Illinois Power Company

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U-0644
P23-83(06-17)-L

Docket No. 50-461

June 17, 1983

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

Dear Mr. Schwencer:

Subject: Clinton Power Station Unit 1
Humphrey Concerns

Reference: IP letter U-0615 dated 3/17/83, G. E. Wuller to A. Schwencer, NRC, subject: Submittal addressing some John Humphrey concerns.

The referenced letter addressed some of the John Humphrey concerns as applicable to the Clinton Power Station (CPS). Enclosed are CPS responses on some additional Humphrey issues for NRC Staff review. Included are Action Plans #1, 2, 3, 4 and 33. We believe that these responses will resolve the particular concern involved.

Please let us hear from you soon if you have any questions on this material.

Sincerely,

G. E. Wuller

G. E. Wuller
Supervisor-Licensing
Nuclear Station Engineering

GEW/lt

enclosure

cc: Dr. H. Abelson, NRC Clinton Licensing Project Manager
Mr. M. B. Fields, NRC CSB
Mr. H. H. Livermore, NRC Resident Inspector
Illinois Department of Nuclear Safety
R. W. Evans, Enercon Services

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Action Plan 1

Issues Addressed

1.1 Presence of local encroachments such as the TIP platform, the drywell personnel airlock and the equipment and floor drain sumps may increase the pool swell velocity by as much as 20 percent.

1.2 Local encroachments in the pool may cause the bubble break through height to be higher than expected.

1.4 Piping impact loads may be revised as a result of the higher pool swell velocity.

Program For Resolution

1. Provide details of the one-dimensional analysis which was completed and showed a 20% increase in pool velocity.

2. The two-dimensional model will be refined by addition of a bubble pressure model and used to show that pool swell velocity decreases near local encroachments. The code is a version of SOLA.

3. The inherent conservatisms in the code and modeling assumptions will be listed.

4. The modified code will be benchmarked against existing clean pool PSTF data.

5. A recognized authority on hydrodynamic phenomena will be retained to provide guidance on conduct of the analyses. This consultant will review the merits of performing these analyses with the modified version of the SOLA code.

6. The effects of the presence of local encroachments on pool swell will be calculated with the two dimensional code. Three-dimensional effects (such as bubble break through in non-encroached pool regions) will be included based upon empirical data.

Response

Items 1-5 are generic questions that have been previously addressed by Grand Gulf (see referenced letters below) however, item 6 is a plant specific analysis.

Items 1-3

Results were submitted in a letter from L. F. Dale, MP&L, to H. R. Denton, NRC, reference #AECM-82/353, dated August 19, 1982. Additional information for Item 3 was provided in a letter from L. F. Dale, MP&L, to H. R. Denton, NRC, reference #AECM-82/497, dated October 22, 1982.

Item 4

Results were submitted in a letter from L. F. Dale, MP&L, to H. R. Denton, NRC, reference #AECM-82/497, dated October 22, 1982.

Item 5

Results were submitted in a letter from L. F. Dale, MP&L, to H. R. Denton, NRC, reference #AECM-82/574, dated December 3, 1982.

Item 6

The modified SOLAV01 computer code was used to determine the effect of the Clinton encroachments on the pool swell transient. The Clinton suppression pool geometry is shown in Figure 1. The most severe encroachment size from a pool swell standpoint is the smallest encroachment where breakthrough does not occur. Pool swell loadings are proportional to the impact velocity and density; pool velocities increase as the encroachment size decreases. However, if breakthrough occurs, the impact density decreases which reduces the resultant loading. The circumferential extent of the encroachment also has an effect on the pool swell transient. The worst case would be at the circumferential midpoint of the encroached circumferential length. This is because the bubble pressure is increased due to the encroachment until the time that coalescence and pressure relief with the adjacent bubbles occur. The following cases were evaluated with these factors in mind. The sump platform, an 8.5 foot encroachment, was evaluated with FSAR assumptions at the location shown in Figure 1 as case A. Breakthrough did not occur in this case, but the resultant loading was not very severe. The equipment hatch, a 5.5 foot encroachment, was evaluated at the location shown in Figure 1 as case B. Breakthrough did not occur early enough to avoid impact on the HCU floor. This 5.5 foot encroachment case is the most severe case due to the larger velocities in the pool relative to the 8.5 foot encroachment. The details of the 5.5 foot encroachment case follow.

To determine the encroachment effect, it was first necessary to develop a reference clean pool base case. In an effort to reduce some of the conservative aspects of the SOLA code to make it more realistic, a "best estimate" drywell pressure history was used. This was done by running the containment response analytic model (References 1, 2) for the Clinton pool geometry and initial conditions to determine the drywell and wetwell pressure time histories. Standard FSAR assumptions were made for the determination of these time histories with the exception of changes in the blowdown model and conditions, the drywell homogenization time, and the wetwell-airspace model. These changes enable the containment analytical model to do a better job in predicting PSTF drywell pressure test data (Reference 3). These pressure histories were input into the modified SOLAVO1 code and the bubble pressure histories were determined for a no encroachment case. The encroachments have no effect on the clean portion of the pool until coalescence occurs circumferentially. The assumption is made that the bubble expands circumferentially and radially at the same rate. Using this criterion, bubbles come together approximately 0.24 seconds after vent clearing, or about 1.2 seconds into the transient. Since the bubble pressures under the various encroachments are larger than the no encroachment bubble pressures, the clean pool bubble pressures would be expected to increase at coalescence. The new equilibrium bubble pressure was taken to be the bubble pressure under a theoretical 360° average encroachment on the inner wall of the suppression pool such that the total surface area of the encroachments are conserved.

Thus, the Clinton clean pool case bubble pressure time history was determined by using the no encroachment bubble pressure history until the time that the bubbles coalesce and the average encroachment bubble pressure history after the coalescence time. Figure 2 shows the input bubble pressure history for the Clinton clean pool case which was derived from the concatenation of the no encroachment and average encroachment cases. Figure 3 shows how the bubble and pool surfaces grow for the resultant clean pool case. The predicted breakthrough elevation is 14.8 feet above the initial pool surface. The velocity of the pool surface at the point of breakthrough is 46 ft/sec.

To determine the effect of the encroachments, the "best-estimate" drywell and wetwell pressure histories were input into the modified SOLAVO1 code with the equipment hatch modeled. Since SOLA is a 2-D code, the implicit assumption is that the encroachment covers a 360° arc and the bubble pressure remains unrealistically high.

This case was used to determine when the bubbles coalesce circumferentially. As before, the assumption is made that the bubble expands circumferentially and radially at the same rate. Using this criterion, adjacent bubbles would be expected to come together approximately 0.21 seconds after vent clearing, or about 1.2 seconds into the transient. The encroached bubble pressure was then ramped down to the clean pool bubble pressure in the time it takes for the acoustic wave to make two round trips between the encroached bubble and free bubble (t = 0.095 sec.). After 1.295 seconds, the clean-case bubble pressure was used to drive the water slug. The bubble pressure history calculated assuming a 360° encroachment is shown in Figure 4. The bubble pressure used in the Clinton encroached case is shown in Figure 5.

The results of the Clinton encroached pool simulation are presented in Figure 6. The peak pool surface velocity is 28 ft/sec, only 61% of the clean pool velocity. Taking credit for a 20% condensation effect, based on PSTF data, would indicate a maximum encroached pool velocity of around 22 ft/sec. Impact of the water slug on the HCU floor I-beam occurred over the outer 2.5 feet at a peak velocity of 10 ft/sec. This liquid impact load is still less than the design values. Comparing the impulse for the encroached and design cases:

$$\frac{I_{encroached}}{I_{design}} \quad \frac{\rho_e V_e}{\rho_D V_D} = \frac{(62.4 \ \frac{lbm}{ft^3}) \quad (10 \ \frac{ft}{sec})}{(17.4 \ \frac{lbm}{ft^2}) \quad (50 \ \frac{ft}{sec})} = 0.72$$

In conclusion, local encroachments such as the Clinton equipment hatch reduce the pool swell velocity which reduces all small structure impact loads. Additionally, the loading on the HCU floor in the vicinity of an encroachment will be less than the HCU floor design loading.

References

1. Bilanin, W. J., "The General Electric Mark III Pressure Suppression Containment System Analytical Model", NEDO-20533, June 1974.

2. Bilanin, W. J. et al, "The General Electric Mark III Pressure Suppression Containment System Analytical Model (Supplement 1)", NEDO-20533, September, 1975.

3. GESSAR II, Appendix 3B, Attachment O Question/Response 3B.3, 22A7000, Rev. 2, June 1981.

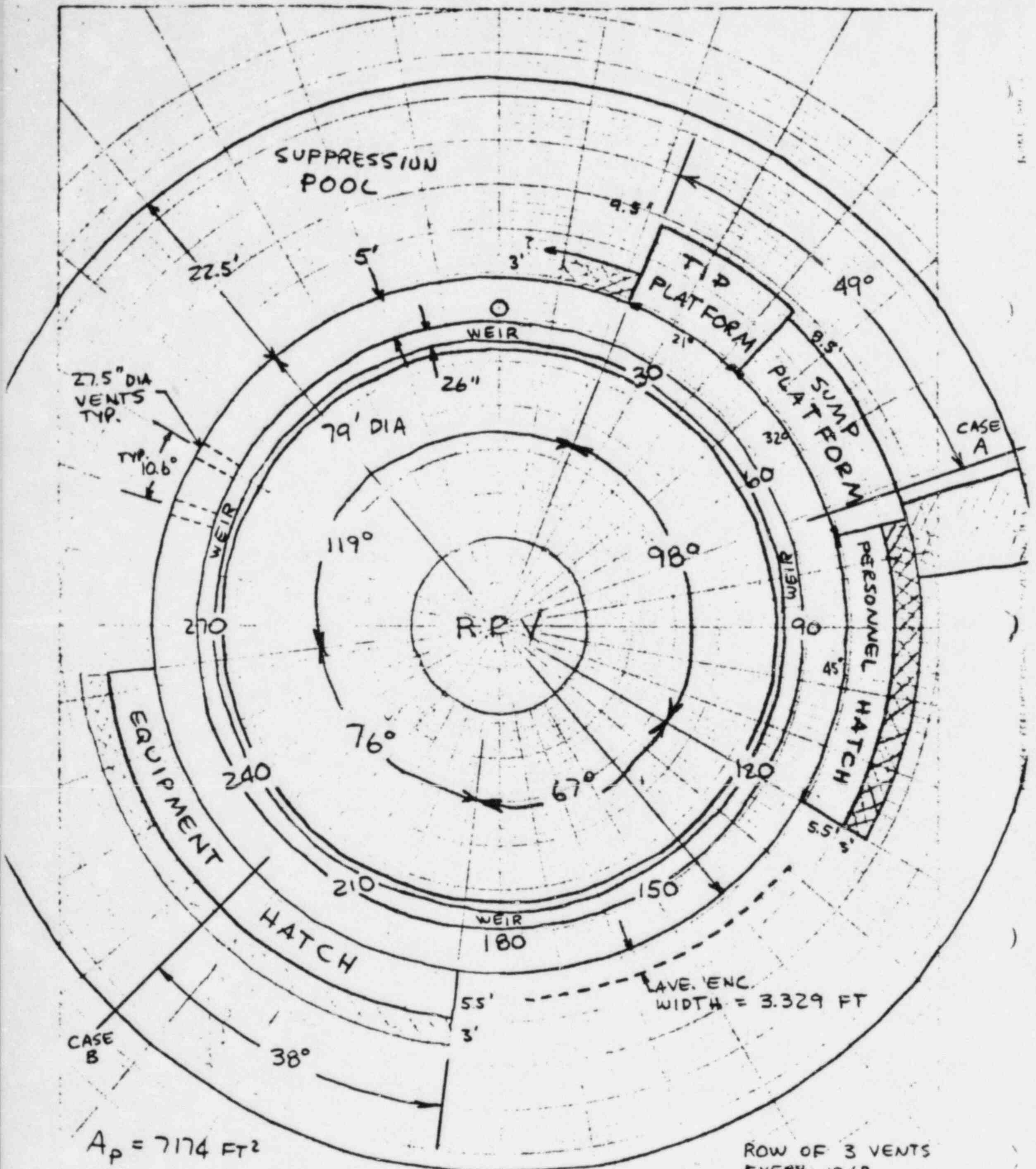

FIGURE 1 CLINTON SUPPRESSION POOL GEOMETRY

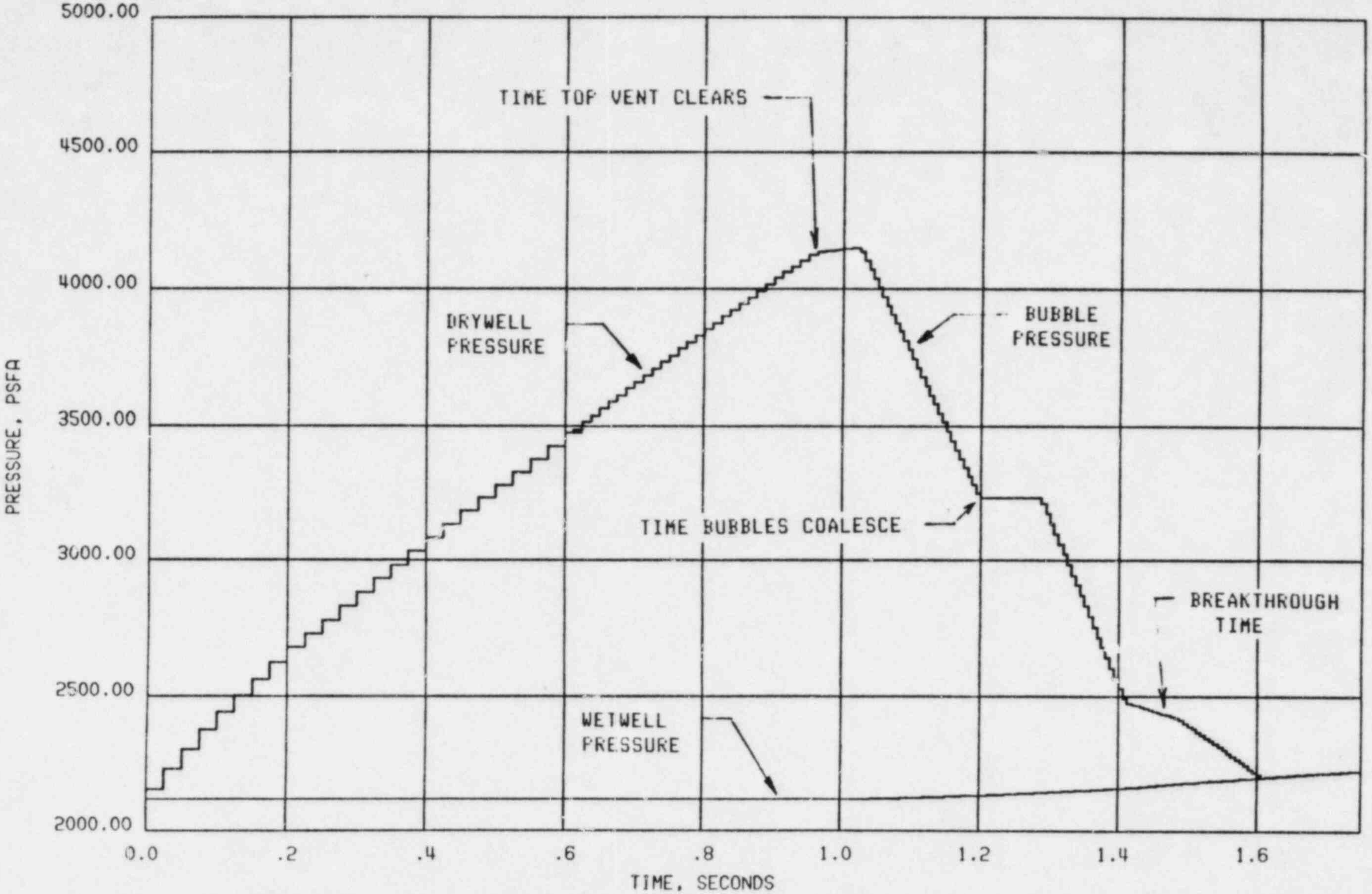

FIGURE 2 PRESSURE HISTORIES, CLINTON CLEAN POOL CASE, WITH BEST ESTIMATE PRESSURES

SOLAVOI MESH FOR CLINTON

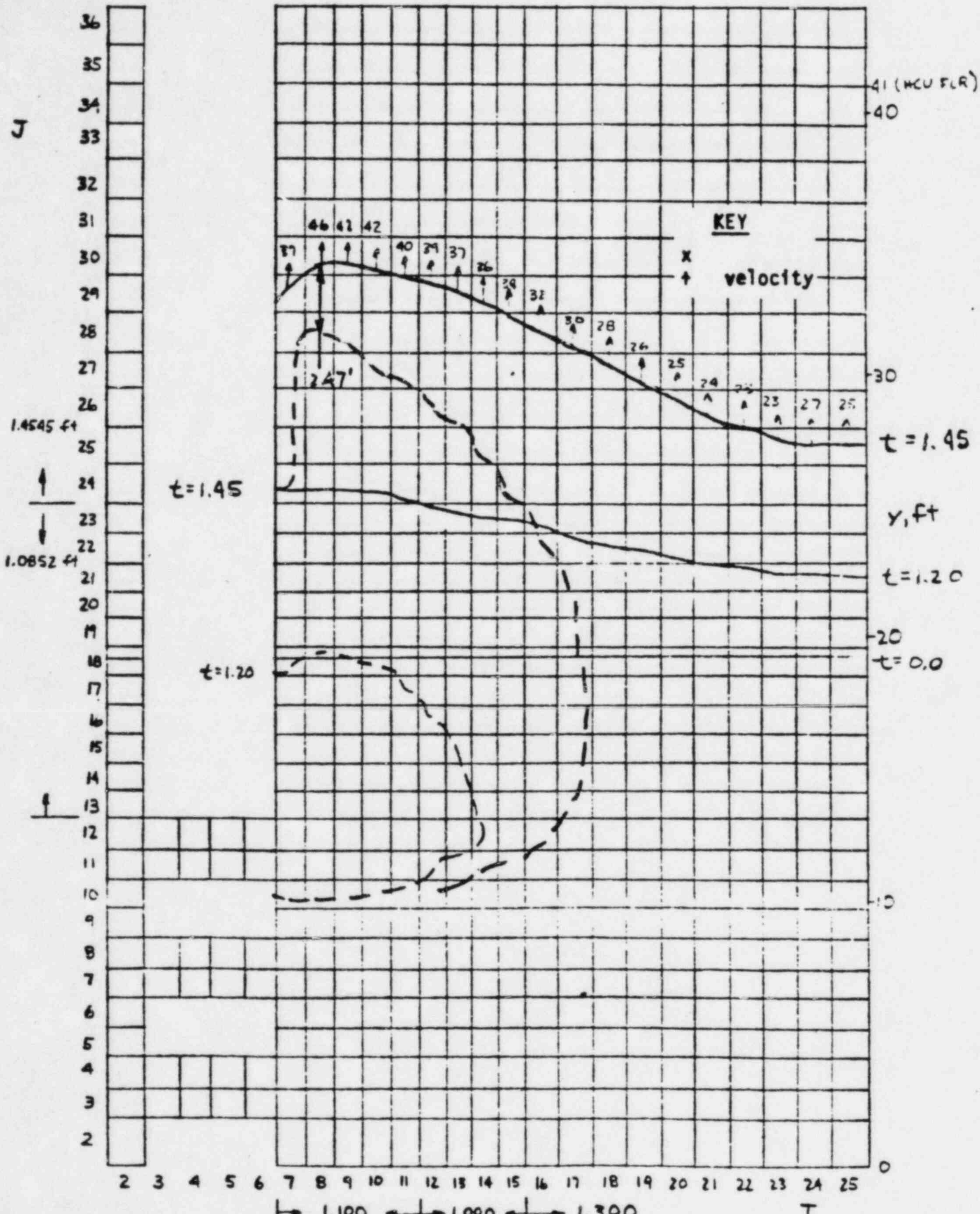

FIGURE 3 CLINTON CLEAN POOL SIMULATION WITH BEST ESTIMATE PRESSURES

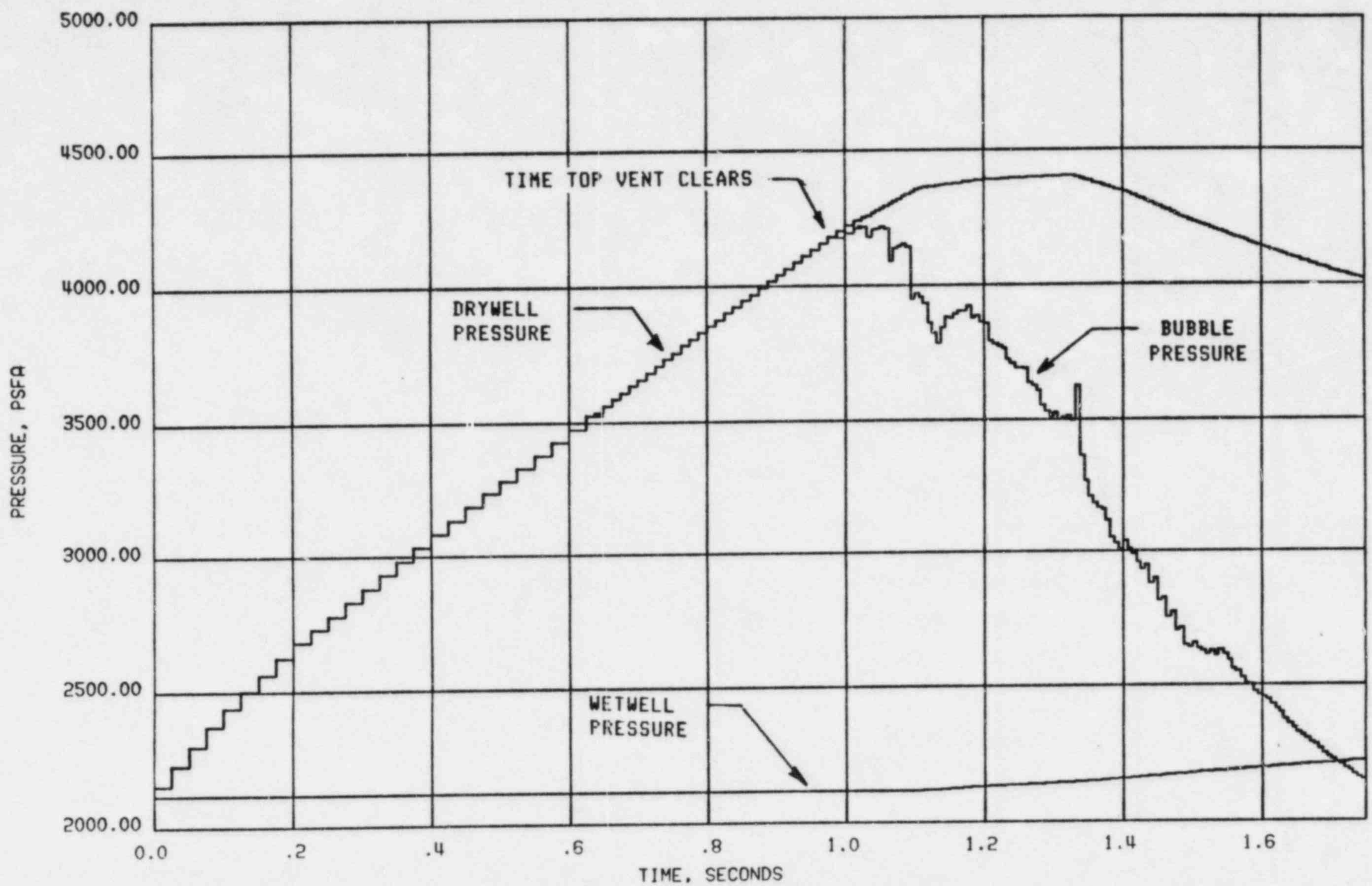

FIGURE 4 PRESSURES HISTORIES, CLINTON 360° ENCROACHED CASE (5.5 FT.), WITH BEST ESTIMATE PRESSURES

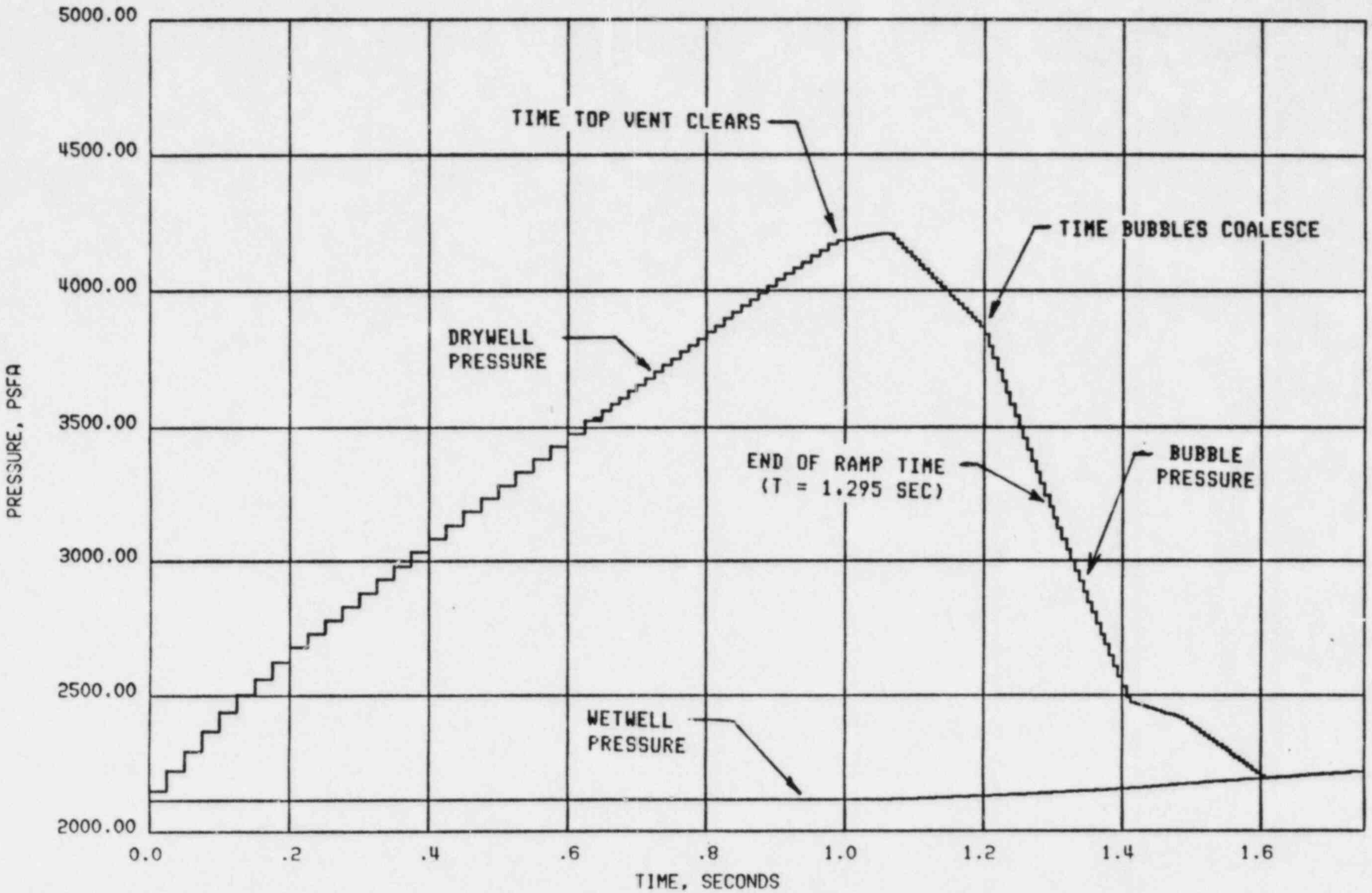

FIGURE 5 CLINTON ACTUAL ENCROACHED CASE, EQUIPMENT HATCH, WITH BEST ESTIMATE PRESSURES

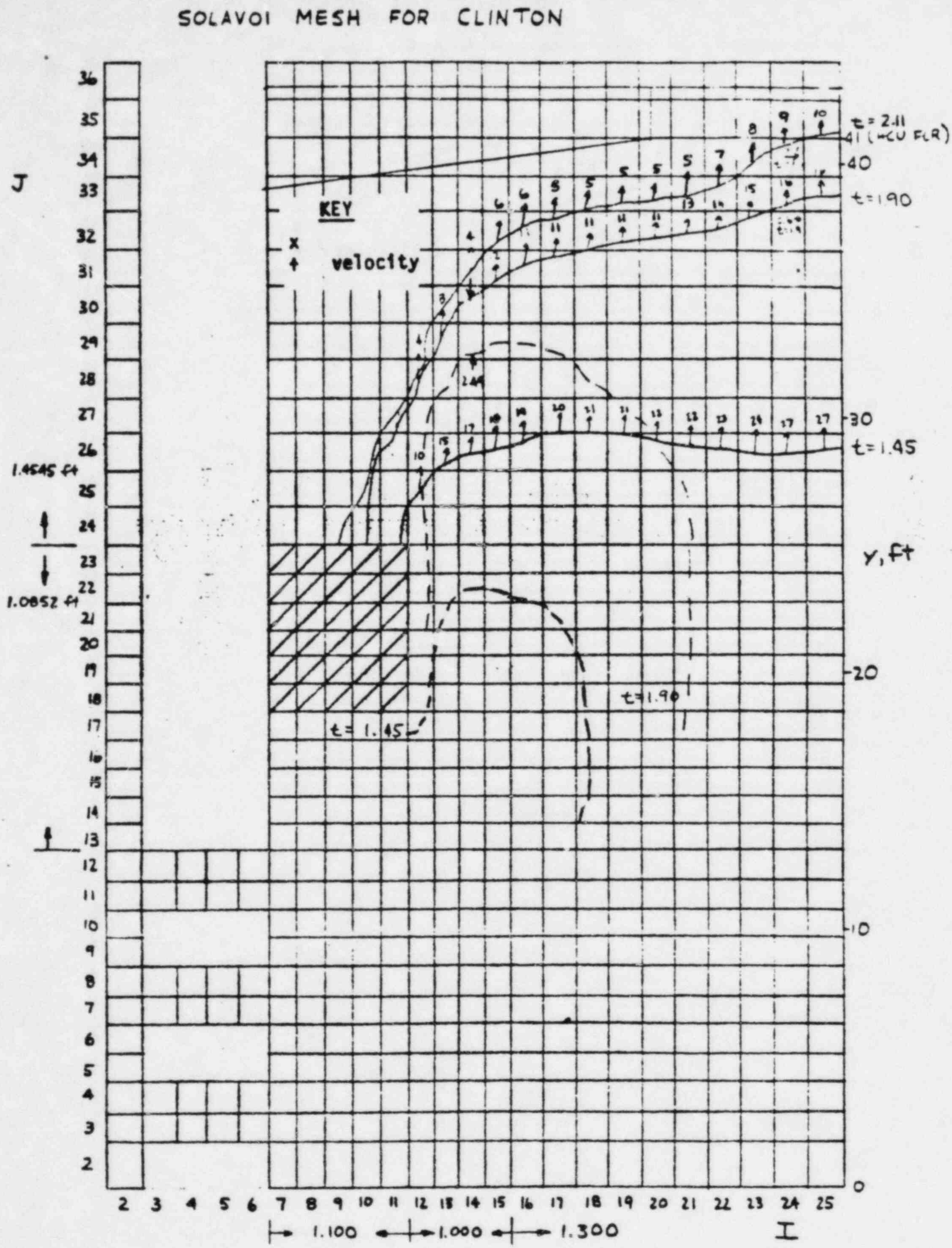

FIGURE 6 CLINTON ENCROACHED POOL SIMULATION, EQUIPMENT HATCH, WITH BEST ESTIMATE PRESSURES

Action Plan 2

Issues Addressed

1.3 Additional submerged structure loads may be applied to submerged structures near local encroachments.

Program for Resolution

1. The results obtained from the two-dimensional analyses completed as part of the activities for Action Plan 1 will be used to define changes in fluid velocities in the suppression pool which are created by local encroachments. Supporting arguments to verify that the results from two-dimensional analyses will be bounding with respect to velocity changes in the suppression pool will be provided.

Response

Pool Swell Boundary Loads

The present load definition specifies the pool swell boundary load on the drywell wall to be the peak drywell pressure. Even with encroachments, this limit will not be affected. There is a concern that the encroachment will increase the bubble pressure and cause the bubble to be translated closer to the containment wall. The pool boundary loading on the containment wall will increase. Pressure on the containment wall is a direct output of the SOLA code. The pool boundary load definition on the containment wall is based on PSTF full scale test data that has been correlated with SOLA output. The maximum containment wall pressure is 88% of the design value. Thus, encroachments do not affect the boundary design loads.

Action Plan 3

1.5 Impact loads on the HCU floor may be imparted and the HCU modules may fail which could prevent successful scram if the bubble breakthrough height is raised appreciably by local encroachments.

Response

Although breakthrough height is a function of local encroachment, the velocity magnitude and profiles are altered to the extent that loads developed on the HCU floor are well within design limits.

Action Plan 4

1.6 Local encroachments on the steam tunnel may cause the pool swell froth to move horizontally and apply lateral loads to the gratings around the HCU floor.

Response

4.1 An assessment will be made of the potential effects which variations in HCU floor support arrangement and grating location may produce. This assessment will result in the selection of a bounding arrangement for defining lateral loads.

4.1A A bounding analysis for determining the horizontal liquid and air flows created by the presence of the steam tunnel and HCU floor will be performed. The forces imposed on the HCU floor supports and gratings will be calculated from this information.

4.2 It will be demonstrated that the affected structures can withstand the lateral loads.

For items 4.1 and 4.1A above, a Clinton-specific analysis was performed by General Electric as follows:

A bounding, steady, potential flow analysis was performed to determine the free jet flow field passing through the HCU floor. This analysis assumed all the rising fluid passed through the HCU floor open area (i.e., no separation of liquid droplets following impact on the solid portion of the HCU floor) and the velocities of the liquid and gas phases are equal.

Due to the configuration of the Clinton HCU floor, radial and circumferentially directed horizontal flows are possible. The potential flow model was applied conservatively, first assuming that all flow was radially directed and subsequently assuming that all flow was circumferentially directed.

The potential flow model was then driven with the same conditions as used for the calculation of a BWR6 HCU floor differential pressure model. This model is documented in Reference 1 and assumes the pool swell froth mixture impacts on the HCU floor, stagnates, and then is reaccelerated due to wetwell pressurization.

The analysis concluded that horizontal loads on the HCU floor are small. For beams the horizontal force is a maximum of 0.48 psid. For grating the horizontal force is a maximum of 0.26 psid.

These loads should be applied to all grating and beams in the HCU floor whether circumferentially or radially directed. Due to the complexity of the HCU floor configuration, attenuation of the maximum beam forces with distance from the concrete sections is not recommended.

The analysis which yields these results is felt to be very conservative, due to the assumptions of steady flow, equal phase velocities, and stagnation of liquid droplets upon impact with solid portions of the HCU floor. In reality, the flow is highly transient. Most of the rising two-phase mixture is expected to impact the solid floor, stagnate, and fall back to the pool surface. Hence, the flow which actually passes through the HCU floor will have total momentum substantially less than determined with this analysis. The calculated loads are thus expected to be bounding and very conservative.

Reference

1. Bilanin, W. J. "Mark III Containment Analytical Model", NEDO-20533, Supplement 1, June 1974.

To address item 4.2:

An assessment has been completed using the suppression pool swell froth lateral pressure loads furnished by General Electric Company under Action Plan Item 4.1. This assessment covered structural steel framing and floor grating at Elevation 755' outside of the drywell in the containment building.

It is concluded that the floor framing and grading are wall within design limits after applying the postulated loads.

Action Plan 33

Issues Addressed

16.0 Some of the suppression pool temperature sensors are located (by GE recommendation) 3" to 12" below the pool surface to provide early warning of high pool temperature. However, if the suppression pool is drawn down below the level of the temperature sensors, the operator could be misled by erroneous readings and required safety action could be delayed.

Program for Resolution

33.1 The emergency procedures will be written to require the operator to verify level in the suppression pool before reading suppression pool temperature (or to specify which suppression pool temperature instruments can be used) following an accident.

Based on the above action, this issue is closed for Clinton Power Station.