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October 31, 1989

William J. Cahill, Jr.
Executive Vice President

U. S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, D. C. 20555

SUBJECT: COMANCHE PEAK STEAM ELECTRIC STATION (CPSES)
DOCKET NO. 50-445
SUPPLEMENT TO PREVIOUS RESPONSE TO THE REQUEST
FOR ADDITIONAL INFORMATION ON FSAR SECTION 3.8
(ULTIMATE CAPACITY OF THE CONCRETE CONTAINMENT)

REF: 1) TU Electric Letter TXX-89569 from William J. Cahill to the USNRC, dated August 16, 1989
2) TU Electric Letter TXX-89725 from William J. Cahill to the USNRC, dated September 28, 1989

Gentlemen:

On July 31, 1989, a public meeting was held in Bethesda, Maryland, to discuss the NRC's Request for Additional Information (RAI) on the amended FSAR Sections 3.7 and 3.8. Reference 1 provided a response to the RAI items discussed in the public meeting. During September 6-7, 1989, the NRC conducted a structural audit at CPSES. As a result of discussions during and after the audit, TU Electric stated (Reference 2) that the ultimate capacity of the Unit 1 concrete containment would be provided. On October 11, 1989, a public meeting was held in Rockville, Maryland, to discuss the results of the ultimate capacity evaluation with the NRC. The ultimate capacity report is attached.

If there are any questions regarding this submittal, please contact Carl Corbin at (214) 812-8859.

Sincerely,

William J. Cahill

William J. Cahill, Jr.

CBC/smp
Attachment

c - Mr. R. D. Martin, Region IV
Resident Inspectors, CPSES (3)

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REPORT

ON

ULTIMATE PRESSURE CAPACITY OF UNIT 1 COMANCHE PEAK STEAM ELECTRIC STATION (CPSES) CONTAINMENT

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SECTION 1

INTRODUCTION AND OBJECTIVES

In the course of the FSAR amendment review (1989) by the Nuclear Regulatory Commission (NRC), a question was raised concerning the ultimate pressure capacity of the CPSES containment. In response to the NRC question, an analysis of the CPSES reinforced concrete containment was performed to estimate the ultimate pressure capacity. Detailed analysis of the containment liner, hatch, locks and penetrations was not performed since existing data indicates that the inherent strength of these metal components exceeds the strength of the concrete containment structure. Although a specific analysis was not performed, the configurations of the CPSES containment liner, hatch, locks and penetrations were compared to those at other pressurized water reactors (PWR's), and conclusions were drawn based on this comparison. The results of the concrete containment evaluation and the configuration comparison of the hatch, locks and the penetrations etc., were presented to the NRC staff in a public meeting held on October 11, 1989. In the meeting, the staff requested further information on the behavior of the concrete containment, the liner, hatch and locks; and a report to further demonstrate that the drawing comparison approach utilized was adequate. This report has been prepared in response to the staff's requests.

The governing design criteria of the CPSES containment are stated in the CPSES FSAR and in the Design Basis Documents (DBD's) (References 1, 2 and 3). The design pressure of the containment is 50 psig (Ref 1). This report provides the evaluation of the ultimate pressure capacity of the containment liner, hatches, penetrations, and the following areas of the reinforced concrete containment:

* General membrane region of the reinforced concrete wall
* General membrane region of the reinforced concrete dome
* Local discontinuity at the reinforced concrete wall and the mat intersection
* Local discontinuity of the reinforced concrete wall-to-dome intersection
* Local discontinuity of the reinforced concrete wall at the equipment hatch area
* Containment mat

Ultimate pressure capacity is defined as the limiting pressure in the containment when the reinforcing steel and the liner both attain a state of general yield with no further increase in section capacity or there is a general yielding of the metal pressure retaining components.

SECTION 2

GENERAL DESCRIPTION OF THE CONTAINMENT

The reactor containment structure is a steel-lined conventionally reinforced concrete PWR containment structure. It consists of a vertical cylindrical wall topped by a hemispherical dome supported on a circular mat. The mat is 147 feet in diameter and is 12 feet thick. The cylindrical wall is 4 feet-6 inches thick with an inside radius of 67.5 feet. The height from the top of the mat to the spring line is 195 feet. The hemispherical dome has an inside radius of 67.5 feet and a thickness of 2.5 feet. There is a transition region of about 10 feet extending from the spring line where the thickness gradually changes from that of the containment wall (4.5 feet) to that of the dome (2.5 feet). The thickness of the liner is 1/2 inch in the dome area, 3/8 inch in the cylindrical wall portion, and 1/4 inch on the top of the mat. The liner is welded to a skirt plate (knuckle plate) which is embedded and anchored in the concrete mat. There is a protective layer of reinforced concrete on top of the mat liner.

There are three major openings in the cylindrical portion of the containment wall These are the equipment hatch (16 feet in diameter), personnel hatch (9 feet in diameter), and the emergency escape lock (5.75 feet in diameter). The containment wall is locally thickened in these regions to allow additional reinforcement to be placed around these openings.

A typical cross-section of the containment is shown on Figure 1. A comparison of the configurations and the material properties of the CPSES containment structure and that of the other PWR containments is shown in Table 1. The reinforcing details of the mat and the containment are contained in the CPSES structural drawings (2323-S1-0500 to 2323-S1-0506).

There are various penetrations (electrical, mechanical and piping), ranging in diameter from 52 inches to 4.5 inches, installed through the containment wall. The area of the liner adjacent to penetrations is locally thickened (i.e., by reinforcing plates) to reinforce this discontinuity and to provide a smooth transition between the 3/8 inch liner and the penetration; see Figure 2. The largest of these penetrations are the main steam and the feedwater penetrations. Table 2 compares the configurations and material properties of the CPSES main steam and feedwater penetrations to other PWR containment penetrations.

The equipment hatch is a single closure penetration with a spherical door, convex side towards the inside of the containment. The personnel air lock is a double enclosure penetration also with spherical doors, the interior door has its convex side towards the inside of the containment. Similarly the emergency escape lock is a double enclosure penetration with flat circular doors. The barrels of these locks and hatch are welded to thickened portions (i.e., by reinforcing plates) of the containment wall liner. Figure 3 shows the configurations of the equipment hatch and personnel air lock and Figure 4 and 5 show the typical reinforcing details around the equipment hatch. Table 3 compares the configurations and the material properties of the CPSES equipment hatch and personnel air lock to other PWR containment equipment hatches and personnel air locks.

SECTION 3

COMPARISON TO OTHER PWR CONTAINMENTS

Tables 1, 2, and 3 provide a comparison of the configuration and material properties of the CPSES containment to other PWR containments.

Review of Table 1 indicates that the configuration of the CPSES containment is very similar to other PWR containments listed. The thickness of the liner is the same as those listed. The inside radius of the containment is the same as that of Main Yankee; is slightly smaller than Seabrook 1 & 2 and Millstone 3 and is slightly larger than Beaver Valley 2 (BV2) (see Table 1). The CPSES containment has a slightly thicker mat and a taller cylindrical wall. The specified concrete and rebar strength are the same as Seabrook and are higher than the others. The specified liner strength is the same as BV2 and is much higher than Seabrook 1 & 2.

Table 2 compares the main steam and feed water geometric configurations to other PWR containments. Review of the sleeve diameter to the sleeve thickness ratio and the reinforcing plate diameter to the sleeve diameter ratio indicates they are very similar.

SECTION 4

METHOD OF ANALYSIS

To evaluate the ultimate pressure capacity of the CPSES containment, a review of other PWR ultimate pressure capacity reports was performed. The reports reviewed are listed in the Reference section of this report (References 7 and 8). These reports cover a range of typical PWR containments with various geometric configurations and material properties. A common conclusion of these reports is that the ultimate pressure capacity is limited by the capacity of the reinforced concrete containment. The metal portions of the pressure retaining components such as the penetrations, hatches, and locks are demonstrated to have higher ultimate pressure capacities than the concrete containment. The design requirements of ASME metal components are, in general, more stringent than the concrete code resulting in higher ultimate capacities. Thus, it is concluded that to estimate the ultimate capacity of a concrete containment, the evaluation need only to concentrate on the concrete containment as long as the configurations and the properties of the metal components are within the range of the parameters evaluated in the referenced reports and the overall liner strains are not excessive.

4.1 Reinforced Concrete Containment and Mat

The evaluation of the concrete containment is based on a linear elastic analysis of the shell. The shell is modeled as a fixed based two dimensional axisymmetric shell of revolution. The material properties are taken as the specified design minimums. Stiffness of the shell is determined using cracked concrete properties based on the patterns of the reinforcing steel and liner. The containment structure is founded on rock subgrade. An assumption is made that the most critical location would be the cylinder wall mat junction. The effects of the mat deformation on the behavior of the containment shell at the shell mat intersection are accounted for based on the results of the nonlinear analysis performed for the design of the containment shell for the 1.5P load case. The nonlinear analysis determines the degree of uplift of the mat and the changes in the containment base shear and moment due to the flexibility of the mat. It is anticipated that at a higher internal pressure, there would be more uplift in the mat and the restraining effect of the mat would be smaller. The reduction in mat stiffness would also reduce the containment base moment and shear. Thus, the use of the moment and shear reduction factor based on the 1.5P case would be conservative.

The containment is analyzed for the load combination of 1.0 Dead + 1.0 P_{max} case. The ultimate pressure capacity P_{max} is determined using an iterative procedure. Initially the shell analysis is performed based on an assumed maximum pressure and the corresponding shell forces and moments are determined. These results are reviewed to identify the critically stressed areas of the shell and the corresponding stresses of the reinforcing steel and liner are determined. The pressure is increased until the value of pressure corresponding to a general state of yield (complete yielding of both the reinforcing steel and liner) is determined (i.e., the ultimate pressure).

The thickened concrete shell areas in the immediate vicinity of the equipment hatch, personnel air lock and emergency escape lock have substantially more reinforcing than the general membrane area. The reinforcing details at these areas are compared to those of the containments with published ultimate pressure capacities (References 7 and 8). A simplified analysis of the embossed concrete ring beam around the equipment hatch is performed and the deformation of the ring beam is compared to that derived from the shell analysis.

The capacities of the concrete sections, in most cases, are based on the ACI 318-83 code allowables with $\phi = 1.0$. In cases where the design code is conservative, realistic assumptions are used. In the 12 foot thick mat area where the code requires a reduction in shear capacity due to the existence of axial tension in the member, even though the tension is much smaller than the modulus of rupture of the concrete, an allowable concrete shear stress of 160 psi (approximately $2.5 \sqrt{f'c}$) is used. Shear friction is utilized to resist shear where the reinforcing steel is essentially perpendicular to the shear plane at the springline. Since only the specified material strengths are used in this analysis, the concrete section capacities calculated could be considered as lower bound values.

4.2 Containment Liner, Hatches and Penetrations

Local discontinuities in the metal liner and associated penetrations (e.g., equipment hatch, personnel and emergency escape hatches, electrical, mechanical and piping penetrations) are not analyzed in this evaluation. As mentioned above, a review of the CPSES liner and penetrations is performed and the configurations are compared to the liner and penetrations in other PWR containments for which ultimate pressure capacitites had been evaluated. The CPSES liner and penetrations though not identical, are similar to those reviewed. Additionally, the reinforcing steel configurations in the concrete areas adjacent to the penetrations and hatches are also reviewed and are determined to be similar to those containments discussed above. In the review of these ultimate capacity reports, there is no indication that penetrations and hatches would limit the ultimate capacity of the containment.

In this evaluation, average strains at various elevations of the liner are determined corresponding to the ultimate pressure and compared to the yield strain of the liner. Since the liner strain is moderate, a comparison is made with conclusions, based on the documentation of other ultimate pressure capacity reports, that the liner and the penetrations would not be the limiting components.

The CB&I stress reports for the CPSES hatch and locks were reviewed and the stresses at the critical areas are proportionally increased to the ultimate pressure and then reviewed for potential failure.

SECTION 5

DISCUSSION OF RESULTS

5.1 Containment Concrete Shell

Yielding of the hoop rebar in the cylindrical wall area began at about 50 feet from the top of the mat (the general membrane region). The hoop reinforcing in this area is two #18 @ 11" center-to-center spacing at each face. At 150 psig, the reinforcing steel and the liner at the membrane zone reached a general yield state whereas the meridional reinforcing bars are still below yield. At this pressure, major cracking is expected to develop in the membrane zone.

At 150 psig the section capacities at the discontinuity areas (i.e. at the base and the springline) still have additional margins. At the springline, the liner is still within its elastic limit. At the base of the containment, the discontinuity moment causes the inside face of the liner to be in tension, however, the liner and the inside face reinforcing bars are still within their elastic limits. The shear reinforcement at the base of the containment is adequate to resist the computed radial shear.

The vertical and horizontal deflections of the containment at 150 psig are shown in Figures 6 and 7. The maximum predicted radial displacement at the membrane region is about 1.7 inches, and the vertical growth of the containment at the apex of the dome is about 3.7 inches. The calculation of the deflection does not consider the changes in the shell wall stiffness due to the yielding of the rebars.

At 150 psig, the deformation of the concrete ring beams in the immediate vicinity of the hatches is shown to be smaller than those computed by the shell analysis at the membrane region. Separation of the ring beam and the containment wall in the order of 0.09 inch is predicted.

5.2 Containment Mat

The containment mat, in general, is not the controlling structural component. The critical area in the mat is at the containment mat junction where there is a substantial shear force. At 150 psig, various diagonal cracks are postulated in this area. In each case, sufficient reinforcing is provided to satisfy equilibrium. The estimated uplift of the mat is in the order of 0.05 inches; and there is sufficient reinforcing in the mat to resist the calculated shears and the moments.

5.3 Containment Liner

The maximum liner hoop strain at 150 psig is about 0.002 at the cylinder wall membrane region. The maximum meridional strain at the base of the containment is about 0.0019 which is less than the yield strain. The welds at the liner and penetration insert plate junctions could have larger strains due to the stress concentration effect. At these strain levels, fracture of the liner is not expected since the material of the liner is very ductile. Thus the liner would have an ultimate capacity of at least 150 psig.

5.4 Equipment Hatch, Personnel Air Lock and Emergency Escape Lock

After reviewing the stress reports (Reference 5) and factoring up the stresses at critical locations, indications are that the critical component of both the equipment hatch and the personnel air lock was the cover flange. Stress in the cover flange resulting from combined bending and axial stress is approximately equal to the yield stress. The corresponding stress in the covers is less than 40% of the minimum specified yield stress.

The critical component of the emergency escape lock (El. 909'-0") was the bulkhead, with a maximum resulting stress exceeding the minimum specified yield stress. The analysis provided in the stress report was a simplified manual calculation; it is expected that a refined analysis would demonstrate the maximum stresses to be substantially lower.

Based on the review of the stress report it is concluded that sections of the three hatches would likely reach yield and undergo plastic deformations though actual failure or rupture would not occur until the pressure exceeds 150 psi.

5.5 Penetrations

The review concluded that penetrations would not be the controlling components. This conclusion is based on the following. Review of Tables 2 and 3 shows that the material properties and configurations of the CPSES penetrations are similar to that for other plants. Stresses due to direct pressure on the sleeves of the penetrations are relatively minor. For the main steam penetration the hoop stress due to the 150 psi would be 2.6 ksi and the longitudinal stress would be 1.3 ksi. The critical stress location for the penetrations is expected to be in the 3/8 inch liner in areas adjacent to the reinforcing plates. These areas are not expected to fail until after the liner in this region starts to yield.

SECTION 6

CONCLUSIONS

A study was performed to estimate the ultimate pressure capacity of the CPSES containment structure. Ultimate pressure capacity is defined as the limiting pressure in the containment when the reinforcing steel and the liner both attain a state of general yield with no further increase in section capacity or there is general yielding of the metal pressure retaining components. The analysis is based on an elastic interactive analysis of the reinforced concrete containment in which the effects of the cracking of the concrete are considered in the analysis. It is concluded that the ultimate pressure capacity of the CPSES containment is 150 psig. At this pressure, both the liner and the reinforcing steel at the membrane region (about 50 feet above the base) reach a general state of yield; corresponding liner hoop strain is about 0.002. The maximum meridional liner strain at the base of the containment is about 0.0019 which is less than the yield strain of the liner. The maximum radial displacement is about 1.7 inches and the vertical displacement at the apex of the dome is about 3.7 inches.

The hatches and the penetrations were also reviewed and their configurations are compared to that of the other PWR containments for which ultimate pressure capacities have been determined. The review indicated that these metal pressure retaining components would not limit the ultimate pressure capacity of the containment.

The material properties used in the CPSES evaluation are the minimum specified design values. The actual material strengths are expected to be significantly greater as can be seen in the comparison made in Table 1. Thus, the concrete section capacities calculated for CPSES could be considered as lower bound values.

SECTION 7

REFERENCES

1. Design Basis Document DBD-CS-073, Containment Structure

2. Design Basis Document DBD-CS-074, Containment Liner and Penetrations

3. Design Basis Document DBD-CS-081, General Design Criteria

4. C.H. Conley, R.N. White, P. Gergely, Strength and Stiffness of Reinforced Concrete Panels Subjected to Membrane Shear, Two-Way and Three-Way Reinforcing, NUREG/CR 2049, April 1981.

5. CB&I Stress Report, CBI Letter DBE-410, Dated April 7, 1977; For CPSES Components

6. Joint ASCE-ACI Task Committee 426 on Shear and Diagonal Tension. The Shear Strength of Concrete Members. Journal of the Structural Division, ASCE, June 1973, pp 1091-1185.

7. Jung, J., Ultimate Strength Analyses of Watts Bar, Maine Yankee, and Bellefonte Containments. NUREG/CR-3724, July 1984

8. Other Ultimate Pressure Capacity reports:
   - South Texas, Letter ST-HL-AE-1489 from Houston Lighting & Power to USNRC dated October 31, 1985, "Submittal of Reactor Containment Building Design Report," (Appendix D, "Containment Ultimate Pressure Capacity Analysis")
   - Millstone 3, "Containment Failure Modes Analysis for the Millstone Nuclear Power Plant Unit 3," April 1983
   - Seabrook 1 & 2, "Containment Ultimate Capacity of Seabrook Units 1 & 2 for Internal Pressure Loads," Study prepared for Public Service Co. of New Hampshire by United Engineering Inc., February 1983

9. White, R.N. and Holley, M.J., Jr. Experimental Studies of Membrane Shear Transfer. Journal of the Structural Division, ASCE, August 1972.

10. Hofbeck, J.A.; Ibrahim, I.O.; and Mattock, A.H. Shear Transfer in Reinforced Concrete, ACI Journal, February 1969, pp 114-128.

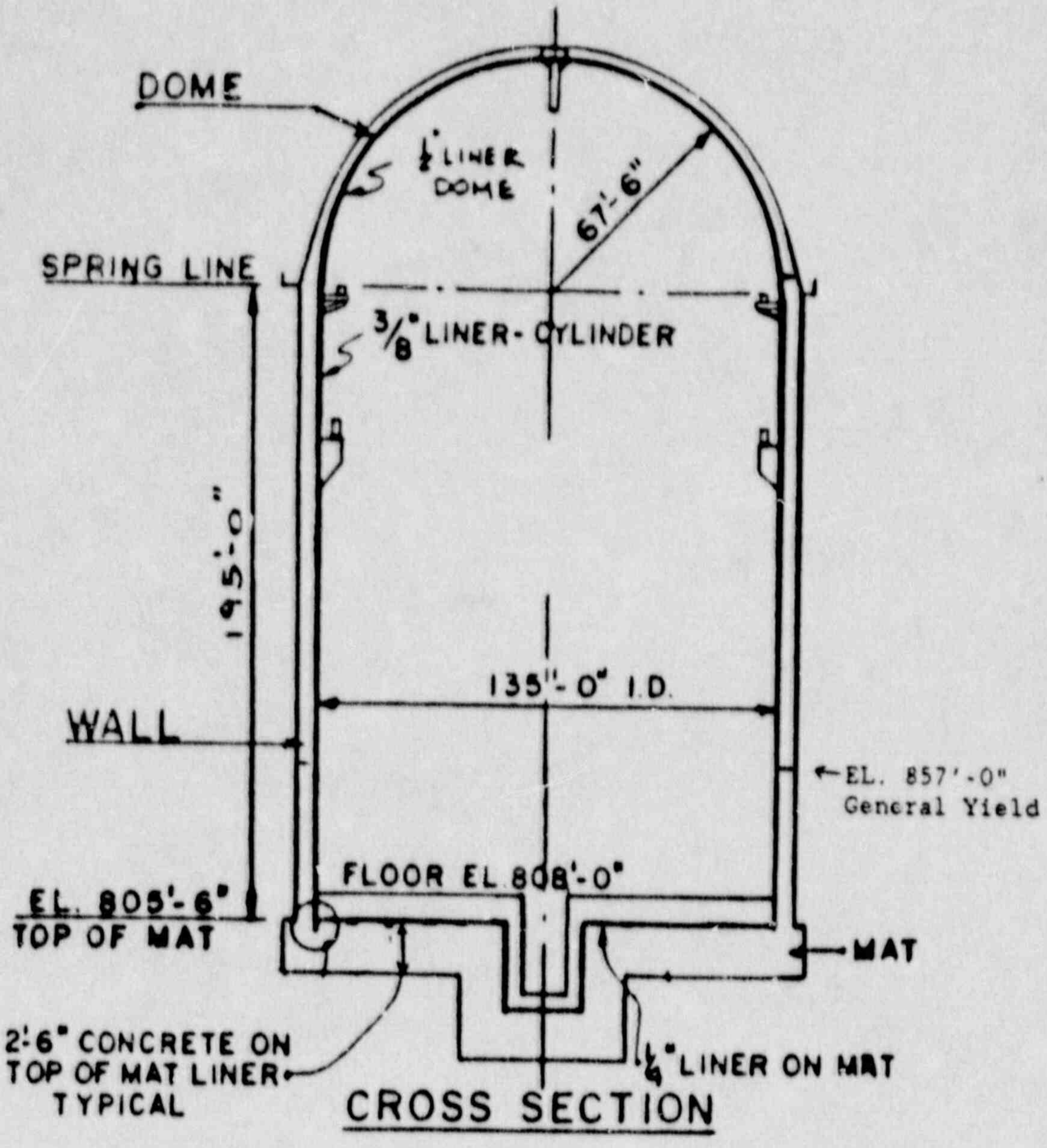
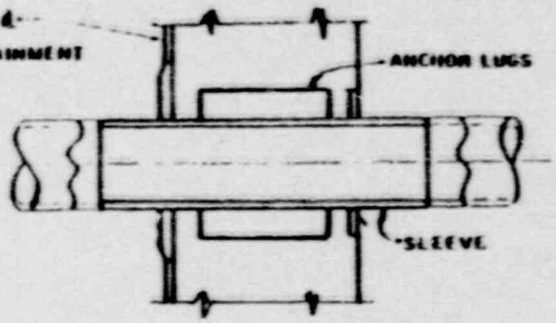
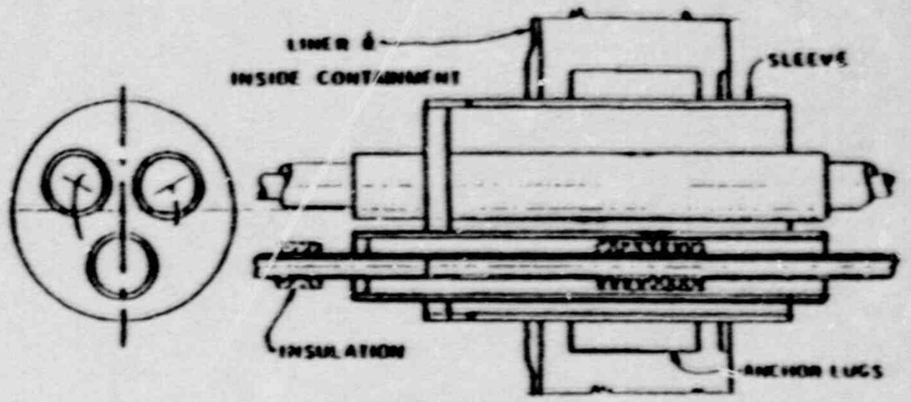


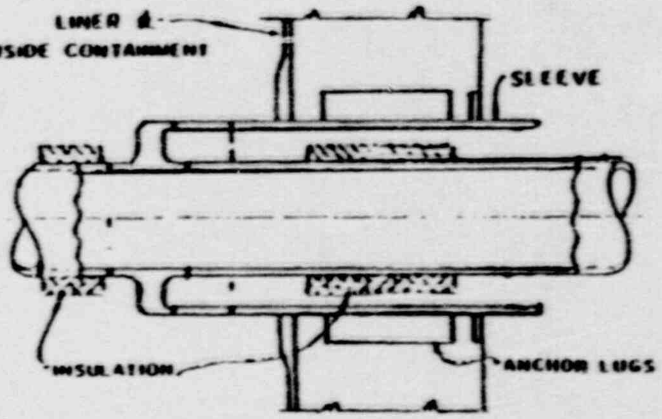
FIGURE 1 CONTAINMENT - ELEVATION



COLD PIPE PENETRATION



MULTIPLE PIPE PENETRATION



HOT PIPE PENETRATION

NOTE: MAIN STEAM PENETRATIONS
-EL. 877.50 FT
FEEDWATER PENETRATIONS
-EL. 856.25 FT

FIGURE 2 CPSES TYPICAL PENETRATION CONFIGURATIONS

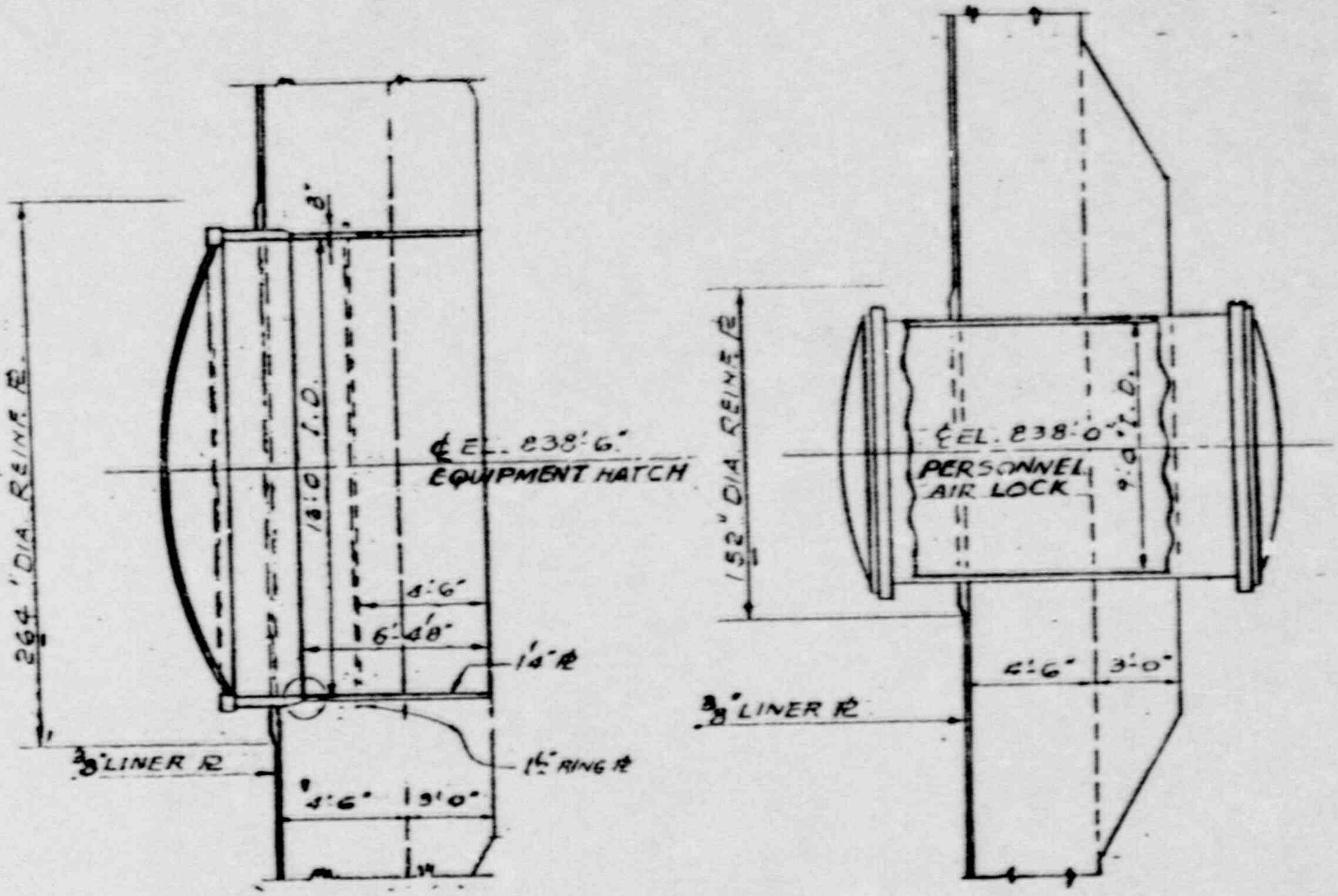


FIGURE 3 CPSES EQUIPMENT HATCH & PERSONNEL AIR LOCK

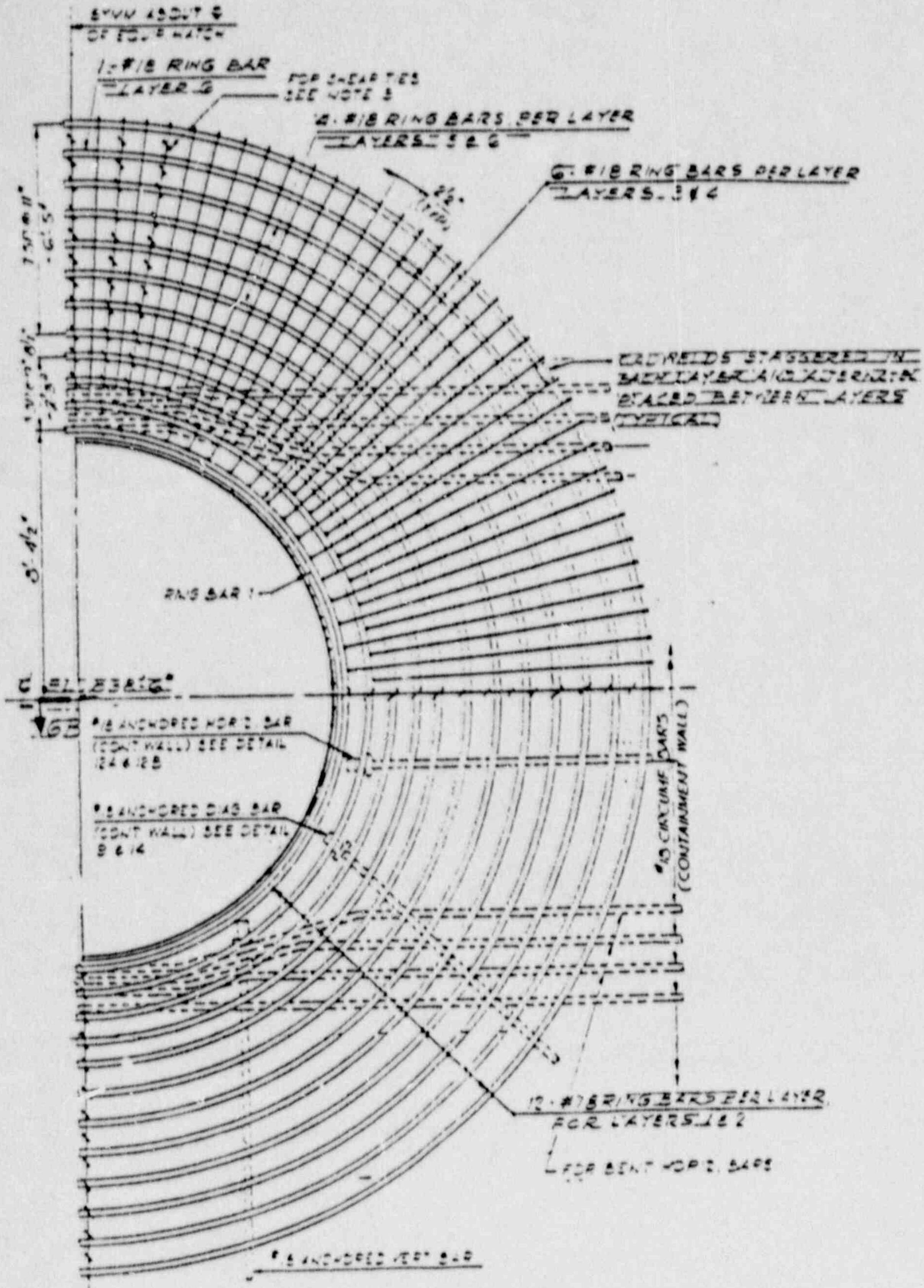


FIGURE 4 CONTAINMENT - EQUIPMENT HATCH
ADDITIONAL REINFORCEMENT

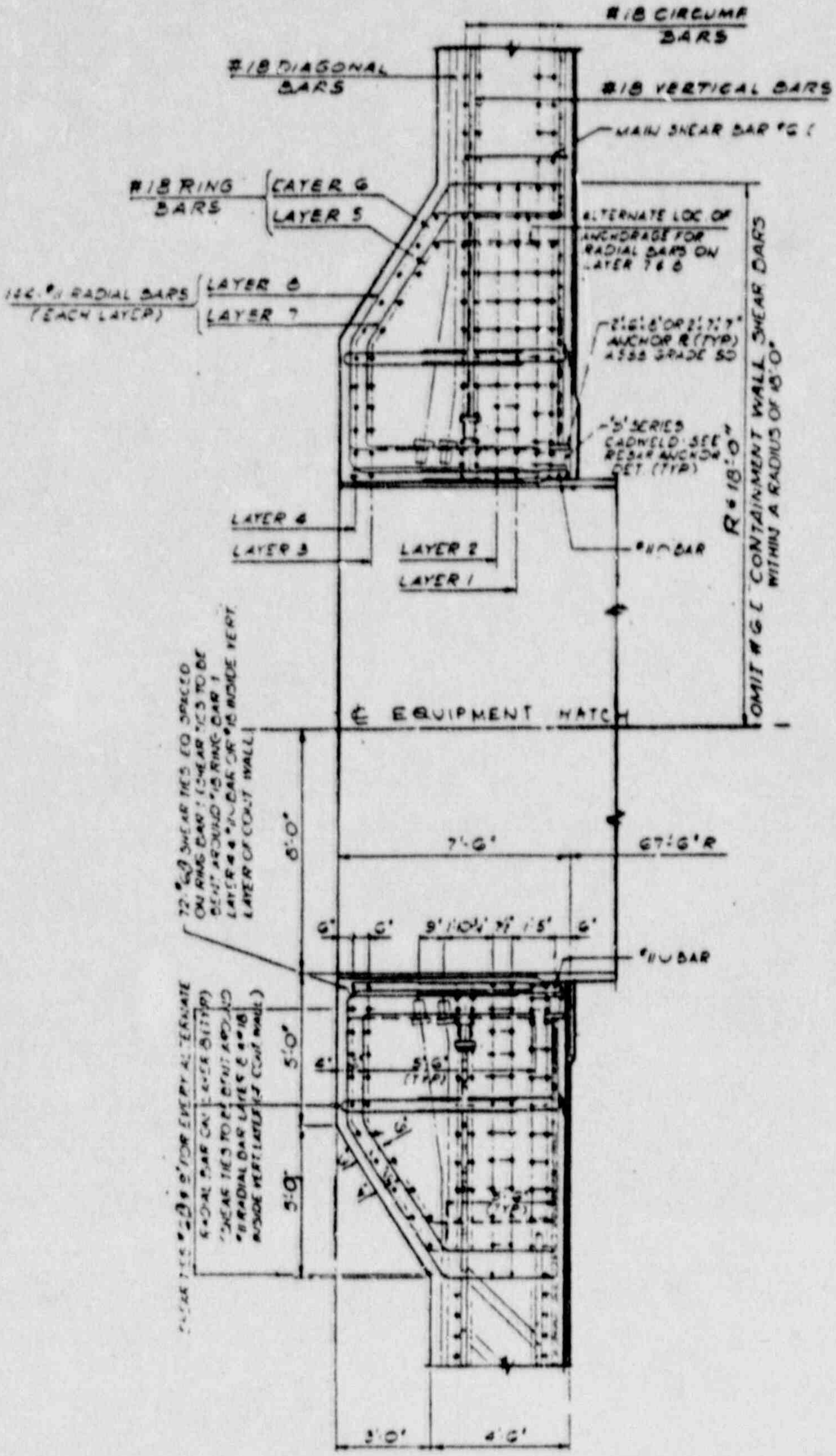


FIGURE 5 CONTAINMENT - EQUIPMENT HATCH ADDITIONAL REINFORCEMENT

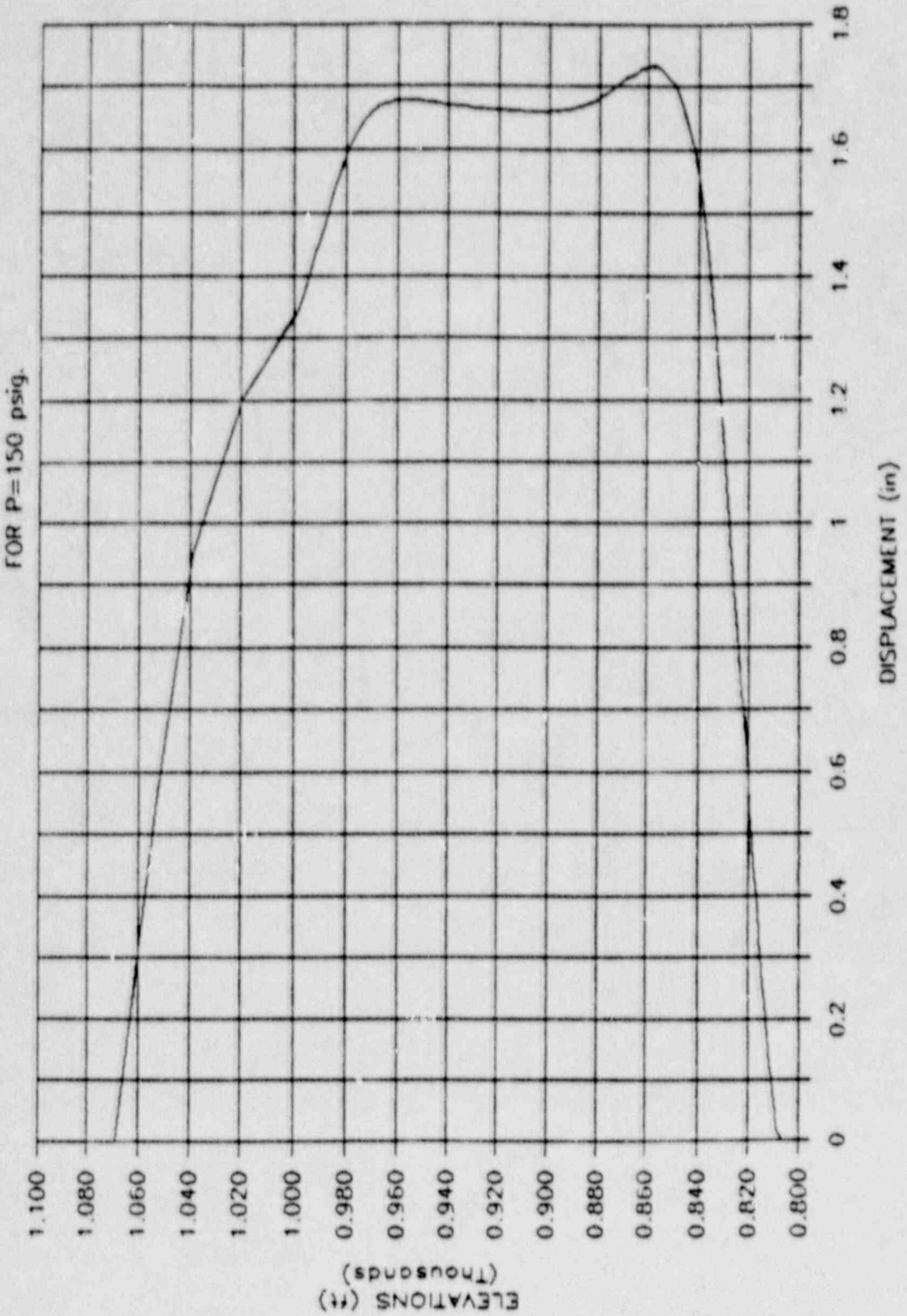


FIGURE 6 CONTAINMENT SHELL - RADIAL DISPLACEMENTS

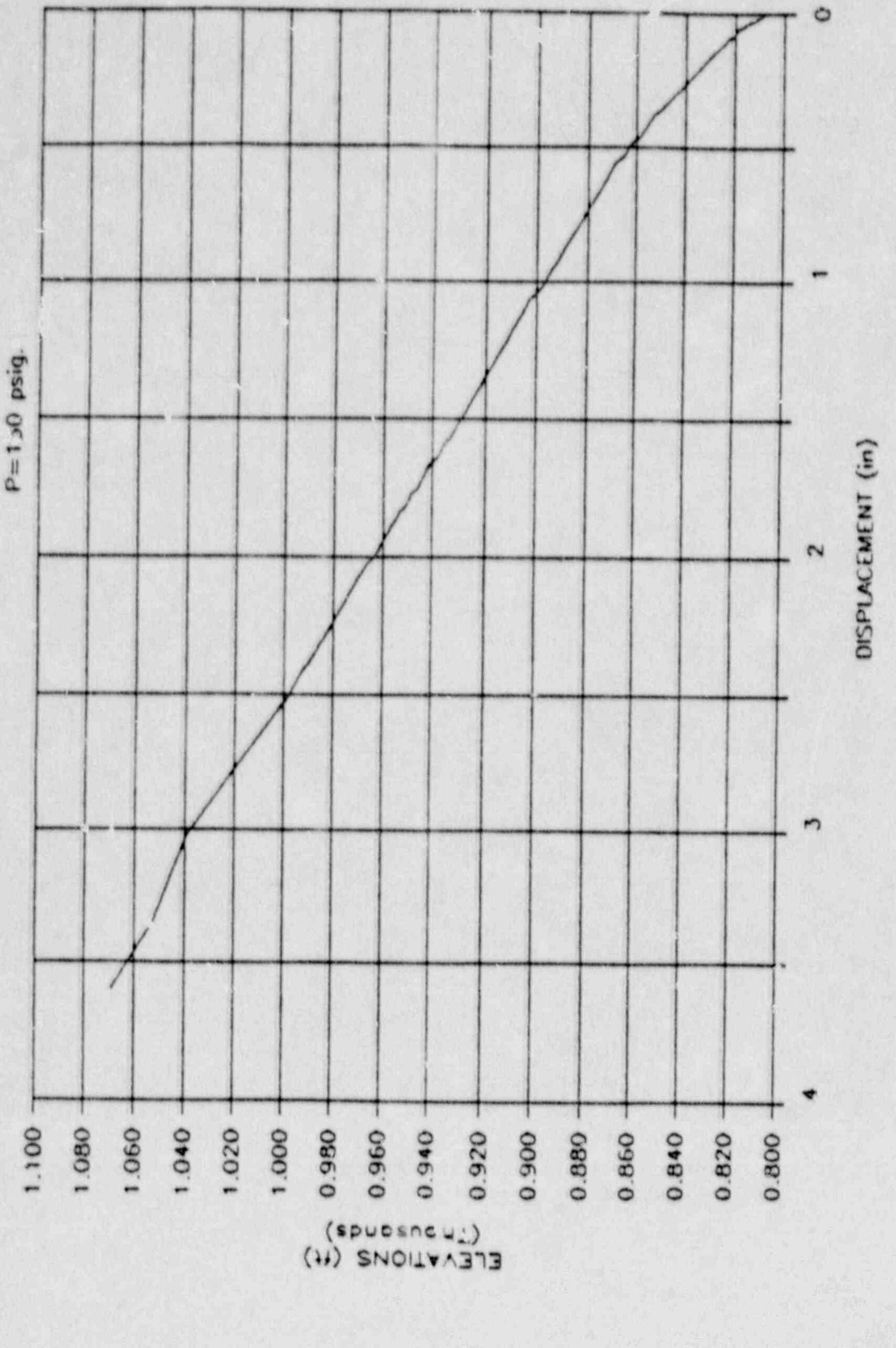


FIGURE 7 CONTAINMENT SHELL - VERTICAL DISPLACEMENTS

NUCLEAR UNIT \ ATTRIBUTE	CONCRETE STRENGTH (psi)	REBAR STRENGTH (psi)	LINER MATERIAL	LINER STRENGTH (psi)	CYLINDER				DOME			MAT	
					HEIGHT (feet)	INSIDE RADIUS (feet)	CONCR. THICK. (feet)	LINER THICK. (inch)	INSIDE RADIUS (feet)	CONCR. THICK. (feet)	LINER THICK. (inch)	CONCR. THICK. (feet)	LINER THICK. (inch)
CPSES 1 (150 psi) *	4,000	60,000	SA-537 CLASS 2	60,000	195.0	67.5	4.5	0.375	67.5	2.5	0.5	12.0	0.25
Seabrook 1 & 2 (150 psi)	4,000 (5,500)**	60,000 (72,400)	SA-516 Gr. 60	32,000 (46,200)	149.0	70.0	4.5	0.375	70.0	3.5	0.5	10.0	0.25
Maine Yankee (96 psi)	3,000	50,000	A-516 Gr. 60	32,000	102.0	67.5	4.5	0.375	67.5	2.5	0.5	10.0	0.25
Millstone 3 (128 psi)	3,000 (5,000)	50,000 (56,500)	SA-537 CLASS 2	50,000 (57,100) 60,000 (78,500)	131.3	70.0	4.5	0.375	70.0	2.5	0.5	10.0	0.25
Beaver Valley 2 (124 psi)	3,000 (4,400)	50,000 (52,000)	SA-537 CLASS 2	60,000 (61,300)	122.0	63.0	4.5	0.375	63.0	2.5	0.5	10.0	0.25

* Ultimate Capacity

** Actual strengths which were used in the evaluation

TABLE 1 CONFIGURATION COMPARISON OF CPSES CONTAINMENT WITH OTHER CONTAINMENTS

	CPSES 1	MILLSTONE 3	BVPS 2
MAIN STEAM PENETRATIONS			
CALCUALTED P_{ult}	----	128 psi	> 124 psi
Sleeve Diameter (D)	52.0	48.0	45.0
Sleeve Thickness (t)	1.5	1.25	1.25
Sleeve Ratio (D/2t)	17.33	19.20	18.00
Sleeve Material	SA-537 Class 2	SA-537 Class 2	SA-537 Gr. B
Yield Strength	60,000	60,000	60,000
Reinf. Plate Diam.(d)	90.0	72.0	90.0
Reinf. Plate Ratio(d/D)	1.73	1.50	2.0
Reinf. Plate Thick.	1.0	2.0	2.0
Reinf. Plate Matl.	SA-537 Class 2	SA-537 Class 2	SA-537 Class 2
Yield Strength	60,000	60,000	60,000
Liner Yield Strength	60,000	50,000 60,000	60,000
FEEDWATER PENETRATIONS			
CALCUALTED P_{ult}	----	131 psi	> 124 psi
Sleeve Diameter	34.0	35.0	28.0
Sleeve Thickness	1.25	1.25	0.625
Sleeve Material	SA-537 Class 2	SA-537 Class 2	SA-312 Type 304
Yield Strength	60,000	60,000	30,000
Reinf. Plate Diam.	60.0	61.0	56.0
Reinf. Plate Thick.	1.0	1.0	1.0
Reinf. Plate Matl.	SA-537 Class 2	SA-537 Class 2	SA-537 Class 2
Yield Strength	60,000	38,000	60,000

TABLE 2 CONFIGURATION COMPARISON OF CPSES MAINSTEAM & FEEDWATER PENETRATIONS WITH THOSE OF OTHER CONTAINMENTS

	CPSES 1	SEABROOK 1&2	MILLSTONE 3	BVPS 2
EQUIPMENT HATCH				
CALCUALTED P_{ult}	....	> 145 psi	170 psi	> 124 psi
Door Thickness (in.)	1.125	n/a	1.0	1.0
Door Material	SA-516 Gr. 70	SA-516 Gr. 60	SA-516 Gr. 70	SA-537 Class 2
Yield Strength (psi)	38,000	32,000	38,000	60,000
Barrel Diameter(ID)(ft.)	16.0	27.5	15.0	14.5
Barrel Thickness (in.)	3.0	3.5	4.5	3.0
Barrel Material	SA-516 Gr. 70	n/a	SA-516 Gr. 70	SA-537 Gr. B
Yield Strength (psi)	38,000	n/a	38,000	60,000
Reinf. Plate Diam.(in.)	22.0	29.67	17.17	18.17
Reinf. Plate Thick.(in.)	1.50	1.75	2.0	1.25
Reinf. Plate Matl.	SA-537 Class 2	n/a	SA-516 Gr. 70	SA-537 Class 2
Yield Strength (psi)	60,000	n/a	38,000	60,000
PERSONNEL AIRLOCK				
CALCUALTED P_{ult}	....	> 150 psi	153 psi	> 124 psi
Door Thickness	0.75	0.625	0.625	0.625
Door Material	SA-516 Gr. 70	SA-516 Gr. 70	SA-516 Gr. 70	SA-537 Class 2
Yield Strength	38,000	38,000	38,000	60,000
Barrel Diameter(ID)	9.0	7.0	7.08	7.08
Barrel Thickness	3.0	0.625	0.625	0.625
Barrel Material	SA-516 Gr. 70	n/a	SA-516 Gr. 70	SA-537 Gr. B
Yield Strength	38,000	n/a	38,000	60,000
Reinf. Plate Diam.	12.67	n/a	10.58	10.58
Reinf. Plate Thick.	1.5	n/a	1.5	1.25
Reinf. Plate Matl.	SA-537 Class 2	n/a	SA-516 Gr. 70	SA-537 Class 2
Yield Strength	60,000	n/a	38,000	60,000

TABLE 3 CONFIGURATION COMPARISON OF CPSES EQUIPMENT HATCH & PERSONNEL AIR LOCK WITH THOSE OF OTHER CONTAINMENTS