MISSISSIPPI POWER & LIGHT COMPANY
Helping Build Mississippi
P. O. BOX 1640, JACKSON, MISSISSIPPI 39205

March 23, 1983

U. S. Nuclear Regulatory Commission
Office of Nuclear Reactor Regulation
Washington, D. C. 20555

Attention: Mr. Harold R. Denton, Director

Dear Mr. Denton:

SUBJECT: Grand Gulf Nuclear Station
Units 1 and 2
Docket Nos. 50-416 and 50-417
License No. NPF-13
File 0260/0272/L-860.0
Humphrey Containment Concerns
AECM-83/0146

REFERENCES: 1. Letter from Mark III Containment Issues Owners Group to H. R. Denton, dated September 24, 1982

2. Letter number AECM-82/475 from L. F. Dale to H. R. Denton, dated December 3, 1982

3. Letter Number AECM-82/641 from L. F. Dale to H. R. Denton, dated December 31, 1982

Reference letter 3 contained a commitment from Mississippi Power & Light Company (MP&L) to respond to a number of questions raised by your staff's consultants regarding MP&L's work addressing the containment concerns raised by Mr. John Humphrey. Attachment one to this letter contains responses to five of the six items listed in reference letter 2.

The only item which has not yet been submitted is an evaluation of condensation oscillation loads which could be produced by discharges from the RHR heat exchanger relief valve discharge line. MP&L is presently participating in a generic effort by the Mark III Containment Issues Owners Group (CIOG) to define these loads. This generic effort will be completed in late April as a result of commitments by the CIOG to respond to questions from the Containment Issues Review Panel. The function and formation of this review panel were discussed in reference letter one.

Reference letter 2 contained the results of MP&L's analyses which were performed to address Humphrey Concern 8.1. These analyses were contained in results from Action Plan 25 in Attachment One to reference letter 2. The CIOG has completed additional studies of end point containment conditions with

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varying combinations of initial containment conditions. MP&L is submitting the results from these additional analyses in Attachment 2 to this letter. These results supercede the information submitted for item 2 of Action Plan 25 in reference letter 2.

Yours truly,

JBRichards for

L. F. Dale
Manager of Nuclear Services

RAW/SHH/JDR:sap
Attachments

cc: Mr. J. B. Richard (w/o)
Mr. R. B. McGehee (w/o)
Mr. T. B. Conner (w/o)
Mr. G. B. Taylor (w/o)

Mr. Richard C. DeYoung, Director (w/a)
Office of Inspection & Enforcement
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Mr. J. P. O'Reilly, Regional Administrator (w/a)
Office of Inspection and Enforcement
U.S. Nuclear Regulatory Commission
Region II
101 Marietta St., N.W., Suite 2900
Atlanta, Georgia 30303

I.1.4 Evaluate the numerical impact on predictions for encroachment effects of uncertainties in analytical assumptions.

I.1.5 Define the sensitivity of local encroachment analytical results to assumptions regarding time at which breakthrough occurs in the bulk pool.

Response: Three sensitivity studies were performed to determine how changes in parameters for the GGNS analysis of local encroachment effects on suppression pool swell affect the results submitted previously in reference 1 by Mississippi Power & Light (MP&L). Results from these studies are compared with the results of MP&L's previously submitted analysis using the peak impact velocity on the bottom of the support beams located two feet below the HCU floor. This parameter is considered singularly important for comparison of results since the peak pool swell height is limited by impact on these beams; i.e., the pool swell cannot rise any further.

The first study investigated the sensitivity of the analytical results to assumptions regarding bubble coalescence time. As noted in reference 1, the analysis completed to date assumes that the bubbles under the encroachment expand at the same rate radially and circumferentially. This assumption results in contact between adjacent bubbles at approximately 0.17 seconds after vent clearing or at approximately 1.0 seconds into the transient.

In the case of GGNS, a pressure difference of more than 3 psi will exist between bubbles formed under the encroachment and bubbles formed in the open pool. At some point in time, the pressure gradient in the circumferential direction will be higher than the pressure gradient in the radial direction due to the 3 psi pressure difference which exists between bubbles under the encroachment and bubbles in the open pool. This difference in pressure gradients will cause the bubble to expand more rapidly in the circumferential direction. The resultant preferential expansion in the circumferential direction causes earlier bubble coalescence than the coalescence time assumed in the existing analysis. MP&L believes that it is therefore unrealistic to postulate any delay in bubble coalescence.

MP&L evaluated decreasing the assumed bubble coalescence time to 0.9 seconds into the transient. The results from this case show that the pool swell velocity when impact occurs at the support beams below the HCU floor is only 65% of the velocity predicted for the previously submitted base case.

The next study investigated the assumptions regarding breakthrough time. Breakthrough was assumed to occur with 2.5 foot slug thickness at 1.275 seconds into the transient for the base case. The impact velocity on the beams below the HCU floor decreased approximately 4% when breakthrough was assumed to occur at 1.175 seconds with a slug thickness of 3.9 feet. When breakthrough was assumed to occur at 1.375 seconds into the transients, the impact velocity increased 12%.

The final study performed investigated the sensitivity of the 0.05 second ramp rate used to equalize the pressure of the clean pool and encroached pool bubbles. When the pressure of the bubbles in the encroached case was instantaneously changed to the bubble pressure for the clean pool bubble, the impact velocity decreased 3%. When a 0.1 second ramp rate was used, the impact velocity increased approximately 17%.

References:

1. MP&L letter AECM-82/497 from Mr. L. F. Dale to Mr. H. R. Denton dated October 22, 1982.

I.6.1 Quantify the maximum lateral loads which could be applied to the RHR heat exchanger relief value discharge line as a result of chugging in the discharge line.

Response The heat exchangers in the Grand Gulf Nuclear Station (GGNS) Residual Heat Removal (RHR) system are each designed with vents at two locations on the steam side of the heat exchanger. The vents remove non-condensible gasses which could collect in the heat exchangers and degrade their performance. When the RHR system is operating in the steam condensation mode, these vents provide a small but continuous dump of steam to the suppression pool through the RHR heat exchanger relief valve discharge line. The flow rate of steam through the relief valve discharge line is such that chugging will occur in the pool as long as the RHR system operates in this mode. Pool boundary and vent lateral loads which result from vertical vent chugging have been extensively investigated in the design of Mark II containments. Technology developed under the Mark II Containment Program has been used to evaluate pool boundary loads in the GGNS suppression pool and lateral loads on the relief valve discharge line due to chugging during operation of the RHR system in the steam condensing mode.

Description of the RHR Heat Exchanger Steam Bypass Geometry

During operation of the RHR system in the steam condensing mode, steam vented from the RHR heat exchanger is bled into the discharge line, downstream of the pressure relief valve in the RHR system. A schematic of the relief valve discharge line and the non-condensible bleed line piping is shown in Figure 1. Steam is extracted from the RHR heat exchanger at two locations, passes through two 2" valves in series which control the steam flow, and enters the relief valve discharge line in its vertical run, outside the containment. The total extraction flow has been estimated to be just under 1 lbm/sec. This flow through the 10" relief valve discharge line results in a steam mass flux of 1.8 lbm/sec ft^2 into the suppression pool. This is within the range of steam mass fluxes over which chugging would be expected to occur in the pool. Chugging from the relief valve discharge line will result in pool boundary loads in the suppression pool and lateral loads on the discharge line. The chugging loads which result from the steam discharges through the RHR heat exchanger relief valve discharge line will be similar to the vertical vent Mark II chugging loads. The methods used to evaluate chugging loads for the Mark II containment are described next.

Description of the Mark II Model for Pool Boundary Chugging Loads

The chugging behavior of vertical vents has been described in several references, e.g. 1 and 2. Briefly, chugging is the mode of condensation which occurs when the supply of steam is too small to sustain continuous condensation at the vent exit. Under these conditions, condensation takes place when the steam-water interface pushes its way into the pool. Condensation will then occur in a brief burst which rapidly depressurizes the steam bubble. This is followed by bubble collapse water re-entry into the vent while the vent system is again pressurized and the steam water interface forced back into the pool. The range of vent exit mass fluxes over which chugging will occur is from well over 10 $lbm/sec\ ft^2$ to under 1 $lbm/sec\ ft^2$.

Chugging loads are produced by rapid steam condensation which results in bubble depressurization and collapse. This excites both the pool and vent and results in a pool boundary pressure composed of the response of both. To evaluate pool boundary loads to this combined pool and vent response, the Mark II chugging model represents the suppression pool as an acoustic media. The pool walls are modeled as rigid boundaries and the pool surface as a constant pressure boundary.

The chug is represented as a point flow source located at the vent exit. The source flow history is composed of two parts; a triangular impulse and a series of decaying sinusoids. This combination source function has been successfully used to represent a wide variety of chugging events, even multivent chugging where the impulse functions are desynchronized to represent phasing of the chugs between vents. The chugging model has been implemented in the computer code IWEGS-MARS, and is described in detail in reference 3.

Evaluation of Pool Boundary Chugging Loads

Input to the IWEGS-MARS code includes the pool geometry, pool acoustic speed and the specification of a chug source. The source which has been selected to evaluate RHR discharge line chugging pool boundary loads simulates a chug which occurred during the original series of Mark II chugging tests (4). A chug from this original test series has been used since the vent length in these tests is similar to the length of the relief valve discharge line. The particular chug chosen is identified as chug #71. It occurred near the end of test run #31 and produced a peak pressure in the 4T test facility of nearly 12 psi. A pressure history for this chug as measured on the bottom of the 4T tank is show in Figure 2. Table 1 gives the chug source parameters for this chug and the chug source parameters which have been used for input to the Grand Gulf pool model. Several of the chug source parameters have been modified. The sinusoidal driver frequencies have been increased to account for the slightly shorter length of the RHR relief valve discharge line and increased acoustic speed in the steam resulting from higher temperatures. Unlike conditions in the pool in an accident situation, the pool should be relatively air free when the RHR is in operation in the steam condensing mode. Therefore, the pool acoustic speed which has been used assumes no air in the pool, but has been adjusted for the flexibility of the Mark III Containment.

Test of vertical vent chugging have shown chug strength variation with several parameters including steam vent mass flux, pool temperature and system pressure. However, there is also a statistical variation between chugs at the same conditions. The chug chosen for the present study was one of the largest amplitude chugs observed in the original Mark II single vent test series and should represent a bounding chug source for the pool boundary chugging load evaluation.

Since the RHR heat exchanger relief valve discharge line is smaller in diameter than the vent in the 4T tests (10" to 24"), there is justification for reducing the magnitude of the impulse used in the chug source. Tests conducted over a series of vent sizes have shown that, although the peak chug overpressure may not decrease dramatically with vent size, the net impulse due to the chug does decrease with vent size. In the present evaluation, the chug source amplitude will not be reduced to insure that a suitably conservative pool forcing function is used.

The load on the containment wall next to the discharge line exit due to chugging from the RHR heat exchanger relief valve discharge line is show in Figure 3. Both the pressure history and the pressure response spectrum (PRS) are shown. The pressure history consists mainly of the chug impulse, followed by damped sinusoid. The PRS shows most of the signal power is near the frequency of the pool's first axial acoustic mode ($\omega = c/4L = 2500/\ 4x18.33 = 33.2$ Hz).

Pressure histories were also calculated at locations throughout the pool. As would be expected, the pressures attenuate sharply moving away from the chug source. In order to have some measure of the load attenuation around the pool, the RMS pressure at several points around the pool boundary were calculated. These are shown in Figure 4.

In order to have a basis for comparing this chugging load to other design basis loads for GGNS an average containment chugging load was obtained by averaging the pressure histories at several locations around the containment perimeter. The same locations on the pool boundary where RMS pressures were calculated were used. The response spectrum for other containment design loads, along with the response spectrum for the RHR chugging load, is shown in Figure 5. It is significant to note that the RHR chugging response is less than the mark III LOCA main vent chugging response and a factor of ten less than the response due to pool swell loads. Figure 6 compares the response spectrum for the RHR chugging load on the wall next to the vent to the response spectrum for the Mark III LOCA main vent local chugging load. Again, the RHR chugging load is bounded. Clearly the pool boundary chugging load from the RHR discharge line, even from this conservative analysis, is still much less than other design basis loads for the Grand Gulf containment.

Evaluation of Lateral Loads due to Chugging

The lateral load definition for a Mark II vent is given in reference (5) as a load history applied over the bottom four feet of the vent. The load history is given by:

$$F(t) = A \sin(\pi t/\tau) \qquad (0 \leq t \leq \tau)$$

where the amplitude A varies from 10 klbf to 30 klbf while the period of load application varies from 6 ms to 3 ms. As pointed out in reference (5), the combination of maximum amplitude, minimum period produces the greatest net load on the vent system.

This load definition is based on the maximum lateral vent load observed in 4T test series on a 24 inch diameter vent. Additional information is supplied in reference (6) to extrapolate this load to a larger vent diameter, using data from additional chugging tests. The formula used to correlate vent lateral load data at other diameters is given as;

$$A = Ao\left(\frac{D}{Do}\right)^N$$

where Ao and Do are the amplitude and diameter for the 4T 24 inch vent lateral load data. The exponent N was found to vary between 0.5 for extrapolation of the 4T maximum loads and 1.7 for extrapolation of the 4T statistical averaged loads. Data from other tests conducted over a wider range of vent diameters show a consistent value of N = 0.7 (6). Data from this same reference showed a maximum amplitude lateral load for a 24 inch vent of 35.9 klbf. In order to use a consistent scaling basis, this higher amplitude lateral load will be scaled down using the formula give above with an exponent of 0.7. This provides consistent scaling of the maximum amplitude lateral load data between 24 inch and 12 inch diameter vents in this test series. With this scaling basis, the 10 inch vent lateral load amplitude becomes 19.5 klbf. To be consistent with the Mark II load definition, two load application amplitudes and periods should be considered. Thus, the lateral load for the RHR relief valve discharge line will be given by the same formula for F(t) give earlier, uniformly distributed over the bottom 4 feet of the discharge pipe exit, with amplitude and period given by;

A = 19.51 klbf = maximum amplitude with

τ (period) = 3 ms

and

A = 6.5 klbf = maximum amplitude with

τ (period) = 6 ms

This vent lateral load definition is a direct extension of the existing Mark II lateral load definition and should provide a suitable conservative design basis load for the RHR discharge line.

These loads have been applied to the RHR heat exchanger relief valve discharge line in combination with normal operating and OBE loads. The resultant stresses are within the code upset allowable stresses.

Table 1 - Chug Source Parameters

Chug Source Parameters	4T Chug #71 (Reference 5)	Grand Gulf Chug Source
pool acoustic speed (ft/sec)	2198	2500*
pool depth (ft)	21	18.83
pool damping parameter (ft)	0.148	0.148
chug impulse magnitude (ft^3/sec^2)	158.9	158.9
chug impulse duration (ms)	.024	.024
chug sinusoid damping parameter	0.05	0.05
chug sinusoid magnitude and frequency		
A_1 (ft^3/sec^2)	10.59	10.59
ω_1 (Hz)	2.3	2.8
A_2	10.59	10.59
ω_2	4.6	5.6
A_3	10.59	13.36
ω_3	11.7	14.2

*based on (see Appendix B, reference 3)

$$c = c_r \, [1 + (BD/hY)]^{-1/2} \cong 2500 \text{ ft/sec}$$

where c_r = 5000 ft/sec rigid wall pool acoustic speed

B = pool bulk modules = 3.36×10^5 lbf/in^2

D = pool outer diameter = 124 ft

h = pool wall thickness = 3.5 ft

Y = pool wall Young's modulus = 2×10^6 lbf/in^2

FIGURE I

SCHEMATIC OF RHR PRESSURE
RELIEF VALVE DISCHARGE LINE

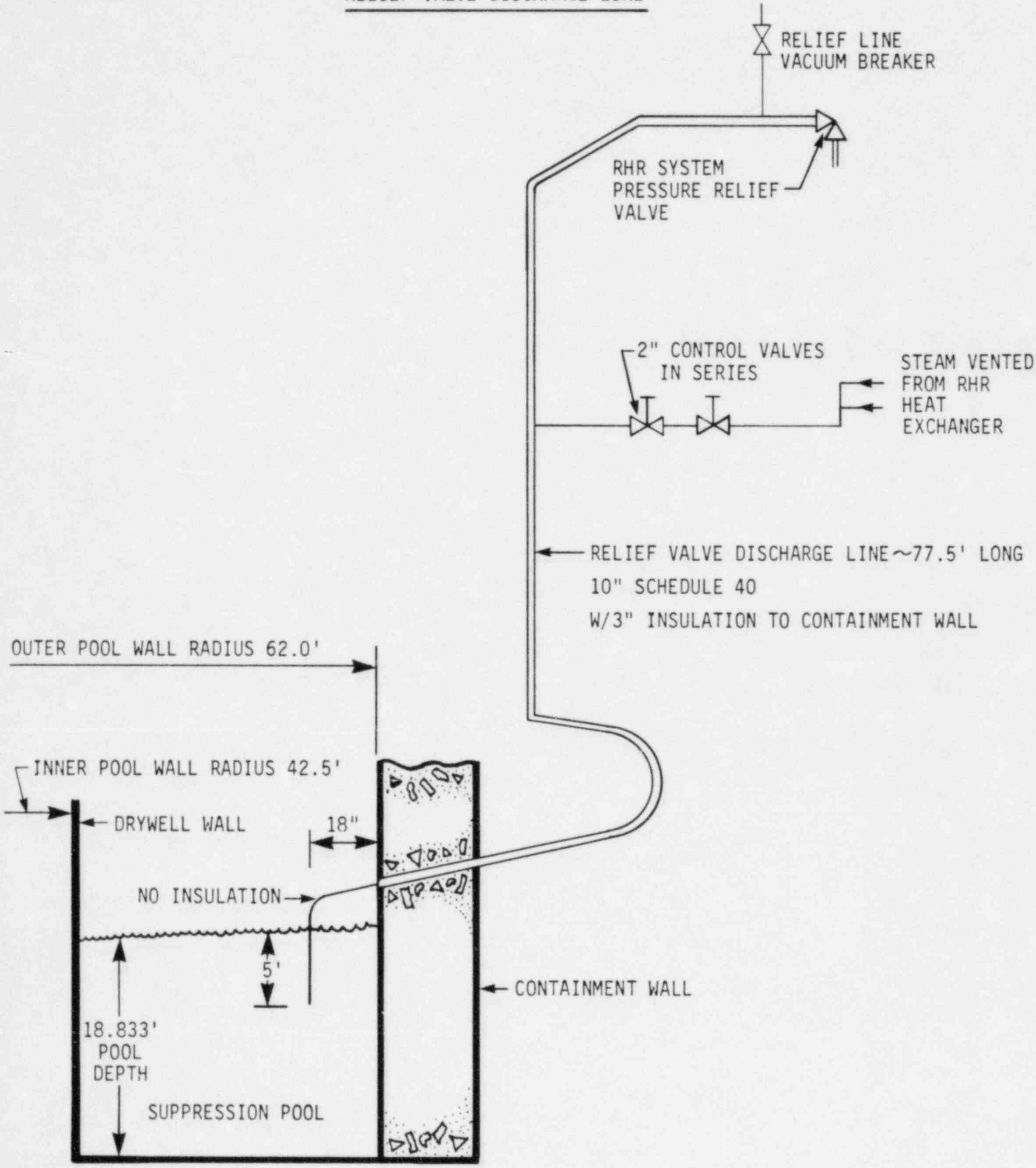


FIGURE 2

4T POOL BOTTOM PRESSURE

CHUG 71

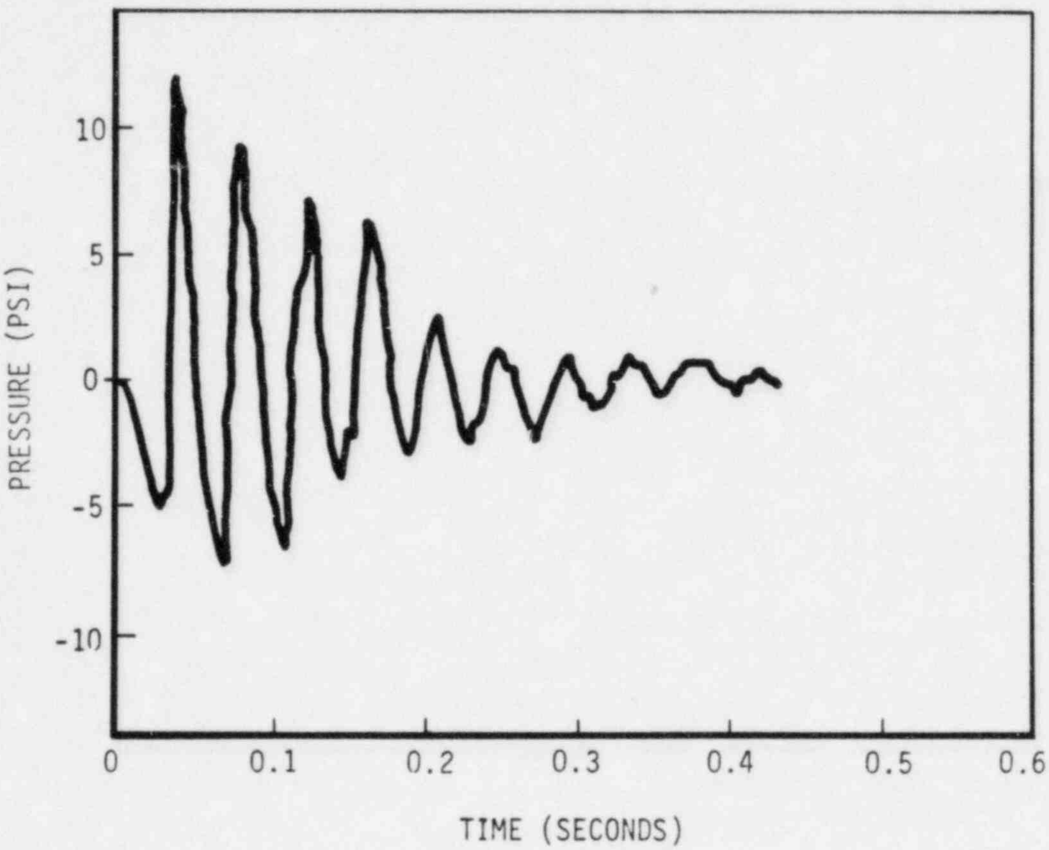


FIGURE 3

GRAND GULF RHR CHUGGING WALL PRESSURE

(CONTAINMENT WALL NEXT TO VENT)

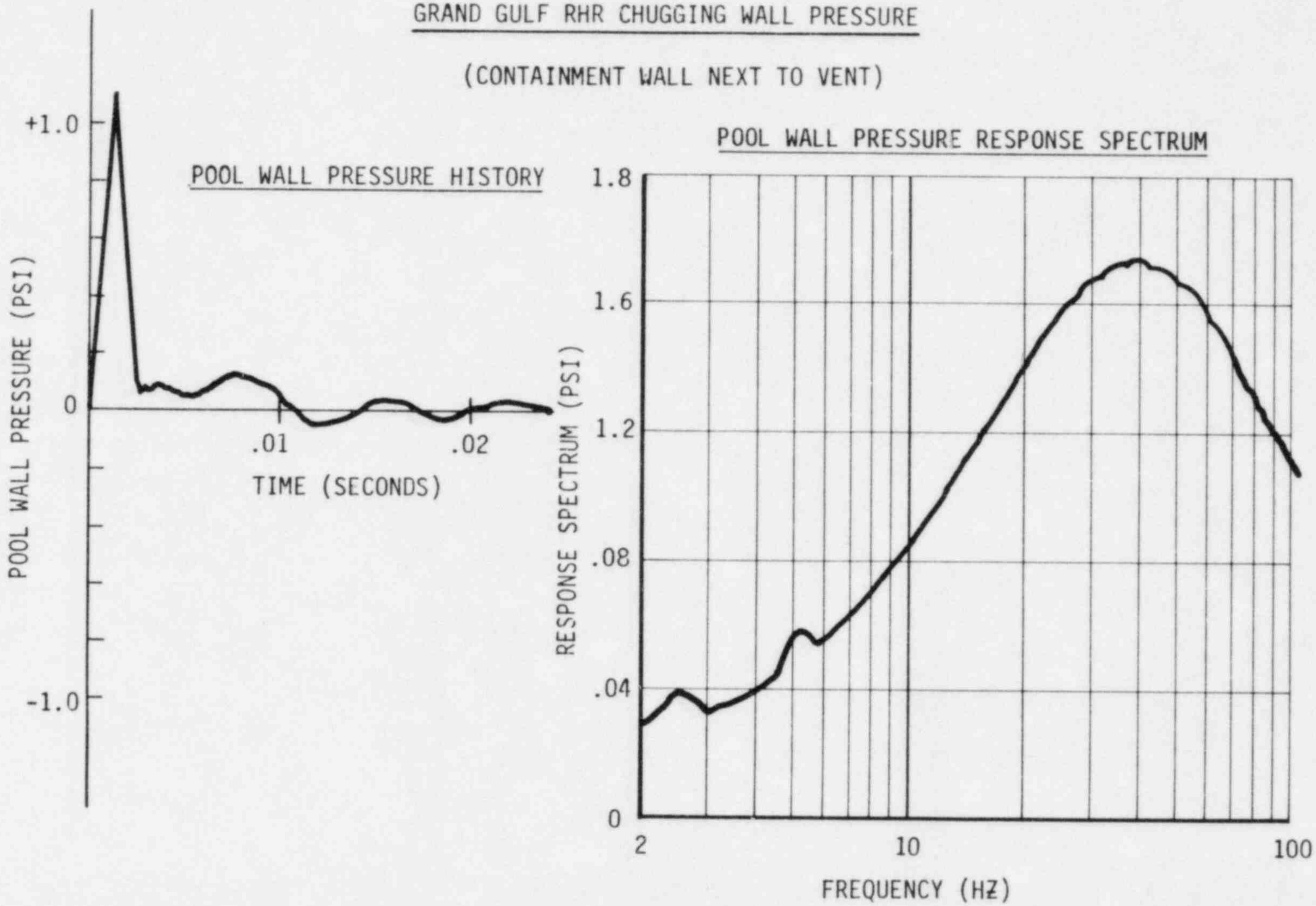


FIGURE 4

GRAND GULF SUPPRESSION POOL

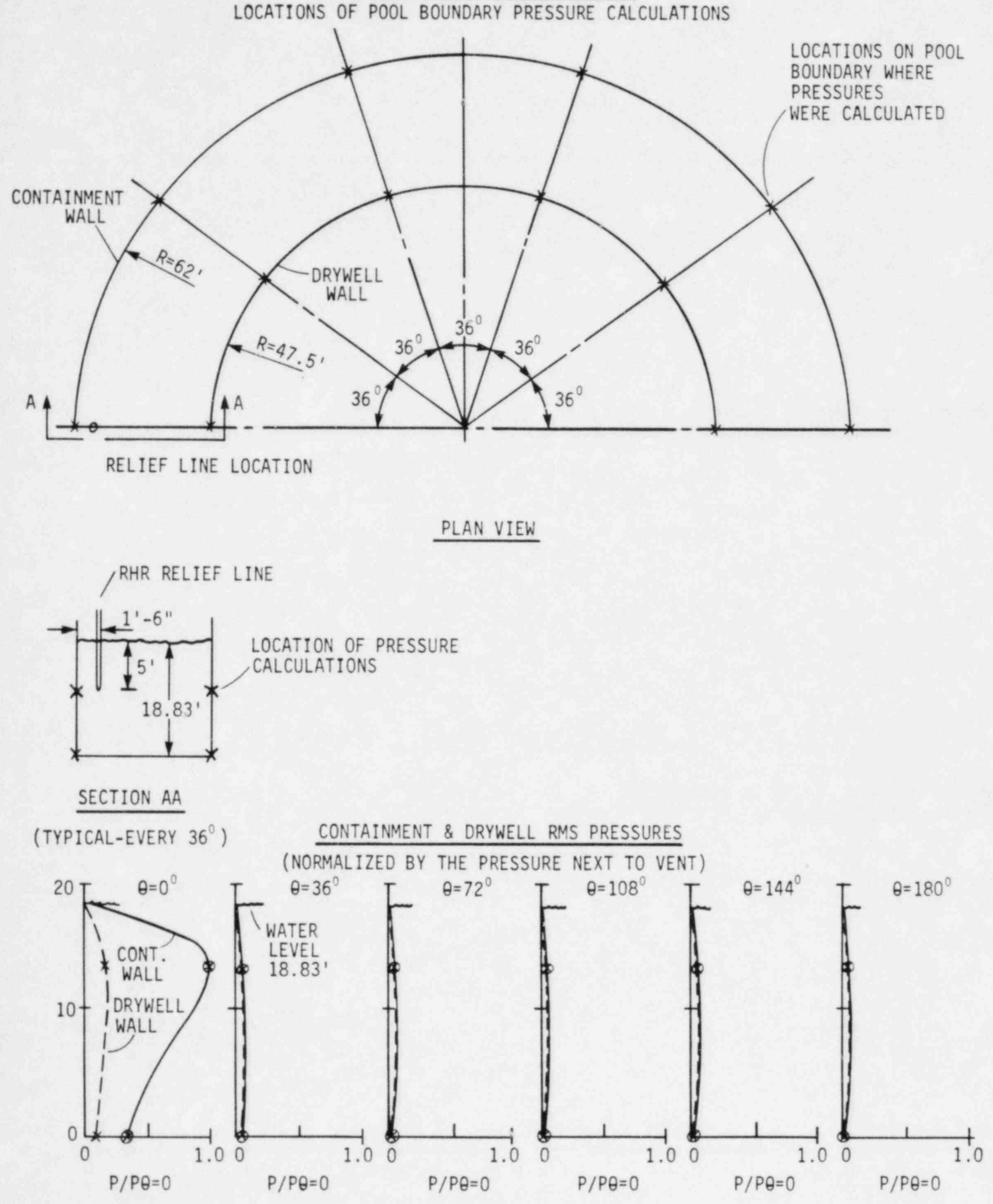


FIGURE 5

AMPLIEFIED RESPONSE SPECTRUM FOR GLOBAL CHUGGIN LOAD

(2% DAMPING)

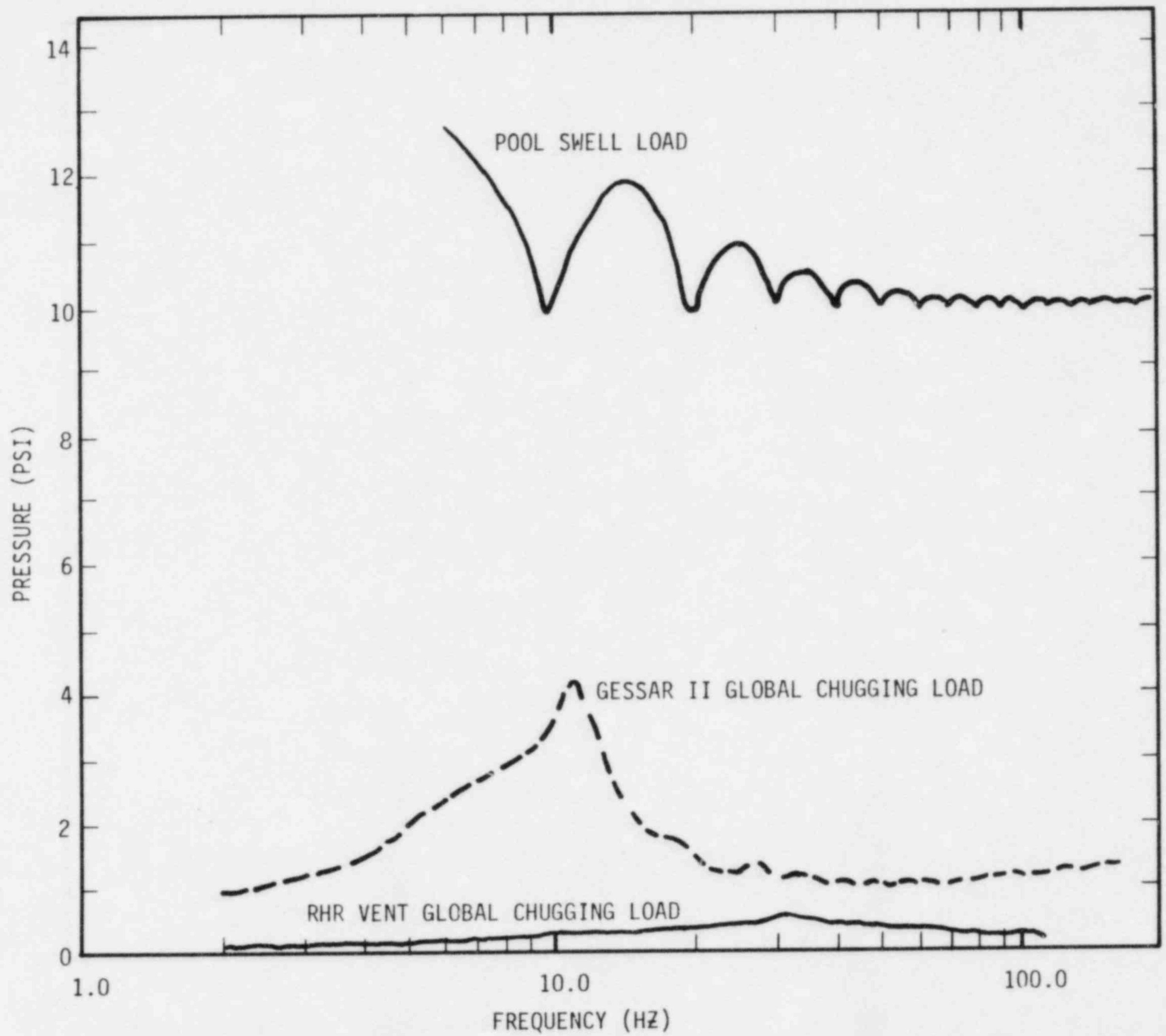
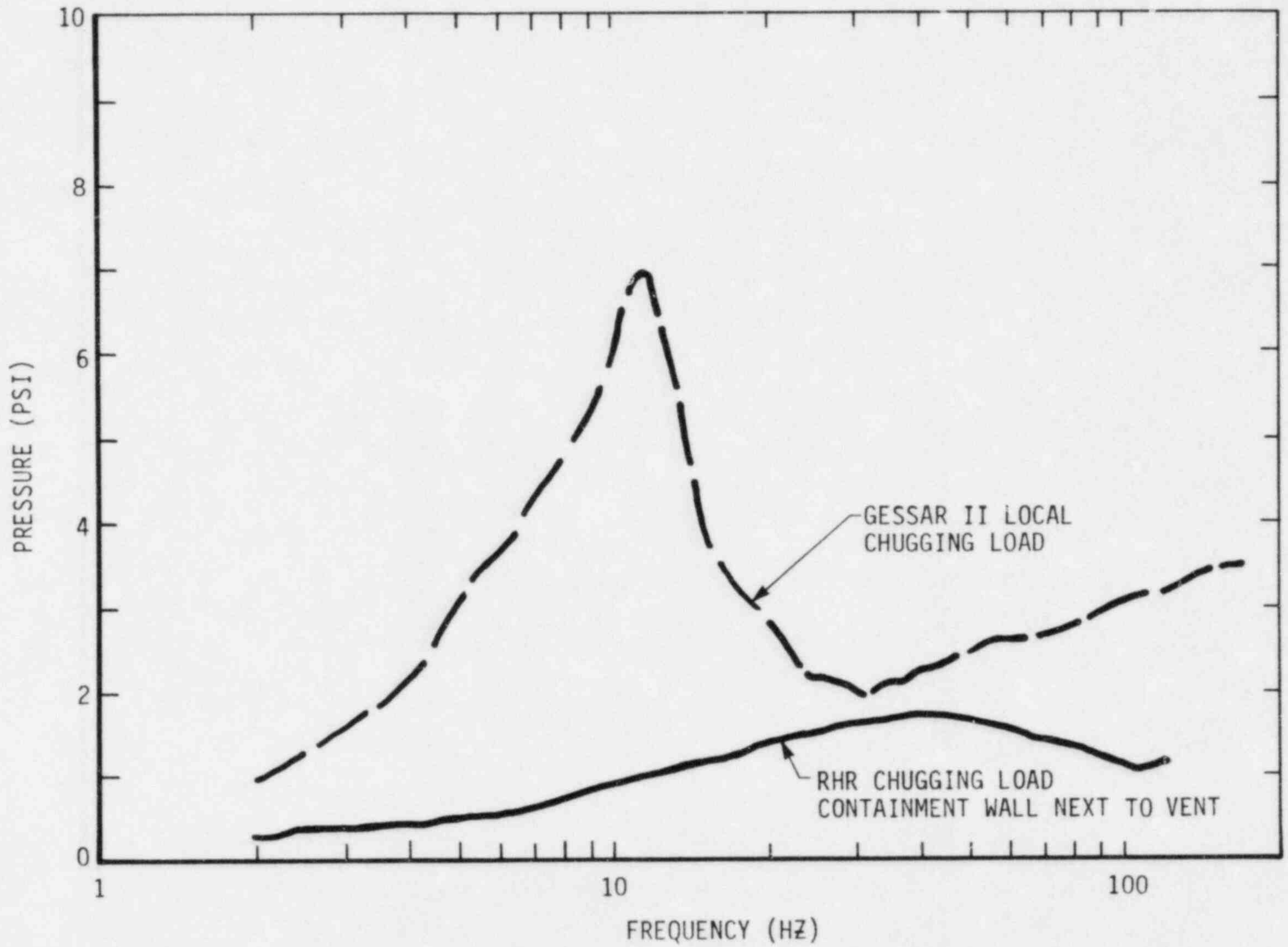


FIGURE 6

AMPLIFIED RESPONSE SPECTRUM FOR LOCAL CHUGGING LOAD

(2% DAMPING)



REFERENCES

1. Patel, B. R. et al., Comparison of Single and Multivent Chugging at Two Scales, General Electric Report NEDE-24781-1-P, January 1980.

2. Healzer, J. M. (editor), Single Vent Chugging Model, General Electric Report NEDE-23703-P, September, 1977.

3. Ashley, G. K., et al., An Approach to Chugging, Bechtel Power Corp. Report, April, 1980.

4. McIntyre, T. R., et al., Mark II Pressure Suppression Test Program Phase I Tests, General Electric Report NEDE-13442-P-01, May, 1976.

5. Anderson, C. J., Mark II Containment Program Evaluation and Acceptance Criteria, U.S. Nuclear Regulatory Commission Report, NUREG-0808, August, 1981.

6. Letter, Buckholz, R. H., General Electric Co. to Karl Kniel, U.S. Nuclear Regulatory Commission, Mark II Containment Program Responses to NRC Questions on Mark II Single VEnt Lateral Loads, Reference MFN-012-81, RHB-111-81, January 16, 1982.

I.A The main steam SRV lines enter the suppression pool at an angle. Consequently, the additional five feet of submergence produced by upper pool dump may actually increase the length of submerged SRV discharge line by as much as eight feet. Although this change should not adversely affect the air clearing loads, it may change the SRV piping thrust loads.

<u>Response</u>: MP&L has recalculated the SRV thrust loads which would result from SRV activation following an upper pool dump. The revised thrust loads accounting for increased water leg in the discharge line are within the upset allowable stresses.

I.B The location of SRV quenchers under the TIP platform may produce changes in the SRV quencher loads.

<u>Response</u>: Detailed analyses have been performed to determine the influence of the encroachment on changes of source phenomena, and to evaluate possible increases in pool boundary loads.

The analyses showed that the only effect on source phenomena due to the encroachment was a decrease in frequency of bubble oscillation by less than three percent. Conceptually, this is understood by realizing that the encroachment forces a larger volume of water to participate during bubble oscillation. This larger volume of water represents an increase in mass in an oscillatory system where all else remains unchanged. The three percent shift in frequency is bounded by the fifteen percent peak broadening, included as design margin, when applying the ARS of the load definition, and is therefore inconsequential. In addition, the following source related occurrences have been examined and the effects of the encroachment on the occurrences were essentially indiscernable:

- SRV water clearing spike
- SRV discharge line maximum pressure
- SRV air cleaning transient and subsequent coalescence into large air bubbles
- SRV peak-to-peak pressure amplitudes due to bubble oscillation, and
- SRV quencher condensation oscillation pressure amplitudes and frequency content.

An accoustic model of the suppression pool was used to evaluate possible increases in the normalized pool boundary loads due to actuation of the SRV located under the encroachment. The input bubble pressure was a five hertz sine wave of unit amplitude. The acoustic model was shown to predict SRV quencher attenuations using Caorso test data. Figure 1 shows a comparison of the attenuation predicted by the acoustic model and the attenuation measured in the Caorso tests. Figure 2 shows that the expected attenuations for the GGNS suppression pool for the clean and encroached pool cases are bounded by the load definition everywhere except high on the drywell wall. This increase over the load definition, however, is bounded by the pool swell load definition.

MP&L concludes that existing load definitions adequately bound all possible increases in SRV loads due to any pool encroachments.

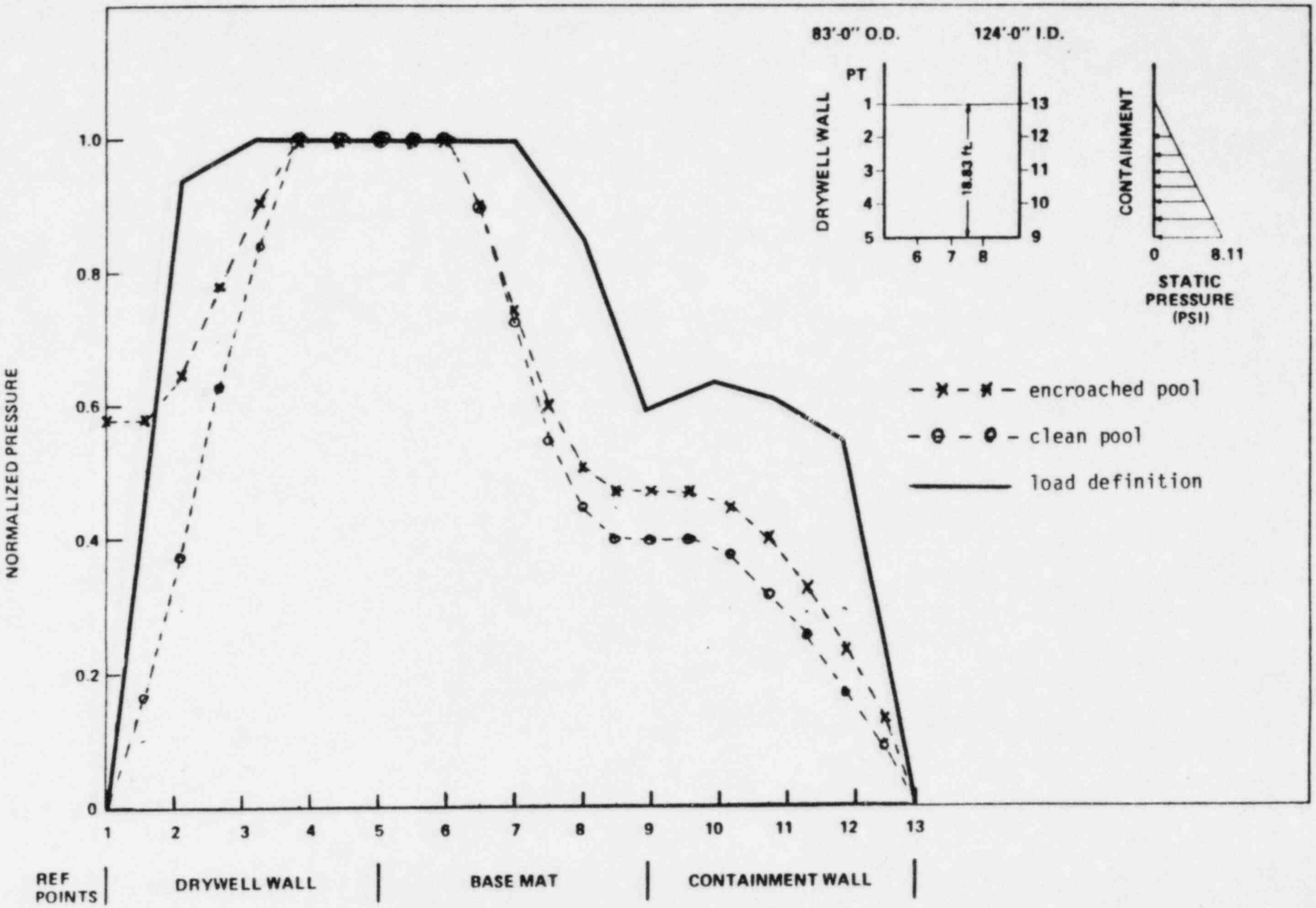


Figure 1 Grand Gulf-Single S/R Valve Normalized Walls - Floor Pressure at 0^{o}

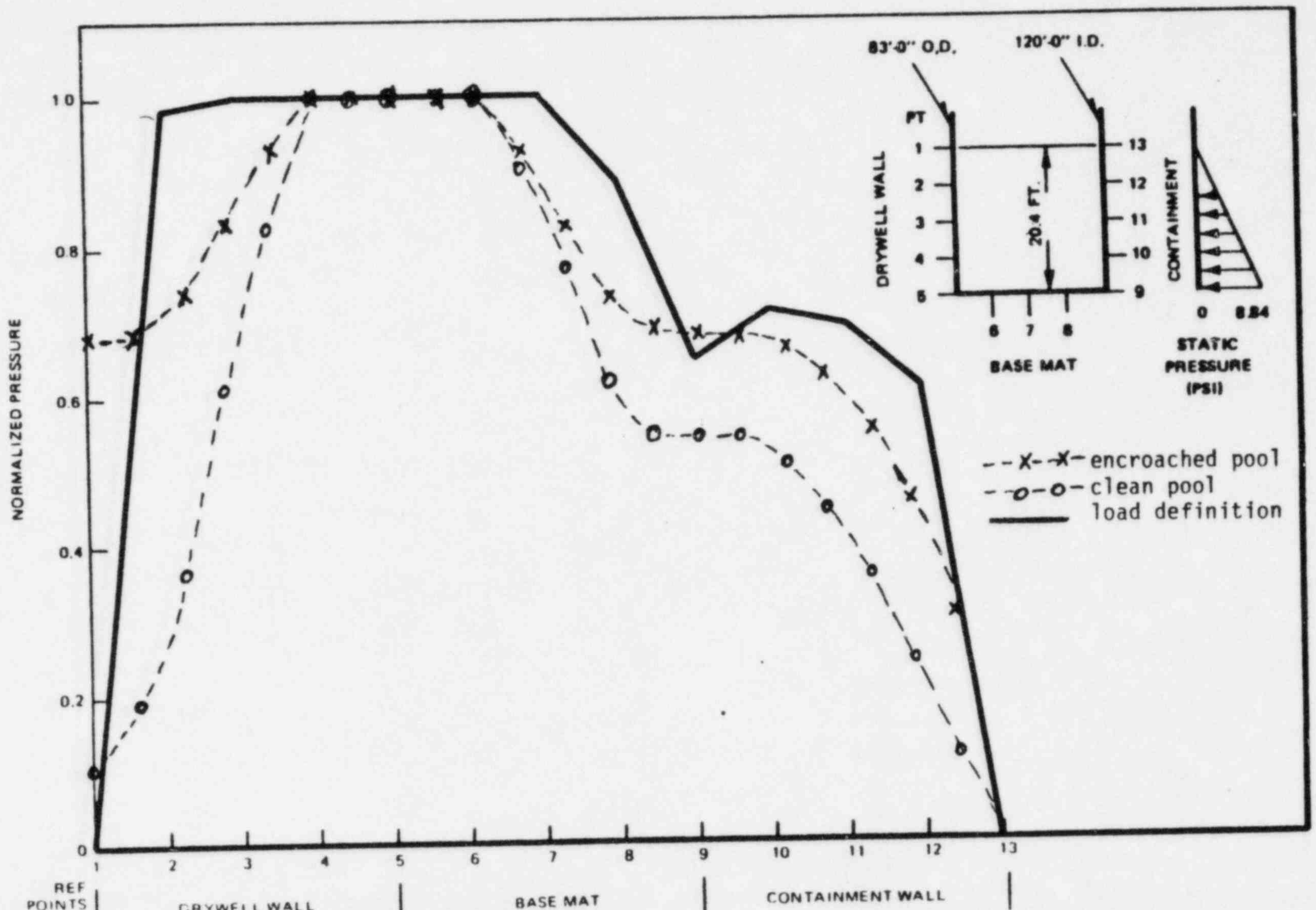


Figure 2. Mark III 238-732 Standard Plant One S/R Valve Normalized Wall Pressure at 4.5° compared with Bounding Mark III Encroachment Configuration Normalized Wall Pressure.

ACTION PLAN 25

I. ISSUES ADDRESSED

8.1 This issue is based on consideration that some technical specifications allow operation at parameter values that differ from the values used in assumptions for FSAR transient analyses. Normally analyses are done assuming a nominal containment pressure equal to ambient (0 psig) a temperature near maximum operating (90°F) and do not limit the drywell pressure equal to the containment pressure. The technical specifications permit operation under conditions such as a positive containment pressure (1.5 psig), temperatures less than maximum (60 or 70°F) and drywell pressure can be negative with respect to the containment (-0.5 psid). All of these differences would not result in transient response different than the FSAR descriptions.

II. PROGRAM FOR RESOLUTION

MP&L will complete an end-point analysis to demonstrate that with all initial containment parameters at worst case values, the containment design pressure is still not significantly exceeded.

III. RESPONSE

MP&L submitted a sensitivity study (see Reference 1) involving drywell and containment initial conditions which affect Design Basis Accident (DBA) long-term containment response. That study basically drew on end-point calculations to establish sensitivity trends governing DBA peak containment pressure. The study concluded that even under conservative (adverse) drywell and containment initial conditions, peak containment pressures would not exceed design (15 psig).

The response provided by MP&L in Reference 1 also discussed at length the non-realistic nature of end-point analyses. As two examples:

1) Such end-point analyses neglect the DBA pressure-reducing action of the safety-grade redundant containment spray trains.
2) They also neglect the inherent energy-absorbing (pressure-reducing) action of the containment and drywell heat sinks -- energy sinks that become significant over the (typically) 4.0-5.0 hours post-LOCA when peak DBA pressure is reached.

A more realistic analysis, reported under Item 3 of Action Plan 25 in Reference 1, evaluated the conservatisms collectively associated with such end-point calculations. To recap the response, FSAR licensing basis assumptions were used in GE's latest proprietary long-term containment response code, SHEX, to establish a reference DBA containment response transient. Then a re-run was made with the conservative (adverse) initial conditions mentioned above in the first paragraph, and with realistic accounting for containment and drywell heat sinks and (non-equilibrium) containment airspace temperatures that result from the counter-effects of pool surface evaporation and heat transfer, and heat transfer from airspace to heat sink. This comparison showed that the resulting "more realistic" peak containment airspace pressure, relative to the "FSAR reference" case, is lower by 4.3 psi.

The Containment Issues owners Group (CIOG) has continued to evaluate varying combinations of conservative initial containment and drywell conditions. The CIOG has expanded the range of initial drywell pressures evaluated up to an initial drywell pressure of 2.0 psig, which corresponds to the drywell pressure that initiates reactor scram and generates a LOCA signal. These studies computed the peak containment pressure under hypothetical conditions where containment design temperatures of 185°F, and 100% RH, are attained in the containment airspace. The entire drywell air mass is assumed to be transferred to the containment with no redistribution to the drywell. The resulting sensitivity trend to varying initial drywell pressure, under "worst-case" initial conditions for all other parameters, is given in Figure 25-1 for initial drywell temperatures of 105°F and 135°F.

These results are excessively conservative with respect to GGNS. As noted in reference 1, the actual calculated peak long term post accident containment temperature is 180°F assuming that thermal equilibrium exists between the suppression pool and the containment air space. This is lower than the end point temperature used in the CIOG sensitivity study. In addition, the CIOG analyses include the vapor pressure of water at 185°F which is also higher than the vapor pressure which would be predicted at GGNS using the conservative licensing basis assumptions.

These results show that under excessively conservative, non-realistic assumptions and a methodology which neglects mitigating engineered safety features (sprays) and which also neglect operator mitigating actions (EPG procedures), it is possible to compute end-point states for the containment airspace which exceed the containment design pressure. The CIOG does not believe that such end-point calculation results are appropriate for assessing the adequacy of containment design. The CIOG feels that no purpose is served in pursuing further end-point computations of this nature and, accordingly, no further analysis on this issue is planned.

Reference

1. AECM-82/574, Item 2 of Action Plan 25.

FIGURE 1

SENSITIVITY OF CONTAINMENT PRESSURE TO DRYWELL INITIAL CONDITIONS