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

T. Su 6

FEB 9 1978

MEMORANDUM FOR: Gus C. Lainas, Chief, Containment Systems Branch, DSS

FROM: T. M. Su, Containment Systems Branch, DSS

THRU: J. A. Kudrick, Section A Leader, Containment Systems Branch, DSS

SUBJECT: SUMMARY OF MEETING WITH MARK II OWNERS GROUP TO DISCUSS THE STATUS OF SRV RELATED LOADS ON CONTAINMENT

On January 19, 1978, a meeting was held between representatives of Mark II owners group, General Electric, the NRC consultants (BNL) and the staff. The purpose of the meeting was to discuss the status of Safety Relief Valve (SRV) related loads on the Mark II containment.

The meeting agenda, attendee list and presentation material are attached. The significant results of the meeting are summarized below:

1. Methodology of Ramshead Load Prediction

The Mark II owners indicated that the methodology described in the Dynamic Forcing Function Report (DFFR) and the topical report (NEDO-24070) will be used for predicting the ramshead loads on the containment structure. This method utilizes the current GE analytical model to predict loads for first SRV actuation. For subsequent actuation, a multiplier of 1.4 is used for positive pressure and 1.6 for negative pressure. The Mark II owners have stated that the use of these multipliers in conjunction with the DFFR methodology provides a bounding load on the containment.

However, we pointed out that two additional items should be included in the method. These are leaking valve effects and bubble oscillating frequency. The Monticello test results show an increase in SRV loads corresponding to leaking valves. Since a leaking valve is a highly possible event, its effects should be addressed. In addition, the bubble oscillating frequency measured from the test deviates substantially from the predicted value. We indicated that the model should be modified in order to predict this important parameter within a reasonable error band. A representative of the Mark II owner's group stated that the bubble efficiency is being investigated in light of the Monticello test results.

Contact:
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492-7711

D-91

2. Method of Calculating Multiple-Valve Actuation Loads

Currently, the DFFR uses the SRSS (square root of sum of the squares) approach for combining loads from multiple-valve actuations. Our consultants, however, disagreed with this approach on the basis of the Monticello test results. A study made by our consultants currently shows that combining multiple-valve loads by the absolute sum method results in calculated loads closer to the Monticello results. Loads calculated by SRSS are in general lower than measured loads. Since the design loads on structures is substantially different between these two methods, we recommended that the Mark II owner's group conduct further investigations of these two methods.

3. Submerged Structure Loads

For submerged structures, the Mark II owner's included water jet loads and drag loads in the investigation. Their program includes analytical model development and experimental confirmation for a single structure within a pool. We stated that the approach of this investigation appears reasonable. However, we directed them to study the effect of a second body on the velocity and pressure fields because in an actual plant design there will be more than one structure in the fields that result from either the discharge of a SRV or from LOCA related phenomena.

4. Fluid and Structure Interaction (FSI)

GE stated that an analytical approach is being developed to investigate FSI effects associated with SRV loads. This work is expected to be completed by June, 1978. This late submittal may result in a slip in the review schedules associated with our A-39 and A-8 generic review programs. We will have further discussions with the Mark II owner's group for this matter.

On the basis of their current assessment, the Mark II owners maintain that FSI effects are insignificant for SRV loads. Dr. Bedrosian of Burns and Roe made a presentation to demonstrate that the loads measured in the Monticello steel torus are conservative for application to a Mark II concrete containment. His method uses a classical text book single degree of freedom model to show that flexible walls amplify the actual loads if the frequency ratio of the source and the tested facility falls within a certain range. He stated that the Monticello SRV loads fall within this range. We believe that this method of assessing the importance of SRV FSI effects has merit and should be

pursued further by the Mark II owners. The Mark II owner's group should provide a formal submission of this evaluation of FSI effects including a detailed description for our evaluation on a schedule consistent with our lead plant review efforts.

5. Pool Temperature Limit

We recommended that each Mark II owner accelerate their schedule to provide us the information related to pool temperature transients which we requested several months ago. We stated that this information is relevant to our evaluation of plant operability. The results of this evaluation will have an impact on the selection of the SRV discharge device; i.e., ramshead vs. quencher. Delays in receipt of this information will be reflected in our licensing review efforts for the lead Mark II plants.

T. M. Su, A-39 Task Manager
Containment Systems Branch
Division of Systems Safety

Attachments:
As Stated

Distribution:
Central File
NRR Reading File
CSB Reading File
E. Case
R. Mattson
S. Hanauer
R. Fraley, ACRS (16)
R. DeYoung
D. Vassallo
D. Skovholt
R. Tedesco
J. Glynn
D. Ross
I&E (3)
NRC PDR
Local PDR
M. Kehnemuyi
J. Kudrick
T. Su

MK II S/R VALVE PHENOMENA MEETING

Attendance

A. R. Smith	G.E.
W. M. Davis	G.E.
A. J. James	G.E.
E. M. Mead	PP&L
R. M. Crawford	S&L
H. C. Brinkman	CG&E
L. H. Frauenholz	GE
S. B. Mucciacciaro	S&W
H. Chau	Lilco
B. R. McCaffrey	Lilco
C. Tung	BNL
P. Huber	MIT (BNL)
G. Bienkowski	Princeton (BNL)
R. H. Scanlan	Princeton (BNL)
T. M. Su	NRC/CSB
J. A. Kudrick	NRC/CSB
C. J. Anderson	NRC/CSB
George Maise	BNL
A. Hafiz	NRC/SEB
G. Lainas	NRC/CSB
J. Glynn	NRC/DSS
R. L. O'Mara	S&W
S. C. Chow	Stone & Webster
C. Lin	S&W
K. J. Green	S&L
J. S. Abel	Commonwealth Edison
R. E. Schaffstall	G.E.
M. G. Mosier	NMPC
H. S. Lu	Ebasco
E. A. Rukos	CFE
T. Zazueta	CFE
C. Oppenheim	ENK
A. F. Deardorff	Nutech (Mk I O.G.)
R. J. Muzzy	GE
H. T. Tang	GE
D. C. Baker	Burns & Roe
H. M. Schoenhoff	Bechtel
E. McFarland	Bechtel
T. Huang	NRC/CSB
M. R. Granback	NIPSCO
A. P. Olson	NSC
R. F. McClelland	GE
Bedros Bedrosian	B&R
G. L. Gelhaus	WPPSS
K. K. Roe	B&R
L. Sobon	GE

INTRODUCTION

- MEETING OBJECTIVES
  - CONTINUING MK II OWNERS GROUP POLICY OF FREQUENTLY ADVISING NRC OF PROGRAM TECHNICAL PROGRESS AND STATUS
  - SAFETY/RELIEF VALVE DISCHARGE PHENOMENA PROGRAM
  - PRIMARY EMPHASIS ON RAMSHEAD TECHNOLOGY
  - MK II QUENCHER TECHNOLOGY CONSIDERATIONS
  - MK II S/RV SEQUENTIAL ACTUATION APPROACH

SRV MEETING AGENDA - MARK II OWNERS GROUP/NRC

I. INTRODUCTION

II. METHODS FOR LOAD PREDICTION - RANSHEAD
- METHODOLOGY
- SUBMERGED STRUCTURES
  - OVERVIEW
  - APPLICATION MEMORANDUM

III. METHODS FOR LOAD PREDICTION - QUENCHER
- METHODOLOGY
- SUBMERGED STRUCTURES

IV. MONTICELLO DATA AND MARK II FSI
- EVALUATION OF FSI DATA FOR S/RV MODEL VERIFICATION.
- ASSESSMENT OF EFFECTS OF FSI IN MK II CONTAINMENTS.

V. POOL TEMPERATURE LIMITS
- REPORT SUMMARY
- TRANSIENT ASSUMPTIONS

MARK II PRESSURE SUPPRESSION CONTAINMENT SYSTEMS

LOADS ON SUBMERGED STRUCTURES DUE TO SRV DISCHARGE THROUGH A RAMSHEAD DEVICE

- DISCUSSION OF SUBMERGED STRUCTURE TECHNOLOGY
- OVERVIEW OF RAMSHEAD SUBMERGED STRUCTURE PROGRAM
- DOCUMENTATION
- SUMMARY OF RAMSHEAD ASSUMPTIONS AND APPLICATION TECHNIQUES
- CONCLUSIONS

MARK II PRESSURE SUPPRESSION CONTAINMENT SYSTEMS

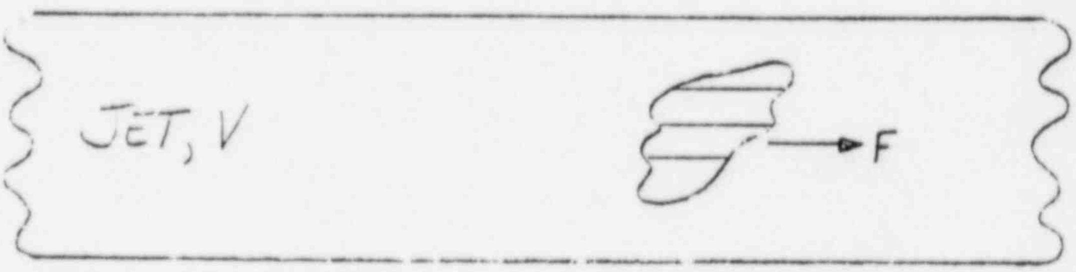
SUBMERGED STRUCTURE LOADS

WATER JET LOADS

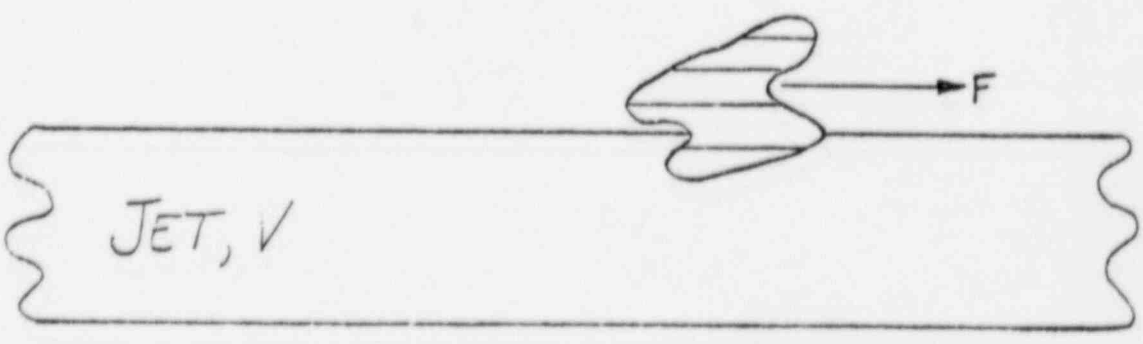
- SOURCE OF JETS
  - MAIN VENTS DURING LOCA
  - RAMSHEAD OR QUENCHER DURING SRV ACTUATION
- LOADING MECHANISMS
  - WATER DRAG/IMPINGEMENT
- BASIC APPROACH
  - PROVIDE JET DEFINITION AND CALCULATE LOADS FROM KNOWN DRAG COEFFICIENTS OR IMPINGEMENT CALCULATIONS

MARK II PRESSURE SUPPRESSION CONTAINMENT SYSTEMS

WATER JET LOADS



$$F = C_D \cdot A \cdot V^2/2g$$



$$F = K_1 \cdot A_1 \cdot V^2/2g$$

MARK II PRESSURE SUPPRESSION CONTAINMENT SYSTEMS

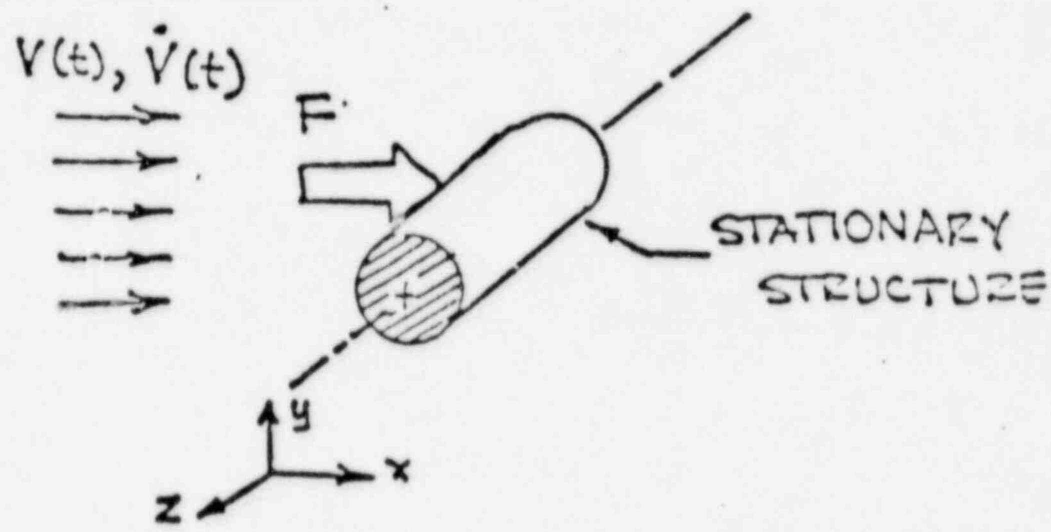
SUBMERGED STRUCTURE LOADS

'BUBBLE' TYPE LOADS

- SOURCE OF BUBBLE
  - MAIN VENTS DURING POOL SWELL
  - RAMSHEAD OR QUENCHER FOLLOWING AIR CLEARING
  - MAIN VENTS DURING CONDENSATION OSCILLATIONS AND CHUGGING

- LOADING MECHANISM
  - STANDARD DRAG ($\propto V^2$) PRODUCED BY VELOCITY FIELDS
  - ACCELERATION DRAG ($\propto \dot{V}$) PRODUCED BY PRESSURE FIELDS

- BASIC APPROACH
  - PROVIDE DEFINITION OF VELOCITY AND ACCELERATION FIELDS AND CALCULATE DRAG FROM KNOWN DRAG COEFFICIENTS AND ACCELERATION DRAG VOLUMES.



FLOW FIELD INDUCED LOADS

$$F = F_s + F_A$$

STANDARD DRAG

$$F_s = C_D A \rho \frac{V(t)^2}{2g_c} \sim V(t)^2$$

ACCELERATION DRAG

$$F_A = \mathbb{V}_A \rho \frac{\dot{V}(t)}{g_c} \sim \dot{V}(t)$$

SUBMERGED STRUCTURES LOADS

- REPORT TITLE - NED #21472-P

  ANALYTICAL MODEL FOR LIQUID JET PROPERTIES FOR PREDICTING FORCES ON SUBMERGED STRUCTURES

- REPORT TITLE - NED #21471-P

  ANALYTICAL MODEL FOR ESTIMATING DRAG FORCES ON RIGID SUBMERGED STRUCTURES CAUSED BY LOCA AND SAFETY RELIEF RAMSHEAD AIR DISCHARGE

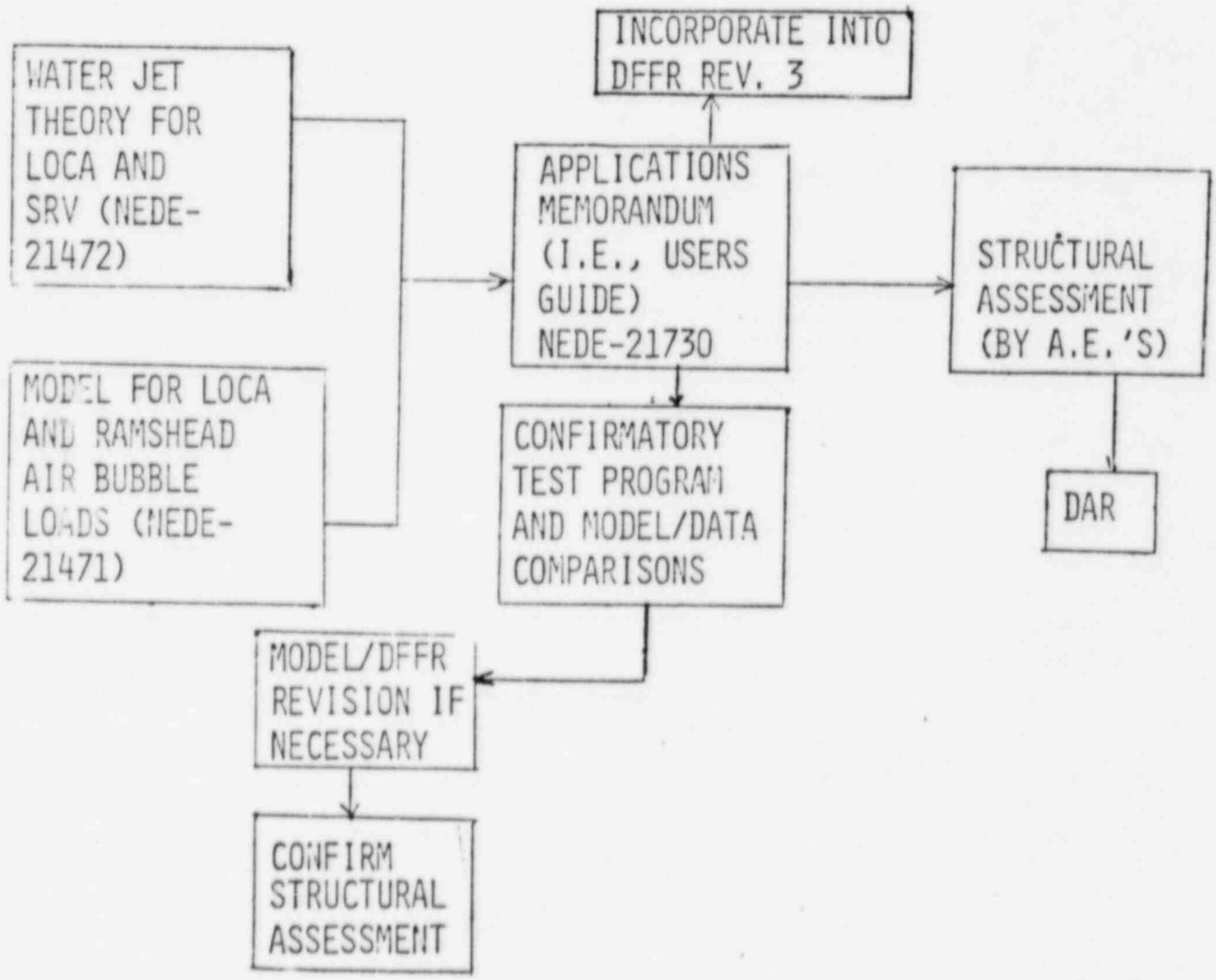
APPLICATION METHOD

- REPORT TITLE - NED #21730

  MARK II PRESSURE SUPPRESSION CONTAINMENT SYSTEMS LOADS ON SUBMERGED STRUCTURES - AN APPLICATION MEMORANDUM

MARK II PRESSURE SUPPRESSION CONTAINMENT SYSTEMS

RAMSHEAD SUBMERGED STRUCTURES PROGRAM



MARK II PRESSURE SUPPRESSION CONTAINMENT SYSTEMS

RAMSHEAD WATER JET LOAD

MAJOR ASSUMPTIONS

- UNSTEADY SUBMERGED JET WITH NO DIVERGENCE OTHER THAN PREDICTED BY MASS/MOMENTUM EQUATIONS. CONSTANT FLUID PARTICLE VELOCITY

- VELOCITY AND ACCELERATION FROM THE DFFR PIPE CLEARING MODEL

- FORCE IS DRAG OR IMPINGEMENT DEPENDING ON GEOMETRY

- DISSIPATION OCCURS WHEN LAST PARTICLE REACHES JET FRONT

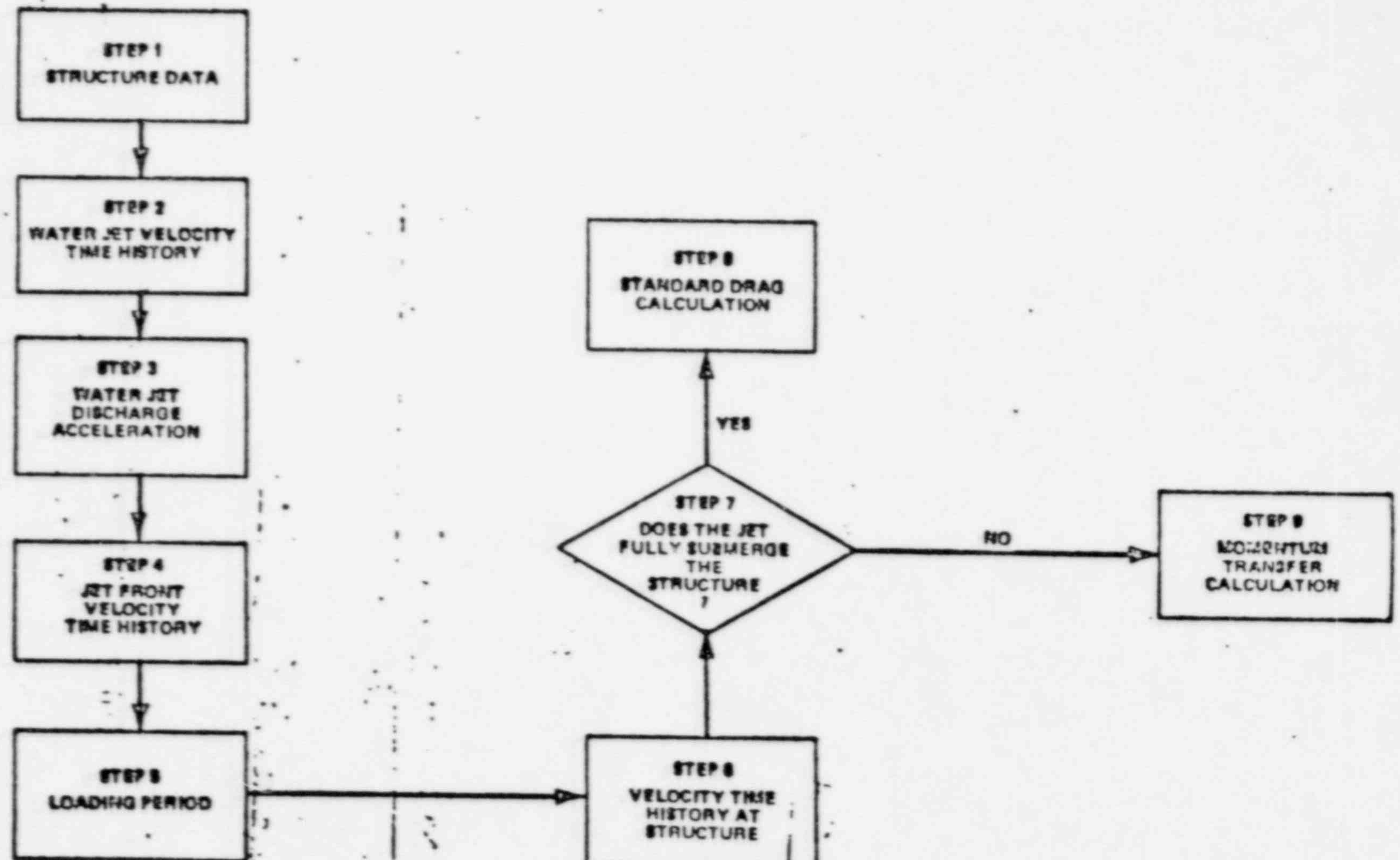


Figure 2-1. Jet Loads Procedure

MARK II PRESSURE SUPPRESSION CONTAINMENT SYSTEMS

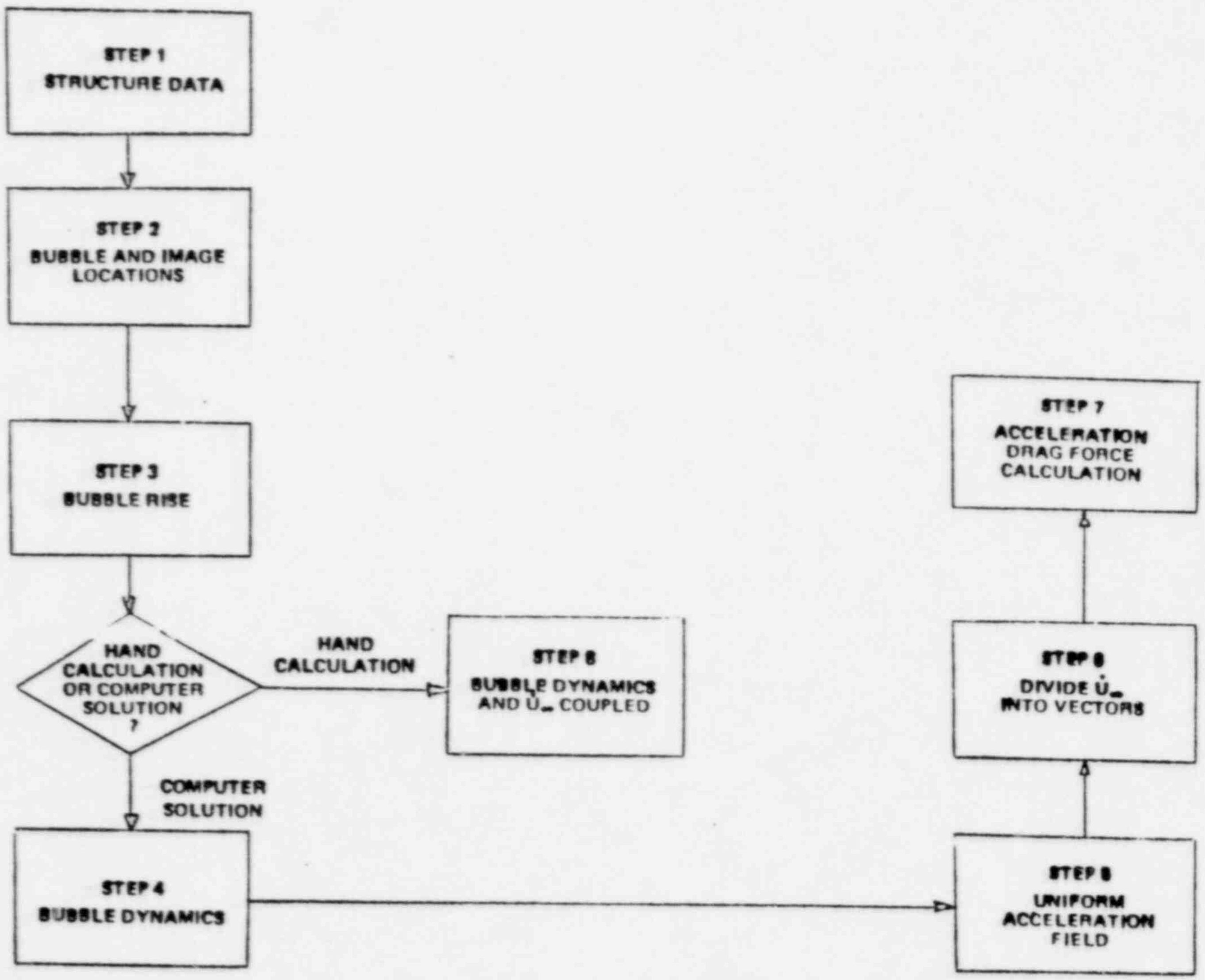
RAMSHEAD AIR BUBBLE LOADS ON SUBMERGED STRUCTURES

MAJOR ASSUMPTIONS

- SPHERICAL BUBBLE FLOW FIELD DESCRIBED BY A POINT SOURCE. FINITE BUBBLE EFFECTS CONSIDERED.
- UNIFORM FLOW FIELD
- BOUNDARIES ACCOUNTED FOR WITH METHOD OF IMAGES
- AIR IS IDEAL GAS
- ACOUSTIC EFFECTS NEGLIGIBLE
- BUBBLE RISE CONSIDERED
- TWO BUBBLES IN PHASE

RAMSHEAD AIR BUBBLE APPLICATION

(NEDE-21730)



MARK II PRESSURE SUPPRESSION CONTAINMENT SYSTEMS

RAMSHEAD SUBMERGED STRUCTURE LOADS

CONCLUSIONS

- LOADS CONSERVATIVELY DEFINED AND DOCUMENTED
- CONFIRMATORY PROGRAM IN PLACE
- DESIGN ASSESSMENT STUDIES UNDER WAY

RAMSHEAD CONDENSATION INSTABILITY

- REVIEW OF LIMITS BEING USED

- REVIEW OF DATA BASE

  G.E. MOSS LANDING

  G.E. SAN JOSE

  FIELD DATA

- SUMMARY

RAMSHEAD CONDENSATION INSTABILITY

LIMITS BEING USED

- MASS FLUX: $G \leq 40\ LB/FT^2\ SEC$

  (REACTOR PRESSURE $\approx$ 200 PSIG)

- LOCAL WATER TEMPERATURE: NON-ATWS EVENTS

  $T_L \leq 160^oF$

  ATWS STUDIES

  $T_L \leq 170^oF$

- POOL THERMAL DISTRIBUTION: $T_L = T_{BULK} + 10^oF$

RAMSHEAD DATA BASE

- G.E. MOSS LANDING

  - 3 TESTS OF 1¼-INCH RAMSHEAD: 152 TO 163°F

- G.E. SAN JOSE

  - 4 TESTS OF 3/4-INCH RAMSHEAD: 170 TO 176° F
  - 1 TEST OF 3/4-INCH RAMSHEAD: NO THRESHOLD (<40 LB_M/FT^2-SEC

  - 13 TESTS OF ½-INCH ELBOW: 160 TO 172° F

  - 7 TESTS OF 3/4-INCH ELBOW: 146 TO 170° F

  - 17 TESTS OF 1-INCH ELBOW: 147 TO 170° F
  - 2 TESTS OF 1-INCH ELBOW: NO THRESHOLD (<40 LB_M/FT^2- SEC)

RAMSHEAD DATA BASE

- RAMSHEAD PLANT DATA
  - PLANT A: 165°F NO INSTABILITY
  - PLANT B: 150°F NO INSTABILITY
  - PLANT C: 146°F NO INSTABILITY
  - PLANT D: 129°F NO INSTABILITY
  - PLANT E: 122°F NO INSTABILITY

SUMMARY

- NO OBSERVED DEVICE-SIZE EFFECT ON THRESHOLD TEMPERATURE
- LIMIT CONFIRMED BY 3/4 INCH RAMSHEAD DATA
- LIMIT SUPPORTED BY FIELD DATA TO OVER 165°F

MARK II PRESSURE SUPPRESSION CONTAINMENT SYSTEMS

DYNAMIC LOADS PRODUCED BY SRV DISCHARGE THROUGH A RAMSHEAD DEVICE

AN OVERVIEW OF LEAD PLANT STATUS

- SUMMARY OF METHODOLOGY DOCUMENTATION
- REVIEW OF:
  1. NEDO-24070, RAMSHEAD SAFETY RELIEF VALVE LOADS METHODOLOGY SUMMARY.
  2. GEN-0394, MARK II BWR SRV RAMSHEAD BUBBLE DYNAMICS ANALYTICAL MODEL COMPARISONS WITH TEST DATA.
- SUMMARY OF LEAD PLANT STATUS

MARK II PRESSURE SUPPRESSION CONTAINMENT SYSTEMS

METHODOLOGY FOR CALCULATING RAMSHEAD BUBBLE LOADS ON POOL BOUNDARY

- METHODS DEFINED IN DFFR SECTION 3.2 AND REFERENCES
  - PIPE CLEARING
  - BUBBLE DYNAMICS
  - METHOD OF IMAGES
  - COMBINATION OF MULTIPLE BUBBLES
  - LOAD CASES
  - TIE DOWN LOADS
- NEDO-24070 PROVIDES "ROADMAP" OF MODEL DEVELOPMENT AND VERIFICATION.
  - PHENOMENA
  - METHODS SUMMARY
  - EXPERIMENTAL VERIFICATION
  - APPLICATION
  - FUTURE WORK
  - CONCLUSIONS

NEDO-24070
77NED351
Class I
October 1977

MARK II CONTAINMENT
SUPPORTING PROGRAM REPORT

RAMSHEAD SAFETY/RELIEF VALVE LOADS
METHODOLOGY SUMMARY

Prepared by
G.L. Anderson

BOILING WATER REACTOR PROJECTS DEPARTMENT • GENERAL ELECTRIC COMPANY
SAN JOSE, CALIFORNIA 95125
GENERAL ELECTRIC

MARK II PRESSURE SUPPRESSION CONTAINMENT SYSTEMS

REVIEW OF NEDO-24070

SECTION 1: INTRODUCTION

- PURPOSE AND CONTENTS OF REPORT

SECTION 2: PHENOMENA

- LINE CLEARING (WATER/AIR)
- BUBBLE OSCILLATION
- STEADY STEAM FLOW

SECTION 3: DESCRIPTION OF ANALYTICAL METHODS

- LINE CLEARING
- BUBBLE DYNAMICS
- METHOD OF IMAGES
- SUPERPOSITION OF LOADS

A. LINEAR ADDITION IF SEQUENCING CONSIDERED

B. $\sqrt{}$ SS ADDITION FOR SIMULTANEOUS DISCHARGE

MARK II PRESSURE SUPPRESSION CONTAINMENT SYSTEMS

REVIEW OF NEDO-24070

SECTION 4: EXPERIMENTAL VERIFICATION OF METHODS

TESTS:
1. QUAD CITIES (1972)
2. SMALL SCALE TEST TANK (1974)
3. MONTICELLO (1976)

CONCLUSIONS

1. QUAD CITIES

- 1972 MODELS BOUND PIPE PRESSURE AND POSITIVE WALL PRESSURE
  - -- REASONABLY PREDICT NEGATIVE PRESSURE
  - -- MODEL REFINEMENTS IMPLEMENTED
- DFFR METHODS FOR POOL BOUNDARY LOADS CONSERVATIVE.

MARK II PRESSURE SUPPRESSION CONTAINMENT SYSTEMS

REVIEW OF NEDO-24070

2. SMALL SCALE TEST TANK

   - MOI ACCURATELY DESCRIBES BOUNDARY CONDITIONS

   - LITTLE DIFFERENCE BETWEEN LINEAR ADDITION AND SRSS SO LONG AS BUBBLE BOUNDARY CONDITIONS SATISFIED.

MARK II PRESSURE SUPPRESSION CONTAINMENT SYSTEMS

REVIEW OF NEDO-24070

3. MONTICELLO

- FOR SINGLE VALVE TESTS, DFFR METHODS CONSERVATIVE FOR POSTIVE PRESSURE AND ACCURATE FOR NEGATIVE PRESSURE
- FOR MULTIPLE VALVE TESTS, DFFR METHODS BOUND POSITIVE PRESSURES (EXCEPT 1 LOCATION) AND ARE GENERALLY WITHIN THE RANGE OF OBSERVED NEGATIVE PRESSURES
- FOR LEAKING VALVES, DFFR PREDICTIONS COMPARABLE TO DATA
- FOR CONSECUTIVE ACTUATIONS, DATA UNDERPREDICTED BY DFFR FIRST ACTUATION METHODS.

MARK II PRESSURE SUPPRESSION CONTAINMENT SYSTEMS

REVIEW OF NEDO-24070

SECTION 5: APPLICATION

- STRUCTURAL ASSESSMENTS PROVIDED IN INDIVIDUAL PLANT DESIGN ASSESSMENT REPORTS
- CONSIDER
  - SINGLE VALVE DISCHARGE (CONSECUTIVE)
  - ADS DISCHARGE (FIRST ACTUATION)
  - ASYMMETRIC CASE (PLANT UNIQUE) (FIRST ACTUATION)
  - ALL VALVE DISCHARGE (FIRST ACTUATION)
- NO SPECIFIC CONSIDERATION OF LEAKY VALVES IS NECESSARY
- CONSECUTIVE ACTUATION : USE MULTIPLIER ON EXISTING DFFR FIRST ACTUATION PREDICTIONS.

MARK II PRESSURE SUPPRESSION CONTAINMENT SYSTEMS

REVIEW OF NEDO-24070

SECTION 6: SUPPORTING PROGRAMS

- REFINED SRV ANALYTICAL MODELS
- FSI EFFECTS ON MONTICELLO CONTAINMENT LOADS DATA
- EVALUATION OF FSI EFFECTS ON MARK II CONTAINMENT STRUCTURES DURING SRV DISCHARGE.

MARK II PRESSURE SUPPRESSION CONTAINMENT SYSTEMS

REVIEW OF NEDO-24070

SECTION 7: CONCLUSIONS

1. LOAD PRODUCING PHENOMENA HAVE BEEN IDENTIFIED.
2. ANALYTICAL MODELS HAVE BEEN DEVELOPED.
3. SUPPORTING EXPERIMENTAL DATA HAS BEEN OBTAINED.
4. DFFR MODELS INCLUDE ALL KEY PARAMETERS AND GIVE CONSERVATIVEL REASONABLE LOADS (GIVEN A MULTIPLIER IS USED FOR CONSECUTIVE ACTUATIONS).
5. STRUCTURAL ASSESSMENTS ADDRESS ALL LOADING CONDITIONS.
6. SUPPORTING PROGRAMS IDENTIFIED.

ZIMMER CONTAINMENT

DESIGN ASSESSMENT FOR SRV LOAD

FSI CONSIDERATIONS

- ASSESSMENT PROGRAM COMMENCED IN 1975 AWARE OF POSSIBLE FSI IN SUPPRESSION POOL; ALSO AWARE OF AMPLE RESERVE CAPACITY TO CARRY SRV LOADS

- ASSESSMENT PROGRAM CONSIDERED TWO ALTERNATES:

  1. PERFORM FSI ANALYSIS TO ASSESS FSI EFFECTS ACCURATELY

     OR

  2. NEGLECT FSI TO ASSESS MARGIN FACTORS EXPEDITIOUSLY, IF FSI EFFECTS ARE RELATIVELY SMALL AND CAN BE BOUNDED BY AVAILABLE RESERVE CAPACITY

- ALTERNATE 2 WAS USED IN ZIMMER

CNK
1-19-73

SRV FSI EFFECTS CONSIDERED NEGLIGIBLE BECAUSE:

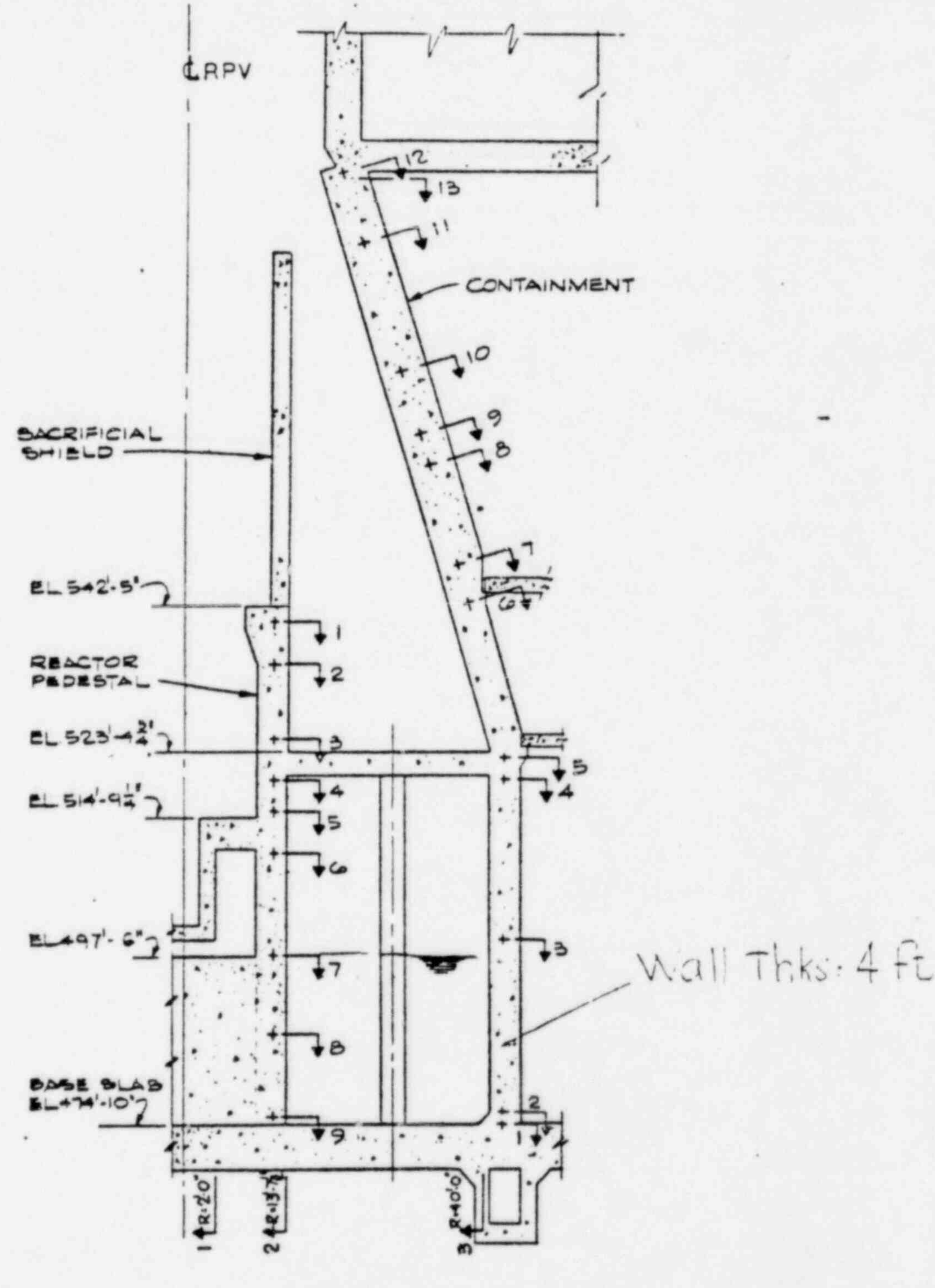
1. THE PRESTRESSED CONCRETE CONTAINMENT IS RELATIVELY RIGID AND SRV LOAD FREQUENCY IS LOW. HENCE FSI EFFECTS ARE ANTICIPATED TO BE SMALL.

2. SRV LOAD COMBINATIONS DO NOT GOVERN CONTAINMENT DESIGN. RESERVE CAPACITY AVAILABLE TO CARRY SRV LOADS IS AMPLE. (SEE DAR TABLES 4.1-1 AND 4.1-3 AND DAR SUPPLEMENT).

3. FORCES INDUCED BY SRV LOADS ARE SMALL COMPARED TO THE TOTAL DESIGN LOADS (SEE DAR SUPPLEMENT). THEREFORE, FORCES DUE TO FSI WOULD BE EVEN SMALLER.

4. CONTAINMENT STRUCTURE MARGIN FACTORS ARE NOT VERY SENSITIVE TO EVEN LARGE VARIATIONS IN SRV LOADS (SEE INTERACTION DIAGRAMS IN DAR SUPPLEMENT).

5. RECENT EXPLORATORY STUDY ON SRV FSI BY BURNS AND ROE CONFIRMS THAT FSI EFFECTS ARE SMALL.



WM. H. ZIMMER NUCLEAR POWER STATION, UNIT 1

MARK II DESIGN ASSESSMENT REPORT

FIGURE 4.1-9

DESIGN SECTIONS - PRIMARY CONTAINMENT, REACTOR SUPPORT AND BASE MAT

TABLE 4.1-1

DESIGN LOAD COMBINATIONS

EQN	LOAD COND	D	L	F	P_O	T_O	R_O	E_O	E_{SS}	P_B	P_A	T_A	R_A	R_R	SRV	ADS	ALL	ASYMMETRICAL
(1)	Normal w/o Temp	1.4	1.7	1.0	1.0	-	-	-	-	-	-	-	-	-	1.5	0	X	X
(2)	Normal w/Temp	1.0	1.3	1.0	1.0	1.0	1.0	-	-	-	-	-	-	-	1.3	0	X	X
(3)	Normal Sev. Env.	1.0	1.0	1.0	1.0	1.0	1.0	1.25	-	-	-	-	-	-	1.25	0	X	X
(4)	Abnormal	1.0	1.0	1.0	-	-	-	-	-	1.25	-	1.0	1.0	-	1.25	X	0	X
4a		1.0	1.0	1.0	-	-	-	-	-	-	1.25	1.0	1.0	-	-	0	0	0
(5)	Abnormal Sev. Env.	1.0	1.0	1.0	-	-	-	1.1	-	1.1	-	1.0	1.0	-	1.1	X	0	X
5a		1.0	1.0	1.0	-	-	-	1.1	-	-	1.1	1.0	1.0	-	-	0	0	0
(6)	Normal Ext. Env.	1.0	1.0	1.0	1.0	1.0	1.0	-	1.0	-	-	-	-	-	1.0	0	X	X
(7)	Abnormal Ext. Env.	1.0	1.0	1.0	-	-	-	-	1.0	1.0	-	1.0	1.0	1.0	1.0	X	0	X
7a		1.0	1.0	1.0	-	-	-	-	1.0	-	1.0	1.0	1.0	1.	-	0	0	0

LOAD DESCRIPTION

D = Dead Loads

L = Live Loads

F = Prestressing Loads

T_O = Operating Temperature Loads

R_O = Operating Pipe Reactions

P_O = Operating Pressure Loads

SRV = Safety/Relief Valve Loads

E_O = Operating Basis Earthquake

E_{SS} = Safe Shutdown Earthquake

P_B = SBA and IBA Pressure Load

T_A = Pipe Break Temperature Load

R_A = Pipe Break Temperature Reactions Load

P_A = DBA Pressure Loads (including all pool hydrodynamic loadings)

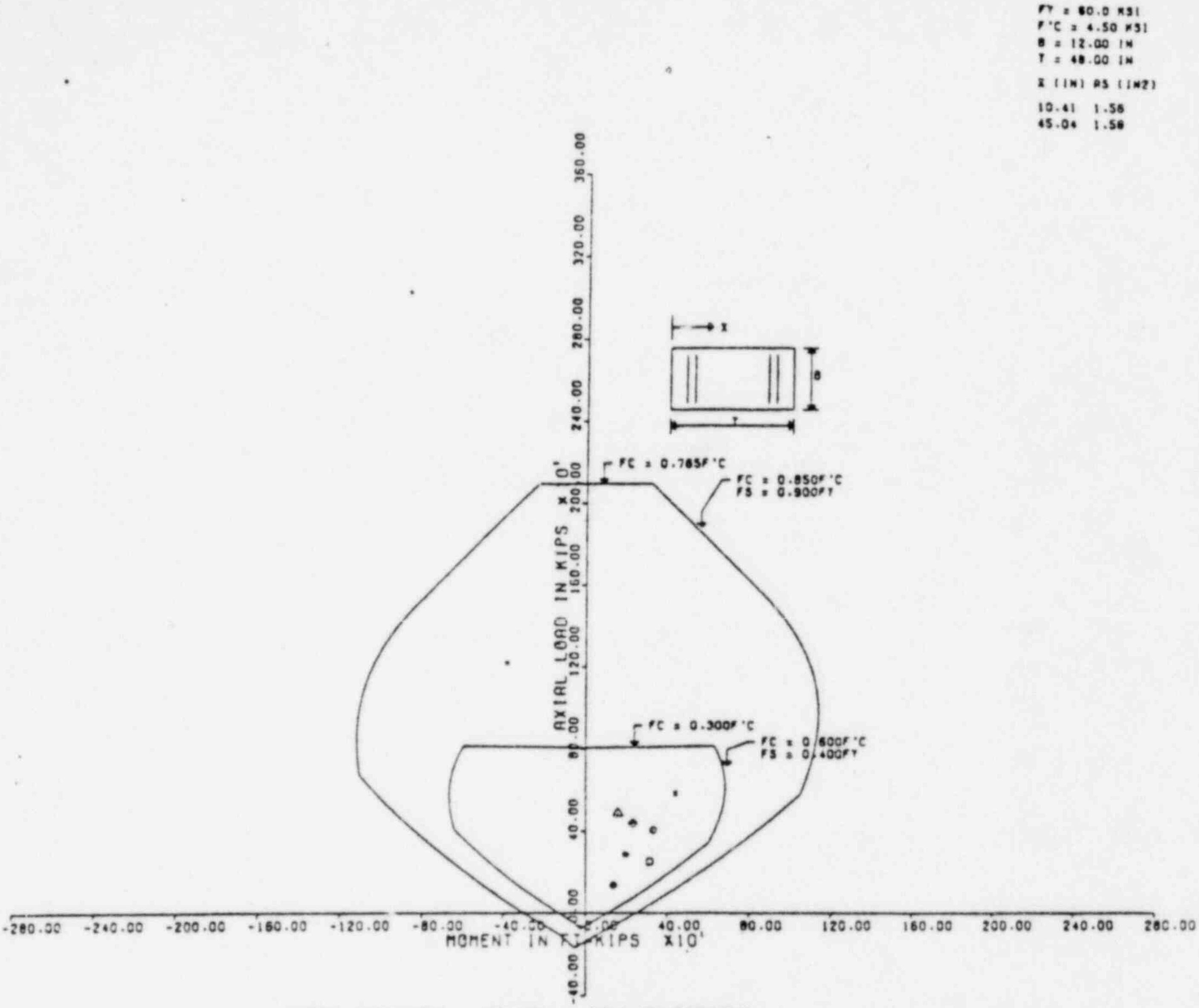
R_R = Reactions and Jet Forces Due to Pipe Break

TABLE 4.1-3

MARGIN TABLE FOR CONTAINMENT ALL VALVE DISCHARGE

LOAD COMBINATION EQUATION* \ STRESS COMPONENT	REINFORCING TENSION		CONCRETE COMPRESSION		SHEAR	
	MARGIN** FACTOR	CRITICAL*** SECTION	MARGIN FACTOR	CRITICAL SECTION	MARGIN FACTOR	CRITICAL SECTION
1	NA	NA	2.8	1	1.8	6
2	8.6	9	2.3	13	1.5	8
3	2.8	11	2.2	1	1.5	8
4	NA	NA	NA	NA	NA	NA
4a	NA	NA	NA	NA	NA	NA
5	NA	NA	NA	NA	NA	NA
5a	NA	NA	NA	NA	NA	NA
6	2.5	11	2.2	1	1.5	8
7	NA	NA	NA	NA	NA	NA
7a	NA	NA	NA	NA	NA	NA

*Refer to Table 4.1-1
**Margin Factor = Allowable Stress/Actual Stress
***Refer to Figure 4.1-9
NA = Not Applicable



ZIMMER CONTAINMENT - SECTION 1 MERID. REINFORCEMENT

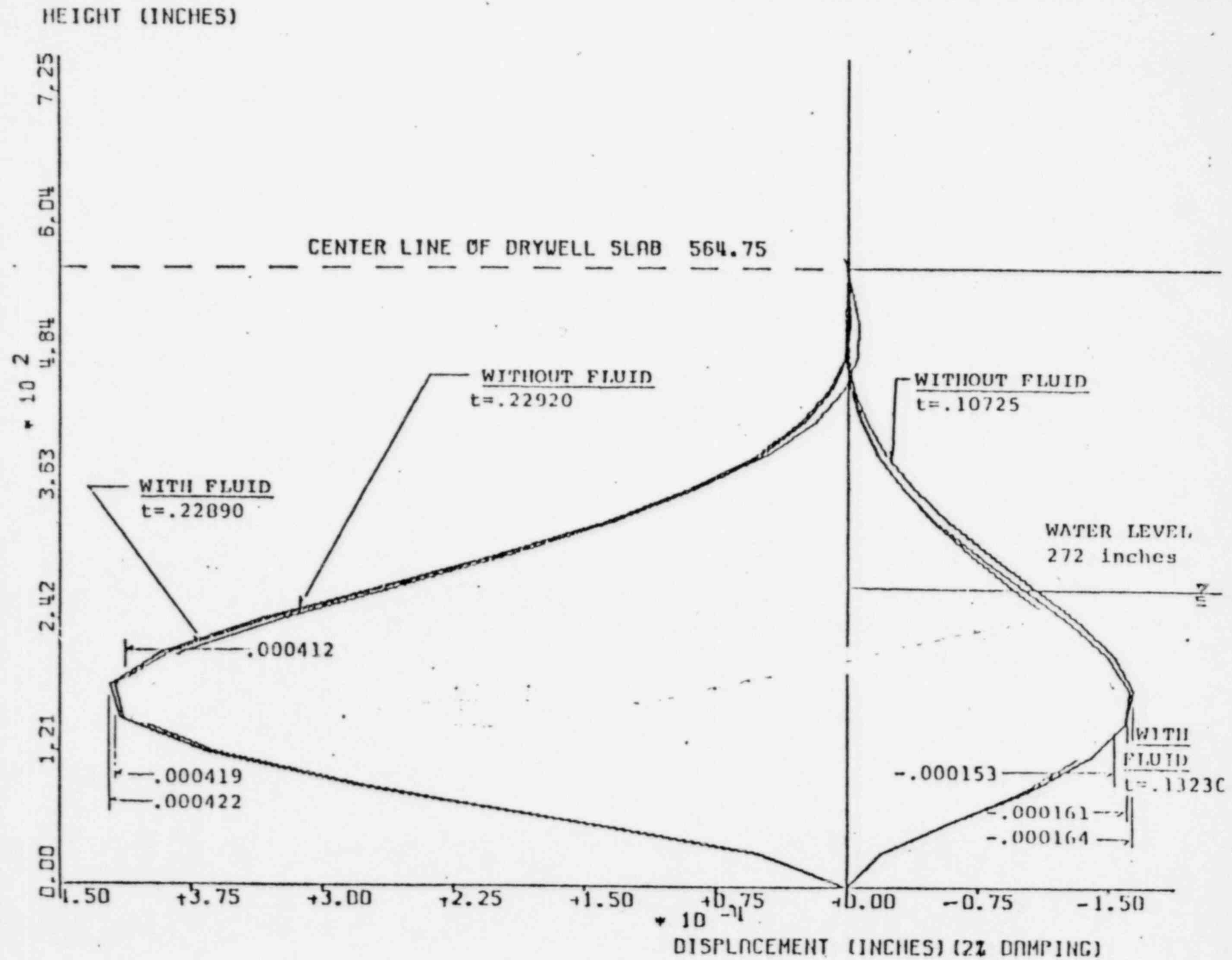
SYMBOL	LOAD COMBINATION
△	1
○	2
×	3
✱	4
⦵	5
□	6
●	7

WM. H. ZIMMER NUCLEAR POWER STATION, UNIT 1

MARK II DESIGN ASSESSMENT REPORT

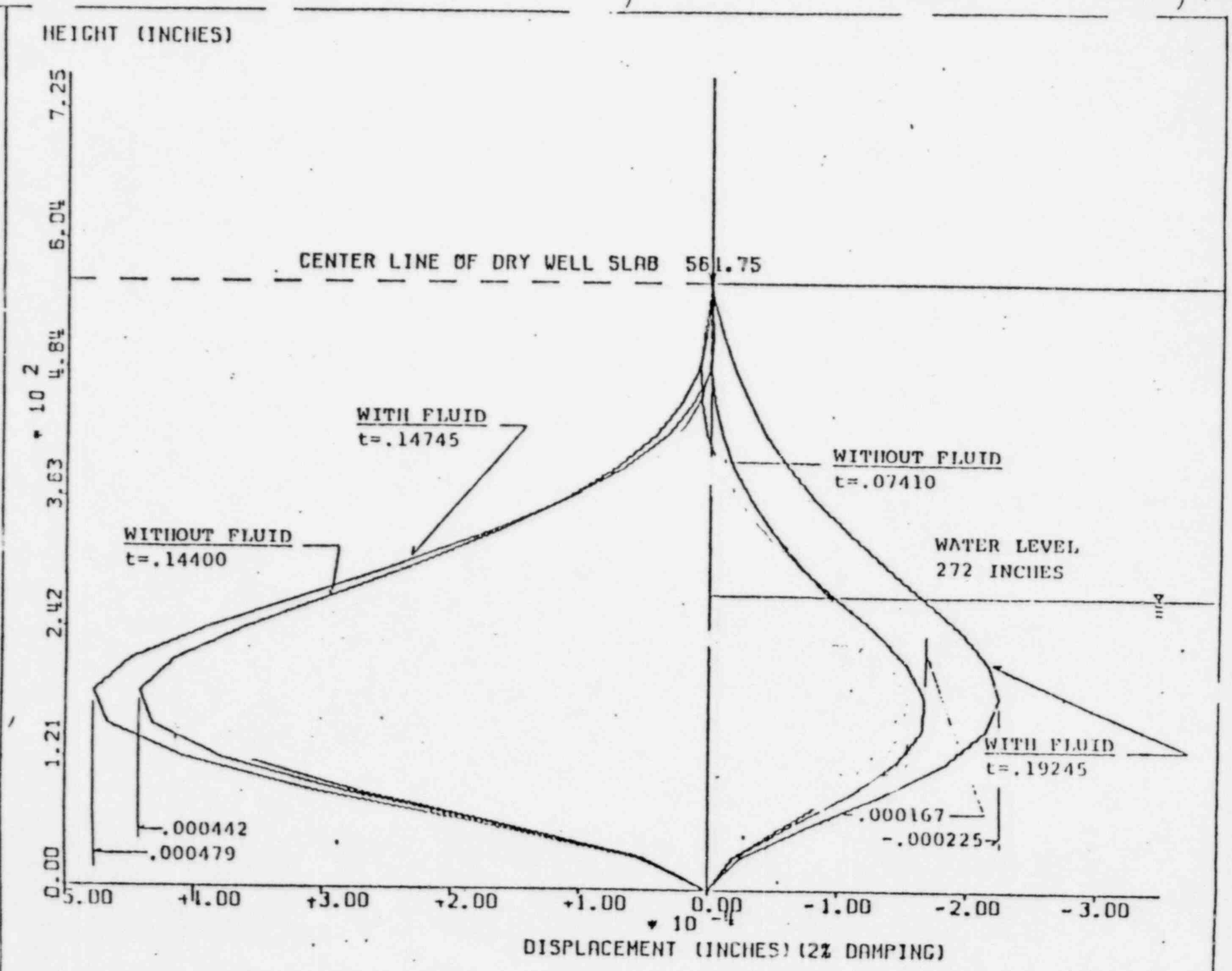
FIGURE 4.1-13

TYPICAL INTERACTION DIAGRAM FOR CONTAINMENT



MAXIMUM RADIAL DISPLACEMENT PROFILE - SRV 5 Hz - ZIMMER

FIGURE 12



MAXIMUM RADIAL DISPLACEMENT PROFILE - SRV 8 Hz - ZIMMER

FIGURE 16

MONTICELLO AND MARK II

FLUID STRUCTURE INTERACTION

- EVALUATION OF FSI DATA FOR S/RV MODEL VERIFICATION (GE)
- ASSESSMENT OF EFFECTS OF FSI IN MARK II CONTAINMENTS (S&L)

EVALUATION OF FSI EFFECTS

- NRC QUESTION

  HOW RESULTS OF FSI STUDIES FROM MONTICELLO CAN BE APPLIED TO MARK II CONCRETE CONTAINMENTS

- RESOLUTION ACTION

  TASK B/0

TASK B/O

- OBJECTIVE

  ASSESS SRV FSI IN MONTICELLO DATA

- METHODOLOGY
  - DEFINE A PRESSURE SOURCE REPRESENTATIVE OF SRV
  - USE A COUPLED HYDRO-STRUCTURE MODEL
  - ANALYZE TWO CASES
    - RIGID
    - AS-BUILT

- METHODOLOGY (CONTD.)
  - CALCULATE INTERFACE PRESSURE AT WALL
  - COMPARE RESULTS OF RIGID AND AS-BUILT CASE
  - CRITERION FOR ASSESSING FSI

    INSIGNIFICANT IF

    $P_{RIGID} \approx P_{FLEXIBLE}$

PRESENT STATUS

- COUPLED HYDRO-STRUCTURE CODE IN PLACE
- DEFINING PRESSURE SOURCE
- MODELING MONTICELLO
- INTERFACE RESPONSE PRESSURE TO BE GENERATED
- REPORT -- 2Q/78

MARK II PRESSURE SUPPRESSION CONTAINMENT SYSTEMS

DYNAMIC LOADS PRODUCED BY SRV DISCHARGE THROUGH A QUENCHER DEVICE

AN OVERVIEW OF LEAD QUENCHER PLANT STATUS

- SEQUENCE OF EVENTS
- STRUCTURAL LOADS CONSIDERED AND IDENTIFICATION OF LOADING METHODOLOGY
- CAORSO TESTS -- STATUS
- SUMMARY OF LEAD QUENCHER PLANT STATUS

MARK II PRESSURE SUPPRESSION CONTAINMENT SYSTEMS

SEQUENCE OF EVENTS

- VALVE OPENING
- WATER LEG CLEARING
- AIR BUBBLE FORMATION
- AIR BUBBLE OSCILLATIONS
- STEAM CONDENSATION
- VALVE CLOSURE

MARK II PRESSURE SUPPRESSION CONTAINMENT SYSTEMS

DYNAMIC LOADS DURING SRV DISCHARGE THROUGH A QUENCHER

STRUCTURE: SRV DISCHARGE PIPING

LOADS:
- PIPE PRESSURE/TEMPERATURE
- FLOW REACTION LOADS (STEADY AND UNSTEADY)

METHODOLOGY:
- FOR UNSTEADY FLOW, USE THE PIPE CLEARING MODEL IN DFFR SECTION 3.1.2.1*
- FOR STEADY FLOW, CLASSICAL ENGINEERING TECHNIQUES

*SAME AS MODEL USED FOR RAMSHEAD.

MARK II PRESSURE SUPPRESSION CONTAINMENT SYSTEMS

DYNAMIC LOADS DURING SRV DISCHARGE THROUGH A QUENCHER

STRUCTURE: QUENCHER

LOADS:
- TORQUE
- LATERAL LOADS
- SUBMERGED STRUCTURE LOADS FROM ADJACENT QUENCHERS

METHODOLOGY:
- DFFR SECTION 3.3.10 FOR TORQUE/LATERAL LOAD
- SUBMERGED STRUCTURES APPLICATIONS MEMORANDUM (TO BE ISSUED FOR QUENCHERS)

MARK II PRESSURE SUPPRESSION CONTAINMENT SYSTEMS

DYNAMIC LOADS DURING SRV DISCHARGE THROUGH A QUENCHER

STRUCTURE: SUBMERGED STRUCTURES

LOADS:
- WATER JET
- STANDARD AND ACCELERATION DRAG DURING AIR BUBBLE OSCILLATION

METHODOLOGY: REPORTS BEING PREPARED

MARK II PRESSURE SUPPRESSION CONTAINMENT SYSTEMS

DYNAMIC LOADS DURING SRV DISCHARGE THROUGH A QUENCHER

STRUCTURE: SUPPRESSION POOL BOUNDARY

LOADS: OSCILLATING PRESSURE CAUSED BY AIR BUBBLES

METHODOLOGY:
- -- DFFR SECTION 3.3
- -- EMPIRICAL CORRELATION FOR POSITIVE PRESSURE
- -- INDEPENDENT OF LINE CLEARING MODEL
- -- 2 Ro/R ATTENUATION
- -- MULTIPLE VALVES ADDES $\sqrt{SS}$
- -- LOAD CASES SAME AS GESSAR
- -- CONSECUTIVE ACTUATION CONSIDERED

NOTE: IMPROVEMENTS IN LOAD DEFINITION MAY BE POSSIBLE AND WORK IS UNDERWAY IN SOME AREAS.

CAORSO SRV DISCHARGE TESTS

STATUS

- FUEL LOADED
- EXPECTED HEAT-UP START-END OF JANUARY 1978
- START FIRST TEST SERIES - MARCH/APRIL 1978

CAORSO SRV DISCHARGE TESTS

TESTS PLANNED

- SINGLE VALVE INITIAL ACTUATION (~ 22 TESTS)

- MULTIPLE VALVE ACTUATION (~ 12 TESTS)

  - 2 ADJACENT VALVES (2 TESTS)
  - 3 ADJACENT VALVES (1 TEST)
  - 4 ADJACENT VALVES (4 TESTS)
  - 4 VALVE SYMMETRIC AROUND POOL (1 TEST)
  - 1 TO 8 VALVES (~ 3 TO 5, NORMAL STARTUP)

- SINGLE VALVE CONSECUTIVE ACTUATIONS (~ 7 TESTS)

  - 5 ACTUATIONS/TEST

MARK II PRESSURE SUPPRESSION CONTAINMENT SYSTEMS

CAORSO QUENCHER TEST PROGRAM

SUMMARY OF POST-TEST ANALYTICAL STUDIES

FOR SINGLE, MULTIPLE AND CONSECUTIVE VALVE ACTUATIONS, EVALUATE DATA ON:

- POOL BOUNDARY LOADS
- BUBBLE PRESSURE
- PIPE CLEARING TRANSIENT (PRESSURE/WATER LEVEL)
- DISCHARGE LINE REFLOOD HEIGHT FOLLOWING VALVE CLOSURE
- SUBMERGED STRUCTURE LOADS (SPOT CHECK)
- CONTAINMENT STRUCTURAL RESPONSE
- QUENCHER LOADS AND RESPONSE

MARK II PRESSURE SUPPRESSION CONTAINMENT SYSTEMS

APPLICATION OF THE QUENCHER

SUMMARY OF LEAD QUENCHER PLANT STATUS

- ALL QUENCHER RELATED DYNAMIC LOADS HAVE BEEN IDENTIFIED AND CONSIDERED
- CONSERVATIVE METHODOLOGY IN PLACE
- WORK UNDERWAY TO IMPROVE QUENCHER METHODS
- CAORSO TESTS WILL PROVIDE CONFIRMATORY DATA

QUENCHER SUBMERGED STRUCTURES

- METHODOLOGY SIMILAR TO RAMSHEAD
- REPORTS TO BE SUBMITTED 2Q78
  - AIR BUBBLE MODEL
  - WATER JET MODEL
  - APPLICATION MEMORANDUM UPDATE

2

ZIMMER CONTAINMENT

DESIGN ASSESSMENT FOR SRV LOAD

FSI CONSIDERATIONS

- ASSESSMENT PROGRAM COMMENCED IN 1975 AWARE OF POSSIBLE FSI IN SUPPRESSION POOL; ALSO AWARE OF AMPLE RESERVE CAPACITY TO CARRY SRV LOADS

- ASSESSMENT PROGRAM CONSIDERED TWO ALTERNATES:

    1. PERFORM FSI ANALYSIS TO ASSESS FSI EFFECTS ACCURATELY

    OR

    2. NEGLECT FSI TO ASSESS MARGIN FACTORS EXPEDITIOUSLY, IF FSI EFFECTS ARE RELATIVELY SMALL AND CAN BE BOUNDED BY AVAILABLE RESERVE CAPACITY

- ALTERNATE 2 WAS USED IN ZIMMER.

CNK
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SRV FSI EFFECTS CONSIDERED NEGLIGIBLE BECAUSE:

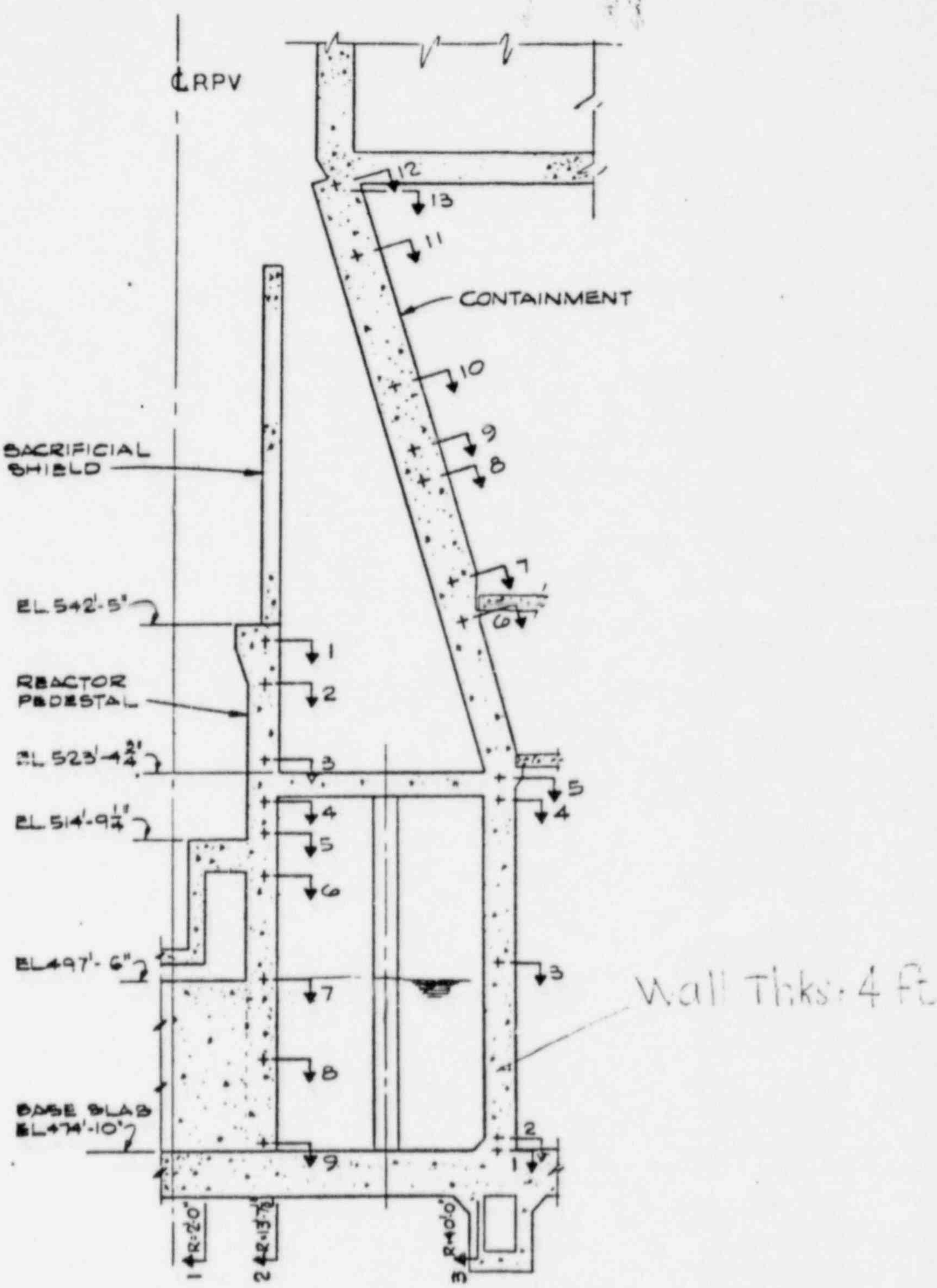
1. THE PRESTRESSED CONCRETE CONTAINMENT IS RELATIVELY RIGID AND SRV LOAD FREQUENCY IS LOW. HENCE FSI EFFECTS ARE ANTICIPATED TO BE SMALL.

2. SRV LOAD COMBINATIONS DO NOT GOVERN CONTAINMENT DESIGN. RESERVE CAPACITY AVAILABLE TO CARRY SRV LOADS IS AMPLE. (SEE DAR TABLES 4.1-1 AND 4.1-3 AND DAR SUPPLEMENT).

3. FORCES INDUCED BY SRV LOADS ARE SMALL COMPARED TO THE TOTAL DESIGN LOADS (SEE DAR SUPPLEMENT). THEREFORE, FORCES DUE TO FSI WOULD BE EVEN SMALLER.

4. CONTAINMENT STRUCTURE MARGIN FACTORS ARE NOT VERY SENSITIVE TO EVEN LARGE VARIATIONS IN SRV LOADS (SEE INTERACTION DIAGRAMS IN DAR SUPPLEMENT).

5. RECENT EXPLORATORY STUDY ON SRV FSI BY BURNS AND ROE CONFIRMS THAT FSI EFFECTS ARE SMALL.



WM. H. ZIMMER NUCLEAR POWER STATION, UNIT 1

MARK II DESIGN ASSESSMENT REPORT

FIGURE 4.1-9

DESIGN SECTIONS - PRIMARY CONTAINMENT, REACTOR SUPPORT AND BASE MAT

TABLE 4.1-1

DESIGN LOAD COMBINATIONS

EQN	LOAD COND	D	L	F	P_O	T_O	R_O	E_O	E_{SS}	P_B	P_A	T_A	R_A	R_R	SRV	ADS	ALL	ASYMMETRICAL
(1)	Normal w/o Temp	1.4	1.7	1.0	1.0	-	-	-	-	-	-	-	-	-	1.5	0	X	X
(2)	Normal w/Temp	1.0	1.3	1.0	1.0	1.0	1.0	-	-	-	-	-	-	-	1.3	0	X	X
(3)	Normal Sev. Env.	1.0	1.0	1.0	1.0	1.0	1.0	1.25	-	-	-	-	-	-	1.25	0	X	X
(4)	Abnormal	1.0	1.0	1.0	-	-	-	-	-	1.25	-	1.0	1.0	-	1.25	X	0	X
4a		1.0	1.0	1.0	-	-	-	-	-	-	1.25	1.0	1.0	-	-	0	0	0
(5)	Abnormal Sev. Env.	1.0	1.0	1.0	-	-	-	1.1	-	1.1	-	1.0	1.0	-	1.1	X	0	X
5a		1.0	1.0	1.0	-	-	-	1.1	-	-	1.1	1.0	1.0	-	-	0	0	0
(6)	Normal Ext. Env.	1.0	1.0	1.0	1.0	1.0	1.0	-	1.0	-	-	-	-	-	1.0	0	X	X
(7)	Abnormal Ext. Env.	1.0	1.0	1.0	-	-	-	-	1.0	1.0	-	1.0	1.0	1.0	1.0	X	0	X
7a		1.0	1.0	1.0	-	-	-	-	1.0	-	1.0	1.0	1.0	1.	-	0	0	0

LOAD DESCRIPTION

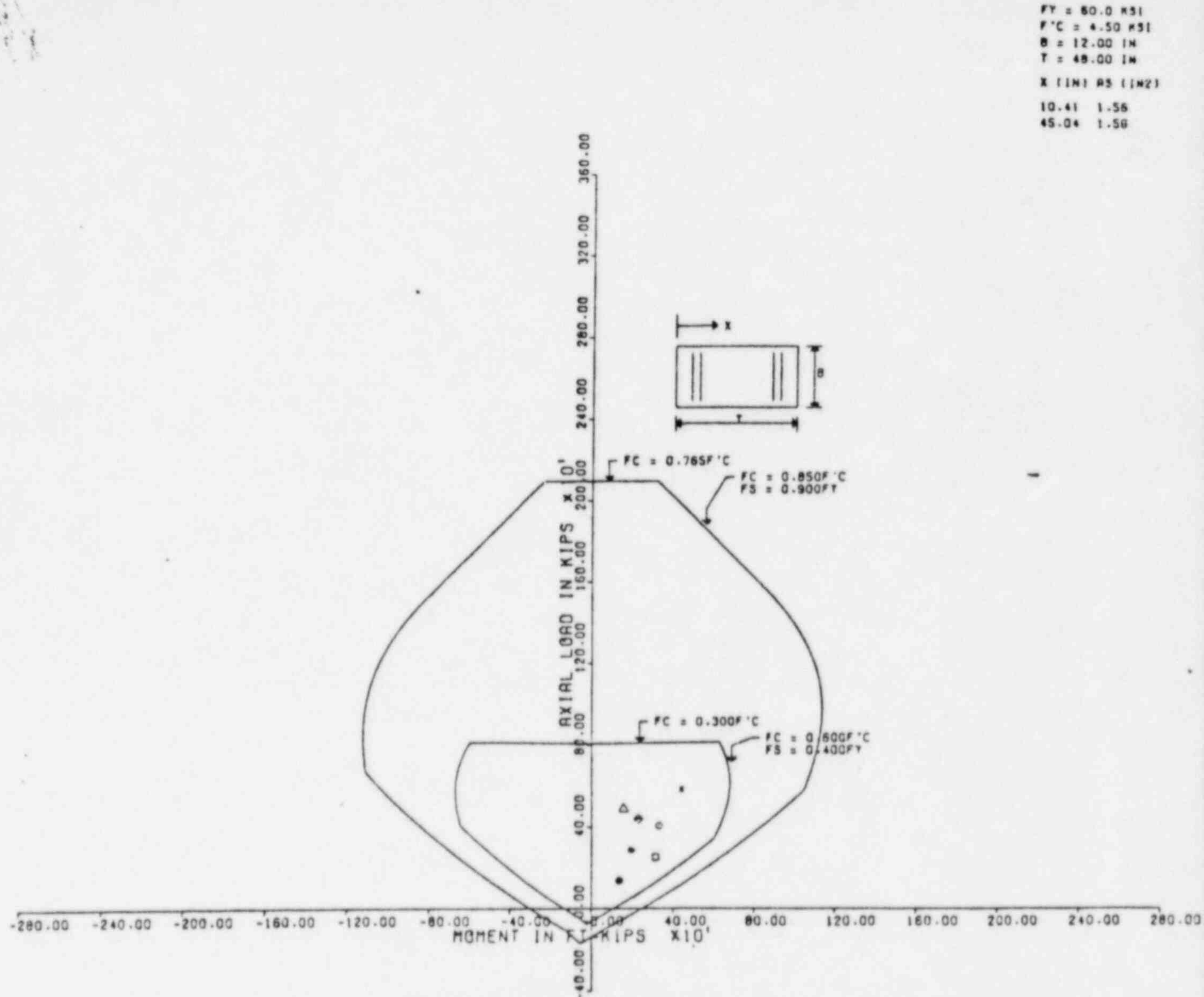
- D = Dead Loads
- L = Live Loads
- F = Prestressing Loads
- T_O = Operating Temperature Loads
- R_O = Operating Pipe Reactions
- P_O = Operating Pressure Loads
- SRV = Safety/Relief Valve Loads
- E_O = Operating Basis Earthquake
- E_{SS} = Safe Shutdown Earthquake
- P_B = SBA and IBA Pressure Load
- T_A = Pipe Break Temperature Load
- R_A = Pipe Break Temperature Reactions Load
- P_A = DBA Pressure Loads (including all pool hydrodynamic loadings)
- R_R = Reactions and Jet Forces Due to Pipe Break

TABLE 4.1-3

MARGIN TABLE FOR CONTAINMENT ALL VALVE DISCHARGE

LOAD COMBINATION EQUATION* \ STRESS COMPONENT	REINFORCING TENSION		CONCRETE COMPRESSION		SHEAR	
	MARGIN** FACTOR	CRITICAL*** SECTION	MARGIN FACTOR	CRITICAL SECTION	MARGIN FACTOR	CRITICAL SECTION
1	NA	NA	2.8	1	1.8	6
2	8.6	9	2.3	13	1.5	8
3	2.8	11	2.2	1	1.5	8
4	NA	NA	NA	NA	NA	NA
4a	NA	NA	NA	NA	NA	NA
5	NA	NA	NA	NA	NA	NA
5a	NA	NA	NA	NA	NA	NA
6	2.5	11	2.2	1	1.5	8
7	NA	NA	NA	NA	NA	NA
7a	NA	NA	NA	NA	NA	NA

*Refer to Table 4.1-1
**Margin Factor = Allowable Stress/Actual Stress
***Refer to Figure 4.1-9
NA = Not Applicable



ZIMMER CONTAINMENT - SECTION 1 MERID. REINFORCEMENT

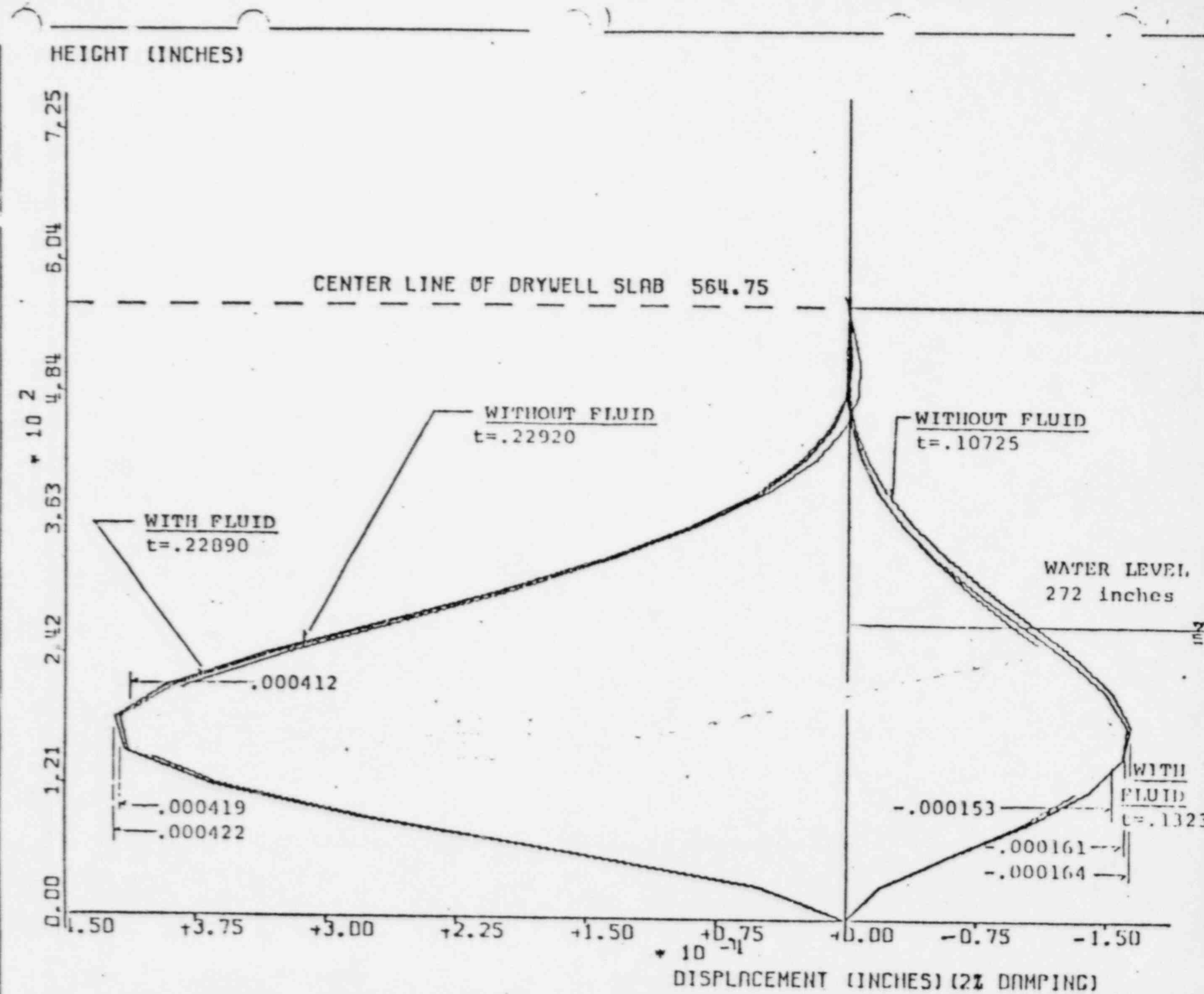
SYMBOL	LOAD COMBINATION
△	1
○	2
×	3
✱	4
⊖	5
□	6
●	7

WM. H. ZIMMER NUCLEAR POWER STATION, UNIT 1

MARK II DESIGN ASSESSMENT REPORT

FIGURE 4.1-13

TYPICAL INTERACTION DIAGRAM FOR CONTAINMENT



MAXIMUM RADIAL DISPLACEMENT PROFILE - S / 5 Hz - ZIMMER

FIGURE 12

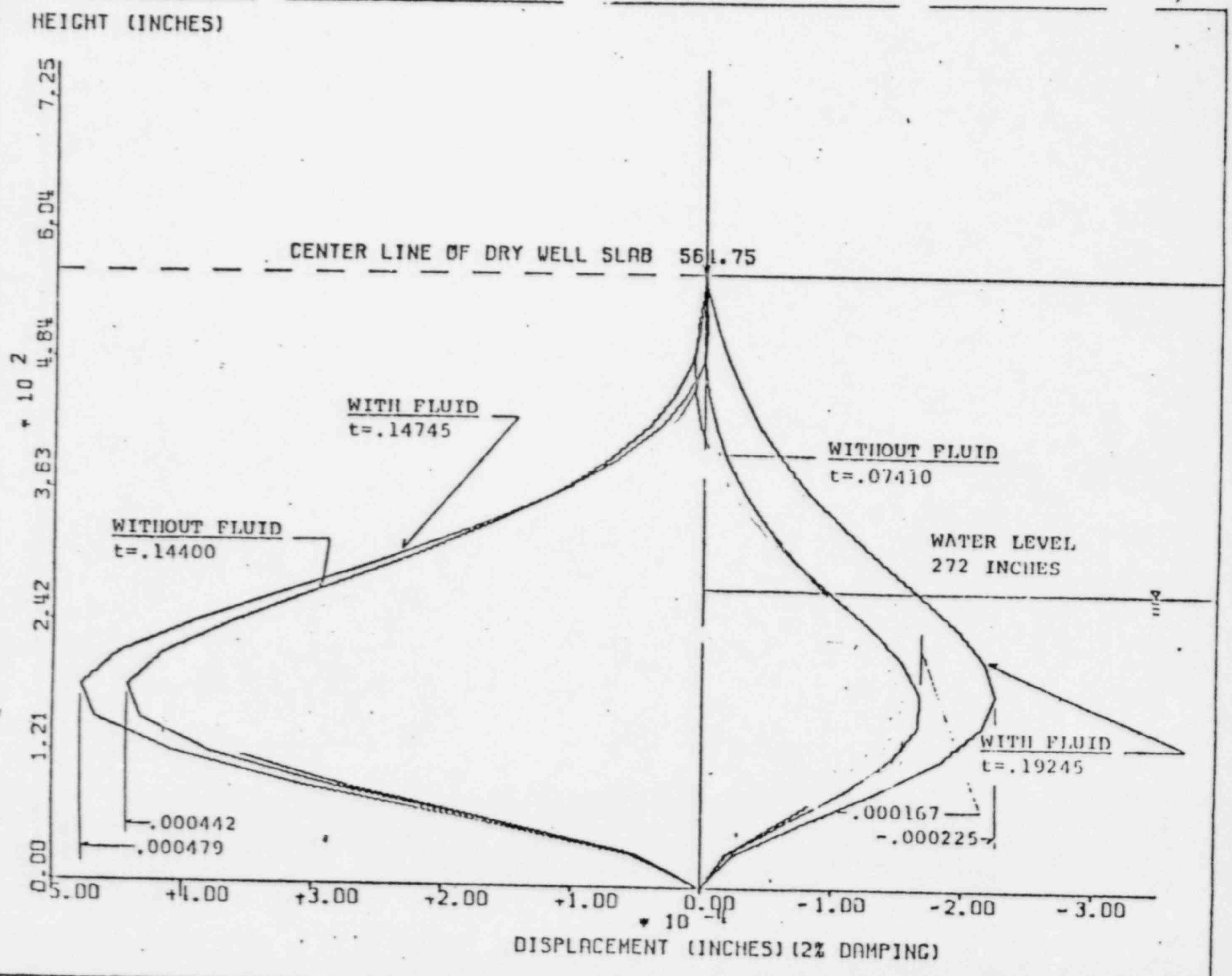


FIGURE 16 MAXIMUM RADIAL DISPLACEMENT PROFILE - SRV 8 Hz - ZIMMER

MONTICELLO AND MARK II

FLUID STRUCTURE INTERACTION

- EVALUATION OF FSI DATA FOR S/RV MODEL VERIFICATION (GE)
- ASSESSMENT OF EFFECTS OF FSI IN MARK II CONTAINMENTS (S&L)

EVALUATION OF FSI EFFECTS

- NRC QUESTION

  HOW RESULTS OF FSI STUDIES FROM MONTICELLO CAN BE APPLIED TO MARK II CONCRETE CONTAINMENTS

- RESOLUTION ACTION

  TASK B/0

TASK B/O

- OBJECTIVE

  ASSESS SRV FSI IN MONTICELLO DATA

- METHODOLOGY

  - DEFINE A PRESSURE SOURCE REPRESENTATIVE OF SRV
  - USE A COUPLED HYDRO-STRUCTURE MODEL
  - ANALYZE TWO CASES
    - RIGID
    - AS-BUILT

- METHODOLOGY (CONTD.)
  - CALCULATE INTERFACE PRESSURE AT WALL
  - COMPARE RESULTS OF RIGID AND AS-BUILT CASE
  - CRITERION FOR ASSESSING FSI

    INSIGNIFICANT IF

    $P_{RIGID} \approx P_{FLEXIBLE}$

PRESENT STATUS

- COUPLED HYDRO-STRUCTURE CODE IN PLACE
- DEFINING PRESSURE SOURCE
- MODELING MONTICELLO
- INTERFACE RESPONSE PRESSURE TO BE GENERATED
- REPORT -- 2Q/78

5

HANDBOOK OF Engineering Mechanics

Engineering

Mathematics
Mechanics of Rigid Bodies
Theory of Structures
Elasticity
Plasticity and Viscoelasticity
Vibrations
Fluid Mechanics

W. FLÜGGE EDITOR-IN-CHIEF

tion for the displacement being

$$x = \frac{2F_0}{k}\left(\frac{t}{t_1} - \frac{\tau}{2\pi t_1}\sin 2\pi\frac{t}{\tau}\right) \qquad 0 < t < \tfrac{1}{2}t_1 \tag{56.96a}$$

In the second region $\frac{1}{2}t_1 < t < t_1$, the response is due to the excitation $2F_0t/t_1$ started at $t = 0$, and a second excitation $-(4F_0/t_1)(t - \frac{1}{2}t_1)$ started at $t = \frac{1}{2}t_1$. Thus, by superimposing the above solution, we arrive at the equation

$$x = \frac{2F_0}{k}\left\{1 - \frac{t}{t_1} + \frac{\tau}{2\pi t_1}\left[2\sin\frac{2\pi}{\tau}(t - \tfrac{1}{2}t_1) - \sin 2\pi\frac{t}{\tau}\right]\right\} \qquad \tfrac{1}{2}t_1 < t < t_1 \tag{56.96b}$$

In the third region $t > t_1$, we add to Eq. (56.96b) the response due to the excitation $(2F_0/t_1)(t - t_1)$ started at $t = t_1$, the result being

$$x = \frac{2F_0}{k}\left\{\frac{\tau}{2\pi t_1}\left[2\sin\frac{2\pi}{\tau}(t - \tfrac{1}{2}t_1) - \sin\frac{2\pi}{\tau}(t - t_1) - \sin\frac{2\pi}{\tau}t\right]\right\} \qquad t > t_1 \tag{56.96c}$$

In all these equations, the variable t/τ can be written as $\frac{t_1}{\tau}\frac{t}{t_1}$, so that t_1/τ becomes the parameter governing the response. The dynamic response factor $n = kx_{max}/F_0$ is

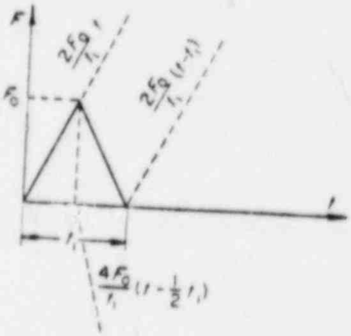


FIG. 56.28. Triangular pulse as superposition of three lines.

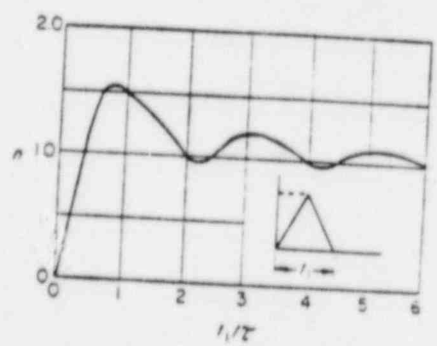


FIG. 56.29. Dynamic response factor for triangular pulse.

very similar to that for the sinusoidal pulse. As t_1/τ is increased from zero, the first peak response increases, and the peak time approaches t_1 as t_1/τ approaches $\frac{1}{2}$. This is evident from differentiating Eq. (56.96c) and equating to zero, which results in the peak-time equation

$$2\cos\frac{2\pi t_1}{\tau}\left(\frac{t_p}{t_1} - 0.5\right) - \cos 2\pi\frac{t_1}{\tau}\left(\frac{t_p}{t_1} - 1\right) - \cos\frac{2\pi t_1}{\tau}\frac{t_p}{t_1} = 0 \tag{56.97a}$$

If we let $t_p/t_1 = 1.0$, the parameter t_1/τ becomes $\frac{1}{2}$, indicating that the first peak response occurs in the region $t_p > t_1$ for $t_1/\tau < \frac{1}{2}$.

To find the value of t_1/τ corresponding to a peak response occurring at $t_p = \frac{1}{2}t_1$, we can differentiate Eq. (56.96a) and obtain the equation

$$1 - \cos 2\pi\frac{t_1}{\tau}\frac{t_p}{t_1} = 0 \tag{56.97b}$$

If t_p/t_1 is set equal to $\frac{1}{2}$, the parameter $t_1/\tau = 2$. Thus, for the range of values $\frac{1}{2} < t_1/\tau < 2$, the peak response occurs in the region $\frac{1}{2}t_1 < t < t_1$, and Eq. (56.96b) must be used.

Introducing the initial conditions $x = \dot{x} = 0$ and replacing ω_n by $2\pi/\tau$, the solution to the continuous sine-wave excitation started at $t = 0$ becomes

$$x = \frac{F_0}{k(\tau/2t_1 - 2t_1/\tau)}\left(\sin\frac{2\pi t}{\tau} - \frac{2t_1}{\tau}\sin\frac{\pi t}{t_1}\right) \qquad t < t_1 \qquad (56.94a)$$

The solution for $t > t_1$ can be obtained by adding to Eq. (56.94a) the same solution, with the time t replaced by $(t - t_1)$

$$x = \frac{F_0}{k(\tau/2t_1 - 2t_1/\tau)}\left[\left(\sin 2\pi\frac{t}{\tau} - \frac{2t_1}{\tau}\sin\frac{\pi t}{t_1}\right) + \left(\sin 2\pi\frac{t - t_1}{\tau} - \frac{2t_1}{\tau}\sin\frac{\pi}{t_1}(t - t_1)\right)\right] \qquad t > t_1 \qquad (56.94b)$$

In determining the peak response, it is necessary to assign a numerical value to the parameter t_1/τ and note whether the peak occurs in the region $t > t_1$ or $t < t_1$. It is evident that for small values of t_1/τ, the peak response occurs in the region $t > t_1$ and Eq. (56.94b) must be used. The dynamic response factor $n = kx_{max}/F_0$ will, in this case, increase with t_1/τ, as shown in the first part of Fig. 56.27.

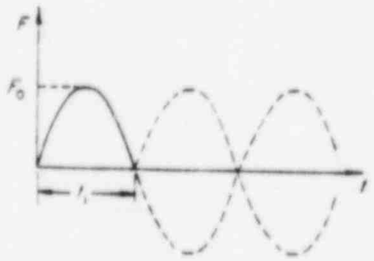


FIG. 56.26. Sinusoidal pulse as superposition of shifted sine waves.

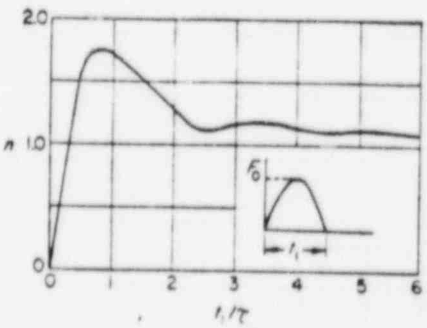


FIG. 56.27. Dynamic response factor for sinusoidal pulse.

As t_1/τ continues to increase, the peak response will occur in the region $t < t_1$, and Eq. (56.94a) must be used. Differentiating it and equating to zero, the time t_p corresponding to the peak response is given by solving the equation

$$\cos\frac{2\pi t_p}{\tau} = \cos\frac{\pi t_p}{t_1} \qquad (56.95)$$

It is evident from this equation that the value of t_1/τ which produces a peak response at $t_p = t_1$ is $t_1/\tau = \frac{1}{2}$. Thus, for all $t_1/\tau > \frac{1}{2}$, the peak response will occur in the interval $t_p < t_1$, where Eq. (56.94a) must be used. As an example, when $t_1/\tau = 2.0$, $\pi t_p/t_1 = 72°$, and its substitution into Eq. (56.94a) results in $n = 1.27$.

Triangular Pulse

The triangular pulse of Fig. 56.28 is another approximation often used for simulating impact loading. For the derivation of the equation for response, the triangular pulse can be considered to be the superposition of three straight lines shown dotted in Fig. 56.28.

In the region $0 < t < \frac{1}{2}t_1$, the response is due to the excitation $2F_0t/t_1$, the equa-

MARK II PRESSURE SUPPRESSION CONTAINMENT SYSTEMS

LOADS ON SUBMERGED STRUCTURES DUE TO SRV DISCHARGE THROUGH A RAMSHEAD DEVICE

- DISCUSSION OF SUBMERGED STRUCTURE TECHNOLOGY
- OVERVIEW OF RAMSHEAD SUBMERGED STRUCTURE PROGRAM
- DOCUMENTATION
- SUMMARY OF RAMSHEAD ASSUMPTIONS AND APPLICATION TECHNIQUES
- CONCLUSIONS

MARK II PRESSURE SUPPRESSION CONTAINMENT SYSTEMS

SUBMERGED STRUCTURE LOADS

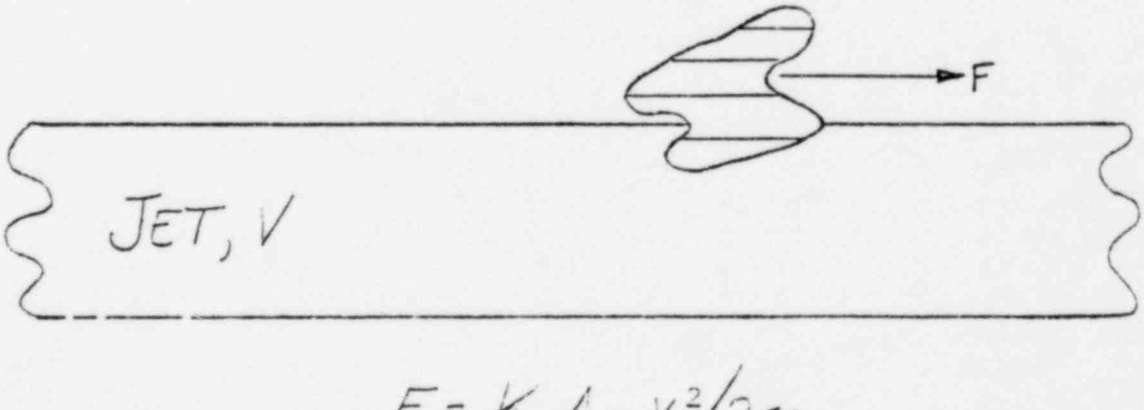
WATER JET LOADS

- SOURCE OF JETS
  - MAIN VENTS DURING LOCA
  - RAMSHEAD OR QUENCHER DURING SRV ACTUATION
- LOADING MECHANISMS
  - WATER DRAG/IMPINGEMENT
- BASIC APPROACH
  - PROVIDE JET DEFINITION AND CALCULATE LOADS FROM KNOWN DRAG COEFFICIENTS OR IMPINGEMENT CALCULATIONS

MARK II PRESSURE SUPPRESSION CONTAINMENT SYSTEMS

WATER JET LOADS

$$F = C_D \cdot V^2/2g$$



$$F = K \cdot A_1 \cdot V^2/2g$$

MARK II PRESSURE SUPPRESSION CONTAINMENT SYSTEMS

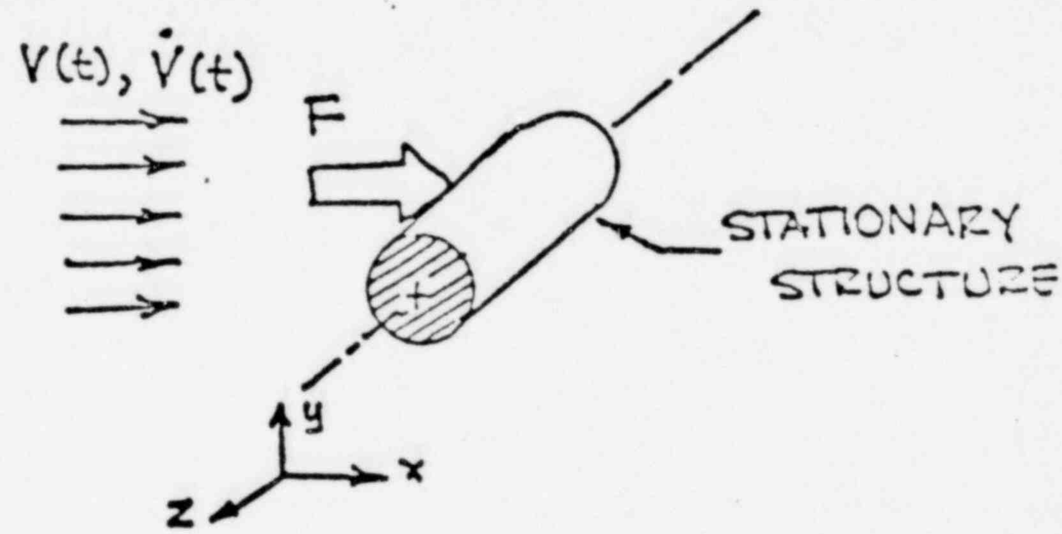
SUBMERGED STRUCTURE LOADS

'BUBBLE' TYPE LOADS

- SOURCE OF BUBBLE
  - MAIN VENTS DURING POOL SWELL
  - RAMSHEAD OR QUENCHER FOLLOWING AIR CLEARING
  - MAIN VENTS DURING CONDENSATION OSCILLATIONS AND CHUGGING

- LOADING MECHANISM
  - STANDARD DRAG ($\propto V^2$) PRODUCED BY VELOCITY FIELDS
  - ACCELERATION DRAG ($\propto \dot{V}$) PRODUCED BY PRESSURE FIELDS

- BASIC APPROACH
  - PROVIDE DEFINITION OF VELOCITY AND ACCELERATION FIELDS AND CALCULATE DRAG FROM KNOWN DRAG COEFFICIENTS AND ACCELERATION DRAG VOLUMES.



FLOW FIELD INDUCED LOADS

$$F = F_s + F_A$$

STANDARD DRAG

$$F_s = C_D A \rho \frac{V(t)^2}{2g_c} \sim V(t)^2$$

ACCELERATION DRAG

$$F_A = \mathbb{V}_A \rho \frac{\dot{V}(t)}{g_c} \sim \dot{V}(t)$$

SUBMERGED STRUCTURES LOADS

- REPORT TITLE - NED #21472-P

  ANALYTICAL MODEL FOR LIQUID JET PROPERTIES FOR PREDICTING FORCES ON SUBMERGED STRUCTURES

- REPORT TITLE - NED #21471-P

  ANALYTICAL MODEL FOR ESTIMATING DRAG FORCES ON RIGID SUBMERGED STRUCTURES CAUSED BY LOCA AND SAFETY RELIEF RAMSHEAD AIR DISCHARGE

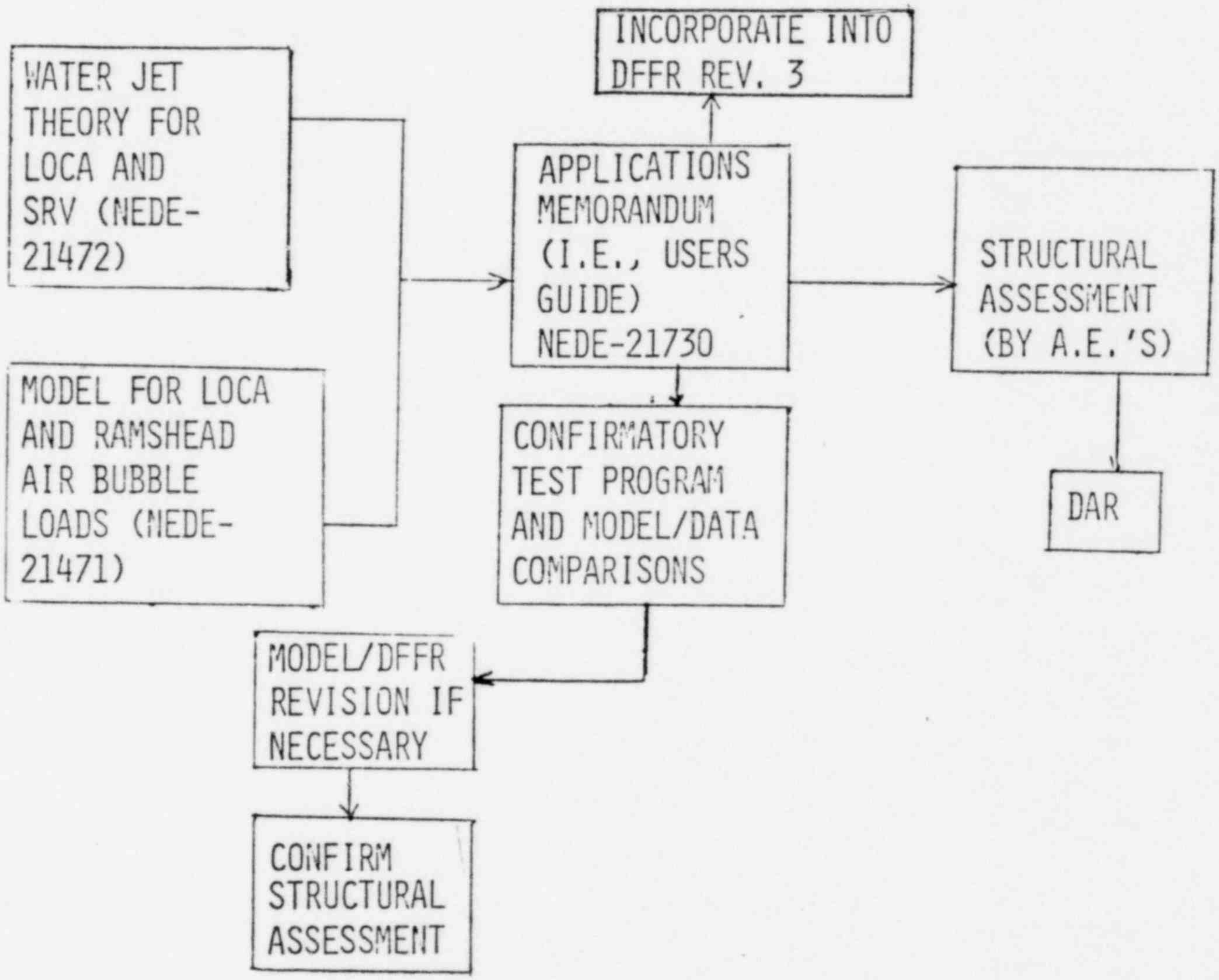
APPLICATION METHOD

- REPORT TITLE - NED #21730

  MARK II PRESSURE SUPPRESSION CONTAINMENT SYSTEMS LOADS ON SUBMERGED STRUCTURES - AN APPLICATION MEMORANDUM

MARK II PRESSURE SUPPRESSION CONTAINMENT SYSTEMS

RAMSHEAD SUBMERGED STRUCTURES PROGRAM



MARK II PRESSURE SUPPRESSION CONTAINMENT SYSTEMS

RAMSHEAD WATER JET LOAD

MAJOR ASSUMPTIONS

- UNSTEADY SUBMERGED JET WITH NO DIVERGENCE OTHER THAN PREDICTED BY MASS/MOMENTUM EQUATIONS. CONSTANT FLUID PARTICLE VELOCITY
- VELOCITY AND ACCELERATION FROM THE DFFR PIPE CLEARING MODEL
- FORCE IS DRAG OR IMPINGEMENT DEPENDING ON GEOMETRY
- DISSIPATION OCCURS WHEN LAST PARTICLE REACHES JET FRONT

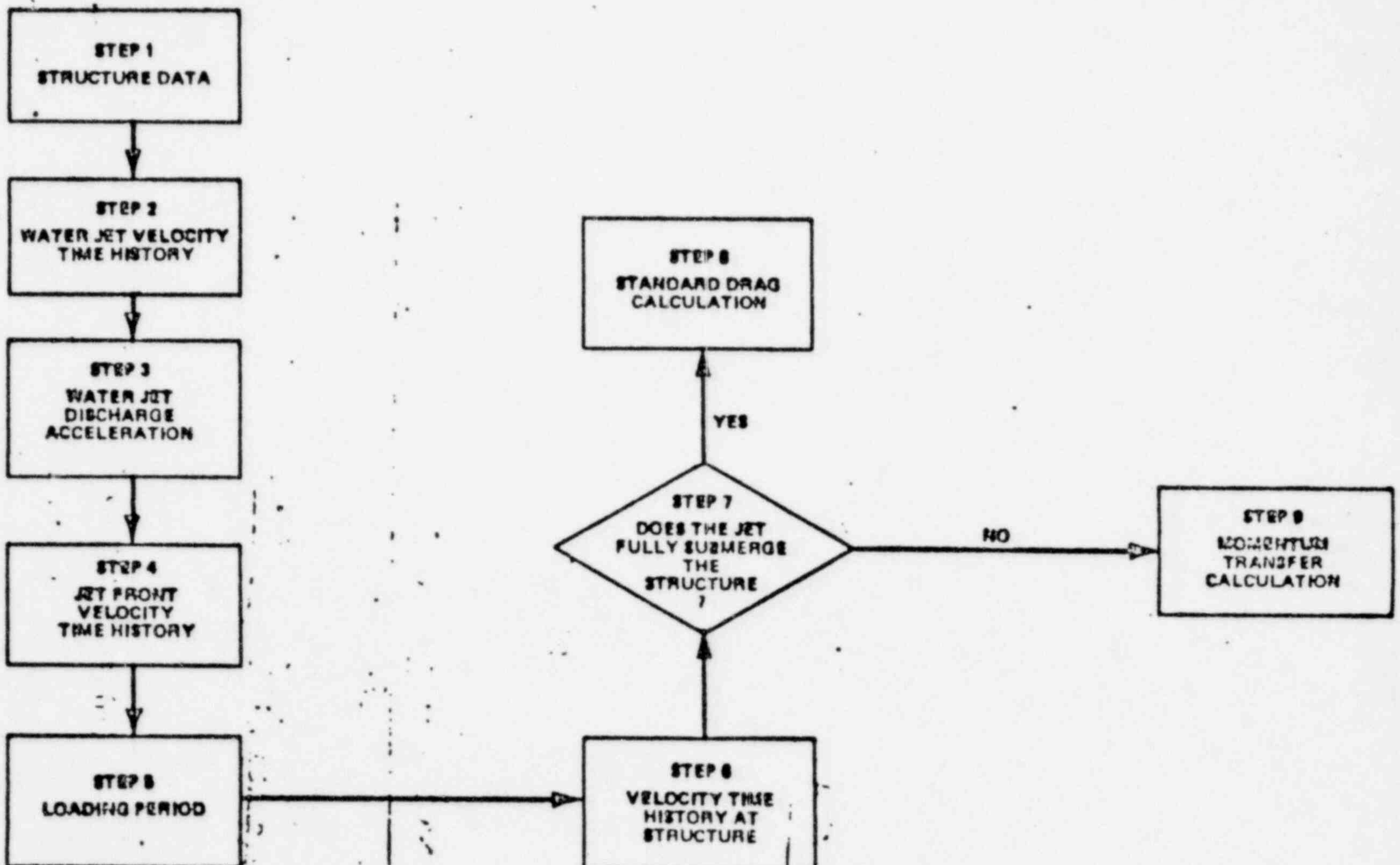


Figure 2-1. Jet Loads Procedure

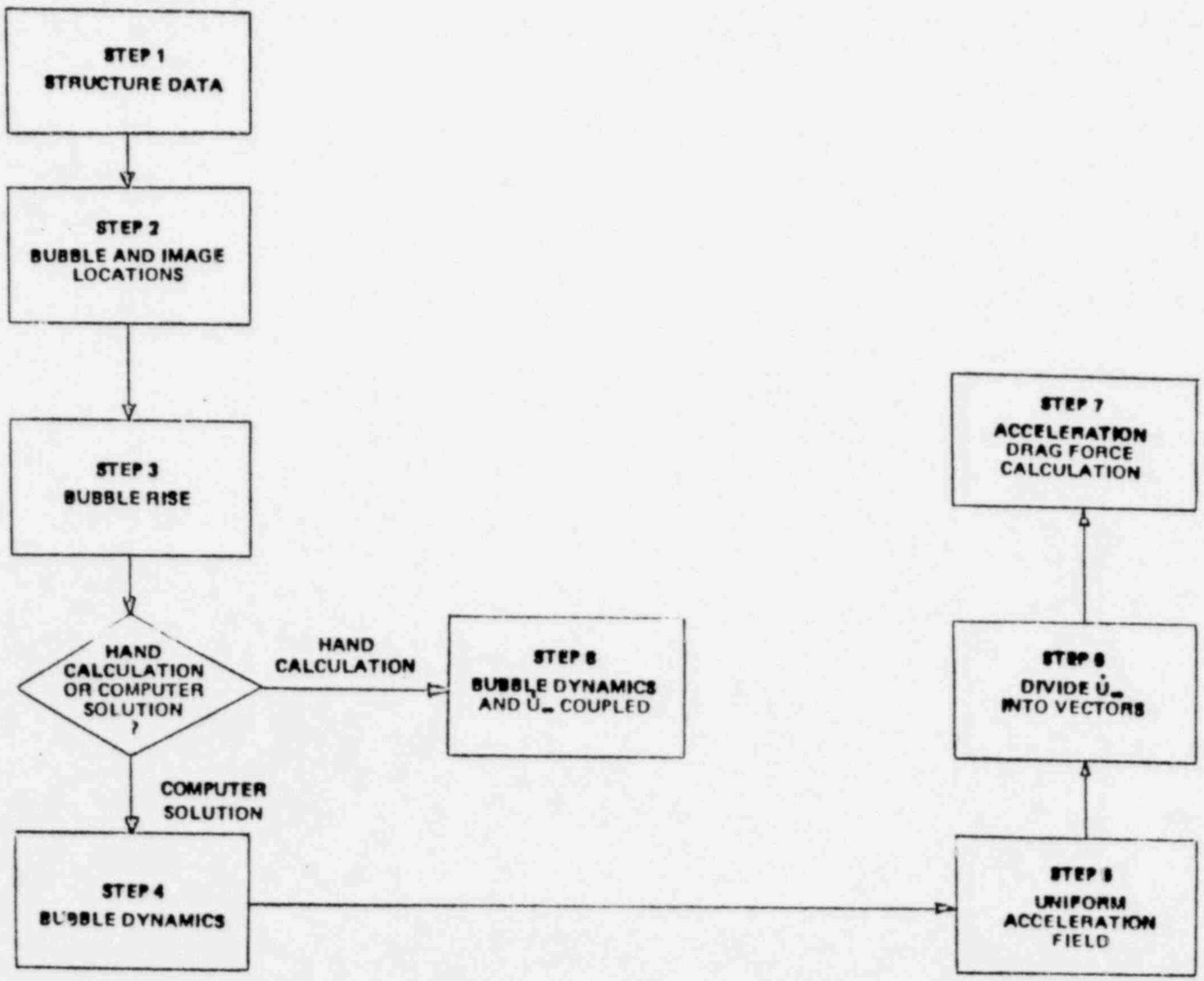
MARK II PRESSURE SUPPRESSION CONTAINMENT SYSTEMS

RAMSHEAD AIR BUBBLE LOADS ON SUBMERGED STRUCTURES

MAJOR ASSUMPTIONS

- SPHERICAL BUBBLE FLOW FIELD DESCRIBED BY A POINT SOURCE. FINITE BUBBLE EFFECTS CONSIDERED.
- UNIFORM FLOW FIELD
- BOUNDARIES ACCOUNTED FOR WITH METHOD OF IMAGES
- AIR IS IDEAL GAS
- ACOUSTIC EFFECTS NEGLIGIBLE
- BUBBLE RISE CONSIDERED
- TWO BUBBLES IN PHASE

RAMSHEAD AIR BUBBLE APPLICATION
(NEDE-21730)



MARK II PRESSURE SUPPRESSION CONTAINMENT SYSTEMS

RAMSHEAD SUBMERGED STRUCTURE LOADS

CONCLUSIONS

- LOADS CONSERVATIVELY DEFINED AND DOCUMENTED

- CONFIRMATORY PROGRAM IN PLACE

- DESIGN ASSESSMENT STUDIES UNDER WAY

RAMSHEAD CONDENSATION INSTABILITY

- REVIEW OF LIMITS BEING USED
- REVIEW OF DATA BASE

    G.E. MOSS LANDING
    G.E. SAN JOSE
    FIELD DATA

- SUMMARY

RAMSHEAD CONDENSATION INSTABILITY

LIMITS BEING USED

- MASS FLUX: $G \leq 40\ LB/FT^2\ SEC$

  (REACTOR PRESSURE $\approx$ 200 PSIG)

- LOCAL WATER TEMPERATURE: NON-ATWS EVENTS

  $T_L \leq 160^oF$

  ATWS STUDIES

  $T_L \leq 170^oF$

- POOL THERMAL DISTRIBUTION: $T_L = T_{BULK} + 10^oF$

RAMSHEAD DATA BASE

- G.E. MOSS LANDING

  - 3 TESTS OF 1¼-INCH RAMSHEAD: 152 TO 163°F

- G.E. SAN JOSE

  - 4 TESTS OF 3/4-INCH RAMSHEAD: 170 TO 176° F
  - 1 TEST OF 3/4-INCH RAMSHEAD: NO THRESHOLD (<40LB$_M$/FT^2-SE

  - 13 TESTS OF ½-INCH ELBOW: 160 TO 172° F

  - 7 TESTS OF 3/4-INCH ELBOW: 146 TO 170° F

  - 17 TESTS OF 1-INCH ELBOW: 147 TO 170° F
  - 2 TESTS OF 1-INCH ELBOW: NO THRESHOLD (<40 LB$_M$/FT^2- SEC)

RAMSHEAD DATA BASE

- RAMSHEAD PLANT DATA
  - PLANT A: 165°F NO INSTABILITY
  - PLANT B: 150°F NO INSTABILITY
  - PLANT C: 146°F NO INSTABILITY
  - PLANT D: 129°F NO INSTABILITY
  - PLANT E: 122°F NO INSTABILITY

SUMMARY

- NO OBSERVED DEVICE-SIZE EFFECT ON THRESHOLD TEMPERATURE
- LIMIT CONFIRMED BY 3/4 INCH RAMSHEAD DATA
- LIMIT SUPPORTED BY FIELD DATA TO OVER 165°F

MARK II PRESSURE SUPPRESSION CONTAINMENT SYSTEMS

DYNAMIC LOADS PRODUCED BY SRV DISCHARGE THROUGH A RAMSHEAD DEVICE

AN OVERVIEW OF LEAD PLANT STATUS

- SUMMARY OF METHODOLOGY DOCUMENTATION
- REVIEW OF:
  1. NEDO-24070, RAMSHEAD SAFETY RELIEF VALVE LOADS METHODOLOGY SUMMARY.
  2. GEN-0394, MARK II BWR SRV RAMSHEAD BUBBLE DYNAMICS ANALYTICAL MODEL COMPARISONS WITH TEST DATA.
- SUMMARY OF LEAD PLANT STATUS

MARK II PRESSURE SUPPRESSION CONTAINMENT SYSTEMS

METHODOLOGY FOR CALCULATING RAMSHEAD BUBBLE LOADS ON POOL BOUNDARY

- METHODS DEFINED IN DFFR SECTION 3.2 AND REFERENCES
  - PIPE CLEARING
  - BUBBLE DYNAMICS
  - METHOD OF IMAGES
  - COMBINATION OF MULTIPLE BUBBLES
  - LOAD CASES
  - TIE DOWN LOADS
- NEDO-24070 PROVIDES "ROADMAP" OF MODEL DEVELOPMENT AND VERIFICATION.
  - PHENOMENA
  - METHODS SUMMARY
  - EXPERIMENTAL VERIFICATION
  - APPLICATION
  - FUTURE WORK
  - CONCLUSIONS

NEDO-24070
77NED351
Class I
October 1977

MARK II CONTAINMENT
SUPPORTING PROGRAM REPORT

RAMSHEAD SAFETY/RELIEF VALVE LOADS
METHODOLOGY SUMMARY

Prepared by
G.L. Anderson

BOILING WATER REACTOR PROJECTS DEPARTMENT • GENERAL ELECTRIC COMPANY
SAN JOSE, CALIFORNIA 95125
GENERAL ELECTRIC

MARK II PRESSURE SUPPRESSION CONTAINMENT SYSTEMS

REVIEW OF NEDO-24070

SECTION 1: INTRODUCTION

- PURPOSE AND CONTENTS OF REPORT

SECTION 2: PHENOMENA

- LINE CLEARING (WATER/AIR)
- BUBBLE OSCILLATION
- STEADY STEAM FLOW

SECTION 3: DESCRIPTION OF ANALYTICAL METHODS

- LINE CLEARING
- BUBBLE DYNAMICS
- METHOD OF IMAGES
- SUPERPOSITION OF LOADS

A. LINEAR ADDITION IF SEQUENCING CONSIDERED

B. $\sqrt{}$ SS ADDITION FOR SIMULTANEOUS DISCHARGE

MARK II PRESSURE SUPPRESSION CONTAINMENT SYSTEMS

REVIEW OF NEDO-24070

SECTION 4: EXPERIMENTAL VERIFICATION OF METHODS

TESTS: 1. QUAD CITIES (1972)

2. SMALL SCALE TEST TANK (1974)

3. MONTICELLO (1976)

CONCLUSIONS

1. QUAD CITIES

- 1972 MODELS BOUND PIPE PRESSURE AND POSITIVE WALL PRESSURE

  -- REASONABLY PREDICT NEGATIVE PRESSURE

  -- MODEL REFINEMENTS IMPLEMENTED

- DFFR METHODS FOR POOL BOUNDARY LOADS CONSERVATIVE.

MARK II PRESSURE SUPPRESSION CONTAINMENT SYSTEMS

REVIEW OF NEDO-24070

2. SMALL SCALE TEST TANK

   - MOI ACCURATELY DESCRIBES BOUNDARY CONDITIONS

   - LITTLE DIFFERENCE BETWEEN LINEAR ADDITION AND SRSS SO LONG AS BUBBLE BOUNDARY CONDITIONS SATISFIED.

MARK II PRESSURE SUPPRESSION CONTAINMENT SYSTEMS

REVIEW OF NEDO-24070

3. MONTICELLO

- FOR SINGLE VALVE TESTS, DFFR METHODS CONSERVATIVE FOR POSTIVE PRESSURE AND ACCURATE FOR NEGATIVE PRESSURE

- FOR MULTIPLE VALVE TESTS, DFFR METHODS BOUND POSITIVE PRESSURES (EXCEPT 1 LOCATION) AND ARE GENERALLY WITHIN THE RANGE OF OBSERVED NEGATIVE PRESSURES

- FOR LEAKING VALVES, DFFR PREDICTIONS COMPARABLE TO DATA

- FOR CONSECUTIVE ACTUATIONS, DATA UNDERPREDICTED BY DFFR FIRST ACTUATION METHODS.

MARK II PRESSURE SUPPRESSION CONTAINMENT SYSTEMS

REVIEW OF NEDO-24070

SECTION 5: APPLICATION

- STRUCTURAL ASSESSMENTS PROVIDED IN INDIVIDUAL PLANT DESIGN ASSESSMENT REPORTS
- CONSIDER
  - SINGLE VALVE DISCHARGE (CONSECUTIVE)
  - ADS DISCHARGE (FIRST ACTUATION)
  - ASYMMETRIC CASE (PLANT UNIQUE) (FIRST ACTUATION)
  - ALL VALVE DISCHARGE (FIRST ACTUATION)
- NO SPECIFIC CONSIDERATION OF LEAKY VALVES IS NECESSARY
- CONSECUTIVE ACTUATION : USE MULTIPLIER ON EXISTING DFFR FIRST ACTUATION PREDICTIONS.

MARK II PRESSURE SUPPRESSION CONTAINMENT SYSTEMS

REVIEW OF NEDO-24070

SECTION 6: SUPPORTING PROGRAMS

- REFINED SRV ANALYTICAL MODELS
- FSI EFFECTS ON MONTICELLO CONTAINMENT LOADS DATA
- EVALUATION OF FSI EFFECTS ON MARK II CONTAINMENT STRUCTURES DURING SRV DISCHARGE.

MARK II PRESSURE SUPPRESSION CONTAINMENT SYSTEMS

DYNAMIC LOADS PRODUCED BY SRV DISCHARGE THROUGH A QUENCHER DEVICE

AN OVERVIEW OF LEAD QUENCHER PLANT STATUS

- SEQUENCE OF EVENTS
- STRUCTURAL LOADS CONSIDERED AND IDENTIFICATION OF LOADING METHODOLOGY
- CAORSO TESTS -- STATUS
- SUMMARY OF LEAD QUENCHER PLANT STATUS

MARK II PRESSURE SUPPRESSION CONTAINMENT SYSTEMS

SEQUENCE OF EVENTS

- VALVE OPENING
- WATER LEG CLEARING
- AIR BUBBLE FORMATION
- AIR BUBBLE OSCILLATIONS
- STEAM CONDENSATION
- VALVE CLOSURE

MARK II PRESSURE SUPPRESSION CONTAINMENT SYSTEMS

DYNAMIC LOADS DURING SRV DISCHARGE THROUGH A QUENCHER

STRUCTURE: SRV DISCHARGE PIPING

LOADS:
- PIPE PRESSURE/TEMPERATURE
- FLOW REACTION LOADS (STEADY AND UNSTEADY)

METHODOLOGY:
- FOR UNSTEADY FLOW, USE THE PIPE CLEARING MODEL IN DFFR SECTION 3.1.2.1*
- FOR STEADY FLOW, CLASSICAL ENGINEERING TECHNIQUES

*SAME AS MODEL USED FOR RAMSHEAD.

MARK II PRESSURE SUPPRESSION CONTAINMENT SYSTEMS

DYNAMIC LOADS DURING SRV DISCHARGE THROUGH A QUENCHER

STRUCTURE: QUENCHER

LOADS:
- TORQUE
- LATERAL LOADS
- SUBMERGED STRUCTURE LOADS FROM ADJACENT QUENCHERS

METHODOLOGY:
- DFFR SECTION 3.3.10 FOR TORQUE/LATERAL LOAD
- SUBMERGED STRUCTURES APPLICATIONS MEMORANDUM (TO BE ISSUED FOR QUENCHERS)

MARK II PRESSURE SUPPRESSION CONTAINMENT SYSTEMS

DYNAMIC LOADS DURING SRV DISCHARGE THROUGH A QUENCHER

STRUCTURE: SUBMERGED STRUCTURES

LOADS:
- WATER JET
- STANDARD AND ACCELERATION DRAG DURING AIR BUBBLE OSCILLATION

METHODOLOGY: REPORTS BEING PREPARED

MARK II PRESSURE SUPPRESSION CONTAINMENT SYSTEMS

DYNAMIC LOADS DURING SRV DISCHARGE THROUGH A QUENCHER

STRUCTURE: SUPPRESSION POOL BOUNDARY

LOADS: OSCILLATING PRESSURE CAUSED BY AIR BUBBLES

METHODOLOGY:
- -- DFFR SECTION 3.3
- -- EMPIRICAL CORRELATION FOR POSITIVE PRESSURE
- -- INDEPENDENT OF LINE CLEARING MODEL
- -- 2 Ro/R ATTENUATION
- -- MULTIPLE VALVES ADDES $\sqrt{SS}$
- -- LOAD CASES SAME AS GESSAR
- -- CONSECUTIVE ACTUATION CONSIDERED

NOTE: IMPROVEMENTS IN LOAD DEFINITION MAY BE POSSIBLE AND WORK IS UNDERWAY IN SOME AREAS.

CAORSO SRV DISCHARGE TESTS

STATUS

- FUEL LOADED
- EXPECTED HEAT-UP START-END OF JANUARY 1978
- START FIRST TEST SERIES - MARCH/APRIL 1978

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

File
BWR-SRV
Generic

FEB 9 1978

MEMORANDUM FOR: Gus C. Lainas, Chief, Containment Systems Branch, DSS

FROM: T. M. Su, Containment Systems Branch, DSS

THRU: J. A. Kudrick, Section A Leader, Containment Systems Branch, DSS

SUBJECT: SUMMARY OF MEETING WITH MARK II OWNERS GROUP TO DISCUSS THE STATUS OF SRV RELATED LOADS ON CONTAINMENT

On January 19, 1978, a meeting was held between representatives of Mark II owners group, General Electric, the NRC consultants (BNL) and the staff. The purpose of the meeting was to discuss the status of Safety Relief Valve (SRV) related loads on the Mark II containment.

The meeting agenda, attendee list and presentation material are attached. The significant results of the meeting are summarized below:

1. Methodology of Ramshead Load Prediction

The Mark II owners indicated that the methodology described in the Dynamic Forcing Function Report (DFFR) and the topical report (NEDO-24070) will be used for predicting the ramshead loads on the containment structure. This method utilizes the current GE analytical model to predict loads for first SRV actuation. For subsequent actuation, a multiplier of 1.4 is used for positive pressure and 1.6 for negative pressure. The Mark II owners have stated that the use of these multipliers in conjunction with the DFFR methodology provides a bounding load on the containment.

However, we pointed out that two additional items should be included in the method. These are leaking valve effects and bubble oscillating frequency. The Monticello test results show an increase in SRV loads corresponding to leaking valves. Since a leaking valve is a highly possible event, its effects should be addressed. In addition, the bubble oscillating frequency measured from the test deviates substantially from the predicted value. We indicated that the model should be modified in order to predict this important parameter within a reasonable error band. A representative of the Mark II owner's group stated that the bubble efficiency is being investigated in light of the Monticello test results.

Contact:
T. M. Su, CSB
492-7711

2. Method of Calculating Multiple-Valve Actuation Loads

Currently, the DFFR uses the SRSS (square root of sum of the squares) approach for combining loads from multiple-valve actuations. Our consultants, however, disagreed with this approach on the basis of the Monticello test results. A study made by our consultants currently shows that combining multiple-valve loads by the absolute sum method results in calculated loads closer to the Monticello results. Loads calculated by SRSS are in general lower than measured loads. Since the design loads on structures is substantially different between these two methods, we recommended that the Mark II owner's group conduct further investigations of these two methods.

3. Submerged Structure Loads

For submerged structures, the Mark II owner's included water jet loads and drag loads in the investigation. Their program includes analytical model development and experimental confirmation for a single structure within a pool. We stated that the approach of this investigation appears reasonable. However, we directed them to study the effect of a second body on the velocity and pressure fields because in an actual plant design there will be more than one structure in the fields that result from either the discharge of a SRV or from LOCA related phenomena.

4. Fluid and Structure Interaction (FSI)

GE stated that an analytical approach is being developed to investigate FSI effects associated with SRV loads. This work is expected to be completed by June, 1978. This late submittal may result in a slip in the review schedules associated with our A-39 and A-8 generic review programs. We will have further discussions with the Mark II owner's group for this matter.

On the basis of their current assessment, the Mark II owners maintain that FSI effects are insignificant for SRV loads. Dr. Bedrosian of Burns and Roe made a presentation to demonstrate that the loads measured in the Monticello steel torus are conservative for application to a Mark II concrete containment. His method uses a classical text book single degree of freedom model to show that flexible walls amplify the actual loads if the frequency ratio of the source and the tested facility falls within a certain range. He stated that the Monticello SRV loads fall within this range. We believe that this method of assessing the importance of SRV FSI effects has merit and should be

pursued further by the Mark II owners. The Mark II owner's group should provide a formal submission of this evaluation of FSI effects including a detailed description for our evaluation on a schedule consistent with our lead plant review efforts.

5. Pool Temperature Limit

We recommended that each Mark II owner accelerate their schedule to provide us the information related to pool temperature transients which we requested several months ago. We stated that this information is relevant to our evaluation of plant operability. The results of this evaluation will have an impact on the selection of the SRV discharge device; i.e., ramshead vs. quencher. Delays in receipt of this information will be reflected in our licensing review efforts for the lead Mark II plants.

T. M. Su, A-39 Task Manager
Containment Systems Branch
Division of Systems Safety

Attachments:
As Stated

Distribution:
Central File
NRR Reading File
CSB Reading File
E. Case
R. Mattson
S. Hanauer
R. Fraley, ACRS (16)
R. DeYoung
D. Vassallo
D. Skovholt
R. Tedesco
J. Glynn
D. Ross
I&E (3)
NRC PDR
Local PDR
M. Kehnemuyi
J. Kudrick
T. Su

MK II S/R VALVE PHENOMENA MEETING

Attendance

A. R. Smith	G.E.
W. M. Davis	G.E.
A. J. James	G.E.
E. M. Mead	PP&L
R. M. Crawford	S&L
H. C. Brinkman	CG&E
L. H. Frauenholz	GE
S. B. Mucciacciaro	S&W
H. Chau	Lilco
B. R. McCaffrey	Lilco
C. Tung	BNL
P. Huber	MIT (BNL)
G. Bienkowski	Princeton (BNL)
R. H. Scanlan	Princeton (BNL)
T. M. Su	NRC/CSB
J. A. Kudrick	NRC/CSB
C. J. Anderson	NRC/CSB
George Maise	BNL
A. Hafiz	NRC/SEB
G. Lainas	NRC/CSB
J. Glynn	NRC/DSS
R. L. O'Mara	S&W
S. C. Chow	Stone & Webster
C. Lin	S&W
K. J. Green	S&L
J. S. Abel	Commonwealth Edison
R. E. Schaffstall	G.E.
M. G. Mosier	NMPC
H. S. Lu	Ebasco
E. A. Rukos	CFE
T. Zazueta	CFE
C. Oppenheim	ENK
A. F. Deardorff	Nutech (Mk I O.G.)
R. J. Muzzy	GE
H. T. Tang	GE
D. C. Baker	Burns & Roe
H. M. Schoenhoff	Bechtel
E. McFarland	Bechtel
T. Huang	NRC/CSB
M. R. Granback	NIPSCO
A. P. Olson	NSC
R. F. McClelland	GE
Bedros Bedrosian	B&R
G. L. Gelhaus	WPPSS
K. K. Roe	B&R
L. Sobon	GE

INTRODUCTION

- MEETING OBJECTIVES
  - CONTINUING MK II OWNERS GROUP POLICY OF FREQUENTLY ADVISING NRC OF PROGRAM TECHNICAL PROGRESS AND STATUS
  - SAFETY/RELIEF VALVE DISCHARGE PHENOMENA PROGRAM
  - PRIMARY EMPHASIS ON RAMSHEAD TECHNOLOGY
  - MK II QUENCHER TECHNOLOGY CONSIDERATIONS
  - MK II S/RV SEQUENTIAL ACTUATION APPROACH

SRV MEETING AGENDA - MARK II OWNERS GROUP/NRC

I. INTRODUCTION

II. METHODS FOR LOAD PREDICTION - RANSHEAD
- METHODOLOGY
- SUBMERGED STRUCTURES
  - OVERVIEW
  - APPLICATION MEMORANDUM

III. METHODS FOR LOAD PREDICTION - QUENCHER
- METHODOLOGY
- SUBMERGED STRUCTURES

IV. MONTICELLO DATA AND MARK II FSI
- EVALUATION OF FSI DATA FOR S/RV MODEL VERIFICATION.
- ASSESSMENT OF EFFECTS OF FSI IN MK II CONTAINMENTS.

V. POOL TEMPERATURE LIMITS
- REPORT SUMMARY
- TRANSIENT ASSUMPTIONS

MARK II PRESSURE SUPPRESSION CONTAINMENT SYSTEMS

LOADS ON SUBMERGED STRUCTURES DUE TO SRV DISCHARGE THROUGH A RAMSHEAD DEVICE

- DISCUSSION OF SUBMERGED STRUCTURE TECHNOLOGY
- OVERVIEW OF RAMSHEAD SUBMERGED STRUCTURE PROGRAM
- DOCUMENTATION
- SUMMARY OF RAMSHEAD ASSUMPTIONS AND APPLICATION TECHNIQUES
- CONCLUSIONS

MARK II PRESSURE SUPPRESSION CONTAINMENT SYSTEMS

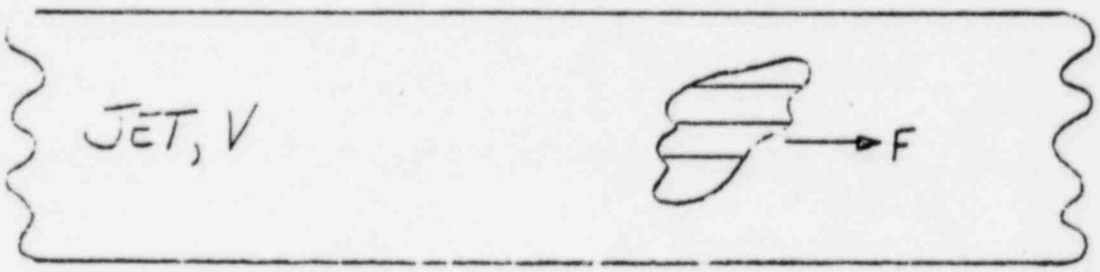
SUBMERGED STRUCTURE LOADS

WATER JET LOADS

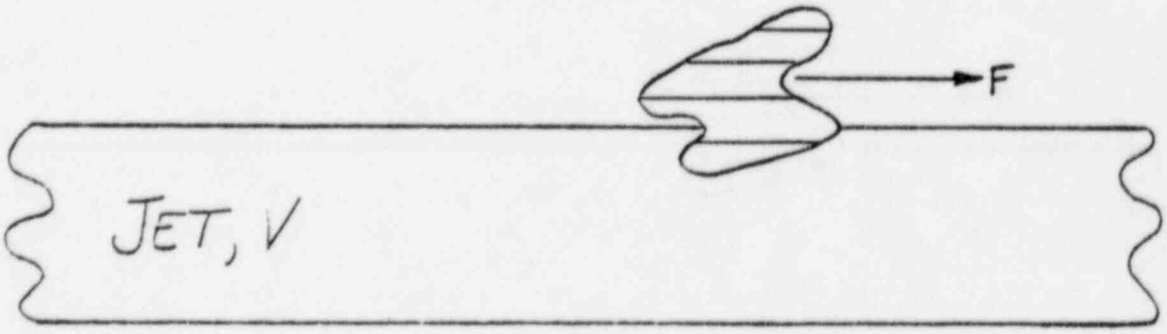
- SOURCE OF JETS
  - MAIN VENTS DURING LOCA
  - RAMSHEAD OR QUENCHER DURING SRV ACTUATION
- LOADING MECHANISMS
  - WATER DRAG/IMPINGEMENT
- BASIC APPROACH
  - PROVIDE JET DEFINITION AND CALCULATE LOADS FROM KNOWN DRAG COEFFICIENTS OR IMPINGEMENT CALCULATIONS

MARK II PRESSURE SUPPRESSION CONTAINMENT SYSTEMS

WATER JET LOADS



$$F = C_D \cdot V^2/2g$$



$$F = K \cdot A_1 \cdot V^2/2g$$

MARK II PRESSURE SUPPRESSION CONTAINMENT SYSTEMS

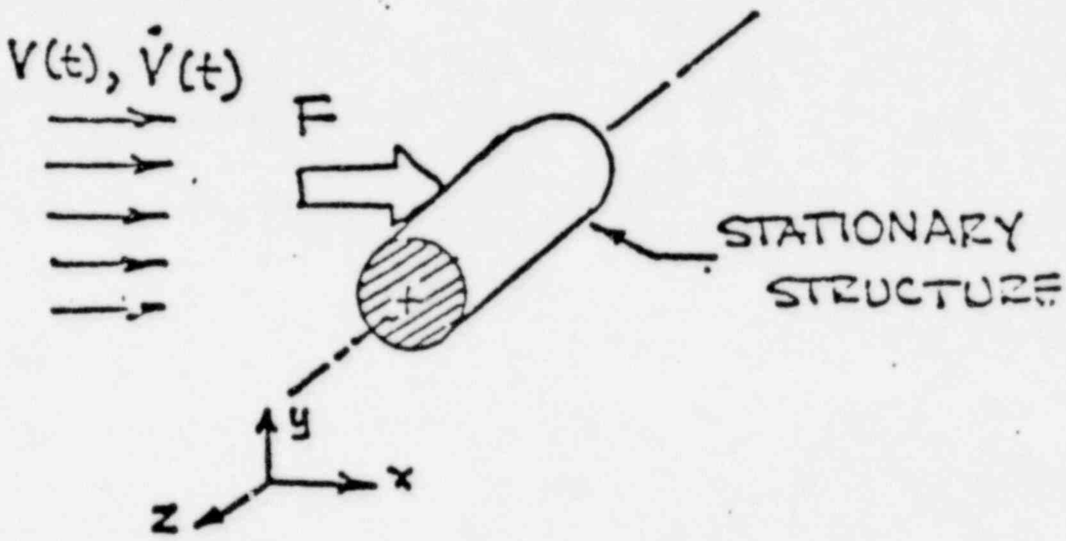
SUBMERGED STRUCTURE LOADS

'BUBBLE' TYPE LOADS

- SOURCE OF BUBBLE
  - MAIN VENTS DURING POOL SWELL
  - RAMSHEAD OR QUENCHER FOLLOWING AIR CLEARING
  - MAIN VENTS DURING CONDENSATION OSCILLATIONS AND CHUGGING

- LOADING MECHANISM
  - STANDARD DRAG ($\propto V^2$) PRODUCED BY VELOCITY FIELDS
  - ACCELERATION DRAG ($\propto \dot{V}$) PRODUCED BY PRESSURE FIELDS

- BASIC APPROACH
  - PROVIDE DEFINITION OF VELOCITY AND ACCELERATION FIELDS AND CALCULATE DRAG FROM KNOWN DRAG COEFFICIENTS AND ACCELERATION DRAG VOLUMES.



FLOW FIELD INDUCED LOADS

$$F = F_S + F_A$$

STANDARD DRAG

$$F_S = C_D A \rho \frac{V(t)^2}{2g_c} \sim V(t)^2$$

ACCELERATION DRAG

$$F_A = \mathbb{V}_A \rho \frac{\dot{V}(t)}{g_c} \sim \dot{V}(t)$$

SUBMERGED STRUCTURES LOADS

- REPORT TITLE - NED #21472-P
  ANALYTICAL MODEL FOR LIQUID JET PROPERTIES FOR PREDICTING FORCES ON SUBMERGED STRUCTURES

- REPORT TITLE - NED #21471-P
  ANALYTICAL MODEL FOR ESTIMATING DRAG FORCES ON RIGID SUBMERGED STRUCTURES CAUSED BY LOCA AND SAFETY RELIEF RAMSHEAD AIR DISCHARGE

APPLICATION METHOD

- REPORT TITLE - NED #21730
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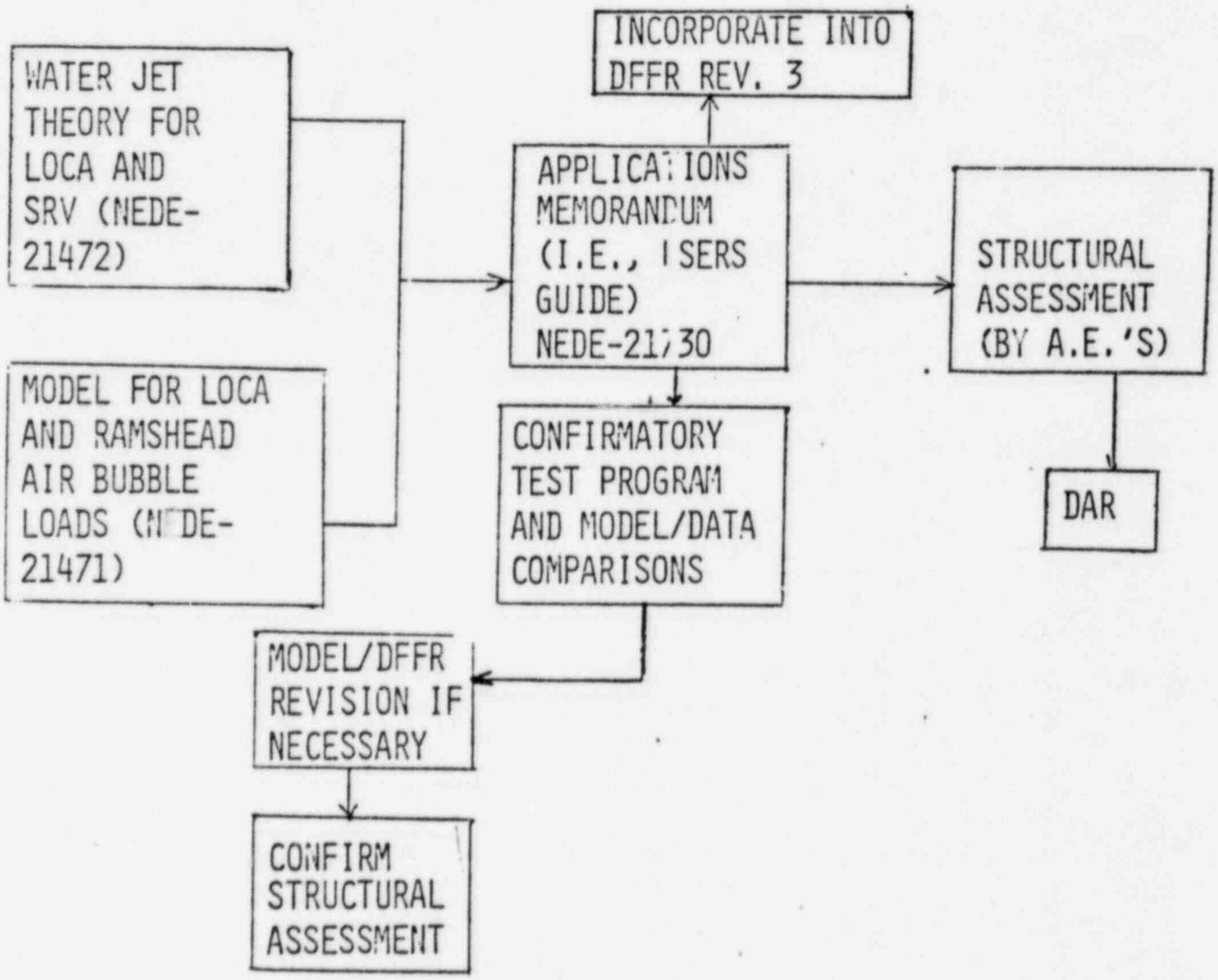
MARK II PRESSURE SUPPRESSION CONTAINMENT SYSTEMS

RAMSHEAD SUBMERGED STRUCTURES PROGRAM



MARK II PRESSURE SUPPRESSION CONTAINMENT SYSTEMS

RAMSHEAD WATER JET LOAD

MAJOR ASSUMPTIONS

- UNSTEADY SUBMERGED JET WITH NO DIVERGENCE OTHER THAN PREDICTED BY MASS/MOMENTUM EQUATIONS. CONSTANT FLUID PARTICLE VELOCITY
- VELOCITY AND ACCELERATION FROM THE DFFR PIPE CLEARING MODEL
- FORCE IS DRAG OR IMPINGEMENT DEPENDING ON GEOMETRY
- DISSIPATION OCCURS WHEN LAST PARTICLE REACHES JET FRONT

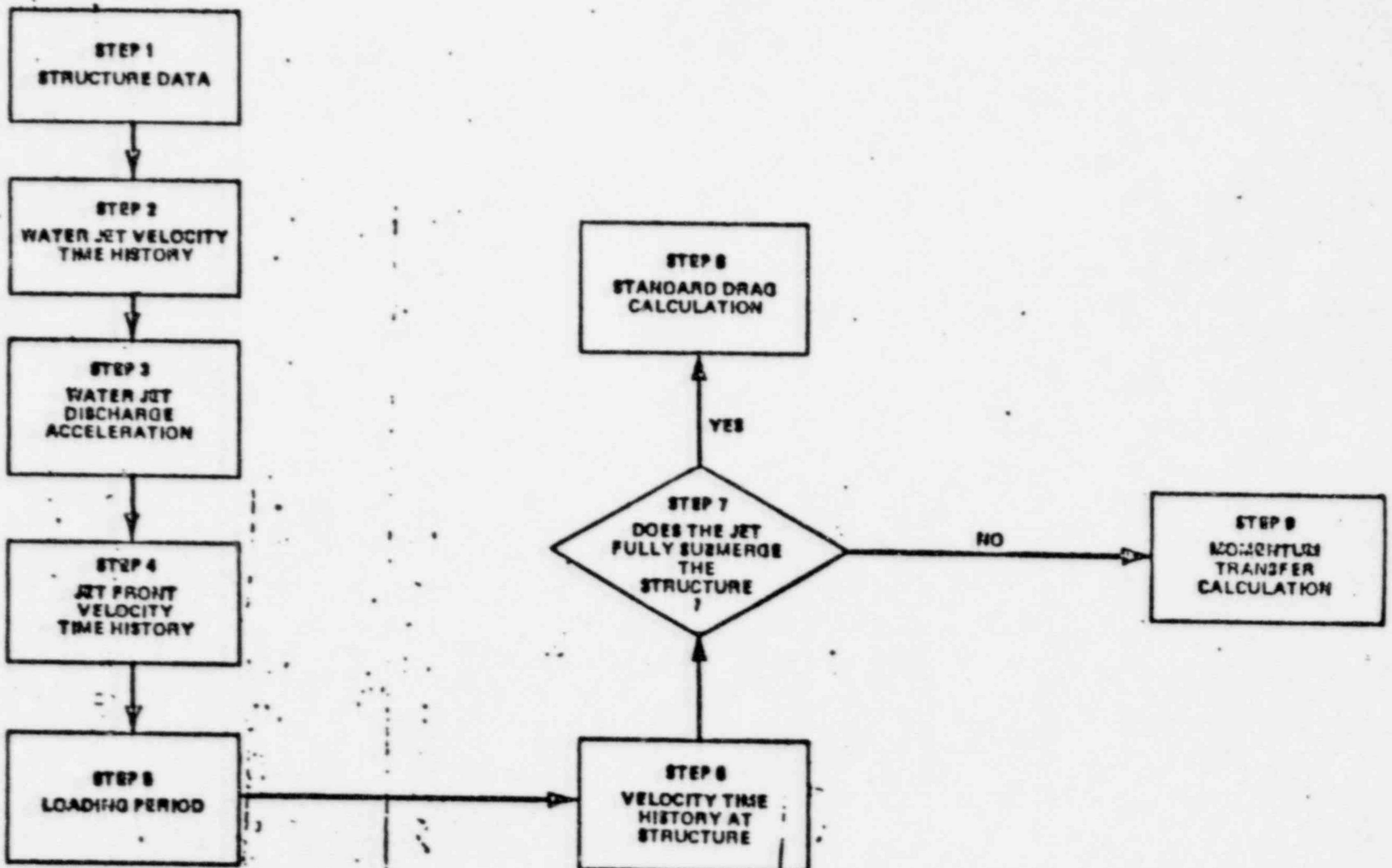


Figure 2-1. Jet Loads Procedure

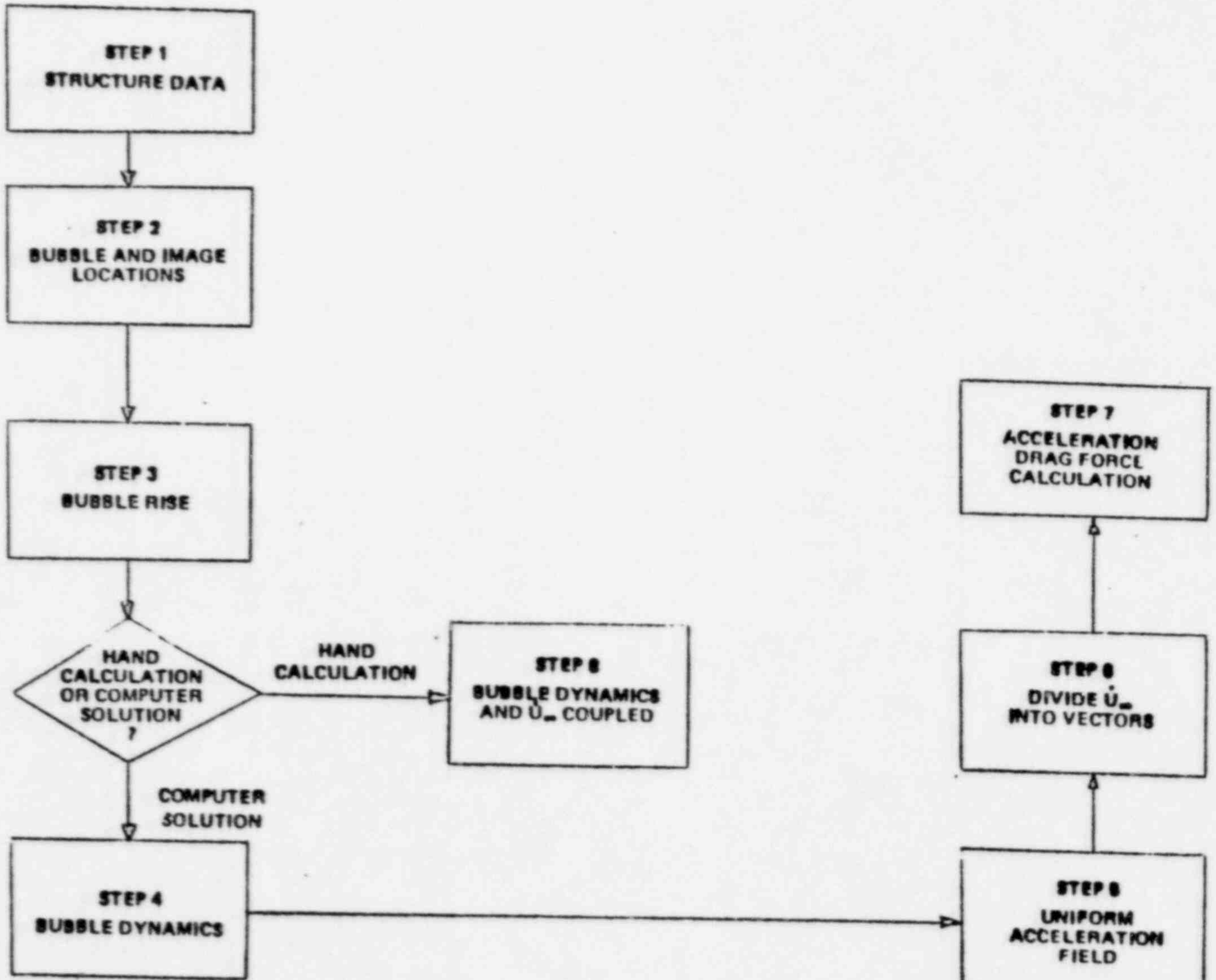
MARK II PRESSURE SUPPRESSION CONTAINMENT SYSTEMS

RAMSHEAD AIR BUBBLE LOADS ON SUBMERGED STRUCTURES

MAJOR ASSUMPTIONS

- SPHERICAL BUBBLE FLOW FIELD DESCRIBED BY A POINT SOURCE. FINITE BUBBLE EFFECTS CONSIDERED.
- UNIFORM FLOW FIELD
- BOUNDARIES ACCOUNTED FOR WITH METHOD OF IMAGES
- AIR IS IDEAL GAS
- ACOUSTIC EFFECTS NEGLIGIBLE
- BUBBLE RISE CONSIDERED
- TWO BUBBLES IN PHASE

RAMSHEAD AIR BUBBLE APPLICATION
(NEDE-21730)



MARK II PRESSURE SUPPRESSION CONTAINMENT SYSTEMS

RAMSHEAD SUBMERGED STRUCTURE LOADS

CONCLUSIONS

- LOADS CONSERVATIVELY DEFINED AND DOCUMENTED
- CONFIRMATORY PROGRAM IN PLACE
- DESIGN ASSESSMENT STUDIES UNDER WAY

RAMSHEAD CONDENSATION INSTABILITY

- REVIEW OF LIMITS BEING USED

- REVIEW OF DATA BASE

  G.E. MOSS LANDING

  G.E. SAN JOSE

  FIELD DATA

- SUMMARY

RAMSHEAD CONDENSATION INSTABILITY

LIMITS BEING USED

- MASS FLUX: $G \leq 40\ LB/FT^2\ SEC$

  (REACTOR PRESSURE $\approx$ 200 PSIG)

- LOCAL WATER TEMPERATURE: NON-ATWS EVENTS

  $T_L \leq 160^oF$

  ATWS STUDIES

  $T_L \leq 170^oF$

- POOL THERMAL DISTRIBUTION: $T_L = T_{BULK} + 10^oF$

RAMSHEAD DATA BASE

- G.E. MOSS LANDING
  - 3 TESTS OF 1¼-INCH RAMSHEAD: 152 TO 163°F

- G.E. SAN JOSE
  - 4 TESTS OF 3/4-INCH RAMSHEAD: 170 TO 176° F
  - 1 TEST OF 3/4-INCH RAMSHEAD: NO THRESHOLD (<40 LB_M/FT^2-SEC
  - 13 TESTS OF ½-INCH ELBOW: 160 TO 172° F
  - 7 TESTS OF 3/4-INCH ELBOW: 146 TO 170° F
  - 17 TESTS OF 1-INCH ELBOW: 147 TO 170° F
  - 2 TESTS OF 1-INCH ELBOW: NO THRESHOLD (<40 LB_M/FT^2- SEC)

RAMSHEAD DATA BASE

- RAMSHEAD PLANT DATA
  - PLANT A: 165°F NO INSTABILITY
  - PLANT B: 150°F NO INSTABILITY
  - PLANT C: 146°F NO INSTABILITY
  - PLANT D: 129°F NO INSTABILITY
  - PLANT E: 122°F NO INSTABILITY

SUMMARY

- NO OBSERVED DEVICE-SIZE EFFECT ON THRESHOLD TEMPERATURE
- LIMIT CONFIRMED BY 3/4 INCH RAMSHEAD DATA
- LIMIT SUPPORTED BY FIELD DATA TO OVER 165°F

MARK II PRESSURE SUPPRESSION CONTAINMENT SYSTEMS

DYNAMIC LOADS PRODUCED BY SRV DISCHARGE THROUGH A RAMSHEAD DEVICE

AN OVERVIEW OF LEAD PLANT STATUS

- SUMMARY OF METHODOLOGY DOCUMENTATION
- REVIEW OF:
  1. NEDO-24070, RAMSHEAD SAFETY RELIEF VALVE LOADS METHODOLOGY SUMMARY.
  2. GEN-0394, MARK II BWR SRV RAMSHEAD BUBBLE DYNAMICS ANALYTICAL MODEL COMPARISONS WITH TEST DATA.
- SUMMARY OF LEAD PLANT STATUS

MARK II PRESSURE SUPPRESSION CONTAINMENT SYSTEMS

METHODOLOGY FOR CALCULATING RAMSHEAD BUBBLE LOADS ON POOL BOUNDARY

- METHODS DEFINED IN DFFR SECTION 3.2 AND REFERENCES
  - PIPE CLEARING
  - BUBBLE DYNAMICS
  - METHOD OF IMAGES
  - COMBINATION OF MULTIPLE BUBBLES
  - LOAD CASES
  - TIE DOWN LOADS
- NEDO-24070 PROVIDES "ROADMAP" OF MODEL DEVELOPMENT AND VERIFICATION.
  - PHENOMENA
  - METHODS SUMMARY
  - EXPERIMENTAL VERIFICATION
  - APPLICATION
  - FUTURE WORK
  - CONCLUSIONS

NEDO-24070
77NED351
Class I
October 1977

MARK II CONTAINMENT
SUPPORTING PROGRAM REPORT

RAMSHEAD SAFETY/RELIEF VALVE LOADS
METHODOLOGY SUMMARY

Prepared by
G.L. Anderson

BOILING WATER REACTOR PROJECTS DEPARTMENT • GENERAL ELECTRIC COMPANY
SAN JOSE, CALIFORNIA 95125
GENERAL ELECTRIC

MARK II PRESSURE SUPPRESSION CONTAINMENT SYSTEMS

REVIEW OF NEDO-24070

SECTION 1: INTRODUCTION

- PURPOSE AND CONTENTS OF REPORT

SECTION 2: PHENOMENA

- LINE CLEARING (WATER/AIR)
- BUBBLE OSCILLATION
- STEADY STEAM FLOW

SECTION 3: DESCRIPTION OF ANALYTICAL METHODS

- LINE CLEARING
- BUBBLE DYNAMICS
- METHOD OF IMAGES
- SUPERPOSITION OF LOADS

A. LINEAR ADDITION IF SEQUENCING CONSIDERED

B. $\sqrt{\ }$ SS ADDITION FOR SIMULTANEOUS DISCHARGE

MARK II PRESSURE SUPPRESSION CONTAINMENT SYSTEMS

REVIEW OF NEDO-24070

SECTION 4: EXPERIMENTAL VERIFICATION OF METHODS

TESTS:
1. QUAD CITIES (1972)
2. SMALL SCALE TEST TANK (1974)
3. MONTICELLO (1976)

CONCLUSIONS

1. QUAD CITIES
   - 1972 MODELS BOUND PIPE PRESSURE AND POSITIVE WALL PRESSURE
     - -- REASONABLY PREDICT NEGATIVE PRESSURE
     - -- MODEL REFINEMENTS IMPLEMENTED
   - DFFR METHODS FOR POOL BOUNDARY LOADS CONSERVATIVE.

MARK II PRESSURE SUPPRESSION CONTAINMENT SYSTEMS

REVIEW OF NEDO-24070

2. SMALL SCALE TEST TANK

   - MOI ACCURATELY DESCRIBES BOUNDARY CONDITIONS

   - LITTLE DIFFERENCE BETWEEN LINEAR ADDITION AND SRSS SO LONG AS BUBBLE BOUNDARY CONDITIONS SATISFIED.

MARK II PRESSURE SUPPRESSION CONTAINMENT SYSTEMS

REVIEW OF NEDO-24070

3. MONTICELLO

- FOR SINGLE VALVE TESTS, DFFR METHODS CONSERVATIVE FOR POSTIVE PRESSURE AND ACCURATE FOR NEGATIVE PRESSURE

- FOR MULTIPLE VALVE TESTS, DFFR METHODS BOUND POSITIVE PRESSURES (EXCEPT 1 LOCATION) AND ARE GENERALLY WITHIN THE RANGE OF OBSERVED NEGATIVE PRESSURES

- FOR LEAKING VALVES, DFFR PREDICTIONS COMPARABLE TO DATA

- FOR CONSECUTIVE ACTUATIONS, DATA UNDERPREDICTED BY DFFR FIRST ACTUATION METHODS.

MARK II PRESSURE SUPPRESSION CONTAINMENT SYSTEMS

REVIEW OF NEDO-24070

SECTION 5: APPLICATION

- STRUCTURAL ASSESSMENTS PROVIDED IN INDIVIDUAL PLANT DESIGN ASSESSMENT REPORTS
- CONSIDER
  - SINGLE VALVE DISCHARGE (CONSECUTIVE)
  - ADS DISCHARGE (FIRST ACTUATION)
  - ASYMMETRIC CASE (PLANT UNIQUE) (FIRST ACTUATION)
  - ALL VALVE DISCHARGE (FIRST ACTUATION)
- NO SPECIFIC CONSIDERATION OF LEAKY VALVES IS NECESSARY
- CONSECUTIVE ACTUATION : USE MULTIPLIER ON EXISTING DFFR FIRST ACTUATION PREDICTIONS.

MARK II PRESSURE SUPPRESSION CONTAINMENT SYSTEMS

REVIEW OF NEDO-24070

SECTION 6: SUPPORTING PROGRAMS

- REFINED SRV ANALYTICAL MODELS

- FSI EFFECTS ON MONTICELLO CONTAINMENT LOADS DATA

- EVALUATION OF FSI EFFECTS ON MARK II CONTAINMENT STRUCTURES DURING SRV DISCHARGE.

MARK II PRESSURE SUPPRESSION CONTAINMENT SYSTEMS

REVIEW OF NEDO-24070

SECTION 7: CONCLUSIONS

1. LOAD PRODUCING PHENOMENA HAVE BEEN IDENTIFIED.

2. ANALYTICAL MODELS HAVE BEEN DEVELOPED.

3. SUPPORTING EXPERIMENTAL DATA HAS BEEN OBTAINED.

4. DFFR MODELS INCLUDE ALL KEY PARAMETERS AND GIVE CONSERVATIVELY REASONABLE LOADS (GIVEN A MULTIPLIER IS USED FOR CONSECUTIVE ACTUATIONS).

5. STRUCTURAL ASSESSMENTS ADDRESS ALL LOADING CONDITIONS.

6. SUPPORTING PROGRAMS IDENTIFIED.

ZIMMER CONTAINMENT

DESIGN ASSESSMENT FOR SRV LOAD

FSI CONSIDERATIONS

- ASSESSMENT PROGRAM COMMENCED IN 1975 AWARE OF POSSIBLE FSI IN SUPPRESSION POOL; ALSO AWARE OF AMPLE RESERVE CAPACITY TO CARRY SRV LOADS

- ASSESSMENT PROGRAM CONSIDERED TWO ALTERNATES:

    1. PERFORM FSI ANALYSIS TO ASSESS FSI EFFECTS ACCURATELY

    OR

    2. NEGLECT FSI TO ASSESS MARGIN FACTORS EXPEDITIOUSLY, IF FSI EFFECTS ARE RELATIVELY SMALL AND CAN BE BOUNDED BY AVAILABLE RESERVE CAPACITY

- ALTERNATE 2 WAS USED IN ZIMMER

CNK
1-19-73

SRV FSI EFFECTS CONSIDERED NEGLIGIBLE BECAUSE:

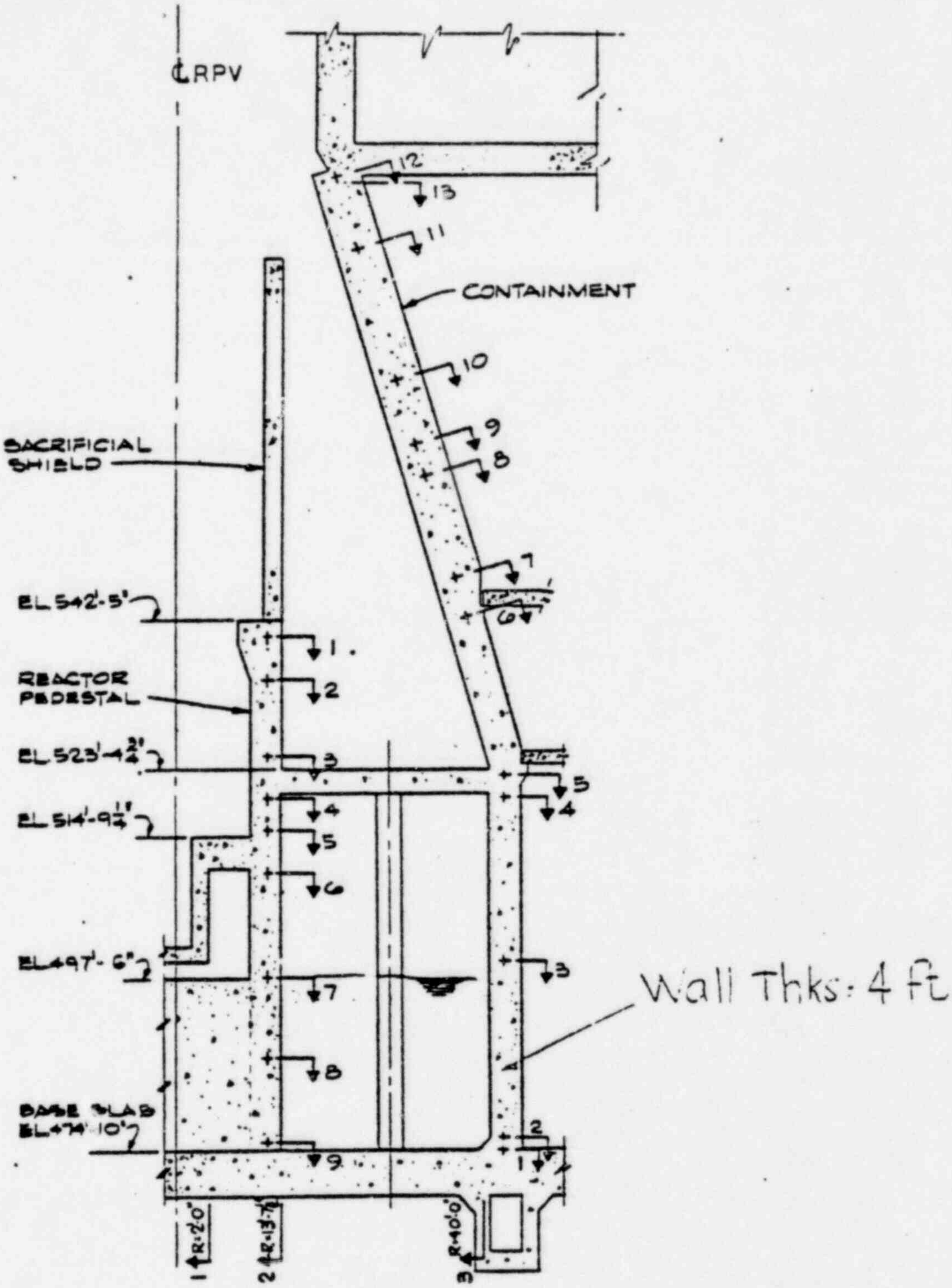
1. THE PRESTRESSED CONCRETE CONTAINMENT IS RELATIVELY RIGID AND SRV LOAD FREQUENCY IS LOW. HENCE FSI EFFECTS ARE ANTICIPATED TO BE SMALL.

2. SRV LOAD COMBINATIONS DO NOT GOVERN CONTAINMENT DESIGN. RESERVE CAPACITY AVAILABLE TO CARRY SRV LOADS IS AMPLE. (SEE DAR TABLES 4.1-1 AND 4.1-3 AND DAR SUPPLEMENT).

3. FORCES INDUCED BY SRV LOADS ARE SMALL COMPARED TO THE TOTAL DESIGN LOADS (SEE DAR SUPPLEMENT). THEREFORE, FORCES DUE TO FSI WOULD BE EVEN SMALLER.

4. CONTAINMENT STRUCTURE MARGIN FACTORS ARE NOT VERY SENSITIVE TO EVEN LARGE VARIATIONS IN SRV LOADS (SEE INTERACTION DIAGRAMS IN DAR SUPPLEMENT).

5. RECENT EXPLORATORY STUDY ON SRV FSI BY BURNS AND ROE CONFIRMS THAT FSI EFFECTS ARE SMALL.



WM. H. ZIMMER NUCLEAR POWER STATION, UNIT 1

MARK II DESIGN ASSESSMENT REPORT

FIGURE 4.1-9

DESIGN SECTIONS - PRIMARY CONTAINMENT, REACTOR SUPPORT AND BASE MAT

TABLE 4.1-1

DESIGN LOAD COMBINATIONS

EQN	LOAD COND	D	L	F	P_O	T_O	R_O	E_O	E_{SS}	P_B	P_A	T_A	R_A	R_R	SRV	ADS	ALL	ASYMMETRICAL
(1)	Normal w/o Temp	1.4	1.7	1.0	1.0	-	-	-	-	-	-	-	-	-	1.5	0	X	X
(2)	Normal w/Temp	1.0	1.3	1.0	1.0	1.0	1.0	-	-	-	-	-	-	-	1.3	0	X	X
(3)	Normal Sev. Env.	1.0	1.0	1.0	1.0	1.0	1.0	1.25	-	-	-	-	-	-	1.25	0	X	X
(4)	Abnormal	1.0	1.0	1.0	-	-	-	-	-	1.25	-	1.0	1.0	-	1.25	X	0	X
4a		1.0	1.0	1.0	-	-	-	-	-	-	1.25	1.0	1.0	-	-	0	0	0
(5)	Abnormal Sev. Env.	1.0	1.0	1.0	-	-	-	1.1	-	1.1	-	1.0	1.0	-	1.1	X	0	X
5a		1.0	1.0	1.0	-	-	-	1.1	-	-	1.1	1.0	1.0	-	-	0	0	0
(6)	Normal Ext. Env.	1.0	1.0	1.0	1.0	1.0	1.0	-	1.0	-	-	-	-	-	1.0	0	X	X
(7)	Abnormal Ext. Env.	1.0	1.0	1.0	-	-	-	-	1.0	1.0	-	1.0	1.0	1.0	1.0	X	0	X
7a		1.0	1.0	1.0	-	-	-	-	1.0	-	1.0	1.0	1.0	1.	-	0	0	0

LOAD DESCRIPTION

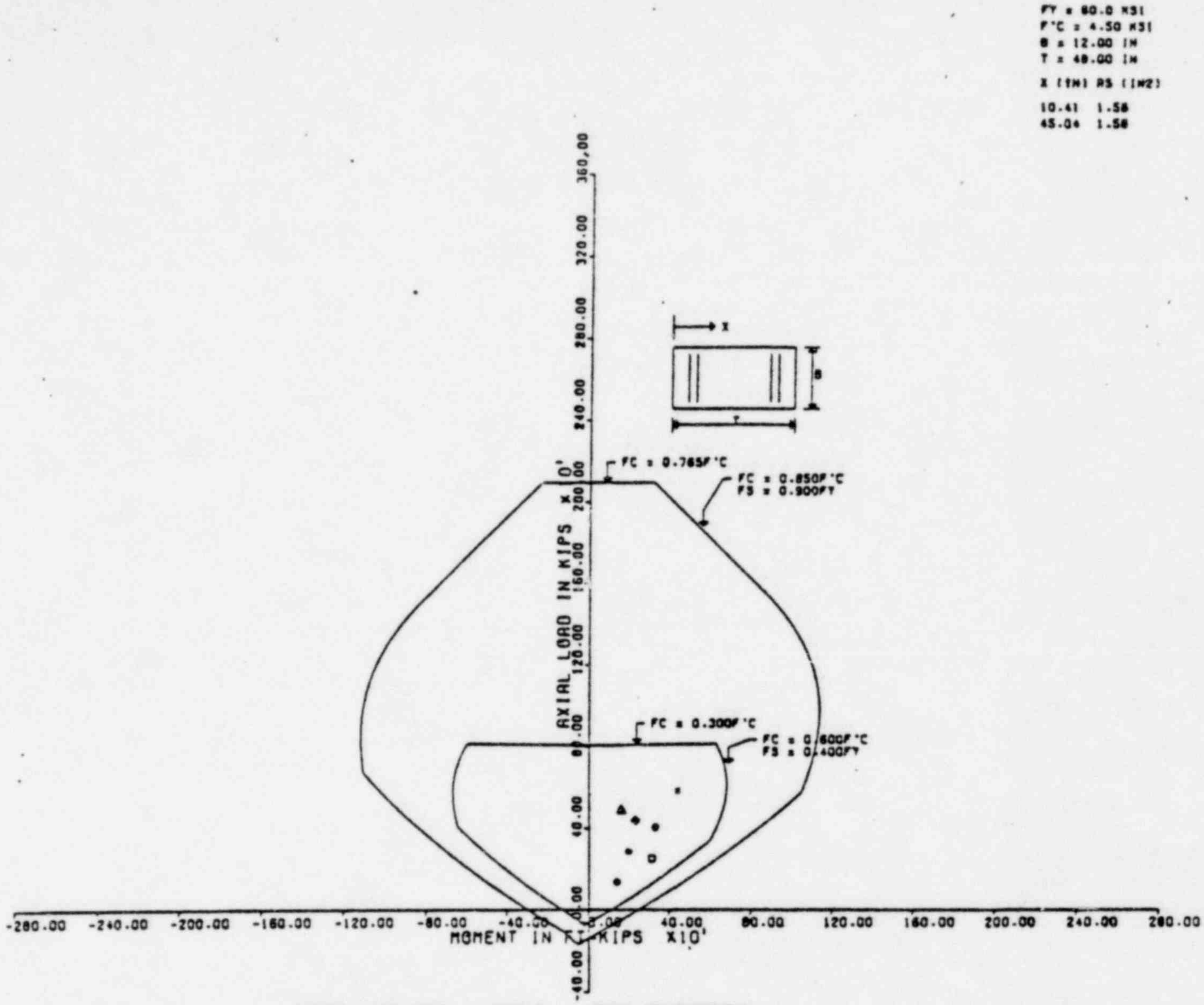
D = Dead Loads
L = Live Loads
F = Prestressing Loads
T_O = Operating Temperature Loads
R_O = Operating Pipe Reactions
P_O = Operating Pressure Loads
SRV = Safety/Relief Valve Loads
E_O = Operating Basis Earthquake
E_{SS} = Safe Shutdown Earthquake
P_B = SBA and IBA Pressure Load
T_A = Pipe Break Temperature Load
R_A = Pipe Break Temperature Reactions Load
P_A = DBA Pressure Loads (including all pool hydrodynamic loadings)
R_R = Reactions and Jet Forces Due to Pipe Break

TABLE 4.1-3

MARGIN TABLE FOR CONTAINMENT ALL VALVE DISCHARGE

LOAD COMBINATION EQUATION* \ STRESS COMPONENT	REINFORCING TENSION		CONCRETE COMPRESSION		SHEAR	
	MARGIN** FACTOR	CRITICAL*** SECTION	MARGIN FACTOR	CRITICAL SECTION	MARGIN FACTOR	CRITICAL SECTION
1	NA	NA	2.8	1	1.8	6
2	8.6	9	2.3	13	1.5	8
3	2.8	11	2.2	1	1.5	8
4	NA	NA	NA	NA	NA	NA
4a	NA	NA	NA	NA	NA	NA
5	NA	NA	NA	NA	NA	NA
5a	NA	NA	NA	NA	NA	NA
6	2.5	11	2.2	1	1.5	8
7	NA	NA	NA	NA	NA	NA
7a	NA	NA	NA	NA	NA	NA

*Refer to Table 4.1-1
**Margin Factor = Allowable Stress/Actual Stress
***Refer to Figure 4.1-9
NA = Not Applicable



ZIMMER CONTAINMENT - SECTION 1 MERID. REINFORCEMENT

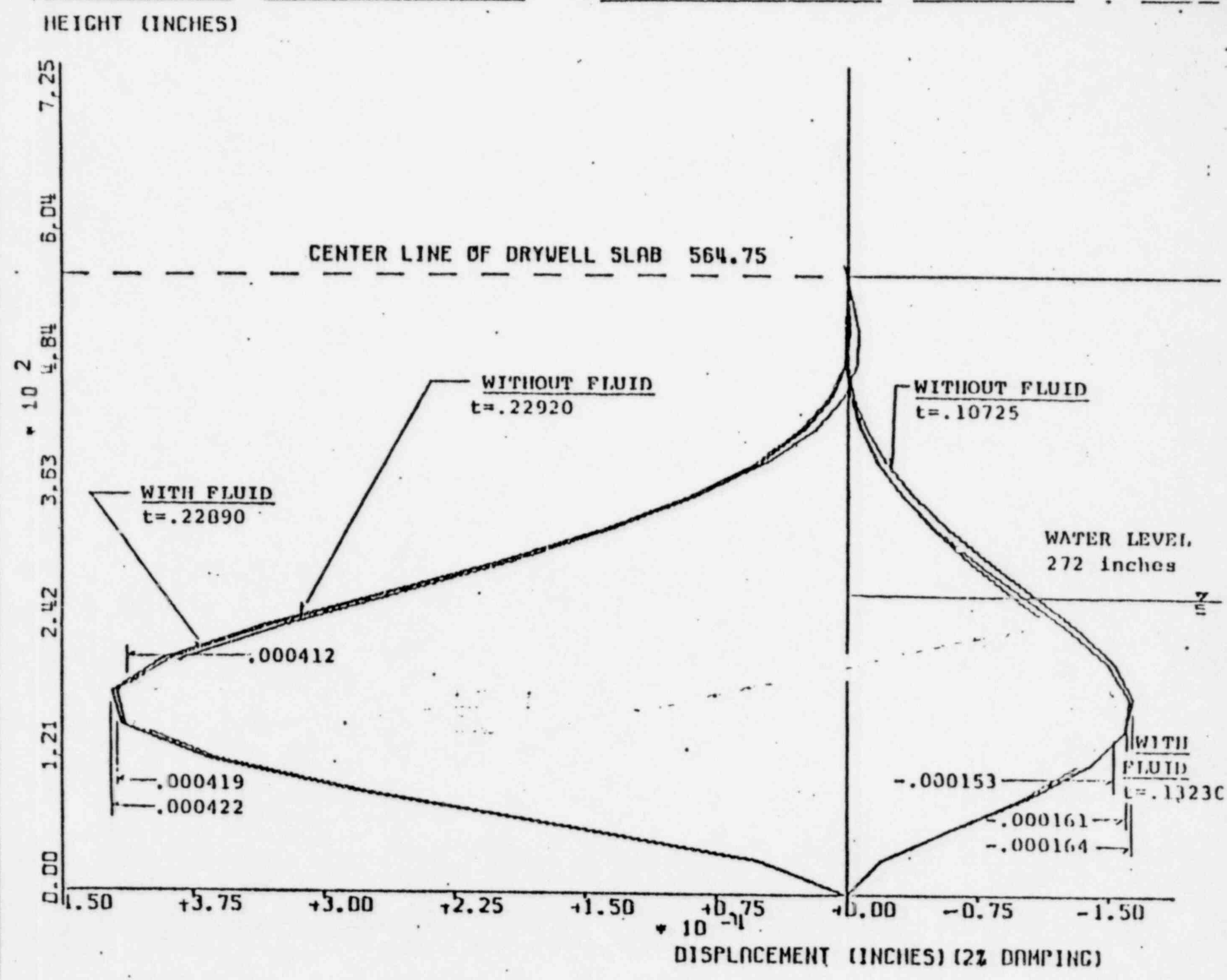
SYMBOL	LOAD COMBINATION
△	1
○	2
×	3
*	4
⊖	5
□	6
●	7

WM. H. ZIMMER NUCLEAR POWER STATION, UNIT 1

MARK II DESIGN ASSESSMENT REPORT

FIGURE 4.1-13

TYPICAL INTERACTION DIAGRAM FOR CONTAINMENT



MAXIMUM RADIAL DISPLACEMENT PROFILE - SRV 5 Hz - ZIMMER

FIGURE 12

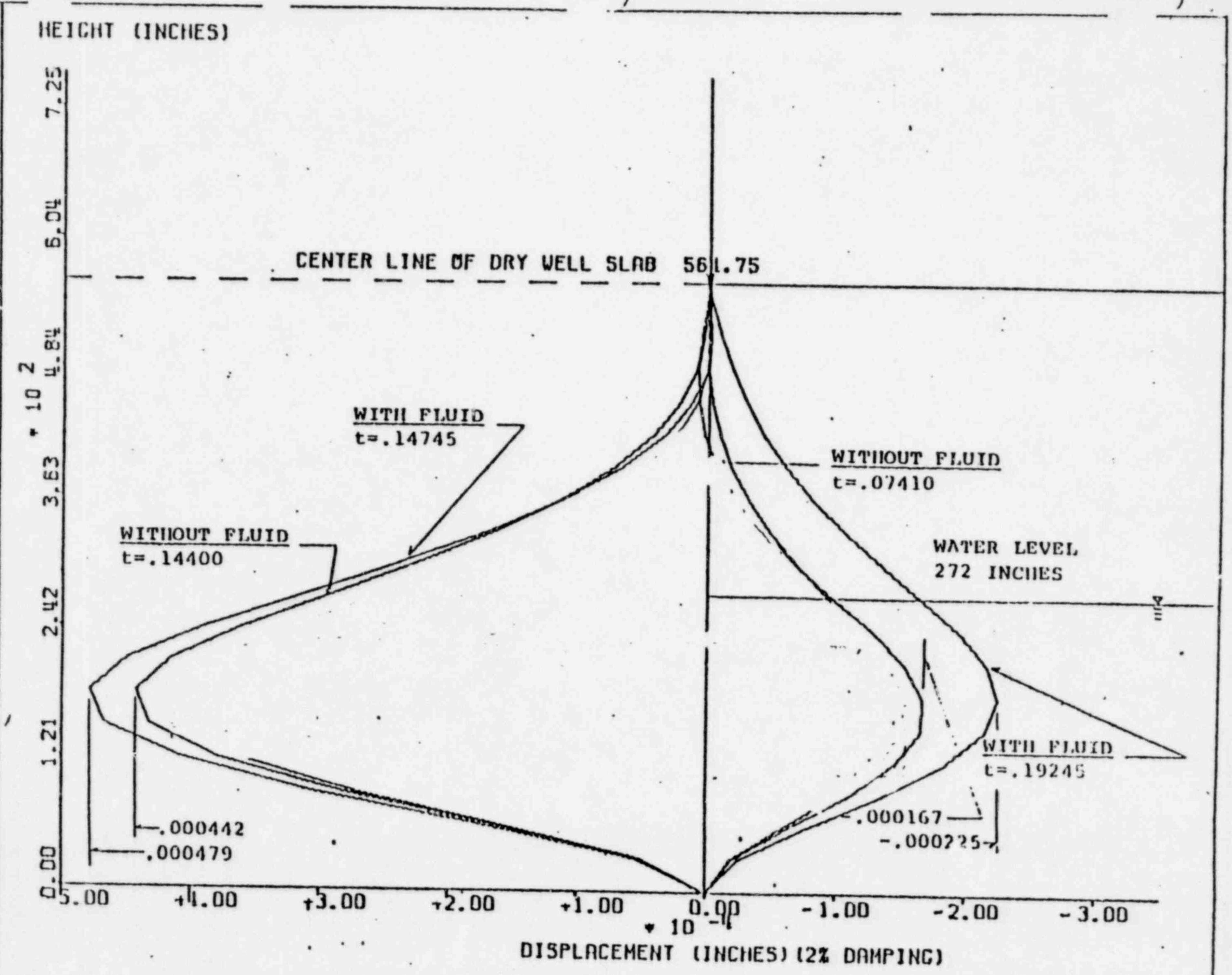


FIGURE 16 - MAXIMUM RADIAL DISPLACEMENT PROFILE - SRV 8 Hz - ZIMMER

MONTICELLO AND MARK II

FLUID STRUCTURE INTERACTION

- EVALUATION OF FSI DATA FOR S/RV MODEL VERIFICATION (GE)
- ASSESSMENT OF EFFECTS OF FSI IN MARK II CONTAINMENTS (S&L)

EVALUATION OF FSI EFFECTS

- NRC QUESTION

  HOW RESULTS OF FSI STUDIES FROM MONTICELLO CAN BE APPLIED TO MARK II CONCRETE CONTAINMENTS

- RESOLUTION ACTION

  TASK B/O

TASK B/O

- OBJECTIVE

  ASSESS SRV FSI IN MONTICELLO DATA

- METHODOLOGY

  - DEFINE A PRESSURE SOURCE REPRESENTATIVE OF SRV
  - USE A COUPLED HYDRO-STRUCTURE MODEL
  - ANALYZE TWO CASES
    - RIGID
    - AS-BUILT

- METHODOLOGY (CONTD.)
  - CALCULATE INTERFACE PRESSURE AT WALL
  - COMPARE RESULTS OF RIGID AND AS-BUILT CASE
  - CRITERION FOR ASSESSING FSI

    INSIGNIFICANT IF

    $P_{RIGID} \approx P_{FLEXIBLE}$

PRESENT STATUS

- COUPLED HYDRO-STRUCTURE CODE IN PLACE
- DEFINING PRESSURE SOURCE
- MODELING MONTICELLO
- INTERFACE RESPONSE PRESSURE TO BE GENERATED
- REPORT -- 2Q/78

MARK II PRESSURE SUPPRESSION CONTAINMENT SYSTEMS

DYNAMIC LOADS PRODUCED BY SRV DISCHARGE THROUGH A QUENCHER DEVICE

AN OVERVIEW OF LEAD QUENCHER PLANT STATUS

- SEQUENCE OF EVENTS
- STRUCTURAL LOADS CONSIDERED AND IDENTIFICATION OF LOADING METHODOLOGY
- CAORSO TESTS -- STATUS
- SUMMARY OF LEAD QUENCHER PLANT STATUS

MARK II PRESSURE SUPPRESSION CONTAINMENT SYSTEMS

SEQUENCE OF EVENTS

- VALVE OPENING
- WATER LEG CLEARING
- AIR BUBBLE FORMATION
- AIR BUBBLE OSCILLATIONS
- STEAM CONDENSATION
- VALVE CLOSURE

MARK II PRESSURE SUPPRESSION CONTAINMENT SYSTEMS

DYNAMIC LOADS DURING SRV DISCHARGE THROUGH A QUENCHER

STRUCTURE: SRV DISCHARGE PIPING

LOADS:
- PIPE PRESSURE/TEMPERATURE
- FLOW REACTION LOADS (STEADY AND UNSTEADY)

METHODOLOGY:
- FOR UNSTEADY FLOW, USE THE PIPE CLEARING MODEL IN DFFR SECTION 3.1.2.1*
- FOR STEADY FLOW, CLASSICAL ENGINEERING TECHNIQUES

*SAME AS MODEL USED FOR RAMSHEAD.

MARK II PRESSURE SUPPRESSION CONTAINMENT SYSTEMS

DYNAMIC LOADS DURING SRV DISCHARGE THROUGH A QUENCHER

STRUCTURE: QUENCHER

LOADS:
- TORQUE
- LATERAL LOADS
- SUBMERGED STRUCTURE LOADS FROM ADJACENT QUENCHERS

METHODOLOGY:
- DFFR SECTION 3.3.10 FOR TORQUE/LATERAL LOAD
- SUBMERGED STRUCTURES APPLICATIONS MEMORANDUM (TO BE ISSUED FOR QUENCHERS)

MARK II PRESSURE SUPPRESSION CONTAINMENT SYSTEMS

DYNAMIC LOADS DURING SRV DISCHARGE THROUGH A QUENCHER

STRUCTURE: SUBMERGED STRUCTURES

LOADS:
- WATER JET
- STANDARD AND ACCELERATION DRAG DURING AIR BUBBLE OSCILLATION

METHODOLOGY: REPORTS BEING PREPARED

MARK II PRESSURE SUPPRESSION CONTAINMENT SYSTEMS

DYNAMIC LOADS DURING SRV DISCHARGE THROUGH A QUENCHER

STRUCTURE: SUPPRESSION POOL BOUNDARY

LOADS: OSCILLATING PRESSURE CAUSED BY AIR BUBBLES

METHODOLOGY:
- -- DFFR SECTION 3.3
- -- EMPIRICAL CORRELATION FOR POSITIVE PRESSURE
- -- INDEPENDENT OF LINE CLEARING MODEL
- -- 2 Ro/R ATTENUATION
- -- MULTIPLE VALVES ADDES $\sqrt{SS}$
- -- LOAD CASES SAME AS GESSAR
- -- CONSECUTIVE ACTUATION CONSIDERED

NOTE: IMPROVEMENTS IN LOAD DEFINITION MAY BE POSSIBLE AND WORK IS UNDERWAY IN SOME AREAS.

CAORSO SRV DISCHARGE TESTS

STATUS

- FUEL LOADED
- EXPECTED HEAT-UP START-END OF JANUARY 1978
- START FIRST TEST SERIES - MARCH/APRIL 1978

CAORSO SRV DISCHARGE TESTS

TESTS PLANNED

- SINGLE VALVE INITIAL ACTUATION (~ 22 TESTS)
- MULTIPLE VALVE ACTUATION (~ 12 TESTS)
  - 2 ADJACENT VALVES (2 TESTS)
  - 3 ADJACENT VALVES (1 TEST)
  - 4 ADJACENT VALVES (4 TESTS)
  - 4 VALVE SYMMETRIC AROUND POOL (1 TEST)
  - 1 TO 8 VALVES (~ 3 TO 5, NORMAL STARTUP)
- SINGLE VALVE CONSECUTIVE ACTUATIONS (~ 7 TESTS)
  - 5 ACTUATIONS/TEST

MARK II PRESSURE SUPPRESSION CONTAINMENT SYSTEMS

CAORSO QUENCHER TEST PROGRAM

SUMMARY OF POST-TEST ANALYTICAL STUDIES

FOR SINGLE, MULTIPLE AND CONSECUTIVE VALVE ACTUATIONS, EVALUATE DATA ON:

- POOL BOUNDARY LOADS
- BUBBLE PRESSURE
- PIPE CLEARING TRANSIENT (PRESSURE/WATER LEVEL)
- DISCHARGE LINE REFLOOD HEIGHT FOLLOWING VALVE CLOSURE
- SUBMERGED STRUCTURE LOADS (SPOT CHECK)
- CONTAINMENT STRUCTURAL RESPONSE
- QUENCHER LOADS AND RESPONSE

MARK II PRESSURE SUPPRESSION CONTAINMENT SYSTEMS

APPLICATION OF THE QUENCHER

SUMMARY OF LEAD QUENCHER PLANT STATUS

- ALL QUENCHER RELATED DYNAMIC LOADS HAVE BEEN IDENTIFIED AND CONSIDERED
- CONSERVATIVE METHODOLOGY IN PLACE
- WORK UNDERWAY TO IMPROVE QUENCHER METHODS
- CAORSO TESTS WILL PROVIDE CONFIRMATORY DATA

QUENCHER SUBMERGED STRUCTURES

- METHODOLOGY SIMILAR TO RAMSHEAD
- REPORTS TO BE SUBMITTED 2Q78
    - AIR BUBBLE MODEL
    - WATER JET MODEL
    - APPLICATION MEMORANDUM UPDATE