TERA PDR
Code 1-15

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

JUL 1 7 1979

Those On The Attached List

Gentlemen:

Subject: Meeting Minutes of the Containment Code Review Group

Enclosed you will find the meeting minutes of the Containment Code Review Group which took place in Silver Spring on June 19, 1979.

Sincerely,

S. Fabic

S. Fabic, Chairman
Containment Code Review Group
Division of Reactor Safety Research

Enclosure: as stated

7908130592.

618235

Addressees of Letter Dated JUL 1 7 1979

W. Butler, NRC
G. Lainas, NRC
W. Paulson, NRC
J. A. Kudrick, NRC
N. Zuber, NRC
R. Cudlin, NRC
C. Anderson, NRC
C. Grimes, NRC
G. Mansfeld, NRC Consultant
A. Sonin, MIT
D. Norris, LLL
E. McCauley, LLL
J. Lehner, BNL
J. Block, CREARE
V. Dhir, UCLA
L. S. Tong, NRC
PDR (2)

618236

CONTAINMENT CODE REVIEW GROUP MEETING MINUTES

Place and Date: Silver Spring, MD June 19, 1979

Attendees: Attachment 1

Introduction:

A meeting of the Containment Code Review Group was held on June 19, 1979, in Silver Spring, Maryland. The proposed agenda enclosed as Attachment 2 had to be modified, because R. Cudlin (NRC/RES) and J. Pitts (LLL) couldn't attend the meeting. Description of foreign experimental programs by G. Mansfeld (NRC/GRS) and E. McCauley (LLL) was confined to the GKSS multivent experiments. Analytical description of chugging and intercompartment flow tests were not discussed.

Conclusions and Recommendations:

S. Fabic provided the status of the current RES containment programs:

- The UCLA program will be terminated end of FY 79, per previous recommendations of this review group.
- The MIT program will continue into FY 80.
- The BEACON code will undergo extensive verification during FY 80.
- RES has incorporated intercompartment flow tests in the FY 80 supplementary and FY 81 budgets. Such tests were recommended at the last review group meeting.
- RES is closely following the BWR tests at GKSS and JAERI.
- The PELE-IC code will be completed soon.

S. Fabic was asking for support by NRR in planning the containment program for FY 81. RES is looking for open issues. Research issues coming out of the TMI accident seem to be in the areas of vented containments and of the hydrogen behavior within containment building.

W. Butler stated that NRR will forward their recommendations as soon as possible. Furthermore, he said that NRR may come up with other issues in the area of containment research (such as containment spray, air coolers, combustible gases, etc.).

C. Grimes mentioned that Mark I seems to be a closed issue.

C. Anderson emphasized again the need for RES programs associated with the Mark II pool dynamic load program (see chapter Mark II Approach/Status).

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NRR confirmed that no independent, Mark III related research should be planned, unless changes are made in the NRR assessment of the Mark III issues and data base.

D. Norris emphasized his plans to accomplish PELE-IC by the end of FY 80.

Discussion:

S. Fabic opened the meeting with a short comment to the assignment of R. Cudlin to the TMI accident related task force.

Fabic emphasized that the subject of the meeting will be steam chugging phenomena in pressure-suppression containments, focusing on specific programmatic recommendations.

Mark I Approach/Status:

Chris Grimes provided an overview of the Mark I load programs (see Handout #1 in Attachment 3). The condensation loads for the Mark I containment design are being derived from test data obtained in the Full-Scale Test Facility (FSTF). The FSTF is an integral part of the Mark I Long Term Program, representing a single bay of the Monticello plant with four pairs of downcomers. The loading conditions being derived are (1) condensation oscillation shell loads, (2) pre and post-chug shell loads, (3) downcomer lateral loads, (4) vent system pressure oscillations, and (5) source functions for submerged structure drag loads. Ten test series have been performed covering design basis, intermediate break, and small break accidents with both liquid and steam blowdowns.

The Mark I condensation oscillation and chugging shell load data have been used to develop equivalent "rigid wall" shell loads for use in plant-unique analyses. The "rigid wall" load is obtained by inferring a source in a NASTRAN coupled consistent-mass-matrix fluid and structural model. The source function is varied until the coefficients of a Fourier expansion match those obtained from a select group of data. The resultant loading function is expressed as an amplitude-frequency histogram. An additional correction factor is applied to the condensation shell loads, which were found to be more significant than the chugging loads, to account for variation in both local and global pool area to vent area ratios.

The Mark I downcomer lateral load functions have been derived from test data as a Resultant Equivalent Static Load (RESL) to be applied at the tip of the downcomer. Four bending strain gauges located on the upper part of the FTSF downcomers were calibrated to known RESLs. The calibration data can then be used to develop "load-reversal" histograms as functions of angular position around downcomer circumference. A "reversal" is equivalent to a load cycle on the downcomers. Both the load magnitudes and number of reversals are then scaled to plant-unique conditions by the ratio of the downcomer dynamic load factors calculated for FTSF and for the plant. The modified histogram is used in a standard fatigue analysis. Multiple-downcomer loading conditions are based on a probablistic approach.

Both the FSTF data and the Mark I condensation load definition techniques are currently under review by the DOR staff and their consultants. A meeting with the Mark I Owner's Group to discuss this material was scheduled for June 21, 1979.

Mark II Approach/Status:

Cliff Anderson provided an overview of the Mark II steam programs (see Handout #2 in Attachment 3). This included a description of the load specifications and the supporting basis for these loads in the Mark II Lead Plants and Long Term Programs. The steam loads discussed consisted of the localized lateral loads on the vents, the submerged boundary condensation oscillation (CO) and chugging loads, and the submerged structure loads.

The Mark II Lead Plant Program utilized a boundary load approach for each of the loads resulting from the steam chugging/condensation oscillation phenomena. This approach was necessary to expedite licensing of the Lead Mark II plants. The approach recognized conservatisms in the experiments. The Lead Plant loads were derived primarily from the 4T and GKM I tests. The conservative nature at the Lead Plant loads is to be confirmed by the Mark II Long Term Program.

The Mark II Long Term Program includes a number of experimental and analytical programs directed at a better understanding of steam chugging/condensation phenomena. These include the extended 4T tests, the Susquehanna-GKM II tests, the multivent CREARE tests, the Bechtel and Burns and Roe improved chugging/CO load specification, the multivent hydrodynamic model and the dynamic lateral load model. The status and schedule for these tests was discussed. The programs are scheduled for completion mid 1980.

The discussion indicated needs for research programs to support NRR review efforts associated with the Mark II pool dynamic loads program. RES is establishing an active interface with the GKSS and the JAERI full scale multivent steam testing effort, to expedite information exchange between these organizations and the NRC. In addition the RES sponsored development of the PELE-IC code at LLL is nearing completion. NRR recommended extended checkout of that code utilizing further problems representative of pressure suppression systems.

Condensation Rate for Chugging:

Professor Sonin provided a brief review of the status of the MIT study on chugging (see Handout #3 in Attachment 3). The purposes of this study are (1) to understand the physical mechanism of chugging, (2) to quantify condensation (heat transfer) rates and (3) to postulate a simplified model for chugging. To reach these goals the following approach is underway: (a) Single-chug experiments in a special device to address (1) and (2), (b) development of a tentative model, including postulated condensation rate equation and (c) simulation of "chugs" in a small flow visualization system to study mixing effects in the pool. Professor Sonin discussed the single-chug small scale experiments conducted with low mass flow rates. He stated that in this case the mechanism of chugging is controlled by cutting off bubbles from the steam supply at the edge of the vent pipe and allowing for eddy transport of cold water to the steam/water interface. Some movies, carefully shot, gave a good impression of these processes. The water spray (in this case 5-20 cm^3, 10°C, derived from postcalculations) causes a rapid condensation with 4-14 milliseconds and a pressure drop in the pipe of about 0.1-0.7 bar. Then wetwell water was sucked into the pipe. The question on extrapolability of these observations to other test conditions or facilities is not yet answered.

GKSS Multivent Experiments:

G. Mansfeld presented a brief overview of the GKSS test program. The program consists of a series of full-scale steam venting tests to study the phenomena occuring in a quasi Mark II type pressure suppression system following a loss-of-coolant accident (e.g. vent clearing, chugging, etc.). The test program is described in the GKSS report 78/I/15. The main variables of the test program are (1) mass flow in the condensation pipe, (2) temperature of the water pool, and (3) back pressure in the wetwell. Tests will start with the 3-pipe test series, perhaps in August/September 1979.

RES is providing technical support in the form of processing, reporting and evaluation of test data through contract with LLL. E. McCauley, who is the project leader of this activity at LLL and who has recently visited GKSS, provided a brief review of the status of the program. He focused mainly on the instrumentation and its problems, such as failure of pressure transducers and water level indicators in the wetwell, and insufficient light for the high speed camera during shakedown tests. GKSS personnel are trying to remove these short comings. Movies from one of the 3 shakedown tests - one more is planned for June/July 1979 - had shown that the chugging processes in all three pipes seem to occur nearly simultaneously (within a few milliseconds of each other). He also mentioned that the GKSS personnel seems to be well prepared for these tests, and are highly interested in a close cooperative work with the NRC.

1/5-Scale Mark I Tests - Extended Analysis of Data:

E. McCauley presented a summary of an extensive analysis of data from the 1/5-scale MK I BWR pressure suppression system tests. Primary focus was placed on computing the hydrodynamic vertical load function (HVFL) and determining the associated peak forces and their standard deviations. These results were used to study the sensitivity of the peak loads to various major parameters. In addition, a complete evaluation of the enthalpy flux variation in the vent system was provided for each test. Finally, pool swell dynamics were quantified for the nominal test and correlated to the observed ringheader strut loads. One of the conclusions is that the 2D torus sector provides a useful test facility for prediction of peak down-loads, but not for predictions of peak up-loads. The latter were found to be somewhat larger in the 90° torus segment, indicating significant 3-D effects.

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PELE-IC Code Status:

D. Norris stated that LLL plans the following tasks for FY 80:

1) PELE-IC will be fully documented to reflect code changes and new features mandated by analytical comparisons with nonproprietary test data, and released for public use.

2) Additional BWR suppression pool dynamic calculations will be carried out, per NRC requests in support of the ongoing test programs. Cases to be run will be chosen to enhance code verification and to provide licensing audit assistance.

The LLL work proposal has not yet been reviewed by NRC.

ATTACHMENT 1

Containment Code Review Group Meeting

Attendance

S. Fabic, NRC/RES
N. Zuber, NRC/RES
G. Mansfeld, NRC/(GRS)
C. Grimes, NRC/NRR
F. Chiang, NRC/NRR
J. Kudrick, NRC/NRR
C. Anderson, NRC/NRR
W. Butler, NRC/NRR
A. Sonin, MIT
D. Norris, LLL
E. McCauley, LLL
C. Landram, LLL
J. Lehner, BNL
H. Townsend, GE
B. Patel, CREARE
J. Block, CREARE
J. Sursock, EPRI
T. Martin, NUTECH
V. Dhir, UCLA

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Attachment 2

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

MAY 25 1979

To Those On The Attached List

Gentlemen:

The next meeting of the Containment Code Review Group is scheduled for June 19, 1979, to be held in the 11th Floor Conference Room, Willste Bldg. (Silver Spring), starting at 9:00 a.m. The subject of the meeting will be steam chugging phenomena in pressure-suppression containments. Again the focus will be on specific programmatic recommendations. Hope you can make it.

Agenda

. Introduction	R. Cudlin, NRC/RES
. Mark I approach/status	C. Grimes, NRC/DOR
. Mark II approach/status	C. Anderson, NRC/DSS
. Condensation Rate for Chugging	A. Sonin, MIT
. Foreign Experimental Programs	R. Cudlin, NRC/RES
. Analytical Description of Chugging	J. Pitts, LLL
. Discussion and Recommendations	All

- Is load measurement in full scale tests sufficient? (single vent, multiple vent, modeling of containment structures?)
- Do we need analytical descriptions of chugging?
- Can chugging be modeled from first principles?

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- Current/Future programs: Do we need to do anything differently? Do we need to do more?

. Intercompartment Flow Tests

S. Fabic

S. Fabic, Chairman
Containment Code Review Group
Division of Reactor Safety Research

Addresses of Letter Dated MAY 5 1979

W. Butler, NRC
G. Lainas, NRC
J. Paulson, NRC
J. A. Kudrick, NRC
E. Imbro, NRC
N. Zuber, NRC
C. Grimes, NRC
R. Cudlin, NRC
C. Anderson, NRC
G. Mansfeld, NRC Consultant
R. Lahey, RPI
A. A. Sonin, MIT
I. Catton, UCLA
E. McCauley, LLL
J. Pitts, LLL
D. Norris, LLL

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Attachment 2

List of Handouts

1. Mark I - LOCA Condensation Loads

2. Mark II - Steam Condensation / Chugging Phenomena,
   - Approach Status

3. MIT study on chugging

POOR ORIGINAL

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Handout 1

MARK I LOCA CONDENSATION LOADS

FULL SCALE TEST FACILITY (FSTF)

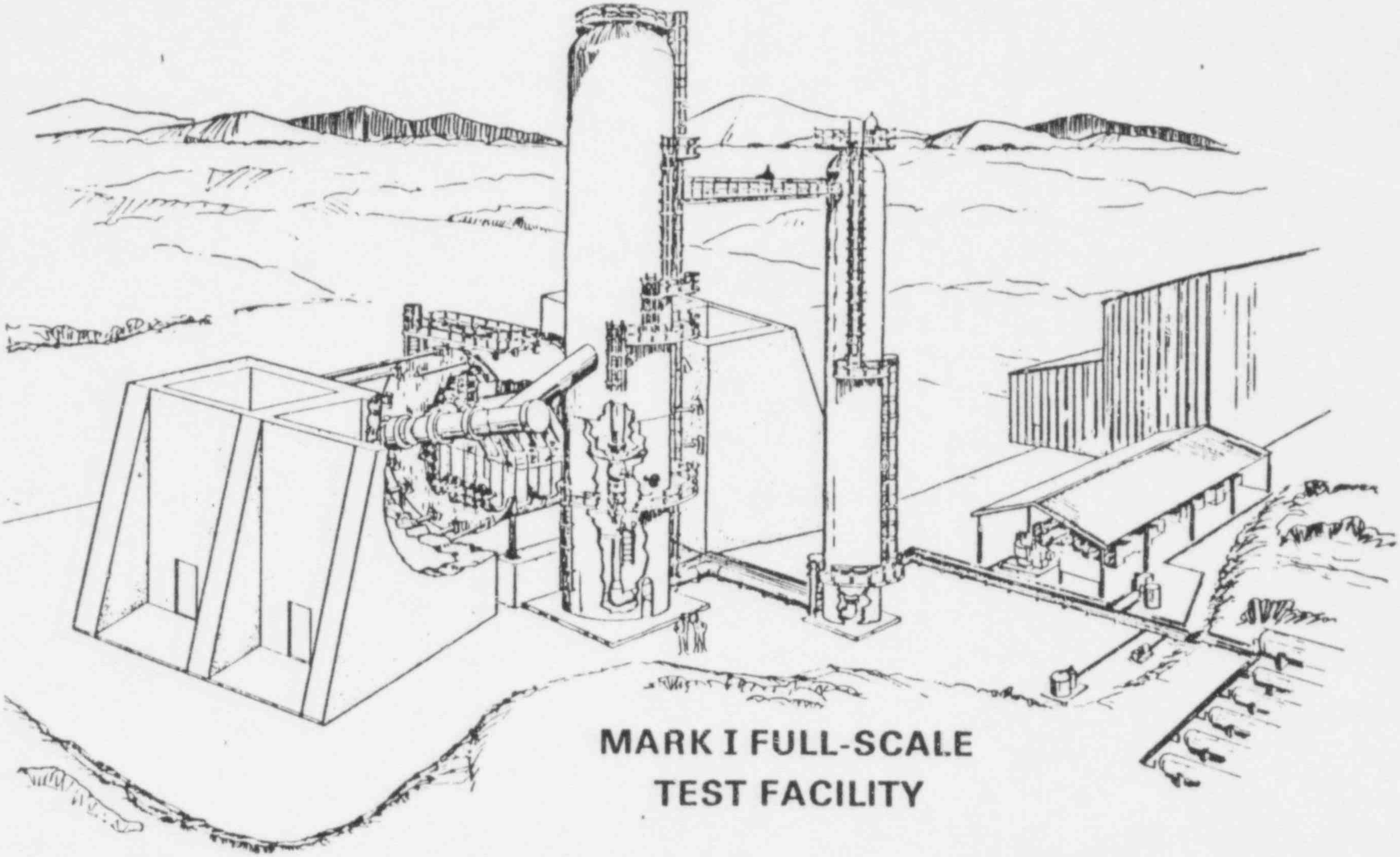
* SINGLE MONTICELLO BAY (AVERAGE STRUCTURAL PLANT)
* 4 DOWNCOMER PAIRS
* 10 TEST SERIES - DBA, IBA, & SBA
  LIQUID & STEAM

LOADING CONDITIONS

* CONDENSATION OSCILLATION SHELL LOADS
* PRE & POST CHUG SHELL LOADS
* DOWNCOMER LATERAL LOADS
* VENT SYSTEM PRESSURE OSCILLATIONS
* SUBMERGED STRUCTURE OSCILLATORY DRAG

618247

presented by Chris Grimes (NRC-NRR) at the Containment Review Group Meeting on June 19, 1979



MARK I FULL-SCALE
TEST FACILITY

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TEST MATRIX

TEST NUMBER	BREAK SIZE	BREAK TYPE	SUBMERGENCE	T_{WW}	P_{WW}
1	Small	Steam	3'4"	70°F	0psig
2	Medium	↓	↓	↓	↓
3	Small	Liquid	↓	↓	↓
4	↓	Steam	↓	↓	*
5	↓	↓	↓	120°F	0psig
6	↓	↓	1'6"	↓	↓
9	↓	↓	4'6"	70°F	↓
10**	↓	↓	3'4"	↓	↓
7	Large	↓	↓	↓	↓
8	↓	Liquid	↓	↓	↓

* Calculated to result in a final wetwell airspace pressure of ~30 psig

** Air sensitivity test performed with vacuum breaker replaced with rupture disc

CONDENSATION OSCILLATION & CHUGGING SHELL LOADS

LOAD SPECIFICATION - BOUNDING TIME INTERVALS

FSI EFFECTS REMOVED - EQUIVALENT "RIGID WALL" FUNCTION

* NASTRAN FSTF STRUCTURE & FLUID (CMM)
* INFERRED SOURCE CORRELATION ON INTEGRAL PRESSURE
* FOURIER DATA EXPANSION
* DEVELOP DOWNCOMER OR WALL FORCING FUNCTION (PSD HISTOGRAM) FROM AMPLIFICATION FACTOR

C/O	TEST M8	1 SEC DATA
PRE-CHUG	TEST M9	ENTIRE TEST
POST-CHUG	TEST M1, M4, & M9	18 EVENTS

POOL AREA / VENT AREA CORRECTION FOR PLANT-UNIQUE LOAD

* C/O ONLY
* PRESSURE ATTENUATION (2D POTENTIAL FLOW)

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MARK I CMM EVALUATION MODEL

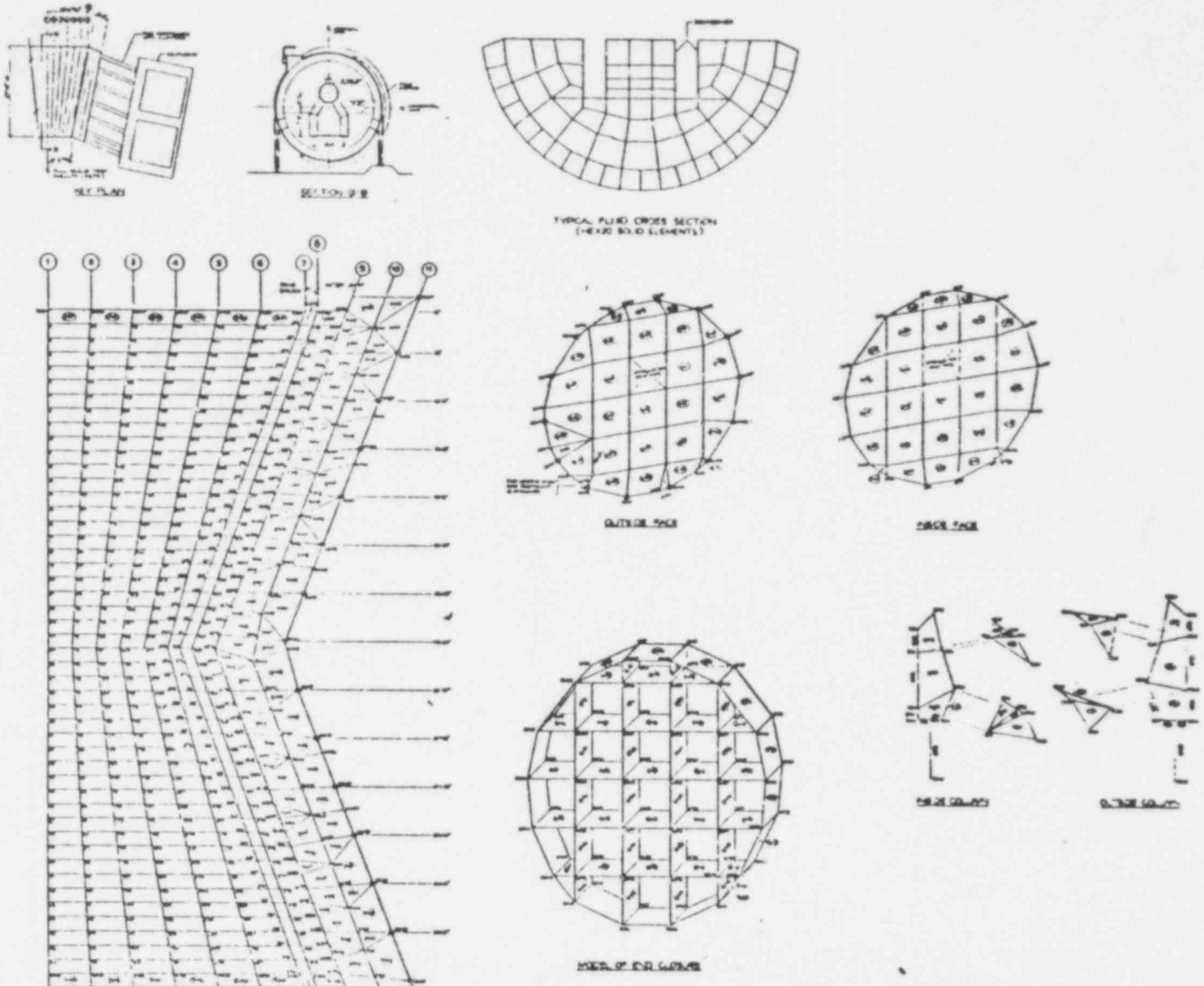

FIGURE 3-2f FINITE ELEMENT MODEL OF PSTF

POOR ORIGINAL

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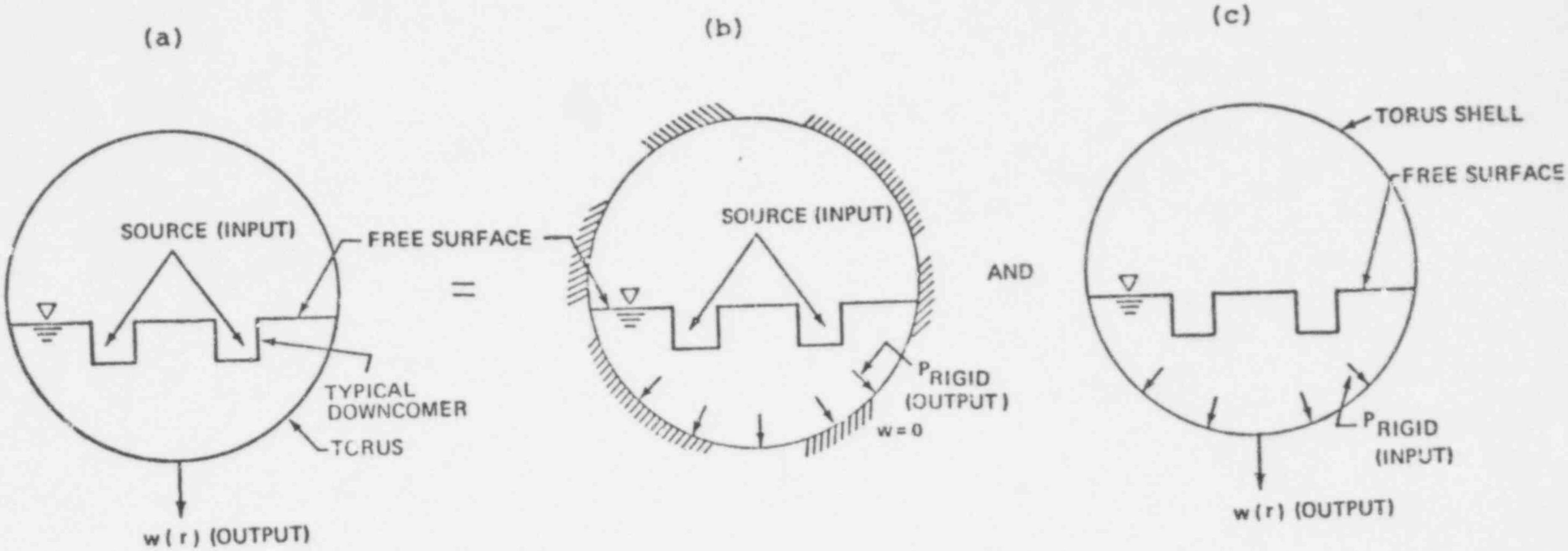
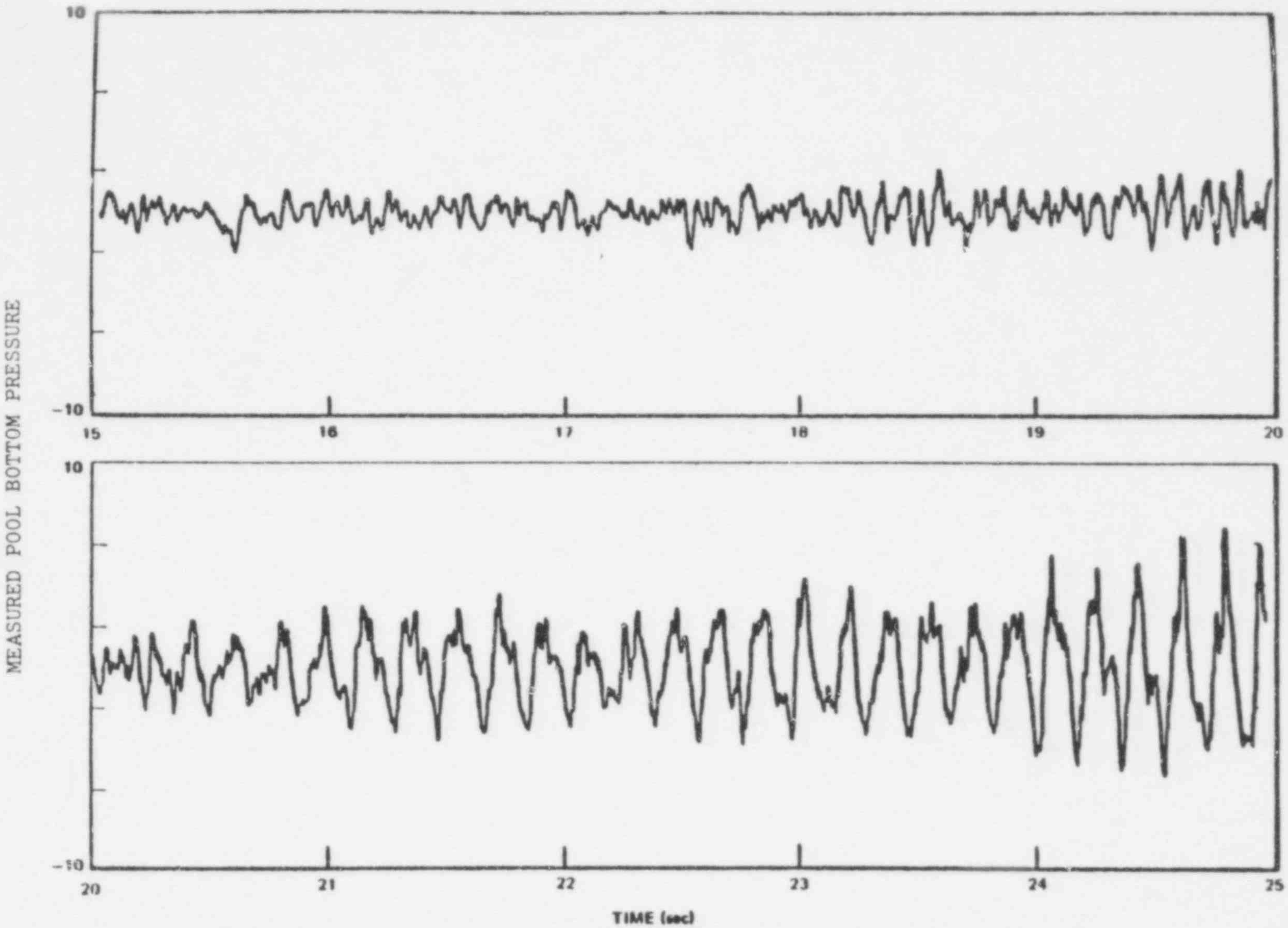


{ANALYSIS OF FLEXIBLE TORUS WITH FORCING SOURCE APPLIED AT THE DOWNCOMER} GIVES SAME RESULT AS {ANALYSIS OF RIGID TORUS WITH FORCING SOURCE APPLIED AT THE DOWNCOMER} FOLLOWED BY {ANALYSIS OF FLEXIBLE TORUS WITH RIGID WALL PRESSURE INPUT AT THE WETTED SURFACE OF THE SHELL}

CONDENSATION OSCILLATION FLOW REGIME



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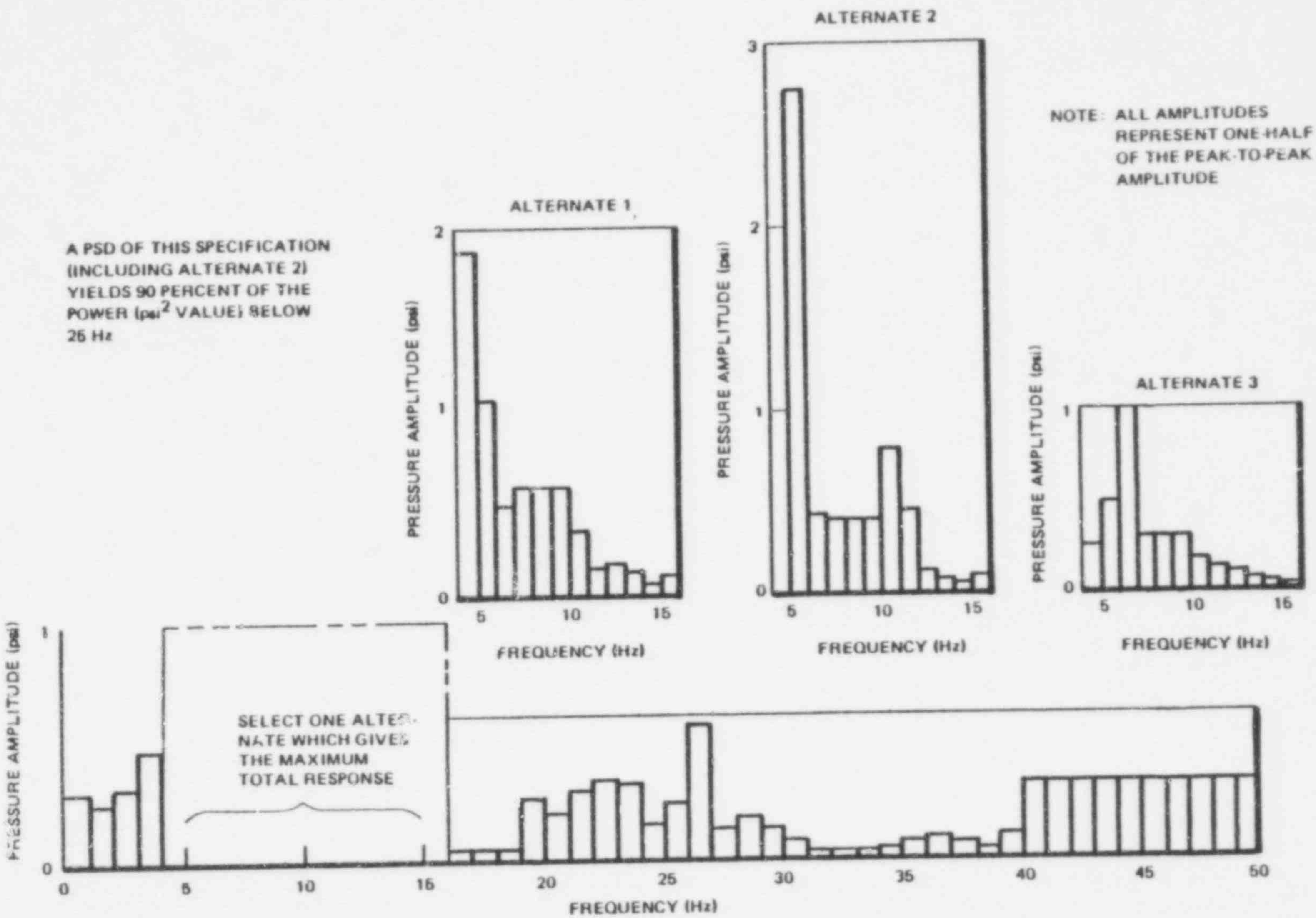
MARK I CONDENSATION OSCILLATION LOADING FUNCTION



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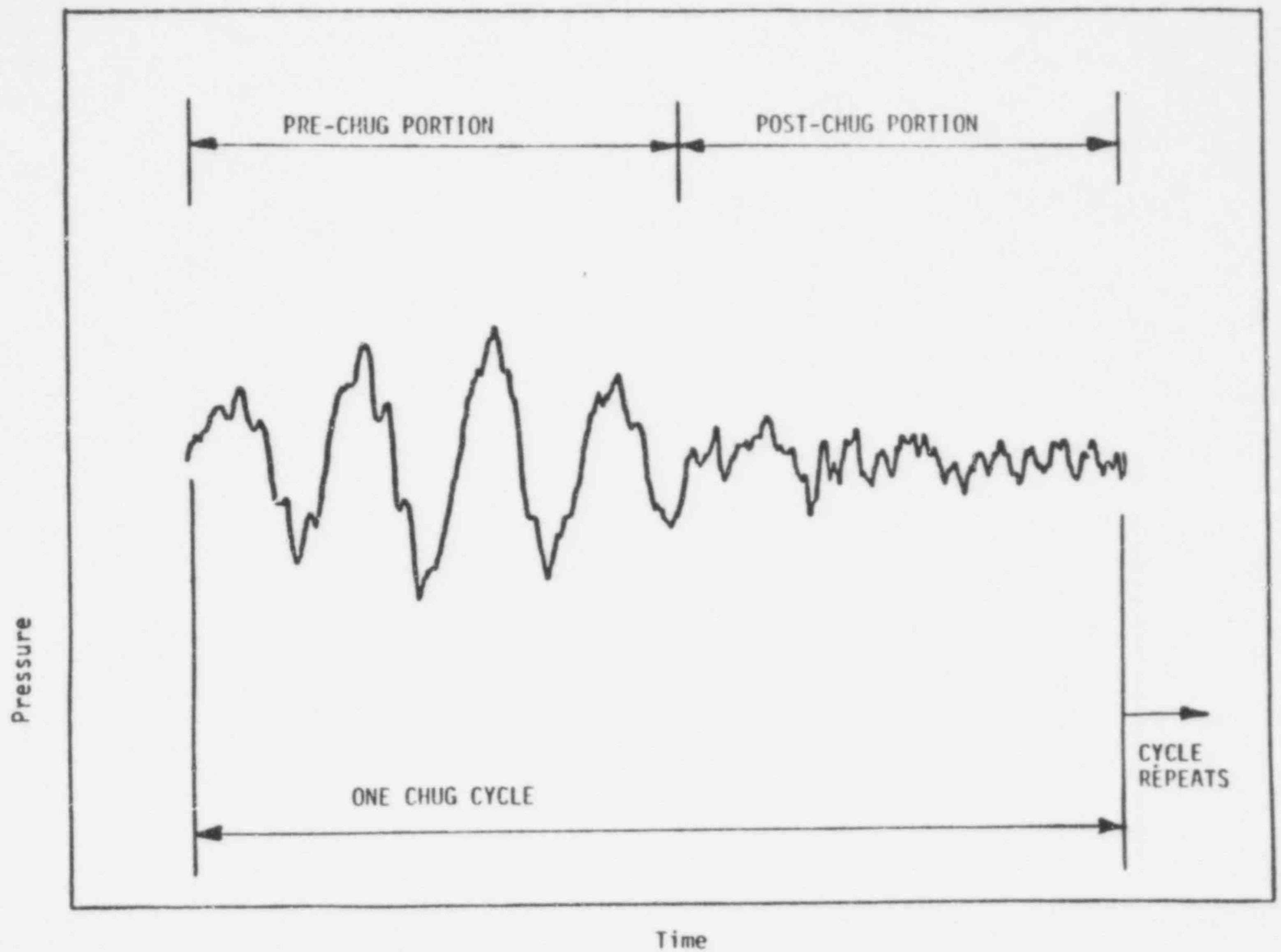
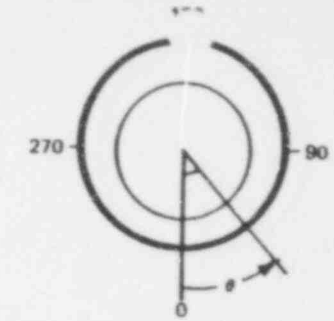

PRE-CHUG PORTION
POST-CHUG PORTION
Pressure
ONE CHUG CYCLE
CYCLE
RÈPEATS
Time

618255

CHUGGING LOAD FUNCTION

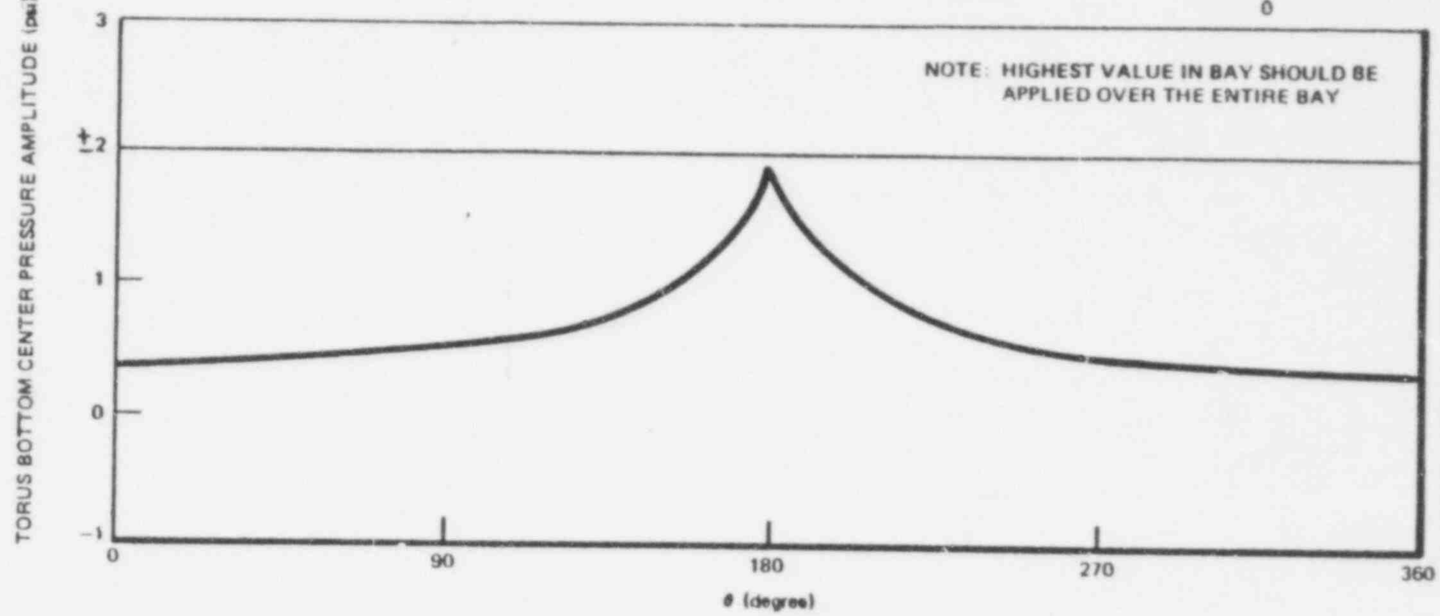


NOTE: THE AMPLITUDE SHOWN HERE REPRESENTS
ONE-HALF OF THE PEAK-TO-PEAK AMPLITUDE

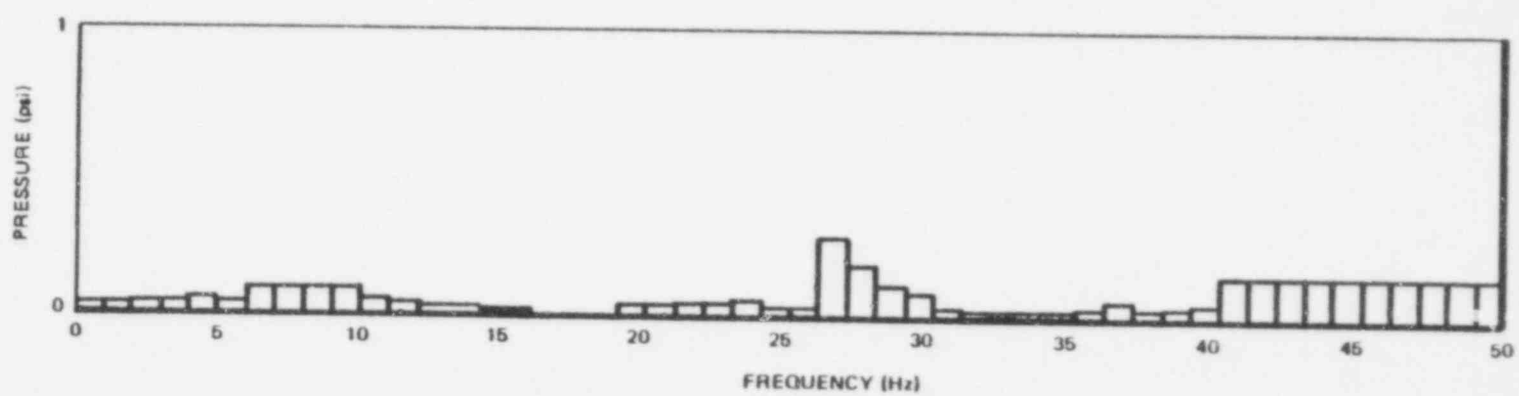
PRE-CHUG

SYMMETRIC & ASYMMETRIC

6.9 to 9.5 hz

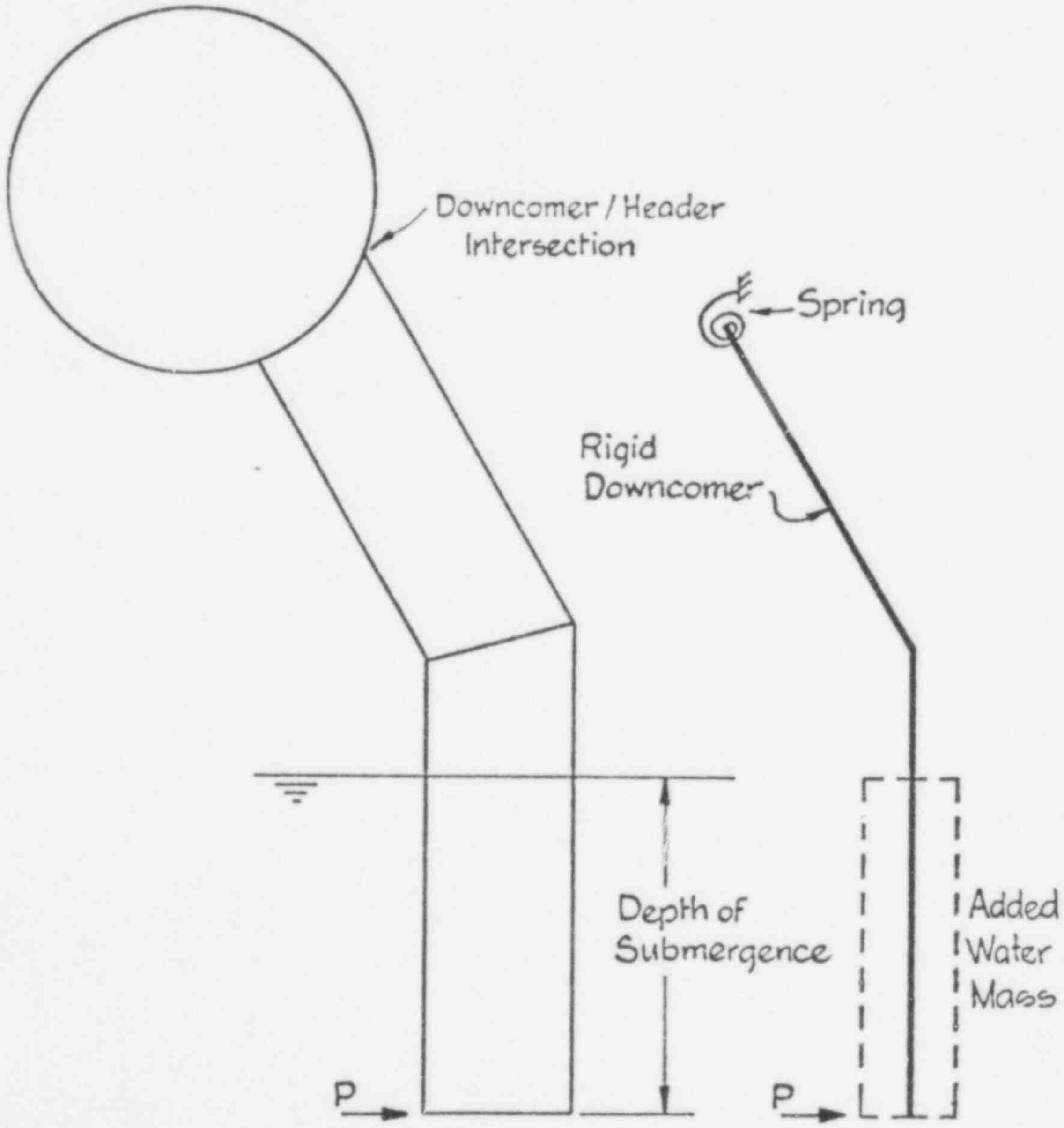


POST-CHUG



DOWNCOMER MODEL

EQUIVALENT SINGLE-DEGREE-OF-FREEDOM SYSTEM



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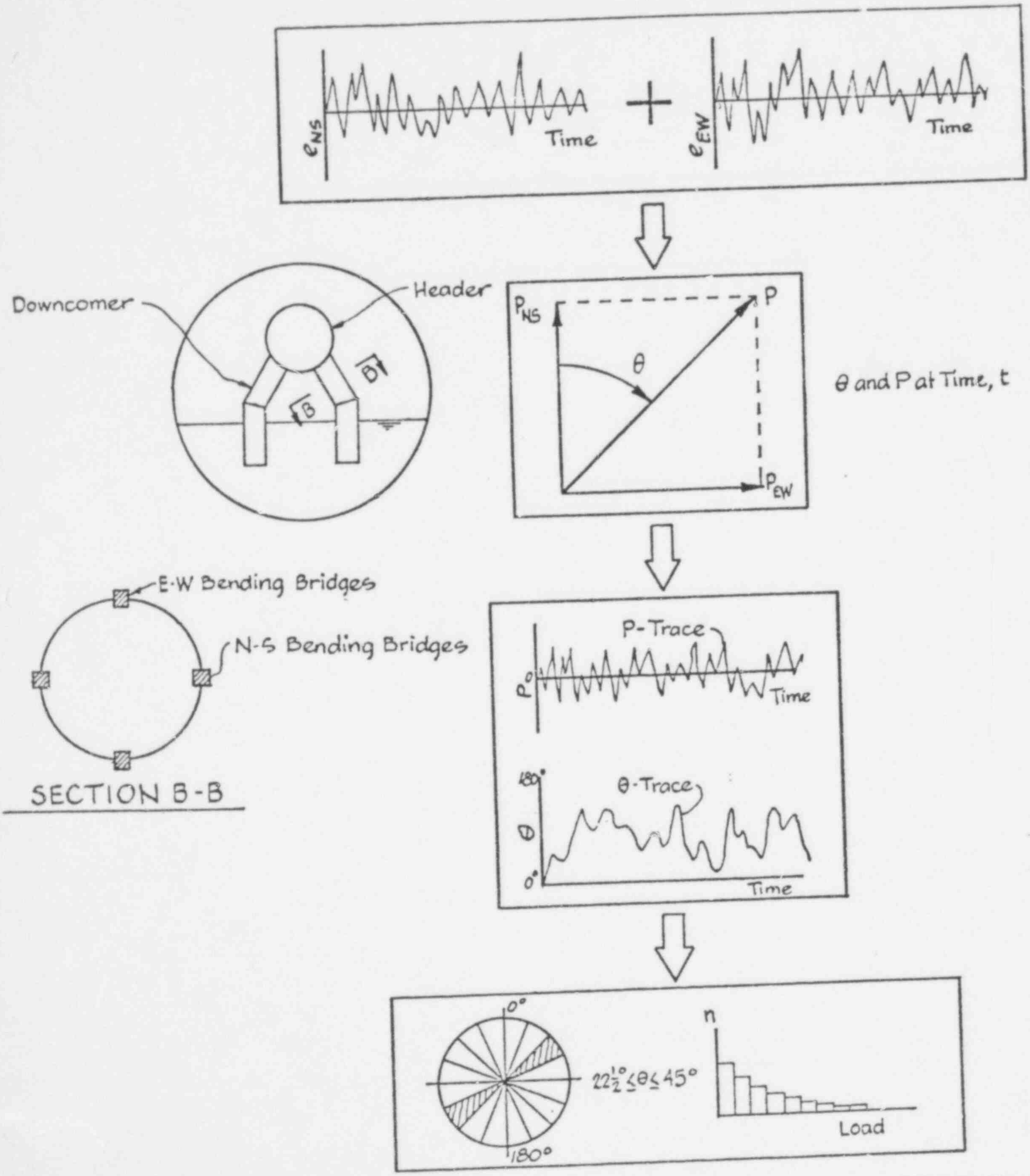
DOWNCOMER RSEL DEFINITION



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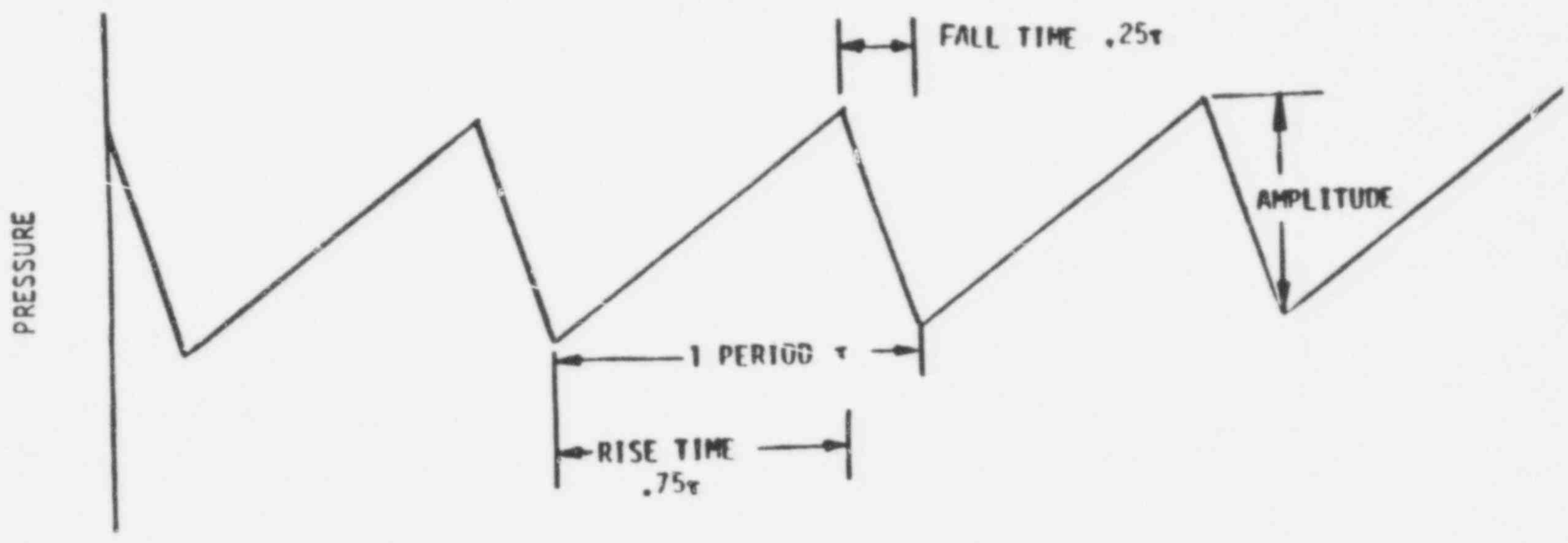
LOAD TYPE	FREQUENCY (Hz)	AMPLITUDE (PSI)		
		Main Vents	Vent Header	Downcomers
Gross Vent System Pressure Oscillation	Use wave form in Figure 1. (0.7 Hz).	± 2.5	± 2.5	± 5.0
Acoustic Vent System Pressure Oscillation	Sinusoidal with frequency varying between 6.9 to 9.5 Hz.	± 2.5	± 3.0	± 3.5
Acoustic Downcomer Pressure Oscillation	Sinusoidal with frequency varying between 40 to 50 Hz.	N/A	N/A	±13.0



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Handout 2

MARK II

STEAM CONDENSATION/CHUGGING PHENOMENA
APPROACH/STATUS

DOWNCOMER LATERAL LOADS

- SINGLE VENT
- MULTIPLE VENT

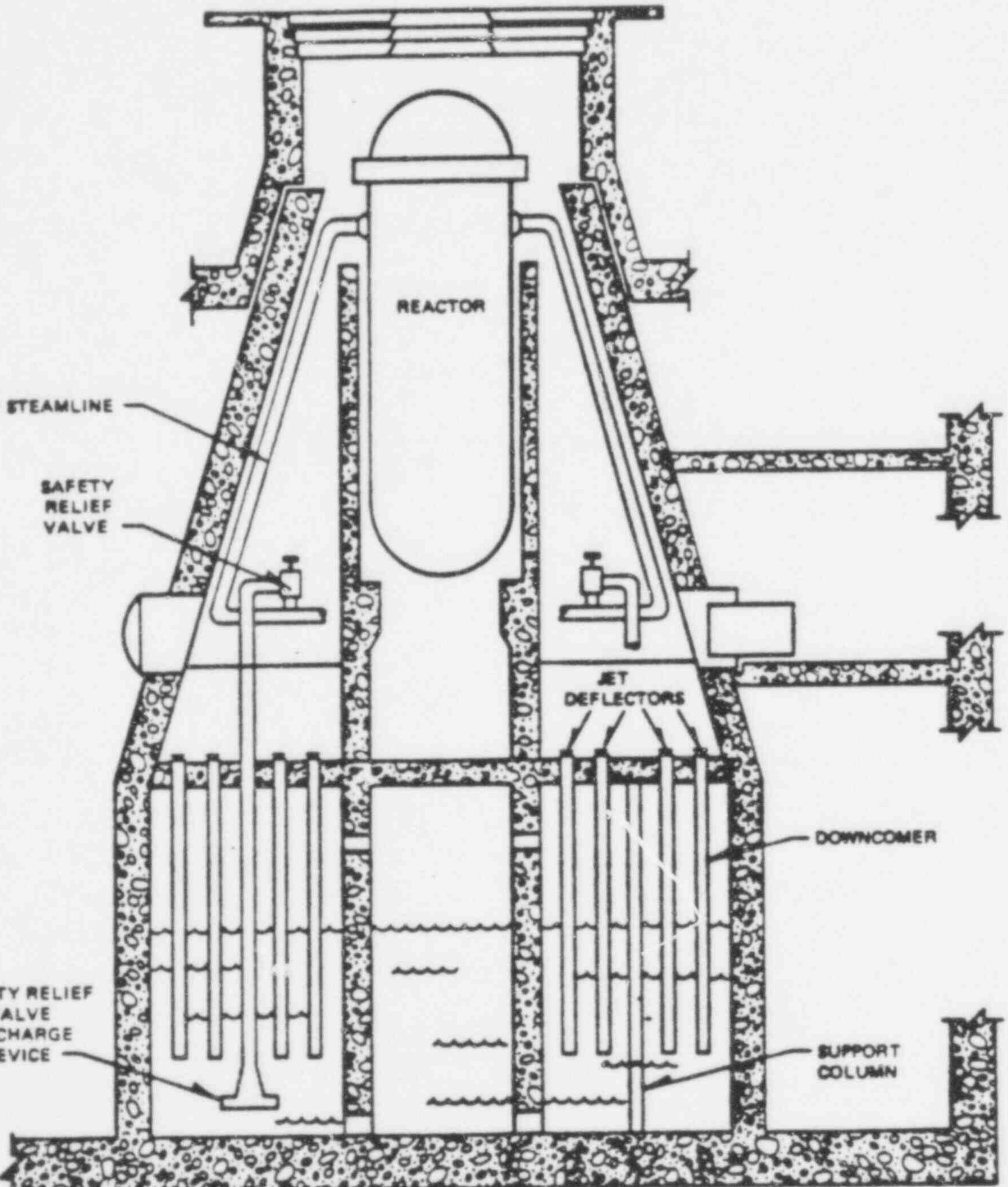
SUBMERGED BOUNDARY LOADS

- CONDENSATION OSCILLATION
- CHUGGING
  - UNIFORM
  - ASYMMETRIC

SUBMERGED STRUCTURE LOADS

presented by Cliff Andersen (NRC-NRR) at the Containment Review Group Meeting on June 18, 1979

618260



Typical Mark II Pressure Suppression Containment

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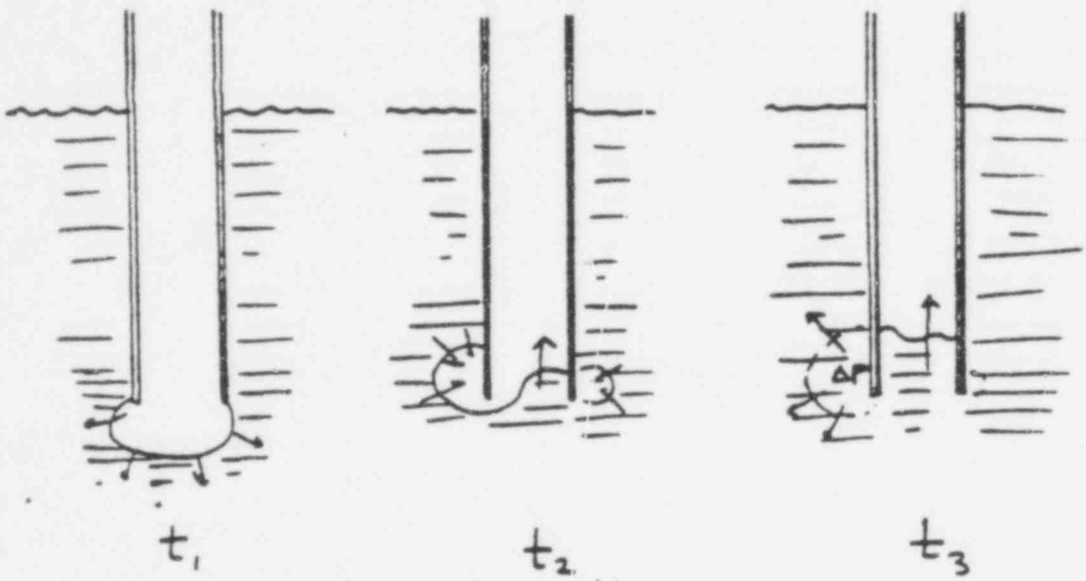
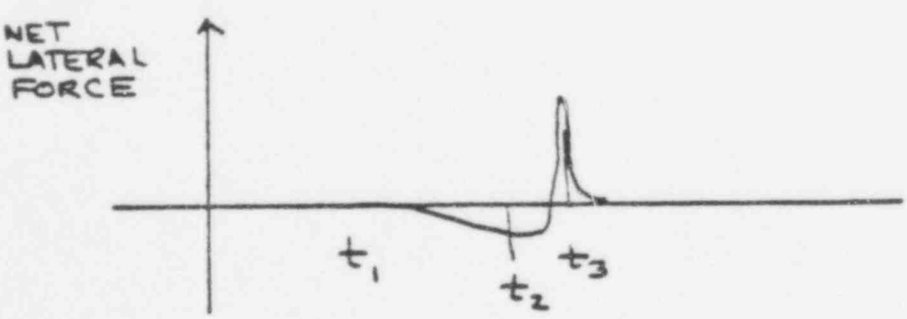
ORIGIN OF LATERAL FORCE DURING CHUGGING





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LOAD SUMMARY

LATERAL LOADS

LOAD OR PHENOMENA	SPECIFICATION	BASIS
*SINGLE VENT	8.8 KIP F ≅ 7HZ 8.8 x F/7 7 < F ≤ 14 HZ	FOREIGN LICENSEE, 4T
	DYNAMIC ANALYSIS F > 14 HZ	
MULTIPLE VENTS	PROBABILISTIC APPROACH RANDOM MAGNITUDE, DIRECTION SIMULTANEOUS CHUG INDEPENDENT 0% AIR-DATA BASE	FOREIGN LICENSEE

TEST FACILITY	MAX. STATIC EQUIVALENT LOAD MEASURED
KWU – GKM (24")	8800 LBF
GE (20")	2400 LBF
KWU – KARLSTEIN (24")	31 500 LBF

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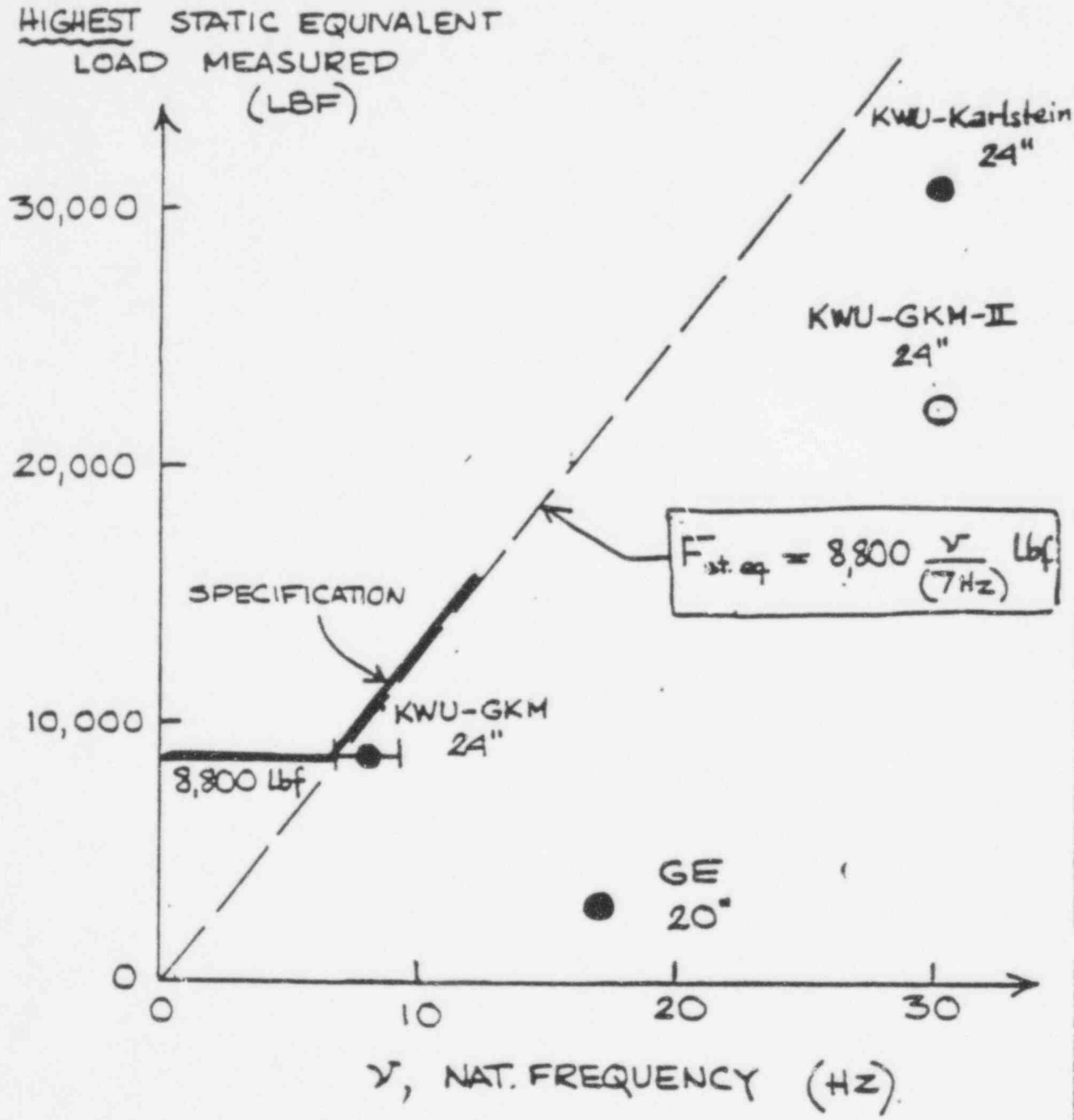

SUMMARY OF DATA

GENERAL FEATURES OF STEAM CONDENSATION AND CHUGGING LOADS

- ORIGIN OF LOADS IS MOTION OF STEAM-WATER INTERFACE AT VENT EXIT.

- DISPLACEMENT EFFECT OF INTERFACE MOTION CREATES PRESSURE TRANSIENTS IN SUPPRESSION POOL WHICH ARE TRANSMITTED TO SUBMERGED BOUNDARIES.

- BEHAVIOR OF "SOURCE" DEPENDS PRIMARILY ON VENT STEAM FLUX RATE.

  - HIGH STEAM FLUX - MOTION IS ESSENTIALLY SINUSOIDAL - AMPLITUDE RELATIVELY CONSTANT

  - LOW STEAM FLUX - MOTION IS UNSTABLE (STEAM BUBBLE COLLAPSE - CHUGGING) FREQUENCY OF OCCURENCE AND AMPLITUDE RANDOM BUT BOUNDED.

- CHARACTER OF SOURCE ALSO SENSITIVE TO AIR CONTENT AND GLOBAL PRESSURE LEVEL; SOME DEPENDENCE ON SUPPRESSION POOL TEMPERATURE.

bnl

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LOAD SUMMARY

POOL BOUNDARY

CONDENSATION LOADS

LOAD OR PHENOMENA	SPECIFICATION	BASIS
HIGH STEAM FLUX > 12 LB/SEC/FT^2	SINUSOIDAL PRESSURE 4.4 PSI-PTP 2-7 Hz SYMMETRIC LOAD UNIFORM BELOW VENTS	FOREIGN LICENSEE, 4T, MARVIKEN DATA CONSERVATIVE APPLICATION CONSERVATIVE
MEDIUM STEAM FLUX 8-12 LB/SEC/FT^2	SINUSOIDAL PRESSURE 7.5 PSI-PTP 2-7 Hz SYMMETRIC LOAD UNIFORM BELOW VENTS	FOREIGN LICENSEE, 4T, MARVIKEN DATA CONSERVATIVE APPLICATION CONSERVATIVE

LOAD SUMMARY

CHUGGING LOADS

LOAD OR PHENOMENA	SPECIFICATION	BASIS
CHUGGING < 8 LB/SEC/FT^2	REPRESENTATIVE 4T PRESSURE TRACE	4T, FOREIGN LICENSEE, MARVIKEN
	UNIFORM BELOW VENTS	
	SYNCHRONIZED CHUGS	
UNIFORM LOADING	+4.8 PSI, -4.0 PSI 20-30 HZ	
ASYMMETRIC LOADING	+20 PSI, - 24 PSI PERIPHERAL VARIATION OF AMPLITUDE MAXIMUM MAX/MIN OPPOSED	

CHUGGING LOAD CONSERVATISMS

- DIRECT APPLICATION OF MAXIMUM LOADS OBSERVED IN A BOUNDING FULL SCALE SINGLE CELL TEST FACILITY (4T)

  — CONSERVATIVE DATA SELECTED PREFERENTIALLY

  — SMALL POOL AREA RELATIVE TO PROTOTYPE

  — LOW AIR CONTENT

- LOADING APPLICATIONS PROVIDE ADDITIONAL CONSERVATISM

  — EXACT VENT SYNCHRONIZATION

  — FREQUENCY CONTENT OF SELECTED PRESSURE SIGNATURE MAXIMIZES STRUCTURAL RESPONSE

  — CONSERVATISM DEMONSTRATED ANALYTICALLY

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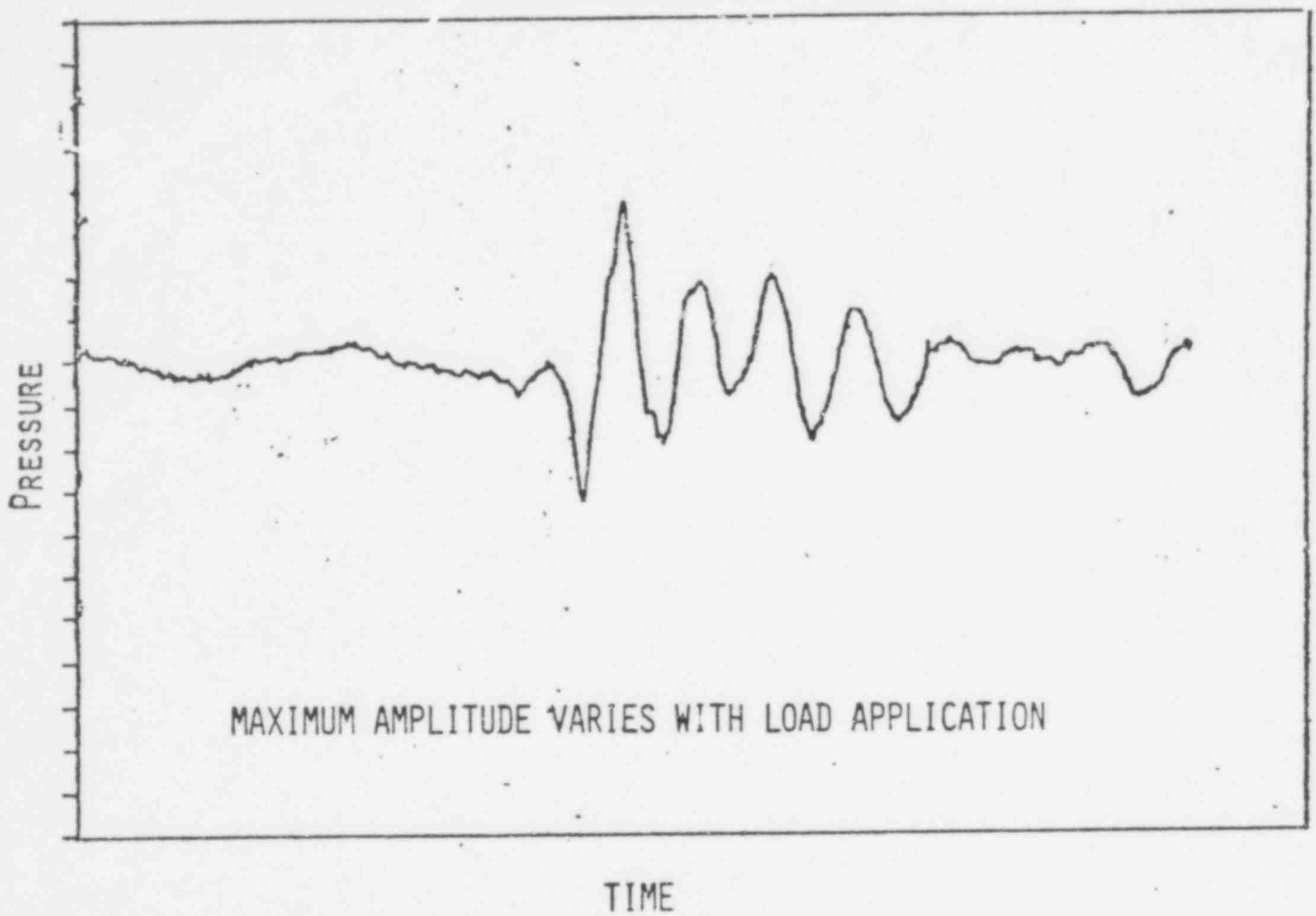
MARK II OWNERS GROUP SPECIFICATION FOR CHUGGING LOADS ON SUBMERGED BOUNDARY

- TEMPORAL VARIATION



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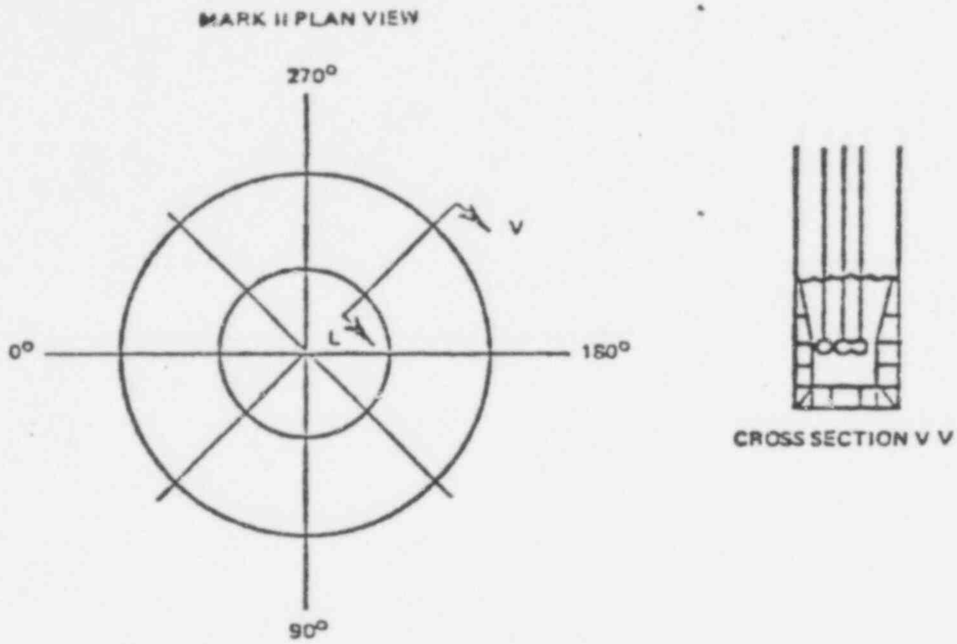
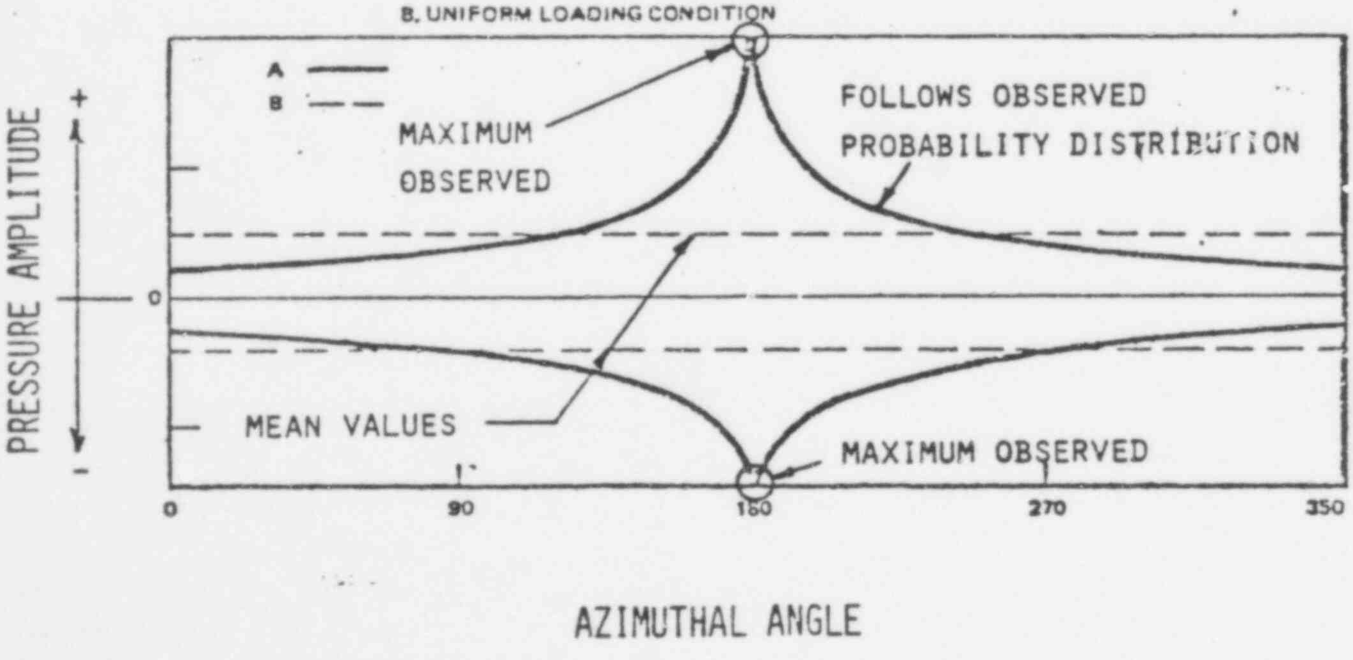
MARK II OWNER'S GROUP SPECIFICATION FOR CHUGGING LOADS ON SUBMERGED BOUNDARY

- SPATIAL VARIATION



A. ASYMMETRIC LOADING CONDITION

B. UNIFORM LOADING CONDITION



618271

C.O./CHUGGING SUBMERGED STRUCTURE LOADS

- TOTAL DRAG	=	ACCELERATION DRAG	+	STANDARD DRAG

- FLOW FIELD FROM SPHERICAL SOURCE AND METHOD OF IMAGES

- SOURCE TIMING AND PHASING CONSIDERS WORST CASE

- VARIABLE SOURCE STRENGTH CONSIDERING NUMBER OF PARTICIPATING VENTS

- SOURCE MAGNITUDE FROM 4T

618272

MARK II LONG TERM PROGRAM
STEAM CONDENSATION/CHUGGING
PHENOMENA STUDIES

DOWNCOMER LATERAL LOADS

- SINGLE VENT LOAD
    - DYNAMIC LOAD MODEL
    - SUSQUEHANNA - KWU TESTS

SUBMERGED BOUNDARY LOADS

- CONDENSATION OSCILLATION
    - EXTENDED 4T TESTS
    - SUSQUEHANNA - KWU TESTS
- CHUGGING
    - MULTIVENT STUDIES
        - CREARE, JAERI AND GKSS TESTS
        - MULTIVENT HYDRODYNAMIC MODEL
    - IMPROVED SOURCE SPECIFICATION STUDIES
        - GENERIC BECHTEL STUDY
        - WPPSS-2 BEDROSIAN STUDY

SUBMERGED STRUCTURE STEAM LOADS

- MULTIVENT HYDRODYNAMIC MODEL
- MC SELECTION OF CHUG AND PHASE SHIFT

618273

CREARE
TEST PROGRAM

OBJECTIVES

- ESTABLISH LOAD TREND WITH NUMBER OF VENTS
- CONFIRM MVHM ASSUMPTIONS
- VERIFY PLANT LOAD APPLICATION METHODS

PROGRAM ELEMENTS

- SCALING ANALYSIS AND SCOPING TEST (PHASE 1)
- MULTIVENT TESTS (PHASE 2)
- APPLICATION OF RESULTS (PHASE 3)

618274

Scope Of
CREARE Tests

Condensation Mapping Tests (CONMAP)

- 1/16 scale, single vent
- flow visualization
- verify MV scoping test matrix
- parametric effects

Single Vent Tests

- 1/10, 1/6, 1/4 scale
- full vent length
- effects of
    - steam mass flux
    - pool temperature
    - steam air content
    - pressure
    - geometry
- Scaling Studies

Multivent Tests

Scale	Vents
1/10	1, 3, 7, 19
1/6	1, 3, 7
1/4	1, 3
5/12	1

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Creare

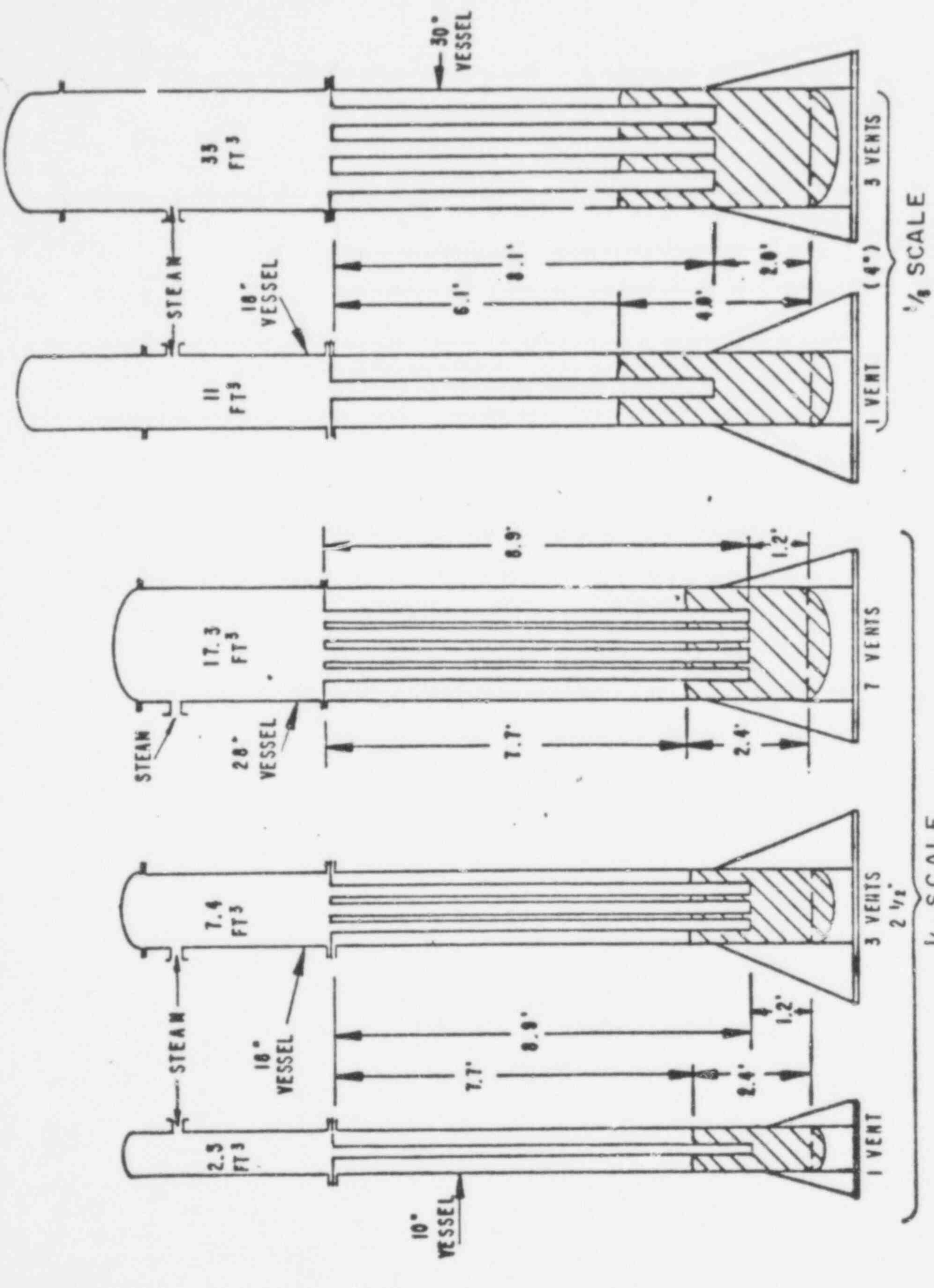
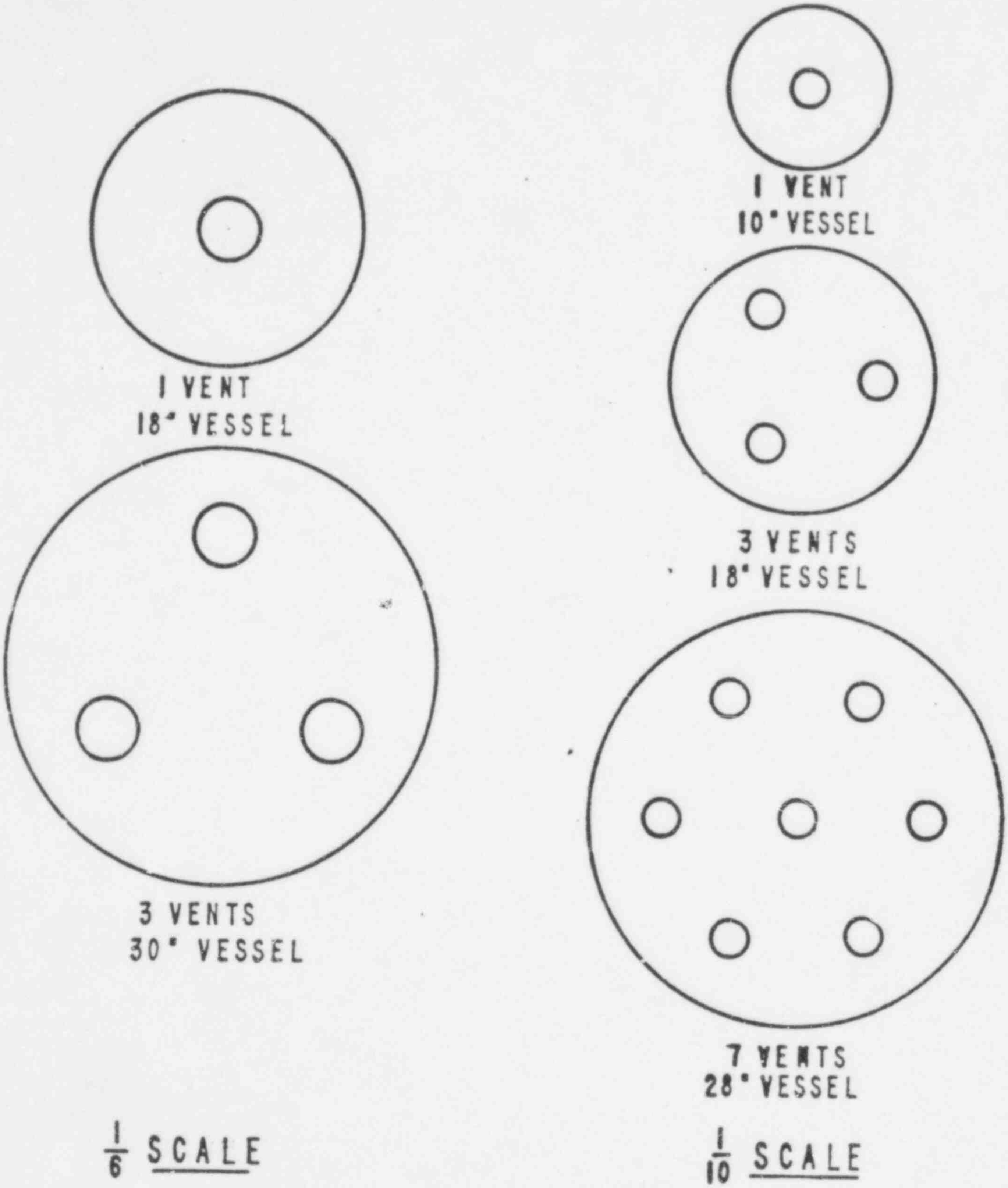


FIGURE 5. VESSELS FOR PHASE I SCOPING TESTS

618276

Creare



PHASE I MULTIVENT GEOMETRIES

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CREARE Tests
Preliminary Observations

Scaling Studies

- No single scheme adequate
- Froude Scaling
  - Pool Swell - Bubble Growth Dynamics
- Mach Scaling
  - Bubble Collapse, Vent Mach Number
- Semi - Empirical Scheme
  - Condensation
- Identify Key Phenomena for Accurate Scaling
- Tests Matrix Cover Various Scaling Schemes

Multivent Tests

- MV multiplier less than one
- MV multiplier decreases with no. vents
- Phasing Information
  - Multiple Chug Statistics
  - Time Window Statistics

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Status Of
CREARE Tests

Phase I	Scaling Analysis, Single Vent Tests, 1/10, 1/6 Multivent Tests (Complete June 1979)
Phase II	Extended Multivent Tests 1/10, 1/6, 1/4, 5/12 Scale (Decision 2Q 1979)
NRC Meeting	Phase I Results Phase II and III Plans (July 17, 18, 1979)
Phase III	Applications Methods Preliminary Based on Phase I (2Q 1979) Final Based on Phase II (3Q 1980)

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Mark II Full Scale
4T C/O Tests

Test Objective

- Confirm current Mark II c/o spec.
- Address vent length effects
- Refine c/o specification

Test Schedule

- Facility Modifications	1Q 1980
- Testing	2Q 1980
- Report	4Q 1980

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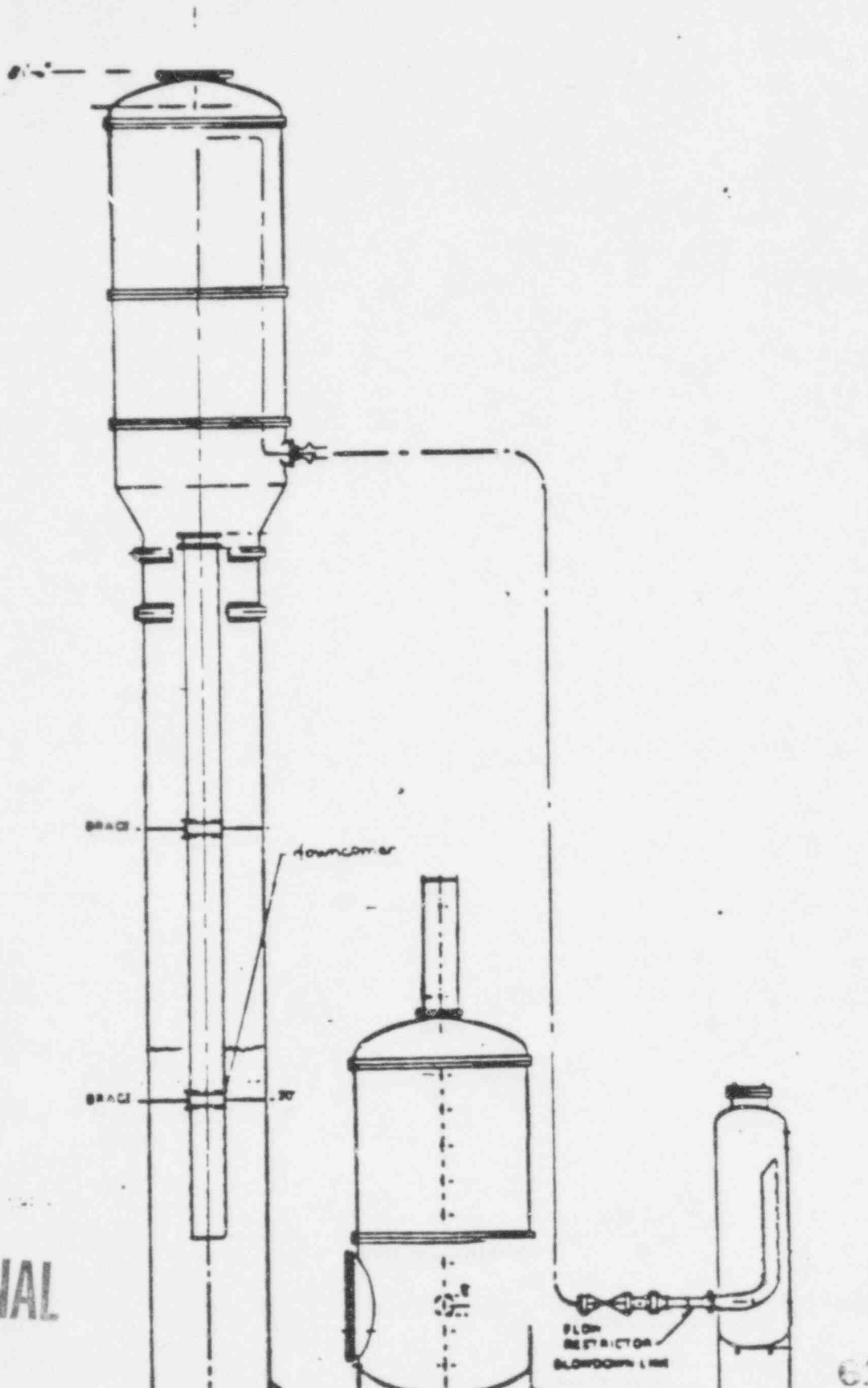
TEST CONFIGURATION FOR MARK II CONDENSATION OSCILLATION TESTS



POOR ORIGINAL

618281

SUSQUEHANNA - KWU
C/O TESTS

TEST OBJECTIVES

- PROTOTYPICAL SUSQUEHANNA TESTS TO
  - CONFIRM CO AND CHUGGING LOADS
- PROTOTYPICAL VENT BRACING
  - DATA SUPPORT REDUCTION IN LEAD PLANT LATERAL LOAD SPECIFICATION

TEST SCHEDULE

TESTING	(3Q 1979)
TEST INTERPRETATION	(2Q 1980)

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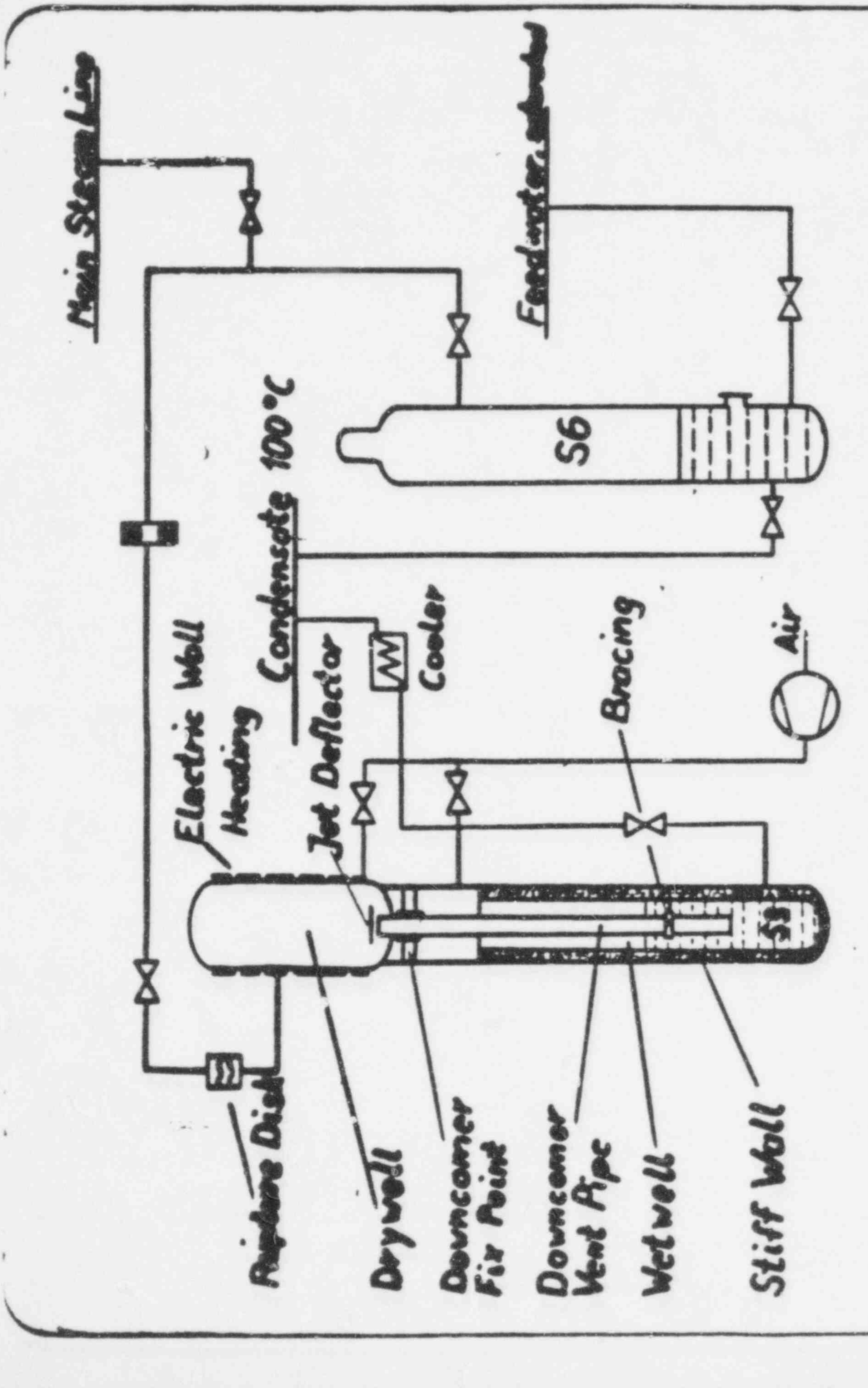
ENCLOSURE 10



GKM II - M

Schematic Diagram to MSL - Break - Tests

618283

JAERI
Full Scale Multivent Tests

Test Measurements

- 245 Measurements
- Pressure
- ΔP
- Temperature
- Water Level
- Strain
- Displacement
- Impact Loads

Test Schedule

- 5 Year Test Program - Start 1977
- Begin Testing April 1979

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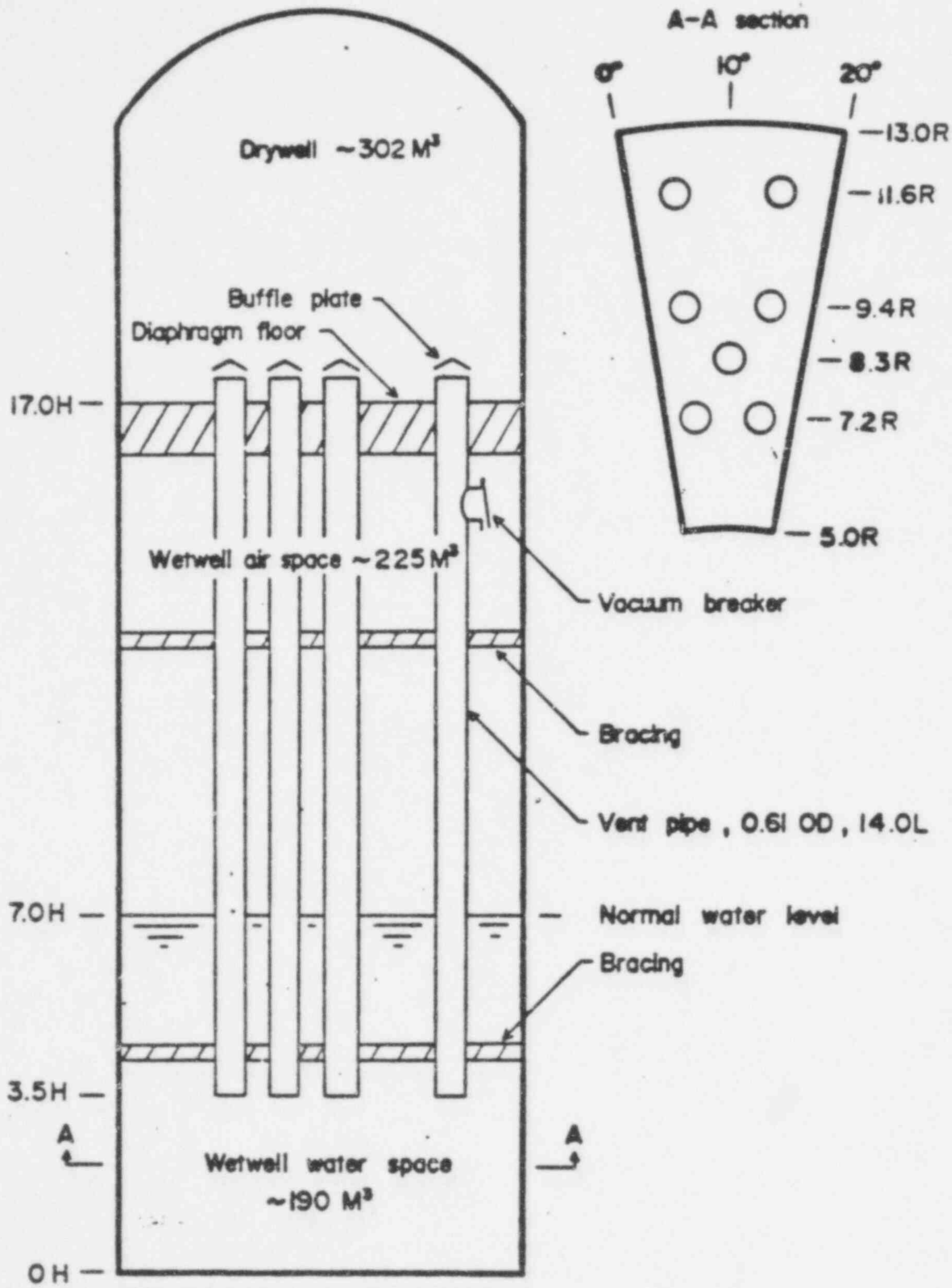

Fig. 2.3 Test containment of full scale Mark 2 CRT

618285

Mk II
Analytical Programs

Multivent Hydrodynamic Model

- Library of 4T Chugs (137)
- Monte Carlo Selection
  - Chug Number
  - Phase Shift
- Hydrodynamic Model
  - Potential Flow
  - Method of Images

Chugging Improvement Programs

(Generic Bechtel Method)

(WPPSS-2 Bedrosian Method)

4T Studies

4T Numerical Model

Chug Source Development

Mark II Application

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MIT study on chugging

Purposes : A. to understand physical mechanism of chugging

B. to quantify condensation (heat transfer) rate, for ex. with semi-empirical correlation which implies scaling.

C. to postulate model for chugging, insofar as that is possible.

Approach : 1. Tentative model, including postulated condensation rate equation.

Kowalchuk & Sonin
NUREG/CR-0221

2. Single-chug experiments in special device, to adress A & B above.

3. Simulated "chugs" in small flow visualization system to study mixing effects in pool (qualitative).

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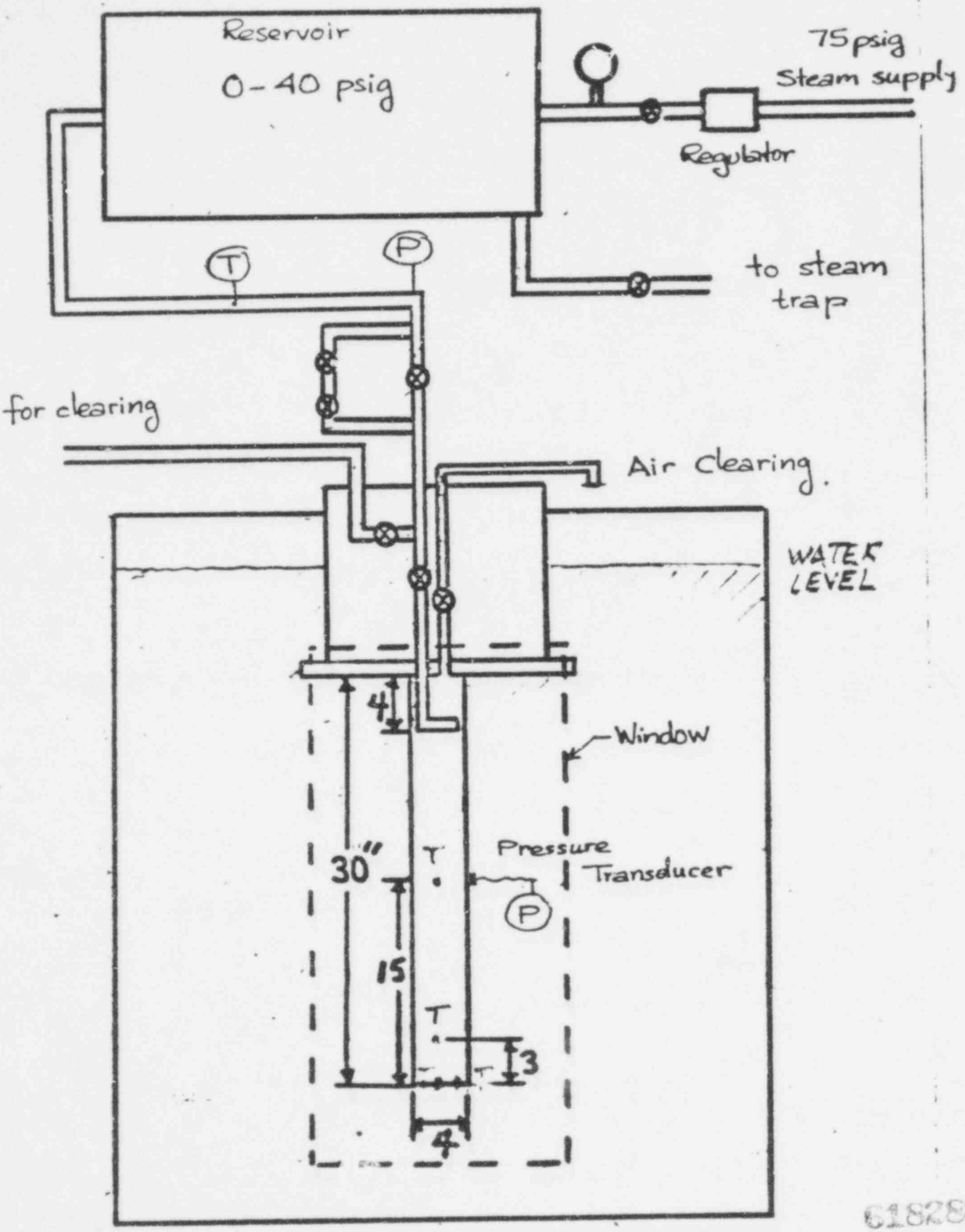
presented by A. Sonin (MIT) at the Containment Review Group Meeting on June 18, 1979

SINGLE - CHUG EXPERIMENT



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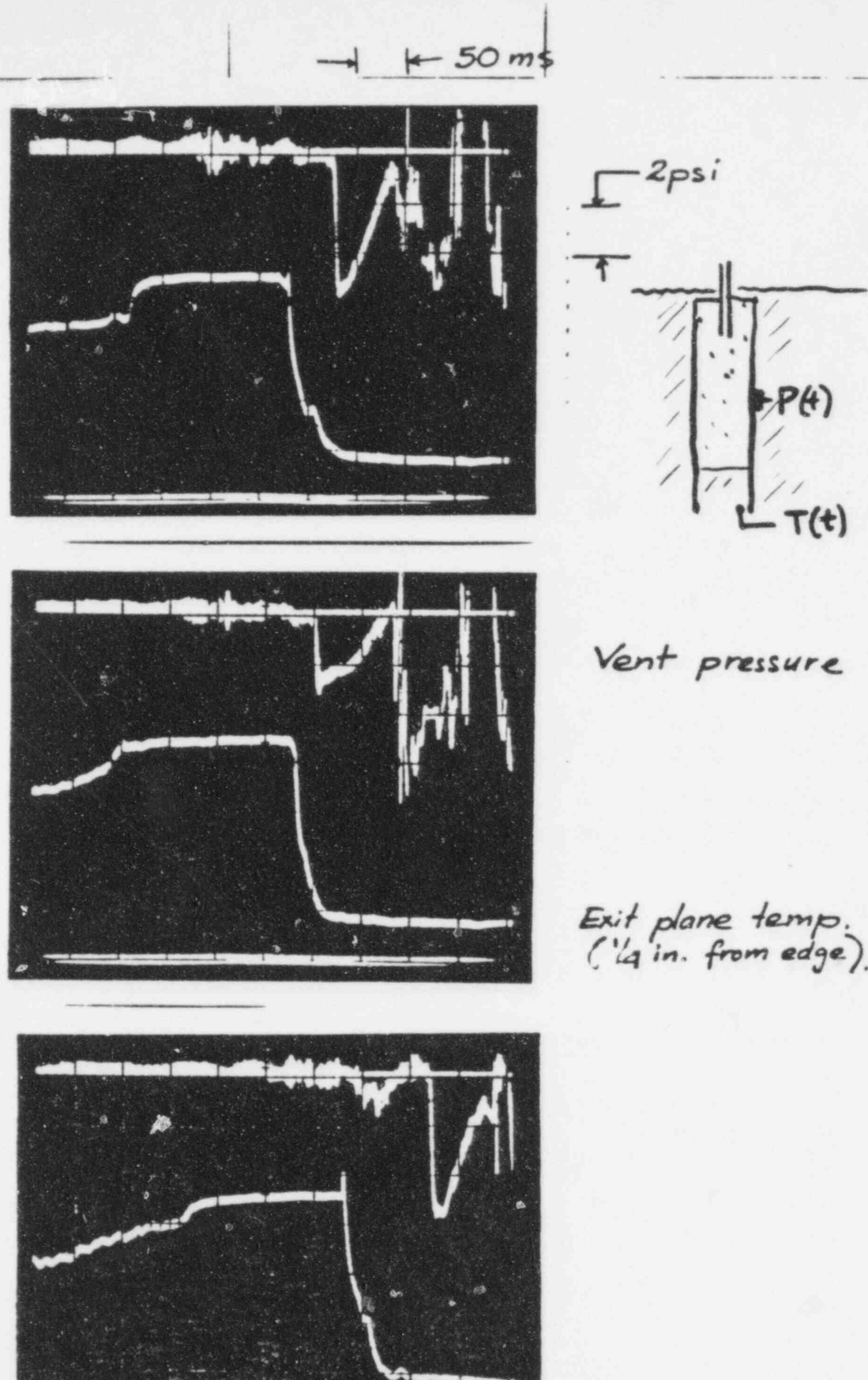

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TYPICAL CONDITIONS : $d = 10$ cm

$(\dot{m}_{steam})_{in} \sim 5$ kg/m²s

$T_{water} \simeq 10°C$

TYPICAL MEASUREMENTS :

Water descent stage : vent pressure ~ 1 bar
water velocity ~ 1 m/s

Chug (depressurization) vent pressure drop ~ 0.1–0.7 bar
duration of drop ~ 4–14 ms

Water ascent stage : water velocity ~ 3–7 m/s

CALCULATIONS FROM MEASUREMENTS

Condensation heat flux during chug (depressurization):

$$\dot{q} \sim (2 - 13.5) \times 10^{7} \ W/m^2$$

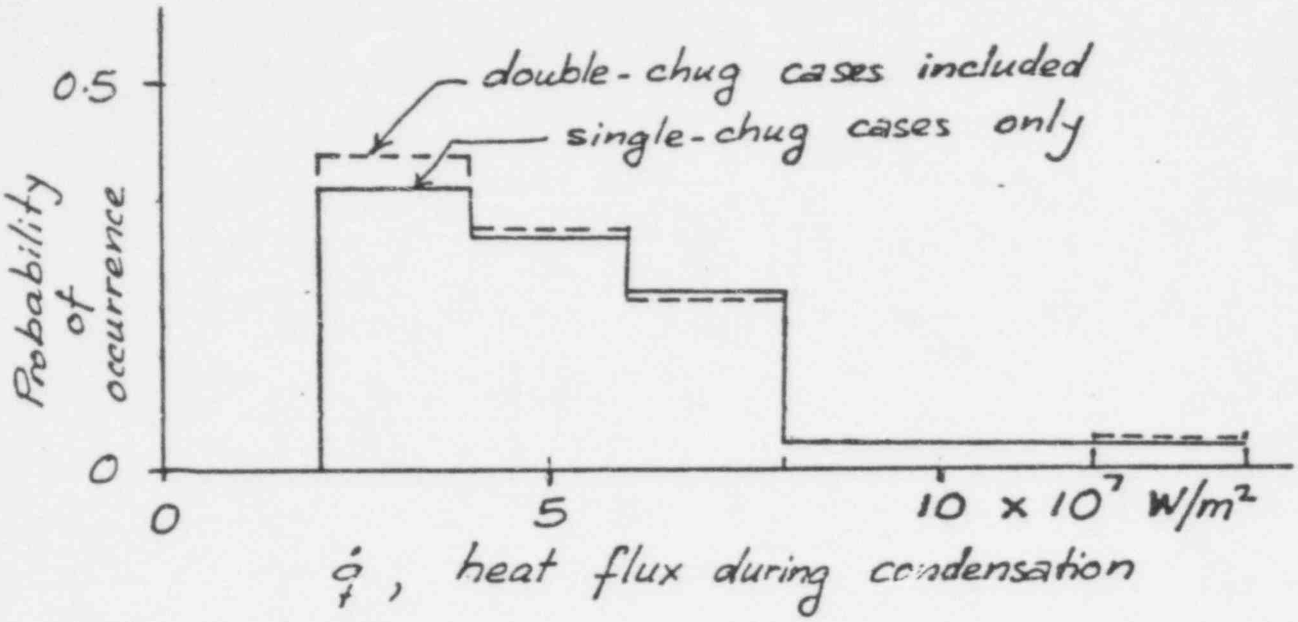
or, 9 – 62 kg/m²s

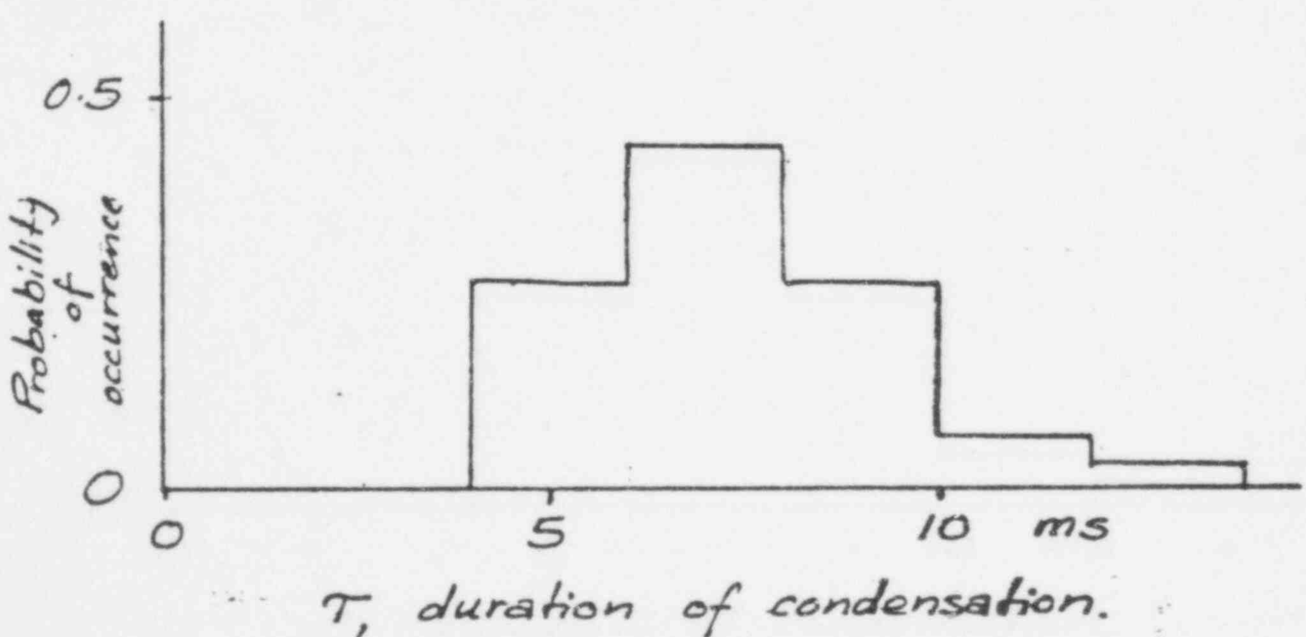
Amount of cold (10°C) water required to cause observed chug pressure drop

$$\sim 5\text{–}20 \ cm^3$$

618290

vent dia. = 10 cm
water descent velocity ~ 1 m/s
steam pressure in vent ~ 1 bar





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Characteristic rates:

thermal flux

$$\frac{\rho\, v_{th}}{4} = \frac{\rho_s}{4}\sqrt{\frac{8RT_s}{\pi}}$$

$$= 96 \ \ kg/m^2 s$$

or, $2 \times 10^8 \ J/m^2 s$.

"energy flux" in water column

$$\rho_w c_w v \, (T_s - T_w) \sim 3.8 \times 10^8 \ J/m^2 s.$$

experiment

$$\dot{q} \sim 5 \times 10^7 \ J/m^2 s.$$

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Kowalchuk & Sonin postulate:

$$\dot{q} = St_c \cdot \rho_w c_w U \, (T_s - T_w)$$

" $St_c \sim 10^{-1}$? "

Experimental match:

$$St_c = \frac{(\dot{q})_{expt}}{\rho_w c_w U \, (T_s - T_w)} \sim \frac{5 \times 10^7 \ W/m^2}{3.8 \times 10^8 \ W/m^2}$$

$$\sim 0.13$$

<u>but</u> postulated time when $\dot{q}$ is "turned on" is clearly incorrect in K & S model.

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