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MINUTES OF THE
ACRS SUBCOMMITTEE MEETING ON
FLUID DYNAMICS
NOVEMBER 16, 1979
SAN FRANCISCO, CALIFORNIA

The ACRS Subcommittee on Fluid Dynamics held a meeting on November 16, 1979, at the Barrett Motor Hotel, 501 Post Street, San Francisco, California. The purpose of this meeting was to develop information for consideration by the ACRS in its review of the Mark I containment long-term program. Notice of this meeting was published on November 1, 1979, in the Federal Register, Volume 44, Number 213; a copy is included as Attachment A. Dr. Andrew Bates was the Designated Federal Employee for the meeting. A list of meeting attendees is included as Attachment B. A tentative presentation schedule is included as Attachment C.

EXECUTIVE SESSION

Dr. Plesset, the Subcommittee Chairman, convened the meeting at 8:30 a.m. and reviewed briefly the schedule for the meeting. Prior to holding discussion with the NRC Staff and the Mark I Owners Group, he solicited comments from the Subcommittee and its consultants on the subject matter. Dr. Catton raised the following questions to be answered during the course of the meeting:

1. How important is the condensation loading of the torus?; what are the locations of the pressure transducers?; how the relationship between the maximum and the torus bottom pressure is arrived at?
2. What is the relationship between the pressure loading and the time between the actuations of Safety Relief Valve (SRV)?
3. Why does the NRC Staff require more Full Scale Test Facility (FSTF) tests?, and what is the nature of those tests?

MARK I LONG-TERM PROGRAM STATUS - MR. GRIMES, NRC STAFF

Mr. Grimes provided a brief summary of the current status of the Mark I containment long-term program indicating that the NRC Staff's acceptance criteria for the long-term program were transmitted to the Mark I licensees on October 31, 1979 so as to enable them to perform plant unique analysis. The NRC Staff and its consultants are in the process of preparing the Safety

Evaluation Report (SER) for the Mark I containment long-term program which is scheduled to be issued in December 1979. He pointed out that there are still some differing technical opinions between the NRC Staff and the Mark I Owners on several aspects of the NRC Staff's acceptance criteria; the NRC Staff and the Mark I Owners have been working together to resolve these dissenting technical issues. The NRC Staff intends to show a film on the pool swell phenomena at a later part of the meeting.

POOL SWELL TESTING PROGRAMS AND LOAD DEFINITION METHODOLOGY

Pool Swell Loads - Mr. V. Tashjian, General Electric Company (GE)

Mr. Tashjian reviewed briefly the pool swell phenomena and indicated that the following pool swell loads are of main interest:

1. Torus vertical loads
2. Torus submerged pressure loads
3. Torus airspace pressure loads
4. Vent system impact and drag loads
5. Submerged structure impact and drag loads
6. Vent header deflector loads

Mr. Tashjian pointed out that, since there are some dissenting technical opinions between the NRC Staff and the Mark I Owners Group on the technical assessment of 3-D/2-D upload multiplier, he would like to concentrate his discussion on this issue. He would also like to present some technical justification for the Mark I Owners' position on the pool swell shape.

Mr. Tashjian stated that several tests were conducted at the GE 1/4 Scale 2-Dimensional Test Facility to determine the pool swell loads; the data obtained from these tests were used to define the pool swell loads as delineated in the Mark I plants Load Definition Report (LDR). On behalf of the Mark I Owners Group, GE also performed an assessment of the 3-Dimensional effects on the Mark I plants by using the data from the tests conducted at Electric Power Research Institute (EPRI) 1/12 scale 3-Dimensional Test Facility. A comparison of the GE 1/4 Scale 2-Dimensional test data and the EPRI 1/12 Scale 3-Dimensional test data (Attachment D, page 1) indicates that the torus uploads observed in the 2-Dimensional tests are consistently higher than those observed in the 3-Dimensional tests. Based on this comparison, he believes that the torus upload obtained from the 1/4 Scale 2-Dimensional tests is conservative and, therefore, there is no need to apply an uncertainty factor, as required by the NRC Staff, to account for the 3-Dimensional effects.

Indicating that he was given to understand in one of the previous Fluid Dynamics subcommittee meetings that the orifice in the EPRI 1/12 scale test choked, but the one in the GE 1/4 Scale did not choke, Dr. Catton asked whether this fact has been factored into the comparison of the 1/4 Scale 2-Dimensional and the 1/12 Scale 3-Dimensional test data.

Mr. Tashjian stated that he believes that consideration has been given to this fact; however, he will confirm whether it has been factored into the comparison of the 2-Dimensional and 3-Dimensional test data at a later part of the meeting.

Mr. Tashjian indicated that the Mark I Owners Group also looked at the results of the 2-Dimensional and 3-Dimensional tests conducted at the Lawrence Livermore Laboratory (LLL). These tests conducted at the 1/5 Scale Test Facility were to provide data to the NRC Staff to aid in their evaluation of Mark I containment pool swell loads. A comparison of the LLL 2-Dimensional and 3-Dimensional test data indicates that the peak torus uploads are higher in the 3-Dimensional case than in the 2-Dimensional case, thus giving an average 3D/2D multiplier somewhat greater than one. Based on the review of the LLL data, the Mark I Owners Group believes that the following factors influence the differences in the peak uploads between the 2-Dimensional and 3-Dimensional tests:

1. Structural oscillations of the 3-Dimensional test facility (Attachment D, page 2).
2. Non-Simultaneous vent clearing between the 2-Dimensional and 3-Dimensional test facilities due to variations in the initial conditions.
3. Interaction between the 2-Dimensional and 3-Dimensional test facilities (Attachment D, page 3).
4. Capacitance and FL/D (flow resistance) differences between the 2-Dimensional and 3-Dimensional test facilities due to the variation in the location of the orifices.

Mr. Tashjian pointed out that, if the above factors are taken into account, he believes that the LLL 3-Dimensional and 2-Dimensional peak uploads would be essentially equal.

Mr. Tashjian stated that, based on the comparisons of the test data obtained from various test facilities, the Mark I Owners Group arrived at the following conclusions:

1. A comparison of the EPRI 3-Dimensional and GE 2-Dimensional test data shows that the 3D/2D upload multiplier is ≤ 1.
2. A comparison of the LLL 3-Dimensional and 2-Dimensional test data confirms that the 3D/2D upload multiplier is $\simeq 1$ when facility and test conditions are matching.

Pool Swell Shape and Vent Header Impact Timing

Mr. Tashjian provided justification for the Mark I Owners position that the vent header impact sweep times defined usir⁊ the Mark I LDR methods are sufficiently conservative and bounding.

Mr. Tashjian stated that the LDR definition of pool swell displacement, velocity, and vent header impact timing in the longitudinal direction were obtained by interpolating halfway between the results given by the EPRI 3-Dimensional vent orifice and downcomer orifice tests. Subsequent to the development of the LDR definition, EPRI performed a series of split orifice tests with orifices placed both in the main vent and downcomers. A comparison of the interpolated vent header impact times with the results of the EPRI split orifice tests indicates that the interpolated vent header impact times as specified in the Mark I LDR are conservative.

Dr. Catton asked whether the Mark I Owners Group has run any tests by using several orifices (4 or 5 orifices) and made a comparison of these results with the split orifice test results.

Mr. Kennedy from GE stated that they did run such tests at the same scale and compared the results with the split orifice test results; they observed that the results are equivalent. However, he believes that the results may be different when one goes from a smaller scale to the full scale because of the compressibilitv effects.

In response to another question from Dr. Catton, Mr. Kennedy stated that the compressibility effects at small scales (1/4 Scale and below) are negligible.

Dr. Catton wondered how the compressibility effects can be neglected at small scales. He stated that he would like to see the analysis pertinent to this issue.

Indicating that there is a potential for either low or medium cycle fatigue, due to some repetitive pressure loads associated with certain safety systems (such as safety relief valve discharge), which would lead to the degradation of the pressure boundary, Dr. Bush asked whether they have looked at the implications of such low-probability accident type loads when superimposed on a degraded pressure boundary.

Mr. Grimes stated that they will look into this issue.

NET VERTICAL PRESSURE LOAD IN THE TORUS - MR. J. RANLET, BROOKHAVEN NATIONAL LABORATORY (NRC CONSULTANT)

Mr. Ranlet stated that the NRC Staff's acceptance criteria for the Mark I containment long-term program requires that the downward and upward net vertical pressure ads on the torus shall be derived from a series of plant-specific 1/4-Scal. Test Facility (QSTF) tests. However, based on the review of the pool swell tests (2-Dimensional and 3-Dimensional) performed by the Mark I Owners Group and the confirmatory tests performed for NRC at the Lawrence Livermore Laboratory, the NRC Staff believes that the following margins should be applied to each loading phase:

1. For the net upward load, a margin equivalent to a value of 21.5% (15% to account for the uncertainties of 3D/2D comparisons plus 6.5% as derived from the statistical analysis of the entire QSTF data base) should be applied to the average upward loads of the QSTF plant-specific test results.
2. For the net downward load, a margin equivalent to a value of 6.3 to 15.5% (derived from the statistical analysis of the entire QSTF data base) should be applied to the average downward loads of the QSTF plant-specific test results.

Mr. Ranlet provided justification for requiring that a margin equivalent to a value of 15%, to account for the uncertainties associated with the 3D/2D comparison, should be applied to the net average upward load obtained from the plant-specific QSTF tests. He pointed out that the Mark I Owners Group, after comparing the results of the GE 1/4 Scale 2-Dimensional tests and EPRI 1/12 Scale 3-Dimensional tests, chose the GE 1/4 Scale 2-Dimensional tests data as the basis for defining the pool swell loads. However, based on the review of the comparison of the GE-EPRI test results, the NRC Staff has concluded that it should not be used to assess the possibility of a 3-Dimensional effect on pool swell uploads for the following reasons:

1. EPRI 1/12 Scale 3-Dimensional Test Facility represents the Browns Ferry Plant configuration; the NRC Staff believes that Browns Ferry geometry is not prototypical of Mark I Plants; the 45° downcomer configuration causes an early bubble breakthrough; such an early breakthrough phenomena attenuates the torus uploads because the wet well airspace is not compressed sufficiently. This early bubble breakthrough did not occur in any of the other plant configurations. (For different plant configurations, see Attachment D, page 4).
2. The tests were conducted at full Δp and at 3 feet 4 inches reduced submergence; such test conditions would minimize the pool swell effects.
3. EPRI tests were conducted at higher values of flow resistance than the GE tests; such high flow resistance would reduce the net uploads.
4. The downcomer orifice size variation caused a distorted pool swell, thus resulting in reduced uploads.

Mr. Raniet stated that in order to obtain additional data base and also to confirm the 3-Dimensional effects on pool swell vertical loads, confirmatory tests were conducted at the LLL 1/5 Scale 2-Dimensional and 3-Dimensional Test Facilities. These tests were performed using Peach Bottom plant configuration at zero Δp and at 4 feet reduced submergence. The results of these tests (Attachment D, page 5) indicated that torus uploads are higher in the 3-Dimensional case than in the 2-Dimensional case. They have also compared the results of some GE (1/4 Scale 2-Dimensional) and EPRI (1/12 Scale 3-Dimensional) tests which were not used by the Mark I Owners Group in the GE-EPRI comparisons; the results of this comparison show that the torus uploads are higher in the 3-Dimensional case than in the 2-Dimensional case (Attachment D, page 5).

Mr. Ranlet pointed out that, in order to determine whether the experimental trend as indicated by the LLL test data was due to a 3-Dimensional effect on pool swell or possibly a mis-match of the 3-Dimensional and 2-Dimensional sectors, a 1-Dimensional transient pool swell analysis for both the LLL 2-Dimensional and 3-Dimensional sectors was conducted. The results of this analysis have shown that the LLL 2-Dimensional and 3-Dimensional sectors were indeed mis-matched due to differences in capacitance and resistance. Therefore, the NRC Staff believes that, to account for the uncertainties associated with the 2-D and 3-D comparisons, the Mark I Owners should apply a margin equivalent to a value of 15% to the average uploads of the QSTF plant-specific test results.

Mr. Steiner, from GE, expressed concern indicating that the NRS Staff's acceptance criterion for the torus upload has excessive conservatism and he believes that it will have significant impact on the torus uploads.

Mr. Grimes, NRC Staff, stated that, on the basis of analyses and model tests, they have developed the criterion for the torus uploads. They have performed several assessments on the basis of the existing knowledge without giving too much consideration for its potential impact or consequences. He pointed out that their main aim is to restore the margins of safety in the plant designs and they have incorporated appropriate techniques in their criterion to reduce the excessive conservatism without affecting the margins of safety.

POOL SWELL FLOW DISTRIBUTION EFFECTS - DR. KOSSAN, NRC CONSULTANT

Dr. Kossan stated that the main objectives of his presentation are to:

1. provide justification to the NRC Staff's acceptance criterion pertinent to the vent header impact timing which requires that the vent header and vent header deflector timings should be derived from the 3-Dimensional test data using orifices only in the main vent line, and
2. show that the techniques employed to develop Mark I LDR definition of the vent header impact timing may not be appropriate.

Dr. Kossan indicated that the Mark I LDR definition of the vent header impact timing was obtained by interpolating the results of the EPRI 3-Dimensional vent orifice and downcomer orifice tests. He stated that there are several uncertainties associated with the techniques employed by the Mark I Owners Group in developing the definition for the vent header impact timing (Attachment E, page 1). Based on several analyses header impact timing (Attachment E, page 1). Based on several analyses and model tests, the NRC Staff has made the following observations:

1. The orifice sizes for the EPRI test model were establishedd by running tests in 1/12 and 1/31 Scale models. He believes that it is very difficult to obtain the exact orifice size experimentally. Without using the appropriate orifice size, it is very difficult to obtain the desired flow; such concern was confirmed by the observation made in the EPRI tests that the ratio of the highest to the lowest downcomer flow rates seemed excessive.
2. Flow calibration tests were run with no water in the wetwell and with uniform exit pressure at all downcomers. However, he believes that during early bubble growth, bubble pressure can vary from one downcomer to another, thus causing a non-uniform exit pressure.
3. The split orifice and the downcomer orifice provide the same flow distribution and sweep time.
4. The split and downcomer orifice tests probably had an excessive flow ratio.

Dr. Kossan stated that for the reasons given above, the NRC Staff believes that several of the techniques used by the Mark I Owners Group in defining the vent header impact timing do not seem to be conservative. They are also not sufficiently confident that the flow distribution in the EPRI tests provides a prototypical representation of a pool swell response. Based on several analyses and test results, the NRC Staff believes that the vent orifice tests provide the most prototypical flow distribution and the best estimate of vent header impact timing. Therefore, the NRC Staff requires that the vent header and vent header deflector timings should be derived from the main vent orifice tests.

Dr. Plesset asked whether the Mark I Owners Group has strong reservations about the NRC Staff's criterion on the vent header impact timing.

Mr. Steiner stated that the Mark I Owners Group believes that the NRC Staff's criterion has excessive conservatism and it would have significant impa ... the design of the pool structure as well as other structures above the pool.

VENT HEADER DEFLECTOR LOAD DEFINITION - MR. KENNEDY, ACUREX CORPORATION

Mr. Kennedy stated that the vent header deflector is located between the pool surface and the vent header for the purpose of deflecting the rising surface of the pool water thus preventing the high velocity impact of the water on the vent header (Attachment F, page 1). He discussed briefly different types of vent header deflectors that are being considered for use in Mark I plants (Attachment F, page 2).

Mr. Kennedy stated that there are two types of methodology used in the prediction of deflector loads:

1. Direct use of deflector load data obtained from the QSTF plant-specific tests.
2. Analytical Methods.

With regard to the prediction of vent header deflector loads by using experimental data, Mr. Kennedy stated that scaled models of actual deflectors, which would be eventually used in the actual plant configurations, were installed in the QSTF Test Facility and tests were run to obtain necessary data (Attachment F, page 3) for vent header deflector load predictions.

Mr. Kennedy stated that for those plants for which the vent header deflector has not been tested through plant-specific QSTF tests, a semi-empirical methodology has been used to calculate the vent header deflector loads. The load is assumed to consist of impact transient, steady drag, and acceleration drag; all these components are defined and added together to obtain the vent header deflector loads. The empirical correlations used to calculate the impact transient, steady and acceleration drags are included in Attachment F, page 4. The instantaneous pool velocity necessary to evaluate the empirical expression is obtained from the QSTF test movie data. The results of the comparison of the QSTF test data and the calculated data (Attachment F, pages 5-7) show that the calculated data is conservative and bounds the measured data. He stated that the comparison of QSTF test data and analytical data obtained with different deflector types and locations indicate that the analytical data over-predicts the deflector load about 33% (Attachment F, page 8).

Mr. Kennedy pointed out that the NRC Staff has some concerns about the methodology used by the Mark I Owners Group in predicting the vent header deflector loads. The NRC Staff believes that the Mark I Owners Group has over-predicted the pool velocity component, but under-estimated the drag coefficient; they expressed concern that this mis-match may produce some non-conservative vent header deflector loads. As a result, the NRC Staff has developed some drag coefficients and suggested that the Mark I Owners Group should use those in calculating the vent header deflector loads. Consequently, the Mark I Owners Group calculated the vent header deflector loads by applying the drag coefficients developed by the NRC Staff along with the pool velocity obtained from the QSTF movie data and observed that the loads were about 20-30% higher than it was predicted earlier; they believe that it is overly conservative and will have significant impact on the structural design.

Mr. Kennedy indicated that as a resolution to NRC Staff's concerns on this issue, the Mark I Owners Group intends to redefine the pool velocity component; they are in the process of doing this and the results will be discussed with the NRC Staff in the near future.

DEFLECTOR LOAD DATA ASSESSMENT - DR. SONIN, MIT, NRC CONSULTANT

Dr. Sonin reviewed briefly the methodologies proposed by the Mark I Owners Group in predicting the vent header deflector loads and the NRC Staff's position in accepting those methodologies. He stated that the Mark I Owners Group has proposed two methodologies to determine deflector loads:

1. Alternative A

   In this methodology, the Mark I Owners Group has proposed to use the data obtained from the plant-specific QSTF tests for predicting the vent header deflector loads.

Based on the review of the plant-specific QSTF tests results and other appropriate information, the NRC Staff believes that this methodology may be used to estimate the vent header deflector loads subject to the following modifications:

a. For cylinderical types of deflectors (Pipe, Pipe with Angles and Pipe with Tees), the loading transients should be adjusted to include the empirical impact spike that is derived from the impact tests of cylinders conducted by EPRI.

b. The 3-Dimensional pool swell effects should be interpreted conservatively as required by the NRC Staff; the QSTF plant-specific loads must be adjusted to account for the effects of impact time delays and pool swell velocity and acceleration differences which result from the uneven spacing of the downcomers.

c. When applying the load to a Mark I containment deflector, the inertia due to the added mass of water impacting the deflector should be accounted for in the structural assessment.

2. Alternative B

This methodology, proposed by the Mark I Owners Group, consists of a semi-empirical approach to calculate the vent header deflector loads for those plants for which the deflectors were not tested by the plant-specific QSTF tests. The load is assumed to consist of impact transient, steady drag, and acceleration drag and all these components are defined and added together to obtain the deflector loads.

Based on the review of this methodology, the NRC Staff believes that the steady drag coefficient used to compute the cylinderical type deflector loads are non-conservative. They also believe that an appropriate force transient for the wedge-type deflectors has not been specified. Unless all the components associated with this methodology are conservatively defined, the NRC Staff believes that this approach may not provide acceptable deflector loads. Therefore, the NRC Staff requires that the steady drag coefficient used in this methodology should be redefined. They also require that, when applying the load to the deflector, the inertia due to the added mass of the water impacting the deflector must be accounted for in the structural assessment.

Dr. Sonin discussed briefly the NRC Staff's definitions for the impact transients and steady drag coefficient (Attachment F, pages 9-13) and stated that the NRC Staff believes that use of these values in the Mark I Owners Group semi-empirical methodology may produce conservative deflector loads.

Dr. Hanauer, NRC Staff, commented that he believes that Mark I Owners semi-empirical methodology for calculating the deflector loads provide inappropriate results not mainly because of the non-conservative drag coefficients but because of the use of the overly conservative pool velocity. He believes that the pool velocity is not at all representative of the actual situation.

Dr. Sonin pointed out that, after realizing the excessive conservatism associated with the prediction of the pool velocity, the Mark I Owners Group has proposed to redefine the velocity component and use that refined velocity component along with the drag specifications provided by the NRC Staff in the Mark I Owners Group semi-empirical methodology. He believes that this proposed technique may be a reasonable solution to this issue; however, the NRC Staff has to review the results of this technique to assure that adequate conservatism exists in this techinque.

Prior to hearing the other scheduled presentations, the Subcommittee and its consultants viewed the following films:

1. Computer simulation of the response in the Mark I torus, developed by the Lawrence Livermore Laboratory, to look at the fluid structure interaction effects.
2. Summary of tests conducted at the Full Scale Test Facility (FSTF) - This film was developed by the General Electric Company for the benefit of Mark I plant Owners to give an overview of the FSTF tests.

FSTF TORUS SHELL PRESSURES AND LOAD DEFINITION BASES

Description of FSTF - Mr. Torbeck

Mr. Torbeck stated that the main objective of the FSTF program is to perform appropriate tests using a representative Mark I containment torus and obtain data to define hydrodynamic loads and dynamic structural response resulting from steam condensation phenomena. He discussed briefly the main characteristics of the FSTF (Attachment G, pages 1 and 2). He also discussed the instrumentations used in the FSTF and their locations (Attachment G, pages 3 and 4). He pointed out that in the FSTF tests a prototypical segment of a Mark I torus and vent system were subjected to ten steam and liquid blowdowns (Attachment G, page 5) simulating a range of Loss-of-Coolant Accidents (LOCAs). The parameters which were varied in the FSTF tests include downcomer submergence, initial pool temperature, blowdown of liquid and steam, and initial wetwell pressure (Attachment G, page 5).

Mr. Torbeck discussed briefly the result of the Condensation Oscillation (CO) tests conducted in the FSTF. The result of the tests conducted in the FSTF to determine the CO loads indicate that the amplitude of the pressure oscillations induced by condensation oscillations on the torus shell is dependent on the break size and the phase of the blowdown fluid (liquid or steam). The highest pressure amplitude was observed during the large liquid break test which simulated the design basis accident conditions. Therefore, the results of the large liquid break test were used as a conservative basis for CO load definition for the design basis accident. He pointed out that in some of the tests conducted with break size equal to 25 percent of the design basis accident area, strong condensation oscillation did not persist. However, in those tests, they observed some pressure oscillations during air carry-over, but the pressure amplitudes were bounded by the peak values of the chugging pressures which occurred following the air carry-over period.

With regard to the test results pertinent to the torus wall pressure amplitude, Mr. Torbeck stated that pressure measurements obtained from various locations on the torus shell show that the longitudinal pressure oscillation amplitude distribution along the torus centerline is essentially uniform. The test results also indicate that the maximum pressure occurs at the bottom dead center of the torus.

In response to a question from Dr. Catton regarding the location of pressure transducers, Mr. Torbeck stated that there is a pressure transducer located immediately below one of the vents; however, that pressure transducer did not register the maximum pressure amplitude.

Dr. Catton wondered how a pressure transducer located very close to the vent exit failed to show the maximum pressure amplitude.

Mr. Torbeck pointed out that the dominant frequencies (about 5 and 10 Hz) were observed during the large steam and large liquid break tests. They also observed that these frequencies vary during other tests. Therefore, the load specification frequency ranges, which were selected to conservatively bound the dominant frequency variances, are 4 to 8 Hz and 8 to 16 Hz.

Mr. Torbeck discussed briefly the FSTF test results pertinent to CO loads on submerged structures, downcomers and vent systems.

Mr. Torbeck reviewed the results of the FSTF tests conducted to gather data for use in the definition of chugging loads. He pointed out that among all the FSTF tests conducted, they observed chugging only during four of the tests. The FSTF blowdowns which simulated the small steam break accidents (Attachment G, page 6) produced the most severe chugging loads, and the data from these tests were used as a basis for chugging load specifications. He pointed out that the FSTF tests conducted with large steam and large liquid break accidents did not produce large chugging like behavior.

Mr. Torbeck stated that by comparing the pool temperature at the bottom of the downcomers with the average downcomer steam mass flux they were able to come up with a bounding value; this comparison also shows that chugging does not normally occur when the pool temperature is high (Attachment G, page 7). He pointed out that a comparison of the dynamic stresses obtained from the condensation oscillation (Large Liquid Break) test and the chugging (Small

Steam Break) test indicate that the condensation oscillations produce significant loads on the torus and downcomer structures and the chugging produces loads that are considerably lower than the condensation oscillations (Attachment G, page 8).

Indicating that the stiffness of the 22.5° sector of the torus which was used to run the FSTF tests is much different than that of a full-scale torus, Dr. Bush wondered how the stresses obtained by running tests in a 22.5° sector can be extrapolated to obtain stresses for the full-scale torus.

Analysis of Full Scale Test Facility for Condensation Oscillation Loading - Mr. Broman, Bechtel Power Corporation

Mr. Broman stated that, based on the comparison of the analytical data and test data, they observed that poor correlation exists between these two; subsequent evaluation of the test data and the structural analysis techniques indicated that the poor correlation was due to the effects of fluid structure interaction on measured wall pressures. Consequently, in September 1978, they have started the structural analysis of FSTF to:

1. extract rigid wall pressures from test data,
2. develop analytical techniques which will predict test results for structural response,
3. assess structural response based on LDR load definitions.

Mr. Broman discussed briefly the basic concepts of the structural analysis that was performed (Attachment G, page 9). He provided also a brief description of the overall procedure used in performing the analysis and of the work performed with respect to fluid structure interaction (Attachment G, page 10).

Mr. Broman reviewed the FSTF analytical model indicating that it is a finite element coupled fluid-structural model of the torus developed using NASTRAN computer program (Attachment G, page 11). He indicated that the FSTF analytical model was verified by the following methods (Attachment G, page 12):

1. Static check cases.
2. Comparison against the results of the shake tests which were performed using an eccentric mass shaker.

3. Comparison against the FSTF test data to determine the ability of the FSTF analytical model to predict FSTF structural response to condensation oscillation loading.

Mr. Broman pointed out that the results of the analysis indicated that the maximum difference between the flexible and rigid wall pressure occur in a frequency range of 16 to 17 Hz (Attachment G, page 13). He indicated that the same type of behavior was also observed during the shake tests.

With regard to the results of the verification performed by using the FSTF test data, Mr. Broman stated that such a verification indicated that the maximum contribution of the source to the cumulative axial membrane stress (total load) is negligible beyond a frequency range of about 30 Hz (Attachment G, page 14). Mr. Broman also pointed out that a comparison of the test data with the analytical data and the LDR data indicated that the analytical method is conservative with respect to the test data (Attachment G, page 15).

Condensation Oscillation Load Definition - Mr. Saxena, General Electric Company

Mr. Saxena reviewed breifly the approach used to develop the condensation oscillation load definition for Mark I torus shell (Attachment G, page 16). He stated that data from the entire condensation oscillation tests of the FSTF were examined and the large liquid and large steam break test runs were selected to obtain data base. The highest pressure amplitude was observed to occur during the large liquid break test. From the large liquid and steam break tests maximum pressure amplitude data segments were selected as data base for use in the load definition (Attachment G, page 17). He discussed briefly the steps taken to reduce the FSTF test data for use in the Mark I torus shell load definition (Attachment G, pages 18 and 19).

Mr. Saxena pointed out that, based on the evaluation of appropriate FSTF test data, they have selected a bounding frequency range to cover the range of frequencies expected in all Mark I plants. The load specification frequency ranges, which were selected to bound conservatively the dominant frequency variances are 4 to 8 Hz and 8 to 16 Hz. For a plant unique structural evaluation, the structural response from each 1 Hz band between 0 and 50 Hz has been analyzed and summed to get the total response. The 0 to 50 Hz total range analyzed would include the frequency spectrum of 4 to 16 Hz range which produces the maximum response.

Mr. Saxena indicated that in order to apply the FSTF data in plant unique geometries, adjustments were made to:

1. account for fluid structure interaction effects in the FSTF data, and
2. account for the differences in the ratio of the pool surface area to vent cross sectional area among the Mark I plants.

Mr. Saxena stated that the Mark I Owners Group believes that the condensation oscillation load definition for Mark I torus shell has been developed conservatively using appropriate FSTF test data and analytical techniques.

Indicating that the fluid structure interaction factor used in the load definition analysis was unique to the FSTF facility, Dr. Zudans asked how such a factor could be used in developing plant-specific loads.

Mr. Broman responded that the main objective of the fluid structure interaction analysis performed on FSTF was to develop a rigid wall load which would not include the fluid structure interaction effects that are unique to a specific Mark I plant. Therefore, every Mark I plant analysis should include the fluid structure interaction effects unique to that specific plant.

<u>TORUS SHELL CONDENSATION LOAD ASSESSMENT - DR. BRENNEN, NRC CONSULTANT</u>

Dr. Brennen reviewed the NRC Staff's position with regard to the condensation oscillatin load definitions and their concerns on the adequancy of the data base used by the Mark I Owners Group in developing the condensation oscillation load definitions.

Dr. Brennen stated that condensation oscillation loads refer to the oscillatory pressure loads imparted to structures due to the unsteady transient behavior of the steam released during a LOCA, occuring near the end of the downcomers. The phenomenon of unsteady condensation involves an unsteady turbulent two-phase flow. He believes that it is very difficult to model such flows through analytical methods. Therefore, the Mark I Owners Group has developed the condensation oscillation load definition based on the results of some tests conducted in FSTF.

Dr. Brennen pointed out that the maximum condensation oscillation loads in FSTF were found to occur during the large liquid break test. The Mark I Owners Group has conducted only one such large liquid break test and based on the results of that one test, they have developed the condensation oscillation load definitions. The NRC Staff believes that the large liquid break test conducted by the Mark I Owners Group provides only one data point; therefore, they believe that statistical variance or load magnitude uncertainty cannot be established with adequate accuracy from a single test run. The NRC Staff believes that the data base used by the Mark I Owners Group for defining the condensation oscillation loads is inadequaate to establish a reasonable measure of the uncertainty in the loading functions.

Dr. Brennen stated that the NRC Staff's position on the condensation oscillation load definition is that they accept the loads developed by the Mark I Owners Group with the condition that each Mark I licensee should perform additional FSTF tests to establish the uncertainty in the condensation oscillation loads and confirm the adequacy of the load specifications.

In response to a question from Dr. Zudans as to whether the NRC Staff expects to get significantly different data from the additional tests, Dr. Brennen stated that there may not be any significant difference; however, until additional tests are run, they may not be able to assure that adequate conservatism exists in the data base used by the Mark I Owners Group in developing the condensation oscillation loads.

Dr. Zudans expressed his personal opinion indicating that the large liquid break test conditions are prototypical for the Mark I design and therefore, he believes that additional tests are not necessary.

Mr. Grimes stated that the NRC Staff's position at this time is that each Mark I licensee should conduct additional FSTF tests to establish the uncertainty levels in the condensation process to assure conservatism and minimum required level of safety in the containment design. However, if the ACRS provides other types of guidance in resolving this matter, the NRC Staff will give consideration.

In response to a question from Dr. Catton regarding the type of additional tests required by the NRC Staff, Mr. Grimes stated that the Mark I licensees should conduct two additional large liquid break tests in the FSTF.

In response to a question from Dr. Bush as to what the NRC Staff would do if the additional two tests show lesser condensation loads, Mr. Grimes stated that they may ask the Mark I Owners Group to submit a proposal for reducing the condensation oscillation loads in accordance with the additional test data.

Mr. Logue, Chairman of the Mark I Owners Group, expressed his concern about the NRC Staff's requirement for additional tests indicating that the additional tests required by the NRC Staff will have significant impact on the cost and schedule for completion of the Mark I plant modifications. He believes that the NRC Staff has never specified that only two additional large liquid break tests are necessary. He is also concerned about the fact that if the results of the additional tests differ from the results of the test already conducted, the NRC Staff may ask for reasons for such differences and may even ask for more tests; it seems like this is going to be an indefinite process.

Dr. Plesset stated that he does not believe that the NRC Staff will be unreasonably requiring more and more FSTF tests from the Mark I Owners.

Mr. Sobon from GE commented that he does not believe that there is a need for additional FSTF tests if consideration is given to the following factors:

1. In the FSTF tests and analytical methods for predicting the containment response, the Mark I Owners Group has ignored the

contribution of heat sink in the drywell to the mass flux of the vent system. He believes that, during the initial phase, the heat sink will absorb some of the energy thus reducing the mass flux of the vent syste for a short period of time.

2. The configuration of the FSTF is made in such a way to purge the air in the drywell in a very short period of time. In view of the fact that any air content in the steam condensation phase would tend to reduce the pressure amplitudes, the quick purging of the air increases the pressure amplitude.
3. The load specification includes the summation of the amplitude from each 1 Hz frequency band between 0 and 50 Hz range; the loads defined in this way are about three times higher than those observed in the FSTF tests.

Mr. Sobon stated that all the above factors coupled together will form a basis to preclude the need for any additional FSTF tests.

DOWNCOMER CONDENSAT'ON LOAD DEFINITION - MR. BROMAN, BECHTEL POWER CORPORATION

Mr. Broman reviewed the work that is underway to reevaluate the downcomer loads during condensation oscillation. He pointed out that this work is being carried out as a result of the concerns expressed by the NRC Staff about the FSTF test data used in defining the downcomer condensation oscillation loads.

Mr. Broman stated that the main approach is to postulate a load definition, based on pressure data measured during the large liquid break FSTF test, for the downcomers during condensation oscillation; this postulated load definition will be analyzed using NASTRAN finite element computer model. Analytical model will be developed to simulate the downcomer configuration as used in the large liquid break FSTF test. The analytical model will be verified using "Jacking" and "Snap" tests of the downcomers (Attachment H, page 1). The results obtained through the analytical method will be compared with the large liquid break FSTF test data to determine the appropriateness of the postulated downcomer condensation oscillation load definition; if there seems to be an improper correlation, the Mark I Owners Group will look at phasing between pressures in adjacent downcomers.

In response to a question from Dr. Zudans with regard to the effects of bending, caused by pressure imbalance outside of downcomers, on the downcomer loads, Mr. Torbeck stated that they do not expect much pressure variation around the downcomers as a result of condensation oscillation.

DOWNCOMER CONDENSATION LOAD ASSESSMENT - MR. GRIMES, NRC STAFF

Condensation Oscillation Loads on Untied Downcomers

Mr. Grimes stated that, based on the review of the information provided in the Mark I LDR with regard to the condensation oscillation loads for "untied" downcomers, the NRC Staff requires that a more accurate determination of the FSTF downcomer response characteristics (natural frequency and damping) should be developed to assure a conservative dynamic load factor scaling. In view of the fact that a frequency of 5.5 Hz is observed to be the natural swinging mode of the downcomers, the driving frequency for the FSTF plant unique dynamic load factor should be assumed to be 5.5 Hz. The NRC Staff believes that, with the correction mentioned above, the proposed Mark I LDR specification will provide a conservative estimate of the condensation oscillation loads on "untied" downcomers.

Condensation Oscillation Loads on Tied Downcomers

Mr. Grimes stated that the results of the comparison of loading conditions observed in "tied" and "untied" downcomers in the FSTF indicated that the strain measurements observed in the "tied" downcomers were significantly lower than those for the "untied" downcomers. Based on a detailed analysis of the downcomer-vent header system, the Mark I Owners Group provided the reasoning for the differences indicating that the downcomer loads during condensation oscillations were primarily an in-phase vertical thrust load caused by the pressure oscillations inside the downcomer, with only a small lateral loading contribution. However, the NRC Staff believes that the existing information seems to be inadequate to provide answer to the question about how well the pressure inside the downcomers are phased to establish a load definition. Therefore, they require that an improved load definition for the "tied" downcomers be developed from the FSTF data.

Chugging Loads on Untied Downcomers

Based on the review of the information provided by the Mark I Owners Group with regard to the "untied" downcomer chugging loads, the NRC Staff believes that the proposed Resultant Static Equivalent Load (RSEL) spectra, as applied to the "untied" downcomers, is acceptable with the following exceptions:

1. The load specification should be based on the maximum measured RSEL load in the FSTF.
2. The fatigue loading analysis for each downcomer shall be based on a statistical loading with a 95% non-exceedance probability.
3. The multiple-downcomer loading to assess statistical directional dependence shall be based on a probability of exceedance of 10^{-4} per LOCA.

Chugging Loads on Tied Downcomers

With regard to the chugging loads on "tied" downcomers, Mr. Grimes stated that the NRC Staff's criteria require the following:

1. The Mark I LDR should specify adequately a procedure for deriving the strain in the tie bar between a downcomer pair.
2. The load direction shall be taken as that which results in the worst loading for the tie bar and its attachments to the downcomers.

MARK I OWNERS PERSPECTIVE - MR. LOGUE, (MARK I OWNERS GROUP CHAIRMAN) PHILADELPHIA POWER & ELECTRIC COMPANY

Mr. Logue, Chairman of the Mark I Owners Group, reviewed briefly the status of the Mark I containment program and the efforts taken by the Mark I Owners Group to resolve several of the concerns expressed by the NRC Staff. He stated that Part A of the Mark I LDR was issued in December 1978 and Part B which includes some revisions was issued in March 1979. Since the issuance of Part B of the LDR, the Mark I Owners Group has met with the NRC Staff several times to resolve the dissenting technical views between the NRC Staff and the Mark I Owners Group. Subsequent to the issuance of NRC Staff's draft acceptance criteria for Mark I containment program in October 1979, the Mark I Owners have planned to make several modifications to their plants (Attachment I).

With regard to the NRC Staff's acceptance criteria on Mark I containment program, Mr. Logue indicated that the Mark I Owners Group has several dissenting views. They have been trying to resolve these technical differences. He believes that the additional requirements of the NRC Staff will have significant impact on the overall cost and schedule for completion of the plant modifications. He believes that the Mark I containment loads are conservatively defined in the Mark I LDR and continuous additions of conservatism are unwarranted; adoption of overly conservative criteria as proposed by the NRC Staff would be counter-productive to the completion of Mark I containment program. A summary of Mark I Owners Position is included in Attachment I, page 3.

SUBCOMMITTEE REMARKS

Subsequent to hearing the scheduled presentations from the Mark I Owners Group and the NRC Staff, Dr. Plesset solicited comments from the Subcommittee and its consultants.

Dr. Bush suggested that clear identification of the symbols and acronyms used in the Mark I containment program reports would be helpful.

Mr. Grimes stated that they plan to include identification of all the acronyms and symbols pertinent to Mark I containment program in a separate NUREG document.

Indicating that several statistical studies show that the probability of occurrence of the DBA break is about two to three orders of magnitude less than that of the intermediate break, Dr. Bush suggested that serious consideration should be given to the relative probabilities of break sizes in analyzing the overall load situation.

Dr. Plesset stated that the Fluid Dynamics Subcommittee will give its report on the Mark I containment long-term program to the ACRS full Committee in the near future.

The meeting was adjourned at 4:45 p.m.

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NOTE: For additional details, a complete transcript of the meeting is available in the NRC Public Document Room, 1717 H St., N.W., Washington, D.C. 20555, or from Ace-Federal Reporters, Inc., 444 North Capital Street, N.W., Washington, D.C.

OCS
(B) Federal Consistency Issues
(C) OCS Lands Act Implementation
(D) OCS Lease Sale Update

For information contact: Alan Powers, 202/343-9314.)

(2) OCS Advisory Board (Plenary Session)
(A) OCS and the Nation's Energy Goals
(B) Role of the OCS Advisory Board
(C) Mexican Oil Spill

For information contact: Alan Powers, 202/343-9314.)

(3) Scientific Committee
(A) Use of Environmental Studies Information in the OCS Leasing Process
(B) Roles of the Scientific Committee
(C) Relationship between "Effects" Studies and Socio-Economic Evaluations
(D) Georges Bank Biological Task Force

For information contact: Piet deWitt, 202/343-7744.)

(4) North and Mid-Atlantic Technical Working Groups
(A) Studies Relating to OCS Oil and Gas Activities
(B) Re-programming of CEIP Funds for OCS State Participation Grants
(C) FY 81 Regional Studies Plan

For information contact: Dick Wildermann, 212/264-2960.)

(5) South Atlantic and Gulf Technical Working Groups
(A) Proposed FY 81 Regional Studies Plans
(B) Review of the Proposed CY 1980 IPP Activities
(C) Role of the Regional Technical Working Groups

For information contact: Sydney Verinder, 504/589-6541.)

(6) Pacific Technical Working Group
(A) FY 1981 Studies Plan
(B) Regional Working Group Schedule for FY 1980

For information contact: Ellen Aronson, 213/688-7234.)

(7) Alaska Technical Working Group
(A) Scoping Meeting for Lease Sale #60
(B) Sale Notice Overview for Beaufort Sea Sale Notice for Lease Sale
(C) Recap of Call for Nominations for Lease Sales #57 and #70

For information contact: Gordy Evler, 907/276-2955.)

The meeting is open to the public. Those persons who are interested may make oral or written statements to a Committee. Such requests should be made to the contact listed for each particular committee. Requests should be made no later than November 23, 1979.

Minutes for the OCS Policy Committee and the OCS Advisory Board Plenary Session will be available for public inspection and copying at the Office of OCS Program Coordination, Room 5150, Department of the Interior, Washington, D.C.

Minutes for the Scientific Committee and the Regional Technical Working [illegible] inspection and copying [illegible] Bureau of Land Management, Department of the Interior, Washington, D.C. or the appropriate Bureau of Land Management OCS Field Offices. Availability of the minutes will be eight weeks after the meeting.

Dated: October 29, 1979.

Alan D. Powers,

Director, Office of OCS Program Coordination.

[FR Doc. 79-33708 Filed 10-31-79; 8:45 am]

BILLING CODE 4310-10-M

INTERNATIONAL DEVELOPMENT COOPERATION AGENCY

Agency for International Development

Privacy Act of 1974, Systems of Records; Annual Publication

AGENCY: Agency for International Development, International Development Cooperation Agency.

ACTION: Systems of Records: Annual Publication.

The Privacy Act of 1974 (5 U.S.C. 552a (e)(4)) requires agencies to publish annually in the Federal Register a notice of the existence and character of their systems of records. The Agency for International Development last published the full text of its systems of records at 42 FR 47371, September 20, 1977. No further changes have occurred, therefore, the systems of records remain in effect as published.

The full text of the Agency for International Development systems of records also appears in Privacy Act Issuances, 1978 Compilation, Volume III, page 692. This volume may be ordered through the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. The price of this volume is $10.25.

James L. Harper,

Privacy Act Officer, Office of Public Affairs.

[FR Doc. 79-33802 Filed 10-31-79; 8:45 am]

BILLING CODE 4710-02-M

NUCLEAR REGULATORY COMMISSION

Advisory Committee on Reactor Safeguards Subcommittee on Fluid Dynamics; Meeting

The ACRS Subcommittee on Fluid Dynamics will hold a meeting on November 16, 1979, at the Barrett Hotel, 501 Post Street, San Francisco, CA to continue its review of topics related to the BWR Mark I Containment Long-Term Program and the NRC Acceptance [illegible] Notice of this meeting was published October 18, 1979 (44 FR 60278).

In accordance with procedures outlined in the Federal Register, Oct. 1, 1979 (44 FR 56408), oral or written statements may be presented by members of the public, recordings will be permitted only during those portions of the meeting when a transcript is being kept, and questions may be asked only by members of the Subcommittee, its consultants, and Staff. Persons desiring to make oral statements should notify the Designated Federal Employee as far in advance as practicable so that appropriate arrangements can be made to allow the necessary time during the meeting for such statements.

The agenda for subject meeting shall be as follows:

Friday, November 16, 1979

8:30 a.m. Until the Conclusion of Business

The Subcommittee may meet in Executive Session, with any of its consultants who may be present, to explore and exchange their preliminary opinions regarding matters which should be considered during the meeting and to formulate a report and recommendations to the full Committee.

At the conclusion of the Executive Session, the Subcommittee will hear presentations by and hold discussions with representatives of the NRC Staff, the Mark I Owners Group, the General Electric Company, and their consultants, pertinent to this review.

In addition, it may be necessary for the Subcommittee to hold one or more closed sessions for the purpose of exploring matters involving proprietary information. I have determined, in accordance with Subsection 10(d) of Pub. L. 92-463, that, should such sessions be required, it is necessary to close these sessions to protect proprietary information (5 U.S.C. 552b(c)(4)).

Further information regarding topics to be discussed, whether the meeting has been cancelled or rescheduled, the Chairman's ruling on requests for the opportunity to present oral statements and the time allotted therefor can be obtained by a prepaid telephone call to the Designated Federal Employee for this meeting, Dr. Andrew L. Bates, (telephone 202/634-3267) between 8:15 a.m. and 5:00 p.m., EST.

ATTACHMENT A

ACRS SUBCOMMITTEE MEETING ON
FLUID DYNAMICS
NOVEMBER 16, 1979
SAN FRANCISCO, CALIFORNIA

Attendees List

ACRS

M. Plesset, Chairman
H. Etherington, Member
I. Catton, Consultant
Z. Zudans, Consultant
S. Bush, Consultant
V. Schrock, Consultant
A. Bates, Staff*
S. Duraiswamy, Staff

*Designated Federal Employee

GE

V. S. Tashjian
A. Mukherjee
R. M. Nelson
G. E. Wade
J. S. Gay
L. J. Sobon
B. W. Smith
L. D. Steiner
T. J. Mulford
B. Kohrs
J. Torbeck
U. Saxena

ACUREX

W. S. Kennedy (GE Consultant)

DETROIT EDISON

D. F. Lehnert

NUTECH

A. F. Deardorff
G. R. Edwards

NRC

C. Brennen, Consultant
C. I. Grimes, DOR
S. H. Hanauer
E. G. Adensam
J. R. Fair, DOR
R. L. Cudlin
R. Kosson, Consultant

MIT

A. A. Sonin (NRC Consultant)

BNL

J. D. Ranlet
J. R. Lehner (NRC Consultant)

PHILA ELEC CO

R. H. Logue

TOSHIBA CO

Y. Takizawa

BECHTEL

R. Broman

ATTACHMENT B

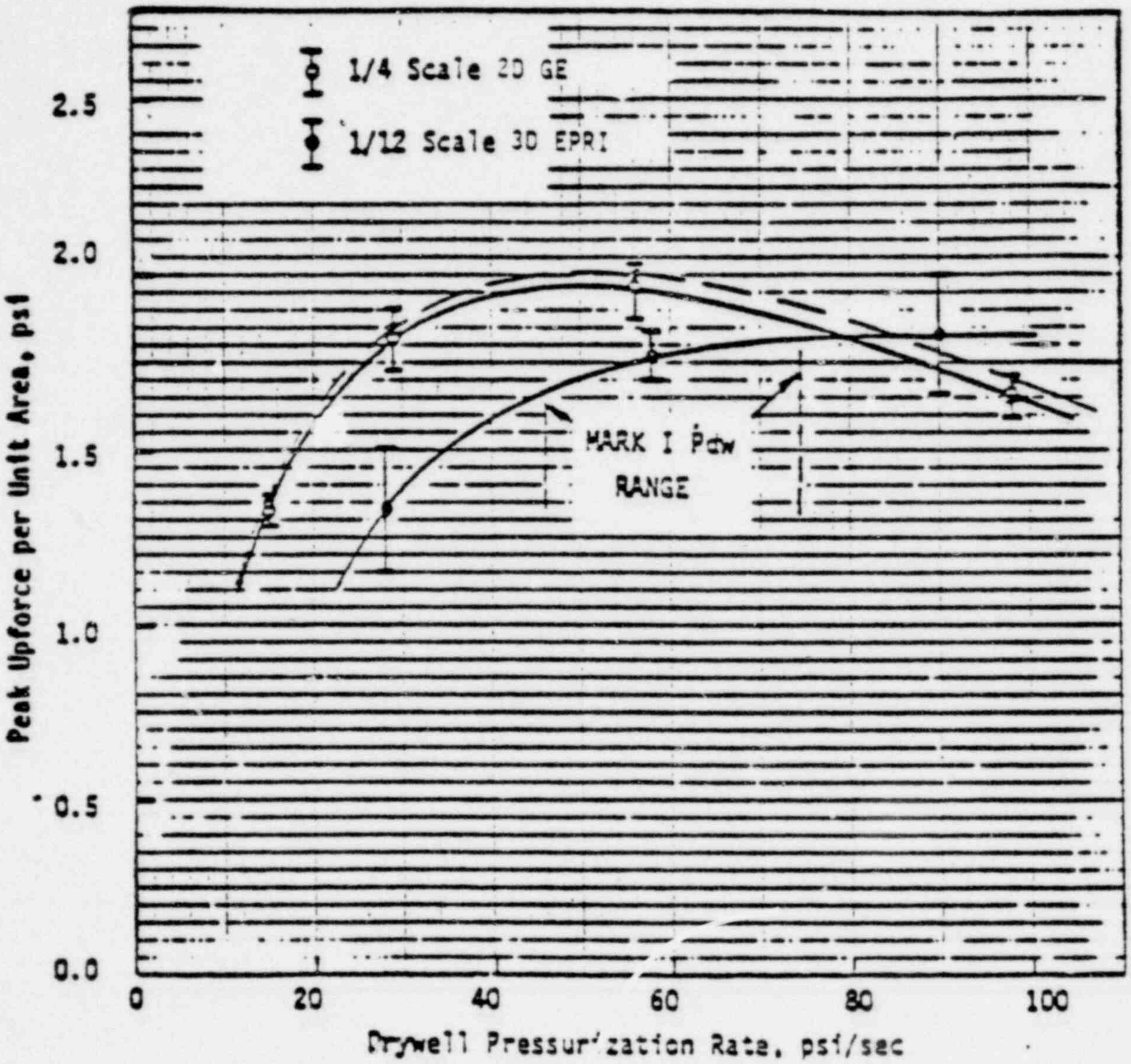
ACRS FLUID DYNAMICS SUBCOMMITTEE

BARRETT MOTOR HOTEL - SAN FRANCISCO

NOVEMBER 16, 1979

8:30AM - ACRS Opening Comments		
8:45AM - Mark I Long Term Program Status	(NRC)	Grimes
9:00AM - Pool Swell Testing Programs & Load Definition Methodology	(GE/Mk I Owners)	TASHJIAN
9:30AM - Net Vertical Pressure Load Data Comparisons	(NRC)	Ranlet
10:00AM - Pool Swell Flow Distribution Effects	(NRC)	Kosson
10:30AM - Vent Header Deflector Load Definition	(GE/Mk I Owners)	Bill Kennedy
11:15AM - Deflector Load Data Assessment	(NRC)	Dr. Sonin
12:00PM - LUNCH		
1:00PM - FSTF Torus Shell Pressures & Load Definition Bases	(GE/Mk I Owners)	John TORBECK, RANDY BROMAN, UMESH SAXENA
2:00PM - Torus Shell Condensation Load Assessment	(NRC)	Dr. Brennen
2:45PM - Downcomer Condensation Load Definition	(GE/Mk I Owners)	RANDY BROMAN
3:30PM - Downcomer Condensation Load Assessment	(NRC)	Grimes
4:15PM - Summary	(GE/Mk I Owners)	BOB LOGUE
5:00PM - Adjourn		

ATTACHMENT C

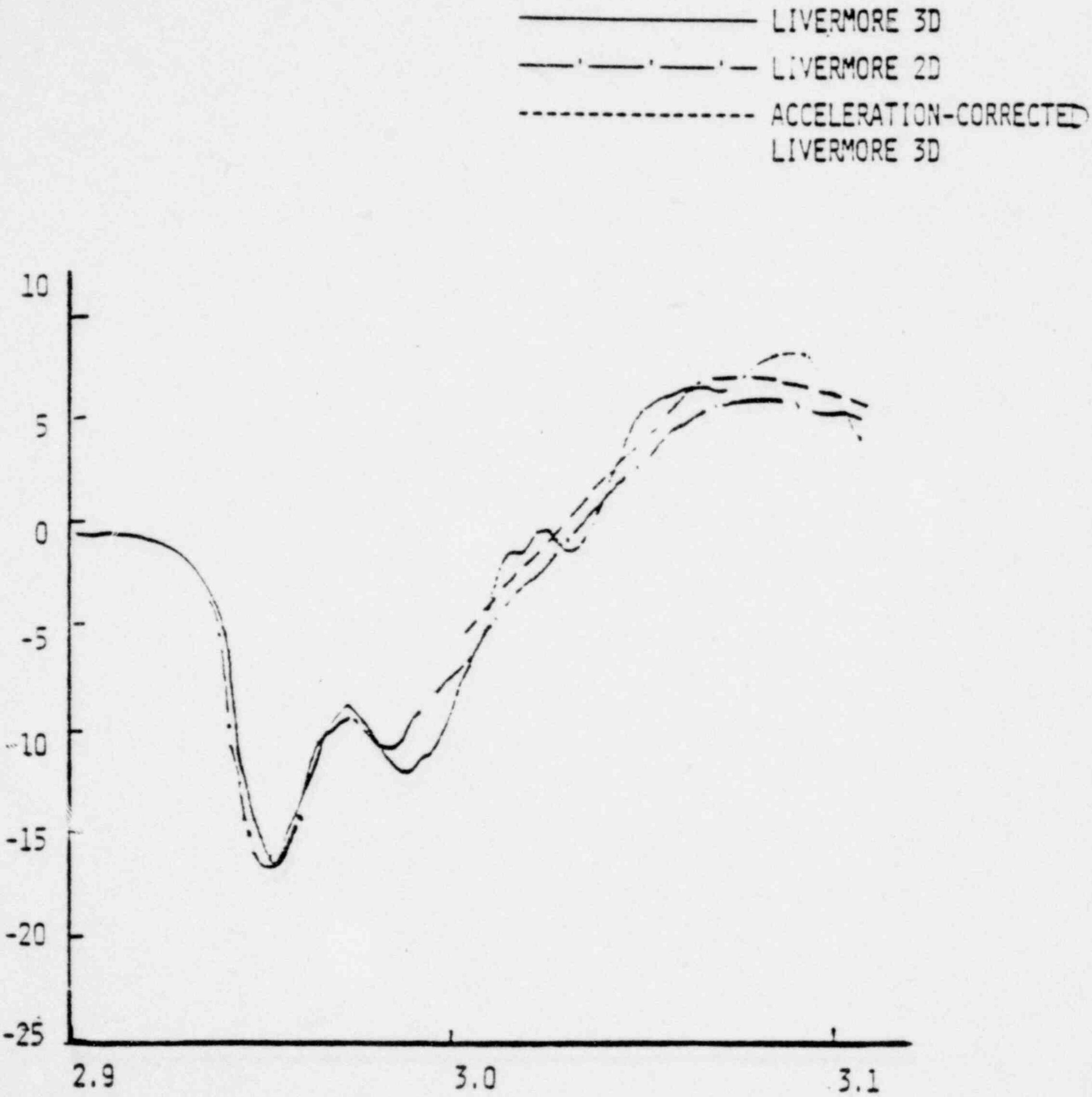


COMPARISON OF PEAK UPFORCES BETWEEN
1/4 SCALE AND 1/12 SCALE

VST - 12
11/16/79

ATTACHMENT D

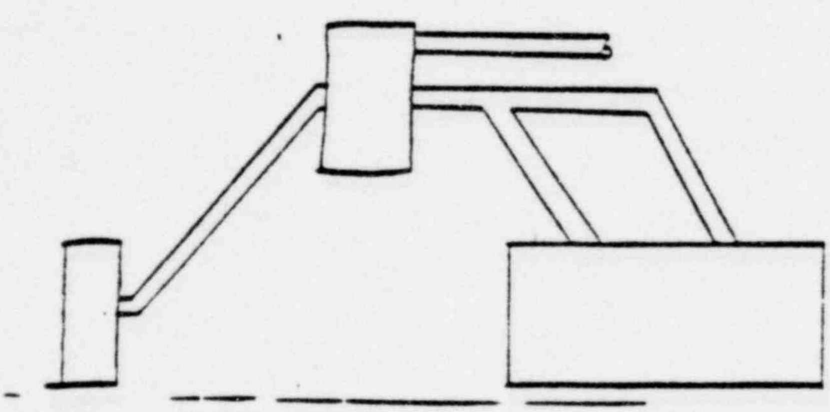
EFFECT OF STRUCTURAL OSCILLATION ON LIVERMORE 3D/2D UPLOAD RATIO



VST - 17
11/16/79

LIVERMORE 2D-3D FACILITY INTERACTION

- COUPLED DRYWELL ENSURES COMMON DRIVING CONDITIONS
- COUPLED DRYWELL PERMITS 2D-3D FACILITY INTERACTION

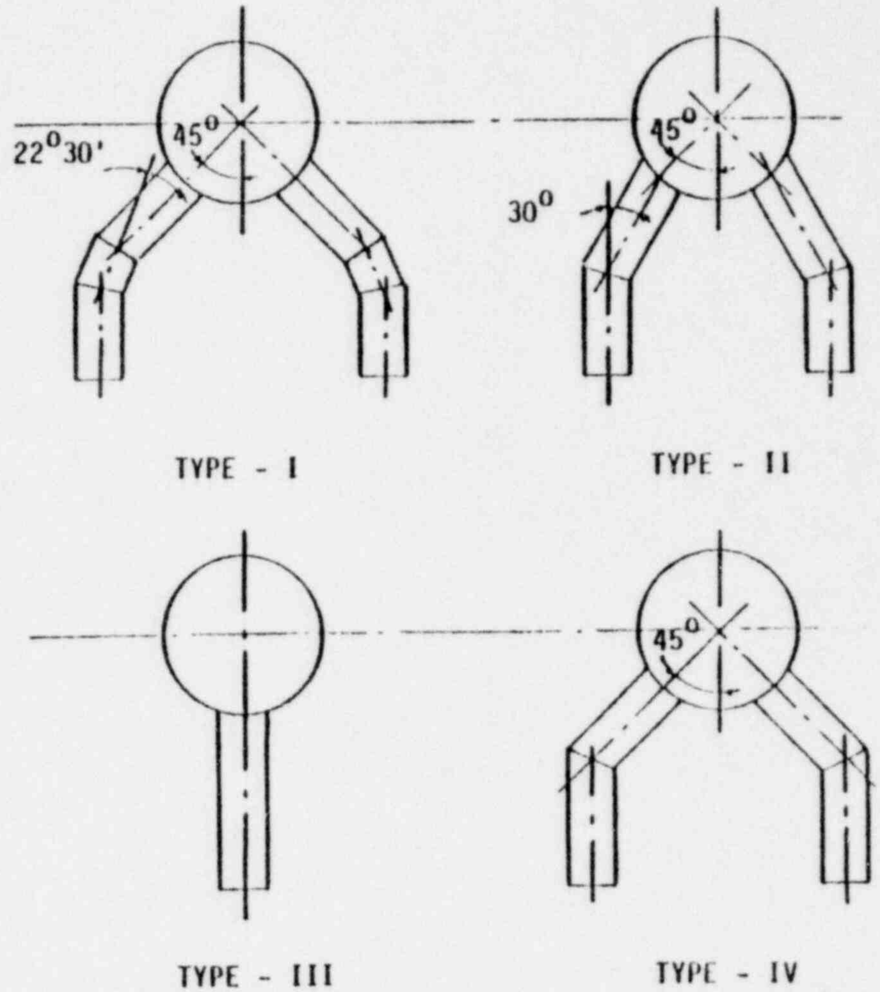


- CONTROL OF INITIAL CONDITIONS EXTREMELY IMPORTANT
  - LARGE FACILITY WILL CONTROL DRYWELL PRESSURE
  - SMALL FACILITY PHENOMENA CAN BE AFFECTED

VST - 16
11/16/79

DOWNCOMER TYPES

Plant	Type	Number of Downcomers
Browns Ferry 1, 2, 3	IV	96
Brunswick 1 & 2	II	96
Cooper Station	II	80
Dresden 2 & 3	II	96
Duane Arnold	III	48
Fermi 2	II	80
Fitzpatrick	II	96
Hatch 1 & 2	II	80
Hope Creek 1 & 2	II	80
Millstone	II	96
Monticello	II	96
Nine Mile Point 1	I	120
Oyster Creek 1	I	120
Peach Bottom 2 & 3	II	96
Pilgrim	II	96
Quad Cities 1 & 2	II	96
Vermont Yankee	II	96



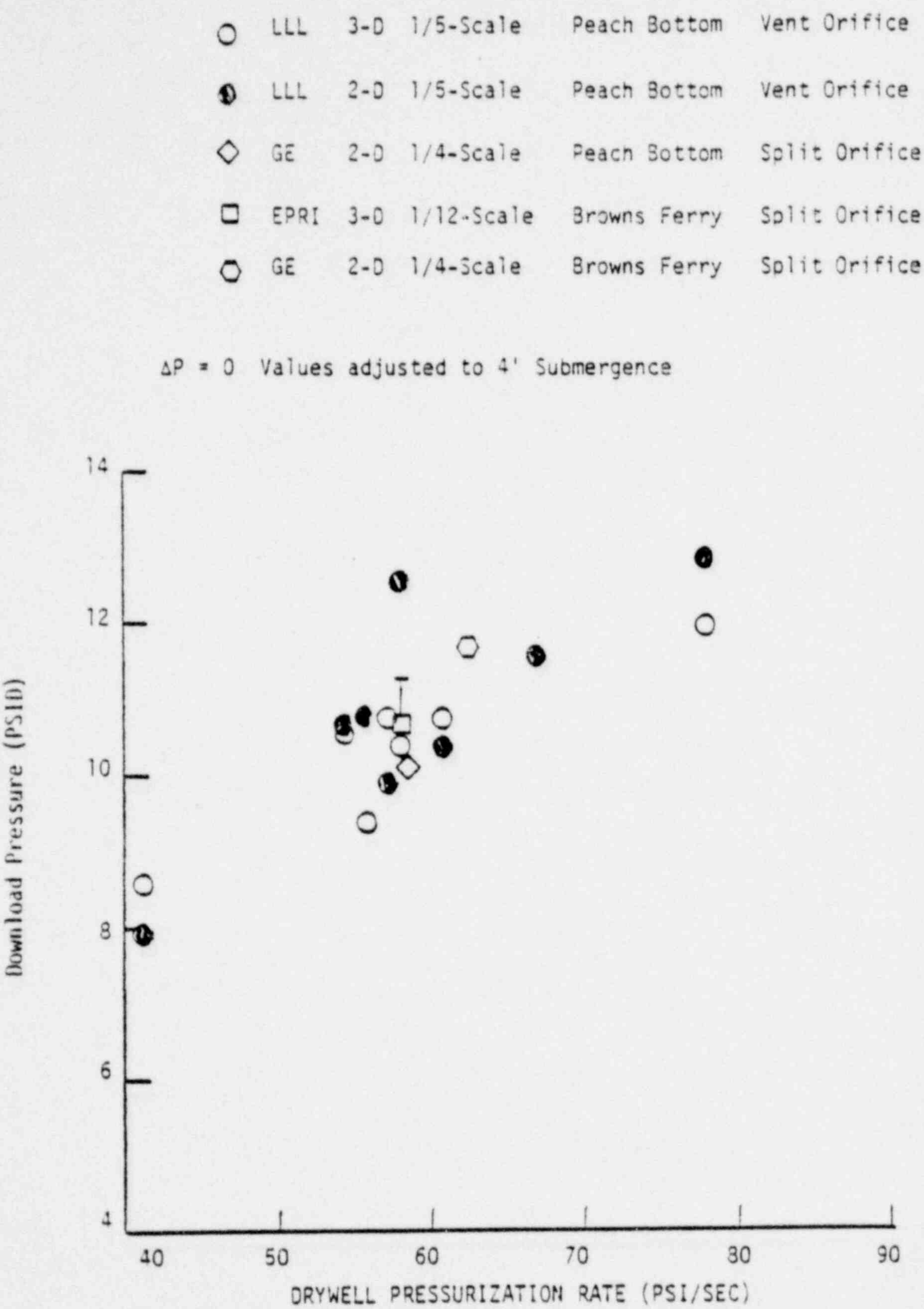


FIGURE 4. Full-Scale Equivalent Download Pressure as a Function of Drywell Pressurization Rate (Zero ΔP, 4 ft. Submergence)

UNCERTAINTIES ASSOCIATED WITH DOWNCOMER ORIFICES

1) FLOW CALIBRATIONS WERE DONE "DRY", WITH UNIFORM EXIT PRESSURE AT ALL DOWNCOMERS. DURING EARLY BUBBLE GROWTH, BUBBLE PRESSURE CAN VARY FROM ONE DOWNCOMER TO THE NEXT.

2) DOWNCOMER PAIR #3, WHICH HAS THE LOWEST FLOW RESISTANCE, HAS THE SMALLEST POOL AREA AND THE HIGHEST BUBBLE PRESSURE DURING EARLY BUBBLE GROWTH.

3) "T" LOSSES WITHIN VENT SYSTEM VARY WITH FLOW SPLIT AMONG DOWNCOMER PAIRS.

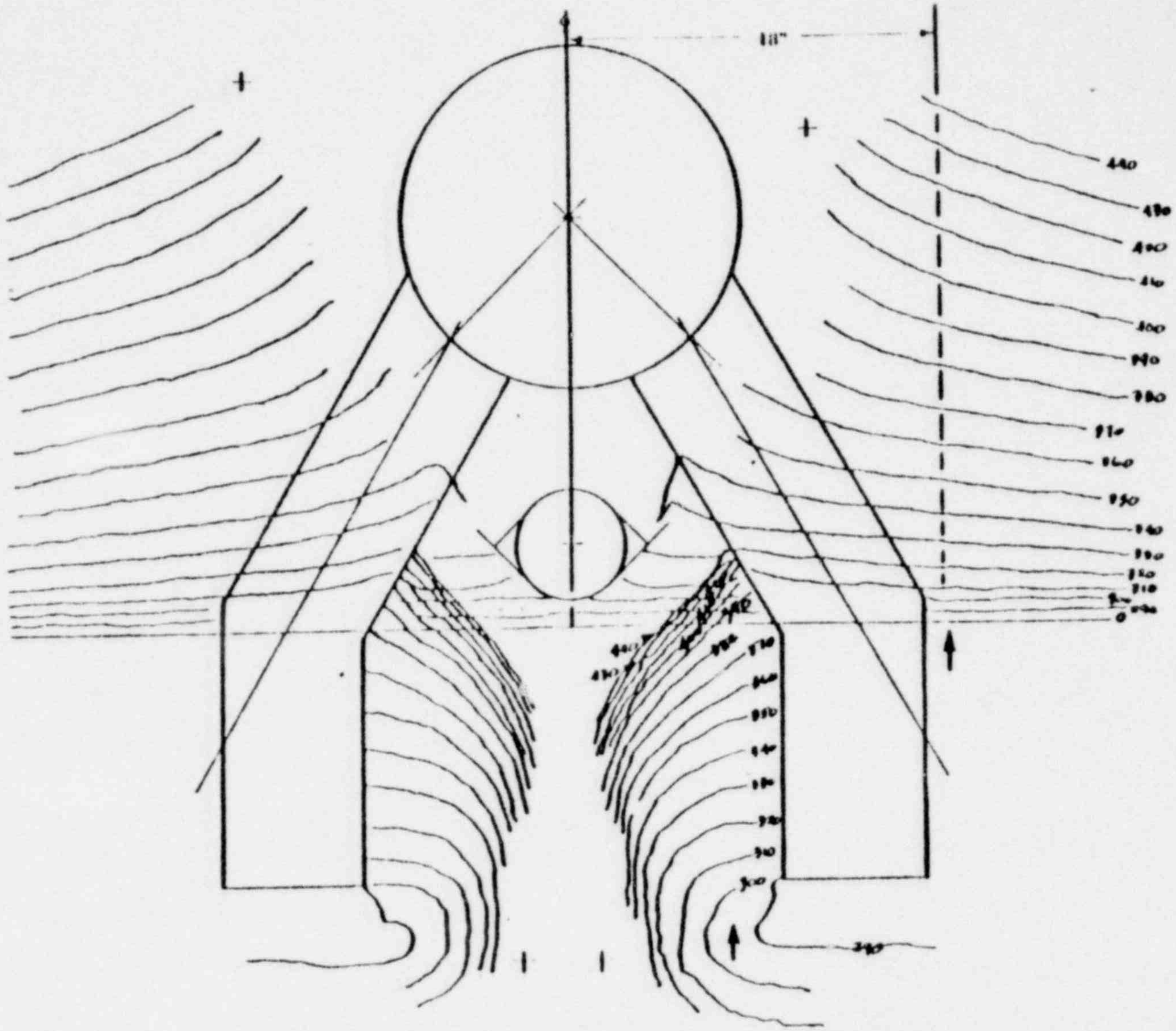
4) ANALYTICAL CALCULATIONS INDICATE MORE UNIFORM FLOW RESISTANCE WHEN INDIVIDUAL DOWNCOMER FLOWS (DUE TO DIFFERENCES IN BUBBLE PRESSURE) ARE MORE UNIFORM.

RLK/5

11/16/79

BROOKHAVEN NATIONAL LABORATORY
ASSOCIATED UNIVERSITIES, INC.

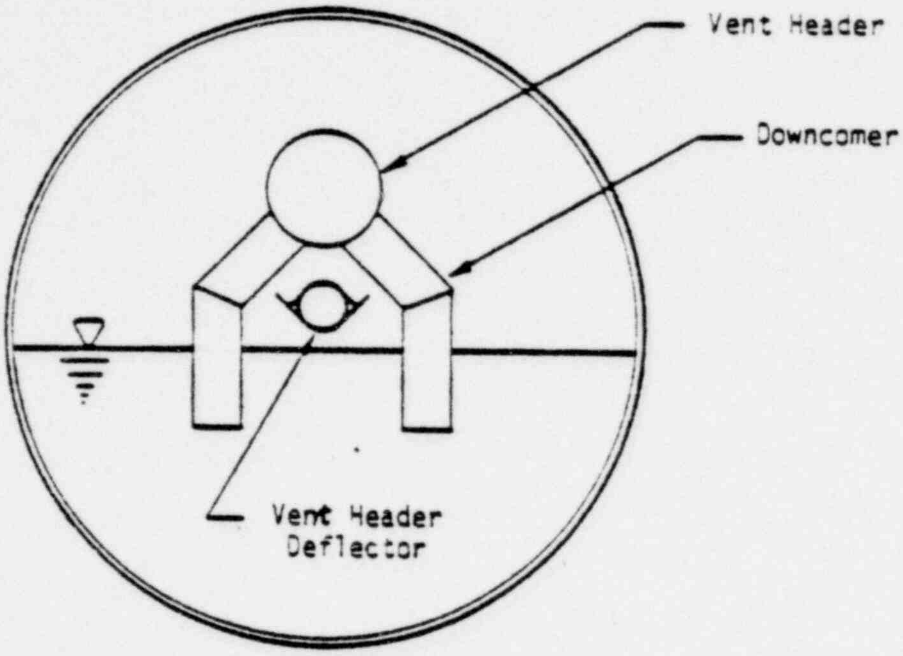
ATTACHMENT E - 1



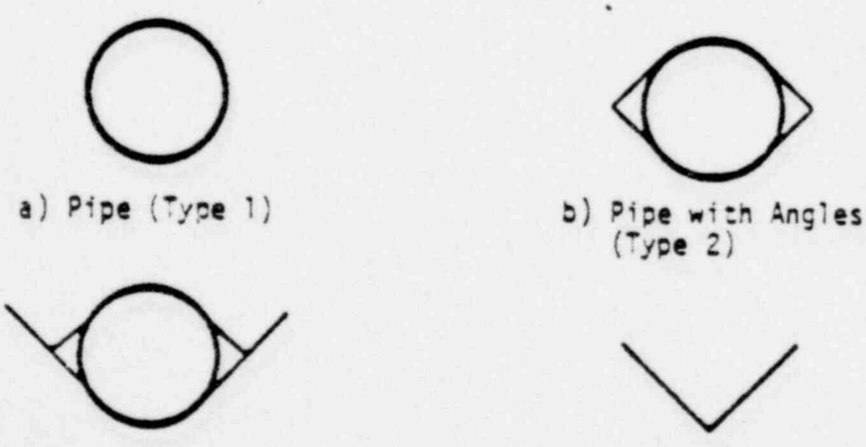
Pool and Bubble Profiles from High-Speed Motion Pictures

ATTACHMENT F

F-1



Typical Vent Header Deflector



RANGE OF PARAMETERS
INFLUENCING DEFLECTOR LOADS
(FULL SCALE VALUES)

	DEFLECTOR LOADS MEASURED IN QSTF (6 PLANTS - 12 CONFIGURATIONS)	REMAINING PLANTS FOR WHICH DATA IS NOT AVAILABLE (7 PLANTS
1) CLEARANCE (IN) (DISTANCE FROM BOTTOM OF DEFLECTOR TO WATER SURFACE)	0 - 21.05	0 - 14.29
2) DEFLECTOR WIDTH (IN)	25.3 - 30.0	20.0 - 26.0
3) $\dot{P}$ (PSI/SEC)	46.1 - 74.0	54.4 - 74.7
4) DOWNCOMER SUBMERGENCE (FT)	3.0 - 4.25	3.33- 4.4

F-3

ACUREX Corporation

LOAD PREDICTION METHODOLOGY

II) LOAD PREDICTION

- LOAD CONSISTS OF IMPACT, ACCELERATION DRAG, BOUYANCY AND "STEADY" DRAG
- IMPACT AND STEADY DRAG CALCULATED BY:

$$D_1 = C_D\,(Y)\,A\,q$$

WHERE $C_D\,(Y)$ = IMPACT & "STEADY" DRAG COEFFICIENT AS A FUNCTION OF DEFLECTOR IMMERSION DEPTH, Y.

A = DEFLECTOR PROJECTED AREA

q = DYNAMIC PRESSURE OF WATER SURFACE = $\frac{1}{2}\rho V^2$

- ACCELERATION DRAG & BOUYANCY CALCULATED BY:

$$D_2 = (M_H(Y) + M_D\,(Y))\dot{V} + M_D\,(Y)g$$

WHERE $M_H(Y)$ = HYDRODYNAMIC MASS OF DEFLECTOR AS A FUNCTION OF Y

$M_D(Y)$ = DISPLACED WATER MASS OF DEFLECTOR AS A FUNCTION OF Y

$\dot{V}$ = ACCELERATION OF WATER SURFACE

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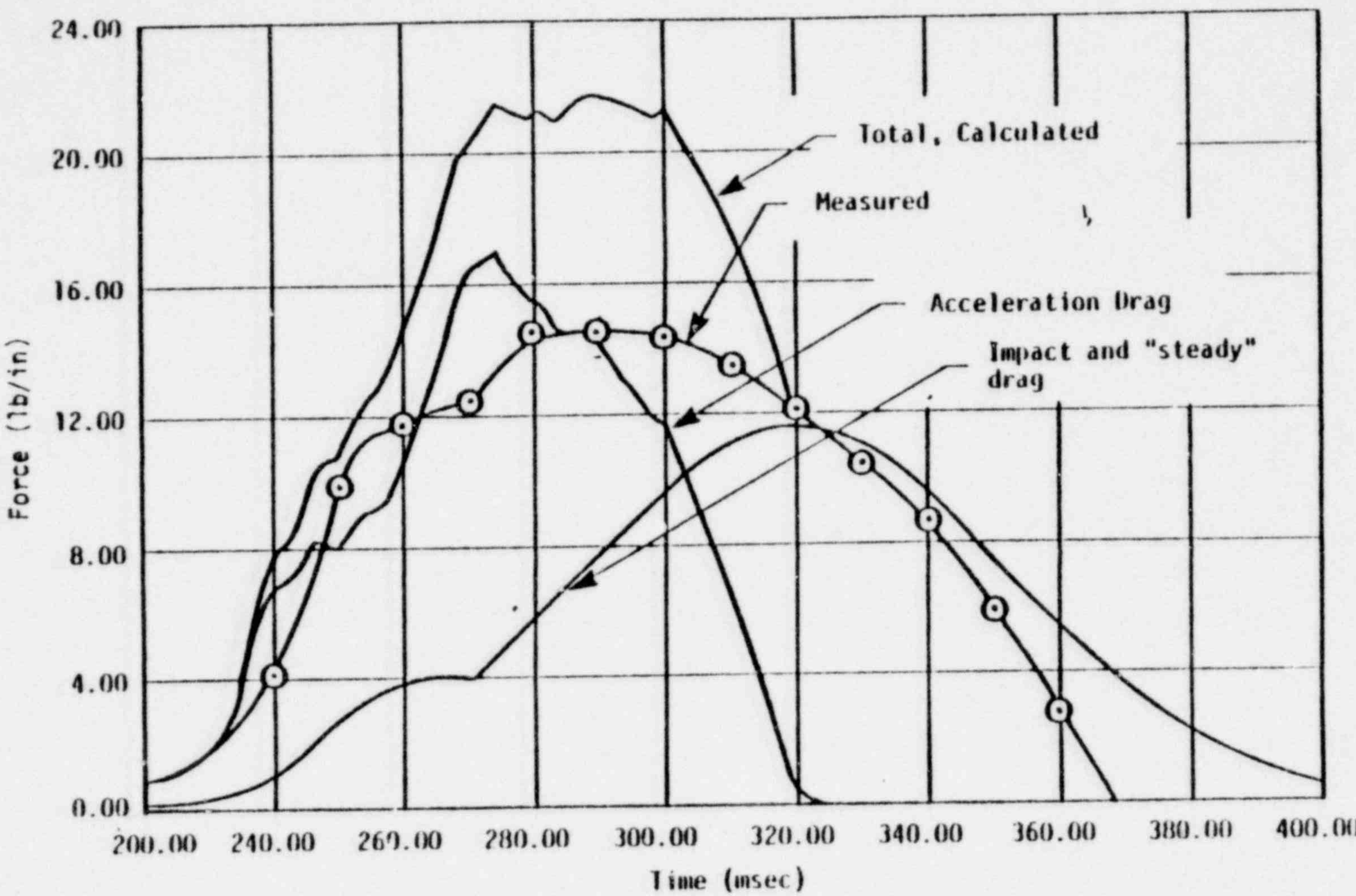
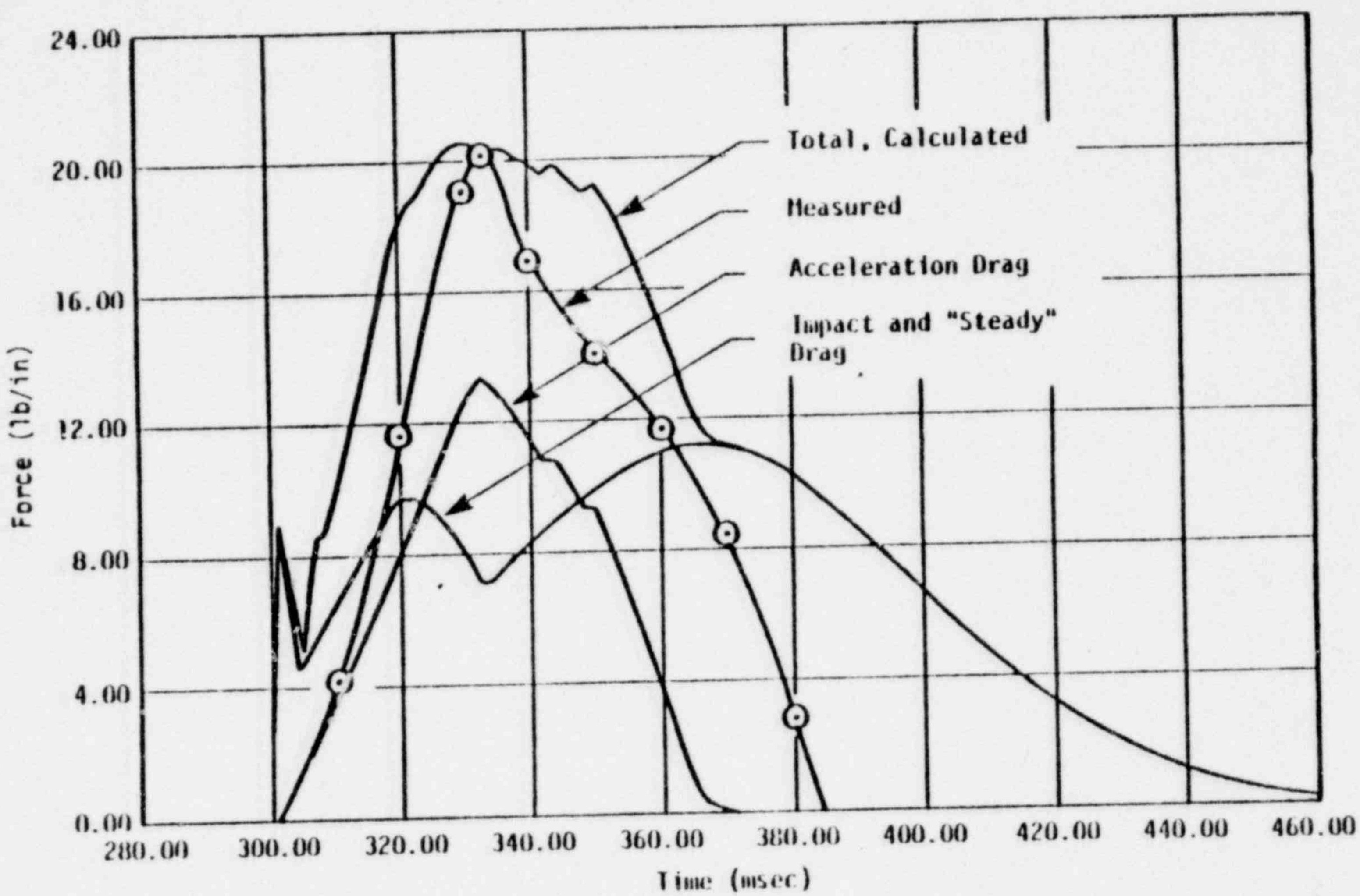
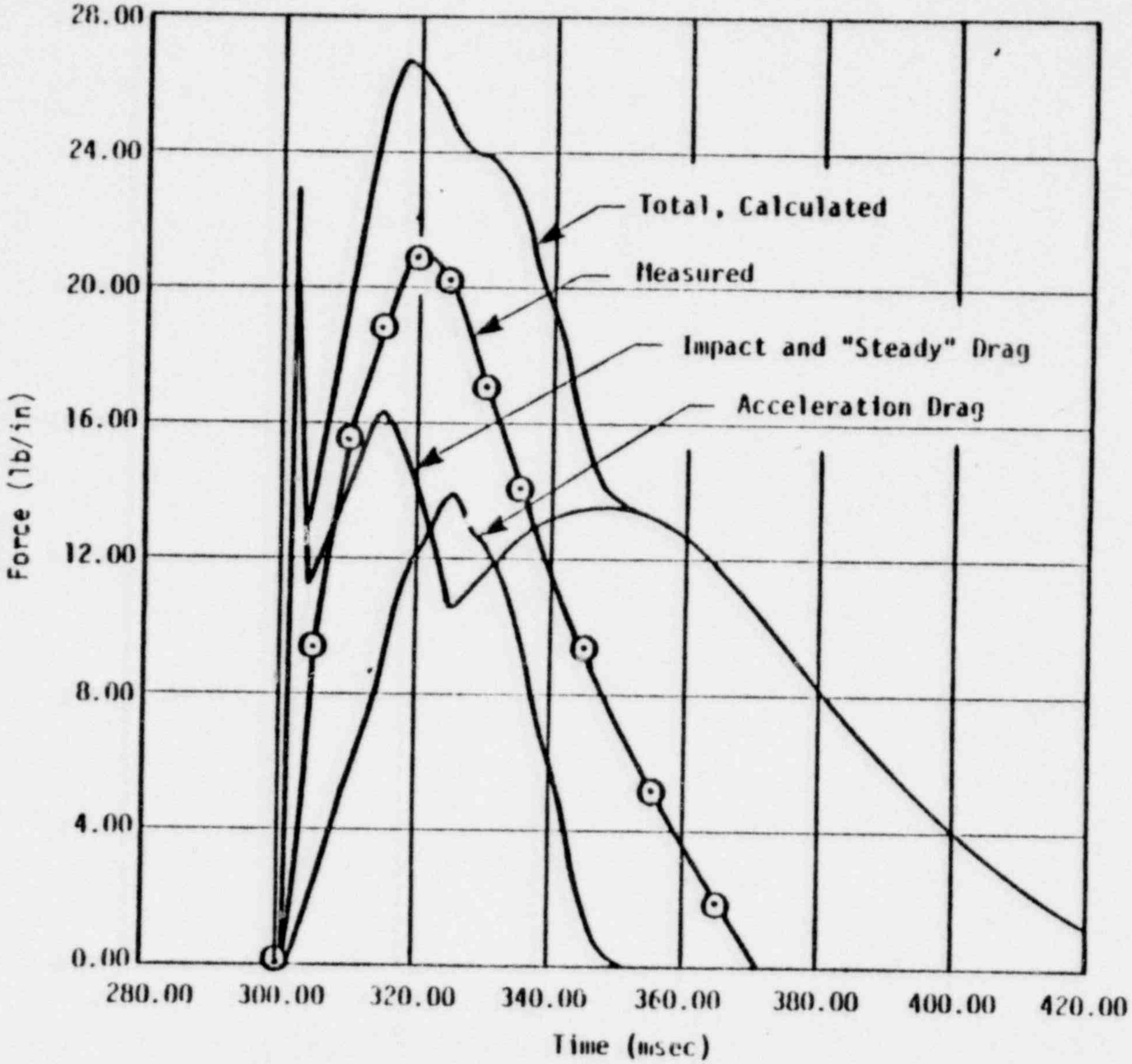


Measured and Calculated QSTF Vent Deflector Loads, Case 1



Measured and Calculated QSTF Vent Deflector Loads, Case 2



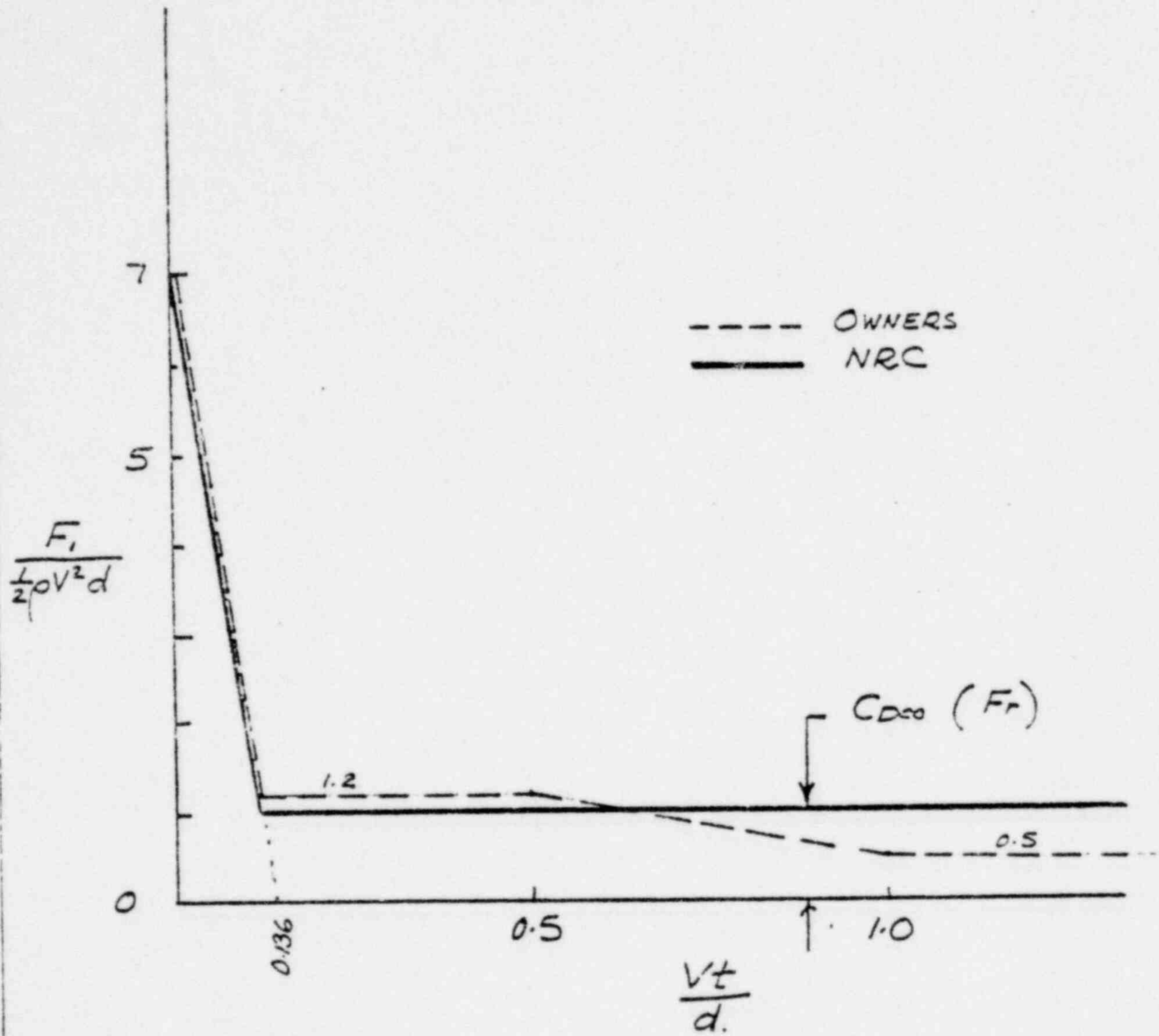
Measured and Calculated QSTF Vent Deflector Loads, Case 3

F-7

COMPARISON OF CALCULATED AND MEASURED PEAK DEFLECTOR LOADS

PLANT	TEST	DEFLECTOR TYPE	CALCULATED / MEASURED	CLEARANCE/WATER SURFACE TO DEFLECTOR (INCHES)
A	5	PIPE W/Ts	1.50	0.0
	17A	PIPE W/Ts	1.00	1.635
	21	PIPE W/Ts	1.28	3.585
B	8	PIPE W/ANGLES	1.10	5.645
	12	PIPE W/ANGLES	1.08	5.645
C	8A	PIPE W/Ts	1.31	0.54
	10	PIPE W/Ts	1.09	0.54
	13	PIPE W/Ts	1.00	3.83
D	6B	PIPE W/ANGLES	1.93	0.575
E	10	PIPE W/ANGLES	1.50	1.13
	15	PIPE W/ANGLES	1.60	1.13
F	10	PIPE W/ANGLES	1.54	1.15
		AVE	1.33	

ACUREX Corporation



IMPACT TRANSIENT / STEADY DRAG FOR CYLINDER

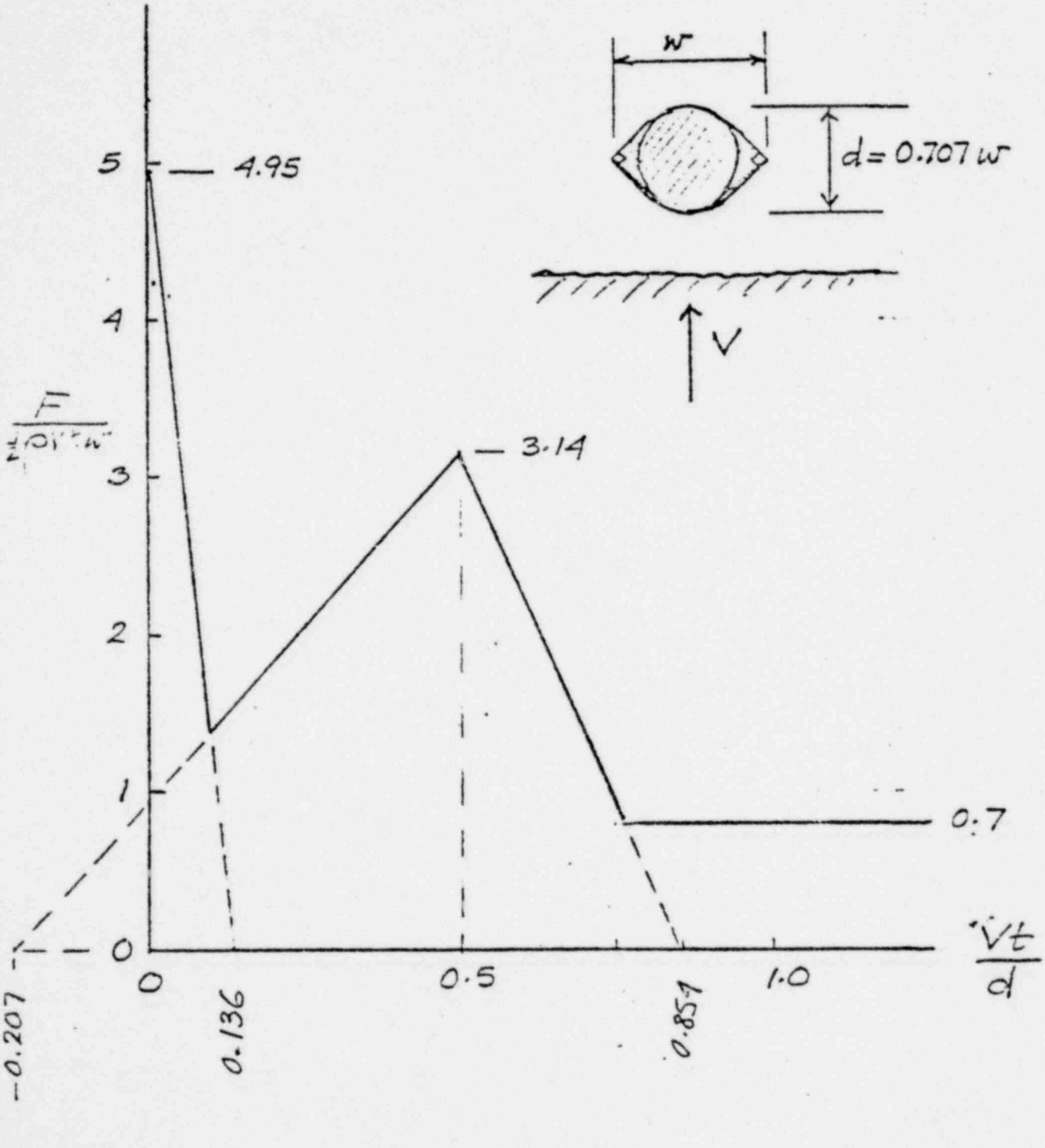


Figure 3: Impact / steady drag force correlation for Type 2 deflector.

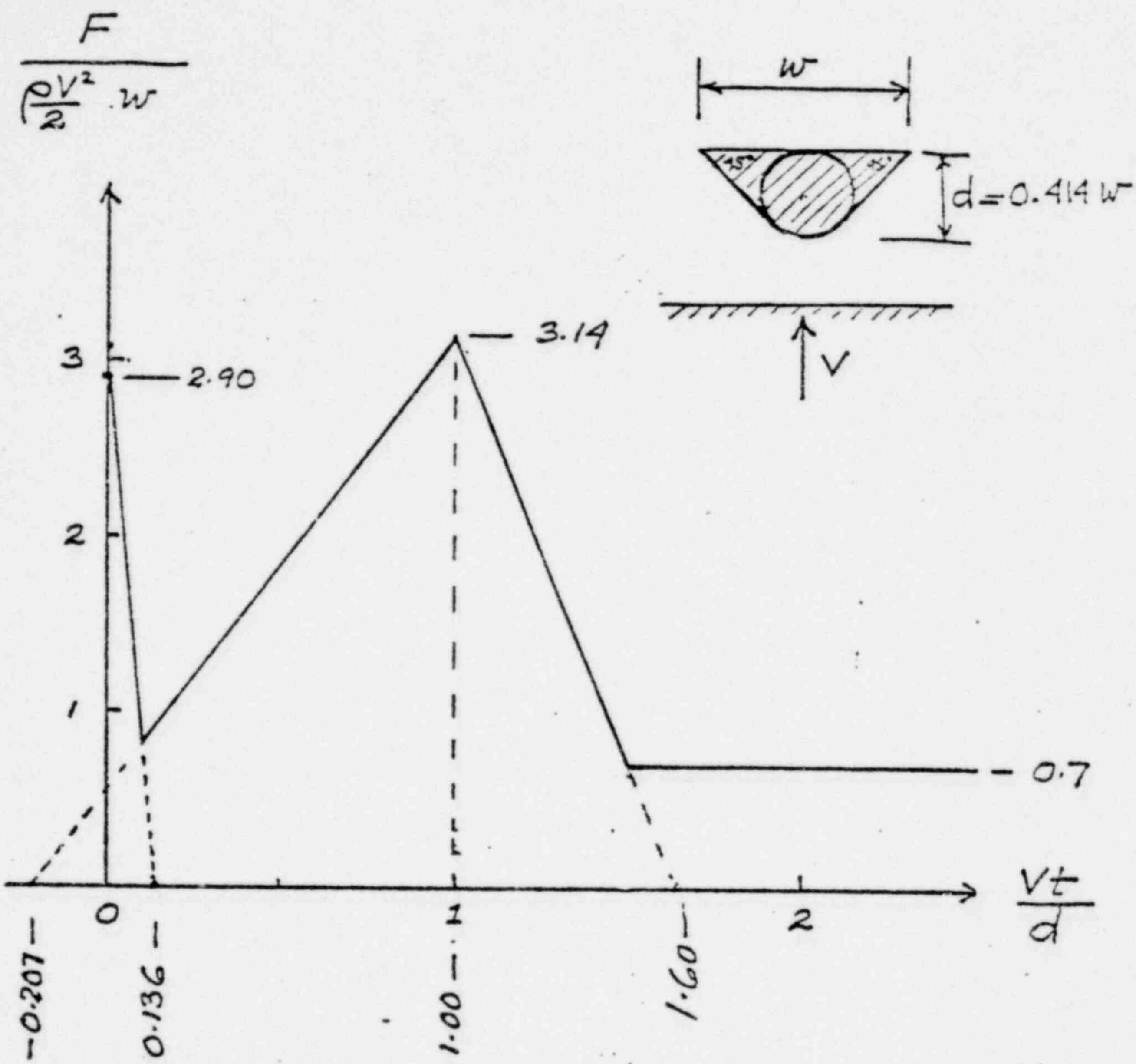


Figure 4: Impact/steady drag force correlation for Type 3 deflector

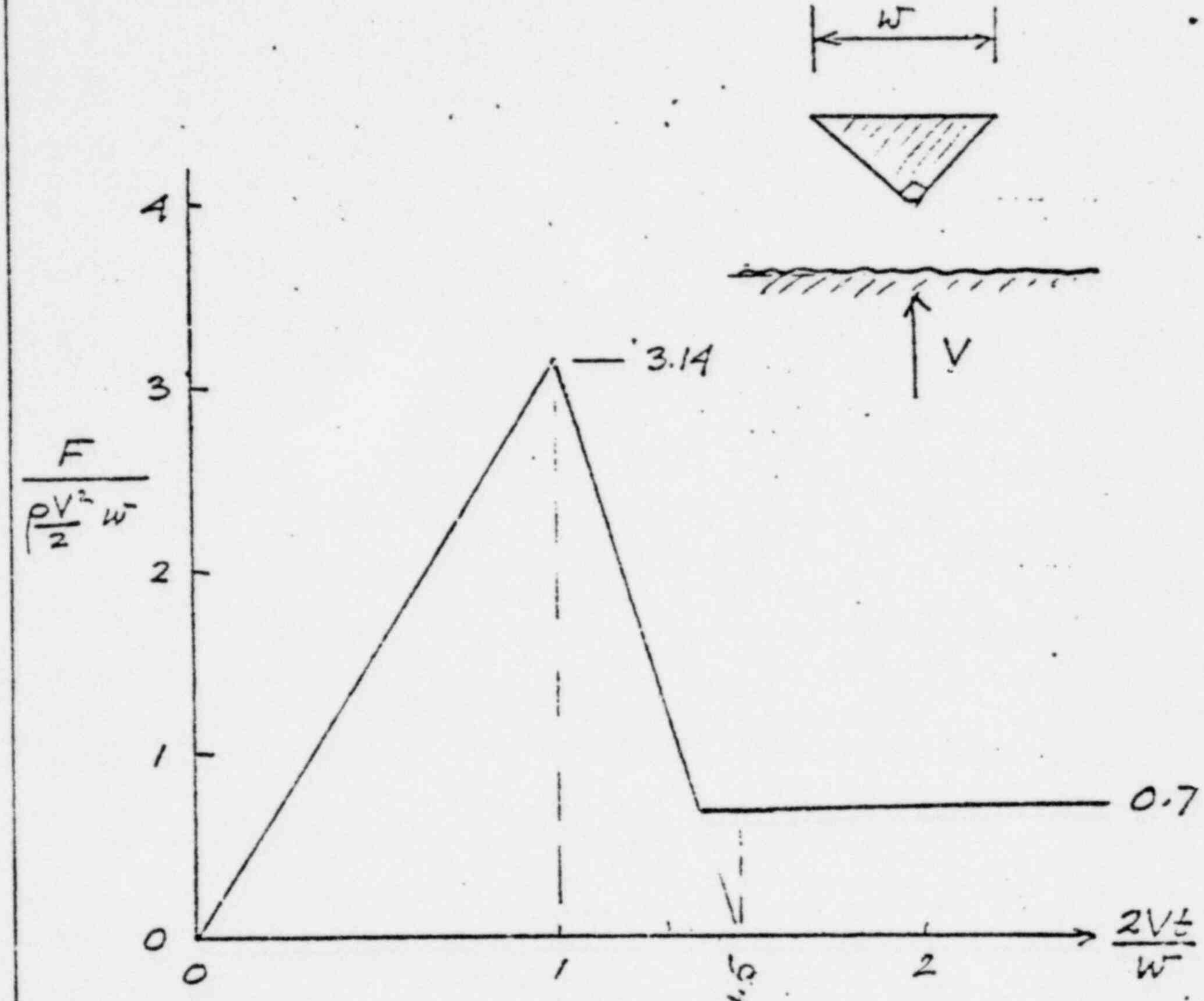
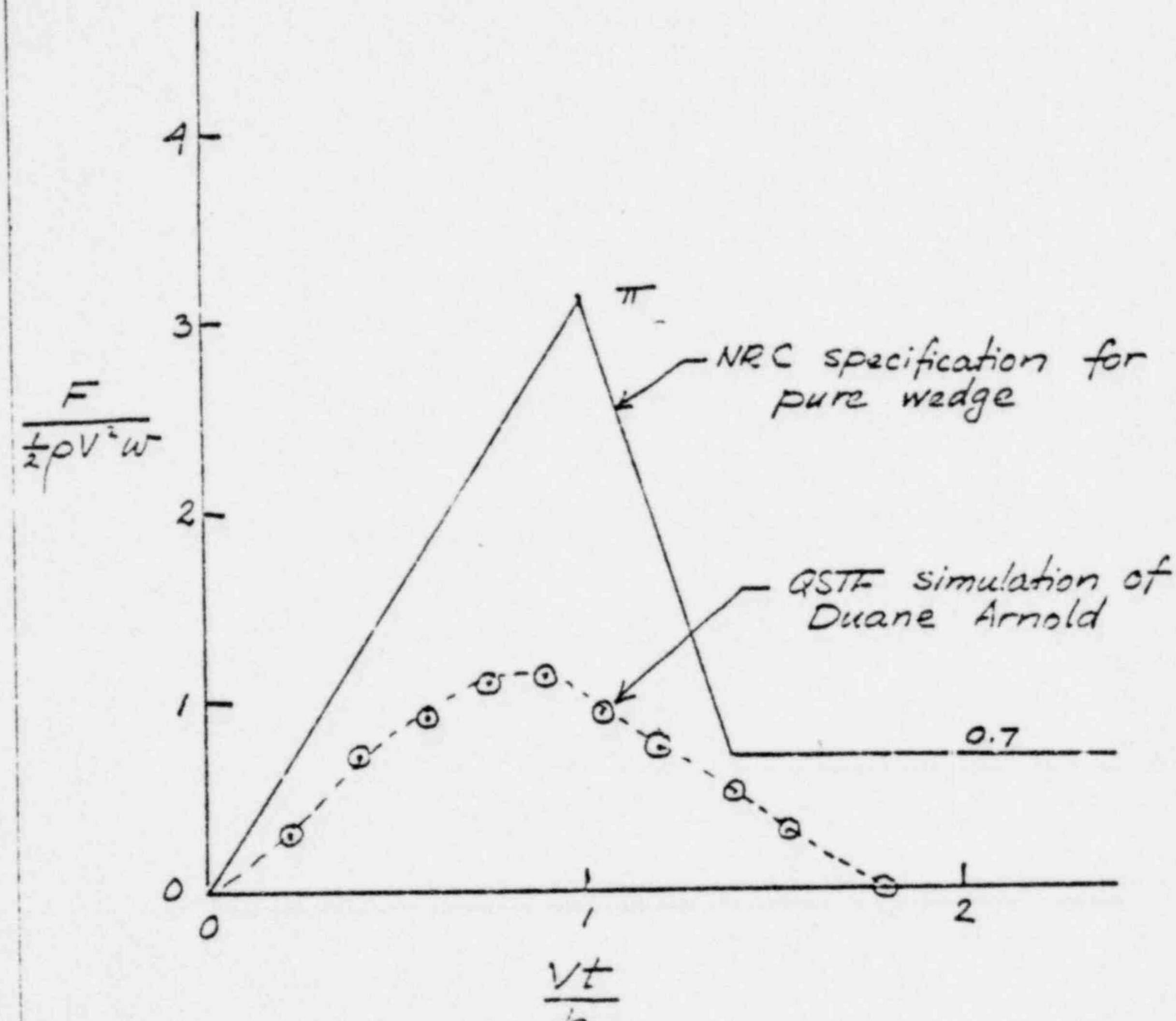
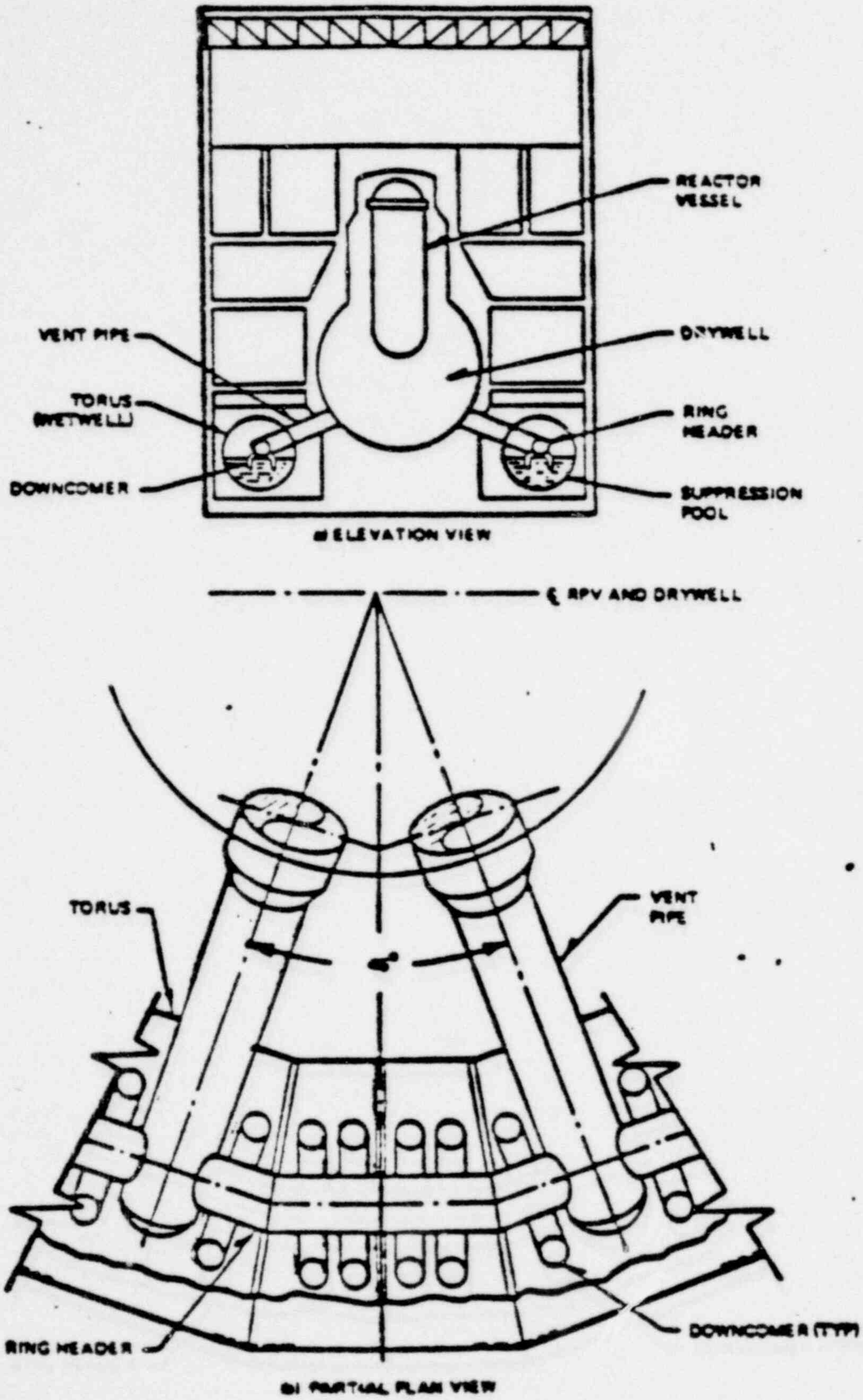


Figure 5: Impact / steady drag force correlation for type 4 deflector.



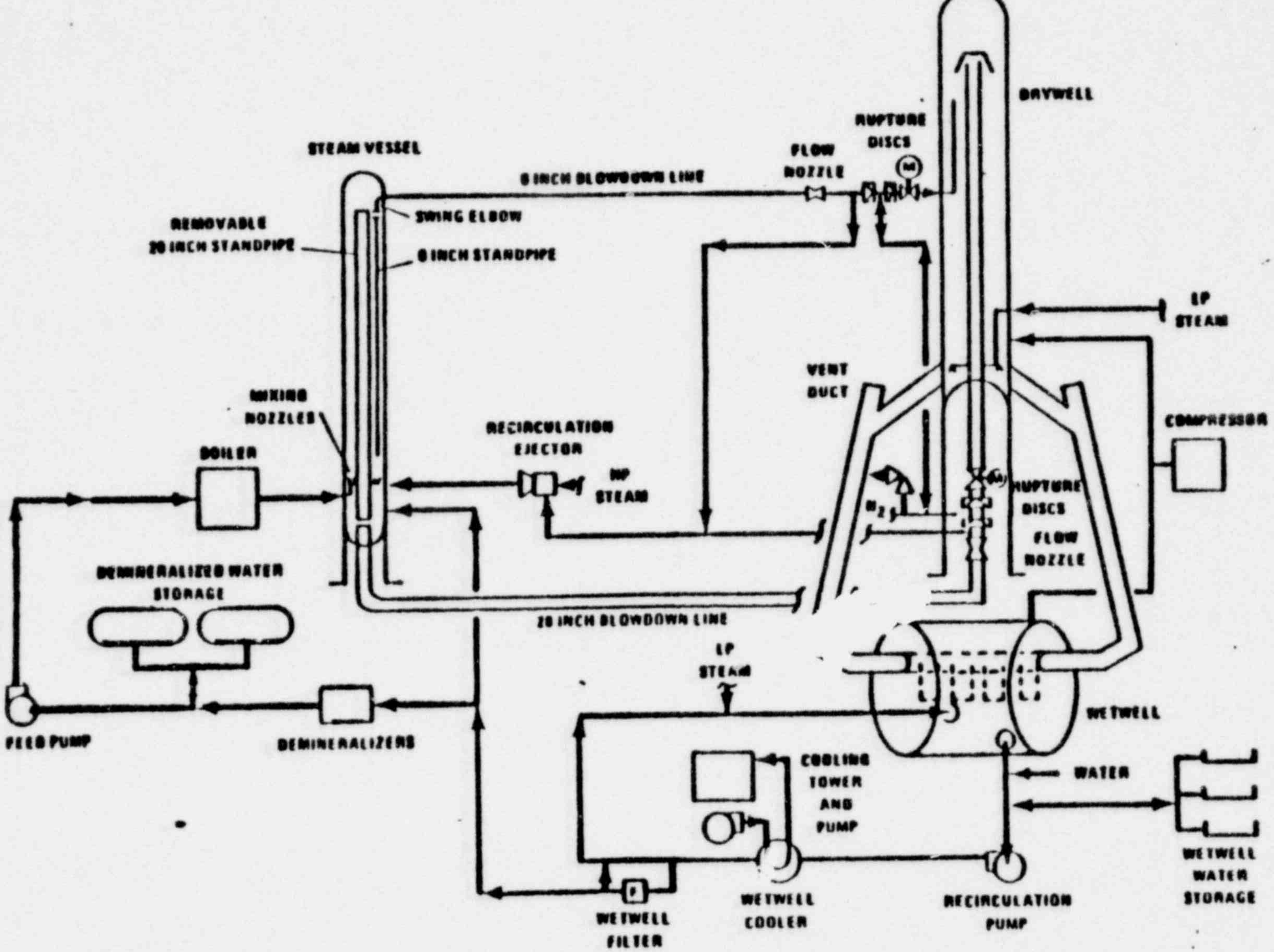
Impact transient for 45° half-angle wedge in uniform flow, compared with data from Mark I QSTF.



Mark 1 Containment Schematic

ATTACHMENT G

SIMPLIFIED FLOW DIAGRAM



POOR ORIGINAL

G-2

G-2

SYSTEM INSTRUMENTATION

DATA RECORDING CAPABILITY

- 256 CHANNELS
- EACH CHANNEL SAMPLED AT 1000 SAMPLES/SEC

PRIMARY MEASUREMENT GROUPS

- TORUS SHELL RESPONSE (ϵ, X, $\ddot{X}$)
- TORUS SUPPORTS STRAINS
- DOWNCOMER BENDING MOMENTS
- RING HEADER STRAINS AT DOWNCOMER ATTACHMENT
- TORUS WALL PRESSURES
- RING HEADER AND VENT PRESSURES
- DOWNCOMER PRESSURE
- DRYWELL PRESSURE
- DOWNCOMER AND RING HEADER LEVEL PROBES
- POOL TEMPERATURE DISTRIBUTION
- SYSTEM FLOW RATES

JET
11/16/79

TEST INSTRUMENT SUMMARY

	PRESSURE	STRAIN	DISPLACEMENT	TEMPERATURE	LEVEL	ACCELERATION	DIFFERENTIAL PRESSURE	TOTAL
WETWELL								
SHELL	26	122	16	54	6	14		222
HEADS						4		4
VENT HEADER	1	28			4			33
HEADER SUPPORTS		16						16
DOWNCOMERS	13	16			16	9		54
WW SUPPORTS		40						40
VENT DUCTS	4			4			2	10
6-INCH BLOWDOWN	3			1				4
18-INCH BLOWDOWN	3			1				4
DRYWELL	2			9			1	12
STEAM VESSEL	1			2			3	6
BASEMAT						6		6
TOTAL	53	222	16	71	26	33	6	427

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FSTF TEST MATRIX SUMMARY

TEST NUMBER*	BREAK CONFIGURATION	PARAMETER INVESTIGATED
M1	SMALL STEAM	REFERENCE TEST
M2	MEDIUM STEAM	BREAK SIZE INCREASED (STEAM)
M3	SMALL LIQUID	BREAK TYPE CHANGED TO LIQUID.
M4	SMALL STEAM	FREESPACE PRESSURE INCREASED.
M5	SMALL STEAM	POOL TEMP. INCREASED
M6	SMALL STEAM	SUBMERGENCE DECREASED AND POOL TEMP. INCREASED.
M9	SMALL STEAM	SUBMERGENCE INCREASED.
M10	SMALL STEAM	VENT AIR CONTENT DECREASED.
M7	LARGE STEAM	BREAK SIZE INCREASED (STEAM).
M8	LARGE LIQUID	BREAK SIZE INCREASED (LIQUID).

* IN ORDER OF PERFORMANCE

Table 6.2.1-1

SUMMARY OF CHUGGING DATA BASE

Test Number	M1	M4	M9	M10
Initial Conditions	nominal	5 psig free space press.	4.5 feet submergence	no vacuum breaker
*Approximate Chugging Periods, Seconds	30-330	26-116	25-305	20-120 250-305
Seconds of Chugging Data Recorded	300	90	280	155
Approximate Number of Downcomer Chugs	670	110	480	200

*Time = 0 is the start of data recording

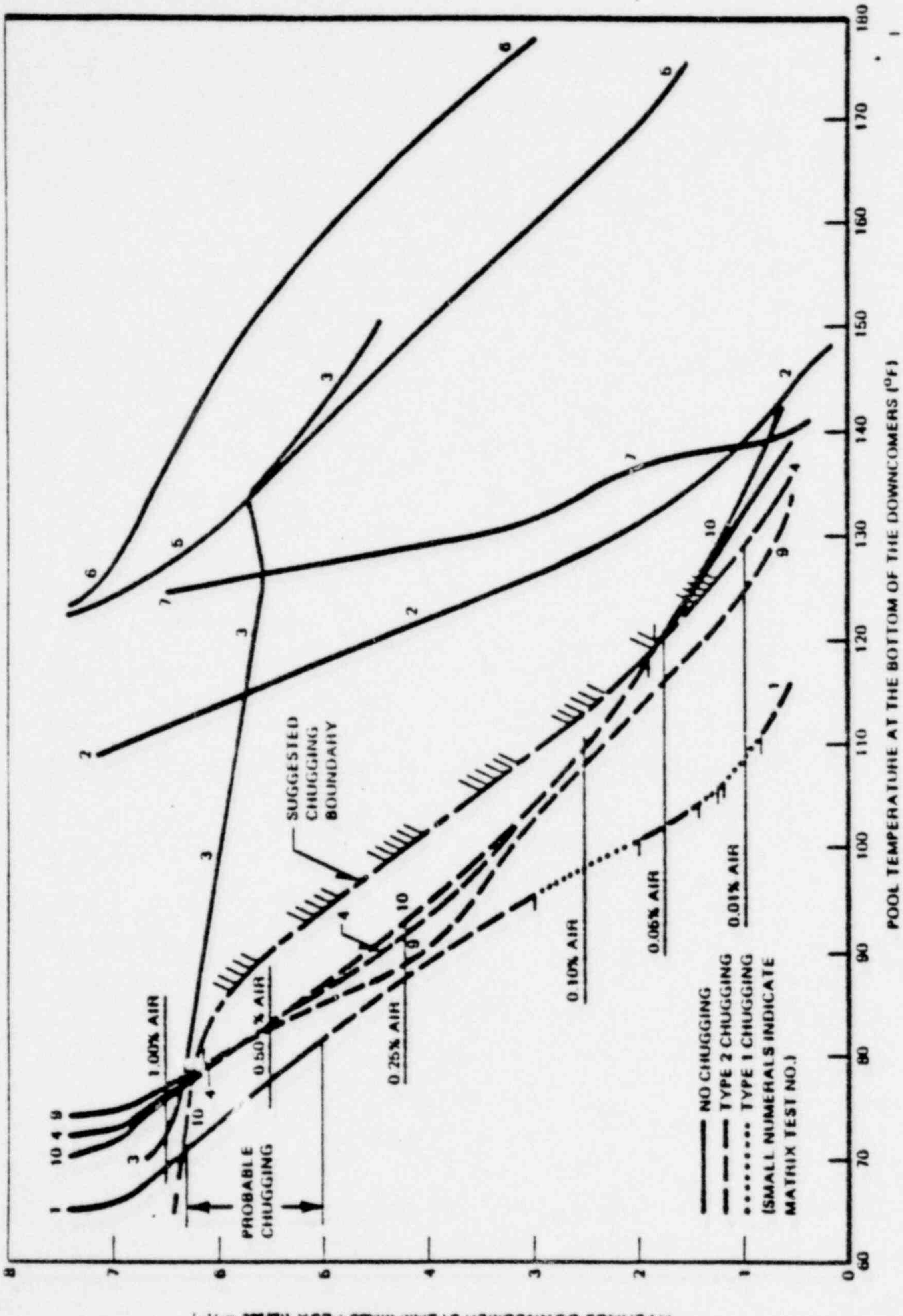

Figure 6.2.1-3. Mass Flux and Pool Temperature Conditions for Chugging

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Table 6.3.1-2

DYNAMIC STRESSES DURING CONDENSATION OSCILLATION AND CHUGGING

	Condensation Oscillation (M8) (psi)	Chugging (M1) (psi)
Wetwell Shell*		
Wetwell Shell	3,800	2,500
Wetwell Shell/Ring Girder Intersection	14,800	2,900
Wetwell Support Columns		
Radial Bending	1,500	300
Longitudinal Bending	500	300
Tensile/Compressive	1,600	500
Vent Header Shell		
Downcomer/Vent Header Intersection		
• "Tied" Downcomers**	14,000	-
• "Free" Downcomers	46,000	25,000

* Maximum surface stress intensity.
** Monticello prototypical tie-straps.

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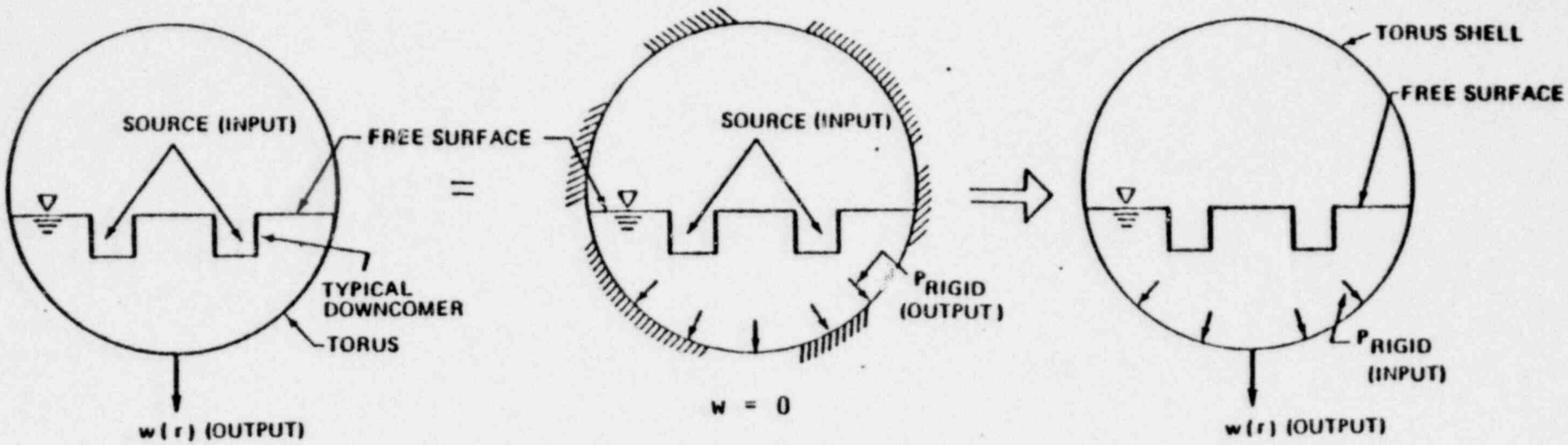
$$\{P_T\} = \{P_S\} + [M_W]\{\ddot{X}\}$$



FLEXIBLE TORUS FORCING SOURCE APPLIED AT THE DOWNCOMER	=	RIGID TORUS FORCING SOURCE APPLIED AT THE DOWNCOMER	⇒	FLEXIBLE TORUS RIGID WALL PRESSURE INPUT AT THE WETTED SURFACE OF THE SHELL

TORUS ANALYSIS FOR CONDENSATION OSCILLATION LOADING

- OVERALL PROCEDURE
  - Basis For Load Definition Is Data Measured In FSTF
  - Periodic Loading. Fourier Expansion Of Loading And Frequency By Frequency Solution
  - Correct Measured Pressures For FSI Effects. Develop Rigid Wall Load Definition
  - Apply Rigid Wall Loading In Plant Unique Analysis. Incorporate Plant Unique FSI In Solution

- DEVELOPMENT OF FSI CORRECTION CURVE
  - NASTRAN Model Of FSTF And Contained Fluid
  - Analyses For Unit Harmonic Sources At Downcomers. Repeat Analysis With Source Frequency Varied In (Approx 1 Hz) Increments Over Range Of Interest
  - Two Series Of Analyses. First Is For Fluid And Actual (Flexible) Structure, And Second Is For Fluid With Rigid Boundary
  - Output Is Wall Pressures. Integrate Wall Pressures To Get Net Vertical Load
  - FSI Correction Curve Is Ratio Of Flexible To Rigid Net Vertical Load, As A Function Of Frequency

FSTF ANALYTICAL MODEL

(DEVELOPED USING NASTRAN COMPUTER PROGRAM)

- STRUCTURAL MODEL
  - One Half Of FSTF (Symmetry Segment)
  - Approx 500 Elements, 500 Nodes
  - Shell Modeled Using Quadrilateral Shell Elements
    Stiffeners And Columns Modeled With Beam Elements

- FLUID MODEL
  - Consistant Mass Matrix Method
  - Fluid Modeled Using Hexagonal Solid Elements
  - Fluid Assumed Incompressible

- LOAD APPLICATION
  - Source Forcing Function At Downcomers

    Or

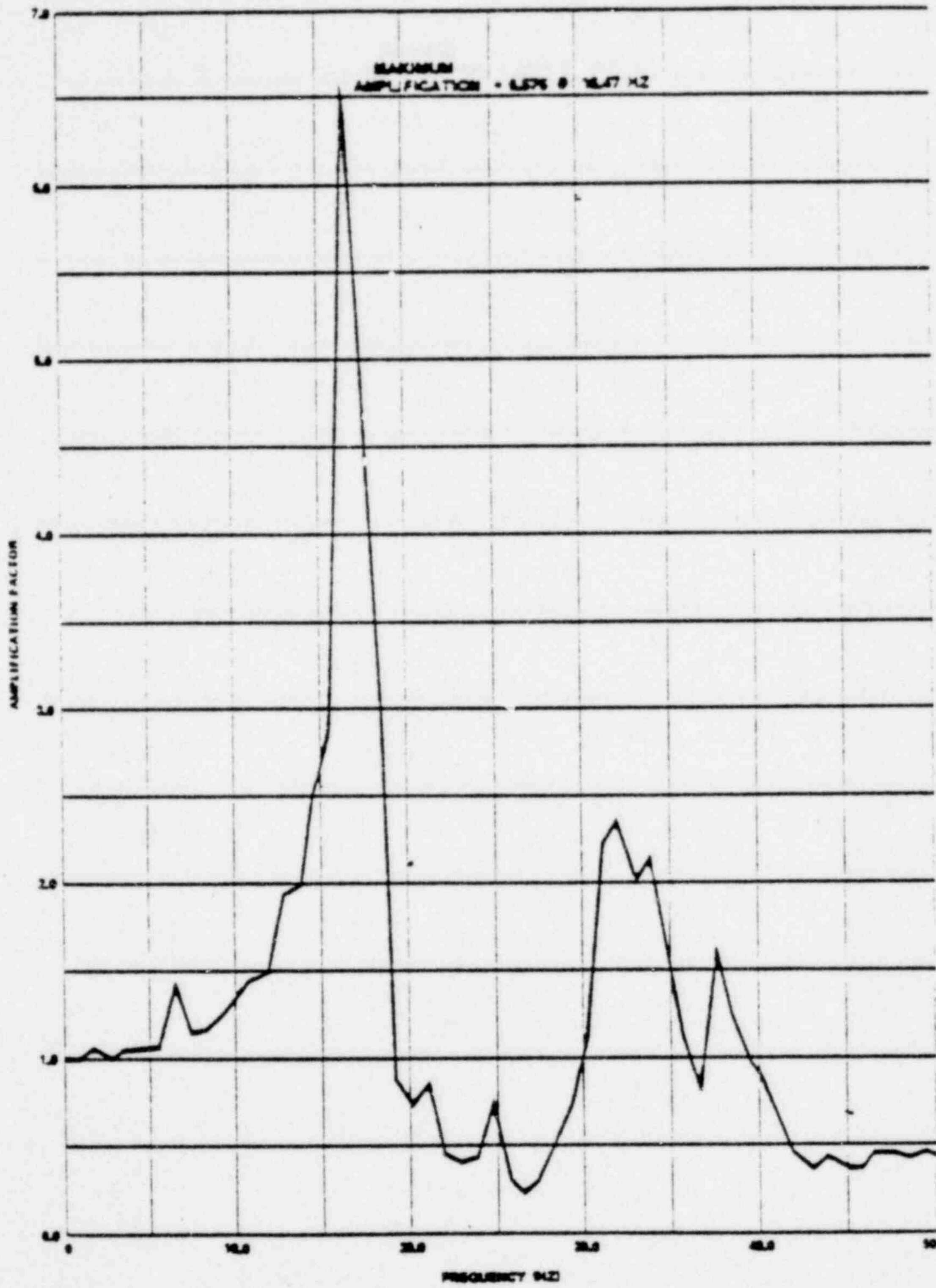
  - Wall Pressure Forcing Function

VERIFICATION OF ANALYTICAL MODEL

- STATIC CHECK CASES

- COMPARISON AGAINST SHAKE TEST RESULTS

- ABILITY TO PREDICT FSTF STRUCTURAL RESPONSE TO CONDENSATION OSCILLATION LOADING
  - Data From Test M-8, Period From 24 To 25 Seconds, Used For Verification
  - Convert Measured Flexible Wall Pressures To Rigid Wall Pressures Using FSI Correction Curve
  - Dynamic Structural Analysis Based On Rigid Wall Loading
  - Compare Predicted Structural Response Quantities With Measured Data



RESULTS OF ANALYSIS

AMPLIFICATION FACTOR FOR TOTAL VERTICAL FORCE VS FREQUENCY
("RIGID" FORCE = "FLEXIBLE" FORCE / AMPLIFICATION FACTOR)

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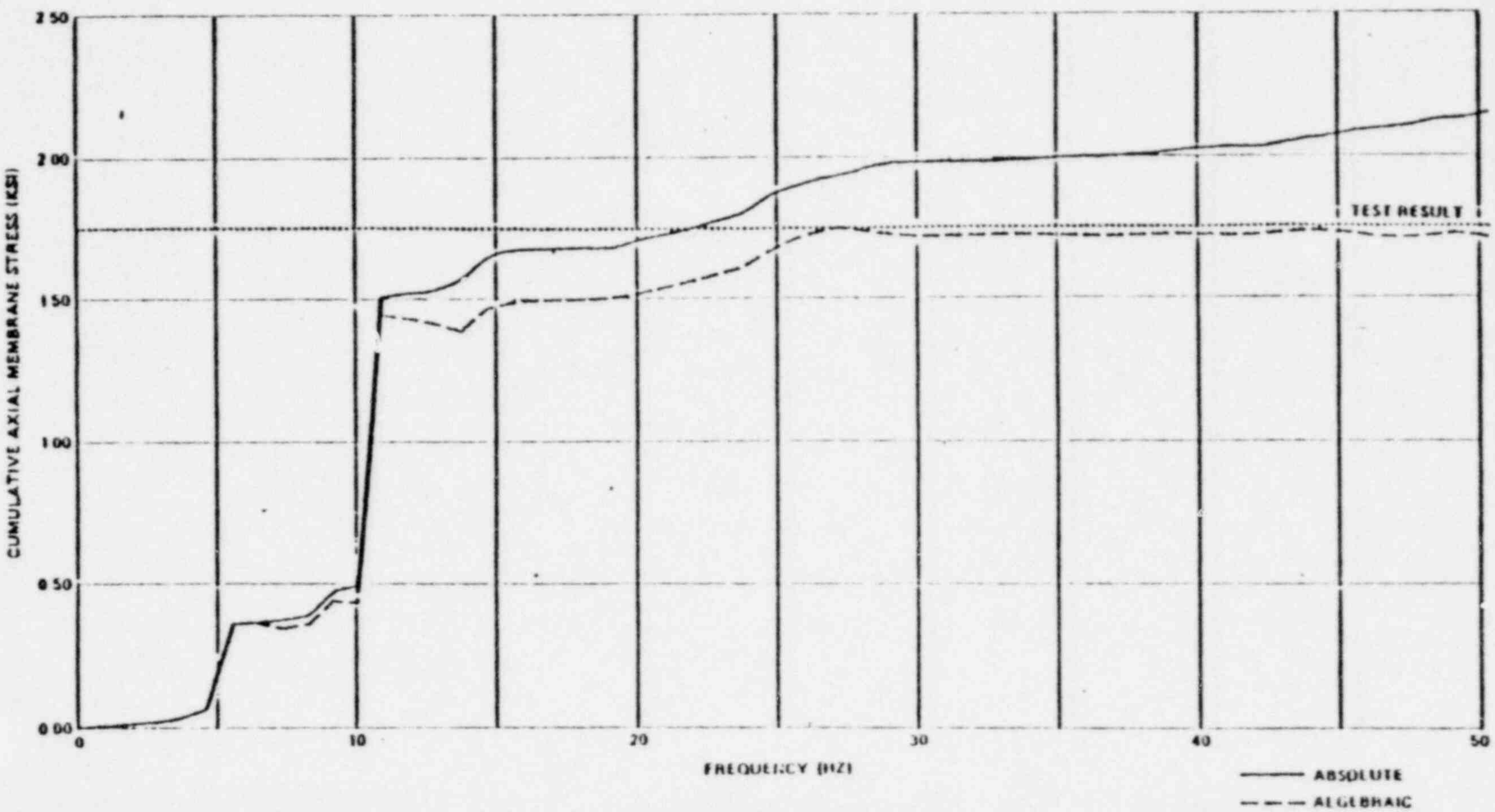
RESULTS OF VERIFICATION RUNS

CUMULATIVE AXIAL MEMBRANE STRESS AT BOTTOM MID-SPAN (SOURCE ANALYSIS)



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CONDENSATION OSCILLATION LOADING

FSTF RESPONSE

QUANTITY		TEST DATA (1)	FSTF ANALYSIS (2)		LDR LOADS (3)			MARGIN
			ALGEBRAIC	ABSOLUTE	CASE 1	CASE 2	CASE 3	LDR CASE 2/TEST DATA
BOTTOM DEAD CENTER	AXIAL MEMBR-ANE (KSI)	1.94	1.80	2.22	3.55	4.57	2.20	2.36
BOTTOM DEAD CENTER	HOOP MEMBR-ANE (KSI)	2.06	1.80	2.35	3.90	4.60	2.45	2.23
BOTTOM DEAD CENTER	RADIAL DEFLEC-TION (INCHES)	0.086	0.101	0.129	.230	.275	.141	3.20
INNER COLUMN AXIAL FORCE (KIPS)		93.3	101	136	254	290	172	3.11
OUTER COLUMN AXIAL FORCE (KIPS)		111.5	116	152	278	320	186	2.87

NOTES:
(1) DATA FOR TEST M-8 TIME PERIOD 24.8 TO 25.9 SECONDS
(2) LOAD APPLIED AT MULTIPLES OF .91 HZ. FREQUENCIES 0-30 HZ CONSIDERED.
(3) LOAD APPLIED AT STRUCTURE NATURAL FREQUENCIES
FREQUENCIES 0-30 HZ CONSIDERED. ABSOLUTE SUM.

MARK I CONDENSATION OSCILLATION

APPROACH

- ENTIRE FSTF CO DATA WAS EXAMINED
- MAXIMUM PRESSURE AMPLITUDE DATA SEGMENTS WERE SELECTED AS DATA BASE
- WALL PRESSURES (24 SENSORS) WERE SPATIALLY AVERAGED → AVERAGE VERTICAL PRESSURE LOADING ON THE TORUS SHELL
- PSD ANALYSES WERE PERFORMED
- FSTF FSI EFFECTS WERE ACCOUNTED FOR
- RIGID WALL PRESSURES AS A FUNCTION OF FREQUENCY WERE SPECIFIED AS LOAD DEFINITION

MARK I CONDENSATION OSCILLATION

DATA BASE

THREE DATA SEGMENTS SELECTED ARE:

TEST RUN	DURATION	POWER
M8	29-33 SEC	MAXIMUM 4-5 Hz
M8	24-28 SEC	MAXIMUM 5-6 Hz
M7	21-25 SEC	MAXIMUM 6-7 Hz

MARK I CONDENSATION OSCILLATION

DATA REDUCTION/ANALYSIS

FOR EACH OF THE SELECTED THREE DATA SEGMENTS...

- WALL PRESSURES INTEGRATED
  - MEASURED WALL PRESSURES (24 SENSORS) WERE SPATIALLY INTEGRATED
  - INTEGRATED VERTICAL PRESSURE TIME HISTORY GENERATED
  - OBTAINED TIME HISTORY REPRESENT OVERALL LOADING ON THE TORUS SHELL
- POWER SPECTRAL DENSITY (PSD) CALCULATED
  - PSD OF EACH 1-SECOND SEGMENT WAS GENERATED
  - PSD VALUES WERE AVERAGED OVER THE FOUR SECONDS
  - AMPLITUDE VS. FREQUENCY VALUES WERE COMPILED
- FSTF FSI ACCOUNTED FOR
  - FSI FACTOR AS A FUNCTION OF FREQUENCY OBTAINED
  - COMPILED AMPLITUDE MULTIPLIED WITH FSI FACTOR - RIGID WALL PRESSURES

MARK I CONDENSATION OSCILLATION

LOAD DEFINITION

- TORUS LOADING DEFINED AS RIGID WALL PRESSURE VS. FREQUENCY

- THREE ALTERNATE FREQUENCY SPECTRA, 4 TO 16 Hz, SPECIFIED

- ALTERNATE SPECTRA BOUND VARIATION OF DOMINANT FREQUENCY WITH TIME OBSERVED DURING THE TESTS

- LOAD DEFINITION:
  - AMPLITUDE VS. FREQUENCY
    - ▲ 0 - 50 Hz RANGE
    - ▲ INCLUDING ONE SPECTRUM 4 - 16 Hz
  - SPATIAL DISTRIBUTION
    - ▲ UNIFORM AXIALLY
    - ▲ LINEAR ATTENUATION WITH SUBMERGENCE
  - PLANT UNIQUE ADJUSTMENT FOR POOL-TO-VENT AREA RATIO DEFINED
  - AMPLITUDE COMPONENTS SPECIFIED AS STEADY STATE LOADING

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EVALUATION OF DOWNCOMER LOADS DURING CONDENSATION OSCILLATION

- STATIC VERIFICATION RUNS
  - Jacking Between Downcomers #5 & 6 (Test #7)
  - Jacking Between Downcomers #6 & 8 (Test #6)
  - Jacking Between Downcomers #7 & 8 (Test #8)
  - Correlate On Load - Deflection Curve
  - Correlate On Strain Guages On Downcomers And Adjacent Header (S5911-S5918, S5921-S5928)
- DYNAMIC VERIFICATION RUNS
  - Modal Analysis To Calculate Downcomer "Swing" Frequency
  - Compare With Results Of Downcomer "Snap" Test
  - Possible Adjustment Of Effective Water Mass In Downcomer
- STATIC PRESSURE RUNS
  - Unit Pressure In Downcomer And Header
  - "Two To One" Pressure In Downcomers And Header
- DYNAMIC ANALYSIS
  - Harmonic Analysis (5.5 Hz Loading)
  - "Two To One" Pressure In Downcomers And Header
  - Correlation With M-8 Test Data (Strains In Downcomer And Adjacent Header)

CLOSURE

Postulated Load Definition Explains Measured Strains ?

Or

Look At Phasing Between Pressures In Adjacent Downcomers

And Finally

Look At Other Tests And Time Periods

ATTACHMENT H

TYPICAL GENERIC MODIFICATIONS TO PLANTS

- T/QUENCHERS
- VENT DEFLECTORS
- TORUS SADDLES
- COLUMN REINFORCEMENTS
- ANCHOR BOLTS
- DOWNCOMER TRUNCATION

. . . . AND CONTINUED USE OF DRYWELL/WETWELL ΔP

ATTACHMENT I

11/16/79

SCHEDULE FOR COMPLETION OF PLANT MODIFICATIONS *

OWNER		PLANT	COMPLETION DATE
TENNESSEE VALLEY AUTHORITY	**	BROWNS FERRY 1,2,3	JUNE 1983
CAROLINA POWER & LIGHT	**	BRUNSWICK 1,2	JUNE 1981
NEBRASKA PUBLIC POWER DIST.		COOPER	MAY 1980
COMMONWEALTH EDISON CO.	**	DRESDEN 2,3	MAY 1982
COMMONWEALTH EDISON CO.	**	QUAD CITIES 1, 2	FEB. 1982
IOWA ELECTRIC LIGHT & POWER		DUANE ARNOLD	APRIL 1981
POWER AUTHORITY STATE OF N.Y.		FITZPATRICK	JAN. 1983
GEORGIA POWER COMPANY	**	HATCH 1,2	JAN. 1983
NORTHEAST UTILITIES SERVICE CO.		MILLSTONE	APRIL 1982
NORTHERN STATES POWER		MONTICELLO	FEB. 1980
NIAGARA MOHAWK POWER CO.		NINE MILE PT.	JUNE 1981
JERSEY CENTRAL POWER & LIGHT		OYSTER CREEK	DEC. 1980
PHILADELPHIA ELECTRIC CO.	**	PEACH BOTTOM 2,3	NOV. 1981
BOSTON EDISON CO.		PILGRIM	MARCH 1981
YANKEE ATOMIC ELECTRIC CO.		VERMONT YANKEE	NOV. 1981

* AS OF MARCH 197[illegible]

** MULTI-UNIT [illegible]S

11/16/79

SUMMARY OF MARK I OWNER'S POSITION

- CONTAINMENT LOADS MORE COMPLEX THAN ORIGINALLY ANTICIPATED
- FURTHER INTERACTION ON LOADS AND STRUCTURAL METHODS REQUIRED - FUNDED THROUGH 1980
- UTILITIES PROCEEDING WITH MODIFICATIONS ON "RISK" BASIS
- EXPECT INTERACTION WITH NRC ON EITHER GENERIC OR PLANT UNIQUE BASIS
- OWNERS BELIEVE CURRENT LDR GIVES PRACTICAL ENGINEERING SOLUTION
- OWNERS REQUEST CONTINUING ACRS/NRC DIALOGUE TO ASSURE BALANCED PROGRAM CLOSURE

11/16/79