ACTION PLAN

FOR

MARK I LOAD DEFINITION REPORT

REVISIONS TO

IMPLIMENT NRC

ACCEPTANCE CRITERIA FOR

COMPLETION OF LONG TERM PROGRAM

8002200112

12/19/79
R.M.N.

NRC ACCEPTANCE CRITERIA

OCTOBER 31, 1979

-

- o CLARIFICATION OF REQUIREMENTS IN CRITERIA

- o DIRECT IMPLICATION OF NRC CRITERIA

  - FOLLOW ON CHANGES IN IMPLIMENTATION DUE TO CLARIFICATION DISCUSSIONS

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LOAD DEFINITION REPORT FOR
MARK I LONG TERM PROGRAM
COMPLETION

- LDR REVISION PROGRESSING BASED ON NRC ACCEPTANCE CRITERIA IMPLEMENTATION

- ISSUE REVISED LDR TO UTILITY/AE's FOR STRUCTURAL EVALUATIONS

  SPRING 1980

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REVISION A - LDR CATEGORIES

CATEGORY I - LOADS WHICH CAN BE CHANGED IN THE LDR IMMEDIATELY

CATEGORY II - LOADS WHICH WILL REQUIRE A NOMINAL AMOUNT OF WORK TO REVISE LDR

CATEGORY III- LOADS WHICH WILL REQUIRE A MORE EXTENSIVE AMOUNT OF WORK TO REVISE LDR

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CATEGORY I LOADS

- VENT SYSTEM THRUST LOADS
- POOL SWELL LOADS
  - TORUS NET VERTICAL
  - TORUS SHELL PRESSURE HISTORY
  - VENT SYSTEM IMPACT & DRAG
  - DOWNCOMER IMPACT & DRAG
  - MAIN VENT IMPACT & DRAG
  - FROTH IMPINGEMENT
- T-QUENCHER LOADS
  - TORUS SHELL PRESSURES

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CATEGORY II LOADS

- o POOL SWELL LOADS
  - \- LOCA JET
  - \- VENT HEADER DEFLECTOR LOADS

    QSTF METHOD
- o CONDENSATION OSCILLATION
  - \- LOCA DRAG LOADS
- o T-QUENCHER LOADS
  - \- WATER JET LOADS
  - \- BUBBLE DRAG LOADS

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CATEGORY III LOADS

- POOL SWELL LOADS
  - IMPACT & DRAG ON OTHER STRUCTURES ABOVE THE POOL
  - LOCA BUBBLE DRAG
  - VENT HEADER DEFLECTOR LOADS

    ANALYTICAL METHOD

- CONDENSATION OSCILLATION
  - LATERAL LOADS ON DOWNCOMERS

- CHUGGING
  - LOCA DRAG LOADS
  - LATERAL LOADS ON DOWNCOMERS

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POOL SWELL DOWNLOAD

NRC CRITERIA:

$$DOWN = DOWN_{MEAN} + 2 X 10^{-5} \quad (DOWN_{MEAN})^2$$

CLARIFICATION:

$$DOWN = DOWN_{MEAN} (1 + 0.00002 \; PEAKDOWN_{MEAN})$$

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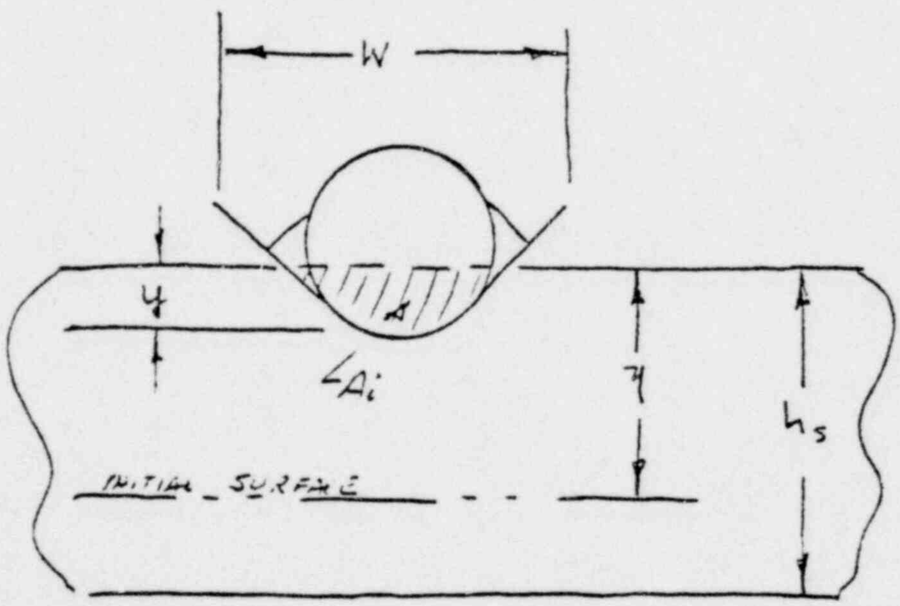
DEFLECTOR LOAD DEFINITION

GOVERNING EQUATIONS

o DEFLECTOR FORCE (REF 1)

$$F' = \underbrace{\rho g A_i}_{\text{BOUYANCY}} + \underbrace{(m'(y) + \rho A_i)\ddot{\eta}}_{\text{ACCELERATION DRAG}} + \underbrace{\frac{\partial m'}{\partial y}\dot{\eta}}_{\text{VELOCITY DRAG}} + \underbrace{(P_s - P_{fs})W}_{\text{LOCAL STATIC PRESSURE}}$$



REF 1 KAPLAN, P & SILBERT M.N "IMPACT FORCES ON PLATFORM HORIZONTAL MEMBERS IN THE SPLASH ZONE", OFFSHORE TECHNOLOGY CONF. PAPER OTC 2498, MAY 1976.

DEFLECTOR LOAD DEFINITION
GOVERNING EQUATIONS (CONT)

o ADDED MASS FROM DRAG COEFFICIENT

$$\frac{\partial m'}{\partial y} = \frac{1}{2}\rho W C_D(y)$$

$$m' = \frac{1}{2}\rho W \int_0^y C_D(\xi)\, d\xi$$

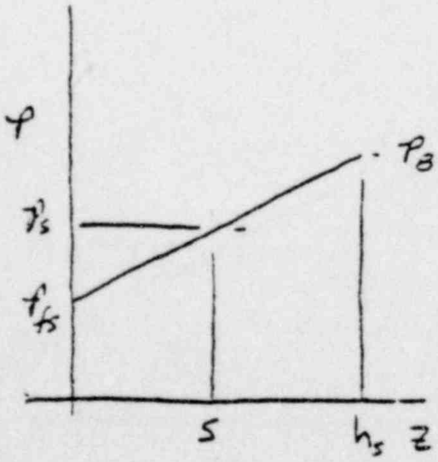
$C_D(y)$ PER ATTACHED GRAPHS EXCEPT THAT STEADY PORTION IS EXCLUDED ($C_D = 0.7$)

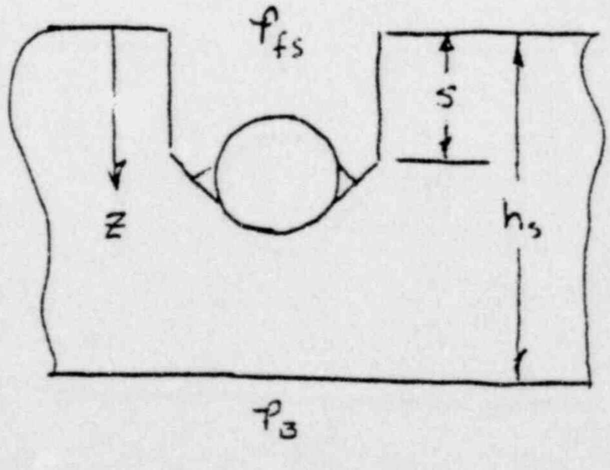
o LOCAL STATIC PRESSURE

$$(P_s - P_{fs})W = sW\rho\left(1 + \frac{F_d}{m_e}\right)$$

WHERE F_d = TORUS DOWNLOAD

m_e = EFFECTIVE MASS





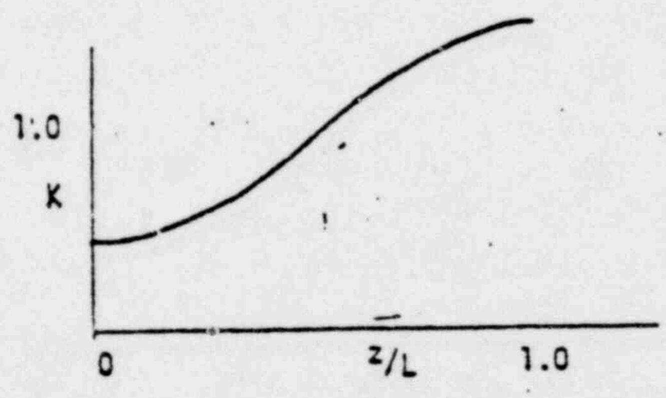
RANGE OF PARAMETERS
INFLUENCING DEFLECTOR LOADS
(FULL SCALE VALUES)

	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

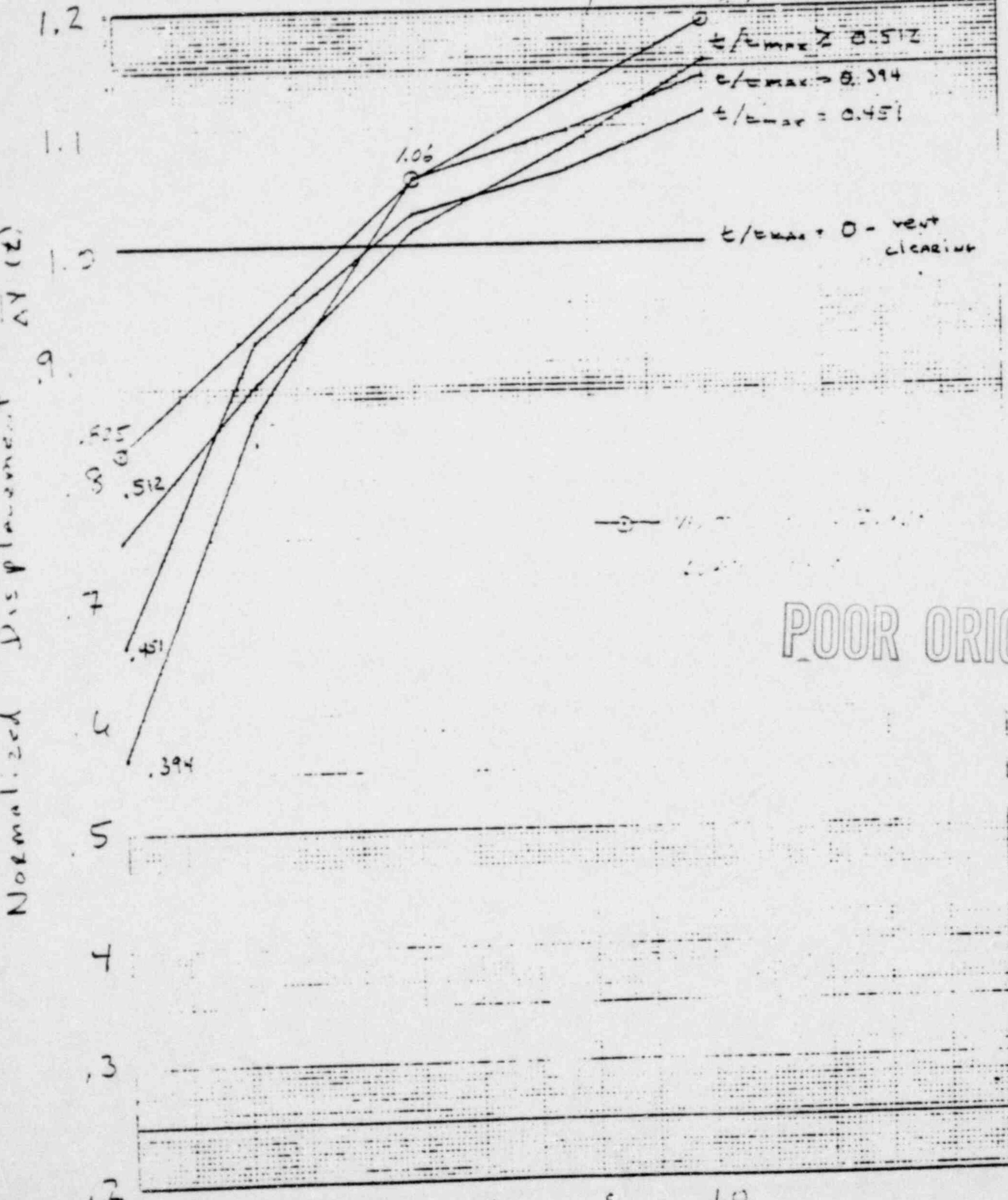
ACUREX Corporation

PROCEDURE FOR CREATING VENT HEADER DEFLECTOR
LOAD DEFINITION FROM QSTF DEFLECTOR LOAD MEASUREMENT

1) Plot K vs z/L using
EPRI Vent orifice data (SEE ATTACHED NUMERICAL FIGURE)



PRELIMINARY



Pool Surface

Displacement Longitudinal Distribution

Rev A

IMAGE EVALUATION
TEST TARGET (MT-3)

6"

MICROCOPY RESOLUTION TEST CHART

2) Surface acceleration given by

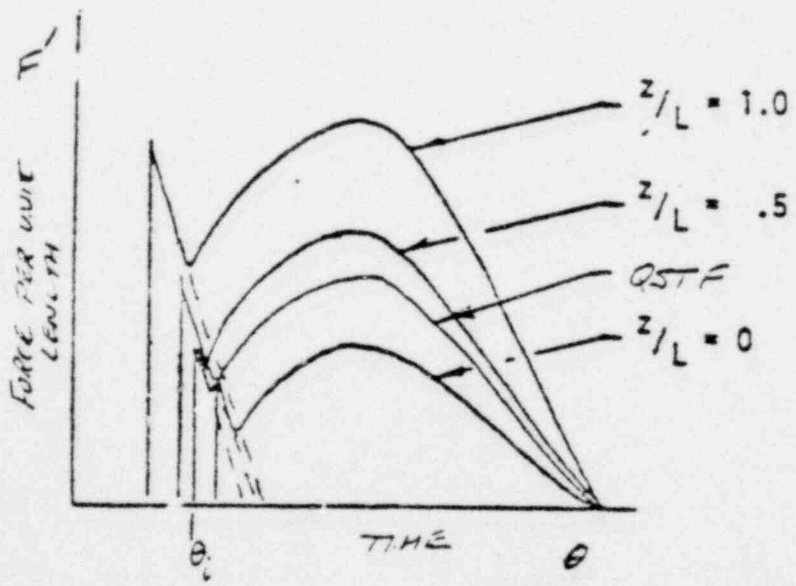
$$\ddot{X}_{Z/L} = K\,\ddot{X}_{QSTF}$$

AND

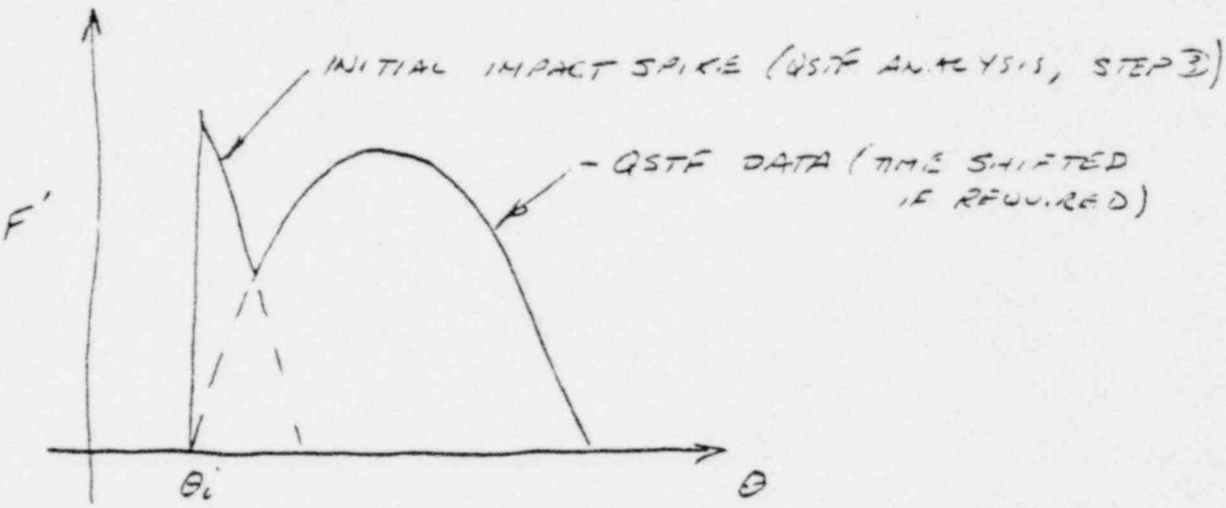
$$\dot{X}_{Z/L} = \int \ddot{X}_{Z/L}\, d\theta$$

$$X_{Z/L} = \int \dot{X}_{Z/L}\, d\theta$$

3) Run existing analysis (NEDO-24612) using NRC criteria drag coefficients and histories from 2) to produce 4 load histories $\left(Z/L = 0,\ .5\ ,\ 1.0 \text{ \& } QSTF \right)$



4) ADD IMPACT SPIKE FROM STEP (3) (QSTF ANALYSIS) TO QSTF MEASURED DATA AT TIME OF FIRST RESP - IN DATA AND ADJUST TIME SCALE TO CAUSE TIME OF IMPACT, θ_i, OF QSTF ANALYSIS AND DATA TO AGREE



5) COMPARE CALCULATED FORCES FROM STEP 3) AT IDENTICAL VALUES OF y, THE PENETRATION DEPTH

y	θ_{QSTF}	$\theta_{Z/2}$	F'_{QSTF}	$F'_{Z/2}$	$F'_{Z/2}/F'_{QSTF}$
y_1	θ_1	θ_4	F_1'	F_4'	ϕ_1
y_2	θ_2	θ_5	F_2'	F_5'	ϕ_2
y_3	θ_3	θ_6	F_3'	F_6'	ϕ_3
⋮	⋮	⋮	⋮	⋮	⋮

6) MULTIPLY THE CURVE FROM STEP 4) BY THE APPROPRIATE $F_{z/l} / F_{QSTF}$ RATIO AT θ_{QSTF} AND PLOT AT THE ASSOCIATED $\theta_{z/l}$ VALUE TO CREATE 3 FORCE HISTORIES (z/l = 0, .5 & 1.0)

7) SCALE THE RESULTS OF STEP 6) TO FULL SCALE BY:

force per unit length

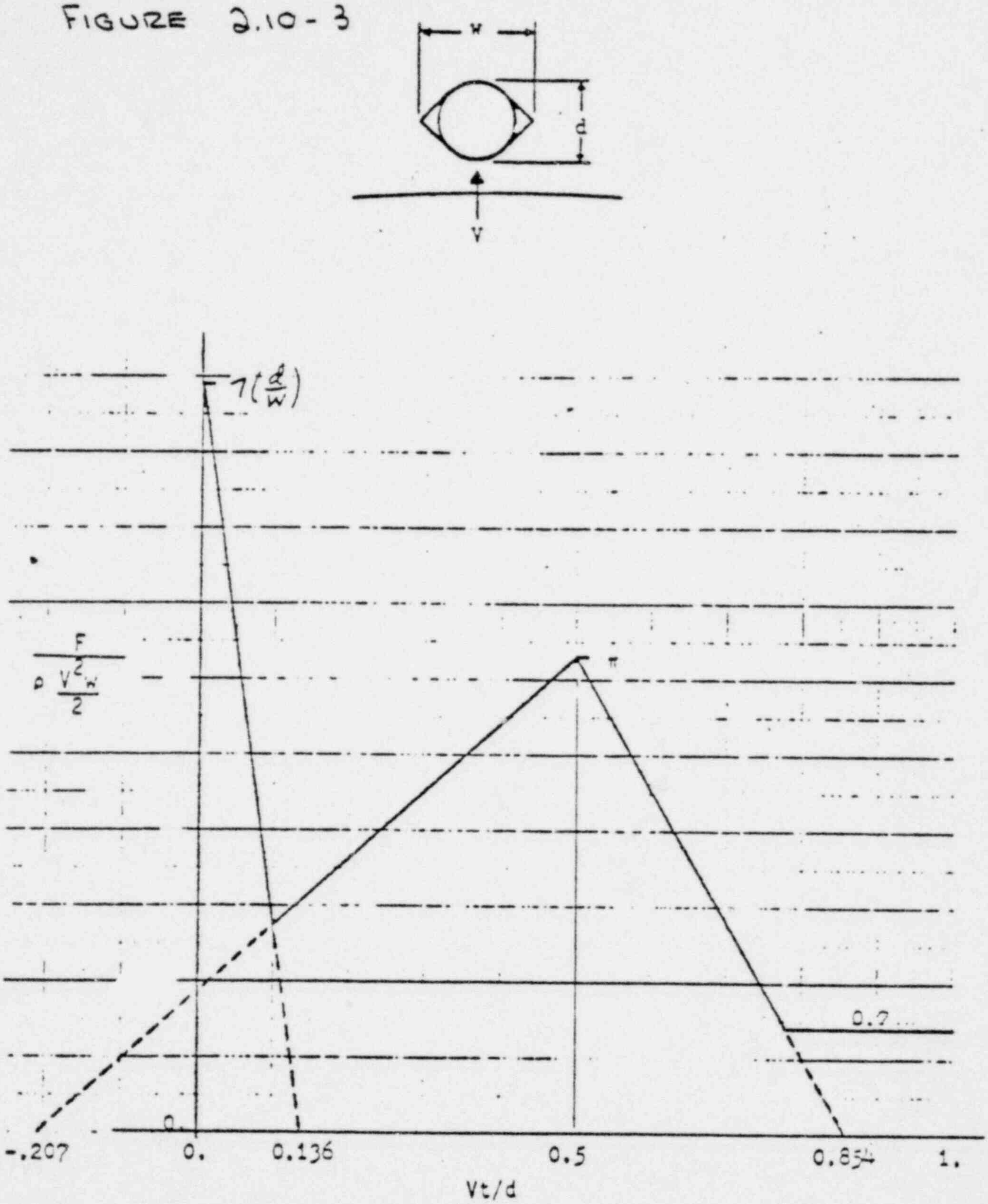
$$F'_{FS} = \frac{1}{\lambda^2} F'_{STEP\ 6)}$$

AT CORRESPONDING TIMES

$$\theta_{FS} = \frac{1}{\sqrt{\lambda}} \theta_{STEP\ 6)}$$

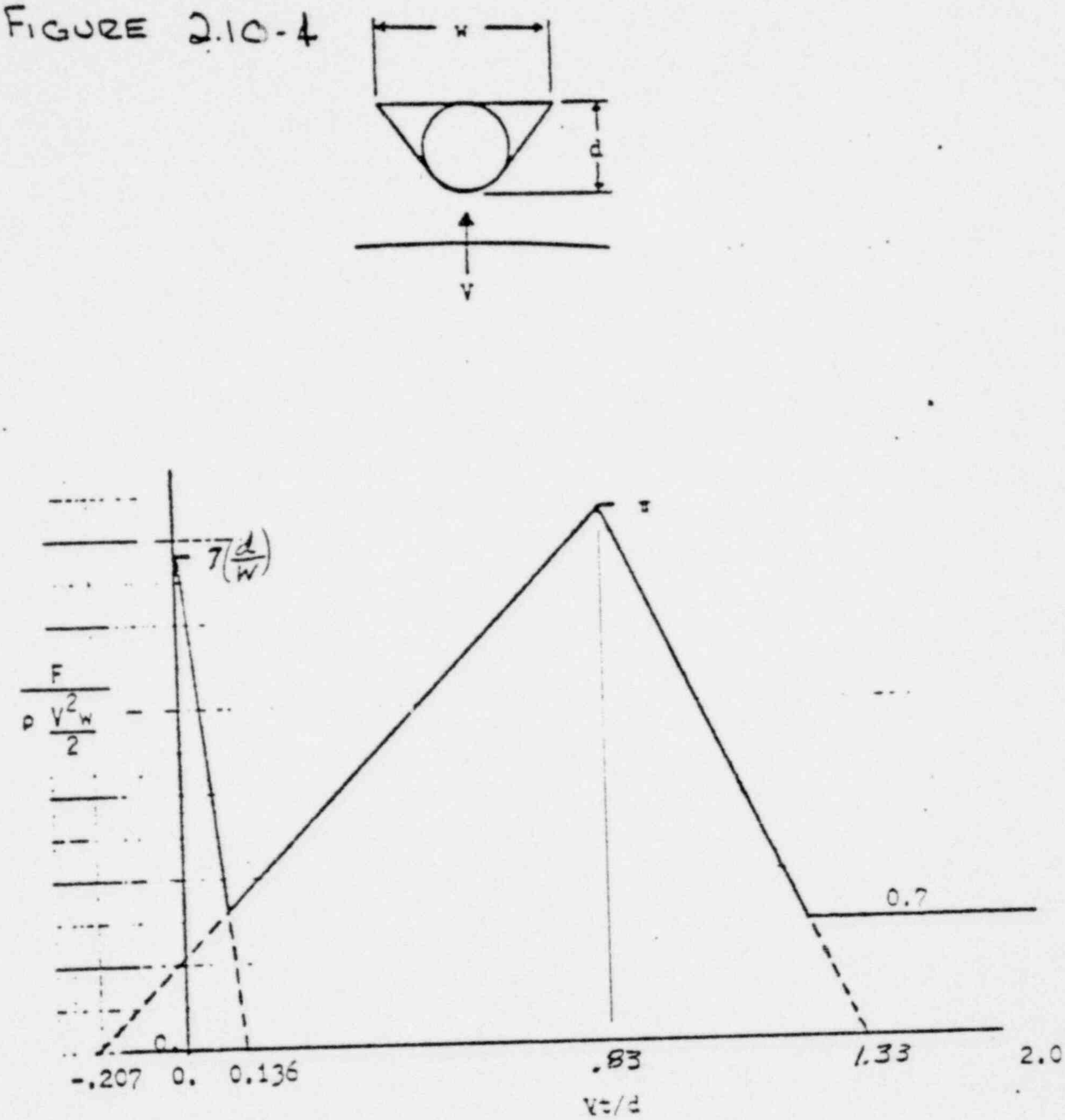
WHERE λ = QSTF SCALE FACTOR (LESS THAN ONE)

FIGURE 2.10-3



Impact and Steady Drag Force Correlation for Type 2 Deflector

FIGURE 2.10-4



Impact and Steady Drag Force Correlation for Type 3 Deflector

THRUST LOAD

- ANALYTICAL MODEL FOR DOWNCOMER INTERNAL PRESSURE CONSERVATIVE FOR ΔP AND ZERO ΔP PREDICTIONS

  - VENT CLEARING PREDICTED LATER THAN QSTF

  - DOWNCOMER PRESSURE DURING TIME BETWEEN VENT CLEARING AND BUBBLE BREAKTHROUGH IS GREATER THAN QSTF

  - ZERO ΔP VENT CLEARING PREDICTED EVEN LATER

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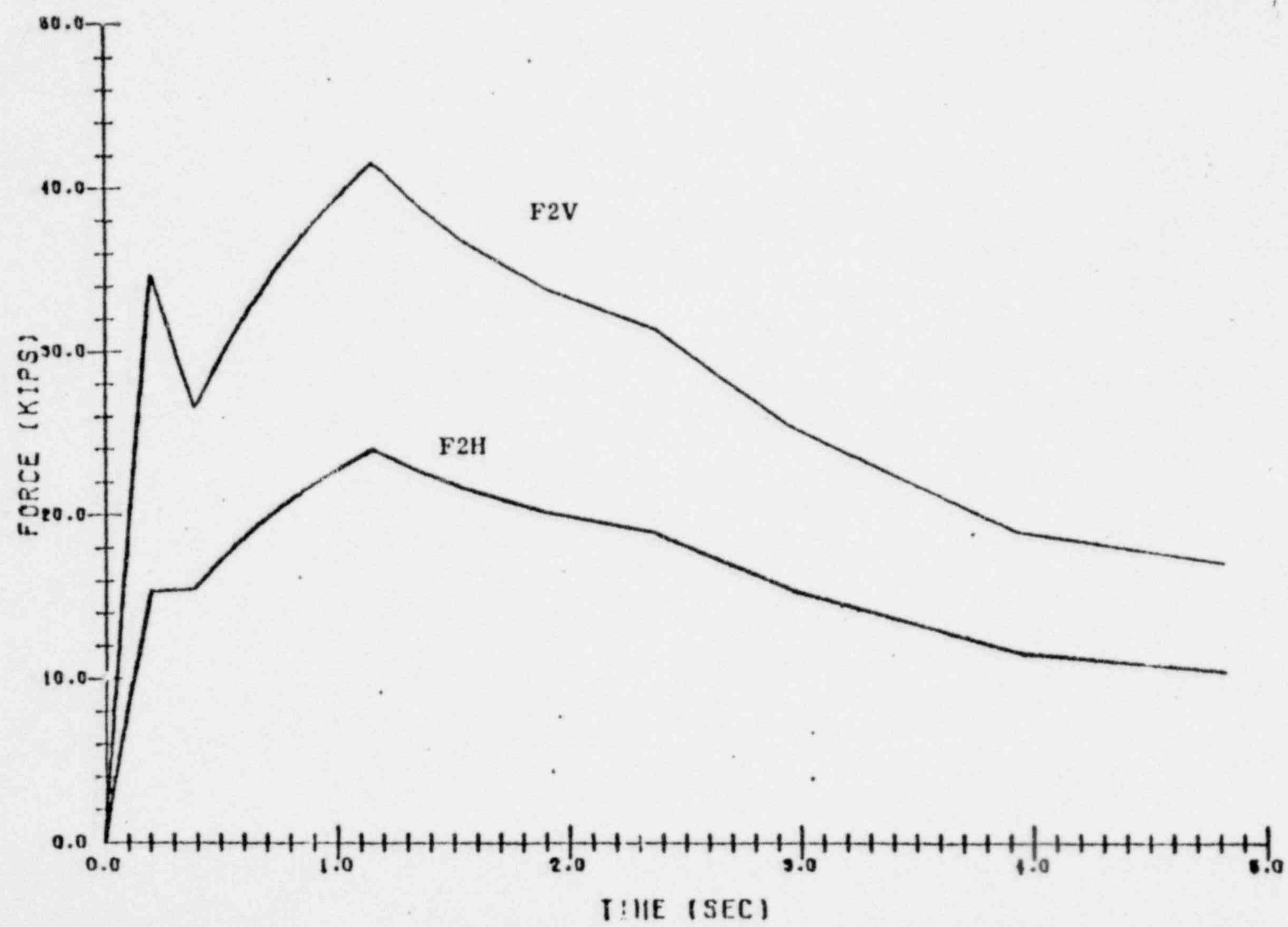
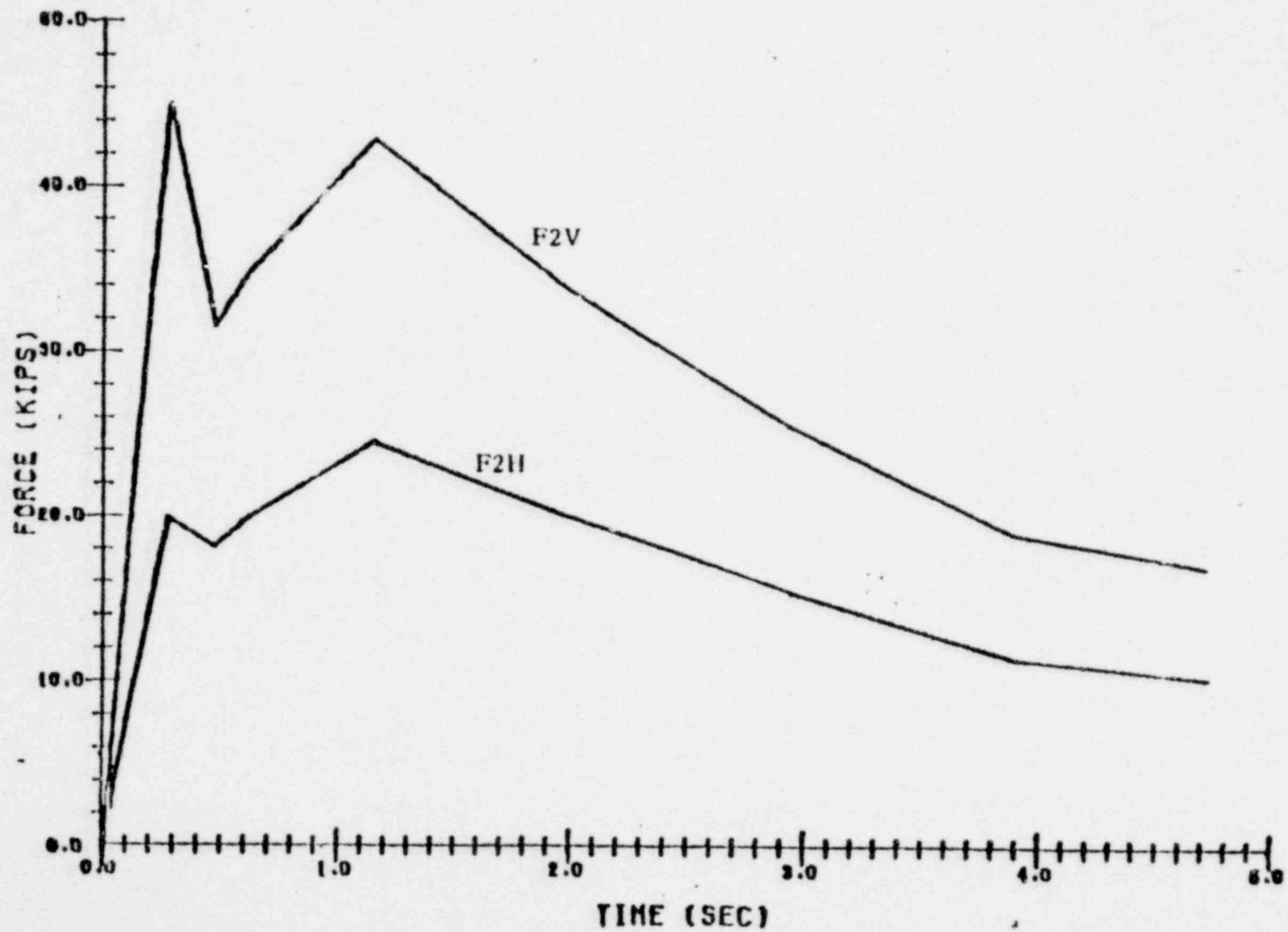
12/19/79



MONTICELLO . MIN. DELTAP VENT THRUST FORCES	VENT HEADER FORCES PER MITRE BEND



MONTICELLO . (O) DELTAP VENT THRUST FORCES	VENT HEADER FORCES PER MITRE BEND

SRV TORUS SHELL PRESSURES

FIRST ACTUATIONS:

- USE LDR FIRST ACTUATION PRESSURE PREDICTION
- USE LDR FIRST ACTUATION FREQUENCY PREDICTION ± 25%

SUBSEQUENT ACTUATIONS

- USE LDR FIRST ACTUATION PRESSURE PREDICTION
- USE LDR SUBSEQUENT ACTUATION FREQUENCY PREDICTION ± 40%

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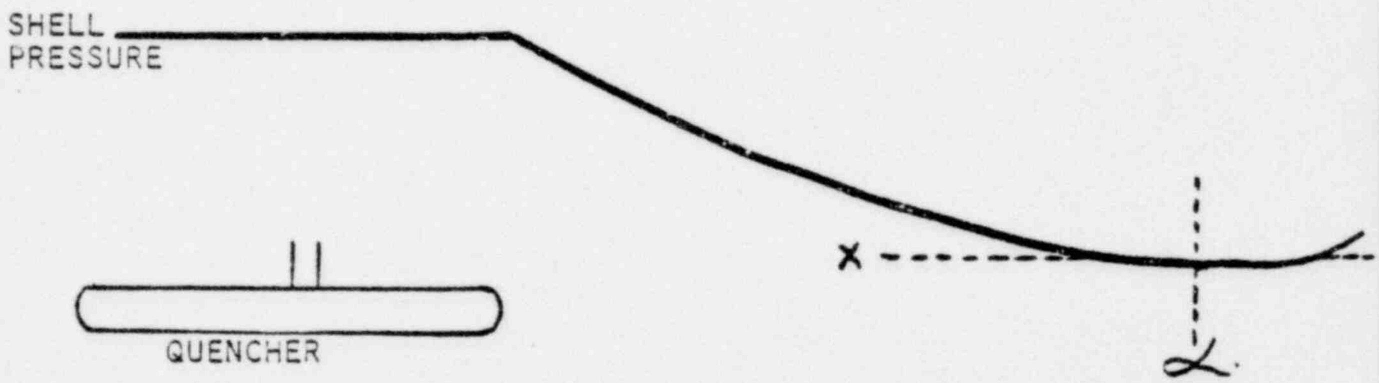
SRV TORUS SHELL PRESSURE ATTENUATION

SOME PRESSURE PREDICTIONS RESULT IN:



RESOLUTION: LIMIT PRESSURE TO "X" AT AND BEYOND α

50° or more

. SEE EQUATION 2-22 NEDE-21878-P

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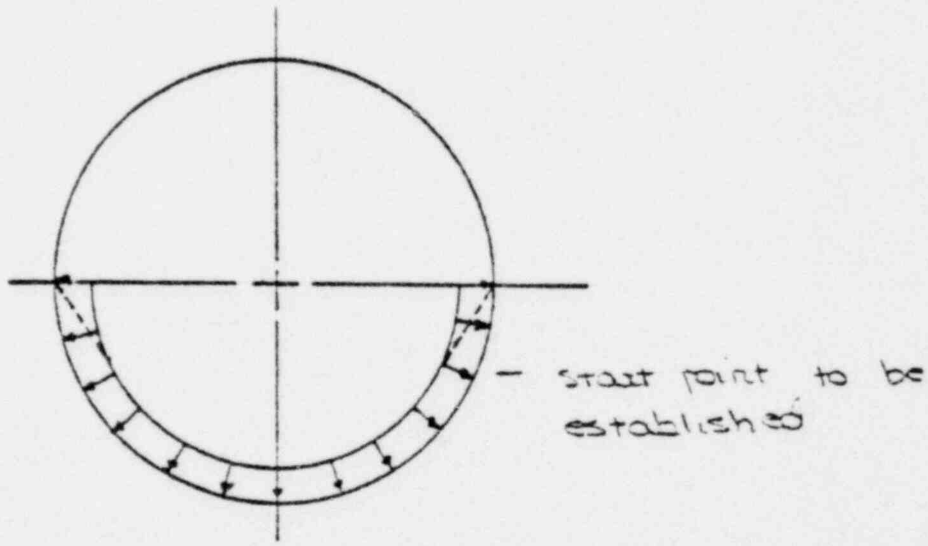
SRV TORUS SHELL PRESSURE ATTENUATION

PRESSURE PREDICTIONS AT LARGE DISTANCES FROM THE QUENCHER RESULT IN:



RESOLUTION: ATTENUATE TO ZERO AT WATER SURFACE

SEE EQUATION 2-23 NEDE-21878-P

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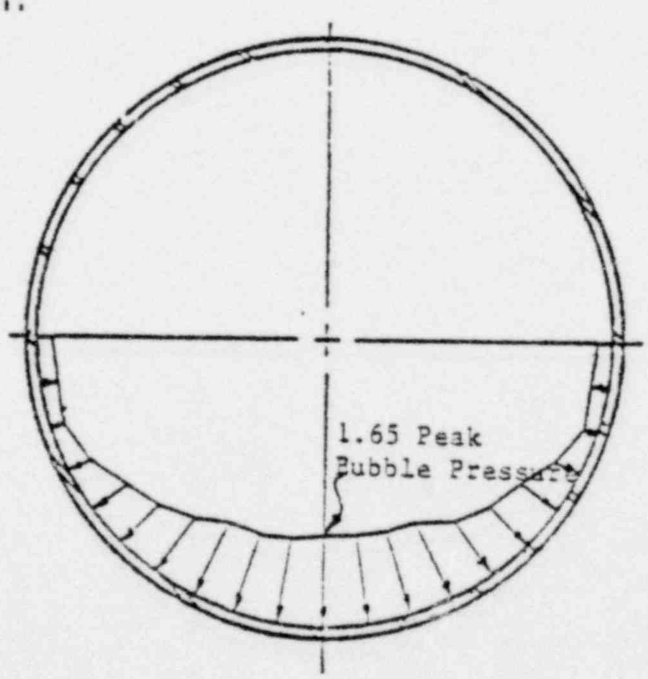
SRV TORUS SHELL PRESSURES FOR

MULTIPLE DISCHARGE LOADS

NRC CRITERIA:

COMBINED PEAK TORUS SHELL PRESSURE LIMITED TO MAXIMUM OF 1.65 TIMES PREDICTED PEAK BUBBLE PRESSURE

CLARIFICATION:



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SUBMERGED STRUCTURES

LOCA BUBBLE DRAG LOAD - FLOW FIELD

NRC CRITERIA:

- AFTER CONTACT BETWEEN BUBBLES OF ADJACENT DOWNCOMERS, POOL SWELL FLOW FIELD ABOVE DOWNCOMER EXIT.

  - UNIFORM FLOW FIELD ABOVE DOWNCOMER EXIT.

  - FLOW FIELD VELOCITY DETERMINED FROM QSTF PLANT UNIQUE TESTS.

  - DRAG LOAD CALCULATION ENDS WHEN BUBBLE ENGULFS STRUCTURE.

SAH-1
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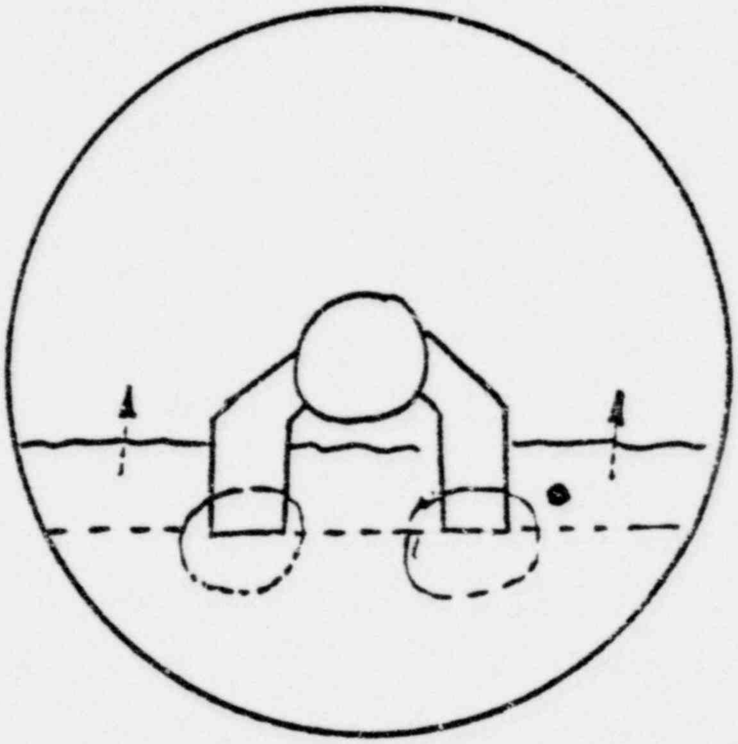
SUBMERGED STRUCTURES

LOCA BUBBLE DRAG LOAD - FLOW FIELD.



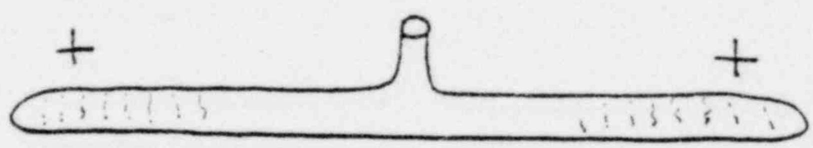
SAH-2
12/19/79

SUBMERGED STRUCTURES

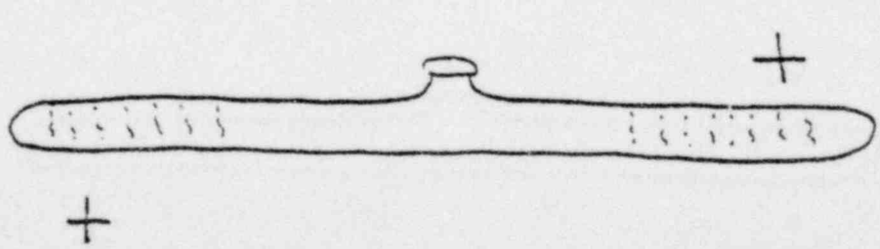
QUENCHER ARM LOADS

- QUENCHER ARM LOADS BASED ON ASSUMED BUBBLE ASYMMETRY.

- MAXIMUM SIDE FORCE CALCULATION
  - MAXIMUM BUBBLE PRESSURE ON ONE SIDE OF ARM.
  - ZERO ON OPPOSITE SIDE



- MAXIMUM MOMENTUM CALCULATION.
  - MAXIMUM POSITIVE BUBBLE PRESSURE ON DIAGONAL OF ARMS
  - ZERO ON REMAINING POSITIONS



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SUBMERGED STRUCTURES

QUENCHER ARM LOADS

- MONTICELLO TQ TEST DATA SUPPORTS NO BUBBLE ASYMMETRY.
  - BUBBLE PRESSURES IN PHASE ON EACH SIDE OF TQ ARMS
  - DIFFERENTIAL PRESSURES SUPPORT IN-PHASE ASSUMPTION.

- LOAD DEFINITION METHODOLOGY CONSERVATIVE BASED ON MONTICELLO DATA.

SAH-2
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FSTF TESTING STATUS

FSTF SNAP TEST-
TEST MATRIX AND STATUS

PURPOSE:

To Determine Damping and Natural Frequency of Mark I Downcomers

TEST MATRIX:

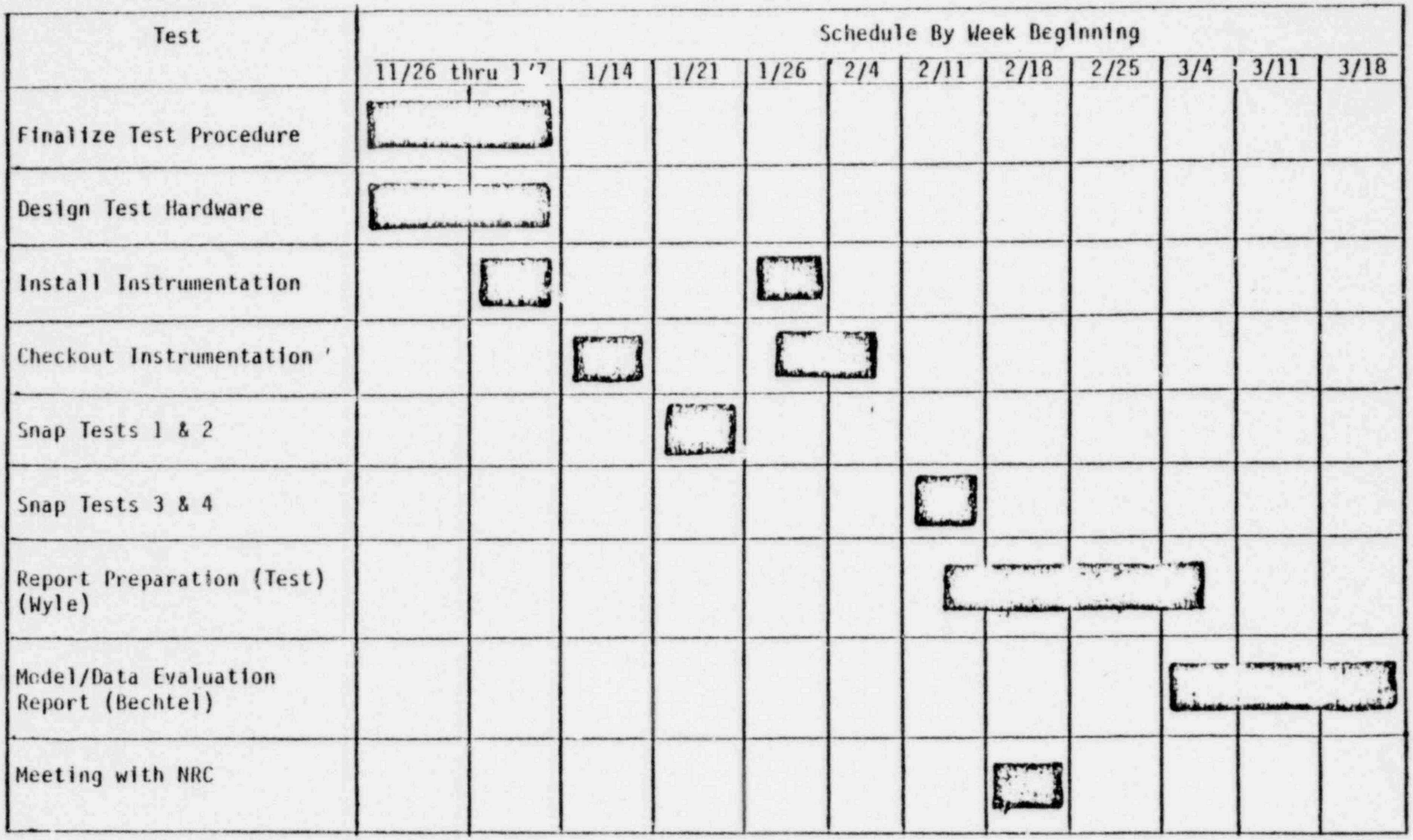
Test No.	D/C Pair	Condition	DC Water Level	Wetwell Water Level
1	5&6	Untied	Dry	Flooded
2	7&8	Untied	Dry	Flooded
3	5&6	Tied	Dry	Flooded
4	7&8	Tied	Dry	Flooded

SCHEDULE:

Complete Tests	February 1980
Complete Test Report	March 1980
Complete Evaluation Report	April 1980

RHK-3

SNAP TEST SCHEDULE



STF C/O RETEST -
TEST MATRIX AND STATUS

PURPOSE:

TO PROVIDE ADDITIONAL STATISTICAL BASIS FOR C/O TEST DATA DURING LARGE LIQUID BREAK TO ASSURE LDR C/O LOAD BOUNDS TEST DATA

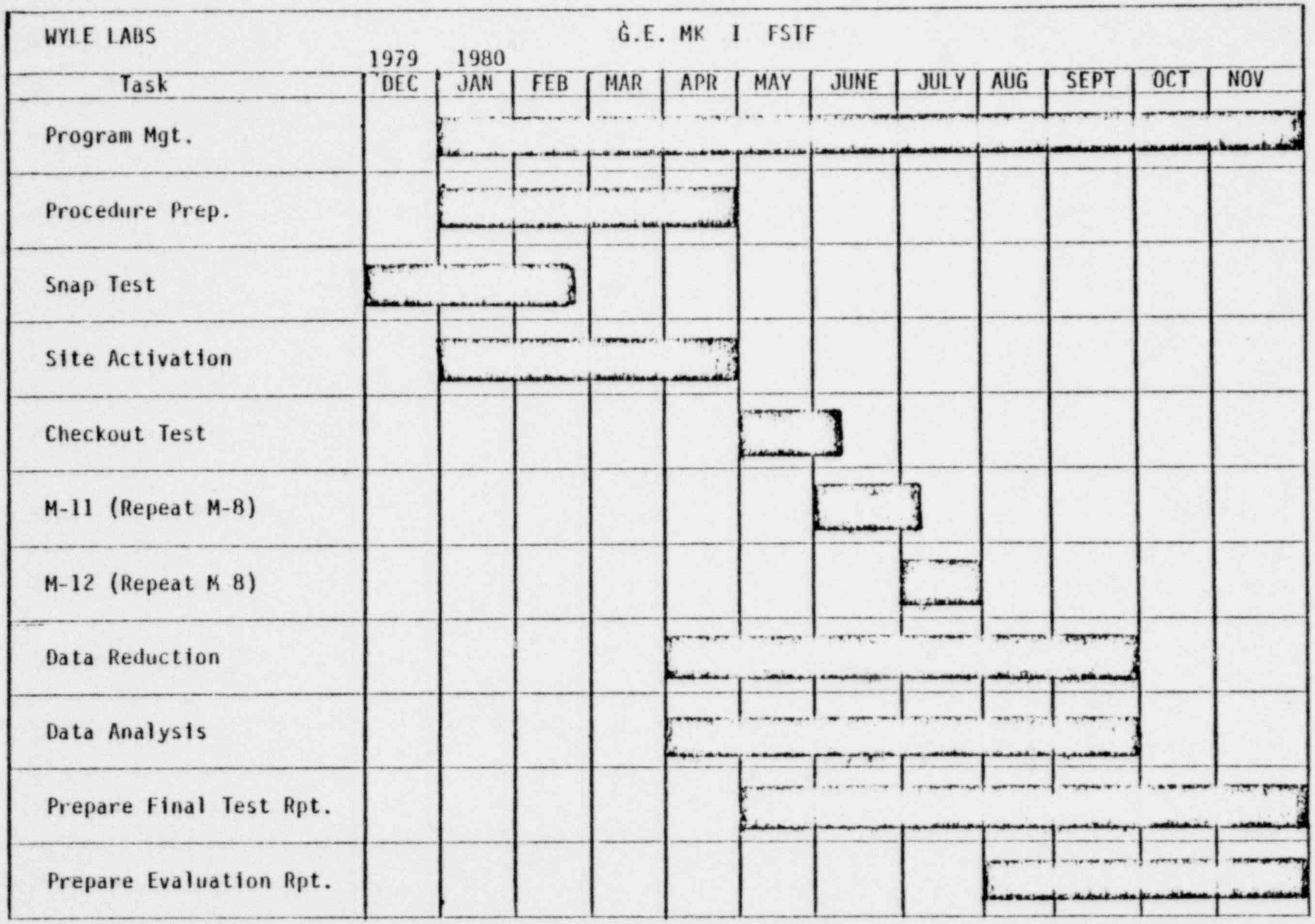
TEST MATRIX:

TEST NO.	SIMILAR TO:
M-11	M-8
M-12	M-8

SCHEDULE:

COMPLETE TESTS	JULY 1980
COMPLETE TEST REPORT	NOVEMBER 1980
COMPLETE EVALUATION REPORT	DECEMBER 1980

MILLSTONE



RHK-5

CLARIFICATION OF DRAG FOR POOL FALLBACK LOADS

The standard drag on a structure of length L is given by:

$$F_s = C_D\, D_{eq} L \frac{\rho U^2}{2g_c}$$

where D_{eq} is the equivalent diameter, as defined in Section 2.14. For cylinders, D_{eq} is simply the diameter, while for structures with sharp corners, $D_{eq} = 2^{1/2} L_{max}$, where L_{max} is the maximum transverse dimension.

The acceleration drag is given by:

$$F_A = \frac{\rho V_A}{g_c} \frac{dU}{dt}$$

where V_A is the acceleration volume, as given in Table I of NEDO 21471, and dU/dt for a free fallback is the gravitational acceleration, g.

The initial fallback load on structures within the air bubble, estimated using the froth fallback criteria of 25% water density and a maximum fallback velocity based on $(y_m - y_s)$ is:

$$F_i = SL \frac{\rho}{4} \frac{U^2}{g_c}$$

where S is the maximum horizontal cross-sectional dimension.

By inspection it may be noted that:

$$F_s = (2C_D) \quad \frac{D_{eq}}{S} \quad F_i$$

Since $D_{eq} \geq S$, it follows that for any value of $C_D > 0.5$, the standard drag load will bound the initial impact load. To provide sufficient conservatism for fallback densities greater than 25%, the minimum value of C_D should be taken as 1.2.

The ratio of standard drag to acceleration drag depends on the shape of the structure,

$$\frac{F_s}{F_A} = \frac{C_D\, D_{eq}\, L\, (y_m - y_s)}{V_A}$$

or

$$\frac{F_s}{F_A} = C_D \frac{(y_m - y_s)}{\pi R} \text{ for cylinders}$$

$$\frac{F_s}{F_A} = C_D \left(\frac{2}{4+\pi}\right) \frac{(y_m - y_s)}{S} \quad \text{for square rods (side, S)}$$

Since $(y_m - y_s)$ is on the order of 10 feet and the submerged structures have cross-sectional dimensions on the order of 0.1 to 1.0 foot, the standard drag is normally dominant. This is in contrast to the pool swell drag loads, where acceleration drag dominates due to rapid bubble growth.

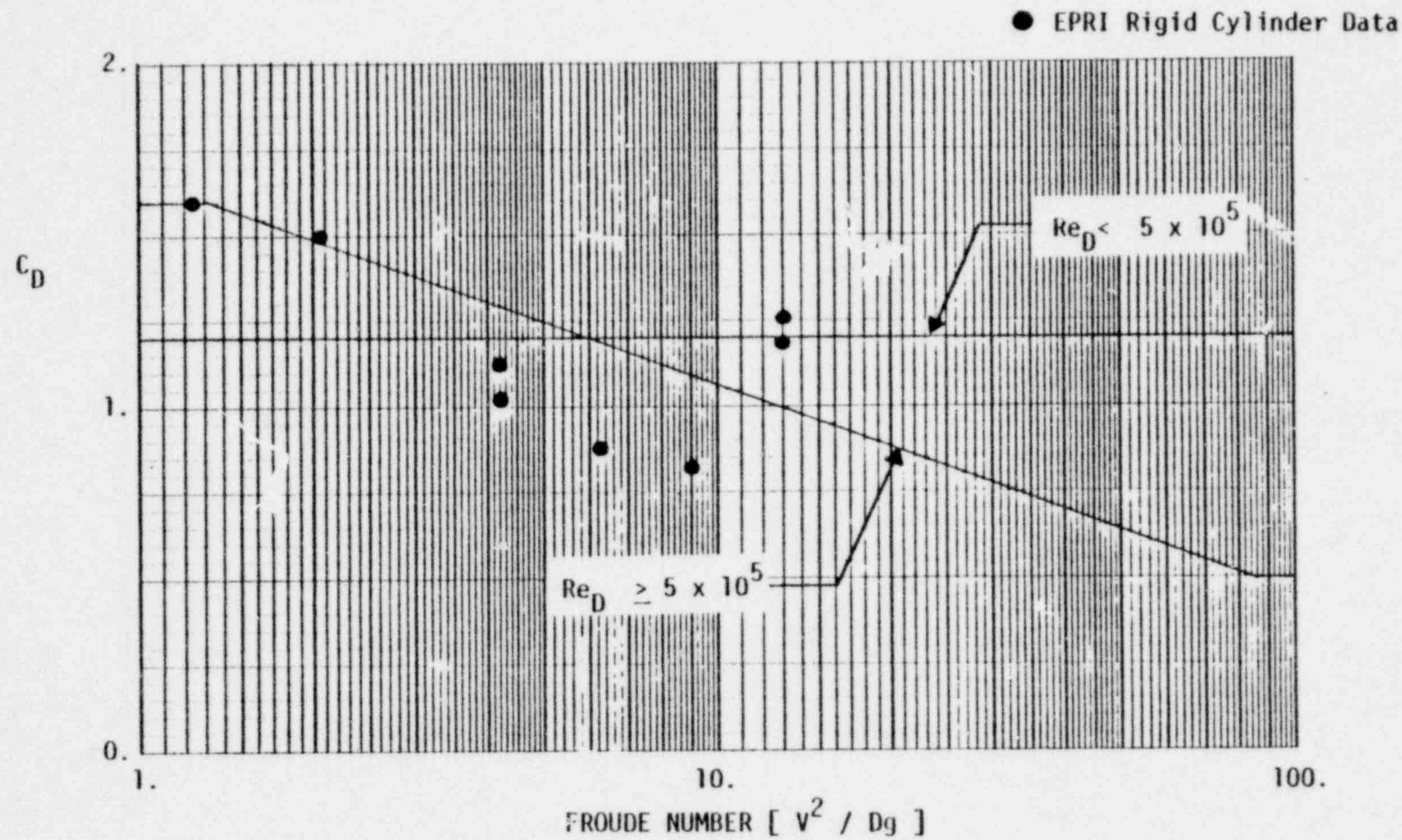


FIGURE 3.5-4 CYLINDRICAL TARGET DRAG COEFFICIENT FOLLOWING IMPACT