APPENDIX A-1
RESPONSES TO NRC QUESTIONS

R2

2356 246

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NRC QUESTIONS DATED JUNE 12, 1976, WITH RESPONSES

Series 020: Containment Systems Branch

Series 030: Structural Engineering Branch

Number Question	Keyword Index to Questions	Response Date	
M020.1	Condensation Oscillations	12/76	A1
M020.2	Single Downcomer Horizontal Condensation Loads	9/76	R2
M020.3	Multiple Downcomer Horizontal Condensation Loads	9/76	
M020.4	Downcomer Horizontal Condensation Load Time History	12/76	A1
M020.5	Pool Swell Surface Velocity	9/76	
M020.6	4T Test Parameter Matrix	9/76	
M020.7	4T Test	12/76	A1
	1. Scaling		
	2. Data Application		
	3. Error Analysis		
	4. Geometry		
	5. Multiple Vent Data		
M020.8	Pool Swell Waves	*6/78*	R3
M020.9	Load Mitigation in Pool	9/76	
M020.10	Plant Specific Application of Pool Swell Model	9/76	
M020.11	Discrepancy in Figure 4.4-18 *(R2:4-28)* Identification	9/76	
M020.12	Fluid Velocity for Drag Loads	12/76	A1
M020.13	Bubble Pressure	*6/78*	R3
	1. Differential Across Equipment		
	2. Calculated Versus Test		
M020.14	Fallback Loads	9/76	
M020.15	Impact Load Design Margins	9/76	

2356 247

NRC QUESTIONS DATED JUNE 12, 1976, WITH RESPONSES

Number Question	Keyword Index to Questions	Response Date	
M020.16	Estimated Pool Swell Parameter Correlations	9/76	R2
M020.17	Table of Loads	9/76	
M020.18	Load Combination Time-Histories 1. Vent Clearing 2. Pool Swell 3. Condensation Loads 4. Drag and Fallback	9/76	
M020.19	Quencher Data Multiple Regression Analysis	9/76	
M020.20	Quencher Data Base	9/76	
M020.21	Quencher Design Loads	9/76	
M020.22	Large Break with SRV Actuation	9/76	
M020.23	Asymmetric Loads	6/78	R3
M020.24	4T Test Data	12/76	
M020.25	Air Tests	12/76	A
M020.26	Primary and Secondary Loads	12/76	
M130.1	SRV Loads	9/76	
M130.2	Load Combination Time History	9/76	
M130.3	Load Combination Probabilities	12/76	A1
M130.4	Soil Modeling	9/76	
M130.5	Liner and Anchoring	9/76	
M130.6	Asymmetric SRV Loads	9/76	
M130.7	Combining SRV and Pool Loads	9/76	

Reference Source: Letter with enclosure, "Request for Additional Information, Mark II Containment Dynamic Forcing Functions Information Report (DFFR)," TO E.A. Borgmann, Cincinnati Gas and Electric Company from J.F. Stolz, NRC, dated June 12, 1976.

2356 248

Margin Notation:
R2 - DFFR Revision 2, 9/76
A1 - DFFR Amendment 1, 12/76
R3 - DFFR Revision 3, 6/78

QUESTION M020.1

Clarify the statement that no load should be applied to the containment walls due to condensation oscillations. Figure 5-7 indicates that condensation oscillations should be applied to the submerged wetwell and Section 6.1.9 of NEDO-11314-08 identifies the condensation oscillation loading that should be applied to the pool boundary as determined from the PSTF tests. R2

RESPONSE

The suppression pool wall pressure data from Phases I, II and III of the
4T program has been reduced and is described in detail in the report,
"Mark II Pressure Suppression Test Program - Phase II and III Tests," A1
NEDE-13468P, submitted to the NRC on January 4, 1977. Application of
this information is described in the memorandum, *"Mark II Pressure*
Suppression Test Program - Phases I, II and III of the *4T Tests,"*
(NEDE23678P), dated *January 1977,* and submitted to the NRC on R3
February 24, 1977. *This information was incorporated into Subsection 4.3 of the DFFR, Revision 3.*

QUESTION M020.2

Discuss the manner by which the mean and maximum horizontal condensation loads should be applied to a single downcomer.

RESPONSE

Downcomer loads are discussed in DFFR Subsection 4.*4* and Table 5-1. R3
The static equivalent load applied to a single downcomer is 8800 pounds based on the maximum observed test load. No mean value is considered.

2356 249

QUESTION M020.3

Discuss the criteria that are used in the multiple loading of the downcomers due to horizontal condensation loads. Specifically, identify what fraction of the downcomers experience a load acting in the same direction and identify and justify the load to be used.

RESPONSE

Multiple loading of the downcomers is discussed in Subsection 4.4.2.4 R3
of the report. In this section, a methodology is described, based on the application of a probabilistic analysis, for determining what fraction of the downcomers experience the application of in-phase loads. *(Also see* R3
question M020.67a and c.)

QUESTION M020.4

It is not obvious how the downcomer horizontal condensation loads, loading time interval, and load period were obtained from the test data presented in NEDE-21078P. Provide specific references and a discussion R2
of how the foregoing parameters were obtained, including any statistical analysis techniques that were used.

RESPONSE

The horizontal loads presented in NEDE-21078 were determined from test data collected from the test facility described in Section 3.2 of the report. Prior to the tests, strain gauges (SGs) and linear displacement transducers (LDTs) which were used for defining vent loads were A1
calibrated by applying known static loads to the 24-in. vent. Based on this static calibration of the SGs and LTDs, test readings from these instruments could be converted directly into static equivalent loads on the vent. These loads are summarized in Section 3 of the report.

As discussed in Subsection 4.*4*.2.3 of the *DFFR*, the maximum load observed during the whole test series was specified as the design load for Mark II vents. This maximum observed load was 8800 lb (static equivalent) and occurred during test number 4. No statistical techniques were involved in the definition of this single vent design load specification.

The loading time interval presented in NEDE-21078 is that a significant vent lateral load will occur approximately once every second. This specification was based on a review of all the recorded test data.

A review of the data summary given in Table 3-6 of NEDE-21078 shows a load frequency slightly less than one per second; however, the complete data base indicates that a one second loading period is more appropriate. The 50 m second loading period specified in *the DFFR* was based on judgement because no direct reading of loading duration was made during the tests.

The loading specification for multiple vents is based on a statistical technique that uses the observed loading probability distribution. This subject is discussed in Subsection 4.*4*.2.4 of *the DFFR*. The 4T test program has provided significant additional insight on the characteristics of the downcomer loads that occur during steam condensation. The true forcing function appears to consist of a short duration, high magnitude impulsive loading, having static equivalent values significantly less than the 8800 lb (static equivalent) specified for Mark II design assessment. The 4T results are discussed in *NEDO*/NEDE-13442P and *NEDO*/NEDE-13468P. *(Also see question M020.67a and c.)*

QUESTION M020.5

The pool swell model discussed in Section 4.4.1 *(R3:4.2.1)* of the DFFR has been used to calculate the water surface velocity associated with the impact pressures presented in Figures 4.4-24 through 4.4-26 *(R3:4-41** *through 4-43*).* Discuss the adequacy of the model to conservatively predict the velocity of the pool surface considering the assumptions that the entire mass of water associated with the vent submergence must be accelerated by the bubble pressure. R2

RESPONSE

R3

The pool swell model described in Subsection 4.2.1 of this report will give water surface velocities that are conservative provided no credit is taken for any loss of energy from the dry well air. Several assumptions used in the model lend to the credibility of this assertion. These are discussed as follows:

1. Following vent clearing, only air flows into the suppression pool rather than a mixture of air and steam. This maximizes the mass flowrate of the noncondensibles and, hence, the resultant pool swell will be maximum.
2. The mass flowrate of air through the vent is calculated based on adiabatic flow with friction. This will tend to maximize the air bubble pressure and hence the pool swell velocity.
3. The air in the drywell is isentropically compressed. This maximizes the peak drywell pressure.
4. Frictional losses between the water and the confining walls are negligible. This will also lead to higher pool surface velocity.

The net effect of these assumptions is to maximize the water surface velocity calculated by the pool swell model. *(Also see question M020.71 and M020.73.)* R3

2356 252

QUESTION M020.6

Provide the matrix of the 4T tests that will provide data relative to the Mark II design. Identify the key pool swell parameters that were obtained from the test data. Identify the range of independent variables that were covered by the test program. R2

RESPONSE

This information is provided in NEDO-21297, "Mark II Supporting Program Report," May 1976, submitted to the NRC on June 9, 1976, NEDO/NEDE-13442P-01, "Mark II Pressure Suppression Test Program," May 1976, submitted to the NRC on May 28, 1976, *and NEDO/NEDE-13468P, December 1976, submitted to the NRC on January 4, 1977.* R3

QUESTION M020.7

Provide the following additional information related to the "4T" tests:

1. Provide a detailed scaling analysis for those parameters that will not be full scale in the tests. Specify the portions of the pool dynamics transient in which the scaling analysis is applicable.

RESPONSE

As discussed in Section 3.3 of the report, "Mark II - Pressure Suppression Test Program - Phase I Tests," *NEDO*/NEDE-13442P-01, the 4T facility was designed to be a real time simulation of a single full scale segment of a typical Mark II pressure suppression containment system. Specifically, the entire pool dynamics transient from bubble initiation through bubble collapse is representative of the pool swell conditions that will occur in an actual Mark II containment. Consequently, no pool swell scaling analyses are necessary. R3 A1

2356 253

The only pool swell phenomenon present in the test facility which would not be duplicated in a Mark II containment is the frictional interaction between the suppression pool water and the wall of the 4T tank. However, typical Reynolds Numbers are on the order of 1×10^7, (tank diameter 7 ft, typical swell velocities 20 ft/sec, and water viscosity 300 lb ft sec^{-2}), and the pool swell transient conditions in the 4T tank are controlled exclusively by water inertia considerations and are not influenced by viscous drag on the tank wall. This is supported by a comparison of the magnitude of viscous shear forces that could retard pool swell with the magnitude of the forces accelerating the pool. If the 4T tank is considered to be a pipe with the pool flowing in it at 24 ft/sec, calculations show the total retarding force is on the order of 200 lb. If the accelerating force is defined as bubble pressure applied over the pool cross-section area, then the net accelerating force is probably in excess of 100,000 lb. This rough comparison clearly demonstrates that wall viscous effects are negligible. A1

Question M020.7 (Continued)

2. Discuss the manner by which test data will be applied to specific plant designs. Include in this discussion the influence of vent flow rate (or transient drywell pressure), vent submergence, and wetwell airspace volume. R2

RESPONSE

The 4T data is not being relied upon to provide an empirical definition of the Mark II pool swell velocity profile. This data is being utilized to confirm the accuracy of the analytical pool swell model de. in the DFFR from which Mark II pool swell conditions are calculated.

A1

Parameters such as vent flow rate, transient drywell pressure, vent submergence and wetwell air space volume are plant unique characteristics that are either defined by the geometry of the plant under consideration or are calculated for that particular plant using the analytical model.

Question M020.7 (Continued)

3. Provide a comprehensive error analysis for the key independent variables measured in the test program. Discuss how these errors were factored into a determination of conservative dependent variables. R2

RESPONSE

This information has been included in the 4T Phase II and III Test Report, *NEDO*/NEDE-13468P, dated December 1976, and transmitted to the NRC on January 4, 1977. A1 R3

Question M020.7 (Continued)

4. Discuss the potential influence of the "4T" geometry and configuration on the test results. Specifically, consider the effects of the tank walls on the measurement of the lateral loads and pool surface velocity, and the effect on the vent exit (i.e., without bolt flange) on the lateral loads and bubble formation.

RESPONSE

The 4T results are representative of the hypothetical accident conditions that could exist in a Mark II containment system and the test facility geometry and configuration are not causing significant distortion of the data. Test facility scaling is discussed in *NEDO*/NEDE-13442P and in the response to question M020.7(1). The question suggests that the tank walls may influence "the measurement of the lateral loads and pool surface velocity." The downcomer bracing system is supported on the tank walls (see Section 3.2 of *NEDO*/NEDE-13442P, and Section 3.1 of *NEDO*/NEDE-13468P). However, no mechanism has been identified whereby this method of downcomer support could influence the magnitude of the chugging lateral loads on the downcomer. The latter are derived from R3 A1 R3

2356 255

accelerometer and strain gauge data using a dynamic structural analysis of the system that uses as input the actual structural characteristic of the downcomer and bracing system (described in Appendix B of *NEDO*/NEDE-13468P). R3

The potential influence of viscous effects at the tank walls on the pool surface velocity observations is discussed in response to Question M020.7(1); pool swell involves very large Reynolds Numbers (typically 10^7) and viscous effects at the tank wall do not significantly influence pool swell. The potential influence of the pool surface shape on the swell characteristics has also been evaluated and the conclusion drawn that surface shape is unimportant. The most significant pool surface parameter affecting pool swell is the ratio of vent area to pool area (Av/Ap). The 4T pool surface area is representative of an actual Mark II unit cell and the Av/Ap ratios used in the 4T tests include more conservative values than those present in any Mark II facility. Consequently, the pool swell data from the 4T facility is representative of the swell conditions which could occur during a postulated loss-of-coolant accident. A1

Question M020.7 (Continued)

5. Identify any multiple vent tests data that can or will be used to substantiate the unit cell approach used in the "4T" test facility. R2

RESPONSE

Multiple vertical vent pressure suppression containment tests have been conducted at the Marviken plant in Sweden. Phase 1 tests are documented in reports published by the joint sponsors of this program. The Electric Power Research Institute (EPRI) has conducted 1/13 scale tests of a Mark II quarter segment based on the Susquehanna plant design. The latter were air tests and provided pool swell information. EPRI issued a test report *(EPRI NP-441)* in the public literature in *April* 1977 and *made* copies available to the NRC. A1 R3

2356 256

QUESTION M020.8

Video tapes of tests performed on a vent system similar to the Mark II design exhibited a significant amount of wave formation in the pool following the initial pool swell transient. Discuss the revelance of this phenomenon to the Mark II design, including the origin and anticipated magnitude of loads due to waves. R2

RESPONSE

The wall pressure probes in the 4T test showed periodic variation in pressure, however, at a given location this periodic behavior is a steady state condition. This variation in pressure could be caused by wave formation at the surface. If the peak to peak amplitude of the measured pressure is attributed solely to surface wave phenomenon, the lateral hydrostatic pressure caused by the waves would be less than 1.0 psi. This is equivalent to waves that are less than 2.0 feet from crest to trough.

The lateral loading caused by waves of the magnitude mentioned above is adequately covered in the design process by the lateral drag forces given in Subsection 4.2.4 of the DFFR. R3

In addition, the seismic design of a typical plant may use a horizontal acceleration of 0.2 g which corresponds to a static pressure increase of about 4.0 psi in the horizontal direction.

Therefore, the above loads which are part of the design loads, will bound any effects due to pool surface waves.

QUESTION M020.9

Discuss the design features of the Mark II containment, or potential design modifications, which would be used to mitigate pool dynamic loads.

2356 257

RESPONSE R2

Based on the pool swell velocities obtained by applying the DFFR model to specific Mark II plants, the loads caused by pool swell on the Mark II wetwell structure are within acceptable limits. For this reason, no need exists for design modifications of the wetwell to mitigate pool swell loads. R3

QUESTION M020.10

In Subsection 4.4.4 *(R3:4.2.3.4)* of this report, all of the Mark II R3
plants have been grouped according to key geometric similarities.
Discuss the manner by which the solutions of the pool swell model for
each of the test cases are to be applied to the other plants in each
class. If the solutions for a test case are to be applied equally to all
other plants in a particular class, justify the approach with respect to
differences in drywell pressure response and geometry between the test
case and other plants in the same class.

RESPONSE

The purpose of the grouping of all Mark II plants was to select one
typical plant from each of the three groups and then analyze these plants
for their pool swell response. The solution obtained for each typical
plant was not intended to be applied to other plants in the same class. R2
Any specific plant whose drywell pressure response and geometrical
parameters are different from that of the typical plant shall be analyzed
for pool swell by using the analytical model given in Subsection 4.2.1. R3

QUESTION M020.11

Subsection 4.4.4 *(R2)* of the report identifies Figure 4-28 *(R2)* as R3
being the transient suppression pool air space pressure, whereas this
figure is apparently the transient bubble pressure. Clarify this
discrepancy.

2356 258

RESPONSE

Subsection 4.4.4 *(R2)* of the report has been modified such that reference to Figure 4-28 *(R2)* is no longer appropriate; however, Figure 4-28 *(R2)* has been changed to reflect the information shown. R3

QUESTION M020.12

Discuss the manner by which fluid velocity is determined for the computation of drag loads on submerged structures and piping.

RESPONSE

The fluid velocities for the computation of the drag loads on submerged structures and piping *due to pool swell* are determined according to the procedures outlined in the DFFR, Revision 2, dated September 1976, Section 4.4*, and DFFR, Revision 3, dated June 1978, Subsection 4.2.* A1 R3 R3

QUESTION M020.13

Subsection 4.4.5.3 *(R3: 4.2.6.2)* of the report indicates that the bubble pressure should be applied as a uniform increase in hydrostatic pressure. R3

1. Justify this approach with respect to potential differential pressures that could be generated across equipment or structures due to bubble propagation through the pool, specifically consider the reactor pedestal and the drywell deck column supports. R2

2. Justify the use of the calculated transient bubble pressure in terms of any relevant test data available from the 4T tests.

RESPONSE

1. *DFFR Subsection 4.2.6.2 presents the methodology for evaulating air bubble loads on the containment walls including the reactor pedestal. This methodology applies a static differential pressure across the wall. Similarly, DFFR Subsection 4.2.4.4* R3
presents the methodology for evaluating air bubble loads on all submerged structures including the drywell floor columns. This submerged structure methodology accounts for the pressure gradient, i.e., acceleration drag forces induced by the air bubble.

2. *The use of the calculated bubble pressure is justified because* A1
it compares favorably with the 4T test. This comparison is shown in Figure 6-12 of NEDO/NEDE-21544-P. (DFFR Revision 3 reference 5.) And is also discussed in DFFR Subsection 4.2.6.2.

QUESTION M020.14

Section 4.4.5.4 *(R3: 4.2.4, 4.2.5, 4.2.6)* of the report indicates that R3
fallback loads are determined assuming the acceleration under gravity of a two-phase fluid. Discuss the manner by which the density of the two-phase mixture is determined. In addition, since the majority of Mark II
plants have an initial wetwell air space height below three times the R2
vent submergence, justify the assumptions of acceleration under gravity with respect to momentum exchanges due to froth impingement on the diaphragm (i.e., rebound velocity).

RESPONSE

Fallback loads are discussed in the revised portions of Subsection 4.*2*. R3
A density of 1.0 (liquid phase) is conservatively used for fallback loads (Subsection 4.*2.4.5*). Pool swell yields no froth (Subsection
4.*2.5*.3) and impact on the diaphragm floor does not occur (Subsection R3
4.*2.5*.5).

2356 260

QUESTION M020.15

The report indicates that a 50% design margin may be applied to the impact loads determined for a structure. Discuss the criteria to be used in determining whether a design margin should be applied to a particular load. *(R3: 4.2.5.1.)* R3

RESPONSE

Subsection 4.2.5.1 has been revised to require the application of the 50% design margin to all impact loads determined for a structure. R3

QUESTION M020.16

Discuss the manner by which the material in Appendix 4.4 *(R2)* of the report is to be used. In addition, describe how the data points used to generate Figures A4-1 through A4-3 were obtained. R3

RESPONSE

The following statement has been inserted into Appendix 4.4 *(R2)* of the R3
report. "The foregoing correlations are not intended to be used in
design computations. Rather, the intent of this material is to allow one
to be able to make an estimate of the effects of V_{max} and H_B on the
pool swell phenomenon. These estimates are helpful for qualitative
assessments of the pool swell phenomenon. The data points used to R2
generate Figures A4-1 and A4-2 were obtained by using the pool swell
model at four different submergence depths with all other plant
parameters held constant."

QUESTION M020.17

Provide a table which summarizes each of the loads depicted in Figures 5-1 through 5-16. For each load, specify the experimental data and/or analysis which form the basis for the load. References to the test data should indicate the specific test runs.

2356 261

RESPONSE

New Tables 2-1 and 5-1 of the report provide the requested information.

QUESTION M020.18

Provide the following clarifications regarding the temporal relationships depicted on the load combination histories:

1. How was the 0.7 sec vent-clearing time determined?

2. The pool swell event is depicted to occur between 0.7 sec and 0.9 sec. The calculations is Subsection 4.4 *(R3: 4.2)* indicate that the pool swell event takes approximately 0.6 sec. Clarify this inconsistency. R3

3. How was it determined that condensation loads would begin at 4 seconds following a postulated LOCA?

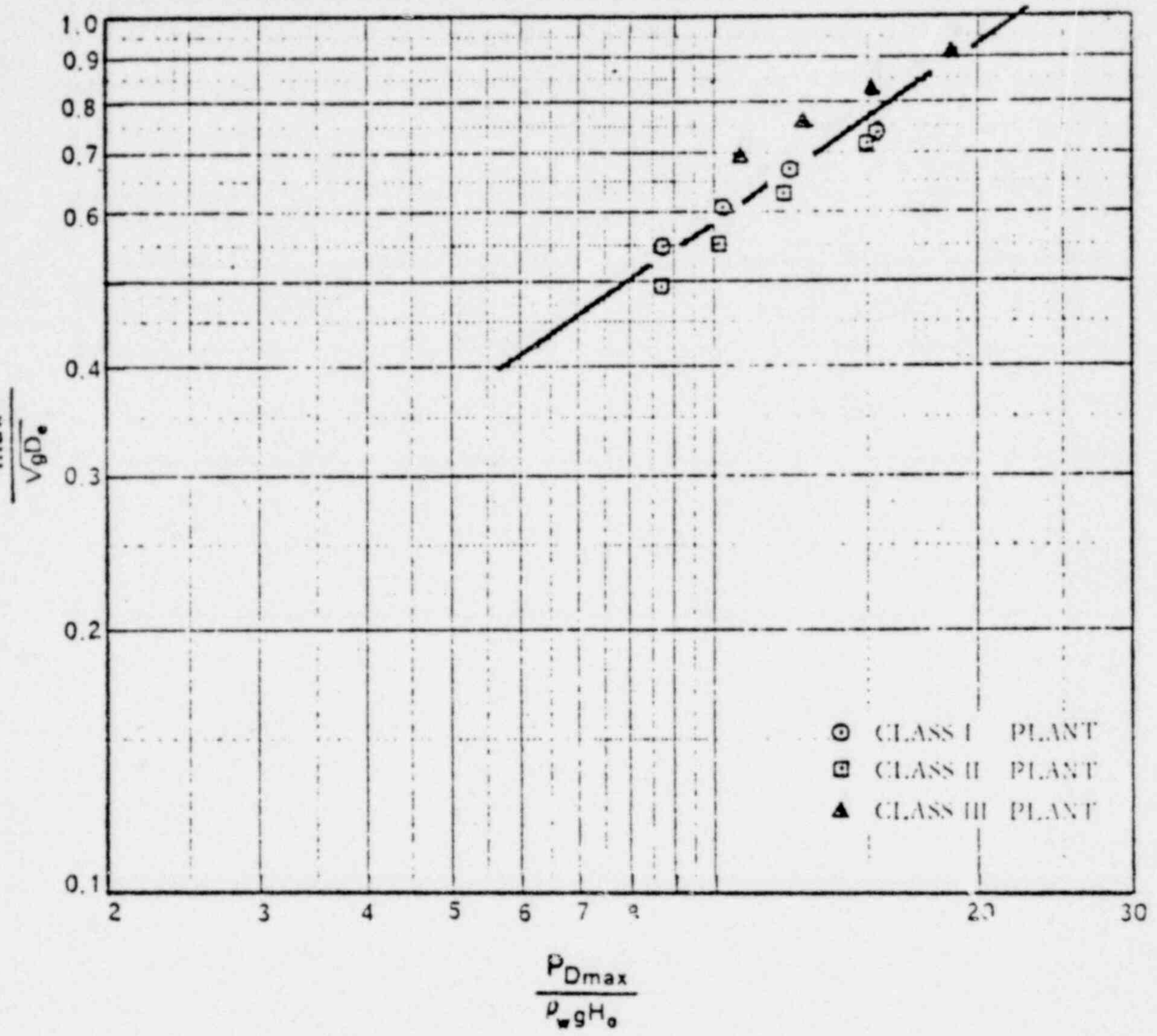
4. Discuss the manner by which the loading time is determined for drag and fallback following impact or froth impingment. R2

RESPONSE

1. The 0.7 second vent-clearing time was determined with the model described in NEDM-10320, "General Electric Pressure Suppression Containment Analytical Model," March 1971, using the typical plant parameters contained in Table 4-1 of the report.

2. Figures 5-1, 5-2, 5-6, 5-7, 5-11 and 5-15 have been revised to be consistent with the breakthrough time of 0.6 second, which is a typical value, *(Table 4.8, Figures 4-26, 4-27, 4-28, 4-30)*. R3
Pool swell begins at 0.7 second, the time of vent clearing, and ends 0.6 second later at 1.3 seconds, the time of breakthrough.

2356 262



R2

Figure A4-1. Correlation For Estimating Maximum Pool Surface Velocity

2356 263

R2

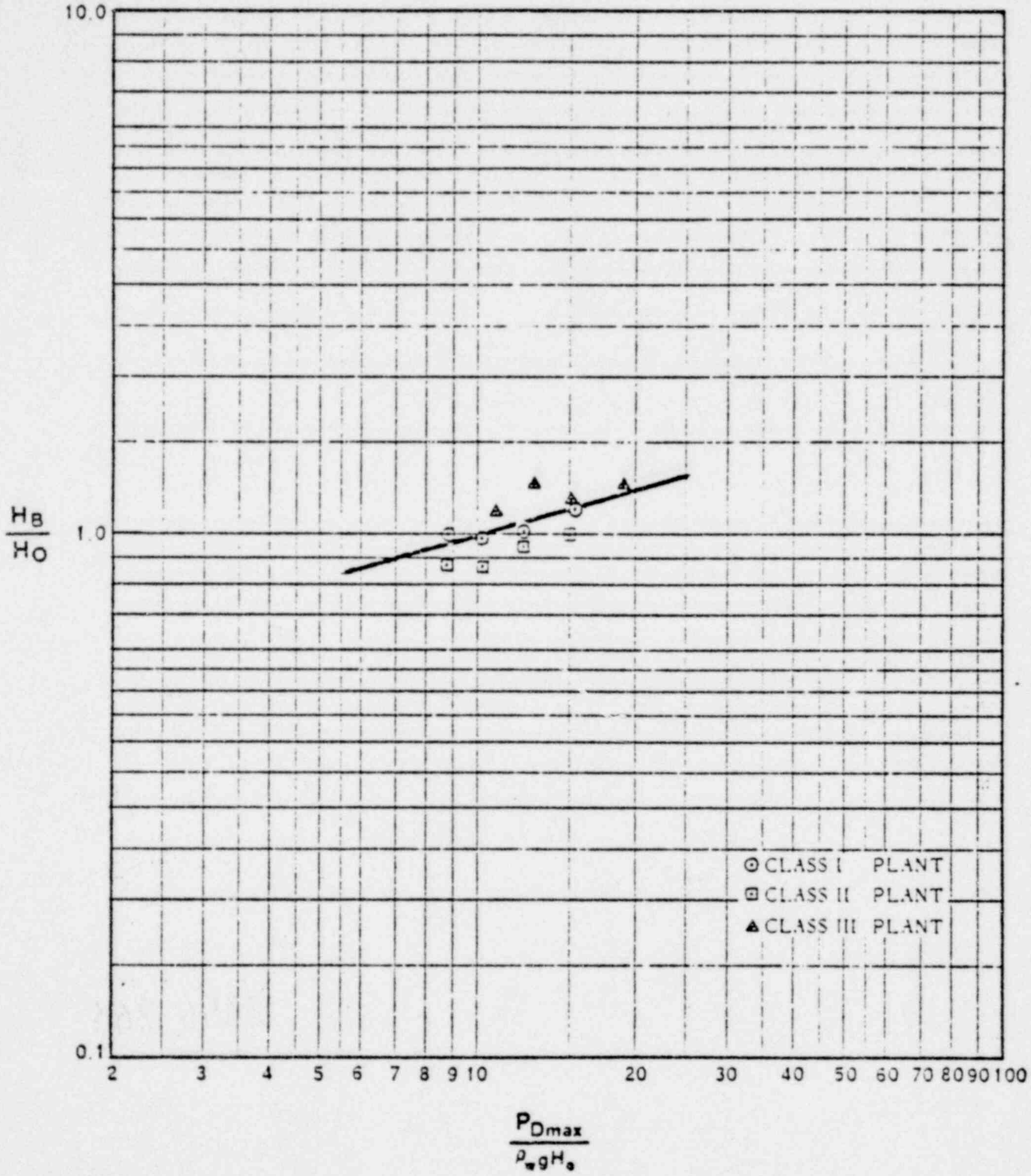


Figure A4-2. Correlation For Estimating Breakthrough Height

2356 264

3. Condensation oscillations are *discussed* in Subsection *4.3 of the DFFR; references 1 and 3 provide the technical basis.* R3

4. The loading time for drag and fallback loads are described in Subsections 4.2.4.4 and *4.2.4.5*, respectively. R3

QUESTION M020.19

Provide a multiple regression analysis for the quencher relief valve design using the entire data base available.

RESPONSE

See Response to Question M020.21.

QUESTION M020.20

Provide the data base being used for the quencher design evaluation. The data should be in tabular form, listing all sensitive test parameters.

RESPONSE

See Response to Question M020.21.

R2

QUESTION M020.21

Provide the design quencher loads to be used and their bases.

RESPONSE

Subsection 3.3 *(R3: 3.1.1, 3.1.3, 3.2.2, 3.3.2, 3.3.3, 3.4.2, 3.5.1)* of the report has been revised entirely and includes the responses to Questions M020-19, M020.20 and M020.21. This information is based on GESSAR Amendment 43, which was accepted by the NRC on July 19, 1976. R3

QUESTION M020.22

The load combinations to be considered for the design assessment of the Mark II containment are presented in Subsection 5.2 of the report. The load combinations for the large line break do not consider actuation of a single SRV concurrent with a large break. Consideration of a single active failure will result in this load combination. Accordingly, we will require that the load combination be considered for the Mark II containment design assessment.

RESPONSE

As noted in Subsection 5.2.4 of the *DFFR*, this load combination will be used in the assessment of structures. R3

QUESTION M020.23

In April 1975, generic questions related to pool swell and SRV loads for Mark II type containments were sent to utilities with Mark II containment. In this letter, we requested that information be supplied to "describe the manner by which potential asymmetric loads were considered in the containment design. Characterize the type and magnitude of possible asymmetric loads and the capabilities of the affected structures to withstand such a loading profile...".

This information was not supplied in the DFFR. Accordingly, we require that an evaluation be presented of asymmetric load in the Mark II containment. Potential asymmetric loads resulting from SRV actuation and from asymmetries in vent flow should be considered. In addition, provide an evaluation of the capability of the Mark II containment for asymmetric pool dynamic loads. R2

RESPONSE

Depending on the location of the SRV discharge lines, asymmetric loads on the containment may occur due to SRV actuation. For design purposes, an asymmetric loading condition has been postulated and is described in Section 3.3.3.3 of the DFFR Revision 3. This asymmetric loading

2356 266

condition is used for the design assessment of the containment and associated structures. Other SRV loading cases, some of which may result in asymmetric loads on the containment, are also presented in Section 3.3.3.3 of DFFR Revision 3.

For asymmetric loads to occur due to LOCA, asymmetries in the vent flow rates would have to exist. However, as discussed here, the nature of the vent system design precludes the occurrence of asymmetric flow, and hence asymmetric loads cannot occur during LOCA.

During a postulated break in the main steam line or the recirculation line, the flow of noncondensibles into the suppression pool causes the pool swell phenomenon but does not begin to occur at the instant the break occurs. A time delay exists because the vents must clear of water before a flow of noncondensibles can begin. For Mark II plants, this time is approximately 0.7 second. R3

The sonic velocity at which the pressure wave travels across the drywell is approximately 1200 ft/sec (dry air at $135^{\circ}F$). If the maximum distance from the break to any location in the drywell is assumed to be 85 feet, about 0.07 second is required for the pressure wave to be transmitted everywhere in the drywell space; this is approximately one-tenth the vent clearing time. Thus, the pressure at the vent entrances has sufficient time to equalize. The flow rate through the vents will be equal because the vents are all of equal length.

Further, deflector plates at the entrance to each vent prevents immediate loading of any one vent, and the vents are approximately 70% full of air. Thus, during the 0.7 second vent clearing time the air initially in the vents will be pressurized equally and each vent will be subjected to an equal pressure drop causing symmetric flow.

Because the flow of noncondensibles through the vents is evenly distributed, the consequent pool swell will also be evenly distributed (i.e., symmetric) as observed in the EPRI 1/13 scale Multi-Vent tests (Reference 14a). Therefore, the loads due to LOCA will also be symmetric.

QUESTION M020.24

The DFFR provides an analytical evaluation of the pool dynamic loads for Mark II containment. At the April 28, 1976, Mark II meeting dealing with Mark II pool dynamic loads, the Mark II Owners Group stated that the 4T tests would provide experimental confirmation of the analytical methods described in the DFFR. It is the position of the staff that acceptance of the pool dynamic loads by the NRC Staff is contingent on the NRC review and acceptance of the results of the 4T test program and a comparison of the test data with the analytical methods described in the DFFR.

RESPONSE

An evaluation of the pool dynamic loads during pool swell for Mark II containments involves the definition of the following parameters: pool swell velocity, peak air bubble pressure, and maximum swell height. The pool surface velocity is used in the determination of impact loads (Subsections 4.2.5.1, 4.2.5.2, and 4.2.5.4) and drag loads (Subsection 4.2.4), while the bubble pressure is used to determine suppression pool wall loads beneath the pool surface (Subsection 4.2.6.2). The pool swell model, as described in Section 4.2.1 of the DFFR, is used for the prediction of these two parameters.

The 4T data is being used as a basis for the maximum pool swell height determination as described in the applications memorandum, "Phases I, II, and III of the *4T* Tests," dated December, 1976, and submitted to the NRC on January 25, 1977. *(Reference 4)*

The maximum pool surface velocity as measured in the 4T tests is compared in Figure 1 with the pool swell model predictions. These tests include two blowdown orifice sizes (2-1/2 and 3 in. diameter), two vent diameters (20 and 24 in.), three vent submergences (9, 11, and 13-1/2 ft) and steam and liquid blowdowns. Over this entire range of test parameters, the pool swell model conservatively predicted the maximum pool surface velocity. Therefore, the model can be confidently used in the prediction of pool swell dynamic loads which are dependent on the pool surface velocity.

The suppression pool wall pressure loads due to the air bubble as measured in the 4T tests have also been compared to the model predictions. This comparison is described in the response to Question M020.13(2). The maximum pool swell height is defined as being equivalent to 1.5 times the initial vent submergence, or the height calculated using the alternate method described in question M020.68.

Further discussions of the pool swell model and a more detailed comparison of the model predictions to the 4T test data are provided in the report, "Mark II Pressure Suppression Containment Systems, An Analytical Model of the Pool Swell Phenomenon," *NEDO*/NEDE-21544-P, published in January, 1977. *(Reference 5)*

QUESTION M020.25

We have not received a detailed description of the test matrix to be conducted for evaluation of the Mark II pool dynamic loads. The description of the 4T test program we have received indicates that 4T air tests have not been covered. In the evaluation of pool dynamic loads for the Mark I and Mark II containment design, air tests were conducted to provide data for some of the pool dynamic loads. Because of the potential for a high air fraction in the vent flow during the early portion of a LOCA, we currently believe that air tests should be conducted as a part of the Mark II pool dynamic load test program.

RESPONSE

No air tests were conducted in the 4T facility because they are considered to be unnecessary both from the standpoint of the Mark II tests objectives and from an evaluation of the pool swell phenomena. In the definition of certain pool swell parameters for the Mark I and Mark III containment designs, air tests were conducted because the test data was to be used directly for design purposes. The vent flow composition (relative amounts of air and steam) could not be accurately defined in, for instance, the Mark III tests. Because the results of the tests were to be applied directly for design purposes, and because the vent flow composition can be a significant parameter in a Mark III facility, it was necessary to ensure that bounding test conditions were obtained. In the case of vent flow, the best way to achieve this was to conduct tests in which the vent flow was 100% air, hence air blowdowns were specified instead of steam blowdowns. The Mark II test program, however, has different objectives. The primary objective of the 4T tests was to provide a wide range of test parameters from which a diverse data base could be obtained for the verification of the pool swell model. The verified pool swell model is then applied to predict the pool dynamic loads resulting from pool swell for the individual plant designs. This approach provides the data required to prove the validity of the analytical model over the complete range of design parameters allowing each design to be evaluated individually. R3 A1

An evaluation of the pool swell phenomena in the 4T facility also indicates that air tests are not necessary. In the test facility, there was approximately 80 feet of 24-in.-diameter pipe connecting the drywell to the suppression pool. This pipe initially contained air, and this air inventory was preferentially purged to the suppression chamber without significant dilution with blowdown steam. Hence, due to the design of the test facility, all the tests were equivalent to an air test during the initial phase of pool swell when the pool is undergoing rapid vertical acceleration. R2

A study has been conducted with the pool swell model to evaluate the potential effect of additional air flow in the vent line on the observed 4T swell. The composition of the vent flow used in the model is shown in Figure 1. The flow is all-air until the air initially in the vent line (14.8 lbm in this case) is exhausted. Then, the flow is a mixture of steam and air, the relative amount equal to ratio of steam and air in the drywell at the time of vent clearing. As can be seen, if the vent line was longer (i.e., if there was more air in the vent line) the vent flow would continue to be all-air longer. A parameter study was done to examine the effect of more air in the vent line on the maximum pool surface velocity. The results of this study are shown in Figure 2. The actual mass of air in the vent line for the reference test conditions was 14.8 lbm, which resulted in a maximum velocity of 18.2 ft/sec. For continuous air flow, the maximum velocity would be 19.7 ft/sec. This comparison indicates that the difference between the actual test, as conducted with a steam blowdown, and an air blowdown is only an 8% increase in the maximum velocity. R2 A1

An examination of the air bubble pressure and the times of maximum pool acceleration and velocity help explain why additional air flow has such a small effect. Figure 3 shows the air bubble pressure for several values of the mass of air in the vent line. First, note that all the curves start off the same because initially they all reflect all-air flow, then that the pressure for the condition with the least amount of air begins to decrease first. Notice also, the time at which maximum pool surface velocity is obtained. Any flow, air or otherwise, after this time, has no effect on the maximum velocity; it only retards the water fallback and creates turbulence.

Up to this time, the 25 lbm curve is nearly identical to the all-air case and hence nearly equivalent maximum velocities would be expected. Figure 2 supports this conclusion. The time of maximum water slug acceleration

A1

R2

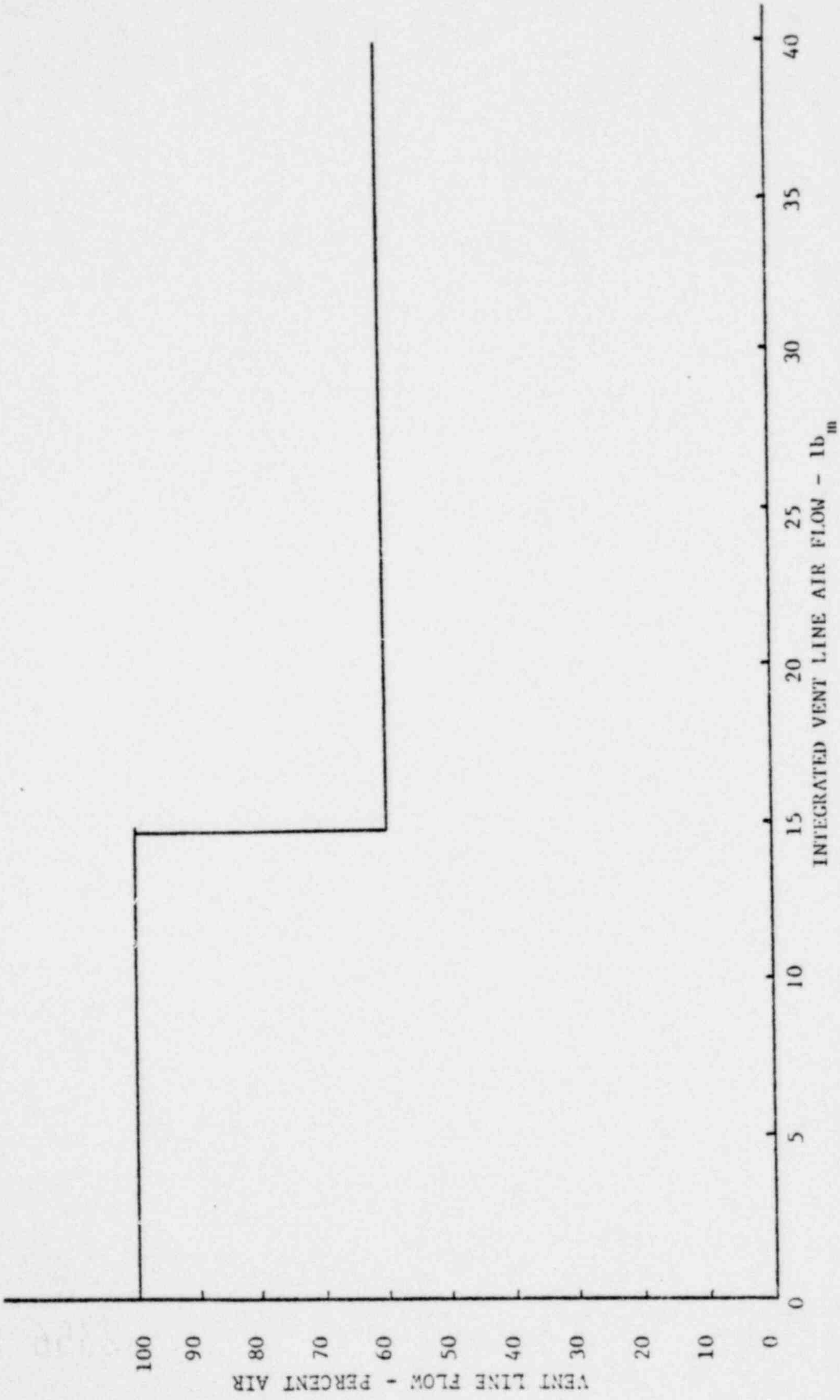


Figure 1. Pool Swell Nodel Vent Flow Composition

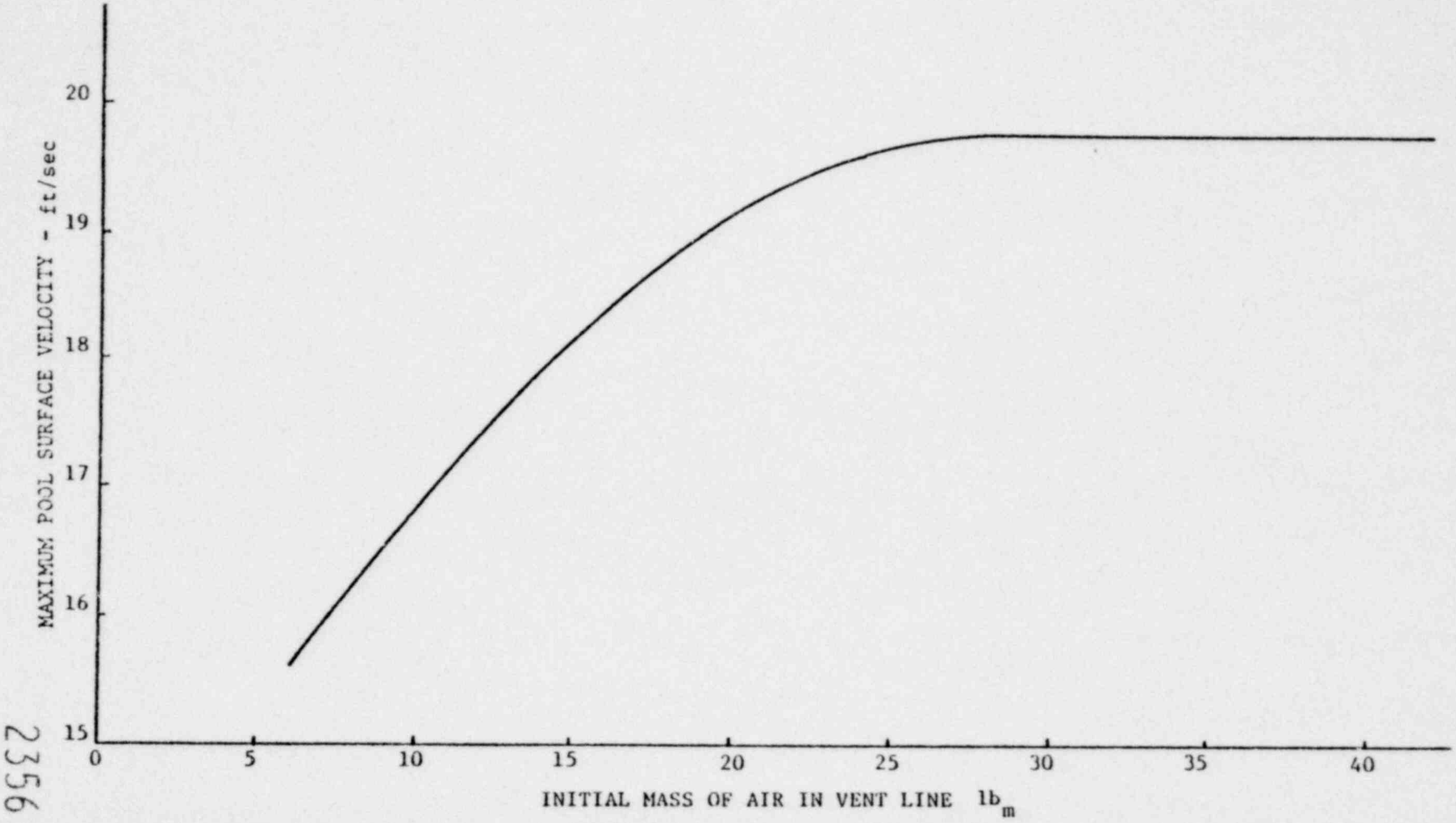


Figure 2. Effect of Initial Mass of Air in the Vent Line R2 A1

2356 273

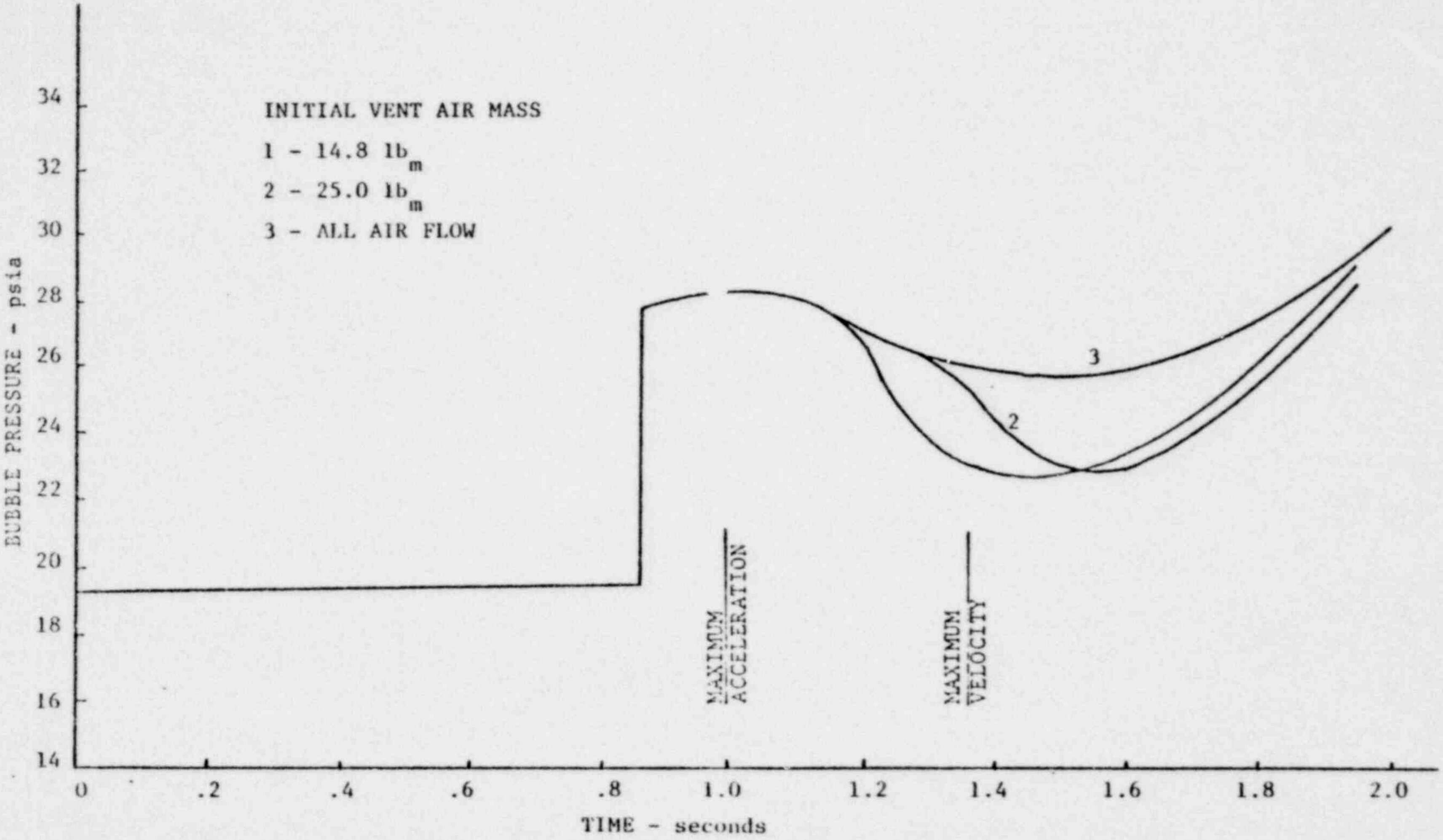


Figure 3. Air Bubble Pressure

is also noted on Figure 3. This occurs very early in the transient, when all the conditions are identical, hence additional air flow would not affect this phase of the transient. The only significant differences between the three pressure curves occurs late in the acceleration phase of the water, when the magnitude of the acceleration is low and the water slug is reaching its maximum height. R2 A1

In summary, the objective of the 4T Mark II test program was to provide a broad data base for pool swell model verification. The program was not intended to provide empirical definitions of pool dynamic loads, hence no bounding values of the vent flow composition are necessary. Further, the design of the test facility provided that all the steam blowdown tests conducted had high air flow during the significant portion of the transient. In addition, parametric studies have shown that air tests would not result in a significant increase in the maximum pool surface velocity. Based on this evidence, there does not appear to be any value in conducting Mark II air tests in the 4T test facility; hence none are planned.

QUESTION M020.26

The DFFR presents a description of a number of LOCA related hydrodynamic loads without differentiating between primary and secondary loads. Provide this differentiating between the primary and secondary LOCA-related hydrodynamic loads. We recognize that this differentiation may vary from plant to plant. We would designate as a primary load any load that has or will result in a design modification in any Mark II containment since the pool dynamic concerns were identified in our April 1975 generic letters.

RESPONSE

The response to this question will vary from plant to plant and is provided in the Design Assessment Report (DAR) for the particular plant.

NRC QUESTIONS DATED JUNE 12, 1976, WITH RESPONSES

QUESTION M130.1

Provide in Section 5 a description of the pressure loadings on the containment wall, pedestal wall, basemat, and other structural elements in the suppression pool, due to the various combinations of SRV discharges, including the time function and profile for each combination. If this information is not generic, each affected utility should submit the information as described above. R2

RESPONSE

Tables 2-1 and 5-1 provide generic load profiles and time-histories. Plant specific information will be provided in the individual plant Design Assessment Reports (DAR's).

QUESTION M130.2

In Subsection 5.2 it is stated that the load combination histories are presented in the form of bar charts as shown in Figures 5-1 through 5-16. It is not indicated how these load combination histories are used. In particular, it is not clear whether only loads represented by concurrent bars will be combined, and it should be noted that depending on the dynamic properties of the structures and the rise time and duration of the loads, a structure may respond to two or more given loads at the same time even though these loads occur at different times. Also, although condensation oscillations are depicted as bars on the bar charts, the procedure for the analysis of structures due to these loads has not been presented. Accordingly, the description of the method should include consideration of such conditions. Also, for condensation oscillation loads and for SRV oscillatory loads, include low cycle fatigue analysis.

RESPONSE

Changes have been made to Figures 5-1 through 5-16 of the report to make them consistent with the new Table 5-1 and other appropriate report paragraphs. Plant specific information will be provided in the individual plant DAR's.

QUESTION M130.3

In discussing the load factors used for loads in various load combinations, the probabilistic approach given on page *(R3: Page 5-7)* includes comparisons of various load combination probabilities. Explain how the load factors and load combinations are established on such a probabilistic approach and how the various orders of magnitude as indicated on page *(R3: Page 5-7)* are obtained and provide the load factors and load combinations thus established.

RESPONSE

The load combination equations and the associated load factors to be used for the assessment of the containment and its internal structures are given in Table 5-2 of the DFFR, Revision *3, June 1978*. The load factors were established to provide safety margins equivalent to applicable codes on concrete containments and other concrete structures. In particular, ASME B&PV Code Section III Division 2, ACI-349 and the Standard Review Plan 3.8 were used for guidance in developing these load factors.

QUESTION M130.4

Through the use of figures, describe in detail the soil modeling as indicated in Subsection 5.4.3 and describe the solid finite elements which you intend to use for the soil.

RESPONSE

See Response to Question M130.6

QUESTION M130.5

Describe the mathematical model which you will use for the liner and the anchorage system in the analysis as described in Subsection 5.6.3.

RESPONSE

See Response to Question M130.6

2356 277

QUESTION M130.6

In Subsection 5.1.1.1 it was stated that the SRV discharge could cause axisymmetric or asymmetric loads on the containment. In Subsection 5.4.1 an axisymmetric finite element computer program is recommended for dynamic analysis of structures due to SRV loads, and no mention is made of the analysis for asymmetric loads. Describe the structural analysis procedure used to consider asymmetric pool dynamic loads on structures and through the use of figures, describe in more detail the structural model which you intend to use. R2

RESPONSE

Responses to Questions M130.4, M130.5, M130.6 will be included in the individual plant Design Assessment Reports (DAR's).

QUESTION M130.7

In Table 5-1, load combinations 4a, 5a and 7a are not acceptable to the NRC Staff. Discharge of a single safety/relief valve must be combined with the remaining loads of these combinations. A load factor of 1.0 on the SRV loads in these combinations is acceptable to the NRC Staff.

RESPONSE

See Response to Question M020.22.

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2356 278