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

APR 16 1975

Gus C. Lainas, Chief, Containment Systems Branch, TR
THRU: John Kudrick, Section A Leader, Containment Systems Branch, TR

MEETING WITH GENERAL ELECTRIC COMPANY - POOL DYNAMIC AND RELIEF VALVE LOADS ON MARK I AND II CONTAINMENTS

On April 10, 1975, a meeting was held in Bethesda, Maryland with the General Electric Company (GE) to discuss our concerns regarding the effects of pool dynamic and relief valve loads on BWR operating reactors and reactors under construction; i.e., reactors utilizing Mark I and Mark II type containments. Copies of the vugraphs used by GE and a list of attendees are enclosed. A summary of the items discussed is as follows:

1. GE summarized their preliminary analysis of pool swell loads on torus internal structures for a typical Mark I plant. The structural analysis was based on swell loads extrapolated from Mark III test data. GE indicated that their conclusion was that some local yielding in the vent header support struts could occur; however, structural failure was not predicted.

2. GE will be advising all their Mark I customers of the potential concern on pool dynamic loads at a meeting in San Jose on April 23-24, 1975.

3. GE indicated that letters were sent to all their Mark II customers regarding potential concerns on relief valve loads and pool dynamic loads in January and February 1975. Each utility is in the process of evaluating their particular design for the loads under consideration.

4. GE stated that they were looking at the availability of facilities and materials to do pool swell testing, including the effects of air compression for Mark I and Mark II configurations.

5. GE stated that they were about to initiate a series of steam quencher tests at their Moss Landing facility. The purpose of these tests was to evaluate the load attenuation effectiveness of a number of relief valve discharge line nozzle designs.

We informed GE that we would consider the information that they had provided in determining our course of action for resolving the concerns on pool dynamic loads for Mark I and II containments. We also indicated that we would need substantially more detailed information in the near future regarding their methods of determining loads for Mark I and II and that testing for these configurations may be necessary.

Robert L. Cudlin
Containment Systems Branch
Division of Technical Review

Enclosures:
As stated
cc: See next page

D-16

cc: S. Hanauer
F. Schroeder
R. Boyd
R. Tedesco
J. Glynn
R. Fraley, ACRS (3)
NRC PDR
J. Kudrick
R. DeYoung
G. Lear
W. Butler
P. Riehm
L. Slegers
D. Crutchfield
K. Goller
A. Gluckmann
L. Shao
R. Maccary
D. Eisenhut
E. Jacobs
J. Shapaker

ATTENDANCE LIST
GE - NRC MEETING
APRIL 10, 1975

GE

L. S. Gifford
P. W. Ianni
C. M. Johnson
L. J. Sobon
D. A. Rockwell

NRC

R. L. Cudlin
J. A. Kudrick
R. L. Tedesco
F. Schroeder
R. C. DeYoung
G. E. Lear
R. S. Boyd
W. R. Butler
P. F. Riehm
L. Slegers
D. M. Crutchfield
J. C. Glynn
K. R. Goller
A. L. Gluckmann
L. C. Shao
R. R. Maccary
G. C. Lainas

PRESSURE SUPPRESSION TESTS
CONDUCTED BY THE GENERAL ELECTRIC COMPANY

NOTE: SOME OF THE DATA GENERATED DURING THE TEST SERIES TABULATED BELOW IS GENERAL ELECTRIC PROPRIETARY INFORMATION.

- HUMBOLDT BAY INITIAL CONDENSING TESTS. SUMMER 1958. GEAP-3143.

- HUMBOLDT BAY INITIAL TRANSIENT TESTS. 1950-59. GEAB-3143.

- HUMBOLDT BAY FULL SCALE 1/48 SEGMENT TESTS. SUMMER 1960. GEAP-3596.

- BODEGA BAY FULL SCALE 1/112 SEGMENT TESTS 1962. BODEGA BAY PSAR. DOCKET NO. 50-205.

- BODEGA BAY QUARTER SCALE 1/8 SEGMENT MULTIPLE VENT TESTS. SPRING 1963. No Documentation to staff

8.22.74

A.J.J.

GENERAL ELECTRIC HORIZONTAL VENT

PRESSURE SUPPRESSION TESTS

DOCUMENTATION

NOTE: MANY OF THESE REPORTS ARE PROPRIETORY TO THE GENERAL ELECTRIC COMPANY

PRESSURE SUPPRESION POOL INVESTIGATIONS JULY 1970, NEDM-13036-1.

PRESSURE SUPPRESSION AND WEIR VENT TEST PROGRAM MINI-WEIR HORIZONTAL VENT TESTS MAY 1972, NEDM-13036-2.

PRESSURE SUPPRESSION TEST PROGRAM SMALL SCALE HORIZONTAL VENT TESTS. OCTOBER 1972. NEDM-13036-3.

MARK III CONFIRMATORY TEST PROGRAM PROGRESS REPORT. APRIL 1973. NEDM-10848.

MARK III ANALYTICAL INVESTIGATION OF SMALL-SCALE TESTS PROGRESS REPORT. AUGUST 1973. NEDM-10976.

THIRD QUARTERLY PROGRESS REPORT: MARK III CONFIRMATORY TEST PROGRAM. NEDO-20210A. DECEMBER 1973.

PRESSURE SUPPRESSION TEST PROGRAM SMALL SCALE TESTS. JANUARY 1974. NEDM-13365.

MARK III CONFIRMATORY TEST PROGRAM PHASE 1 - LARGE SCALE DEMONSTRATION TESTS. OCTOBER 1974. NEDM-13377.

FOURTH QUARTERLY PROGRESS REPORT: MARK III CONFIRMATORY TEST PROGRAM. NEDO-20345. APRIL 1974.

FIFTH QUARTERLY PROGRESS REPORT: MARK III CONFIRMATORY TEST PROGRAM. NEDO-20550. JULY 1974.

A.J.J. 2/6/75

SIXTH QUARTERLY PROGRESS REPORT: OCTOBER 1974. (LETTER TRANSMITTAL TO NRC STAFF).

SEVENTH QUARTERLY PROGRESS REPORT: MARK III CONFIRMATORY TEST PROGRAM. NEDO-20732. DECEMBER 1974.

A.J.J. 2/6/75

NRC ACTIVITY ---- CONTAINMENT PHENOMENA

SAFETY/RELIEF DYNAMICS

S/R PIPE CLEARING

- SOME MARK I START-UP TESTS SHOWED VIBRATION DAMAGE -
- QUAD CITIES #2 TEST TO INVESTIGATE PIPE CLEARING - 10/72
- LOOSE HEADER HANGERS AT QUAD CITIES #2 - 12/72
- NEDO-10859 - VENT MODEL + QUAD CITIES DATA - 4/73
- ADDENDA FOR TOPICAL REPORT FILED - 5/73
- NRC REQUESTED MORE INFORMATION - 9/73
- GE SUBMITTED RESPONSE TO NRC - 11/73
- TORUS TESTING AT BROWN'S FERRY #1 - 12/73
- TVA FILED TEST REPORT -
- TVA/GE AGREED TO MORE TESTS ON BROWN'S FERRY #2 -
- NRC LETTER TO GE ON NEDO-10859 SOUGHT MORE TEST DATA - 3/74
- GE HELD SEMINAR OF MARK I OWNERS, RE: TESTS - 4/74

- JOINT PRESENTATION MADE TO NRC ON TESTING - 4/74
- SEVERAL MARK I OWNER'S REQUESTED GE WITHDRAW -
- GE WITHDREW FROM LEAD IN LETTER TO NRC - 5/74
- NRC STATES QUAD CITIES DATA NON-CONCLUSIVE FOR NEDO-10859 - 9/74
- NRC REQUEST FOR GE MARK II - III PLANS - 1/75
- NRC LETTER TO MARK I UTILITIES ON PLAN - 2/75
- GE GROUP TESTING INFORMATION TO ASSIST CLIENTS - 3/75
- GE RESPONSE TO 1/75 NRC REQUEST - 3/75

NRC ACTIVITY -- CONTAINMENT PHENOMENA

SAFETY/RELIEF DYNAMICS

HIGH TEMPERATURE CONDENSATION

- GE MEETING WITH NRC ON PHENOMENA - 11/74
- GE RECOMMENDATIONS SUBMITTED AS REQUESTED - 12/74
- GE TRANSMITTED "WHITE PAPER" TO CLIENTS - 12/74
- NRC LETTER TO GE ASKING MARK II-III PLAN - 1/75
- NRC LETTER TO MARK I UTILITIES ON PLAN - 2/75
- GE INFO PACKAGE TO ASSIST CLIENTS - MARK I - 3/75
- GE RESPONSE TO 1/75 NRC REQUEST RE MARK II & III - 3/75

3-22-75

NRC ACTIVITY -- CONTAINMENT PHENOMENA

LOCA DYNAMICS

- START PSTF TESTING (VERIFY MARK III MODEL) - 11/73
- REORIENTED TEST TO BOUND IMPACT LOADS ABOVE POOL - 2/74
- REPORTED TO NRC VERBALLY IN PROGRESS MEETING ON TYPICAL NEW LOADS - 4/74
- REFERENCE MARK III LOAD CRITERIA CHANGES IN GESSAR - 5/74
- REFERENCE MARK III CONFIGURATION CHANGES IN GESSAR - 7/74
- NRC REPORTS PSTF DATA INSUFFICIENT TO UPPER BOUND IMPACT LOADS - 10/74
- START 1/3 SCALE TESTS TO CONFIRM UPPER BOUND - 12/74
- NRC NOTED POTENTIAL APPLICABILITY TO MARK I & II - ~~2/75~~ 4/74

3-22-75

PP&L ANNOUNCEMENT

- PP&L/SUSQUEHANNA MARK II IN EARLY STAGES OF WETWELL CONSTRUCTION
- WETWELL DESIGN IS DIMENSIONALLY MOST DIFFICULT OF THE MARK II'S RELATIVE TO NEW PHENOMENA
- WETWELL IS CONSTRUCTION CRITICAL PATH -- ≈10 DAYS FLOAT
- DECISION TO STOP WORK CURRENTLY APPLIES ONLY TO UNIT #2 RPV PEDESTAL
- EVALUATE NEW LOADINGS vs. EXISTING DESIGN CAPABILITY
- IDENTIFY ANY NECESSARY STRUCTURAL FIXES
- INCORPORATE INTO DESIGN & CONSTRUCTION AT FRONT END TO NEGATE NEED FOR RETROFIT LATER
- ONE TO THREE MONTHS TO RESOLVE IS CURRENT ESTIMATE
- KEEP CORRECTLY DESIGNED PLANT ON CONSTRUCTION SCHEDULE

MARK II CONTRACTUAL INVOLVEMENT CONTAINMENT

PURCHASER/OWNER RESPONSIBILITY

- DESIGN
- SUPPLY
- CONSTRUCT
- MEET NSSS INTERFACE REQUIREMENTS

GE RESPONSIBILITY

- PROVIDE NSSS INTERFACE REQUIREMENTS
  - PHYSICAL/DIMENSIONAL
  - ENERGY RELEASE FROM NSSS PIPE BREAK
  - ENERGY RELEASE FROM S/R VALVE DISCHARGE at valve
- CALCULATE PEAK P & T FOR CONTAINMENT RESPONSE TO LOCA RELEASE --- OPTION FOR SAR

Annex I

PRIMARY CONTAINMENT ANALYSIS DATA (all data to be provided by Purchaser)

A.	**General**		
	1. Operating Pressure (Max)	*7.7	psig
	2. Design Pressure	48	psig
	3. Test Pressure	55	psig
	4. Permissible Leak Rate at Test Pressure	*0.5	%/day
B.	**Drywell**		
	1. Net Air Volume (including vents)	234,700	ft^3
	2. Normal Operating Temperature	* 135	°F 150 °F
	3. Relative Humidity @ Normal Operation	*20	%
	4. Total Vent Area	276	ft^2
	5. Vent Loss Coefficient ($\frac{fl}{D}$)	*2.5	
	6. Submergence of Vent Pipe End	11.0	ft **
C.	**Suppression Chamber**		
	1. Gas Volume	155,750	ft^3 **
	2. Water Volume	122,400	ft^3 **
	3. Normal Operating Temperature (Max. at pre-hotstandby)	88°F	
D.	**RHR Cooling Service Water**		
	1. Source of water	SUSQUEHANNA RIVER	
	2. Type of water	FRESH	(fresh/salt)
	3. Maximum Natural Sink Temperature	88	°F

*Value to be used unless otherwise instructed by Purchaser.

** VALUES GIVEN AT NORMAL POOL DEPTH (23 FEET).

RELIEF VALVE DISCHARGE

EFFECTS IN THE SUPPRESSION POOL

NATURE OF CONCERN

- DISCHARGE PIPE CLEARING
  - FORCES DUE TO PIPE CLEARING OF AIR
  - SHORT DURATION
  - HIGH LOADS

- STEAM QUENCHING INSTABILITY
  - VIBRATION PHENOMENON
  - OBSERVED TO RESULT FROM HIGH LOCAL TEMPERATURES
  - LONG DISCHARGE DURATION
  - OPERATIONAL CONCERN

JLM
12/6/74

PIPE CLEARING FORCES

BACKGROUND

MINOR DAMAGE IN MARK I TORUS

STRUCTURAL MODIFICATIONS WERE MADE

TEST PROGRAM AND REPORT - QUAD CITIES

MODELS DEVELOPED

ADDITIONAL TESTS AT TVA

JLM
12/6/74

CURRENT DEVELOPMENTS

MODELS DEVELOPED FOR MARK III

TEST FACILITY UNDER CONSTRUCTION TO CONFIRM BUBBLE MODEL

MARK III WORK INDICATED POTENTIAL IMPACT ON MARK II

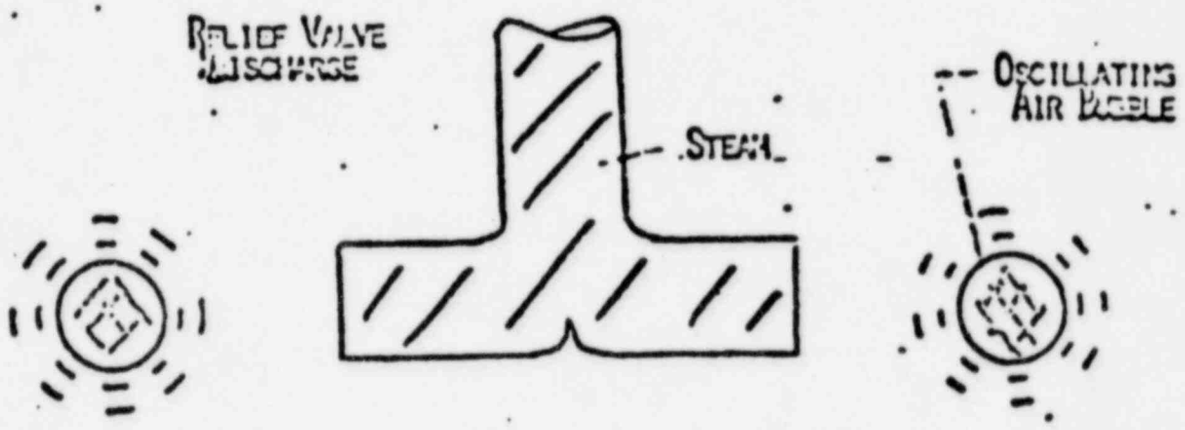
WORK APPLIED TO DEVELOP BOUNDING CONDITIONS FOR MARK II

MARK II MODEL IS STARTED

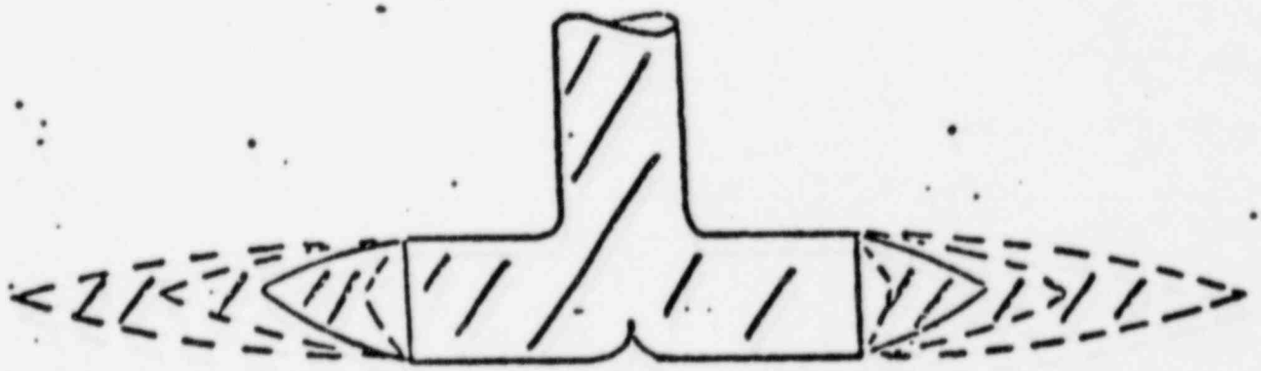
FORCE REDUCING QUENCHERS ARE BEING EVALUATED AGAINST ALL CONCERNS

JLM
12/6/74

RELIEF VALVE LOAD DEFINITION



AIR CLEARING LOAD



HIGH TEMPERATURE CONDENSATION

RAMSHEAD

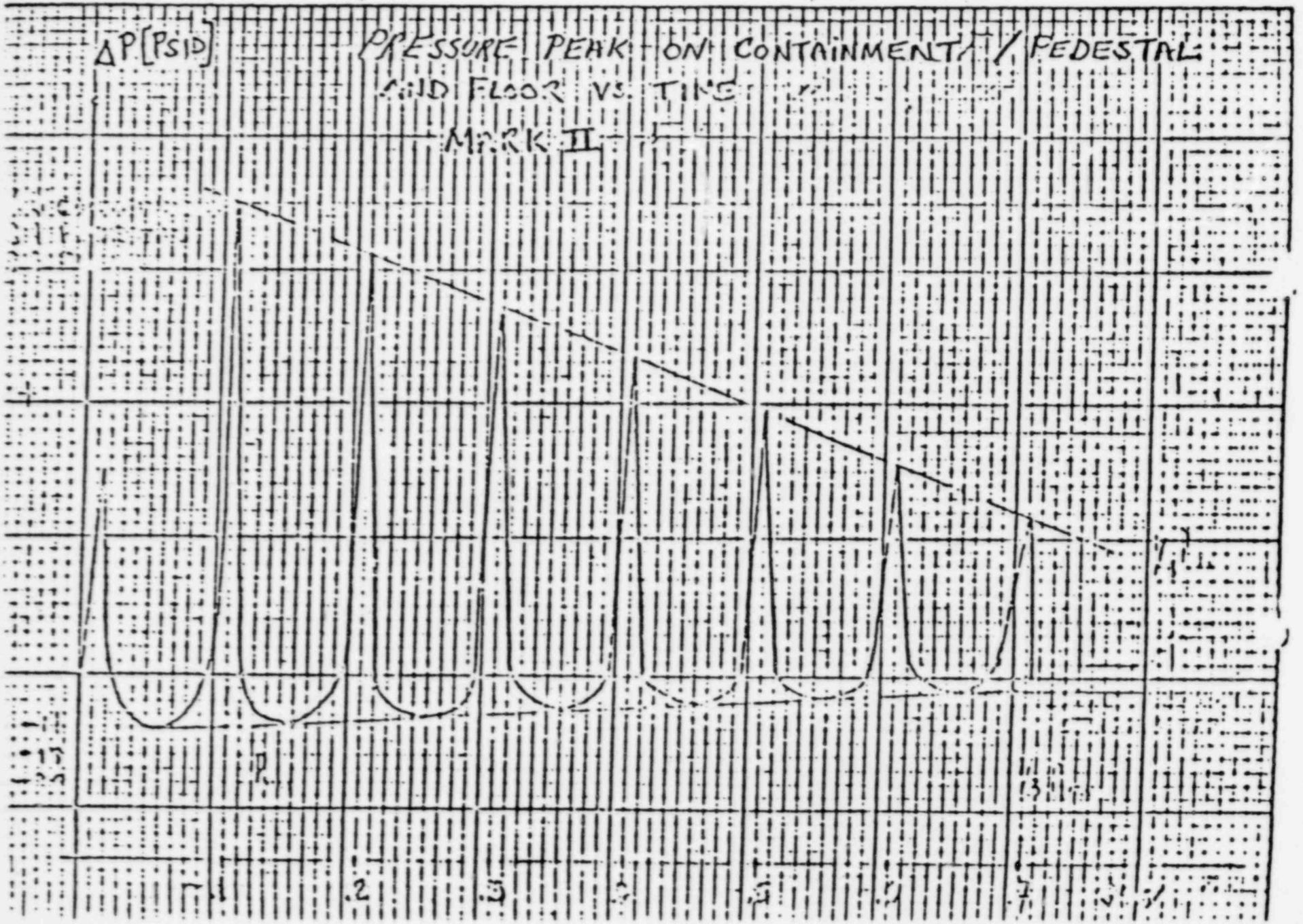
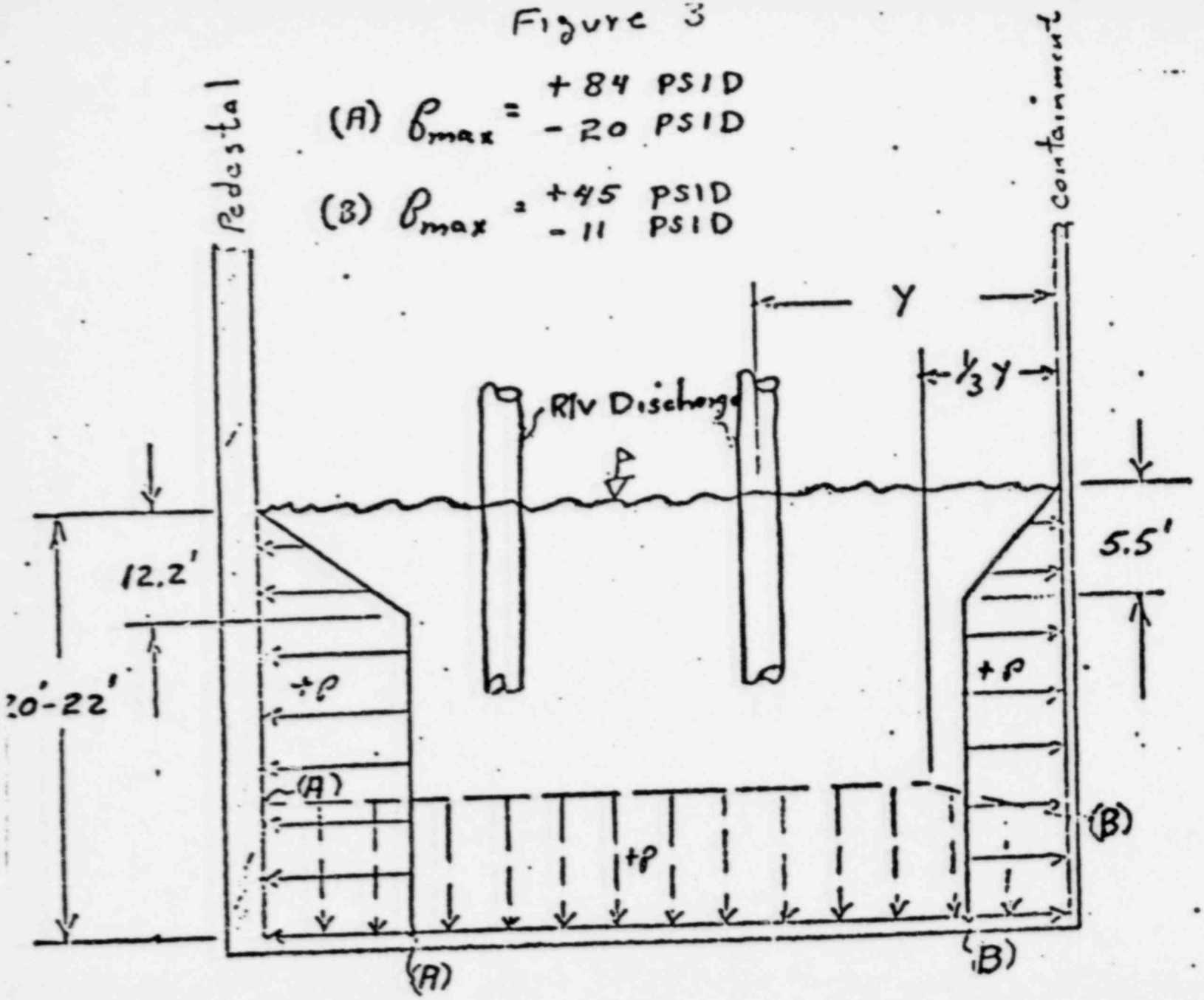

ΔP [PSID]
PRESSURE PEAK ON CONTAINMENT / PEDESTAL
AND FLOOR VS. TIME
MARK II

Figure 3

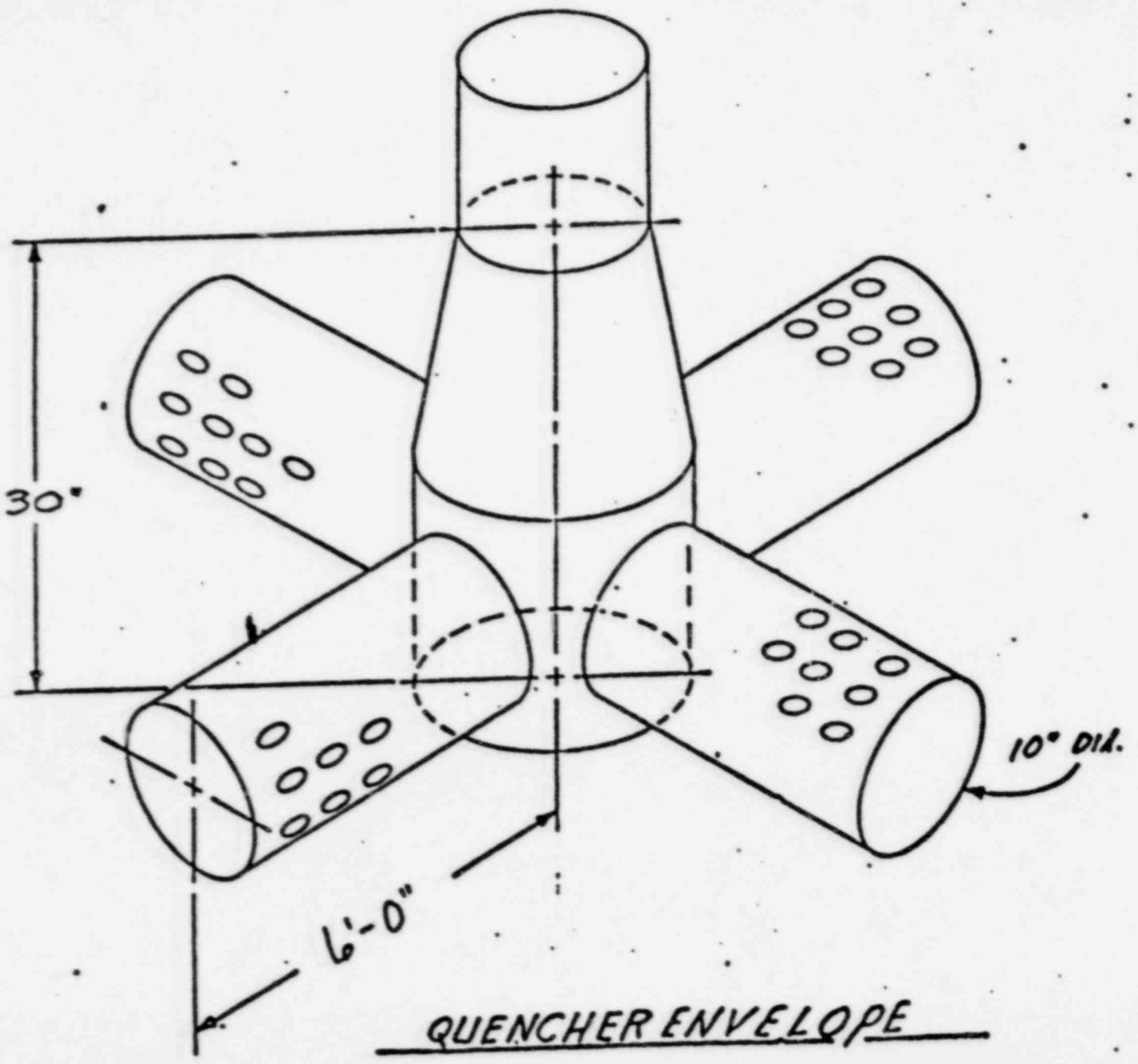
(A) P_{max} = +84 PSID, -20 PSID

(B) P_{max} = +45 PSID, -11 PSID

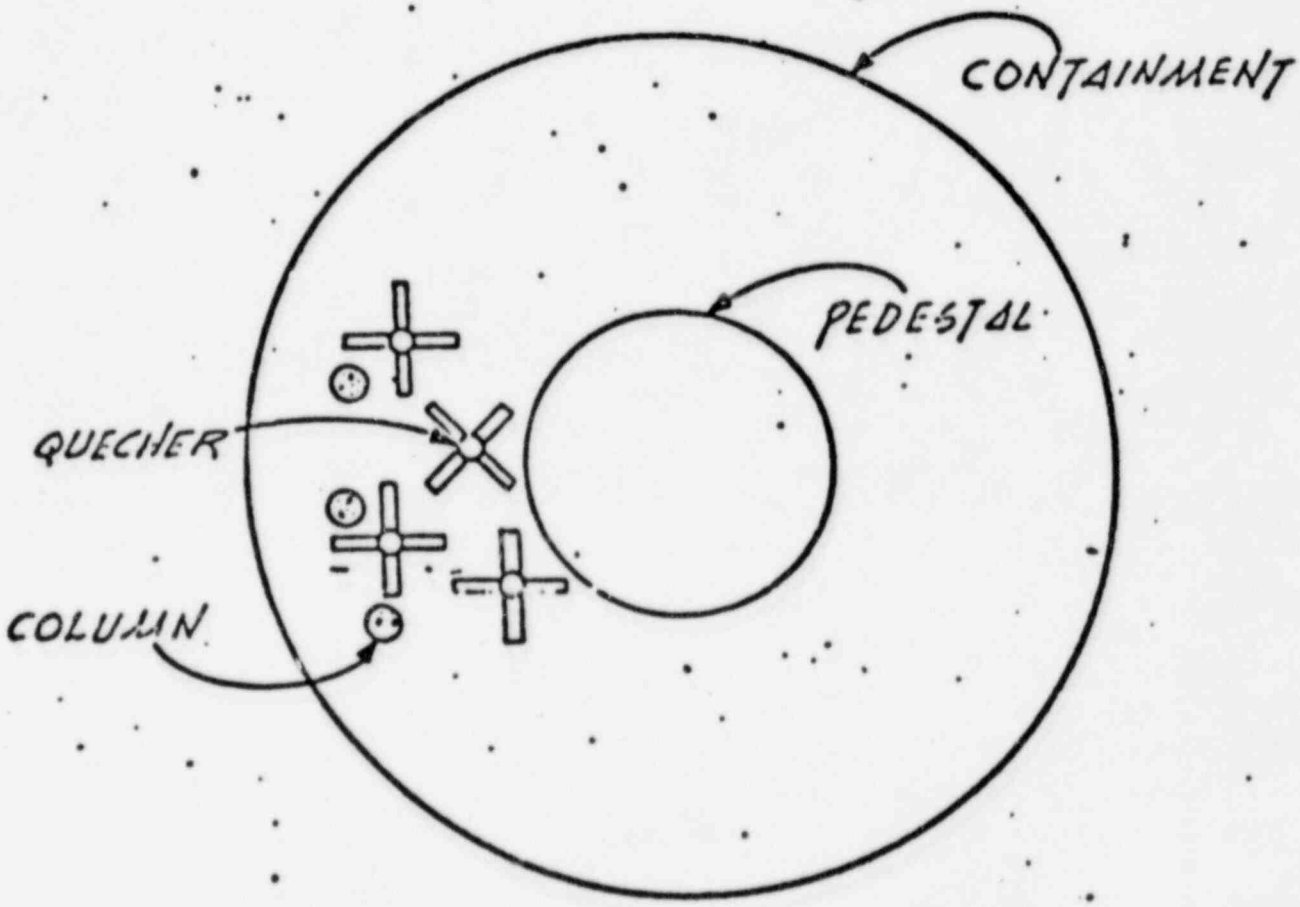


S/R Valve Air Clearing Pressure Distribution
MK II

ENGINEERING CALCULATION SHEET
SHOP ORDER NO.
SUBJECT
DATE
BY
SHEET OF



QUENCHER ENVELOPE



MK II
PLAN VIEW QUENCHER

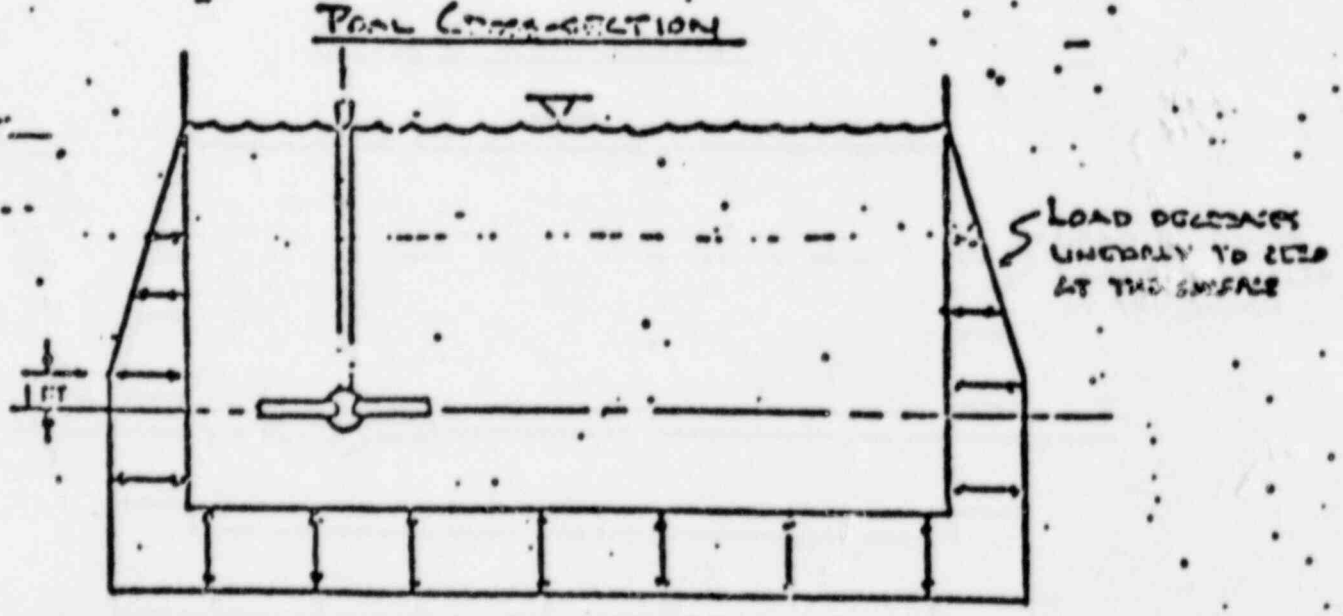
TABLE 2

MAXIMUM CLEARING LOADS AFFECTING CONTAINMENT STRUCTURE

PMAX	25 PSI
PMIN	-10 PSI
FREQUENCY	3 TO 7 HZ
DURATION	.75 SEC

NOTE: (1) MULTIPLE VALVE MAXIMUM IS THE SAME AS SINGLE VALVE MAXIMUM.

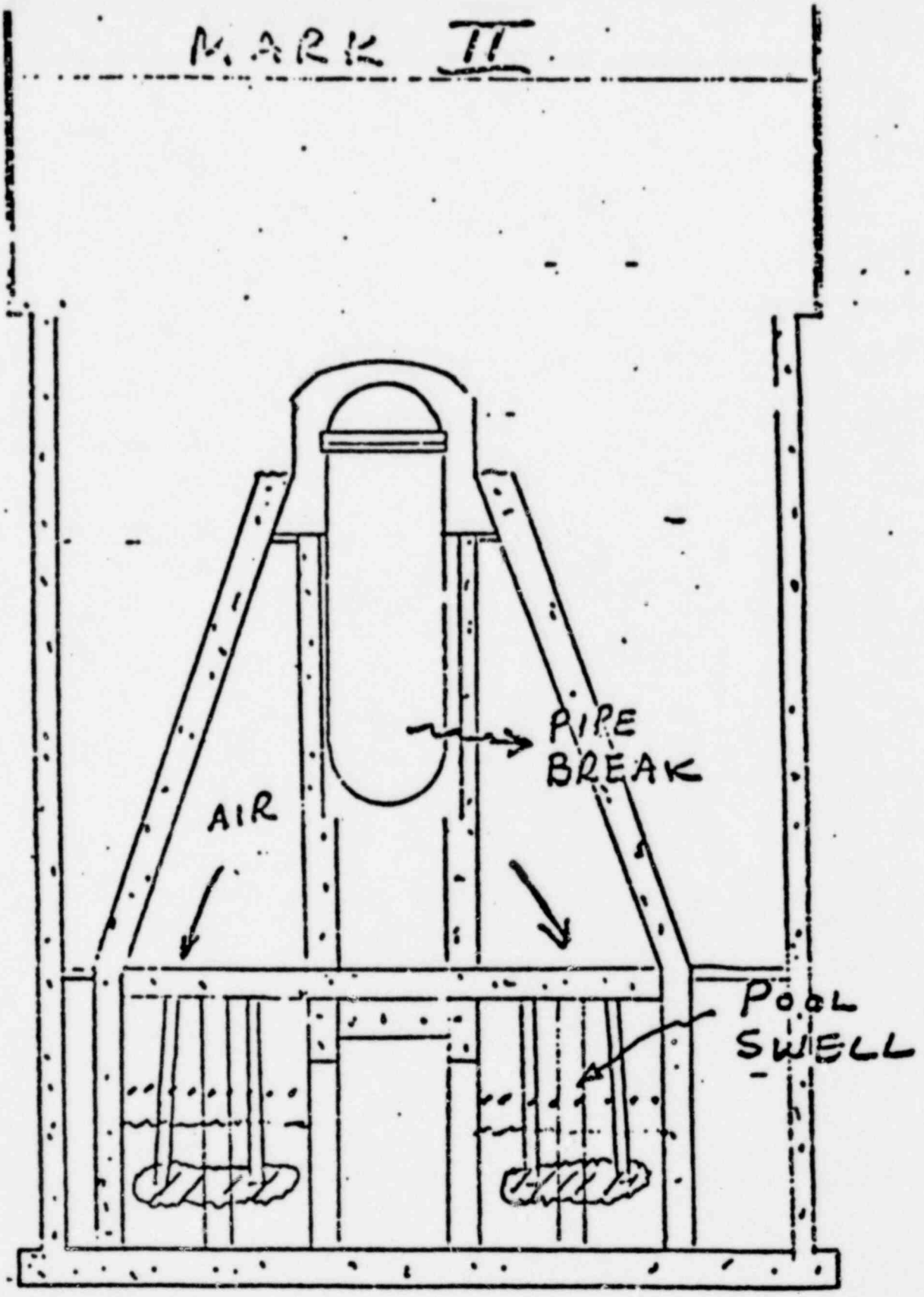
2. AREA OF APPLICATION OF ABOVE PRESSURE LOADS



POOL SWELL LOADS

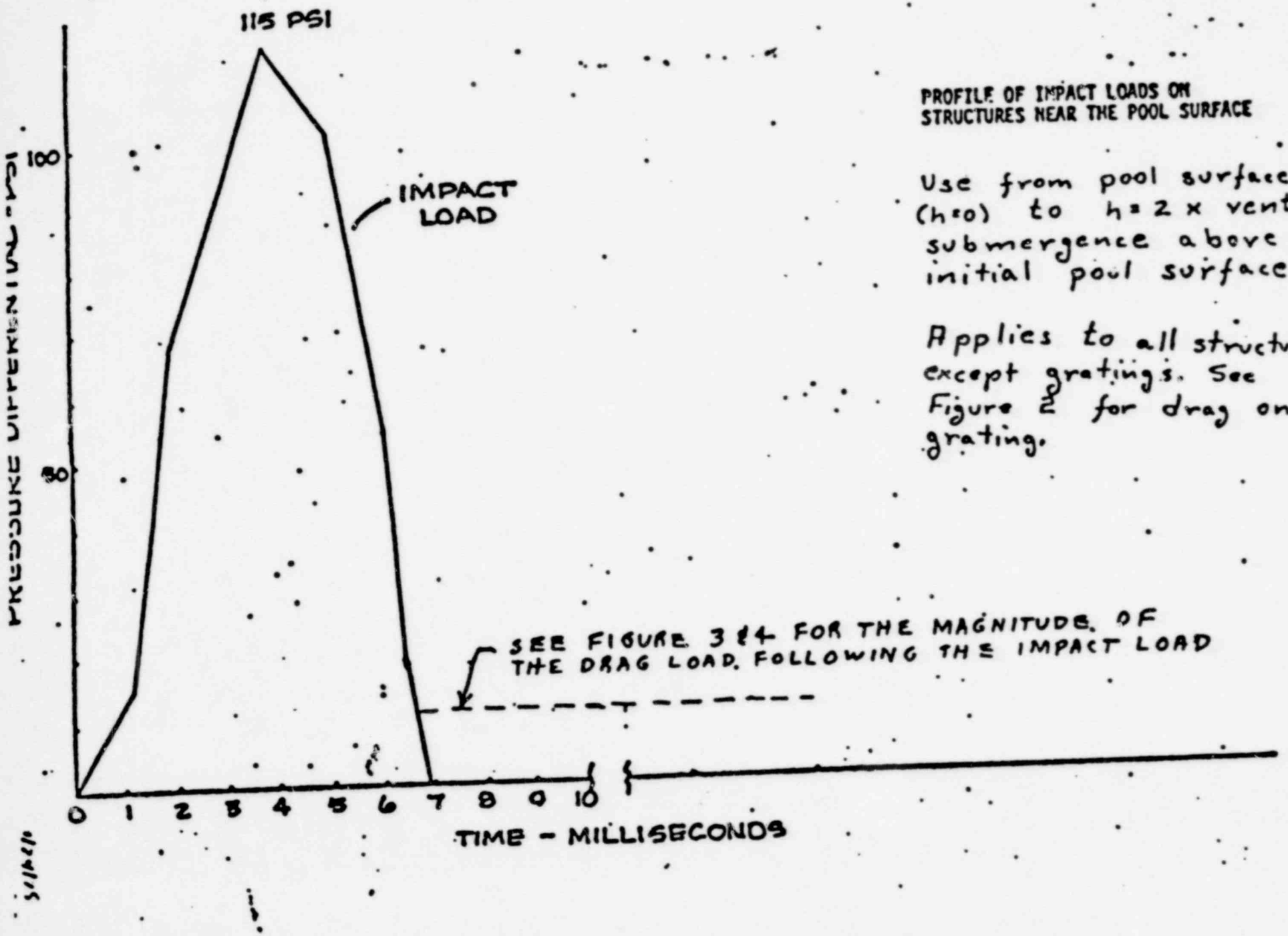
MARK II

1/24/75



PRIMARY AND SECONDARY CONTAINMENT

Figure 1



PROFILE OF IMPACT LOADS ON STRUCTURES NEAR THE POOL SURFACE

Use from pool surface (h=0) to h = 2 x vent submergence above initial pool surface.

Applies to all structures except gratings. See Figure 2 for drag on grating.

MARK II STRUCTURES

IN SUPPRESSION POOL AREA

CONTAINMENT

PEDESTAL

DIAPHRAM FLOOR & COLUMNS

VERTICAL VENTS & VACUUM BREAKERS

S/R VALVE DISCHARGE PIPES

CATWALKS & MISC. STRUCTURES

COMBINATION LOADS FOR STRUCTURAL ANALYSIS

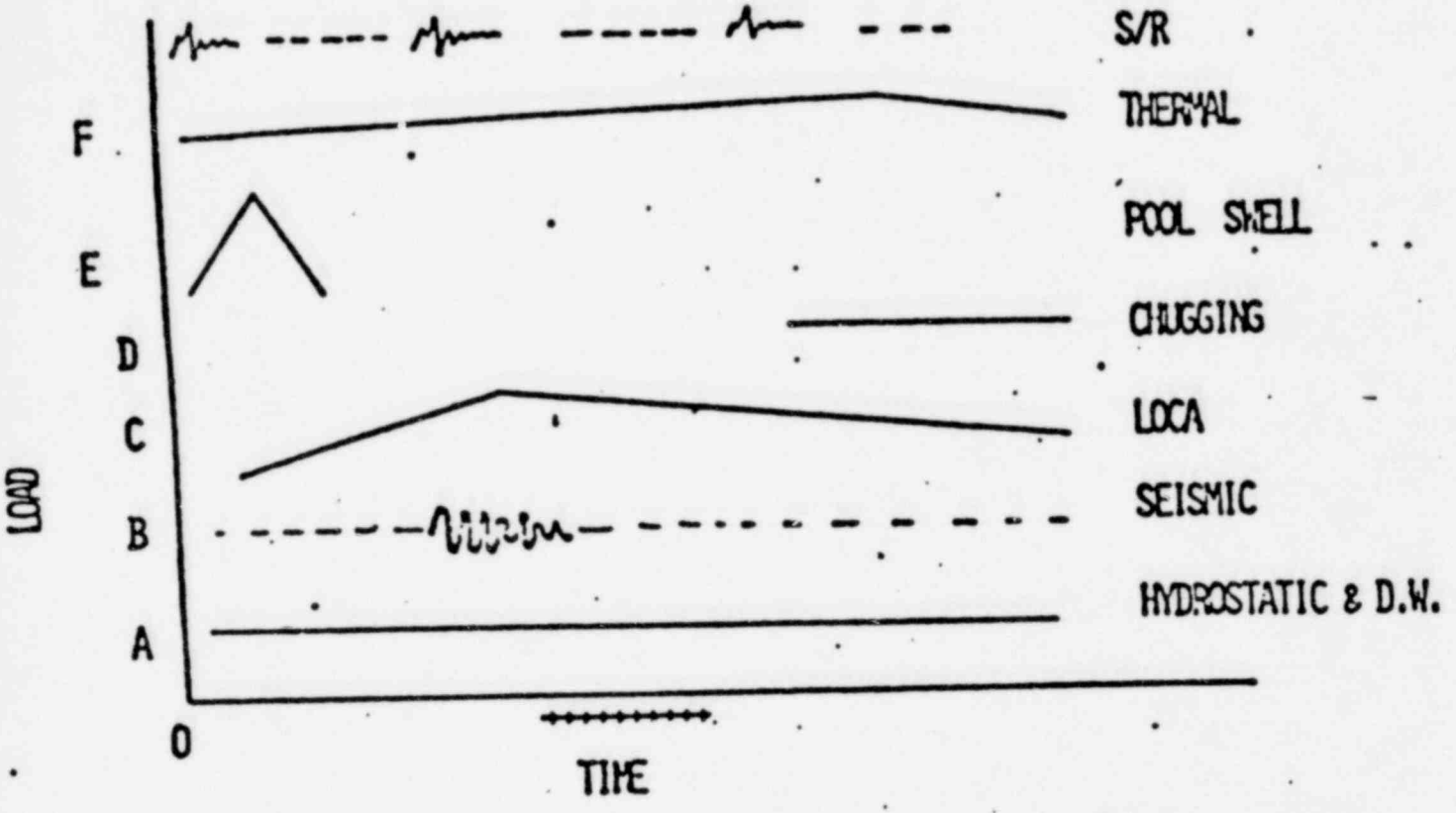
EXAMPLE: SUPPRESSION CHAMBER WALLS, BASEMAT AND RV PEDESTAL

- DEAD LOAD
- LIVE LOAD
- HYDROSTATIC LOADS
- PRESSURE AND COINCIDENT TEMPERATURE LOADS
- SEISMIC LOADS
- S/R DISCHARGE CLEARING LOADS
- MAIN VENT CLEARING LOAD
- MAIN VENT HORIZONTAL LOAD (INDIRECT)
- POOL SWELL LOAD (INDIRECT)

SUPPRESSION CHAMBER LINER (ACT AS LEAK-TIGHT MEMBRANE)

- HYDROSTATIC LOADS
- PRESSURE AND COINCIDENT TEMPERATURE LOADS
- S/R DISCHARGE CLEARING LOADS
- MAIN VENT CLEARING LOADS

TYPICAL LOADING COMBINATIONS



S/R	S/R (PRT)
SEISMIC	SEISMIC
THERMAL	LOCA
HYDROSTATIC	HYDROSTATIC
DEAD WEIGHT	DEAD WEIGHT

Introduction

Background

MK III, II, I

Key Loads Examined MK I

R. Valves

Horiz. Vent. Load

Pool swell - Most critical

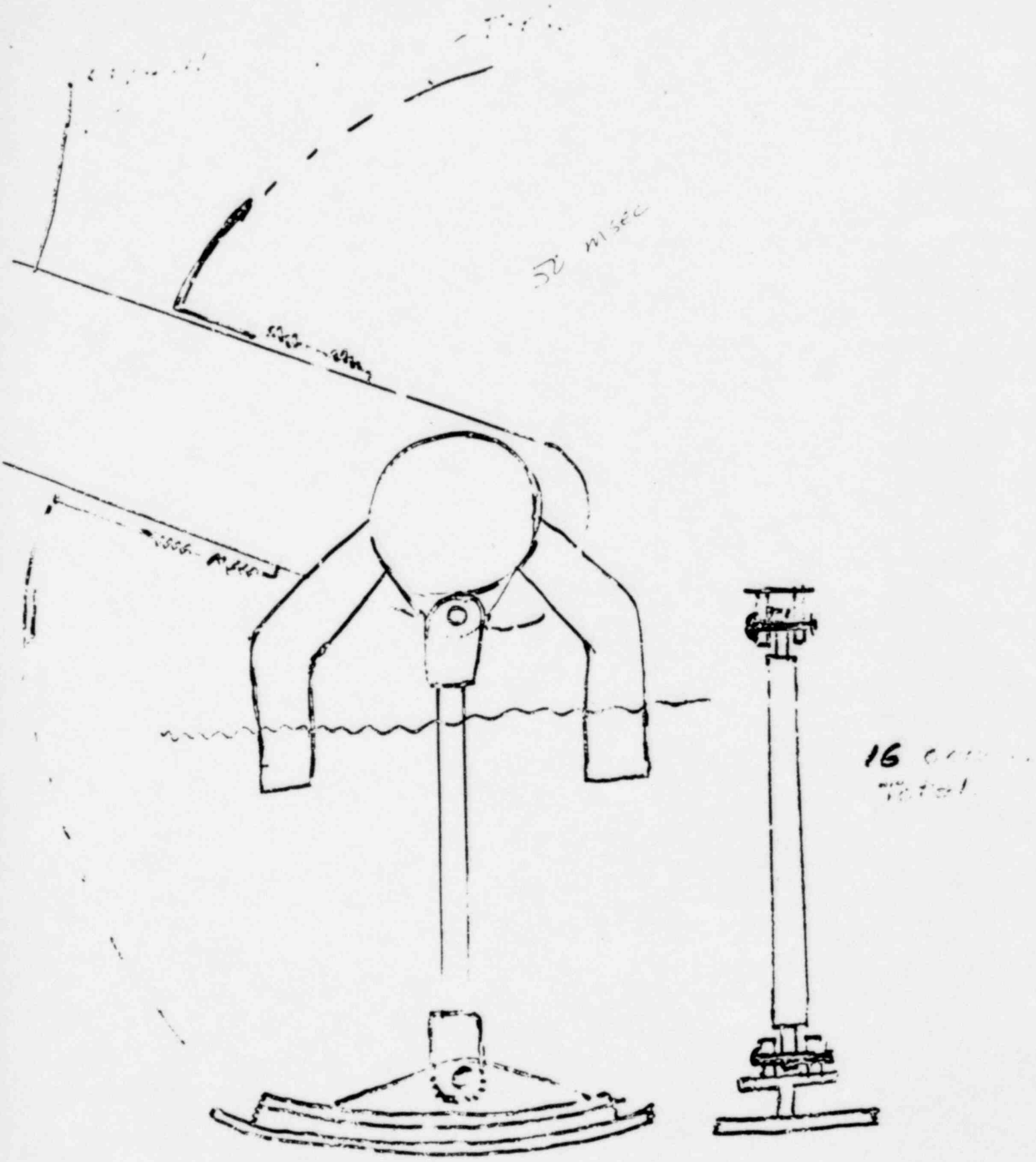
Pool swell Discussion

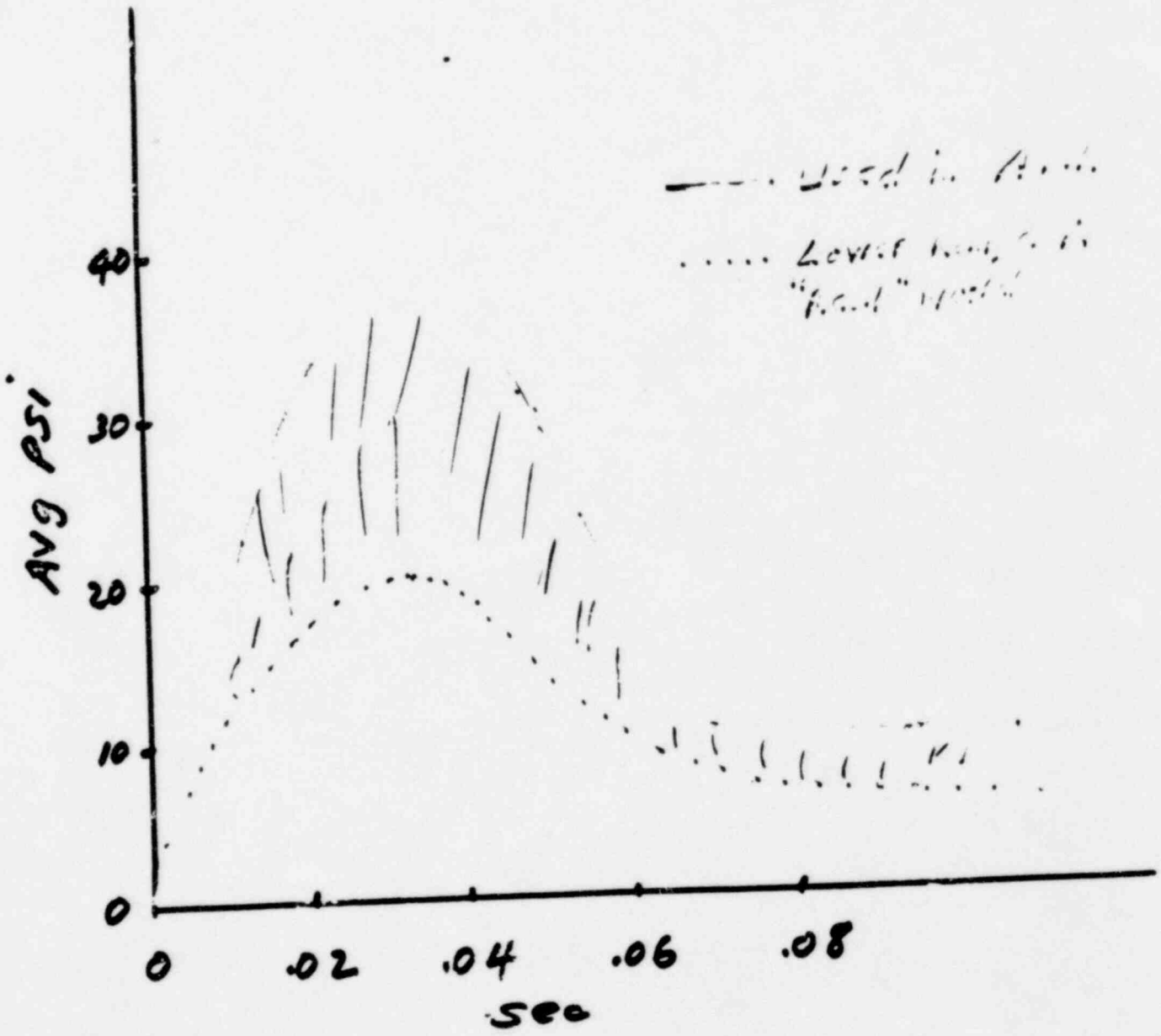
Load

stress Anal.

Action plans

Conclusions




AVG PSI
40
30
20
10
0
0
.02
.04
.06
.08
sec

MARK I HEADER LOAD CONSERVATISMS

BOUNDARY CONDITIONS

ASSUMED ALL AIR CARRY OVER

USED BREAKTHROUGH HEIGHT OF 2 X SUBMERGENCE
BODEGA INDICATED 1.5 X

USED INFINITE OCEAN (SOLID WATER)

1-2'LIGAMENT EXPECTED AT HEADER ELEVATION

PEAK DW PRESSURE CONSERVATISMS

MODEL

CALCULATED LOAD IS 20% HIGHER THAN MEASURED (USING TEST BOUNDARY CONDITIONS)

CONCLUSION: TOTAL CONSERVATISM MAY BE AS HIGH AS FACTOR OF TWO

DAR 4.9.75

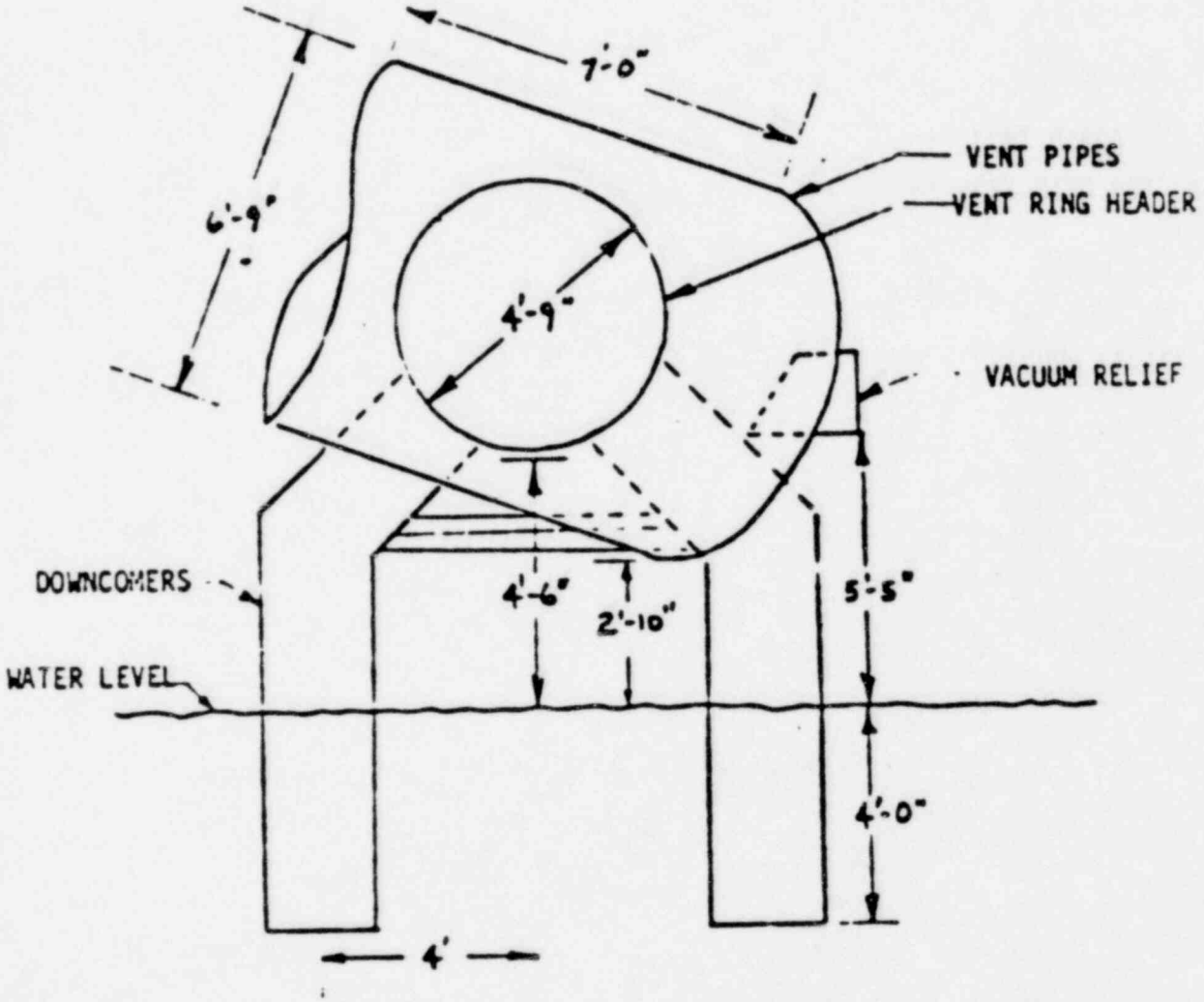


FIGURE B. MARK I TYPICAL VENT SYSTEM (BROWNS FERRY)

LOADS SUMMARY

BASED ON PRELIM DYNAMIC STRUCTURAL ANALYSIS.

- EFFECT OF BELLOWS & PIPE

_ DEAD LOADS 20K

_ JET LOADS 120K

_ POOL SWELL LOAD, (P V TIME)

_LINEAR ANALYSIS _ KEY ASSUMPTION

CAPABILITY OF COLUMN.	252 K	BASED ON MIN. YIELD POINT
" " BOLT,	282 K	
" " ~~HOLD~~ WELD	255 K	
" " PLATE	184 K	

RESULTANT TENSION 780,000 "EQUIV. LINEAR"

No PROBLEM
- DEFLECTION OF COL = .575"
- DEFLECTION OF VENT = .35"

KEY IS CLEVIS NOT RUPTURING AT LESS THAN COLUMN Y.P. SO THAT:

(A) COLUMN CAN ABSORB ENERGY IN PLASTIC RANGE (~1%)

(B) POOL LOAD DROPS TO LESS THAN 780,000

EXAMPLE 1% COLUMN STRAIN X 700,000 IN #.

APPLIED ENERGY X 500,000M# TO ENTIRE PIPING SYSTEM

IMPULSE CAN BE HANDLED WITH MINOR DISTORTION OF SYSTEM.

CLEVIS WILL NOT RUPTURE BECAUSE

(A) CABPABILITY

BASED ON "ONSET OF DISTORTION" NOT ON RUPTURE.

(B) USED MINIMUM MAT'L PROPERTIES

(C) "CONSERVATIVE" ANALYSIS BY ANALYSTS

BEST JUDGMENT IS THAT CLEVIS WILL HOLD TOGETHER TO ENABLE COLUMN TO STRETCH.

EVEN IF CLEVIS FAILS - (PRELIMINARY LINEAR DYNAMIC)

MIAN VENT PIPE "MOVES" UP 2-3" - STOPS AT 1"

MIAN VENT STRESS 30-40,000 psi

WORST STRESS IS RING HEADER ATTACHMENT TO MAIN VENT 5% YIELD.

BENDING 2/3

TENSION 1/3

(MAIN VENTS SUPPORT RING.)

NO BY-PASS OF STEAM EXPECTED.

(COULD TOLERATE 2 FT ^{2} BY-PASS FOR LOCA WITH NO CONDENSATION)

STRESS ANALYSIS CONSERVATISMS

1. LOAD APPLIED UNIFORMLY ALONG HEADER.

   SENSIVITY COULD BE AS HIGH AS 2

2. JET LOAD TIMING VS STATIC

3. MINIMUM YIELDS USED.

4. "FAILURE" DEFINITION NOT TRUE FAILURE

Mark I Actions to Date

Pool Dynamics

1. Conservative est pool swell - Done
2. Structure search for key concern. - Done
3. Prelim anal of key concern - (Ok) - Done
4. Detailed anal of key concern - started
5. Prelim est of other loads - Done

Conclusions:

1. Loss of containment integrity - shell or ring header - will not occur given the DBA LOCA & most probable course.
2. Detailed structural evaluation req'd to determine potential for local yielding or deformations to decide whether or not re-inforcing is needed for 40yr life consistent with codes, NRC req'mnts.

Action Plans - Mark I

Pool Dynamics

1. Ring Header Struct. Anal. ~ 4 wks
2. Pool swell Load Test on 20" Header ~ 6 wks
3. Clevis tests to failure < 4 wks
4. Get better est. of load ~ 4-6 wks
   - Examine assumptions & applic.
   - Incorp item 2
5. Get better est of other loads ~ 4 wks
6. Perform detailed struct anal of each. 76-12 wk

R.V. Loads

1. B.F. Test analyses - (almost done) ~ mid May
2. Detailing B.F 2 Tests (" ") ~ " "
3. Examine Torus tests & analyses. < 6 mos.?