GULF STATES
UTILITIES COMPANY

POSITION
REGARDING

SAFETY/RELIEF VALVE DISCHARGE TESTING AT RIVER BEND STATION

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1.0 INTRODUCTION

The U.S. Nuclear Regulatory Commission (USNRC) published NUREG-0763 "Guidelines for Confirmatory Inplant Tests of Safety-Relief Valve Discharges for BWR Plants" in May 1981 (Reference 1). Also, a large scale safety relief valve (SRV) discharge test program was conducted in the Republic of China, at the Kuosheng Nuclear Power Station Unit 1 in August 1981. This report provides an examination of the NUREG-0763 criteria and demonstrates that an inplant SRV discharge test is not required for the River Bend Station.

Section 4 of NUREG-0763 (Reference 1), "Rationale for Plant-Specific Tests," provides five criteria which must be satisfied to show that existing test data is applicable to a particular plant. These criteria were established to examine the key parameters that affect the hydrodynamic loads and pool temperature gradients, and are not concerned with plant parameters which do not affect these loads. Specifically, the criteria address plant similarities for the quenchers, SRV discharge lines and their configuration, mass flow rates, suppression pool geometries, and structural parameters in the pool region which might influence the loading definition. The criteria do not consider differences in

plant parameters which do not affect this loading definition.

The Cleveland Electric Illuminating Co. (CEI) prepared a detailed comparison based on the five NUREG-0763 criteria for the Perry plant to demonstrate similarities with Kuosheng. This criterion comparison showed conclusively that the quenchers, SRV discharge line parameters, flow characteristics, and geometry can be considered similar. This information was presented to the USNRC in August 1982 (Reference 2). In order to obtain further assurance for Criterion five, the USNRC requested that a number of structural comparisons be made to demonstrate that fluid/structure interaction (FSI) effects are similar for both plants. The comparisons were completed in January 1983 (References 3 and 4) and the USNRC accepted CEI's no-test position for the Perry plant in a letter dated March 1, 1983 (Reference 5).

The principal structural influence on the FSI effects in the pool region is the radial response of the containment and drywell structures. The initial study requested by the USNRC demonstrated that the use of a factored Kuosheng measured pressure time history in the Perry structural model gave reasonable agreement between the

calculated radial accelerations and measured test accelerations in the pool region. Comparisons of calculated versus measured accelerations were made at node points away from the pool region, but were inconclusive because of the differences in structural properties. To ensure that Perry and Kuosheng are structurally similar in the pool region, the USNRC requested that an additional study be performed using the single valve discharge plus SRV condensation oscillation (SRV + SRVCO) design load case. This load case was input to the individual plant analytical models and the results demonstrated good comparison in the pool region for the radial direction (Reference 4).

Both of these studies showed differences when comparing the vertical responses. These differences were judged, by the USNRC, to be unimportant to the SRV discharge load definition, as they have only a very minor affect on FSI results. The differences in vertical response are strongly influenced by the stiffness of the complete building and are an indication of the total building inertia and the equivalent soil springs, rather than any FSI effects.

Based on the studies and comparisons presented, the USNRC agreed that, in the pool region, the concrete backed free-standing steel containment Perry plant is structurally similar to the Kuosheng concrete containment, and that FSI affects will be similar for both plants. Furthermore, the USNRC agreed that the Kuosheng test data is applicable to Perry and that it is unnecessary to perform a separate inplant SRV discharge test for Perry (Reference 5).

This report provides a comparison of the NUREG-0763 criteria for River Bend, to Perry, Grand Gulf, and Kuosheng and demonstrates that the conclusions reached by the USNRC for Perry are applicable to River Bend. The report shows that all important quencher, SRV discharge line, suppression pool geometry, and structural properties are similar to Kuosheng and, therefore, the Kuosheng SRV discharge test data provides an adequate confirmation for the design loads used for River Bend, and an inplant SRV discharge test is not required for River Bend.

2.0 COMPARISON TO NUREG-0763 CRITERIA

NUREG-0763 sets forth guidelines to be used in determining the need for plant specific tests and defines the types of tests and instrumentation required to satisfy the USNRC criteria. The key parameters affecting the suppression pool hydrodynamic loads have been identified by extensive generic test programs. Section 4, of NUREG-0763 (Reference 1) includes the statement: "... applicants may be able to demonstrate that discharge conditions in their plants are sufficiently similar to conditions previously tested to obviate the need for any new tests ..." It is the intent of this report to examine each of the five criteria in Section 4 of NUREG-0763 and demonstrate that such similarities exist between Kuosheng and River Bend, and that a sound basis exists for the definition of the SRV discharge hydrodynamic loads. Where appropriate, particularly in discussion of Criterion five, reference is made to the similarity studies performed by CEI for the Perry plant.

2.1 Criterion One

Criterion one requires a plant specific test if:

> "The discharge device is geometrically different from devices tested previously."

A comparison of the dimensional similarities of the quenchers installed at Kuosheng, Grand Gulf, River Bend, and Perry is provided in Table 2.1 and referenced to Figure 2.1. As can be seen by a review of this table, the quenchers are all of very similar configuration. The major difference in the quenchers is the angle of the reducer taper, where River Bend (10.75°) and Perry (10.75°) are bound by Kuosheng (17.1°).

The inside diameters of the quencher hubs for Perry and River Bend are slightly smaller than Kuosheng which will have no discernable influence on the predicted suppression pool pressures.

The Perry dimensions have been investigated by the USNRC, and the Kuosheng data was found to be acceptable. As the River Bend quenchers are dimensionally similar to those at Perry, Criterion One is satisfied and a test is not required.

2.2 Criterion Two

Criterion two requires a plant specific test if:

> "The discharge-line parameters--line length, area and volume, quencher submergence, vacuum-breaker size, and available pool area per quencher--differ significantly from values previously tested. An assessment of "significant" differences shall be based on previously established empirical correlations between changes in these parameters and resultant changes in variables of interest, or on analytical considerations."

The SRV discharge line parameters which affect suppression pool pressures do not differ significantly between the Kuosheng, Grand Gulf, River Bend, and Perry plants as shown in Table 2.2. For the parameters listed, the most important parameter to consider in determining the peak SRV hydrodynamic loads according to the GE methodology (Appendix 6A of the River Bend Final Safety Analysis Report (FSAR)) is the SRV discharge line (SRVDL) air volume. This is demonstrated in Table 2.3 where a comparison of peak predicted pressure (PRD1) is

presented. The minimum SRVDL air volume at River Bend is 45.6 cu. ft. which is enveloped by the air volumes for the SRVDL tested at Kuosheng which ranged from 42.7 to 47.7 cu. ft. The maximum SRVDL air volume at River Bend is 50.0 cu. ft.; this is the same as the maximum volume line at Kuosheng (not included in the test program) and is enveloped by the maximum SRVDL air volume at Perry (55.7 cu. ft.). The same size vacuum breakers are used for both Kuosheng and River Bend. The quencher submergence and pool area per quencher are essentially the same.

A quantitative assessment of the effects of these parameters is provided in Table 2.3. As shown in this table, the maximum predicted pool pressure (PRD1) for the River Bend plant is the lowest for all four plants at .02 Bars (.3 psid) less than Kuosheng's PRD1.

Table 2.4 contains the mean of the peak pressures measured by the sensors within the region of expected maximum pressure for first and consecutive acutations of the Kuosheng low-low set SRV. Figure 2.2 shows the location of the sensors listed in Table 2.4. The Kuosheng design pressures are also shown in Table 2.4 to permit direct comparison to test results. Based on the large margin between actual Kuosheng test pressures and

based on the measured V-5 SRV discharge line pressures extrapolated back to the SRV exit using appropriate frictional and local loss factors. The estimated pressure drop from the SRV exit to the test sensor was 32 psid and the estimated back pressure approximately half the 625 psi allowable. Assuming the River Bend frictional losses are greater than Kuosheng by the ratio of the line lengths and the local loss factor is approximately equal, then the expected pressure drop for River Bend at the same test conditions would be about 35 psid.

An SRV test is not required to satisfy Criterion Two as the River Bend SRV discharge line parameters meet the requirements of Criterion Two ensuring that the SRV flow remains choked with line pressures well below the allowable.

2.3 Criterion Three

Criterion Three states:

> "The flowrate of the steam per unit area of discharge line and the net flowrate of the steam through the line may determine the air-column compression dynamics and pool-temperature gradients during an extended actuation. If either of these differs significantly from conditions previously tested, new inplant tests shall normally be required".

As shown by Table 2.3, the design steam flowrates and the steam per unit area, are the same for Kuosheng, Grand Gulf, River Bend, and Perry. Therefore, the effects of the air-column compression dynamics and pool temperature gradients will be similar to those measured during the Kuosheng tests.

The extended valve actuation tests performed at Kuosheng conclusively demonstrated that the X-quencher performs in a satisfactory manner and meets its design criteria. Since the River Bend quenchers are similar to those at Kuosheng, the extend actuation behavior of the

River Bend suppression pool will be similar to that documented for Kuosheng, and there is no need to perform an extended valve actuation test. The steam flowrates and steam per unit area are also identical to the design values for the Grand Gulf Nuclear Station. The USNRC has accepted Grand Gulf's position that the Kuosheng test data adequately describes the suppression pool behavior and has documented this acceptance in Appendix C to Supplement No. 1 of the Grand Gulf Safety Evaluation Report (NUREG-0831), dated December, 1981. This SER states that the generic Mark III issues resolved by the prototype (Kuosheng) testing were the pool thermal mixing and X-quencher condensation performance.

This satisfies Criterion Three for River Bend and an SRV test is not required.

2.4 Criterion Four

Criterion Four states that:

> "Quencher location and orientation in the pool and the pool geometry may affect peak boundary pressures and frequencies of air-bubble oscillation. Thermal mixing in the pool is also expected to be affected by these variables. No quantitative criteria can be formulated for determining when quencher/pool configuration changes may be sufficient to require new inplant tests. As the range of plant and pool geometries that have been tested increases, the need for testing all new pool configurations may disappear. Present policy shall be to require inplant testing if it cannot be shown that all features of the pool configuration are similar to those previously tested in a plant."

As shown by Table 2.5, the quencher locations for Kuosheng, Grand Gulf, River Bend, and Perry are similar. All plants utilize quenchers with 80°-80°-80°-120° arm angles with the quencher hub vertical center line 5.0 feet from the drywell wall. Table 2.5 shows an

unimportant variation in the distance from the horizontal arm center line to the pool floor of from 4.5 feet for Perry to 5.64 feet for River Bend. The pool widths vary from 17.5 to 20.5 feet with pool depth varying from 18.5 to 19.7 feet. The submergence depth for all four plants is similar with an insignificant variation from 13.8 to 14.1 feet.

The main difference in the quencher designs is the method of support. Kuosheng uses double box beam supports cantilevered from the drywell wall (Figure 2.2); Grand Gulf has a horizontal cantilever welded to the drywell wall and a vertical quencher pedestal and diagonal strut from the drywell wall to the SRV discharge line (Figure 2.3). Perry and River Bend both have vertical pedestals under the quencher and horizontal diagonal struts from the drywell wall to the SRV discharge line (Figures 2.4 and 2.5). The Kuosheng supports tend to confine the discharging bubble and introduce minor variations into the air bubble pressure and frequency. The Grand Gulf, River Bend, and Perry supports are similar and are expected to have an insignificant influence on the frequency or pressure amplitude of the discharging bubbles. The USNRC considered these differences in the evaluation of the Perry submittal and determined that they are acceptable.

As the River Bend and Perry suppression pools are dimensionally similar, this satisfies Criterion Four and an SRV test is not required.

2.5 Criterion Five

Criterion Five states:

> "The characteristics of the containment structure may affect peak boundary pressure and frequencies of air-bubble oscillation. For example, inplant tests conducted in a concrete containment will not be considered to have direct application for a free-standing steel containment unless adequate justification for fluid/structure interaction has been demonstrated. Otherwise, inplant tests will be required for plants whose structural characteristics are significantly different from the previous tests."

The principal concern addressed by this criterion is to ensure that: "... adequate justification for fluid/structure interaction has been demonstrated." A review of the studies required by the USNRC Structural Engineering Branch (SEB) for the Perry plant, in response to this concern, confirms that similarities in fluid/structure interaction were the main intent of this criterion. The studies provided by CEI, for Perry, adequately demonstrated these similarities, and a review

of Table 2.6 shows that River Bend is structurally similar to Perry and Kuosheng in the critical pool region. River Bend and Perry have free-standing steel containment structures with concrete filled annuli and similar geometrical and material properties. The important dimensions and materials have been included in the tables to emphasize the structural similarities.

The analytical models used for Kuosheng, Grand Gulf, River Bend and Perry are provided in Figures 2.6, thru 2.9. These models consist of an assemblage of shell and solid quadrilateral elements with the water mass added to the appropriate nodes as lumped masses, using a tributary area approach. The Perry analysis for SRV discharge loads also used a second structural model consisting of the containment, annular fill, and shield building for the detailed analysis of the annular concrete and its effects.

The Ghosh-Wilson axisymmetric shell of revolution program ASHSD was used to calculate the response of all four plants to the SRV discharge loads using the direct integration solution technique. The results of these analyses are displacement, stress, and acceleration time histories at node points throughout the models. Soil/ structure interaction effects are accounted for in the

ASHSD models and the analytical results show no significant carry over of response to the adjacent structures. This conclusion has been confirmed by measured accelerometer results taken during the Kuosheng tests.

In the region of the suppression pool there is virtually no difference in the horizontal structural characteristics of Kuosheng, River Bend or Perry as they are all steel lined concrete containments. The plants are also similar in their vertical structural characteristics regarding fluid/structure interaction, but, as described below, similarity of vertical response is not anticipated. Figures 2.10 thru 2.13 provide general arrangements for the reactor building of each plant, and Figures 2.2 through 2.5 show the suppression pool cross sections. Table 2.6 provides the important material and geometrical properties. These demonstrate the great similarities for the plants in the critical suppression pool region. The most significant difference, affecting only the vertical response, is the foundation material shear wave velocity where River Bend is the softest site at 960 fps.

At the request of the USNRC SEB, a number of structural comparison studies were performed to compare the measured and predicted SRV and SRV + SRVCO responses for Perry and Kuosheng. The results of these studies were reported to the USNRC in letters dated November 17, 1982 (Reference 3) and January 14, 1983 (Reference 4) and showed that FSI results would be similar for both plants. Because River Bend is geometrically and materially similar to both Perry and Kuosheng, the results of these studies are directly applicable to River Bend and it is not necessary to repeat this work.

The first study requested by the SEB utilized a measured pressure time history from the Kuosheng tests as the input forcing function for the Perry structural models to predict the response of the Perry reactor building to measured suppression pool SRV discharge loads. Based on the response spectra generated by this study, it was concluded that the Perry models effectively predicted the accelerations measured during the Kuosheng test (Reference 3). The high frequency exceedances of the predicted acceleration response spectra seen during the Kuosheng test were also predicted by the Perry model. These exceedances were described and are not a concern for structures, piping or equipment for the following reasons:

1. Strain measurements taken during the Kuosheng tests verified that high accelerations at high frequency produced little actual stress.

2. Generic studies conducted by GE and reported in NEDE-25250 show that at frequencies above 60 Hz, high accelerations are of no concern.

3. For equipment qualified by test, the actual test response spectra (TRS) is generally far above the predicted high frequency exceedances.

4. River Bend design response spectra include the high frequency effects of SRVCO which were not included in the Perry design. Therefore, high frequency exceedances would be less than predicted for Perry and of no consequence to the plant safety.

The second study requested by the USNRC SEB was an analytical model comparison for the Perry and Kuosheng plants. It was requested that a comparison of the calculated design response spectra be made for the SRV + SRVCO load case in the suppression pool region. This comparison showed good radial agreement with considerable differences in the vertical response.

These differences are due to physical and analytical variances in the models. The significant physical differences are basemat thickness and shear wave velocity. The analytical differences consist of different damping values, computer model element types (shell elements throughout for Perry and a mixture of shell and solid elements for Kuosheng), material properties (some orthotropic for Kuosheng and all isotropic for Perry) and the forcing functions (Perry is a continuous SRV + SRVCO event compared to Kuosheng's envelope of three worst SRV cases plus SRVCO). These differences affect the vertical response to a greater degree than the horizontal response.

The vertical response is relatively unimportant in FSI considerations. This is because the vertical response is influenced by the stiffness and mass of the entire building to a far greater extent than the radial response, whereas FSI is primarily a function of the structural rigidity of the suppression pool boundaries. All plants are beyond the "threshold" limits for rigidity insofar as FSI is concerned. Therefore, comparisons of vertical response are more indicative of different total building inertia or mass and equivalent soil springs than they are of FSI.

The results of this second study are directly applicable to River Bend. However, in response to a NRC request, Reference 6, the River Bend design response spectra for the critical SRV and SRVCO cases have been added and plotted with the Kuosheng and Perry design spectra. The points selected are shown in Figure 2.8 and are the containment/shield building at mid pool depth (elevation 80') and pool surface (elevation 90') and the drywell wall at the pool surface (elevation 90'). The resulting spectra comparisons are shown in Figures 2.14 through 2.19.

Examination of these spectra show that the FSI behavior of Kuosheng, Perry and River Bend plants is similar in the pool region. Therefore, the results of the Perry structural studies are directly applicable to River Bend. It is not necessary to perform any additional work, nor to conduct an inplant SRV discharge test, as the Kuosheng test results confirm that the SRV discharge hydrodynamic loads used for the River Bend design are conservative.

3.0 CONCLUSIONS

In conclusion, a review of the preceding discussion demonstrates that the important parameters of River Bend satisfy the criteria of Section 4 of NUREG-0763. The discharge device is geometrically similar, the discharge line parameters are similar, the steam flow rates are identical, the quencher locations and orientation are similar and finally the containment structures are similar in the pool region. This means that the test data generated from the Kuosheng tests is sufficient to establish the conservative nature of the SRV discharge hydrodynamic loads. The existing SRV discharge hydrodynamic load test data base is sufficient to establish that the GESSAR load methodology (Appendix 6A of River Bend FSAR) has been conservatively developed for the air bubble pressure and frequency time histories.

Additional testing at River Bend will serve no useful purpose in extending the limits of this load data base since the important River Bend design parameters have been tested at Kuosheng. Therefore, the data from the Kuosheng test provides the prototypical data base required to satisfy the River Bend commitment to confirm the SRV discharge hydrodynamic loads used in the design of the plant, and no inplant SRV discharge test is required at River Bend.

4.0 REFERENCES

1. "Guidelines for Confirmatory Inplant Tests of Safety-Relief Valve Discharges for BWR Plants," USNRC NUREG-0763, May 1981.

2. Letter, "Perry Nuclear Power Plant Docket Nos. 50-440; 50-441 Proprietary Information - Safety Relief Valve Hydrodynamic Loads," D.R. Davidson, CEI to A. Schwencer, NRC dated October 8, 1982.

3. Letter, "Perry Nuclear Power Plant Docket Nos. 50-440; 50-441, Additional Information on SRV Hydrodynamic Loads," D. R. Davidson, CEI to A. Schwencer, NRC dated November 17, 1982.

4. Letter, PY-CEI/NRC-0005L "Perry Nuclear Power Plant Docket Nos. 50-440; 50-441, Additional Information on SRV Hydrodynamic Loads," M. R. Edelman, CEI to B. J. Youngblood, NRC dated January 14, 1983.

5. Letter, "Acceptability of CEI's Proposal for Deleting the Requirements of Inplant Tests of the Safety Relief Valves System at the Perry Nuclear Power Plant (Units 1 & 2)," B. J. Youngblood, NRC to M. R. Edelman, CEI dated March 1, 1983.

6. Letter, "Structural Aspects of Safety Relief Valve (SRV) Discharge Tests at River Bend Station," A. Schwencer, NRC to W. J. Cahill, Jr., GSU dated November 14, 1983.

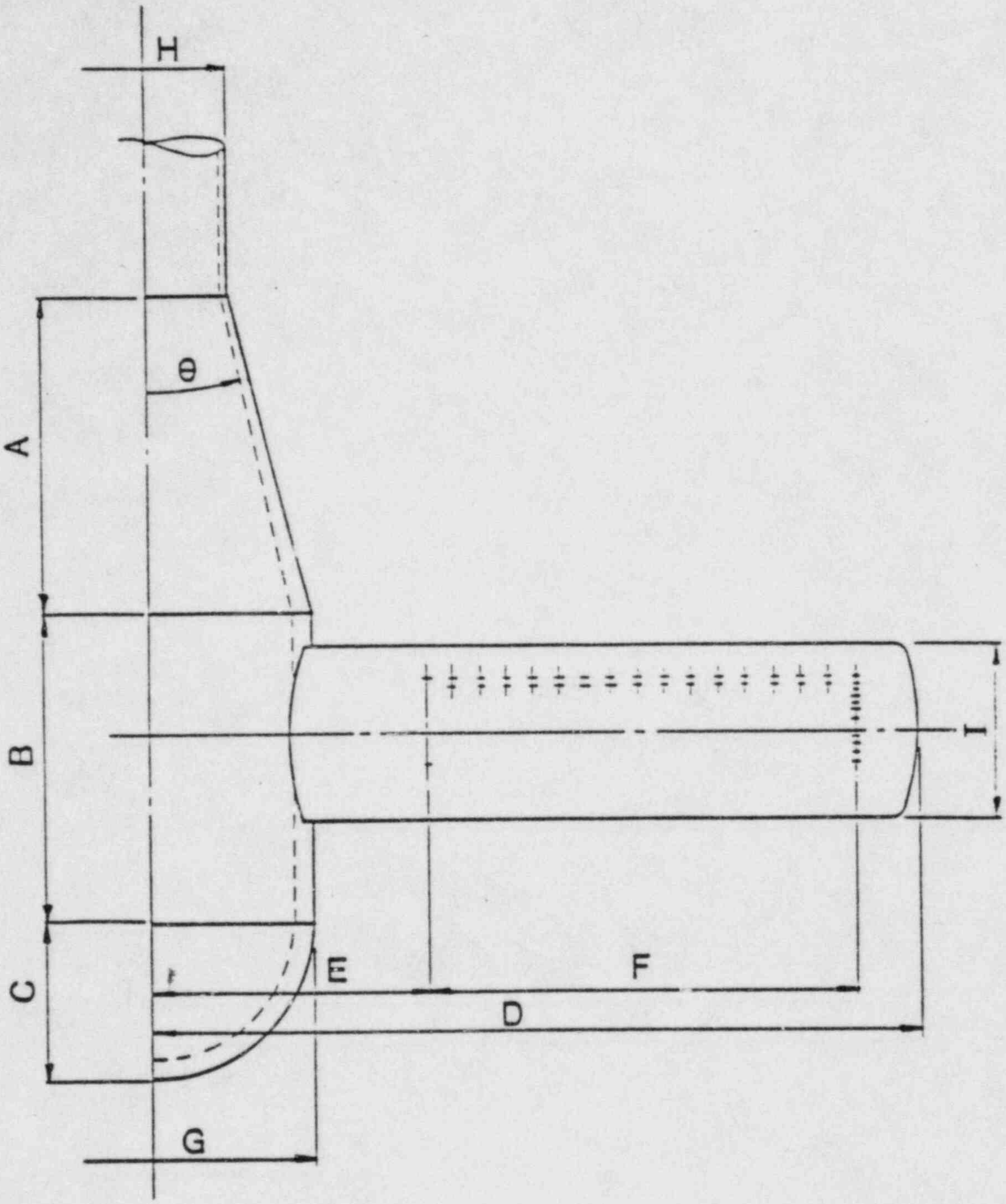
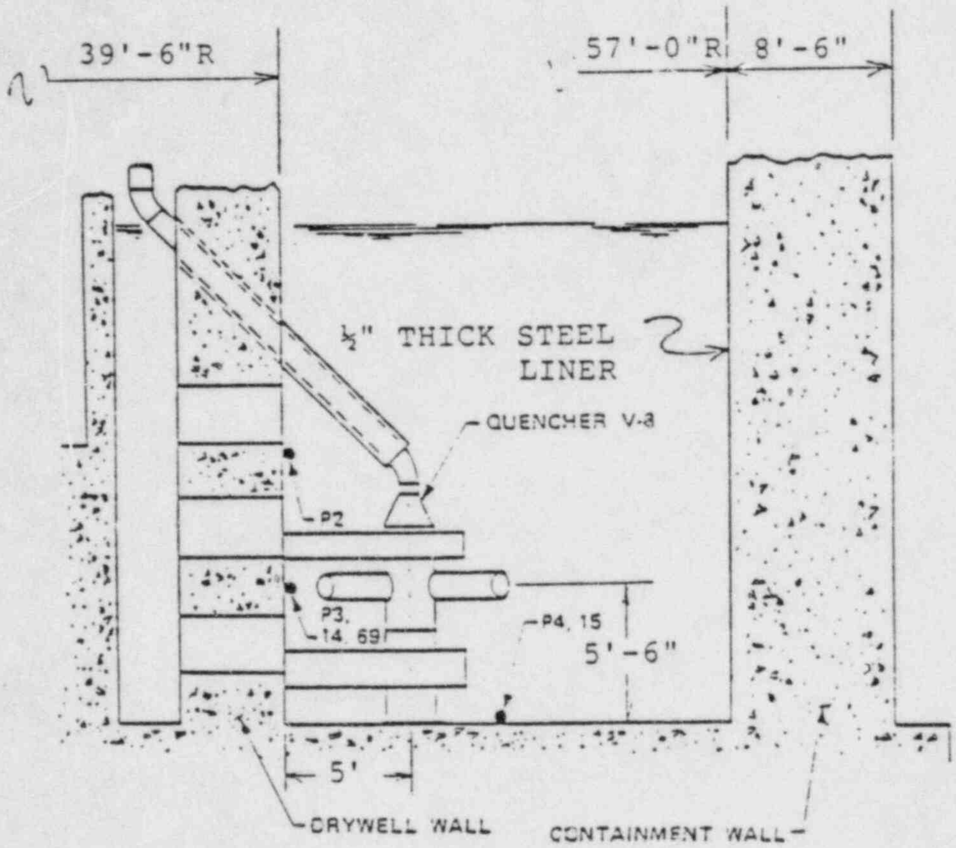


Figure 2.1

X-QUENCHER GEOMETRY

Dimensions are given in Table 2.1.



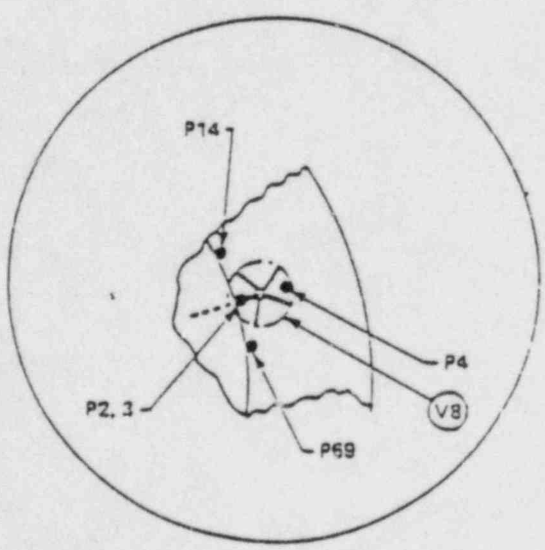


Figure 2.2

KUOSHENG SUPPRESSION POOL CROSS SECTION AND POOL PRESSURE SENSOR LOCATIONS

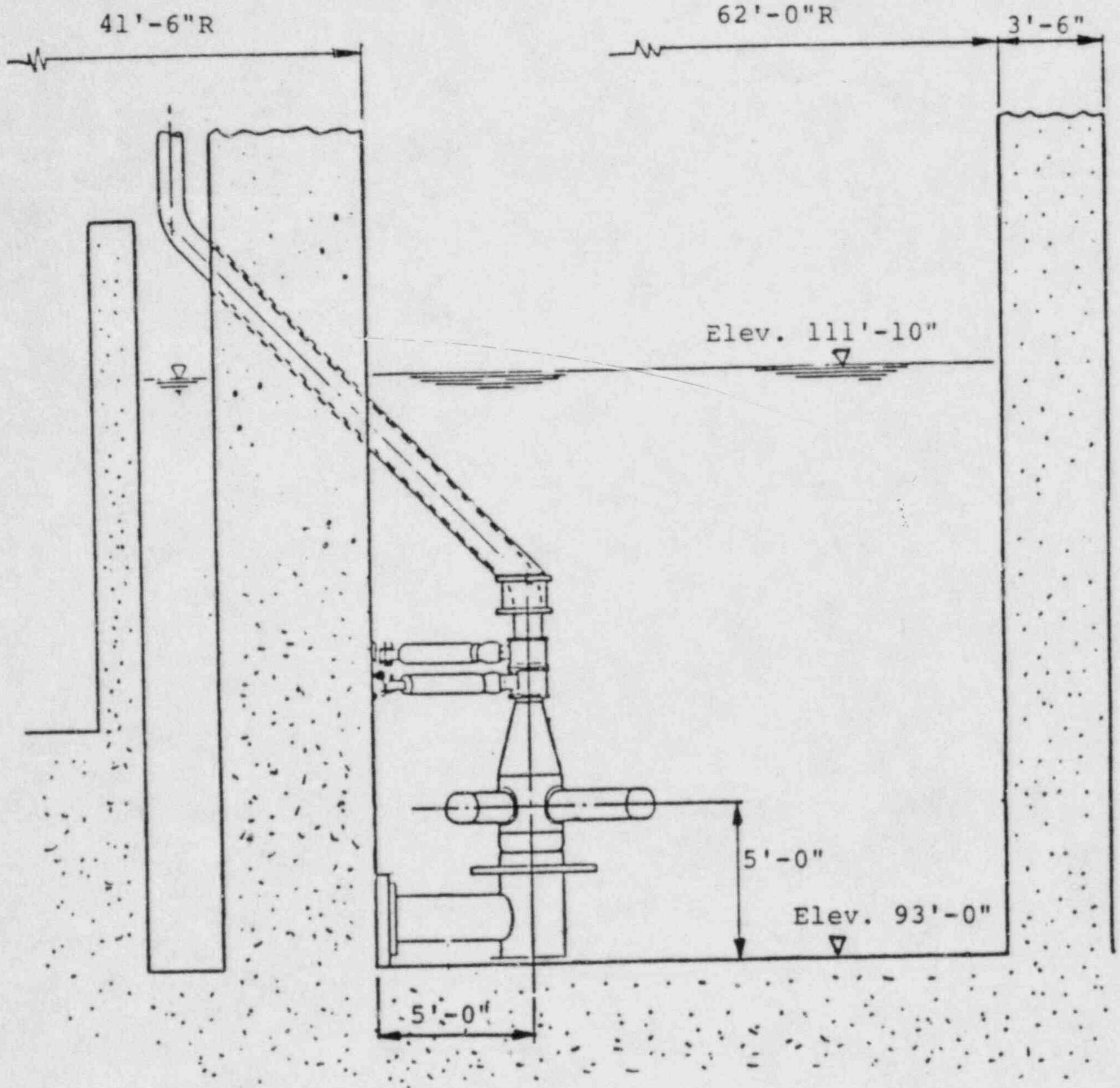


Figure 2.3

GRAND GULF SUPPRESSION POOL CROSS SECTION

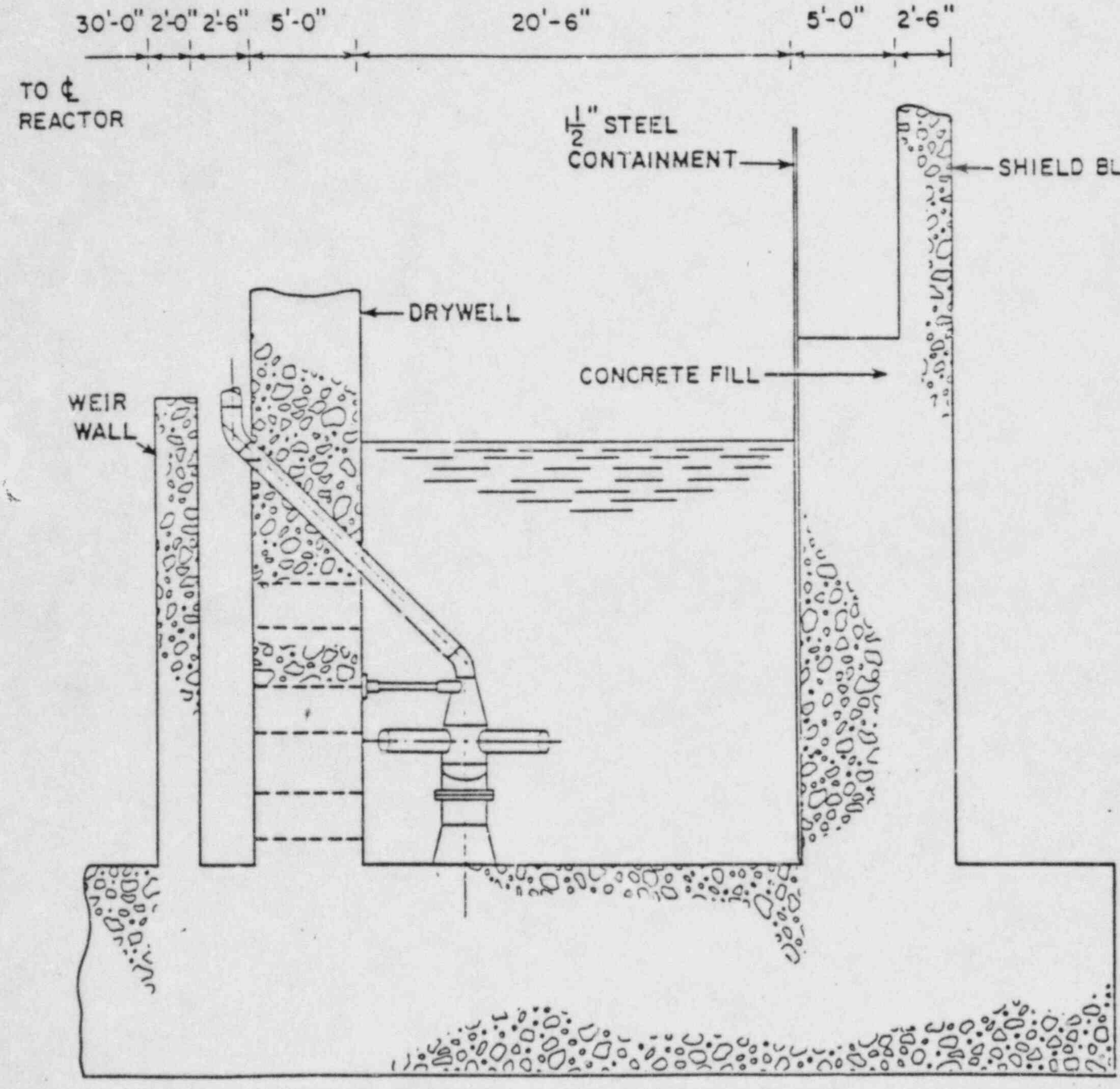


Figure 2.4

RIVER BEND SUPPRESSION POOL CROSS SECTION

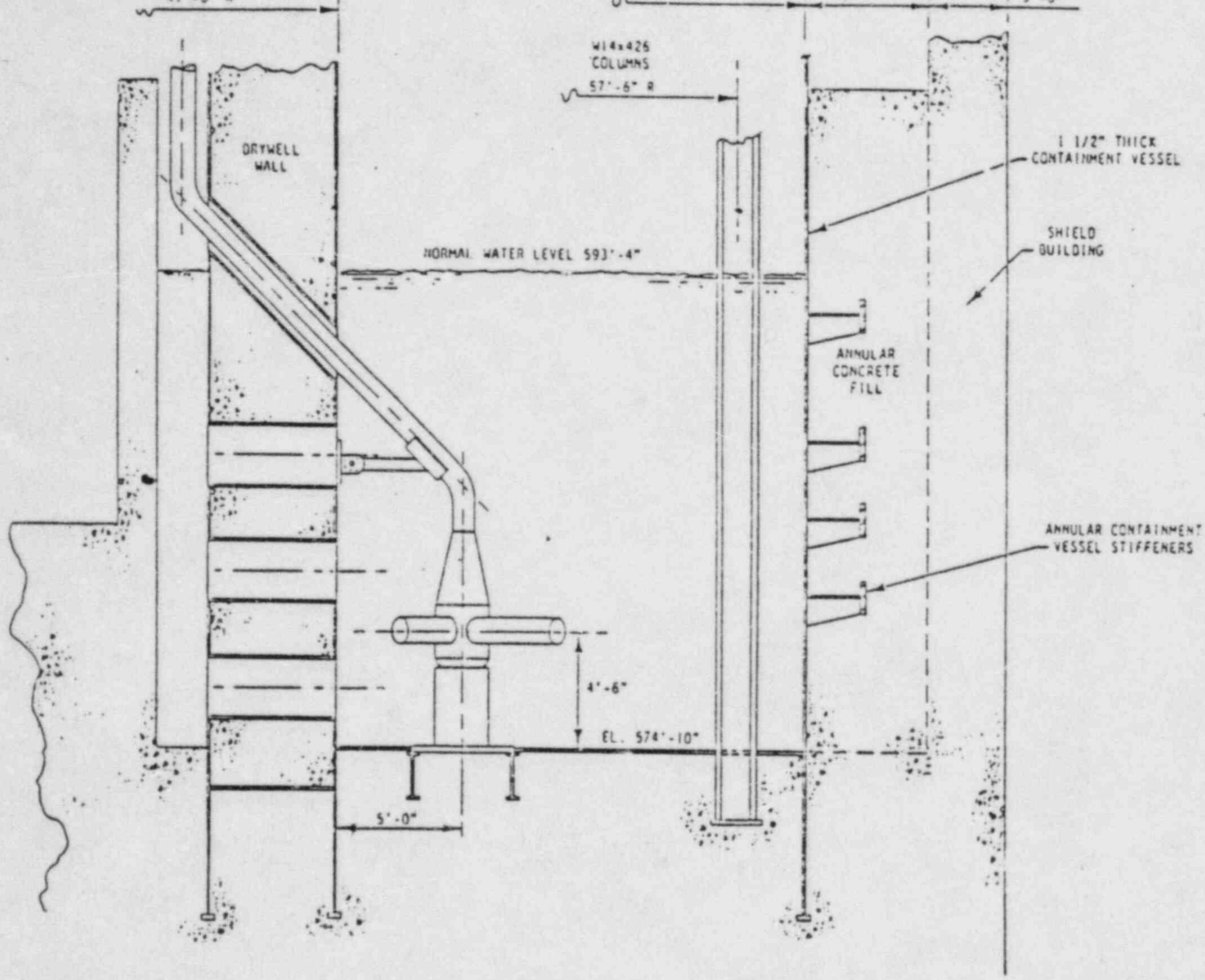


Figure 2.5

<u>PERRY SUPPRESSION POOL CROSS SECTION</u>

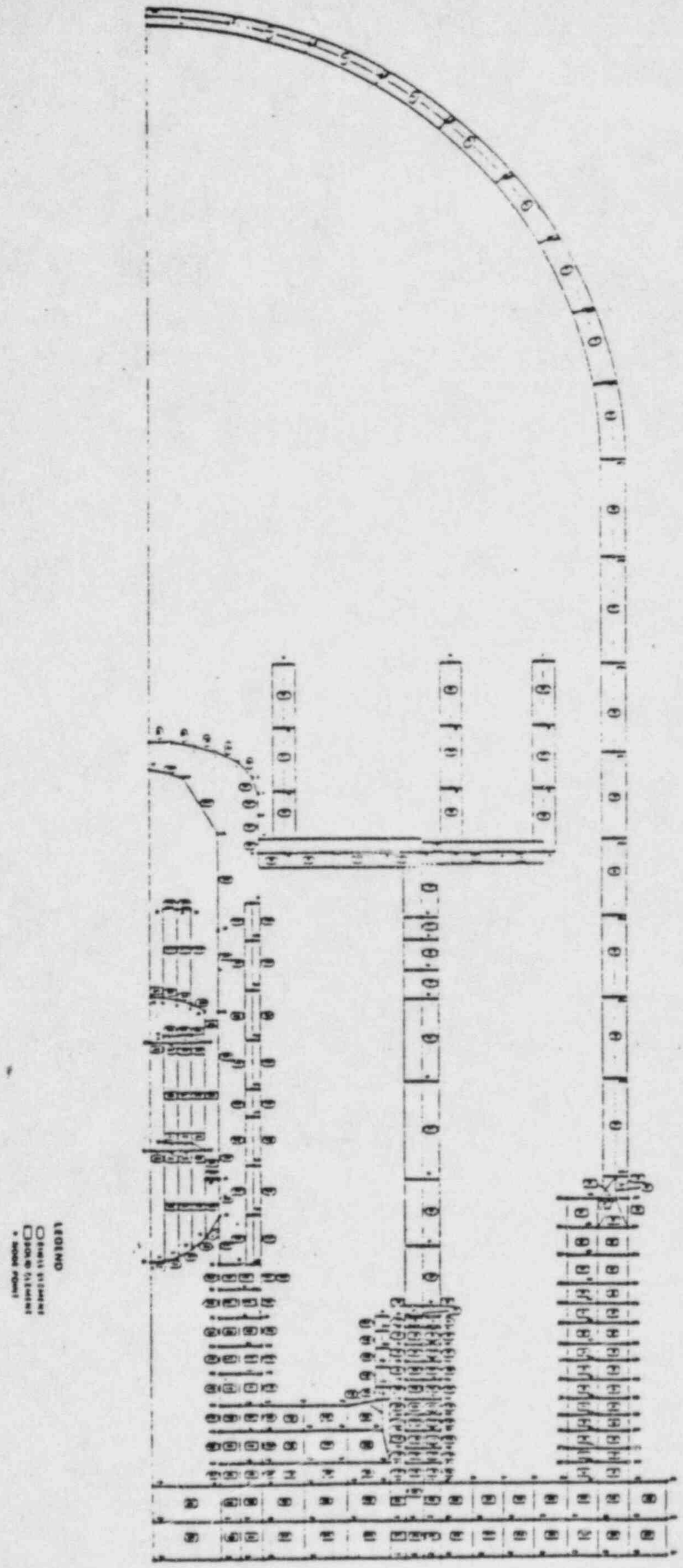


Figure 2.6

KUOSHENG REACTOR BUILDING ANALYTICAL MODEL FOR HYDRODYNAMIC LOADS

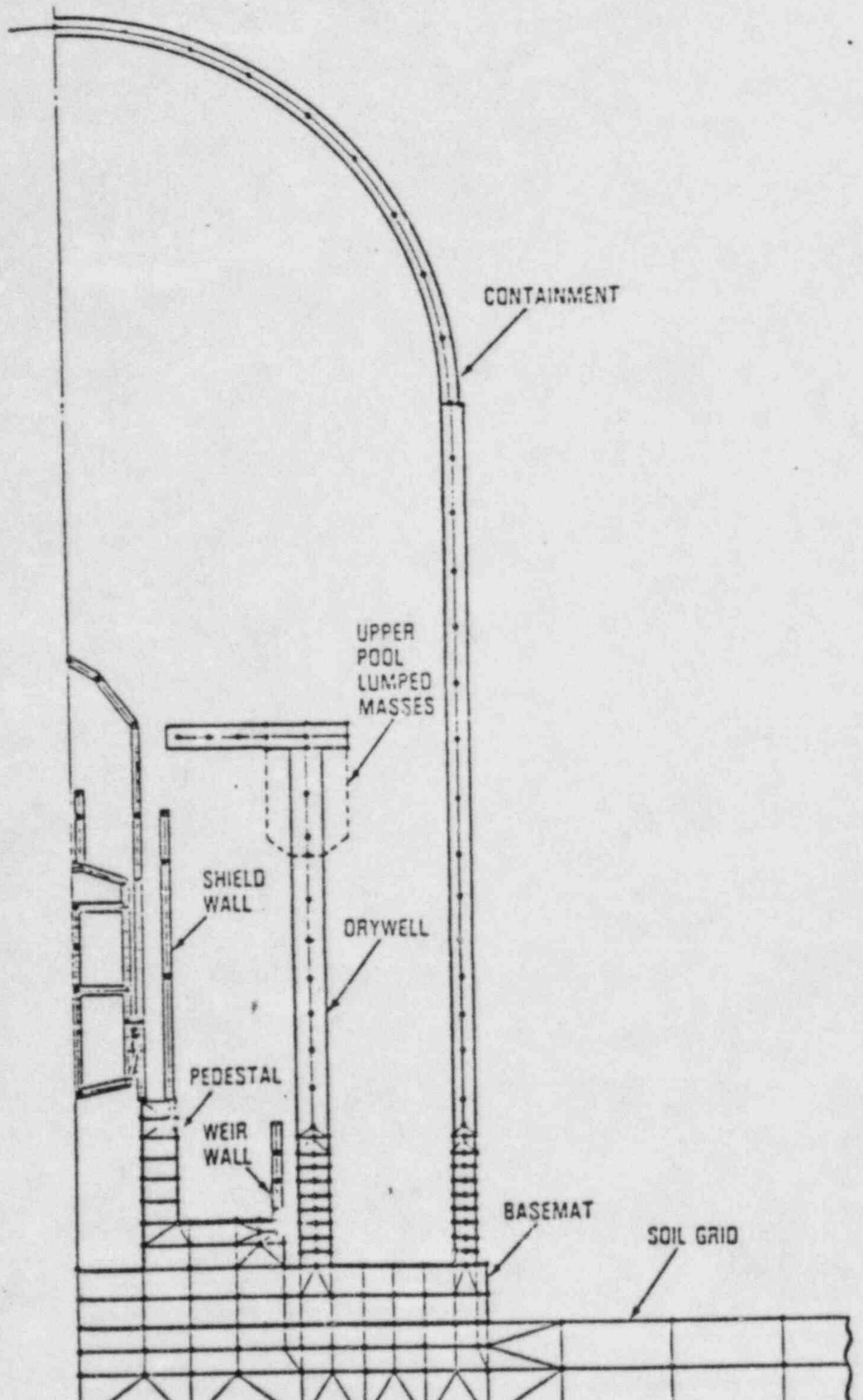


Figure 2.7

GRAND GULF ANALYTICAL MODEL FOR HYDRODYNAMIC LOADS

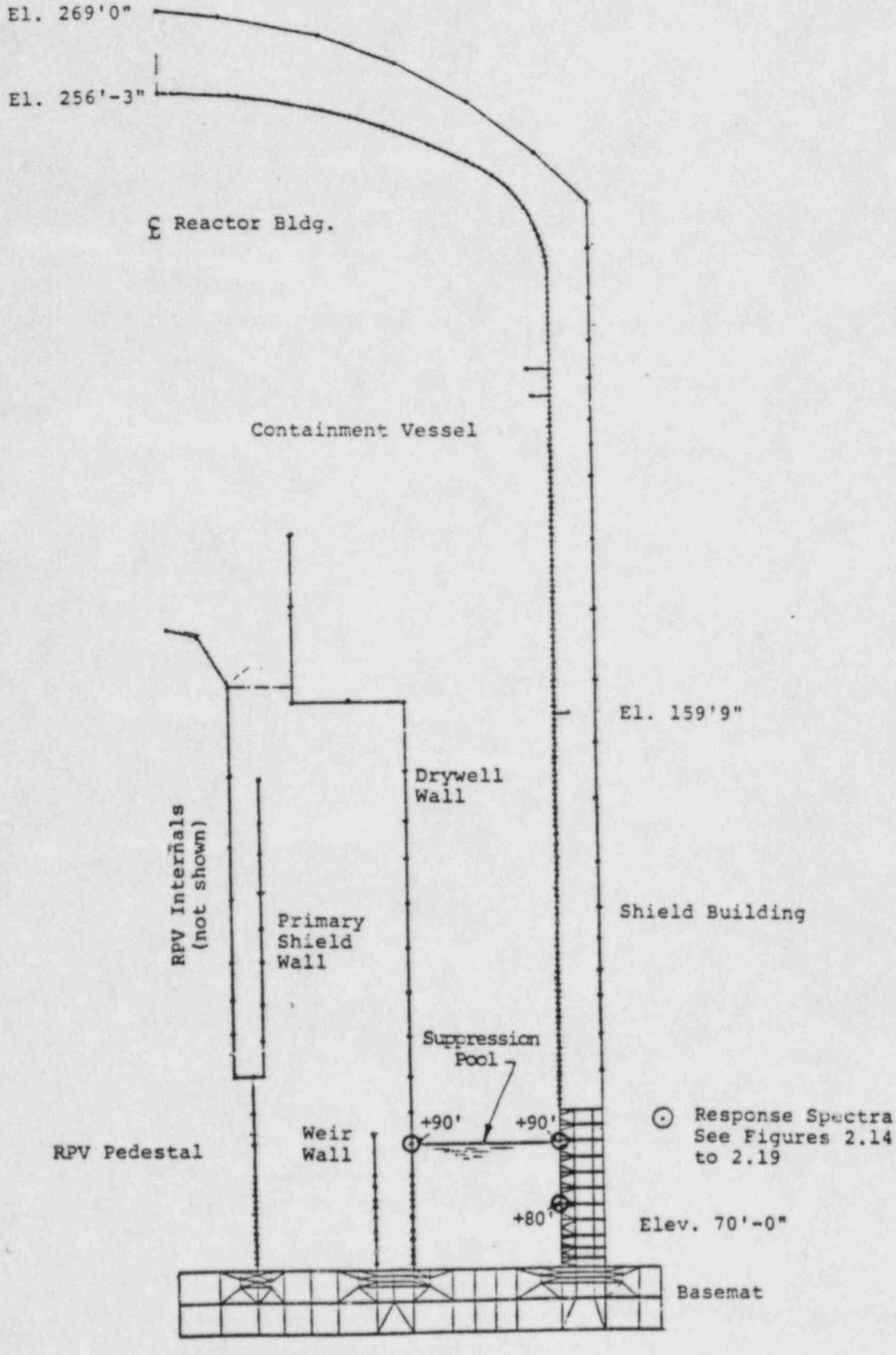


Figure 2.8

RIVER BEND REACTOR BUILDING ANALYTICAL MODEL FOR HYDRODYNAMIC LOADS

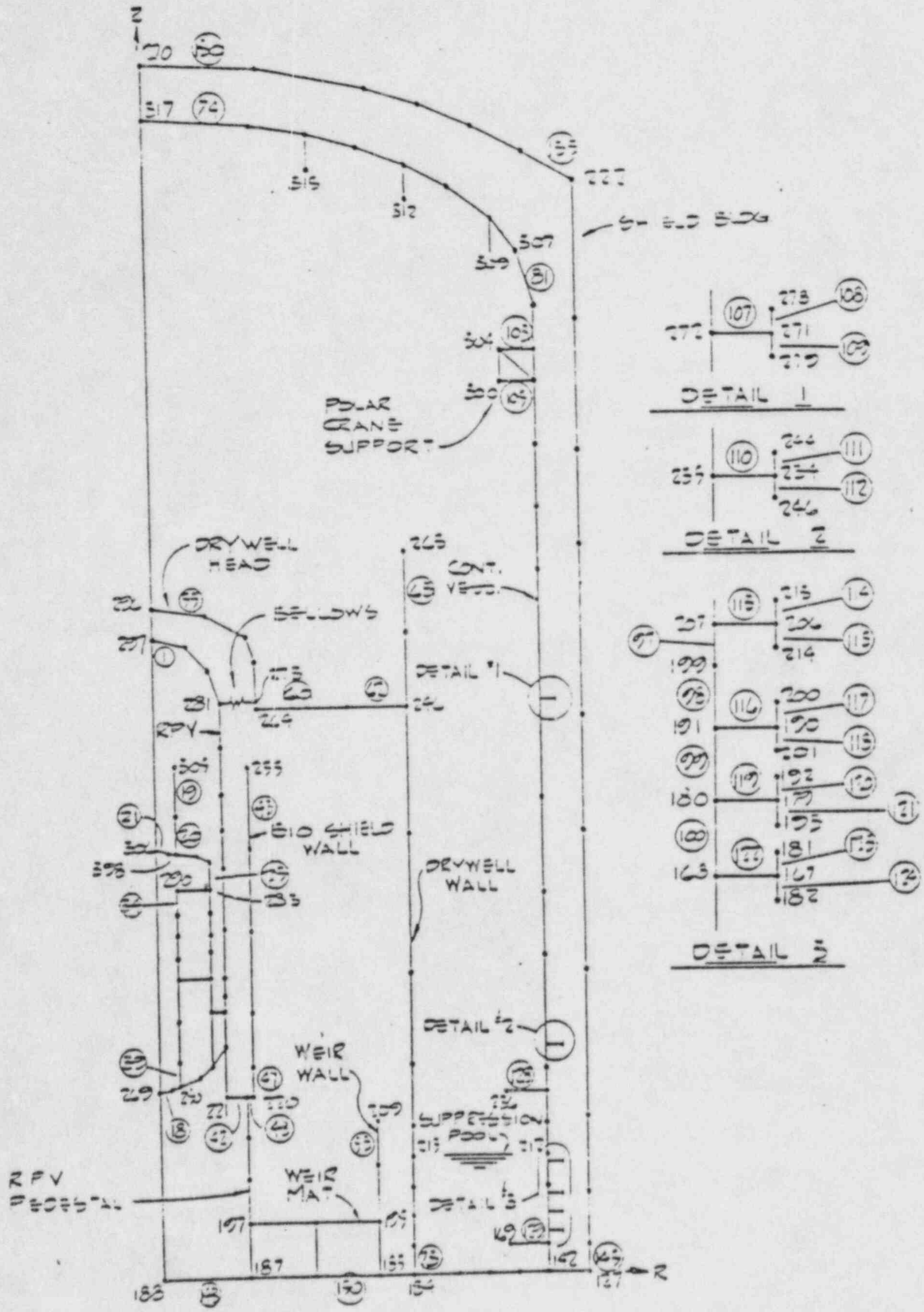


Figure 2.9

PERRY REACTOR BUILDING ANALYTICAL MODEL FOR HYDRODYNAMIC LOADS

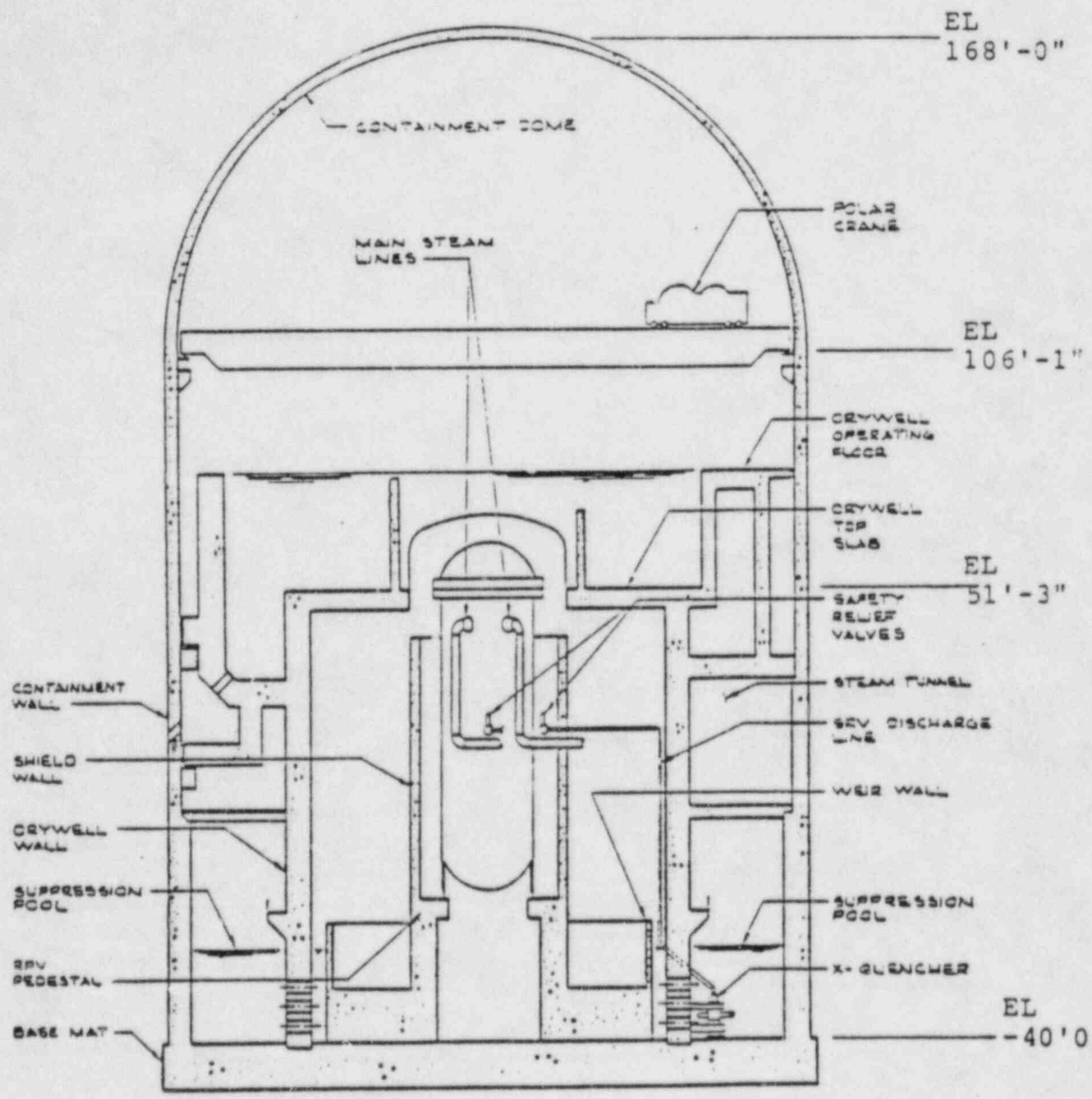


Figure 2.10

KUOSHENG REACTOR BUILDING GENERAL ARRANGEMENT

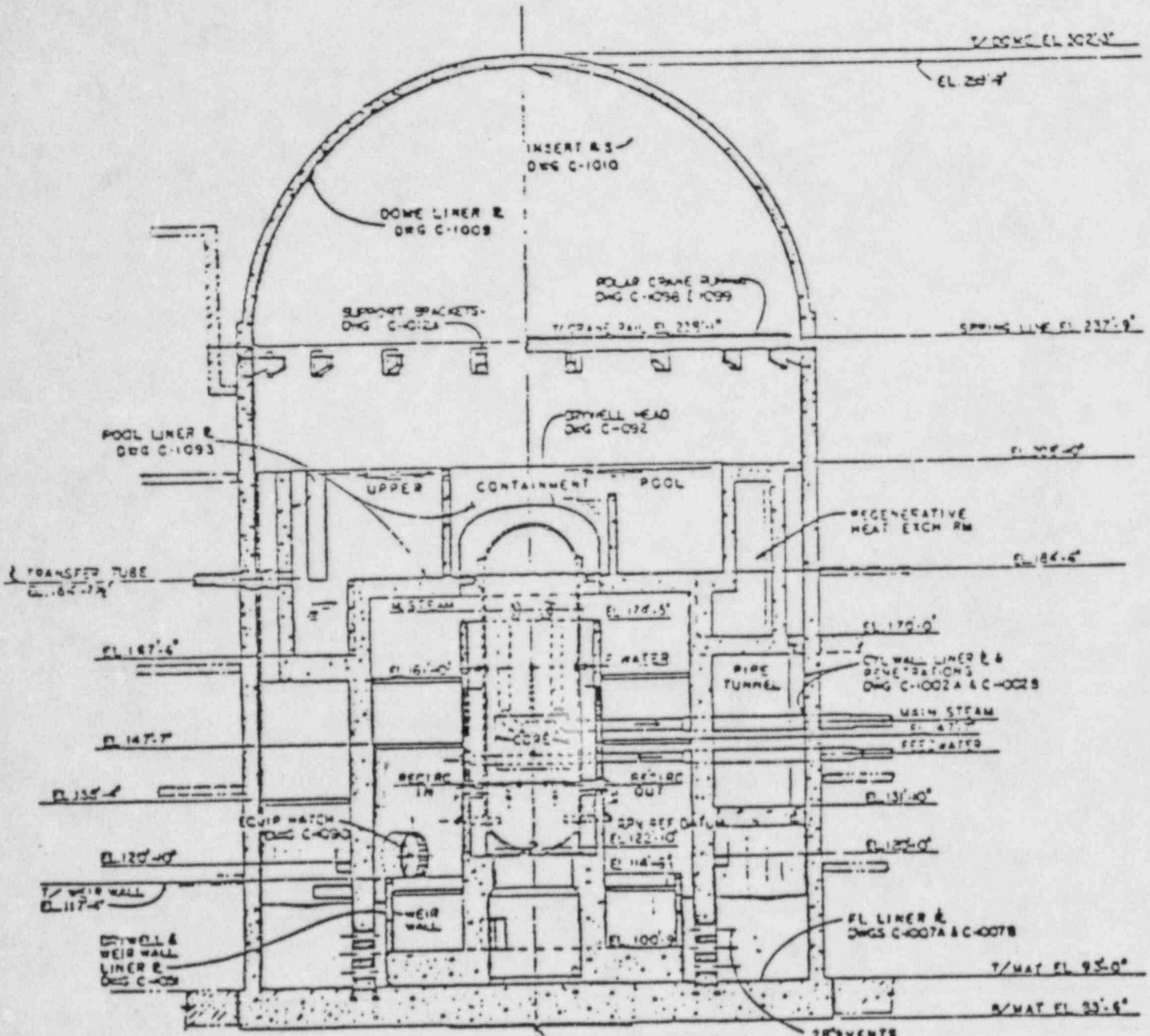


Figure 2.11

GRAND GULF REACTOR BUILDING

GENERAL ARRANGEMENT

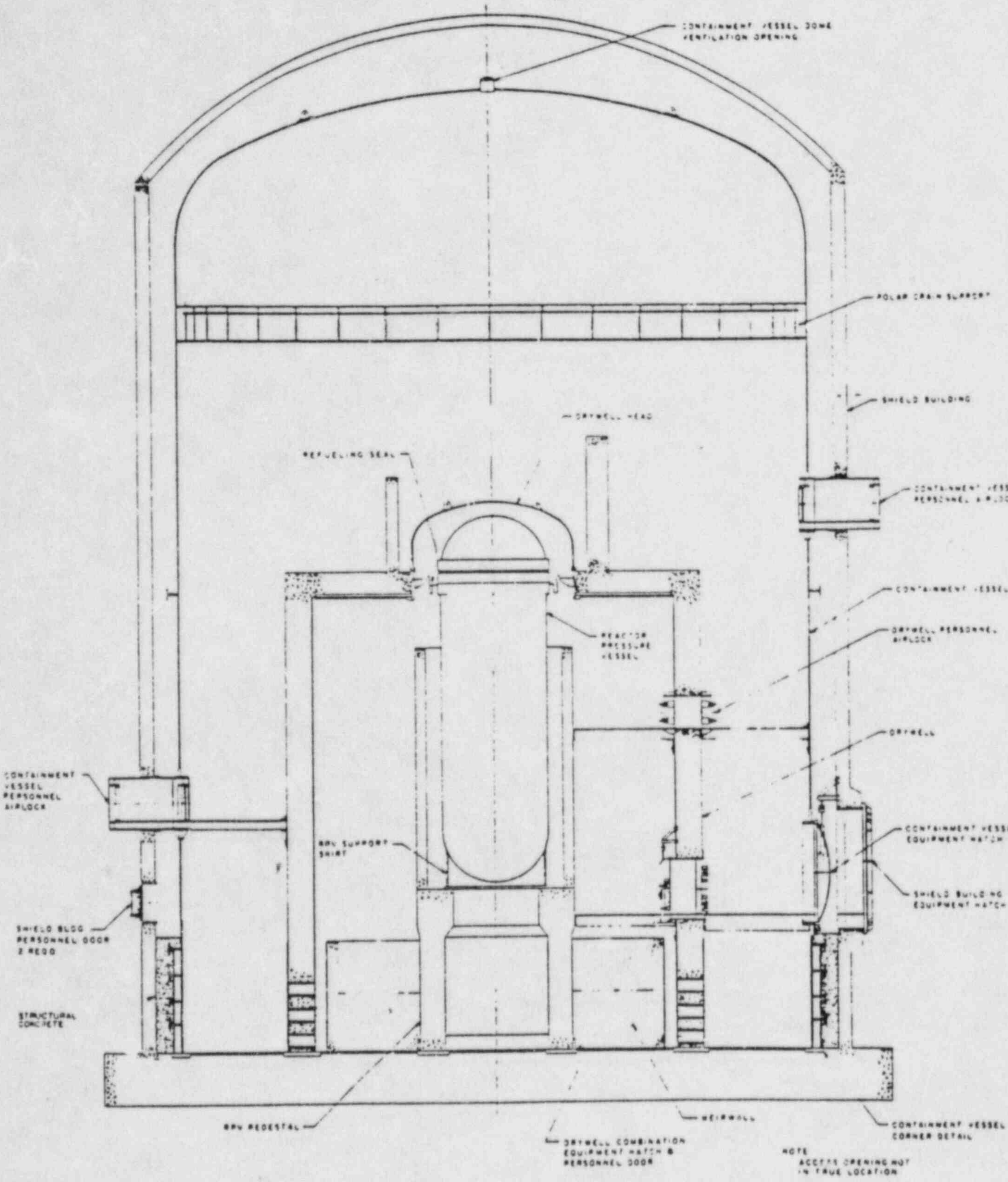


Figure 2.12

RIVER BEND REACTOR BUILDING GENERAL ARRANGEMENT

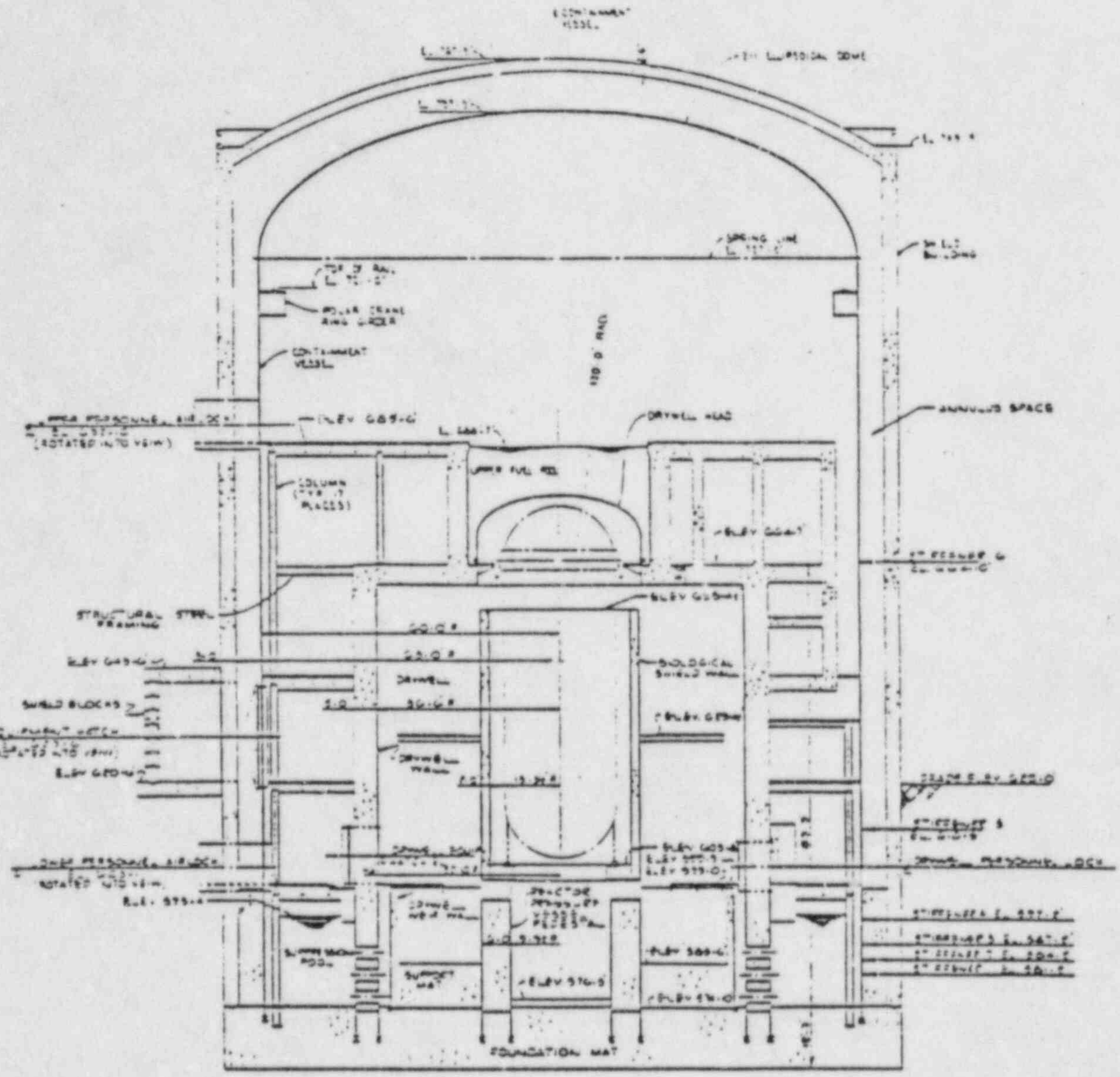


Figure 2.13

PERRY REACTOR BUILDING GENERAL ARRANGEMENT

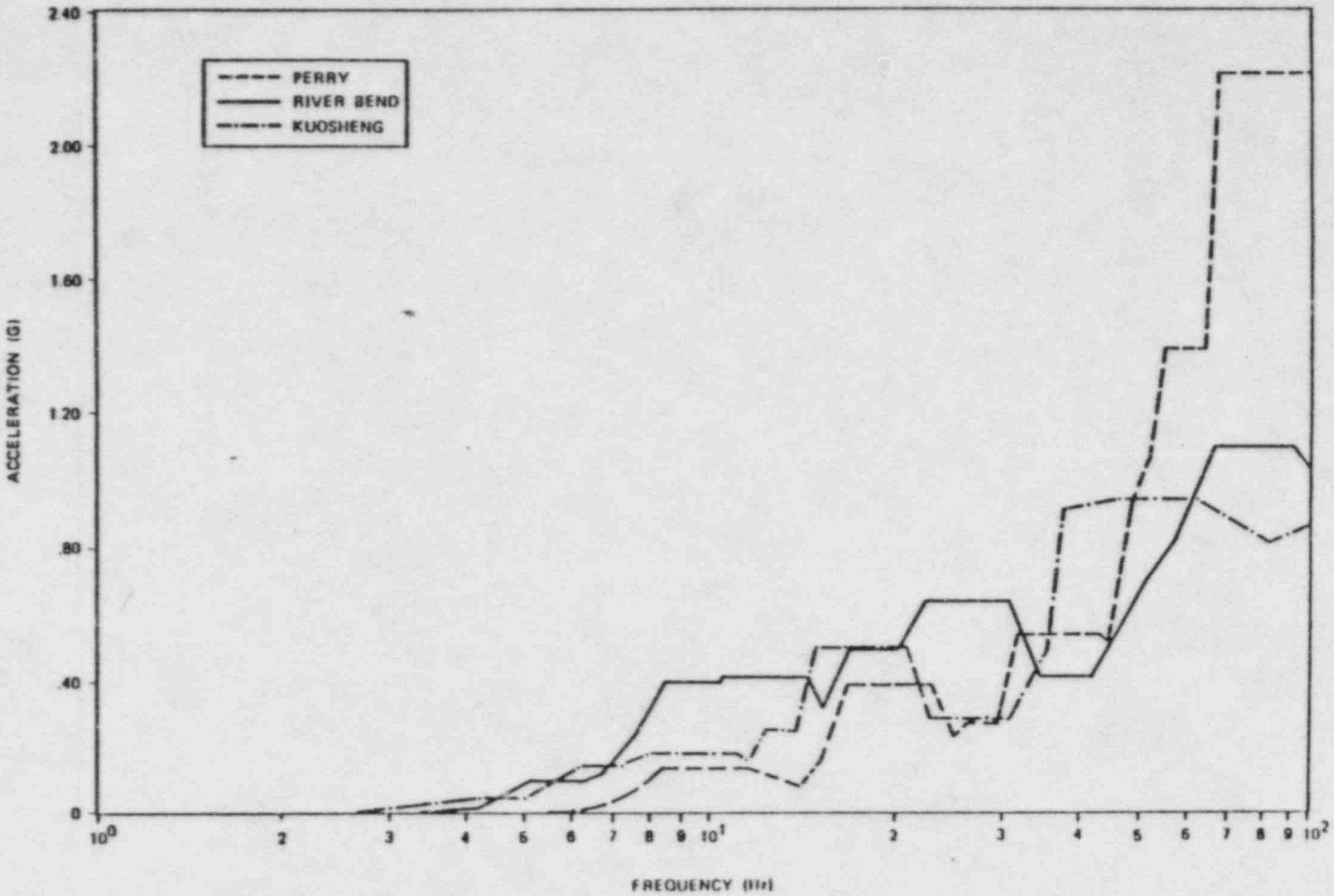


Figure 2-14

DESIGN RESPONSE SPECTRA COMPARISON – SRV + SRVCO
CONTAINMENT ELEVATION 80'-0" – RADIAL

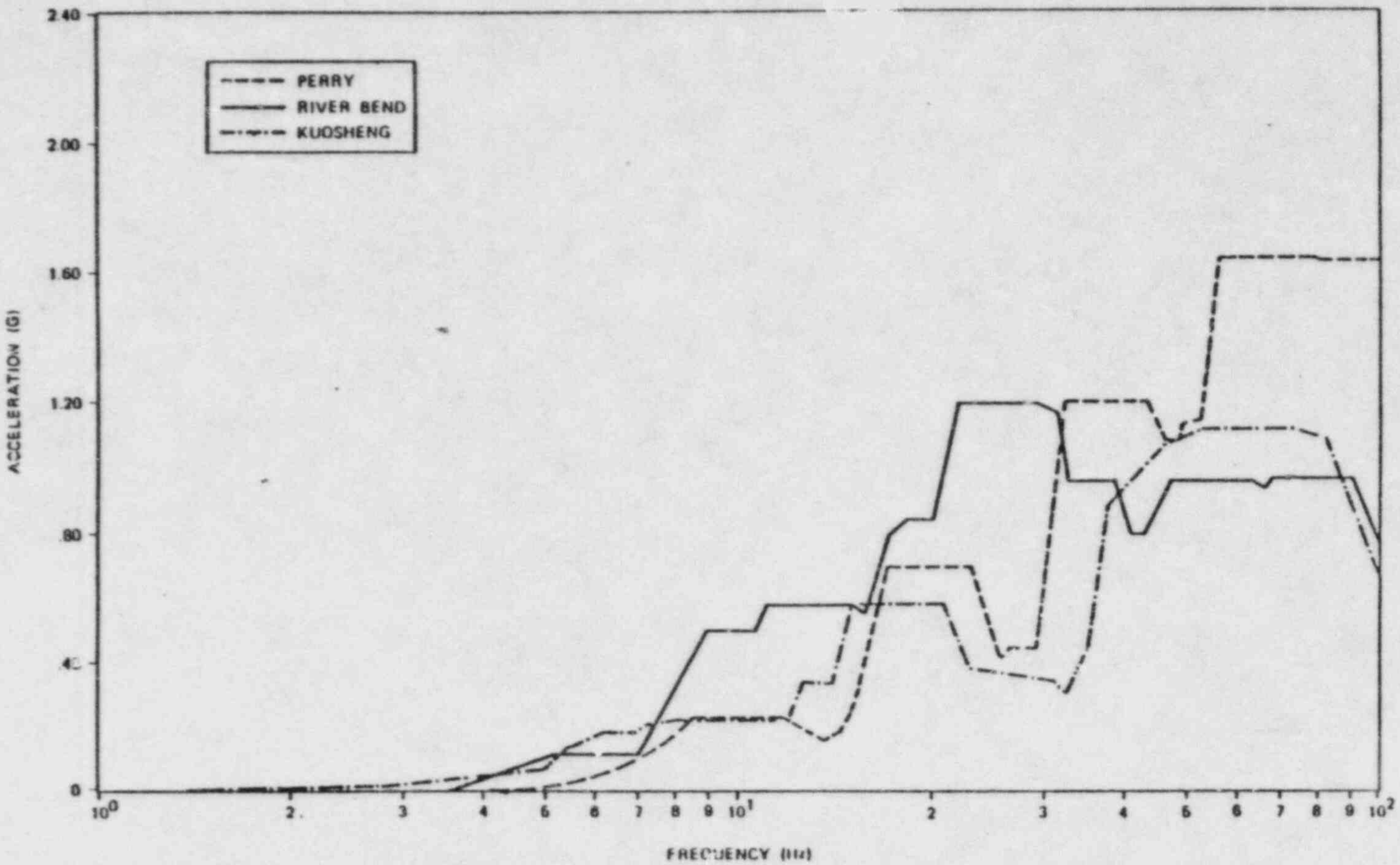


Figure 2-15

DESIGN RESPONSE SPECTRA COMPARISON SRV + SRVCO
SHIELD BUILDING ELEVATION 90"-0" – RADIAL

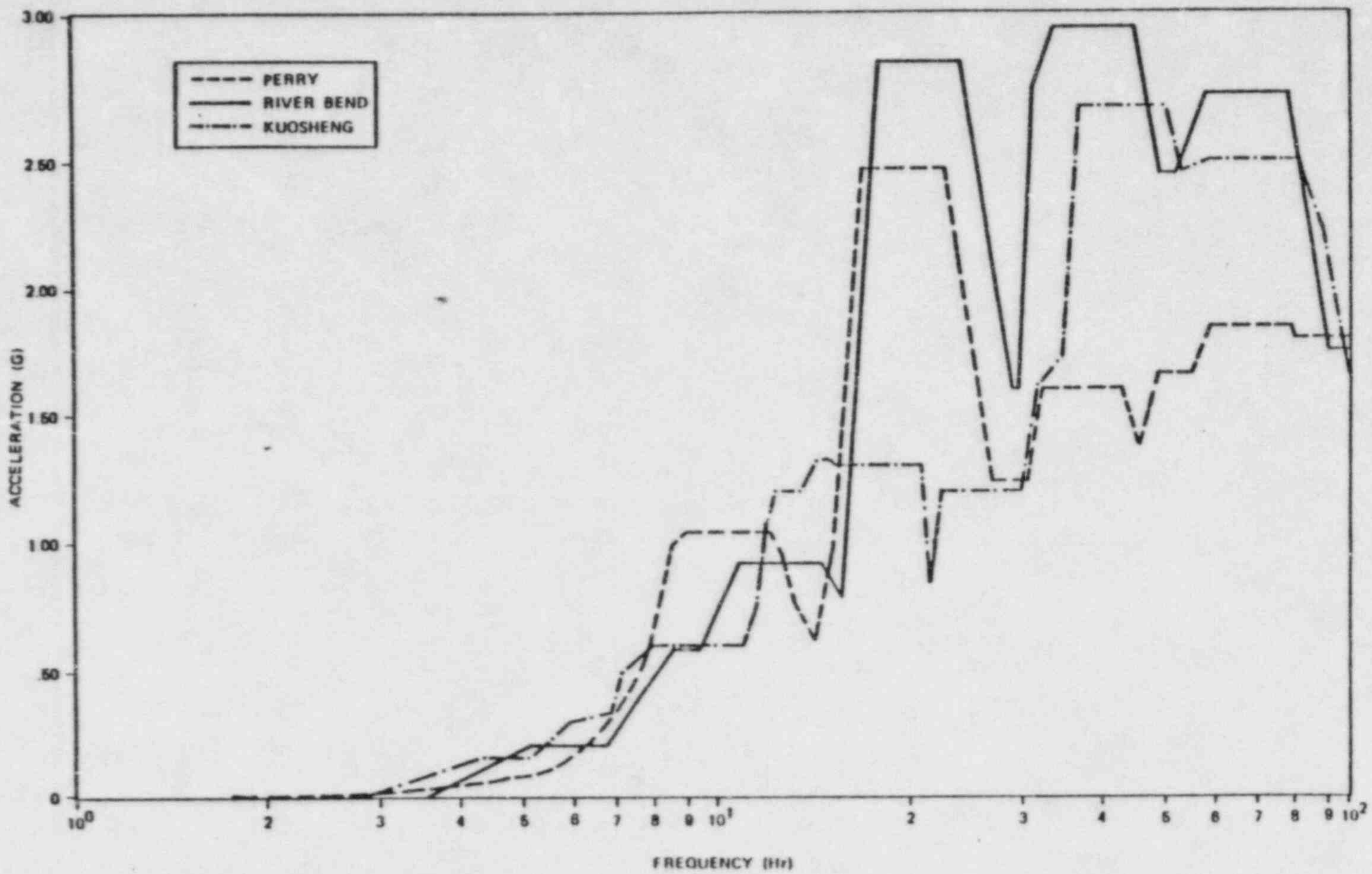


Figure 2-16

DESIGN RESPONSE SPECTRA COMPARISON – SRV + SRVCO
DRYWELL WALL ELEVATION 90'-0" – VERTICAL

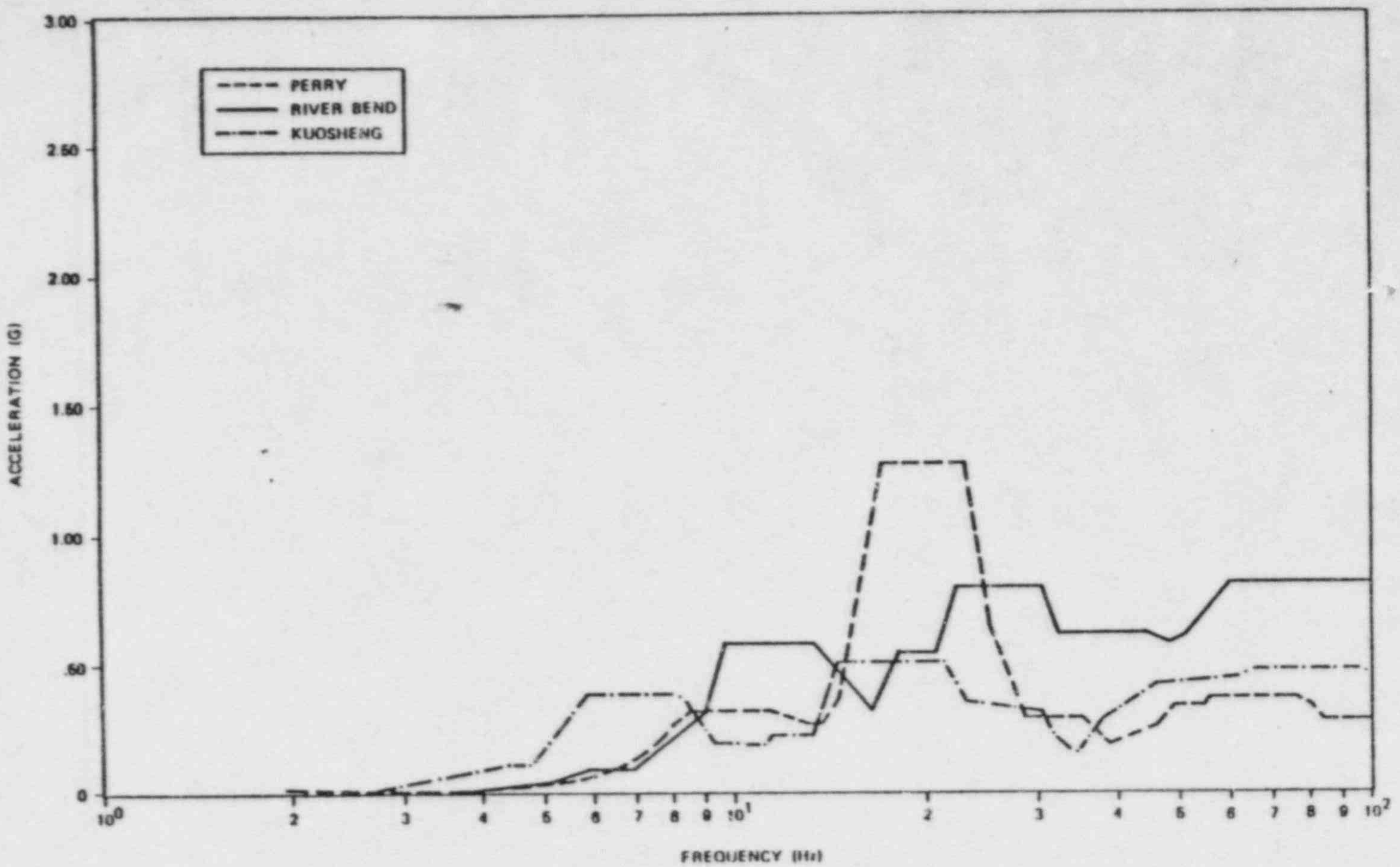


Figure 2-17

DESIGN RESPONSE SPECTRA COMPARISON – SRV + SRVCO
CONTAINMENT ELEVATION 80'-0" – VERTICAL

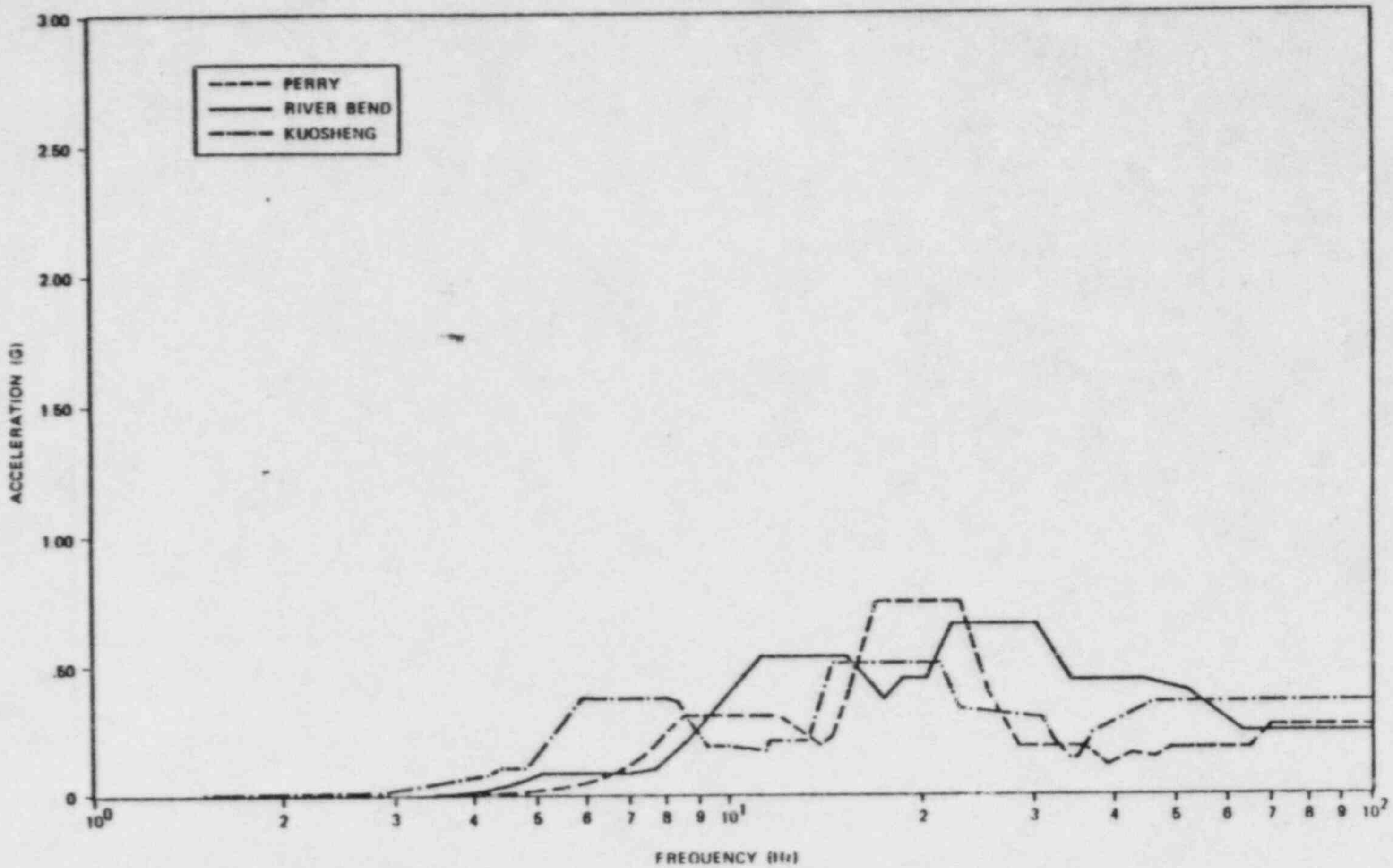


Figure 2-18

DESIGN RESPONSE SPECTRA COMPARISON – SRV + SRVCO SHIELD BUILDING ELEVATION 90′-0″ – VERTICAL

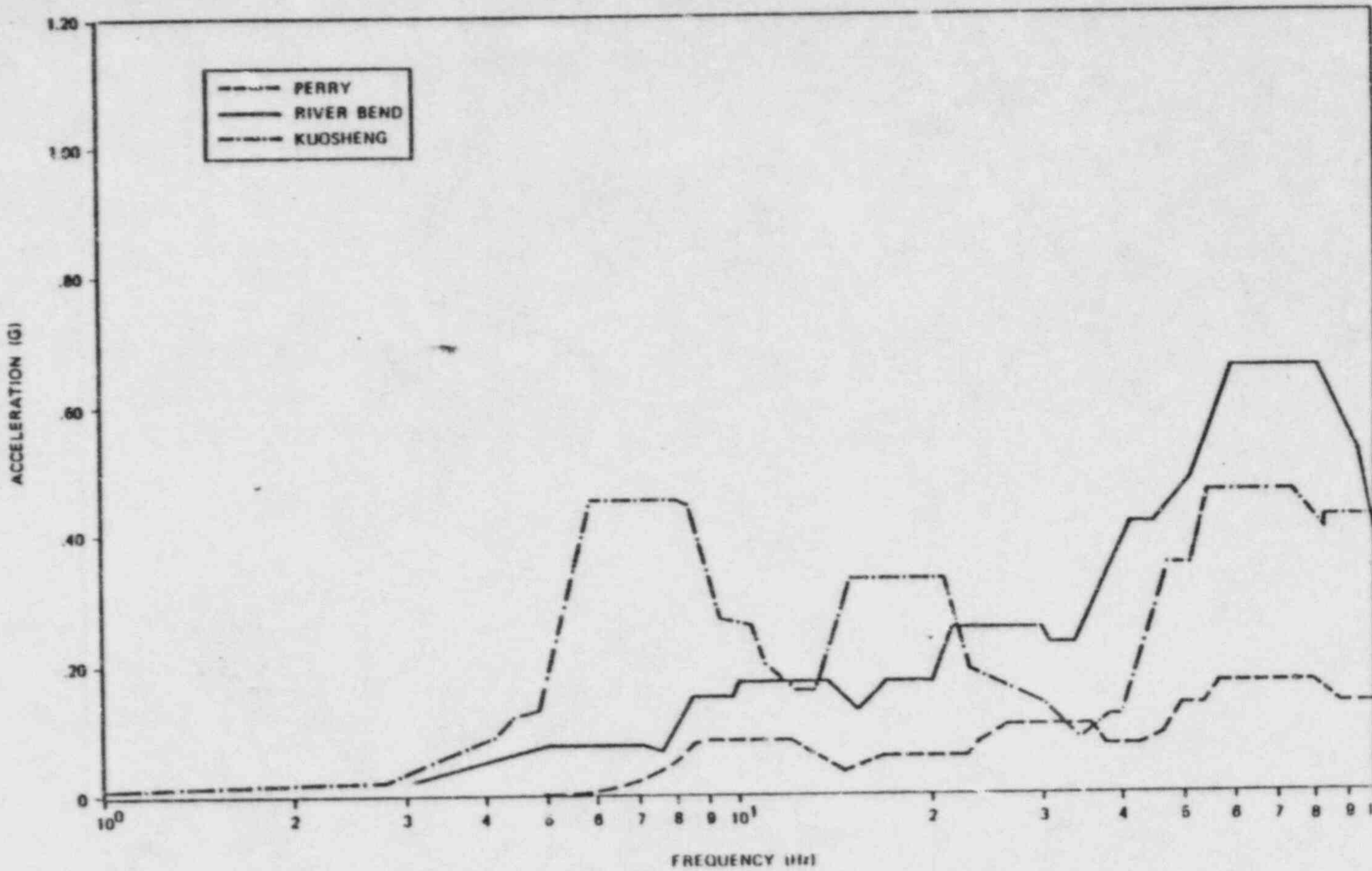


Figure 2-19

DESIGN RESPONSE SPECTRA COMPARISON – SRV + SRVCO
DRYWELL WALL ELEVATION 90'-0" – RADIAL

Table 2.1

CRITERION 1: X-QUENCHER COMPARISON

(1)	Parameters	Kuosheng	Grand Gulf	River Bend	Perry
A	Reducer Length (ft)	1.667	2.317	2.216	2.813
B	Hub Length (ft)	3.229	2.00	2.00	2.00
C	Bottom Cap Length (ft)	~1.0	~0.85	0.969	~0.85
D	Hub ℄ to end of arm (ft)	4.875	4.875	4.875	4.875
E	Hub ℄ to first row of holes (ft)	1.896	1.896	1.885	1.896
F	Length of hole pattern (ft)	2.625	2.625	2.624	2.624
G	Hub diameter (in.)	24" Sch. 80	24" sch. 120	24" sch. 140(2)	24" Sch. 140
H	SRVDL diameter (in.)	10" Sch. 80	10" Sch. 80	10" sch. 80	10" Sch. 40S
I	Arm diameter (in.)	12" Sch. 80	12" Sch. 80	12" sch. 80	12" Sch. 80
	Hole diameter (in.)	0.391	0.39	0.391	0.391
	No. of holes (4 arms)	1496	1496	1496	1496
	Reducer taper (degrees)	17.1	10.4	10.75	10.75
	Angle between arms (degrees)	80-80-80-120	80-80-80-120	80-80-80-120	80-80-80-120

(1) See Figure 2.1 for Nomenclature

(2) Hub is forged and machined. Cross section is comparable to 24-in. diameter Sch. 140 pipe.

Table 2.2

CRITERION 2: DISCHARGE LINE PARAMETERS

Parameters	Kuosheng	Grand Gulf	River Bend	Perry
SRVDL Air Volume (ft^3)/SRVDL Length (ft)	V5-42.7/74.4 V7-47.7/82.4 V8-46.0/79.6	V12-56.8/93.1	V1-50.0/102.8 V14-45.6/83.5	V1-55.7/107.3 V3-44.9/82.6
Pool Area/Quencher (ft^2)	332	333	400.5	310
Submergence (ft)	13.8	13.8	14.1	14.0
Vacuum Breakers	2-10" Ø/Line	2-10" Ø/Line	2-10"Ø/Line	2-6" Ø/Line

Note: 1) The air volumes and line lengths for Kuosheng and Grand Gulf are for the SRVD lines tested.

2) The air volumes and line lengths for River Bend and Perry are the maximum and minimun values in the plants.

3) Line lengths given are from SRV to air-water interface plus WCL (Table 2.3)

Table 2.3

QUENCHER/BUBBLE PRESSURE COMPARISONS

Parameters	Kuosheng	Grand Gulf	River Bend	Perry
Number of Quenchers	16	20	16	19
Quencher Area (ft^2)	74.66	74.66	74.66	74.66
Maximum SRVDL Air Volume (ft^3)	50.0	57.5	50.0	55.7
Steam Flow Rate (Tonne/hr.)	520.0	520.0	520.0	520.0
Pool Temperature (°F)	100	100	100	100
Water Column Length (ft)	17.9	16.5	18.2	17.4
Valve Opening Time (sec)	0.020	0.020	0.020	0.020
Submergence (ft)	13.8	13.8	14.1	14.0
Containment Pressure (psia)	14.7	14.7	14.7	14.7
Pool Surface Area (ft^2)	5304	6666	6408	5899
Contribution to PRD1 (Bars) (50-50 Maximum Positive ΔP)				
VAAQ	0.086	0.166	0.086	0.146
LNTW	-0.028	-0.028	-0.028	-0.028
WCL	0.297	0.148	0.316	0.269
WCL2	-0.293	-0.111	-0.258	-0.213
AWAQ	-0-	-0-	-0-	-0-
AWQ2	-0-	-0-	-0-	-0-
PRD1 for SVA (Bars)	0.539	0.596	0.537	0.595

NOTES AND DEFINITIONS OF TERMS FOR TABLE 2.3

1. The calculation for PRD1 was developed by GE and is reported in Section 3BA.12.6, Appendix 3B of GESSAR II, GE document 22A7000.

2. The values for VAAQ, LNTW, etc., in Table 2.3 are the contribution of each term of the equation for PRD1 and not the value of the term. The equation for PRD1 is given in Section 3BA.12.6.1.1 as:

$$
\begin{aligned}
PRD1 = \; & 0.421 \\
& +2.58\ (VAAQ-0.1706) \\
& +0.1377\ (LNTW-3.83) \\
& +0.206\ (WCL-4) \\
& -0.0176\ (WCL2-16) \\
& -0.0336\ (AWAQ-20) \\
& +0.000761\ (AWQ2-400)
\end{aligned}
$$

where:

VAAQ = Air volume in SRV discharge line (M^3) divided by the quencher area (M^2)

LNTW = Natural log of the suppression pool temperature (°C)

WCL = Actual water leg from centerline of quencher arm to air water interface (M)

WCL2 = $(WCL)^2$

AWAQ = Effective pool surface area per quencher divided by the quencher area

AWQ2 = $(AWAQ)^2$

Table 2.4

MEAN OF THE MEASURED PEAK PRESSURES FOR KUOSHENG LOW-LOW SET SRV

Pressure Sensor*	Mean Of Peak Pressures First Actuations (psid)	Mean Of Peak Pressures Consecutive Actuations (psid)	Design Pressure (psid)
P2	+1.40 -1.81	+1.72 -3.03	+16.6 -7.38
P3	+4.38 -2.91	+4.29 -3.57	+16.6 -7.38
P4	+5.86 -4.51	+5.38 -5.91	+16.6 -7.38
P14	+1.79 -2.10	+2.07 -2.34	+16.6 -7.38
P69	+1.75 -2.02	+1.88 -2.31	+16.6 -7.38

* As shown on Figure 2.2, all sensors were located within two quencher arm radii of the quencher centerline. Therefore, per the design load methodology each sensor is expected to sense design pressure.

Table 2.5
CRITERION 4: QUENCHER LOCATION
AND POOL DIMENSIONS

Parameters	Kuosheng	Grand Gulf	River Bend	Perry
Suppression Pool Width (ft)	17.5	20.5	20.5	18.5
Suppression Pool Depth (ft)	19.2	18.8	19.7	18.5
Quencher Location				
Radius (ft)	44.5	46.5	44.5	46.5
℄ of arms above floor (ft)	5.5	5.0	5.6	4.5
℄ of quencher from drywell wall (ft)	5.0	5.0	5.0	5.0
Quencher Support	Double box beams to drywell wall.	Cantilever from drywell wall at base; rigid struts from SRVDL to drywell wall.	Welded to base mat embedments; rigid struts from SRVDL to drywell wall.	Welded to base mat embedments; rigid struts from SRVDL to drywell wall.

Table 2.6

PHYSICAL SIMILARITIES COMPARISON OF KUOSHENG, GRAND GULF, RIVER BEND AND PERRY REACTOR BUILDING GEOMETRIES

Parameters		Kuosheng	Grand Gulf	River Bend	Perry
Basemat					
Diameter	(ft)	141	134	150	136
Thickness	(ft)	10.8	9.5	10.0	12.0
Concrete Compressive Strength	(psi)	5,000	5,000	4,000	3,000
Rebar Minimum Yield	(psi)	60,000	60,000	50,000	60,000
Soil Shear Wave Velocity	(fps)	2,300	1,600	960	4,900
Shield Wall					
Inside diameter	(ft)	25.8	28.7	25.8	27.6
Thickness	(ft)	2.0	2.0	2.0	2.0
Construction		Steel plate structure with concrete fill	Steel plate structure with concrete fill	Steel plate structure with concrete fill	Steel plate structure with concrete fill
Drywell					
Inside Diameter	(ft)	69	73	69	73
Thickness	(ft)	5	5	5	5
Steel Face Plate Thickness	(in.)	0.75	1.5	0.375	1.0

PHYSICAL SIMILARITIES COMPARISON OF KUOSHENG, GRAND GULF, RIVER BEND AND PERRY REACTOR BUILDING GEOMETRIES

(Concluded)

Parameters	Kuosheng	Grand Gulf	River Bend	Perry
Drywell (Cont.)				
Steel Face Plate Material	ASTM A-572 with A-240 Type 304 S.S. clad	ASTM A-537 ClA with Type 304L S.S. clad	ASME SA-240 Type 304L S.S.	ASME SA-516, Gr. 70 with SA-240, Type 304 S.S. clad
Concrete compressive strength (psi)	5,000	5,000	5,000	5,000
Rebar minimum yield (psi)	60,000	60,000	50,000	60,000
Containment In Pool Region				
Inside Diameter (ft)	114	124	120	120
Thickness (ft)	8.5	3.5	7.0	8.0
Steel Liner Thickness (in.)	0.25	0.25	1.5	1.5
Steel Liner Material	SA-285 Gr. A	ASTM A285 Gr.A	SA-516 Gr.70	SA-516 Gr. 70
Steel Liner Yield Strength (psi)	24,000	24,000	38,000	38,000
Concrete Compressive Strength (psi)	5,000	5,000	3,000	5,000
Rebar minimum yield (psi)	60,000	60,000	50,000	60,000