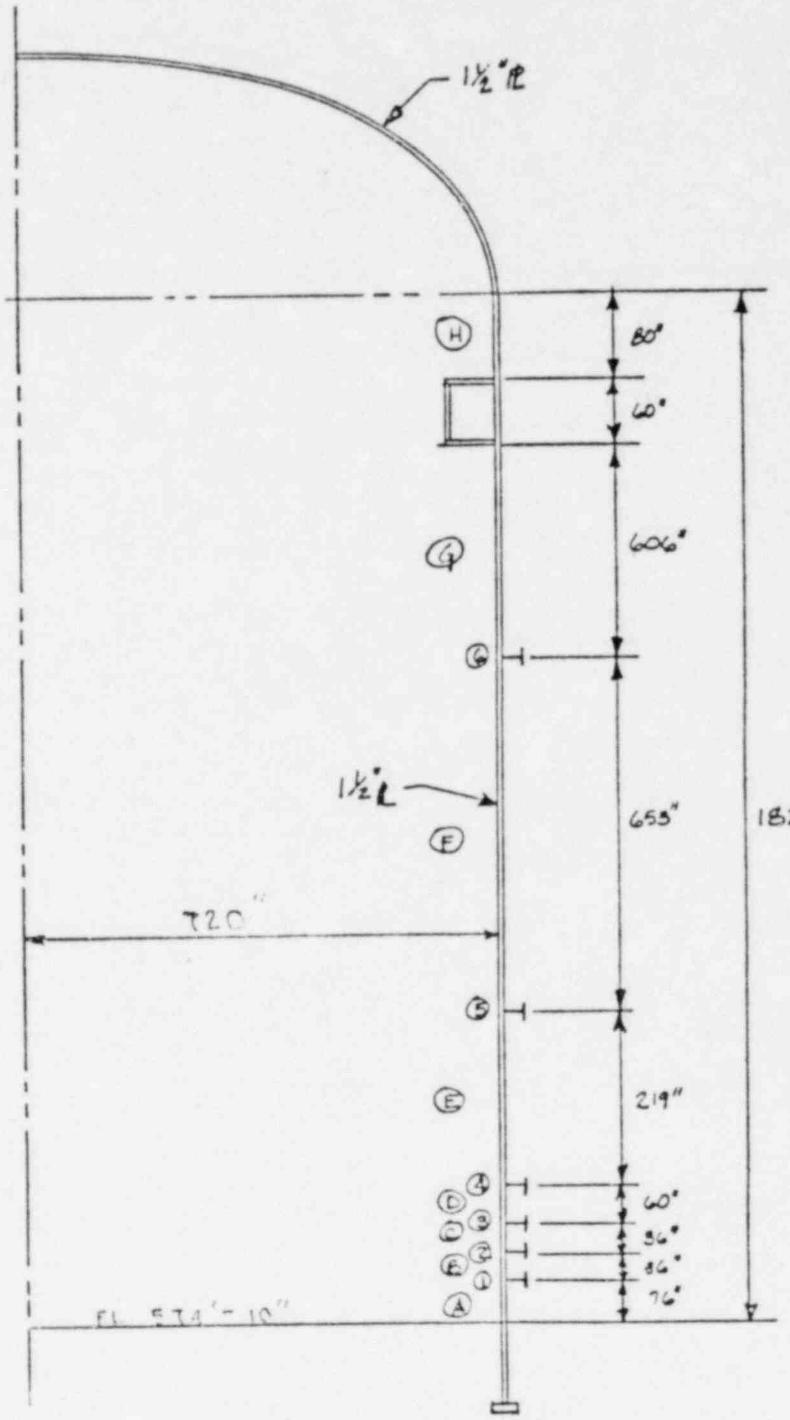
1. An axisymmetric buckling analysis was to be performed and submitted for staff review in order to assess more realistically the safety margin inherent to the containment vessel.

2. More realistic combinations of stresses, as applicable, were to be used, i.e., use concurrent states of meridional and hoop stresses.

3. In addition to the load cases presented with the external pressure due to inadvertent containment spray actuation, results were to be presented for the same cases without spray actuation.

The axisymmetric bifurcation analysis, Attachment No. 2, shows that the NRC safety margins were satisfied for all loads conservatively combined per Tasks 1 and 2 above. Task 3, above, was not pursued since the NRC safety margins were met even with the external pressure. Attachment No. 2 provides a detailed description of the bifurcation analysis.

PERRY CONTAINMENT VESSEL



Original Buckling Analysis

(Baker Method)
(PSI)

Section	Actual Ext. Pres.	Buck. Ext. Pres.[1]	Actual Axial Stress	Buck. Axial Stress[2]
E	2.597	17.2	3290.	11043.
F	.864	4.7	2535.	11528.
G	.864	4.95	1858.	11528.
H	.864	15.52	1016.	11043.

Note 1: From Baker, Fig. 10-15

Note 2: From Baker, P. 229-230, Fig. 10-9

Interaction Equation

(Baker Method)

Section	Interaction Equation	Factor of Safety
E	.449	2.23
F	.404	2.48
G	.394	2.54
H	-	-

From Baker, Fig. 9-2, $R_1 + R_2 \leq 0.5$

$$R_1 = \frac{\text{actual axial compressive stress}}{\text{axial buckling stress}}$$

$$R_2 = \frac{\text{actual external pressure}}{\text{external buckling pressure}}$$

LOAD COMBINATIONS

(CODE CASE N - 284)

Service Level A:	DL + LL + P + SRV
Service Level B:	DL + LL + P + SRV + OBE
Service Level C:	DL + LL + P + SRV + SSE
Service Level D:	N/A; No significant containment vessel local dynamic loads are defined.

AXIAL COMPRESSION

(CODE CASE N - 284)

Elevation	M_ϕ $l_\phi / \sqrt{rt}$	$\alpha_{\phi l}$	σ_ϕ (PSI)	C_ϕ	$\sigma_{\phi el}$ (PSI)	$\sigma_{\phi s}$ $\frac{\sigma_\phi \cdot FS}{\alpha}$	$\sigma_{\phi s}$ $\frac{\sigma_\phi \cdot FS}{\alpha}$
Service Level A						FS = 3.0	FS = 2.0
600'-7"	(219) 6.66	.265	-1842.	.605	35066.	20853.	13902.
634'-6"	(653) 19.86	.252	-1438.	.605	35066.	17119.	11413.
690'-4"	(606) 18.43	.252	-1310.	.605	35066.	15595.	10397.
720'-7"	(140) 4.26	.346	-670.	.605	35066.	5809.	3873.
Service Level B						FS = 3.0	FS = 2.0
600'-7"			-2820.			31925.	21283.
634'-6"	Same as Service Level A	Same as Service Level A	-2180.	Same as Service Level A	Same as Service Level A	25952.	17302.
690'-4"			-1799.			21417.	14278.
720'-7"			-995.			8627.	5751.
Service Level C						FS = 2.5	FS = 1.67
600'-7"			-3394.			32019.	21389
634'-6"	Same as Service Level A	Same as Service Level A	-2599.	Same as Service Level A	Same as Service Level A	25784.	17224.
690'-4"			-2038.			20218.	13506.
720'-7"			-1109.			8013.	5353.

EXTERNAL PRESSURE

(CODE CASE N - 284)

Elevation	$\alpha_{\theta 1}$	σ_θ (PSI)	$C_{\theta r}$	σ_{hel} (PSI)	$\sigma_{\theta s}$ $\frac{\sigma_\theta \cdot FS}{\alpha}$	$\sigma_{\theta s}$ $\frac{\sigma_\theta \cdot FS}{\alpha}$
Service Level A					FS = 3.0	FS = 2.0
600'-7"	.8	757.	.153	8868.	2839.	1893.
634'-6"	.8	658.	.048	2782.	2468.	1645.
690'-4"	.8	582.	.052	3014.	2183.	1455.
720'-7"	.8	2224.	.254	14722.	8340.	5560.
Service Level B					FS = 3.0	FS = 2.0
600'-7"		720.			2700.	1800.
634'-6"	Same as Service Level A	598.	Same as Service Level A	Same as Service Level A	2243.	1495.
690'-4"		473.			1774.	1183.
720'-7"		4145.			15544.	10363.
Service Level C					FS = 2.5	FS = 1.67
600'-7"		704.			2200.	1497.
634'-6"	Same as Service Level A	570.	Same as Service Level A	Same as Service Level A	1781.	1190.
690'-4"		410.			1281.	856.
720'-7"		5107.			15959.	10661.

Interaction Equation

(Code Case N-284)

Elevation	NRC Factors of Safety	Code Case N-284 Factors of Safety
Service Level A		
600'-7"	.64 (2.04)*	.35 (1.03)*
634'-6"	1.25	.65
690'-4"	.94	.50
720'-7"	N/A	N/A
Service Level B		
600'-7"	.99	.59 (1.16)*
634'-6"	1.38	.76
690'-4"	.94	.53
720'-7"	1.16	N/A
Service Level C		
600'-7"	.96	.58 (.97)*
634'-6"	1.13	.65
690'-4"	.74	.44
720'-7"	1.20	N/A

$$\frac{\sigma_{\phi s} - .5\sigma_{hel}}{\sigma_{\phi el} - .5\sigma_{hel}} + \left(\frac{\sigma_{\theta s}}{\sigma_{hel}}\right)^2 \leq 1.0$$

*Includes 25% reduction per NRC.

N/A: no check required if $\sigma_{\phi s} < .5\ \sigma_{hel}$

PNPP CONTAINMENT VESSEL
OVERALL BUCKLING ANALYSIS

ELASTIC BIFURCATION ANALYSIS

I. ANALYSIS BASIS

A. Purpose

Per the NRC's request, an axisymmetric elastic bifurcation analysis was conducted for the PNPP containment vessel to evaluate its margin of safety against buckling.

B. Model

The containment vessel was considered to be an idealized axisymmetric shell structure as shown in Figure 1. The vessel above the crane girder was not considered in the model since the Newport News Industrial Corporation analysis, Action Item 11, presented in the Febrary 11, 1982 meeting with the NRC, has justified that no buckling problem exists in the dome region. The vessel was assumed to be fixed at the bottom and at the ends of four ring stiffeners located in the area of filled annulus. The top of the vessel is conservatively assumed as free for the buckling mode N=1, and as pinned for the other buckling patterns.

C. Loads

The two types of load combination that were considered are as follows:

1. DL + LL + P + SRV + OBE - Service Level B

2. DL + LL + P + SRV + SSE - Service Level C

Service Level A and Service Level D were neglected because they are less severe.

D. Stresses

The stress distribution in the vessel for each load component was obtained from the containment vessel stress analysis results. These stress results are based on the latest vessel stress analyses with the containment fix concrete and are lower than the stress levels used for the preliminary analysis which were based on the unfixed vessel analyses. The controlling safety relief valve actuation case was the one valve subsequent actuation case. This case has the highest containment vessel design pressures and resultant stresses - more severe than either the 19 valve or 2 valve cases. In performing the load combination of stresses, a conservative philosophy was followed, i.e., for nonaxisymmetric loads the worst meridions were considered and for dynamic loads the maximum membrane compressive stresses in the whole time history were considered.

E. Analysis

First, the knockdown factors in different regions were calculated based on the equations specified in the Code Case N-284. For the area in the equipment hatch region, the corresponding knockdown factors were further factored by 0.75 to satisfy the current NRC requirement of 25% reduction for large pentrations exceeding 10% of the vessel diameter. The combined stress distribution was amplified according to the values of the knockdown factors in each region and then was input into the computer program KSHEL3B written by Dr. Kalnin to evaluate the critical prestress multiplier. This critical prestress multiplier was used to compare with the safety factors specified by the NRC and Code Case N-284.

II. ANALYSIS RESULTS

The predicted buckling mode is a local buckling which occurs at the area between the stiffeners at El. 610'-5" and El. 664'-10". In other words, it occurs, as expected, at the area where the equipment hatch is located. The critical prestress multiplier for service level C is 2.97 compared with the safety factor 2.5 per NRC and 1.67 per Code Case N-284. The critical prestress multiplier for service level B is 3.26 compared with the safety factor 3 per NRC and 2 per Code Case N-284. This comparison is also listed in Table 1.

III. CONCLUSION

The axisymmetric bifurcation analysis has confirmed that the containment vessel is safe against buckling. The axisymmetric bifurcation analysis meets the latest NRC factors of safety even with the 25% reduction for large openings in the equipment hatch region. Since the axisymmetric bifurcation analysis with containment sprays meets the NRC's current factor of safety requirements against buckling, an analysis without the sprays is not required.

TABLE 1

A comparison between the critical prestress multiplier and the safety factors specified by NRC and Code Case N-284.

	Service Level B	Service Level C
Critical prestress multiplier from elastic bifurcation analysis	3.26	2.97
Factor of Safety per NRC	3	2.5
Factor of Safety per Code Case N-284	2	1.67

Gilbert Associates, Inc. Reading, Pennsylvania CALCULATION	SUBJECT Perry Containment Vessel Buckling		CISID		PAGE OF PAGES
	REV. 0	1	2	3	
	MICROFILMED				
	ORIGINATOR S S HSIEH				
	DATE 5/11/82				

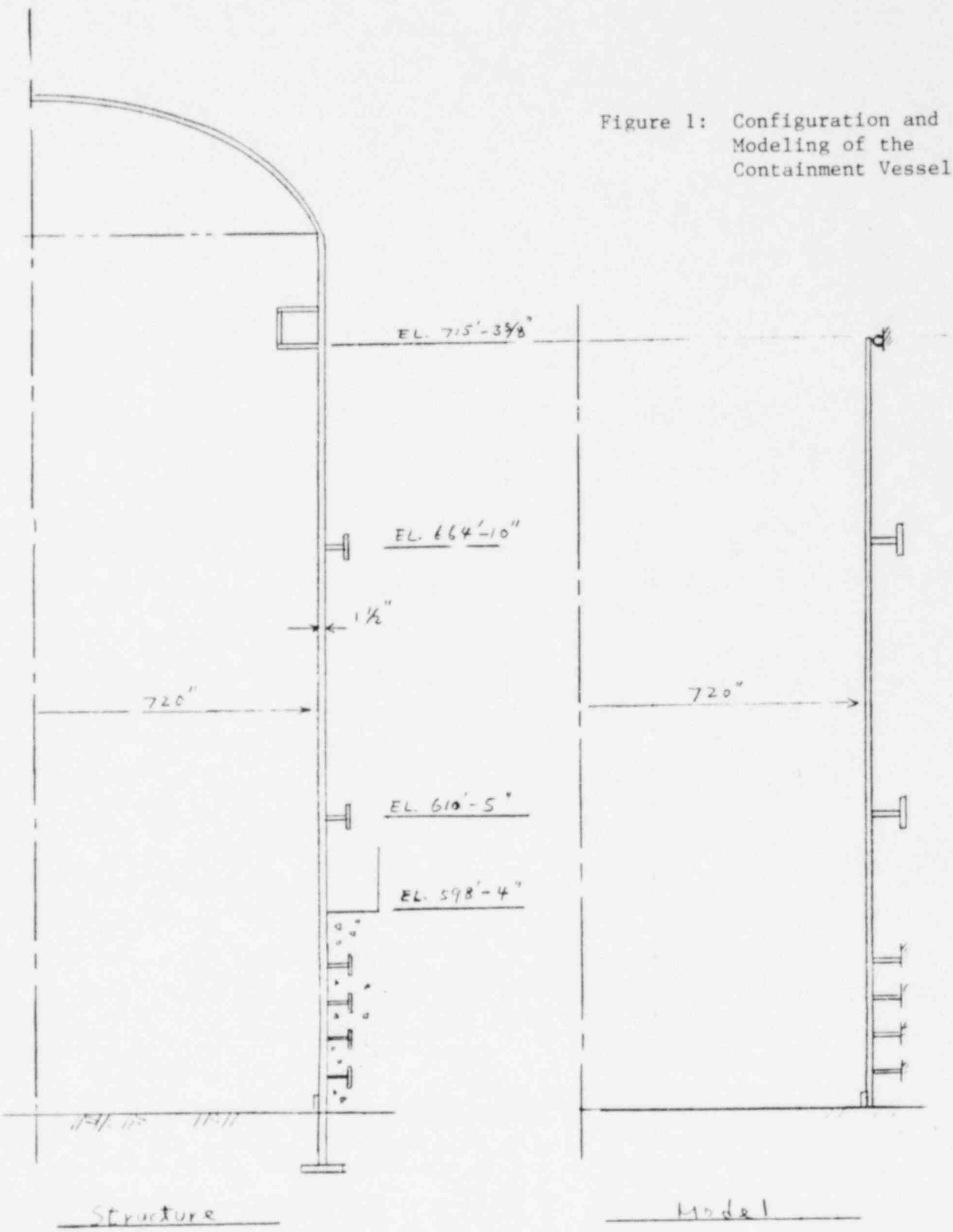


Figure 1: Configuration and Modeling of the Containment Vessel