Enclosure 2

Nebraska Public Power District

Cooper Nuclear Station

# PLANT UNIQUE ANALYSIS REPORT

Mark I Containment Program

Revision 0

April, 1982

# INTRODUCTION

- CNS MARK I CONTAINMENT REEVALUATION COMPLETE
- REEVALUATION BASED ON LOADS NOT CONSIDERED IN ORIGINAL DESIGN
- PUAR
  - DESCRIBES EVALUATIONS PERFORMED
  - LOAD DEFINITIONS
  - MODIFICATIONS INSTALLED
  - ACCEPTANCE CRITERIA
  - EVALUATION RESULTS
- PRESESENTATION ATTENDEES
  - MR. L. KUNCL, (NPPD) DIVISION MANAGER, NUCLEAR ENGINEERING
  - MR. J. PILANT, (NPPD) DIVISION MANAGER, LICENSING AND QA
  - MR. R. D. BOYLE, (NPPD) MANAGER NUCLEAR ENGINEERING
  - MR. D. W. OGDEN, (KE) PROJECT MANAGER, CNS MARK I PROGRAM
  - MR. R. J. STUART, (EDS) VICE PRESIDENT
  - MR. M. N. SHULMAN, (EDS) DIVISION MANAGER, ADVANCED ANALYSIS
  - MR. R. BROMAN, (EDS) DIVISION MANAGER, ENGINEERING SERVICES
  - MR. A. P. CIMENTO, (EDS) SUPERVISING ENGINEER, ADVANCED ANALYSIS

# PRESENTATION CONTENTS

SUMMARY
OF CONTAINMENT
MODIFICATIONS

SUMMARY
OF LOAD DEFINITION
AND TREATMENT

SUMMARY
OF STRUCTURAL
EVALUATIONS

# OVERVIEW OF PROGRAM HISTORY

- ORIGINAL DESIGN CONSIDERED ONLY DESIGN TEMPERATURE AND PRESSURE FOR LOCA

- IDENTIFICATION OF ADDITIONAL LOADS
  - MARK III CONTAINMENT LARGE SCALE TESTING
  - MARK I OPERATING EXPERIENCE

- NRC REQUEST IN 1975
  - FEBRUARY, S/RV DISCHARGE
  - APRIL, NEW LOCA LOADS

- FORMATION OF OWNER'S GROUP
  - SHORT TERM PROGRAM
  - LONG TERM PROGRAM

# SHORT TERM PROGRAM

- OBJECTIVE
  - VERIFY INTEGRITY AND FUNCTIONAL CAPABILITY
  - JUSTIFY CONTINUED OPERATION

- RESULTS
  - REPORT OUTLINING TASKS IN 1975
  - EVALUATIONS COMPLETED IN 1976

    REQUIRED ACTIONS TAKEN

    REQUIREMENT FOR PUA ESTABLISHED

    FUNCTIONAL PERFORMANCE OF CONTAINMENT DEMONSTRATED

    FACTOR OF SAFETY OF 2 AGAINST FAILURE

# LONG TERM PROGRAM

- INITIATED IN JUNE 1976

- OBJECTIVES
  - DESIGN BASIS LOADS
  - RESTORE ORIGINAL SAFETY MARGINS

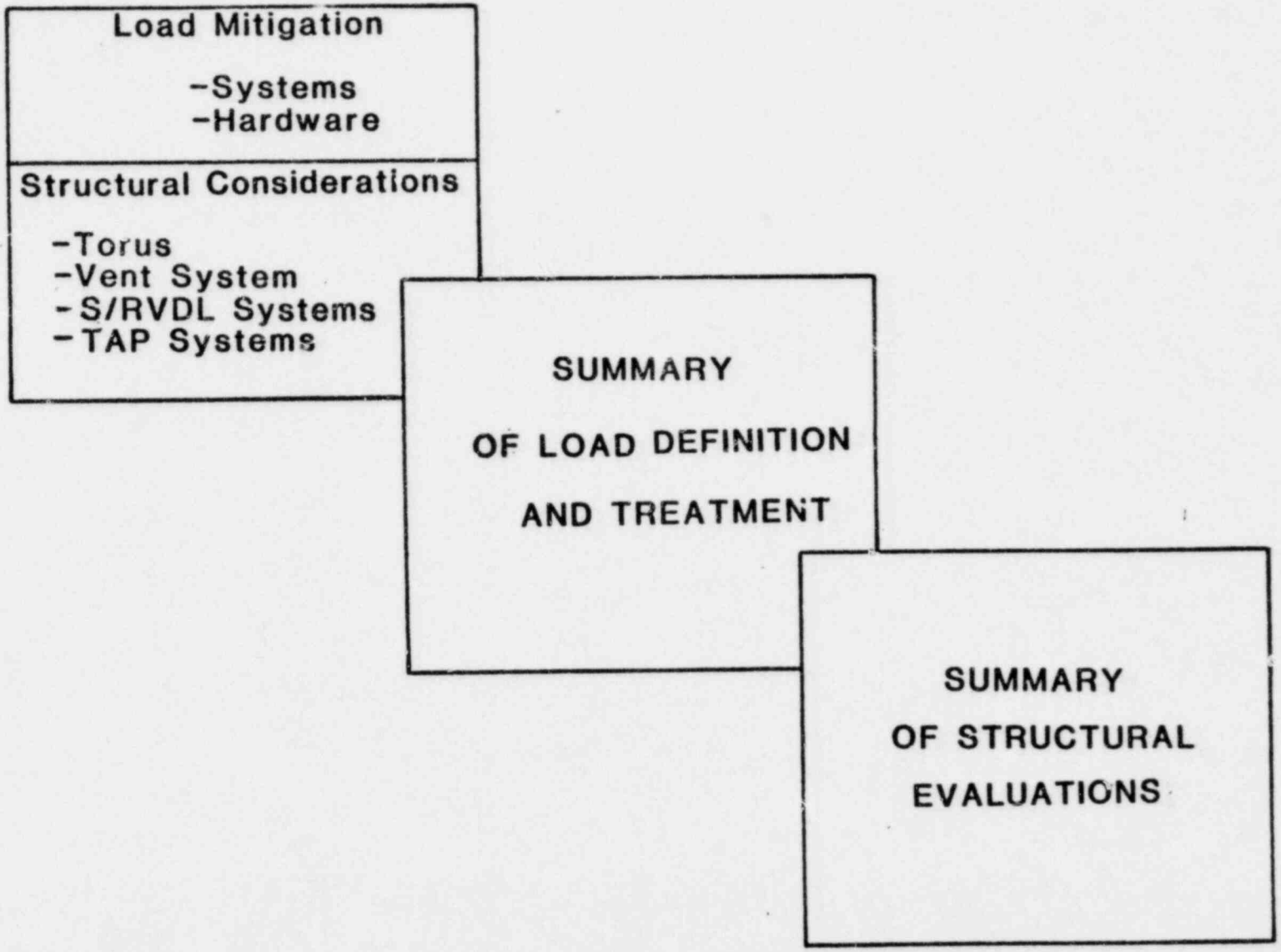
- REQUIREMENTS
  - EXTENSIVE TESTING AND ANALYSIS PROGRAM
  - ESTABLISH CRITERIA
  - EVALUATE LOAD MITIGATION DEVICES AND SYSTEM MODIFICATIONS
  - PLANT UNIQUE ANALYSIS AND MODIFICATIONS

- STATUS
  - PUAR COMPLETED
  - MODIFICATION TO BE COMPLETED BY SEPTEMBER 1982

## DESIGN CRITERIA

| | Original Requirements | New Requirements | Exceptions |
|---|---|---|---|
| Structural | ASME B&PV Code, Section III June 1967 | Mark I Structural Acceptance Criteria PUAAG - As modified by NRC Acceptance Criteria | Dynamic Response Combination |
| Piping | USAS B31.1 1967 | Mark I Structural Acceptance Criteria PUAAG - As modified by NRC Acceptance Criteria | Dynamic Response Combination |
| Systems | FSAR | Mark I Structural Acceptance Criteria PUAAG - As modified by NRC Acceptance Criteria | None |
| Loads | Design Pressure and Temperature | G.E. Load Definition Report (Nov. 1981) as modified by NRC Acceptance Criteria | DBA CO Random Phasing MVA S/RV Pressure Combination 30% R.H. in S/RVDL |

# PRESENTATION CONTENTS - SUMMARY OF MODIFICATIONS

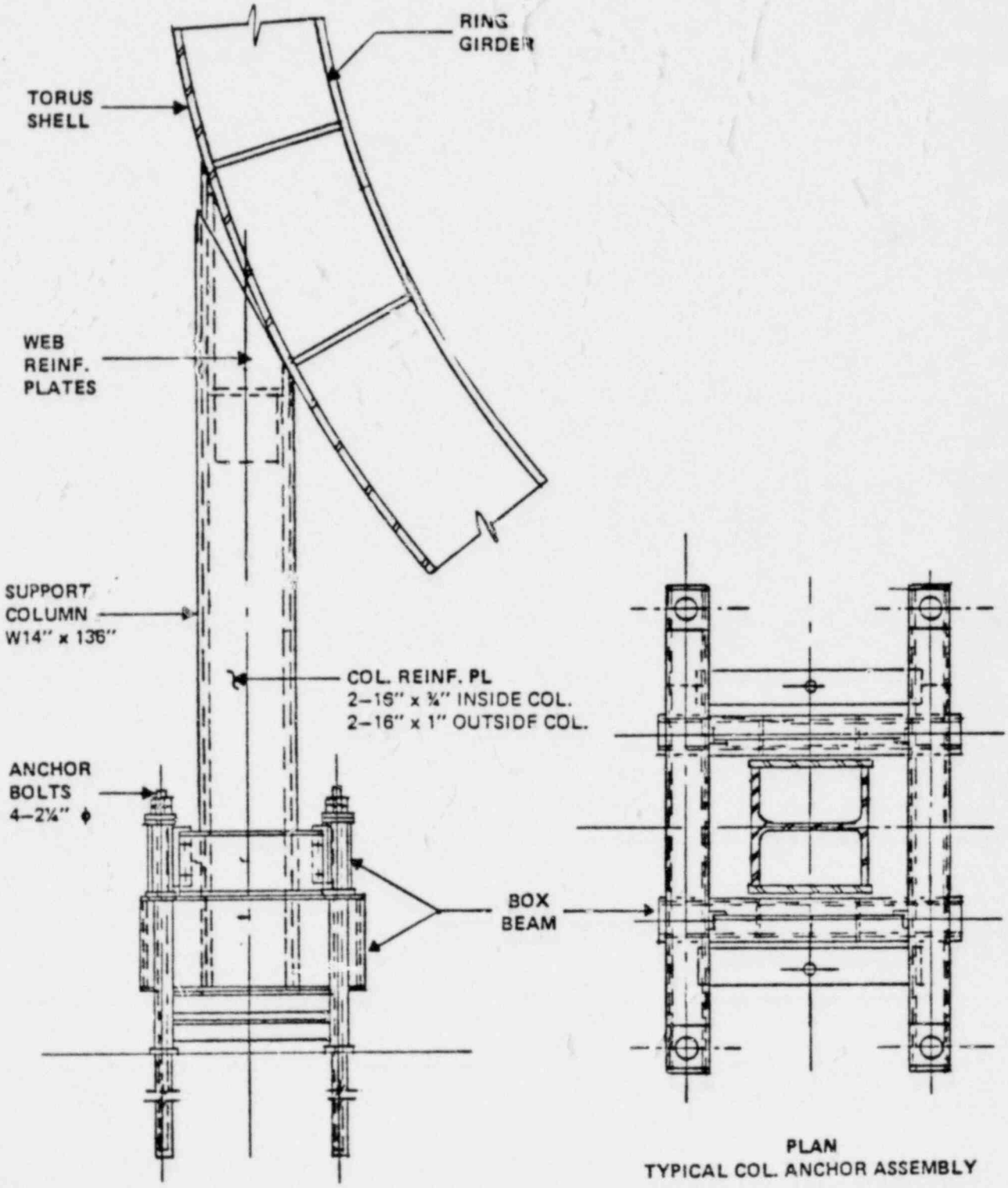


# SUMMARY OF CONTAINMENT MODIFICATIONS

- LOAD MITIGATION
  - PUMP AROUND SYSTEM - MAINTAIN $\Delta P$
  - S/RV LOW-LOW SET LOGIC
  - MSIV WATER LEVEL TRIP
  - TORUS TEMPERATURE MONITORING SYSTEM
  - TRUNCATION OF DOWNCOMER
  - VENT HEADER DEFLECTOR
  - T-QUENCHER INSTALLATION

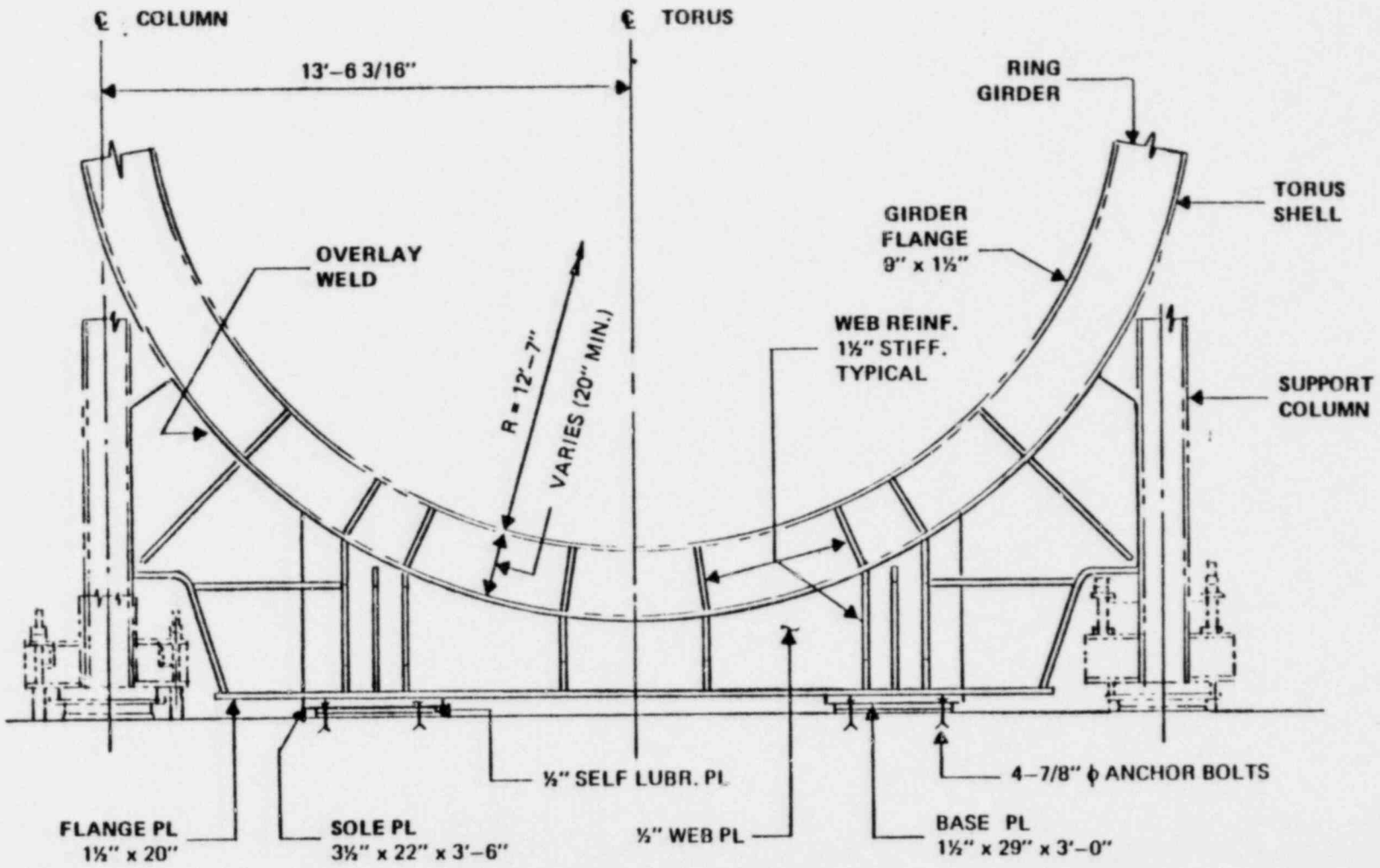
- STRUCTURAL REINFORCEMENT
  - TORUS SUPPORTS STRENGTHENED
  - ADDITION OF SADDLES
  - TORUS RING GIRDER STIFFENERS
  - DOWNCOMERS REINFORCED
  - VENT SYSTEM SUPPORT ALTERED
  - VACUUM BREAKERS REINFORCED
  - PLATFORM AND MONORAIL SUPPORTS REINFORCED
  - S/RVDL PIPING REROUTED
  - S/RVDL PIPE SUPPORTS MODIFIED, ADDED
  - TAP SUPPORTS MODIFIED, ADDED
  - INTERNAL AND SMALL BORE PIPE REROUTED
  - PUMP AND VALVE CONFIGURATIONS STRENGTHENED

OBJECTIVE: INCREASED COLUMN CAPACITY



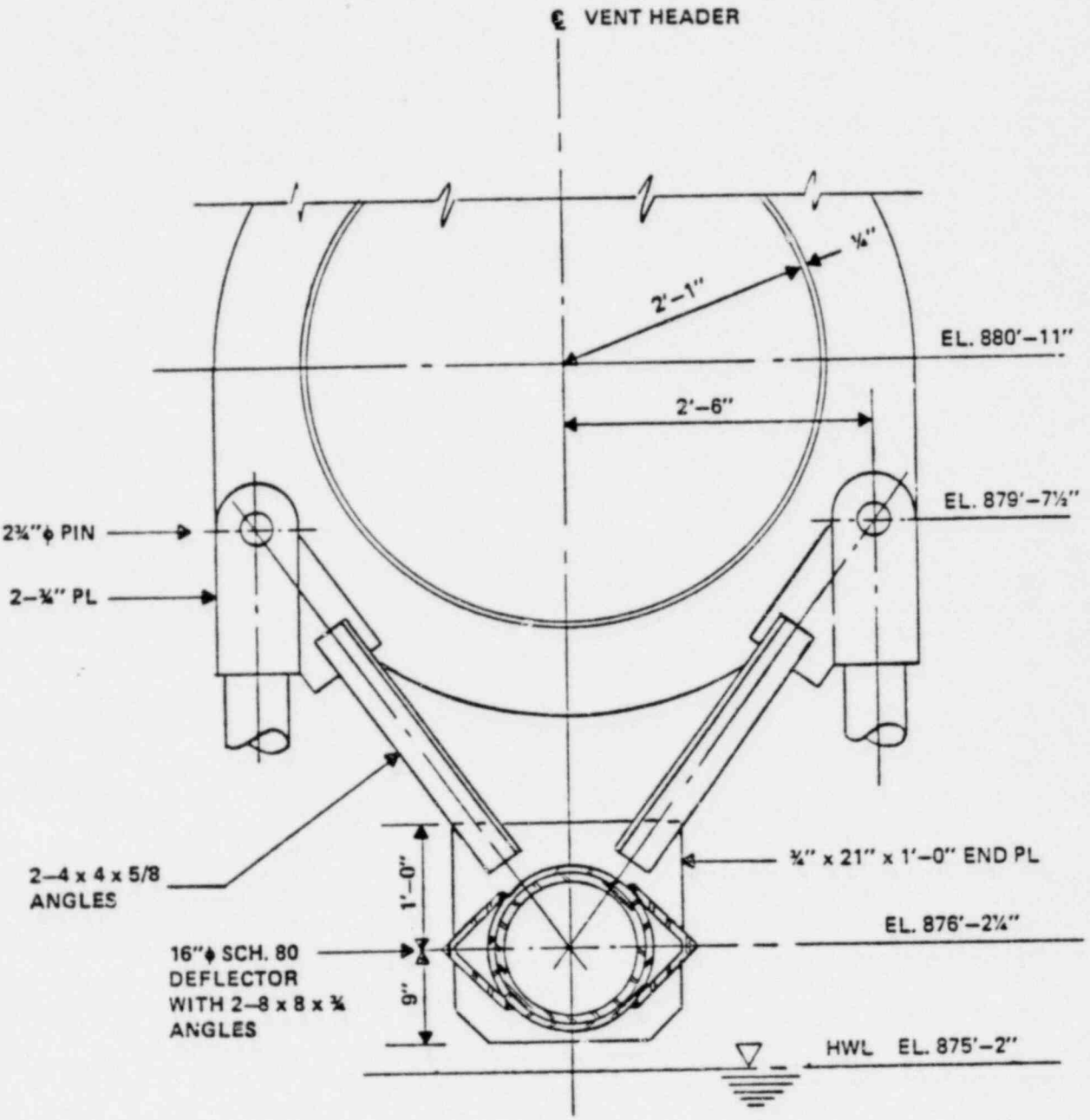

TORUS SUPPORT COLUMN

OBJECTIVE: INHIBIT SHELL OVALIZATION



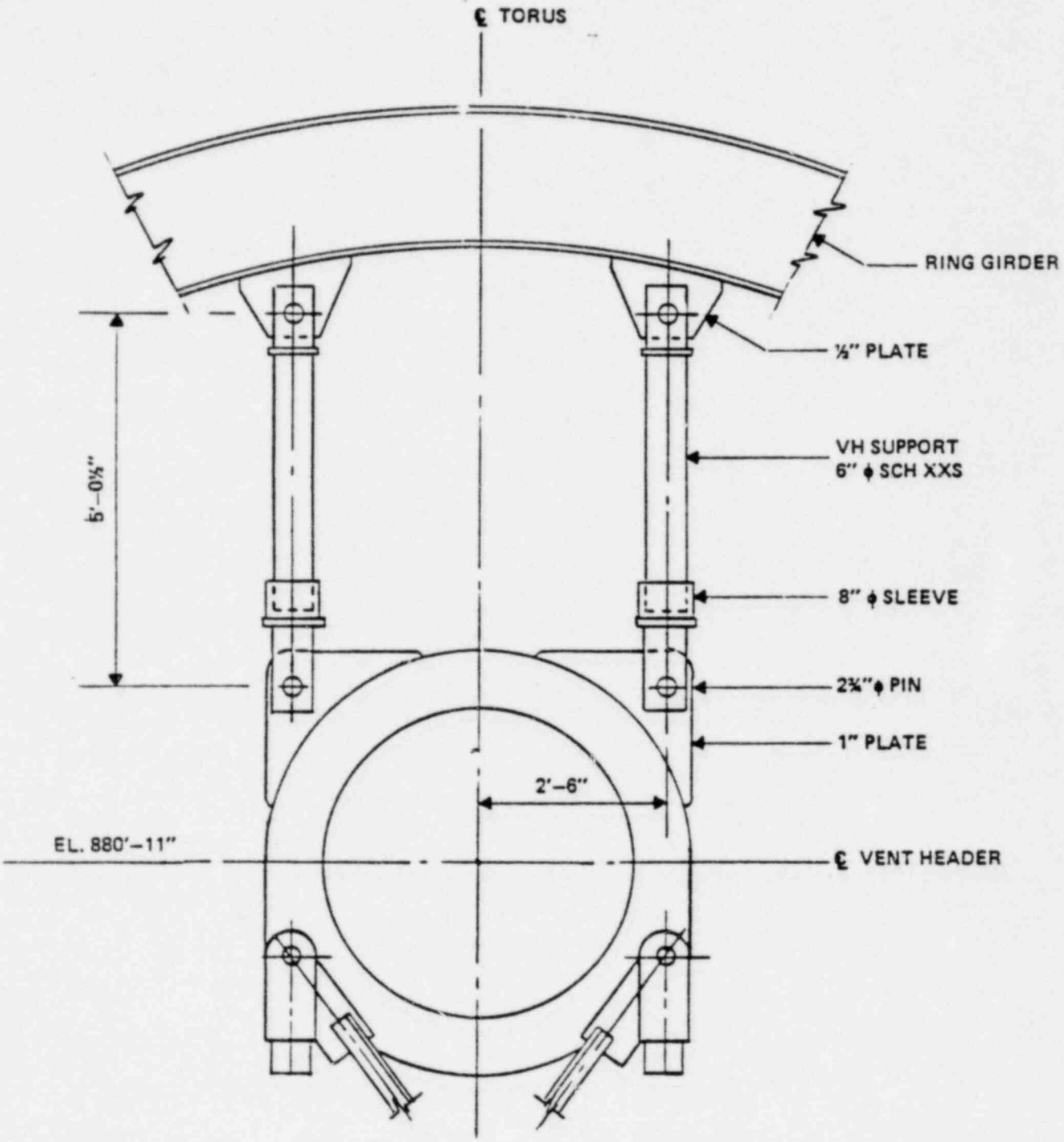

TORUS SADDLE

OBJECTIVE: MITIGATE POOL SWELL LOADS ON VENT HEADER



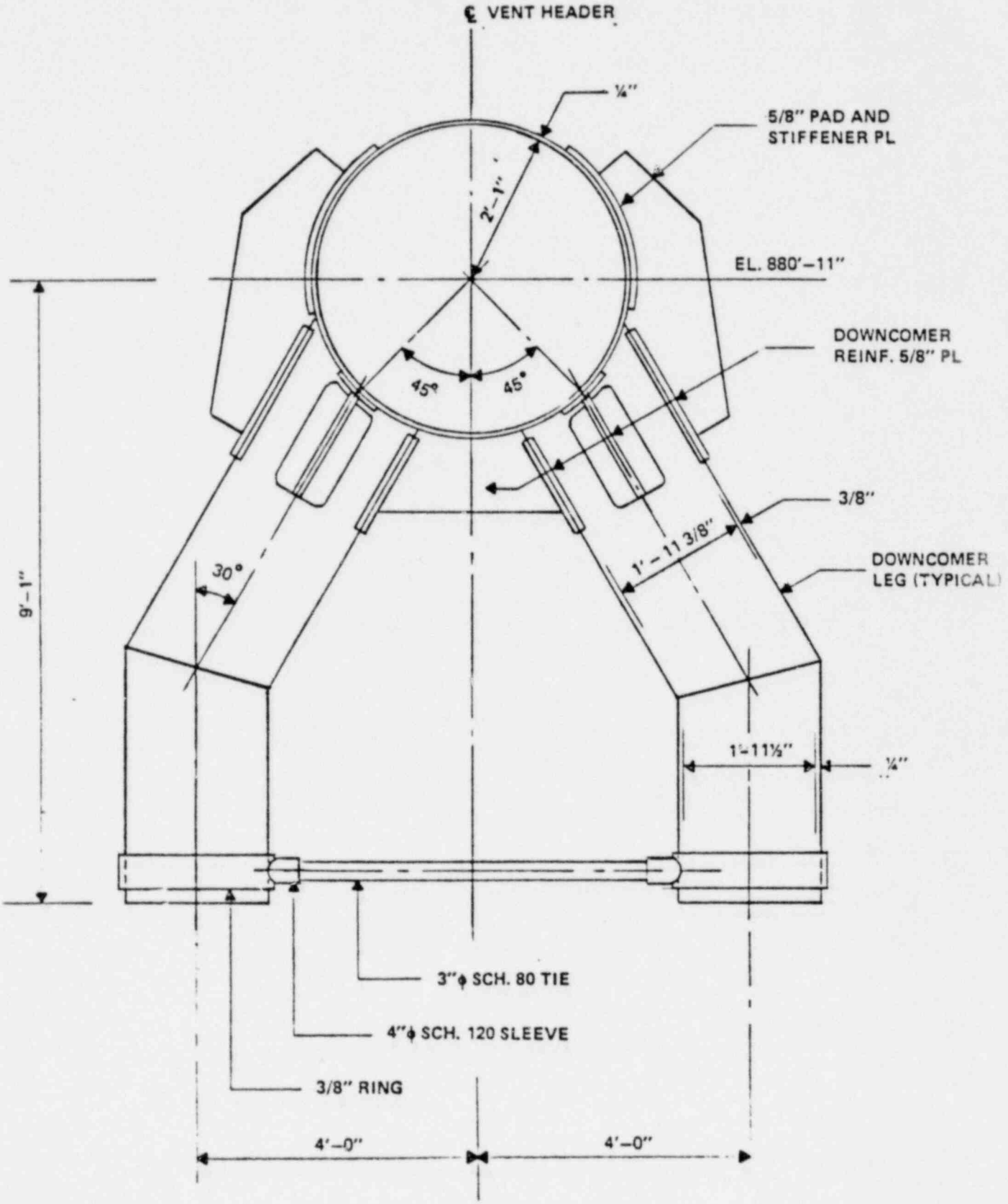

VENT HEADER DEFLECTOR

OBJECTIVE: REDUCE DRAG LOADS ON VENT HEADER SUPPORTS



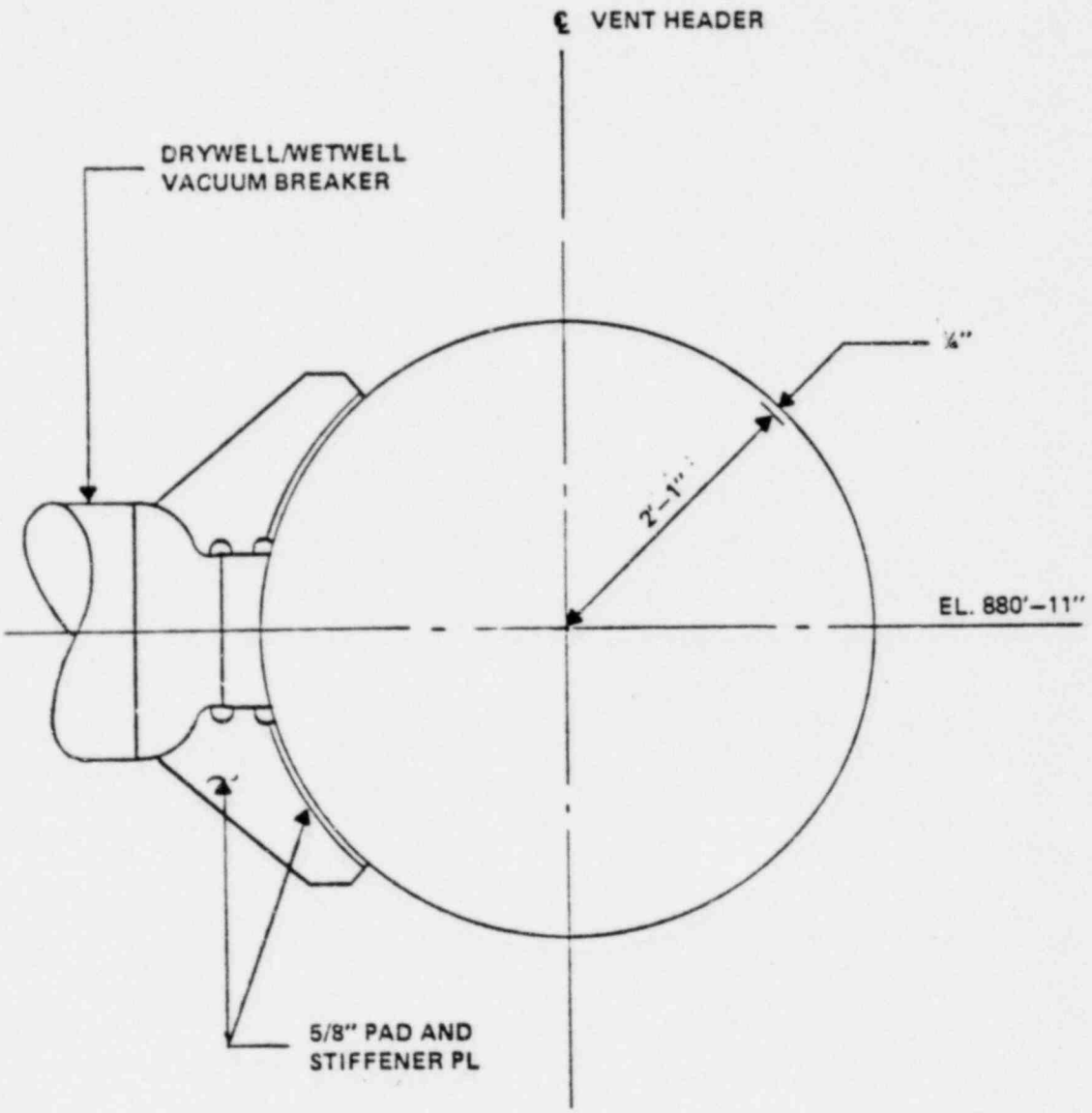

VENT HEADER SUPPORT COLUMNS

OBJECTIVE: REDUCE STRESSES AT INTERSECTION




DOWNCOMER REINFORCEMENT

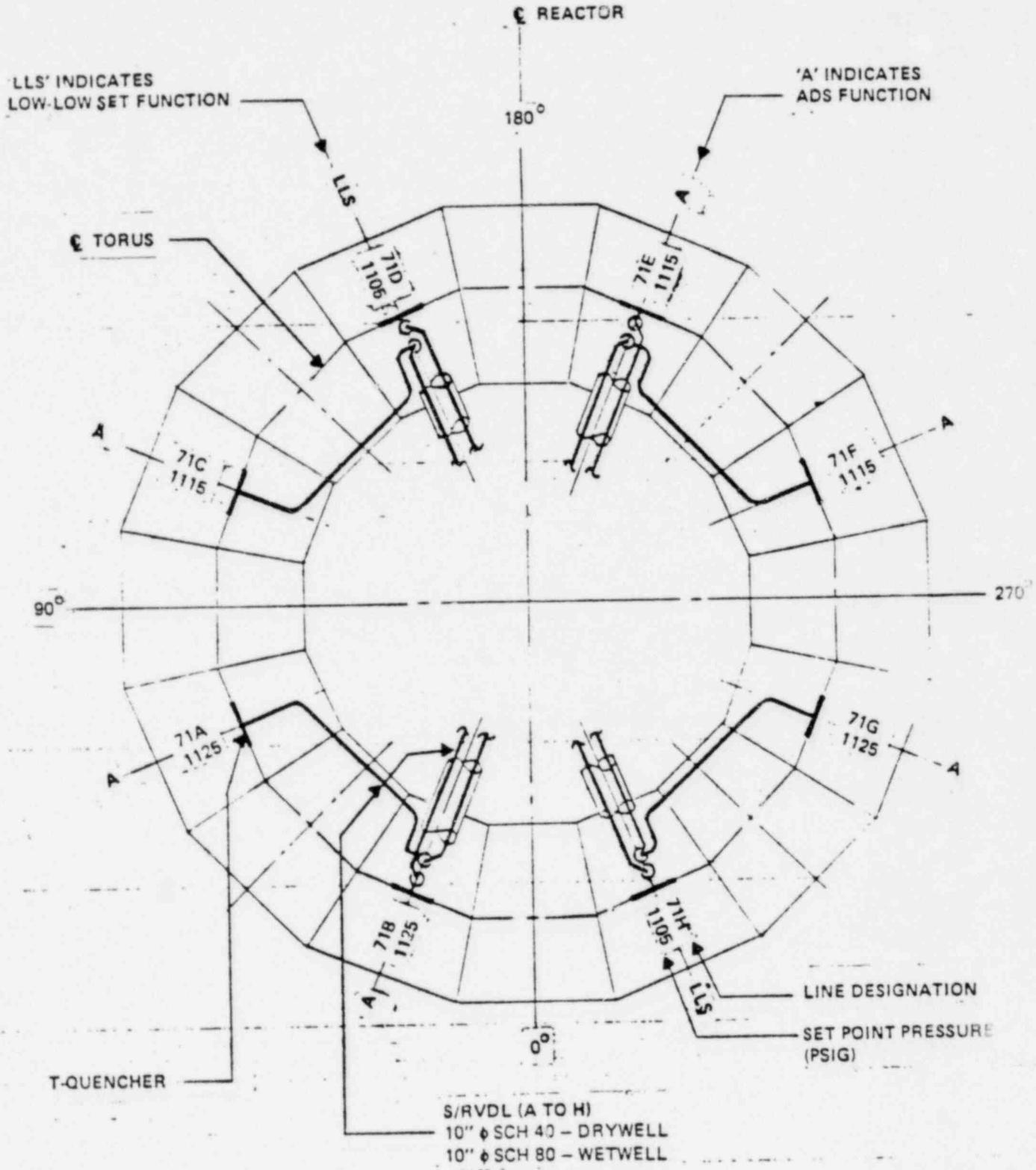
OBJECTIVE: REDUCE STRESSES AT PENETRATION DUE TO POOL SWELL IMPACT AND FROTH IMPINGEMENT




DRYWELL/WETWELL VACUUM BREAKER REINFORCEMENT

## OBJECTIVES:

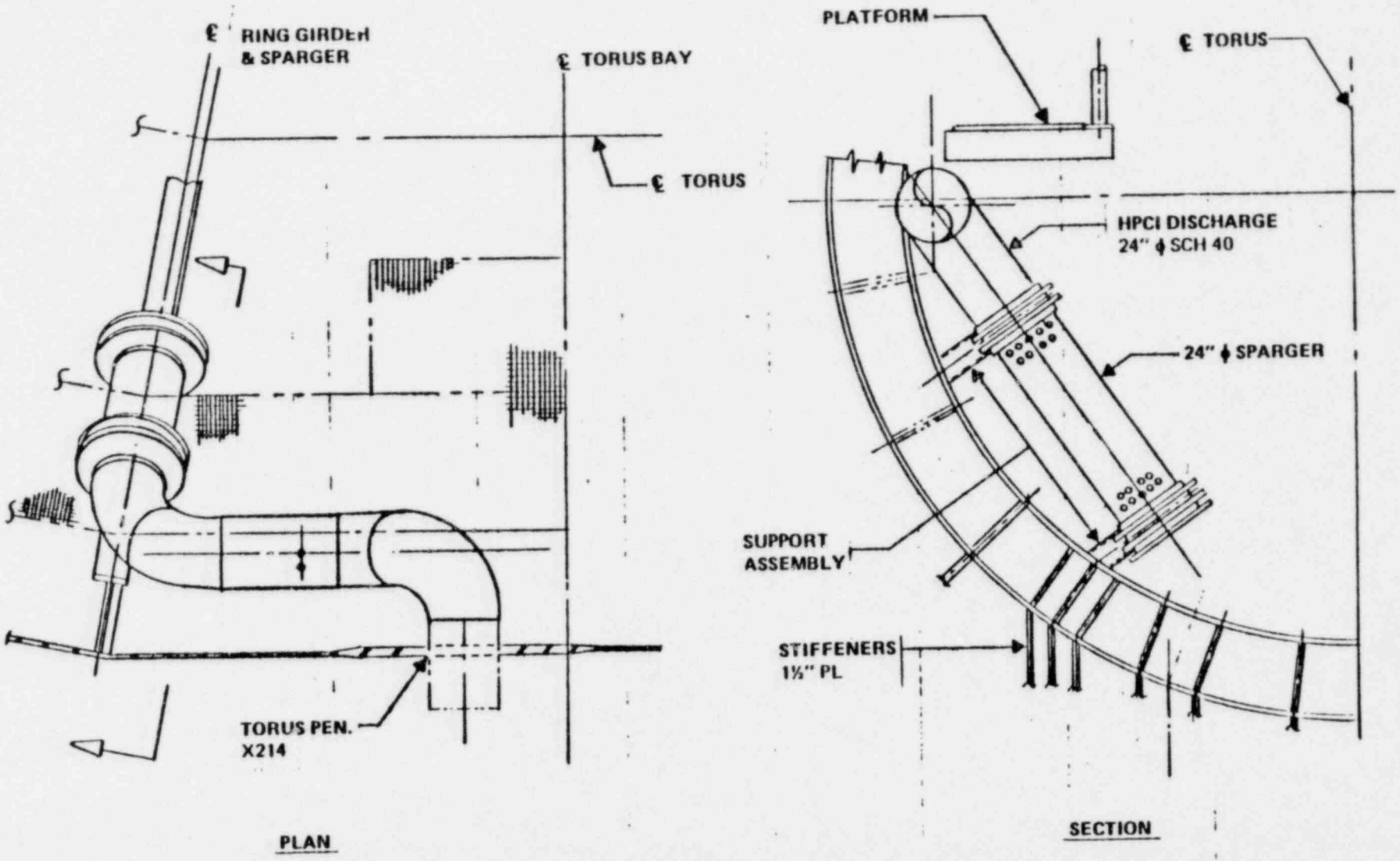
-INSTALLATION OF T-QUENCHERS: BETTER DISCHARGE DEVICE DISTRIBUTION
-REROUTE PIPE; MINIMIZE LOADS
-RESUPPORT PIPING WETWELL AND DRYWELL: QUALIFY FOR LINE CLEARING LOADS




WETWELL ROUTING OF S/RVDLS

OBJECTIVE :

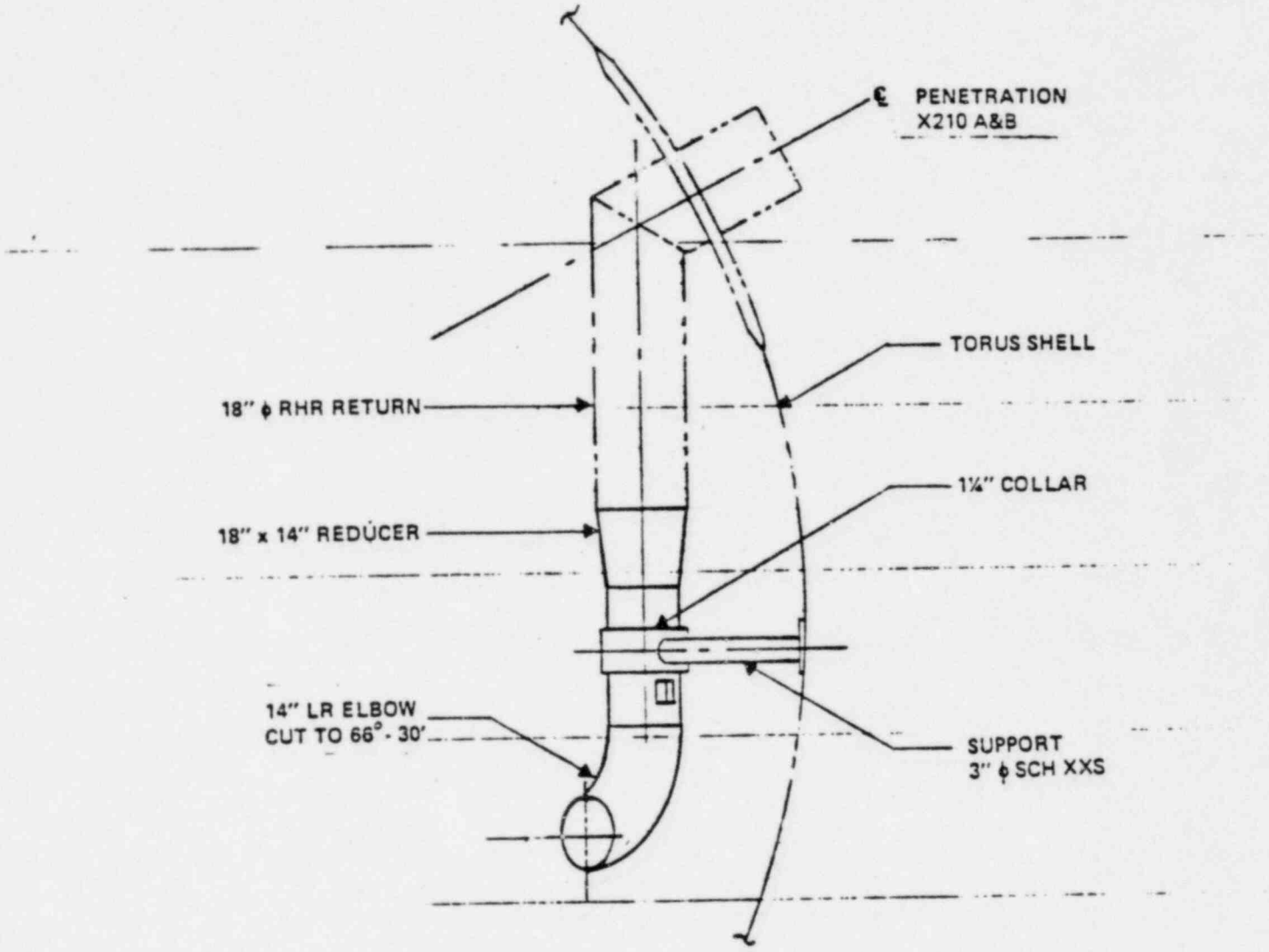
TO REDUCE DRAG LOADS




HCPI TURBINE EXHAUST - REROUTE/RESUPPORT

OBJECTIVES:

-IMPROVE POOL CIRCULATION (THERMAL MIXING)
-BRACE FOR HIGH DRAG LOADS




RHR PUMP TEST RETURN LINE MODIFICATION

# TORUS ATTACHED PIPING MODIFICATIONS

- PIPE SUPPORTS ON LARGE BORE TAP
  - 14 ADDED
  - 137 OF 239 MODIFIED
- SMALL BORE TAP
  - 60 NEW OR MODIFIED SUPPORTS
  - 4 LINES REROUTED
- BRANCH PIPING
  - 25 NEW OR MODIFIED SUPPORTS
- VALVES
  - 13 VALVES REINFORCED
- TORUS SHELL PENETRATIONS
  - 3 PENETRATIONS REINFORCED
- ECCS PUMPS
  - 4 PUMP ANCHORAGES REINFORCED

# SYSTEM MODIFICATIONS

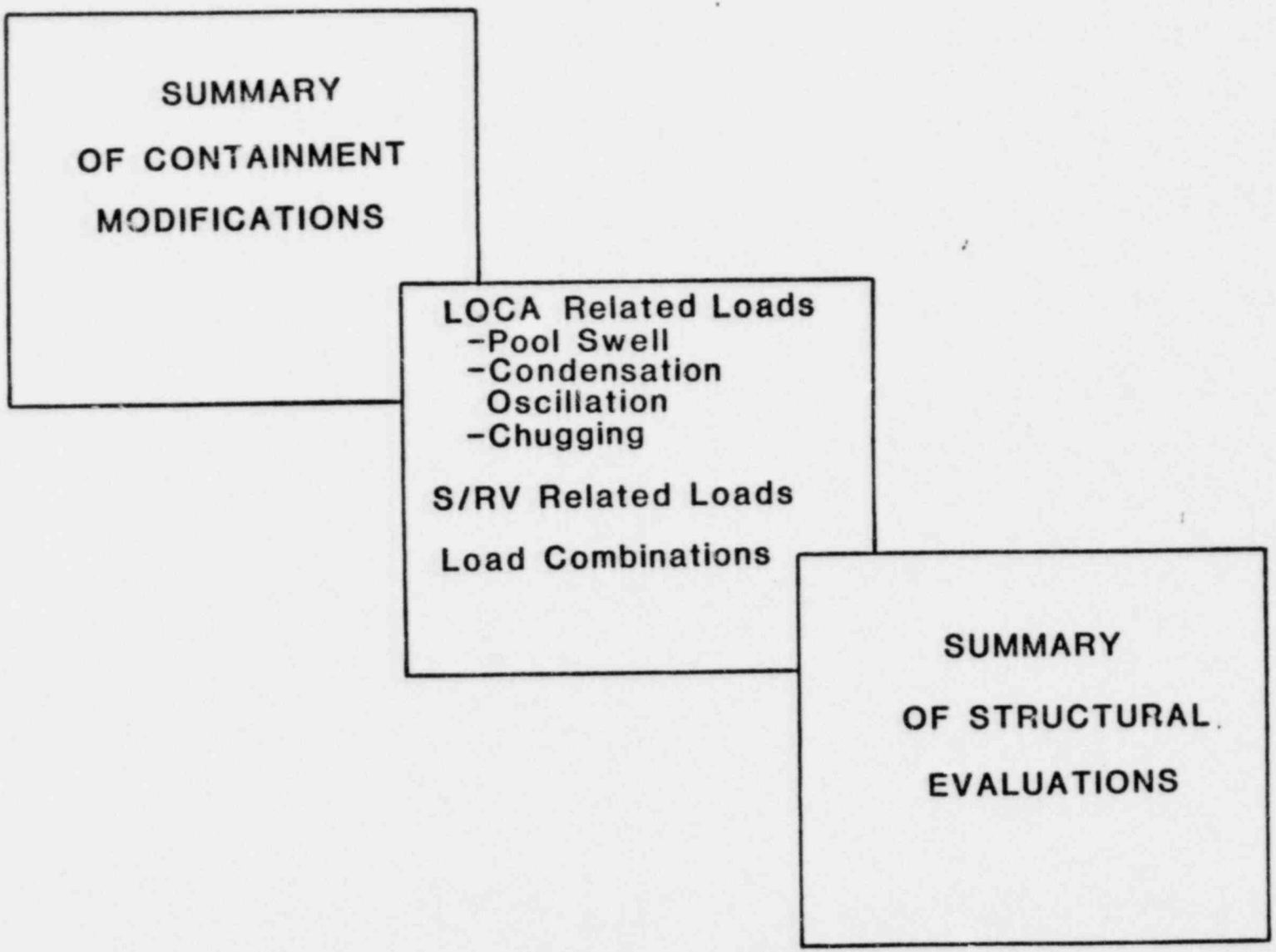
- DRYWELL-TO-WETWELL $\Delta P$
  - MAINTAIN PRESSURE DIFFERENTIAL BETWEEN DRYWELL AND TORUS
  - MITIGATE POOL SWELL LOADS ON TORUS AND VENT SYSTEM

- LOW-LOW SET RELIEF LOGIC
  - INCREASE REACTOR DEPRESSURIZATION FOLLOWING S/RV ACTUATION
  - INCREASE TIMING BETWEEN ACTUATIONS
  - REDUCE LOADS DUE TO CONSECUTIVE ACTUATIONS AND NUMBER OF S/RV ACTUATIONS

- MSIV WATER LEVEL TRIP
  - DELAY MSIV ISOLATION TO RELEASE MORE REACTOR ENERGY
  - ELIMINATE 2ND ACTUATIONS OF S/RV DURING IBA/SBA

- POOL TEMPERATURE MONITORING SYSTEM
  - MEASURE LOCAL POOL TEMPERATURES NEAR T-QUENCHERS
  - ENSURE POOL TEMPERATURES STAY WITHIN ALLOWABLE LIMITS

# PRESENTATION CONTENTS - LOAD DEFINITION AND TREATMENT



# SUMMARY OF LOAD DEFINITION AND APPLICATION

- LOAD DEFINITION IS BASED ON:
  - GE LOAD DEFINITION REPORT
  - MARK I PUAAG
  - NRC ACCEPTANCE CRITERIA
  - NRC SAFETY EVALUATION REPORT

- PLANT UNIQUE LOAD DEFINITIONS

- LOAD APPLICATION

# LOADS AND LOAD COMBINATIONS

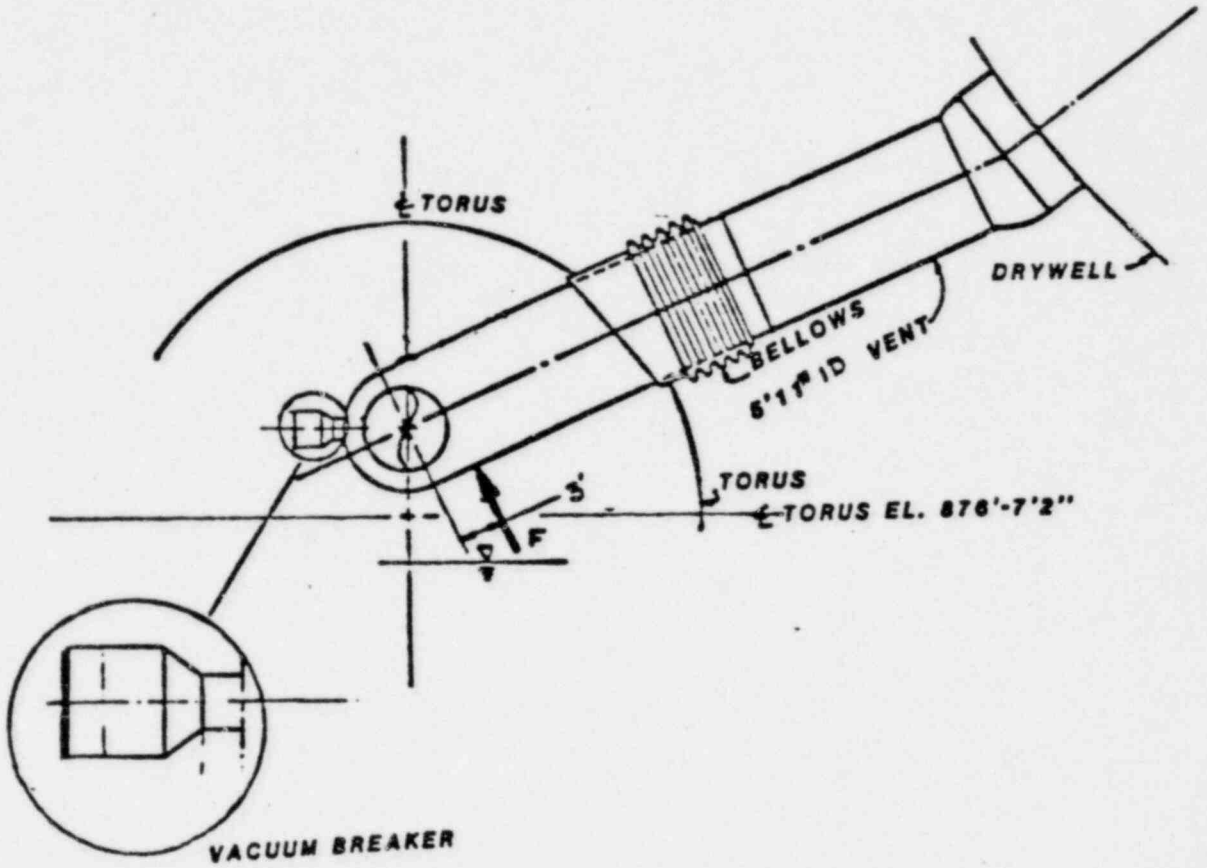
- THERMAL-HYDRAULIC PARAMETERS
  - BASED ON CNS FSAR
  - ALTERED BY SYSTEM MODIFICATION
  - USED BOTH ZERO $\Delta P$ AND CURRENT $\Delta P$
- ORIGINAL DESIGN LOADS
  - DEAD LOADS
  - SEISMIC LOADS
  - PRESSURE AND TEMPERATURE
  - VENT THRUST LOAD
  - JET FORCES ON DOWNCOMER PIPES
- LOCA RELATED LOADS
- S/RV DISCHARGE RELATED LOADS
- DETERMINATION OF LOAD COMBINATIONS

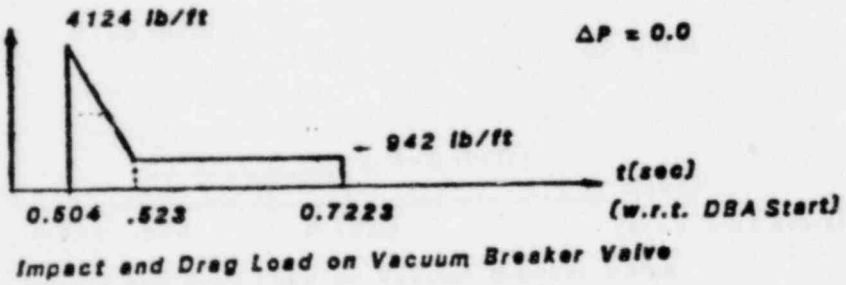
# LOCA RELATED LOADS

- CATEGORIES OF A LOCA
  - DESIGN BASIS ACCIDENT (DBA)
  - INTERMEDIATE BREAK ACCIDENT (IBA)
  - SMALL BREAK ACCIDENT (SBA)

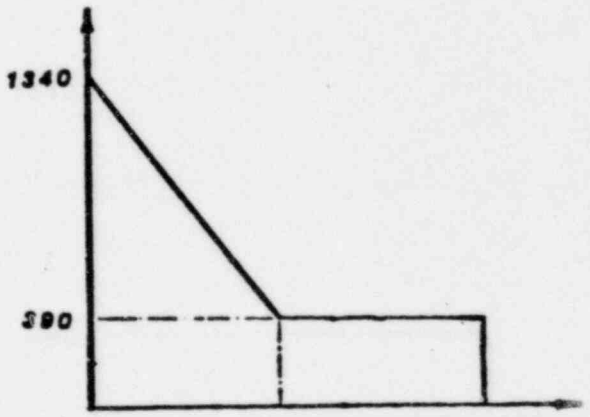
- SPECIFIC LOADS AND TRANSIENTS
  - PRESSURE AND TEMPERATURE
  - VENT SYSTEM THRUST
  - POOL SWELL
  - CONDENSATION OSCILLATION
  - CHUGGING

| LOAD/STRUCTURE MATRIX<br>LOADS | Torus Shell | Torus Support System | Main Vents | Vent Header | Downcomers | Vent Header Deflector | Above HWL | Below HWL and Above Downcomer Exit | Below HWL and Below Downcomer Exit | Safety/Relief Valve Discharge Lines |
|---|---|---|---|---|---|---|---|---|---|---|
| LOCA RELATED LOADS | | | | | | | | | | |
| Containment Pressure and Temperature | X | X | X | X | X | X | X | X | X | X |
| Vent System Thrust Loads | | | X | X | X | | | | | |
| *Loads Associated with Pool Swell | | | | | | | | | | |
| Torus Net Vertical Loads | X | X | | | | | | | | |
| Torus Shell Pressure Histories | X | X | | | | | | | | |
| Impact and Drag Loads | | | | | | | | | | |
| Vent System Impact and Drag | | | X | X | X | X | | | | |
| Other Structures | | | | | | | X | | | X |
| Froth Impingement | | | X | | | | X | | | |
| Pool Fallback | | | | | | | | X | X | |
| LOCA Jet | | | | | | | | | X | X |
| LOCA Bubble Drag | | | | | | | | X | X | X |
| Condensation Oscillation | | | | | | | | | | |
| Torus Shell Loads | X | X | | | | | | | | |
| Vent System Loads | | | X | X | X | | | | | |
| Other Submerged Structures | | | | | | | | X | X | |
| Chugging | | | | | | | | | | |
| Torus Shell Loads | X | X | | | | | | | | |
| Vent System Loads | | | X | X | X | | | | | |
| Other Submerged Structures | | | | | | | | X | X | X |
| S/RV DISCHARGE RELATED LOADS | | | | | | | | | | |
| Torus Shell Loads | X | X | | | | | | | | |
| T/Q Water Jet Loads | | | | | | | | X | X | X |
| T/Q Air Bubble Induced Loads | | | | | X | | | X | X | X |
| S/RVDL Clearing Loads | | | | | | | | | | X |
| T-Quencher Thrust Loads | | | | | | | | | | X |




Impact and Drag Load on Vacuum Breaker Valve

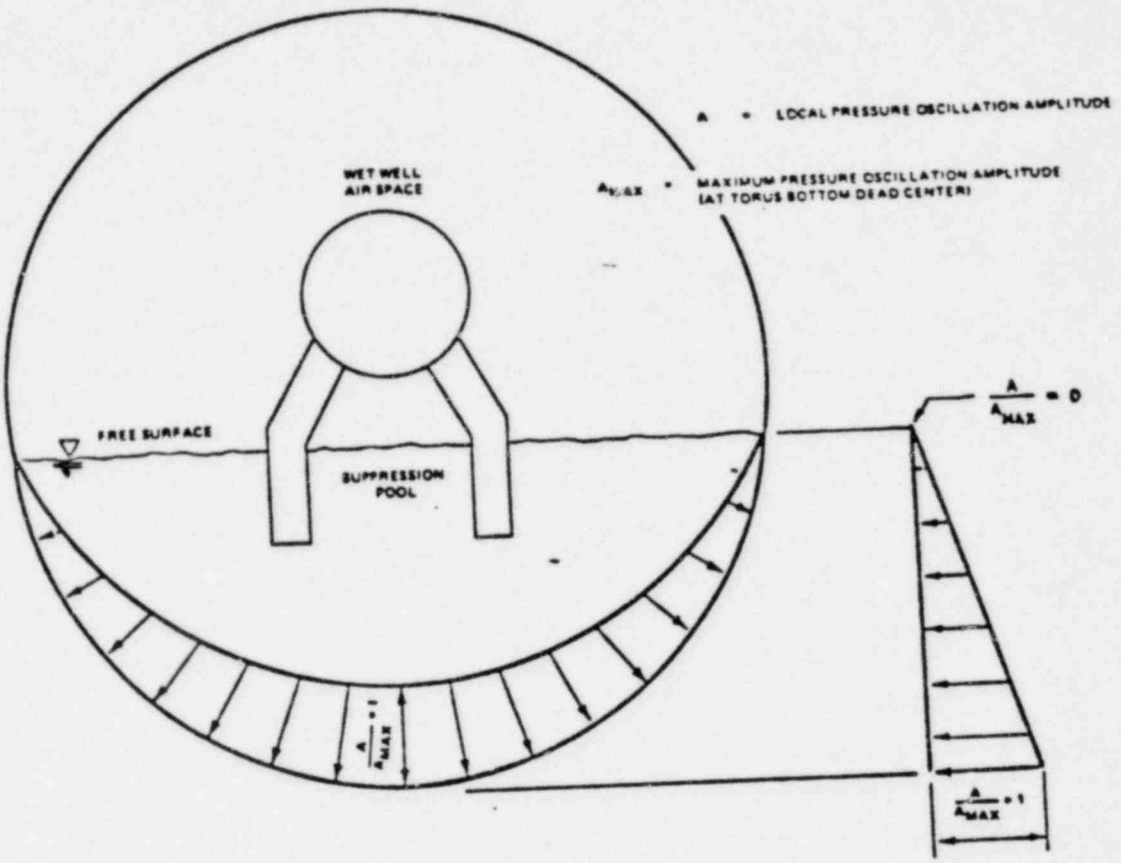



Impact and Drag Load on Main Vent F

FIGURE 2.17

POOL SWELL IMPACT/DRAG LOAD TRANSIENTS
ON MAIN VENT, ΔP = 1.0 psid

| LOAD/STRUCTURE MATRIX<br><br>LOADS | Torus Shell | Torus Support System | Main Vents | Vent Header | Downcomers | Vent Header Deflector | Above HWL | Below HWL and Above Downcomer Exit | Below HWL and Below Downcomer Exit | Safety/Relief Valve Discharge Lines |
|---|---|---|---|---|---|---|---|---|---|---|
| LOCA RELATED LOADS | | | | | | | | | | |
| Containment Pressure and Temperature | X | X | X | X | X | X | X | X | X | X |
| Vent System Thrust Loads | | | X | X | X | | | | | |
| Loads Associated with Pool Swell | | | | | | | | | | |
| Torus Net Vertical Loads | X | X | | | | | | | | |
| Torus Shell Pressure Histories | X | X | | | | | | | | |
| Impact and Drag Loads | | | | | | | | | | |
| Vent System Impact and Drag | | | X | X | X | X | | | | |
| Other Structures | | | | | | | X | | | X |
| Froth Impingement | | | X | | | | X | | | |
| Pool Fallback | | | | | | | | X | X | |
| LOCA Jet | | | | | | | | | X | X |
| LOCA Bubble Drag | | | | | | | | X | X | X |
| *Condensation Oscillation | | | | | | | | | | |
| Torus Shell Loads | X | X | | | | | | | | |
| Vent System Loads | | | X | X | X | | | | | |
| Other Submerged Structures | | | | | | | | X | X | |
| Chugging | | | | | | | | | | |
| Torus Shell Loads | X | X | | | | | | | | |
| Vent System Loads | | | X | X | X | | | | | |
| Other Submerged Structures | | | | | | | | X | X | X |
| S/RV DISCHARGE RELATED LOADS | | | | | | | | | | |
| Torus Shell Loads | X | X | | | | | | | | |
| T/Q Water Jet Loads | | | | | | | | X | X | X |
| T/Q Air Bubble Induced Loads | | | | | X | | | X | X | X |
| S/RVDL Clearing Loads | | | | | | | | | | X |
| T-Quencher Thrust Loads | | | | | | | | | | X |



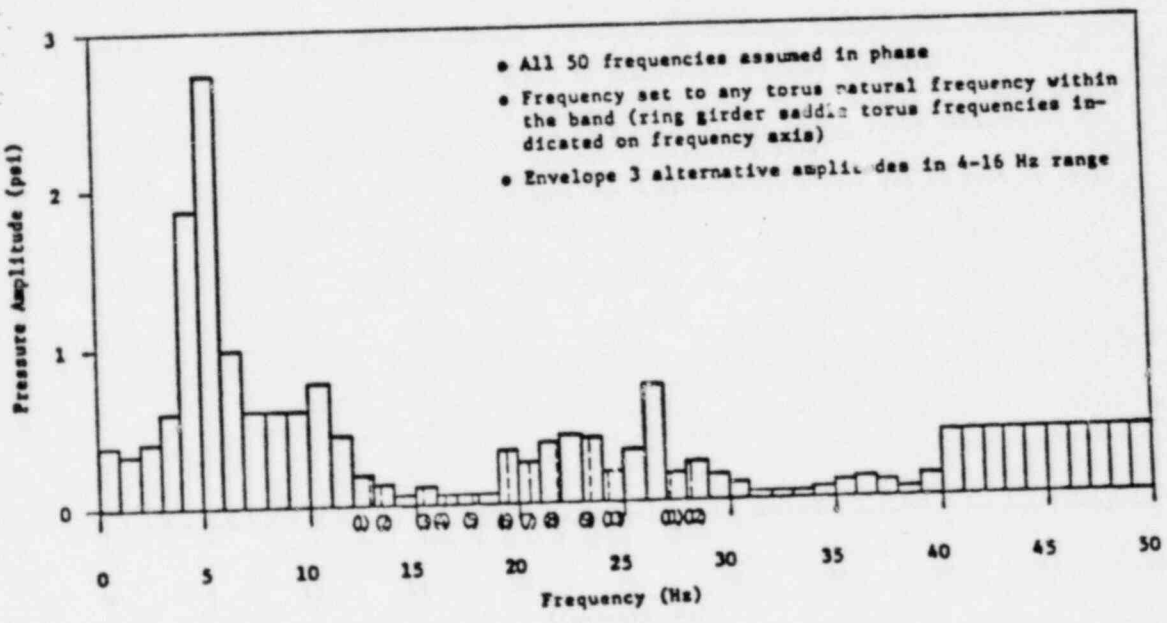




FIGURE 2.21

TORUS PRESSURE AMPLITUDE DISTRIBUTION FOR CONDENSATION OSCILLATION

# DBA CO RANDOM PHASING

- DESCRIPTION
  - DESIGN RULE FOR COMBINING STRUCTURAL RESPONSES TO CO LOAD HARMONICS
  - 4 ASUM + 46 SRSS
  - 1.3 X TIME HISTORY WITH RANDOM PHASE ANGLES
- REASONS
  - FSTF TEST DATA SHOWS RANDOMNESS
  - ASUM RULE SIGNIFICANTLY OVERPREDICTS FSTF DATA
  - OTHER AREAS OF CONSERVATISM IN CO LOAD DEFINITION
- JUSTIFICATION
  - EMPIRICAL DATA
    - o EXAMINE FSTF DATA FOR RANDOMNESS
    - o DESIGN RULE PREDICTIONS BOUND FSTF MEASURED RESPONSE
  - ANALYTICAL STUDIES
    - o STATISTICAL STUDIES WITH RANDOM PHASING
    - o DESIGN RULE EXCEEDS 84% NEP LEVEL
  - GENERIC MARK I REPORT

| LOAD/STRUCTURE MATRIX<br><br>LOADS | Torus Shell | Torus Support System | Main Vents | Vent Header | Downcomers | Vent Header Deflector | Above HWL | Below HWL and Above Downcomer Exit | Below HWL and Below Downcomer Exit | Safety/Relief Valve Discharge Lines |
|---|---|---|---|---|---|---|---|---|---|---|
| LOCA RELATED LOADS | | | | | | | | | | |
| Containment Pressure and Temperature | X | X | X | X | X | X | X | X | X | X |
| Vent System Thrust Loads | | | X | X | X | | | | | |
| Loads Associated with Pool Swell | | | | | | | | | | |
| Torus Net Vertical Loads | X | X | | | | | | | | |
| Torus Shell Pressure Histories | X | X | | | | | | | | |
| Impact and Drag Loads | | | | | | | | | | |
| Vent System Impact and Drag | | | X | X | X | X | | | | |
| Other Structures | | | | | | | X | | | X |
| Froth Impingement | | | X | | | | X | | | |
| Pool Fallback | | | | | | | | X | X | |
| LOCA Jet | | | | | | | | | X | X |
| LOCA Bubble Drag | | | | | | | | X | X | X |
| Condensation Oscillation | | | | | | | | | | |
| Torus Shell Loads | X | X | | | | | | | | |
| Vent System Loads | | | X | X | X | | | | | |
| Other Submerged Structures | | | | | | | | X | X | |
| *Chugging | | | | | | | | | | |
| Torus Shell Loads | X | X | | | | | | | | |
| Vent System Loads | | | X | X | X | | | | | |
| Other Submerged Structures | | | | | | | | X | X | X |
| S/RV DISCHARGE RELATED LOADS | | | | | | | | | | |
| Torus Shell Loads | X | X | | | | | | | | |
| T/Q Water Jet Loads | | | | | | | | X | X | X |
| T/Q Air Bubble Induced Loads | | | | | X | | | X | X | X |
| S/RVDL Clearing Loads | | | | | | | | | | X |
| T-Quencher Thrust Loads | | | | | | | | | | X |

| LOAD/STRUCTURE MATRIX<br>LOADS | Torus Shell | Torus Support System | Main Vents | Vent Header | Downcomers | Vent Header Deflector | Above HWL | Below HWL and Above Downcomer Exit | Below HWL and Below Downcomer Exit | Safety/Relief Valve Discharge Lines |
|---|---|---|---|---|---|---|---|---|---|---|
| LOCA RELATED LOADS | | | | | | | | | | |
| Containment Pressure and Temperature | X | X | X | X | X | X | X | X | X | X |
| Vent System Thrust Loads | | | X | X | X | | | | | |
| Loads Associated with Pool Swell | | | | | | | | | | |
| Torus Net Vertical Loads | X | X | | | | | | | | |
| Torus Shell Pressure Histories | X | X | | | | | | | | |
| Impact and Drag Loads | | | | | | | | | | |
| Vent System Impact and Drag | | | X | X | X | X | | | | |
| Other Structures | | | | | | | X | | | X |
| Froth Impingement | | | X | | | | X | | | |
| Pool Fallback | | | | | | | | X | X | |
| LOCA Jet | | | | | | | | | X | X |
| LOCA Bubble Drag | | | | | | | | X | X | X |
| Condensation Oscillation | | | | | | | | | | |
| Torus Shell Loads | X | X | | | | | | | | |
| Vent System Loads | | | X | X | X | | | | | |
| Other Submerged Structures | | | | | | | | X | X | |
| Chugging | | | | | | | | | | |
| Torus Shell Loads | X | X | | | | | | | | |
| Vent System Loads | | | X | X | X | | | | | |
| Other Submerged Structures | | | | | | | | X | X | X |
| *S/RV DISCHARGE RELATED LOADS | | | | | | | | | | |
| Torus Shell Loads | X | X | | | | | | | | |
| T/Q Water Jet Loads | | | | | | | | X | X | X |
| T/Q Air Bubble Induced Loads | | | | | X | | | X | X | X |
| S/RVDL Clearing Loads | | | | | | | | | | X |
| T-Quencher Thrust Loads | | | | | | | | | | X |

# S/RV DISCHARGE TORUS SHELL PRESSURES
# MULTIPLE VALVE ACTUATIONS

- DESCRIPTION
  - COMBINATION METHOD FOR SPATIAL DISTRIBUTION OF TORUS PRESSURES DUE TO MVA
  - 1.2 X SRSS OF PRESSURE FROM EACH DISCHARGE DEVICE

- REASONS
  - ABSOLUTE SUM OF PRESSURES ASSUMES IN-PHASE BEHAVIOR OF BUBBLES
  - NO PHYSICAL BASIS FOR IN-PHASE BEHAVIOR
  - MVA PRESSURES LIMIT DESIGN

- JUSTIFICATION
  - PLANT UNIQUE STATISTICAL STUDY
  - MODEL ACTUAL PHASING OF BUBBLES WITH RANDOM VARIATION OF PLANT PARAMETERS
  - 1.2 SRSS PRESSURE BOUNDS RESULTS OVER 90% OF THE TIME

# S/RV TORUS SHELL PRESSURES
# 30% RELATIVE HUMIDITY

- DESCRIPTION
  - INITIAL S/RVDL RELATIVE HUMIDITY OF 30%
  - IBA/SBA CONDITIONS ONLY
  - ADS ACTUATION ONLY

- REASONS
  - PURE AIR MASS ASSUMPTION UNREALISTIC
  - STEAM IN DRYWELL DURING IBA/SBA
  - AT ADS, DRYWELL AIR PURGED TO WETWELL

- JUSTIFICATION
  - EXAMINED

    DRYWELL STEAM CONTENT TRANSIENTS
    CNS S/RVDL VACUUM BREAKER SET POINTS
  - SHOW 90-100% RH IN DRYWELL
  - SHOW 30% RH IN S/RVDL IS STILL CONSERVATIVE

# LOAD COMBINATIONS

- TORUS SHELL
- VENT SYSTEM
- INTERNAL STRUCTURES ABOVE POOL
- SUBMERGED STRUCTURES
- S/RVD PIPING
- TORUS ATTACHED PIPING
- FATIGUE
  - BASIS FOR 40 YEAR LIFE

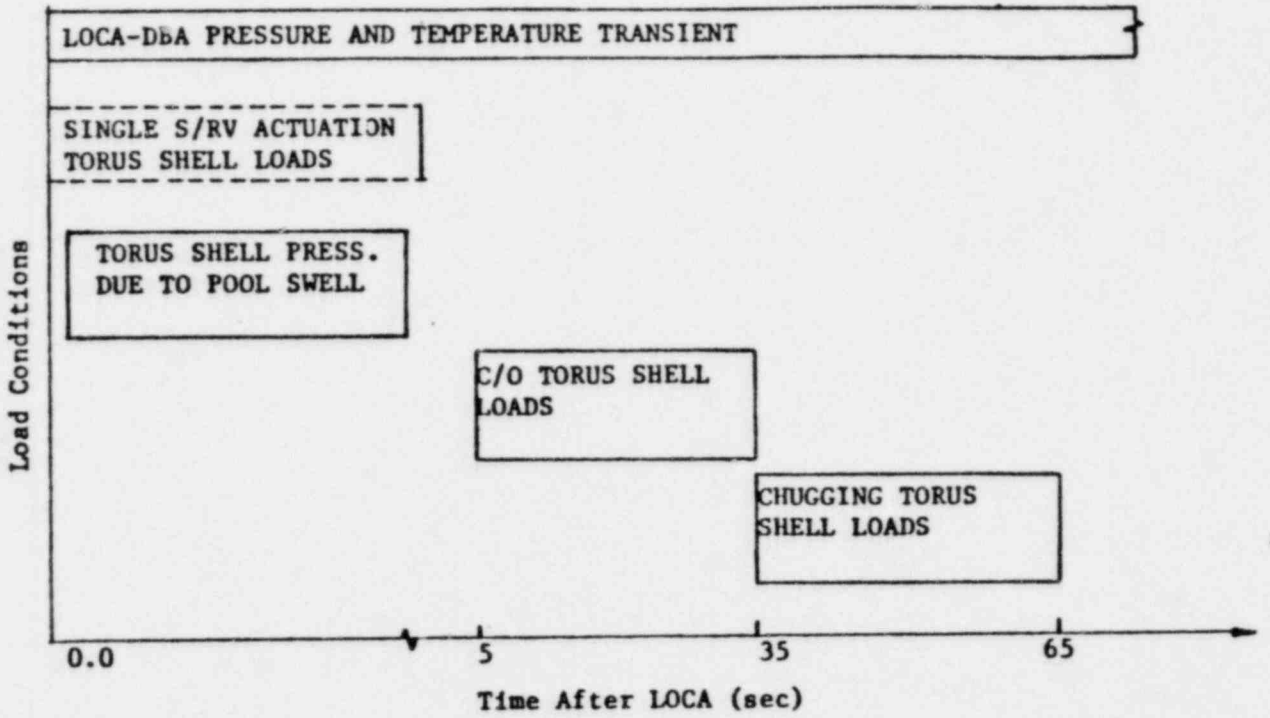
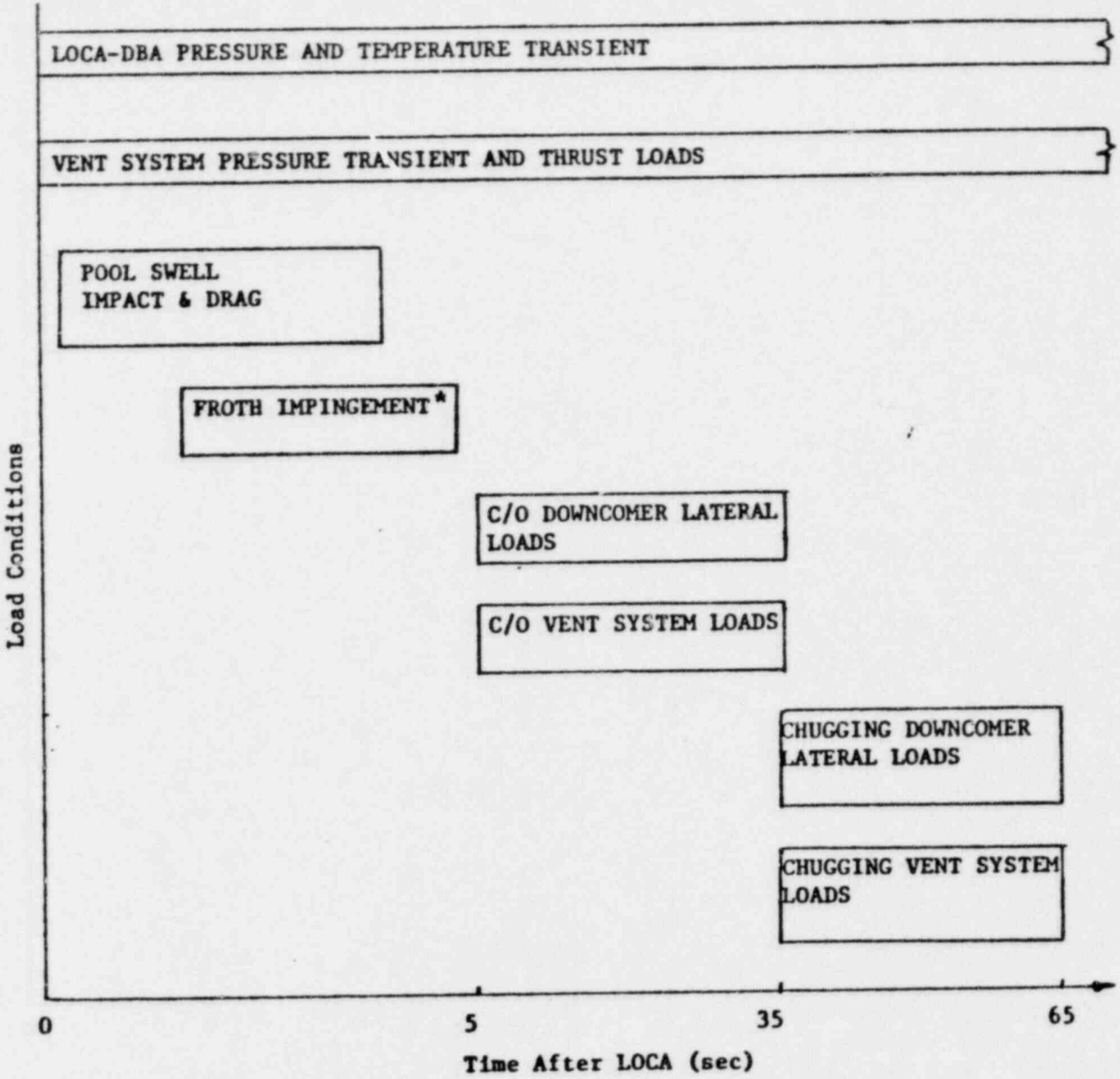



FIGURE 2.25

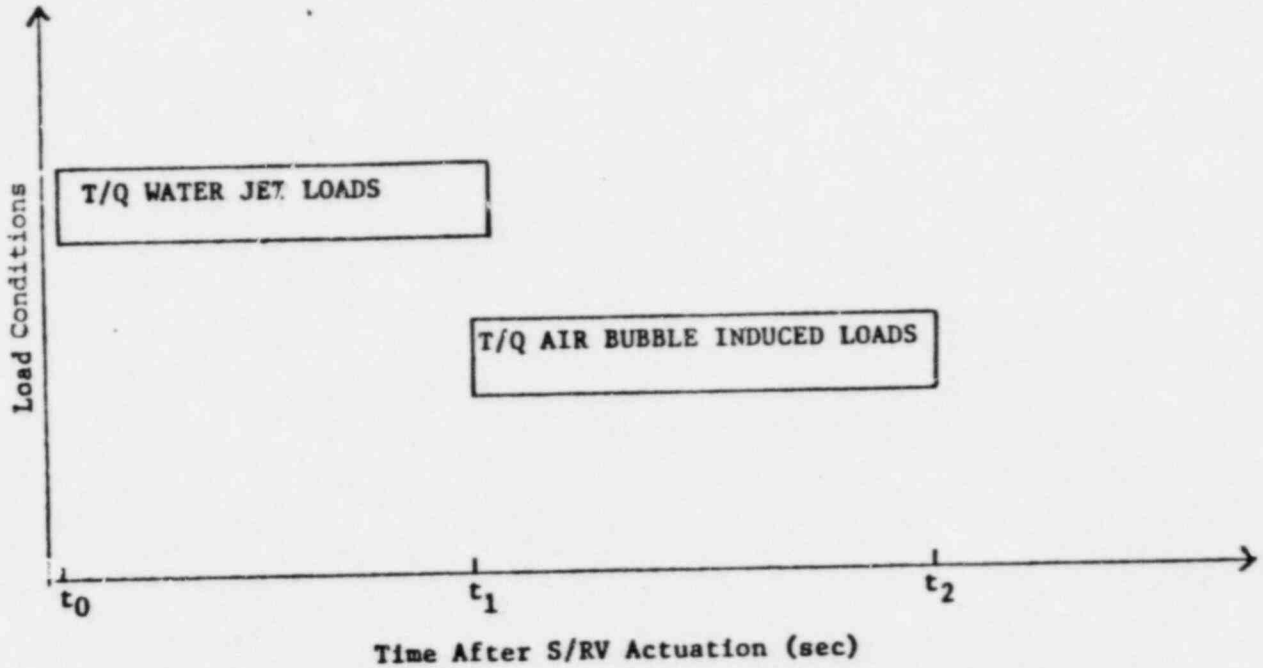
TORUS SHELL LOAD COMBINATIONS FOR LOCA-DBA




*For main vent only.
**For submerged portion of downcomers see also Figure 2.32

FIGURE 2.28

VENT SYSTEM LOAD COMBINATIONS FOR LOCA-DBA**




$t_0$ = S/RV actuation time

$t_1$ = S/RVDL water clearing time

$t_2$ = time at which S/RV bubbles reach pool surface

FIGURE 2.35

S/RV DISCHARGE LOADS ON SUBMERGED STRUCTURES

# PRESENTATION CONTENTS - STRUCTURAL EVALUATION

SUMMARY
OF CONTAINMENT
MODIFICATIONS

SUMMARY
OF LOAD DEFINITION
AND TREATMENT

Torus Shell & Support
Vent System & Supports
S/RV Discharge Piping
Torus Attached Piping

# TORUS SHELL

- LOADS
  - 27 LOAD COMBINATIONS DEFINED
  - POTENTIALLY BOUNDING ONES CONSIDERED

- DESIGN ALLOWABLES
  - CLASS MC VESSEL - SUBSECTION NE
  - BUCKLING ALLOWABLES

- ANALYSIS METHODS
  - SHELL MODELS
    - 1/32 SEGMENT COUPLED SHELL-FLUID MODEL
    - 1/4 SEGMENT PLATE ELEMENT MODEL-SEISMIC
  - STATIC ANALYSIS
    - PRESSURE AND TEMPERATURE
    - GRAVITY
    - SEISMIC
  - DYNAMIC ANALYSIS
    - POOL SWELL
    - DBA CO
    - CHUGGING
    - S/RV DISCHARGE

- CODE EVALUATION
  - MAXIMUM SHELL STRESS
  - FATIGUE USAGE

# TORUS SHELL BUCKLING ALLOWABLES

- DESCRIPTION
  - INVESTIGATION OF DYNAMIC TORUS BUCKLING
  - BUCKLING NOT A CONCERN FOR MARK I LOADS
- REASONS
  - CODE COMPRESSIVE STRESS ALLOWABLES BASED ON STATIC, UNIFORM LOADS
  - MARK I LOADS ARE DYNAMIC, NON-UNIFORM
  - COMPRESSIVE STRESSES OF SHORT DURATION
- JUSTIFICATION
  - LOCA TRANSIENTS NOT CONTROLLING
    - HIGH WETWELL PRESSURE
  - S/RV DISCHARGE EVENTS CONTROL
  - EMPIRICAL EVIDENCE
    - IN-PLANT TESTS
  - CONFIRMATORY NONLINEAR ANALYSIS
    - GENERIC STUDY
    - FACTOR OF SAFETY = 7
    - SATISFY ASME CODE REQUIREMENTS
  - APPLICATION TO CNS
    - GEOMETRY
    - LOADS

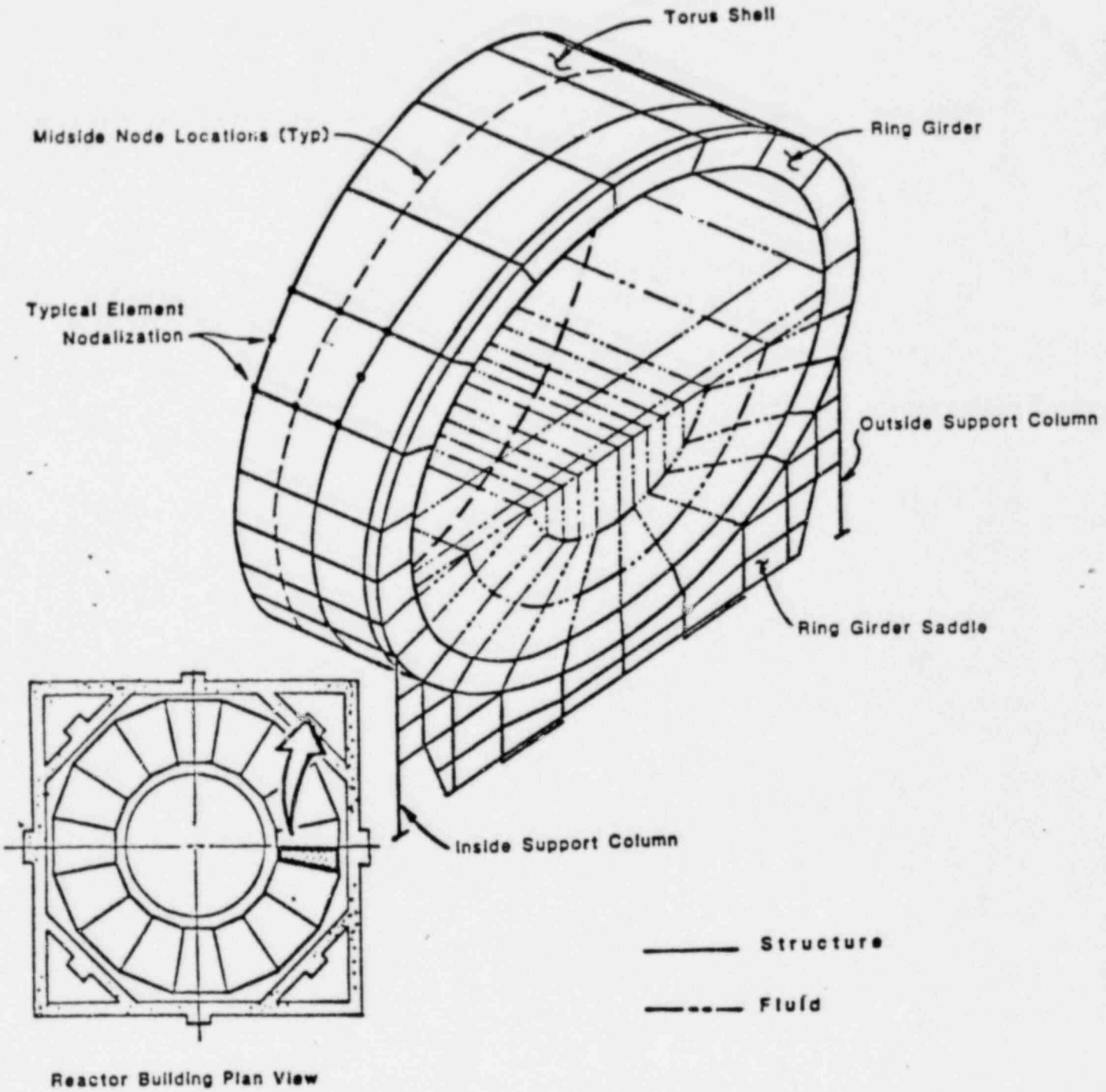



FIGURE 3.1

1/32 SECTION TORUS MODEL

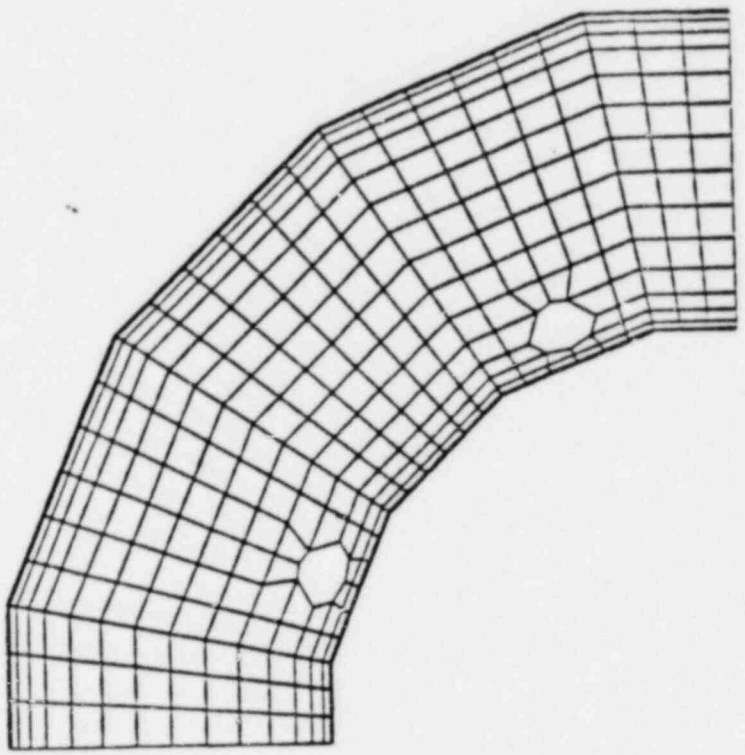


FIGURE 3.2

90° SECTION TORUS MODEL

# TORUS SUPPORT SYSTEM

- DESIGN LOAD COMBINATIONS
  - COLUMN AND ANCHORAGE
    - TORUS SHELL LOADS
  - SEISMIC TIES
    - NET LATERAL LOAD
      - SEISMIC
      - S/RV DISCHARGE
      - PRE-CHUG
  - RING GIRDER SADDLE
    - TORUS SHELL LOADS
    - PRESSURE AND TEMPERATURE

- DESIGN ALLOWABLES
  - LINEAR COMPONENTS - APPENDIX XVII
  - PLATE AND SHELL SUPPORTS - SUBSECTION NF

- ANALYSIS METHODS
  - SUPPORT COLUMNS
  - ANCHORAGE ASSEMBLY
  - SEISMIC TIES

  } SUBSECTION NF AND APPENDIX XVII

  - RING GIRDER SADDLE
    - USED 1/32 SEGMENT SHELL MODEL
    - NONLINEAR ANALYSIS USED FOR INTERMEDIATE SUPPORTS

- CODE EVALUATION
  - MAXIMUM COLUMN/ANCHORAGE LOAD
  - MAXIMUM FATIGUE USAGE

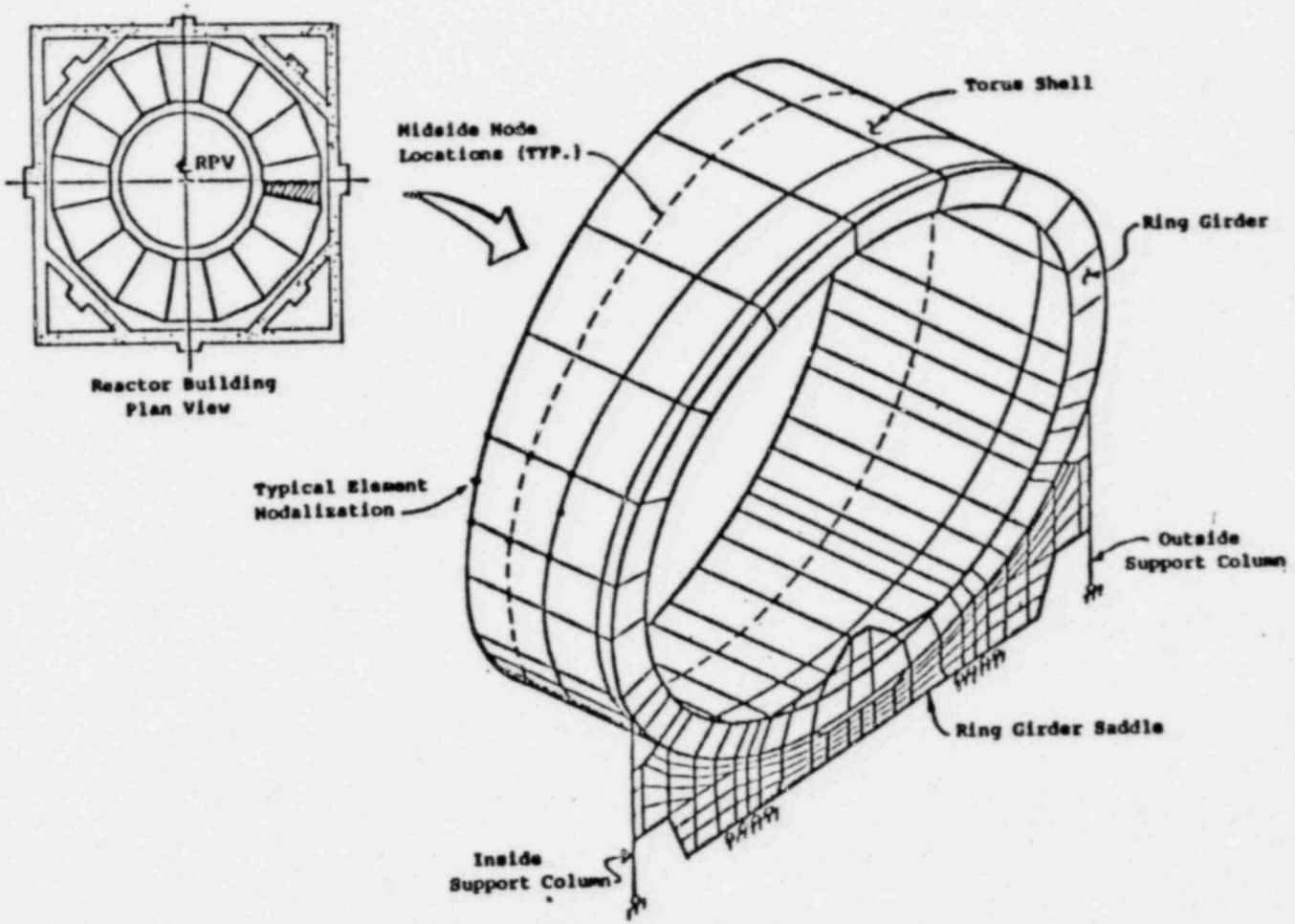



FIGURE 3.3

1/32 SECTION TORUS MODEL WITH DETAILED RING GIRDER SADDLE

# RING GIRDER

- LOADS
  - SHELL LOAD COMBINATIONS
  - SUBMERGED STRUCTURE
  - CONCENTRATED REACTIONS

- DESIGN ALLOWABLES
  - MC SUPPORT - SUBSECTION NF
  - EXCEPT PORTION WITHIN LIMITS OF SHELL REINFORCEMENT WHERE SUBSECTION NE IS USED

- ANALYSIS METHODS
  - RING GIRDER

    ALL STRESSES FROM 1/32 SEGMENT MODEL EXCEPT FOR STRESSES DUE TO DRAG LOADS, WHICH ARE DETERMINED SEPARATELY

  - RING GIRDER ATTACHMENTS

    REACTIONS FROM VENT SYSTEM APPLIED AS EQUIVALENT STATIC LOAD

- CODE EVALUATION
  - MAXIMUM STRESS IN RING GIRDER
  - MAXIMUM STRESSES IN WELD TO SHELL
  - MAXIMUM FATIGUE USAGE

# TORUS SHELL PENETRATION AND ATTACHMENTS

- PENETRATIONS AND ATTACHMENTS INCLUDE:
  - TAP PENETRATIONS
  - SEISMIC TIES
  - MONORAIL SUPPORTS
  - ECCS PIPING SUPPORTS

- ANALYSIS METHOD
  - REACTIONS FROM APPROPRIATE ANALYSIS
  - WRC BULLETIN 107 USED TO OBTAIN LOCAL STRESSES

- LOAD COMBINATIONS
  - RESPONSE TO TWO DYNAMIC EVENTS COMBINED BY SRSS

# DYNAMIC RESPONSE COMBINATION

- DESCRIPTION
  - COMBINATION METHOD FOR PEAK RESPONSES TO TWO (S/RV + LOCA) DYNAMIC LOADS
  - 1.1 X SRSS OF PEAK DYNAMIC RESPONSES
  - ASUM OF REMAINING DYNAMIC LOADS
- REASONS
  - ASUM RECOGNIZED AS CONSERVATIVE (E.G. NUREG-0484)
  - PUAAG ALLOWS CDF METHOD WITH 84% NEP
- JUSTIFICATION
  - EXAMINE CDF'S USING MARK I DATA (GENERIC STUDY)
  - SHOW 1.1 SRSS BOUNDS 84% NEP
  - CONFIDENCE LEVEL >90%
  - CONFIRM FINDINGS WITH CNS DATA

# VENT SYSTEM AND SUPPORTS

- VENT HEADER AND MAIN VENT
  - VENT SYSTEM ANALYSES
  - VENT HEADER AND MAIN VENT PENETRATIONS

- DOWNCOMER AND TIEBARS
  - DOWNCOMER/VENT HEADER INTERSECTION
  - DOWNCOMER ITSELF

- SIMPLIFIED ANALYSIS PERFORMED ON:
  - VENT DRAIN LINE
  - VENT HEADER DEFLECTOR
  - VENT HEADER SUPPORT SYSTEM

# VENT SYSTEM ANALYSES

- FINITE ELEMENT MODELS
  - 1/16 SEGMENT SHELL MODEL
  - BEAM MODEL - NON-SYMMETRIC LOADS
  - DOWNCOMER/VENT HEADER INTERSECTION MODEL

- STATIC ANALYSES
  - PRESSURE AND TEMPERATURE
  - GRAVITY AND SEISMIC
  - VENT SYSTEM THRUST

- DYNAMIC ANALYSES
  - POOL SWELL, TIME HISTORY
  - CO, FREQUENCY DOMAIN
  - CHUGGING, EQUIVALENT STATIC
  - S/RV DISCHARGE, EQUIVALENT STATIC

- CODE EVALUATION
  - MAXIMUM STRESSES
    - MAIN VENT
    - HEADER
    - PENETRATIONS

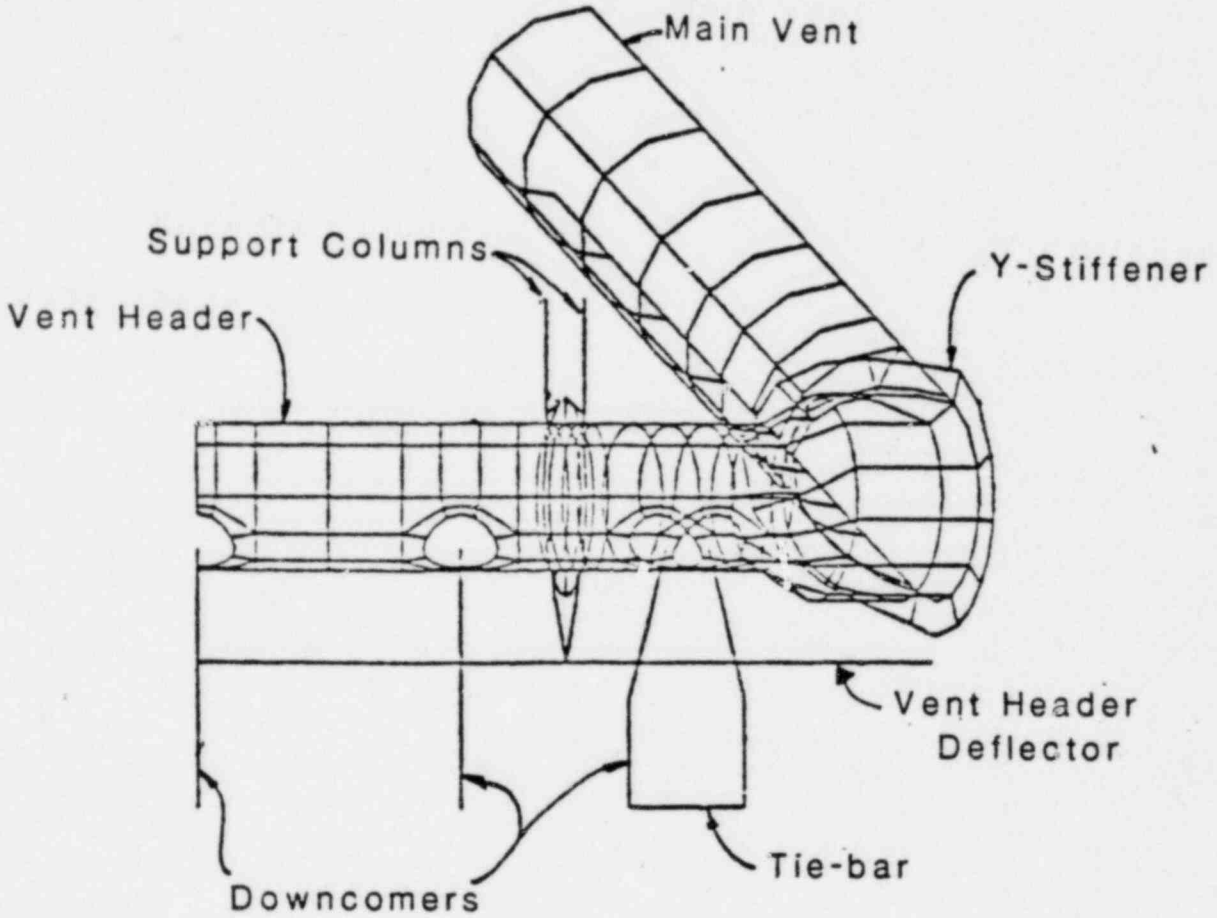



FIGURE 4.1

1/16TH FINITE ELEMENT SHELL MODEL OF VENT SYSTEM

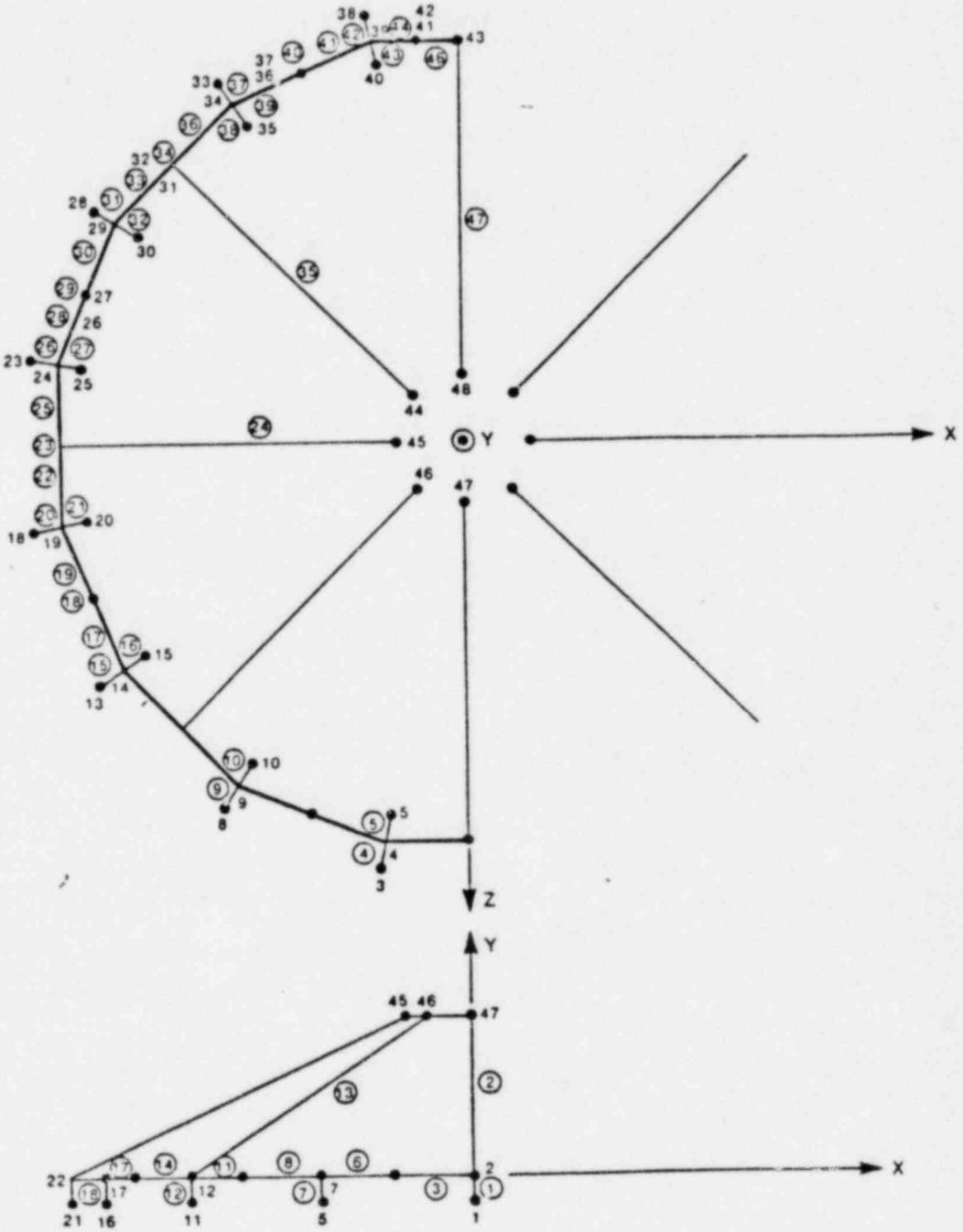



FIGURE 4.2

180° VENT SYSTEM BEAM MODEL

# DOWNCOMER/VENT HEADER INTERSECTION ANALYSIS

- DESIGN ALLOWABLES
  - MC COMPONENT $\Longrightarrow$ SUBSECTION NE
  - $P_L$ AND $P_L + P_B$ ALLOWABLE INCREASED BY 30% BASED ON LIMIT ANALYSIS

- FINITE ELEMENT MODEL
  - DETAILED LOCAL MODEL
  - UNIT LOAD CASES

- EQUIVALENT STATIC ANALYSIS
  - POOL SWELL
  - CO LATERAL LOAD
  - CHUGGING LATERAL LOAD
  - S/RV DISCHARGE DRAG LOADS

- DOWNCOMER ANALYZED USING DETAILED MODEL

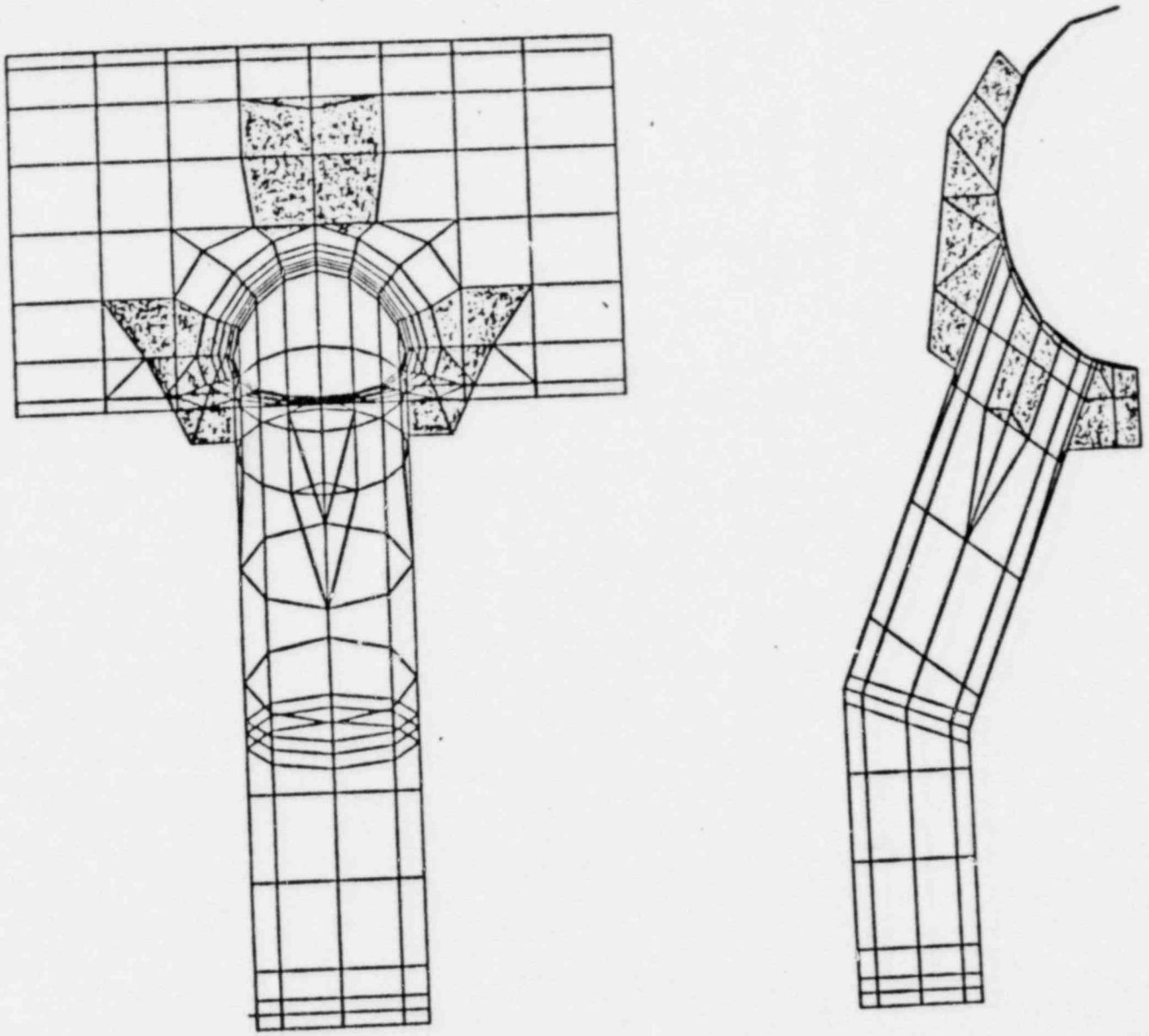


FIGURE 4.13

DETAILED DOWNCOMER/VENT HEADER INTERSECTION MODEL
INCLUDING GUSSET PLATE STIFFENERS

# S/RV DISCHARGE LINES

- DRYWELL PIPING
  - DETERMINED BOUNDING LOADS FROM MAIN VENT PENETRATION COMBINATIONS
  - SEPARATE MODEL FOR EACH LINE

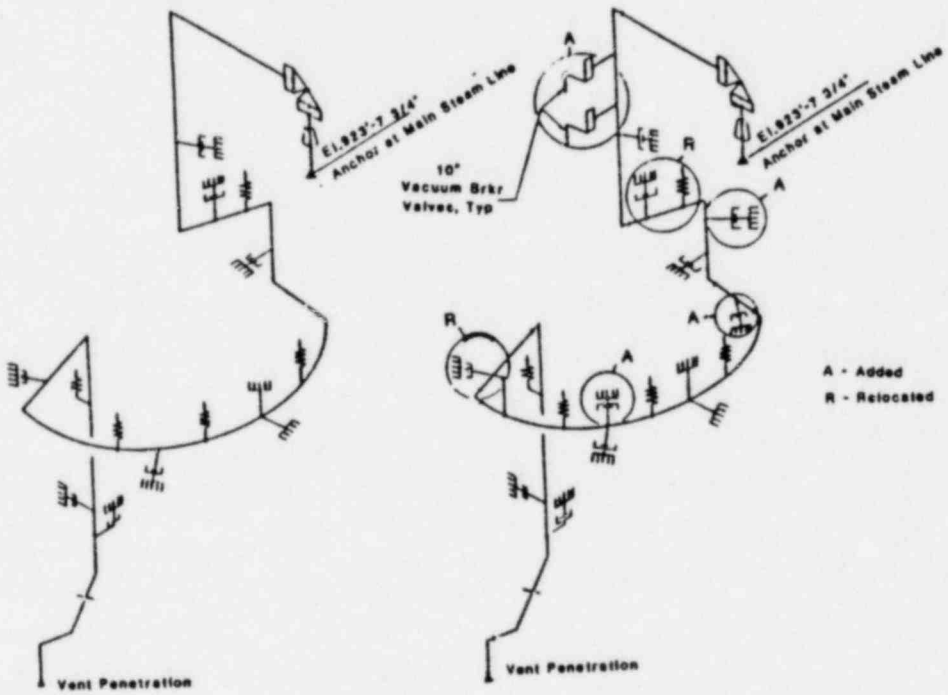



Figure 5.1
Representative Drywell S/RVD Line Model (line 71G)
Before and After Modifications

  - STATIC ANALYSIS
  - DYNAMIC ANALYSIS

    TIME HISTORY FOR THRUST LOADS

    RESPONSE SPECTRA FOR VENT SYSTEM MOTION

# S/RV DISCHARGE LINES

- WETWELL S/RVD PIPING
  - LOADS
    - S/RVD THRUST AND WATER CLEARING
    - POOL SWELL
    - CO AND CHUGGING DRAG
    - T-QUENCHER AIR BUBBLE DRAG

- T-QUENCHER EVALUATION

- VACUUM BREAKERS
  - LOADS
    - PRESSURE AND TEMPERATURE TRANSIENTS
    - GRAVITY AND SEISMIC
  - COMPONENT EVALUATED
    - ALL PRESSURE RETAINING PARTS
    - HINGE ARM SHAFT
    - FLANGE AND FLANGE BOLTS

# TORUS ATTACHED PIPING

- EXTERNAL PIPING
  - ANALYSIS
    - LARGE BORE - A TORUS COUPLING INCLUDED - MULTI-LEVEL RESPONSE SPECTRA
    - SMALL BORE - UNCOUPLED RESPONSE SPECTRA
    - BRANCH LINES
    - PUMPS AND VALVES

- INTERNAL PIPING
  - DYNAMIC LOADS
    - POOL SWELL
    - CO AND CHUGGING DRAG
    - S/RV DISCHARGE DRAG
    - TORUS SHELL MOTION

- LOADS ON PIPE SUPPORTS INCLUDE SUBMERGED STRUCTURE LOADS

# POOL TEMPERATURE EVALUATION

- DESIGN CRITERIA
  - 200°F LOCAL TEMPERATURE LIMIT
  - TRANSIENT CONDITIONS
- TRANSIENT ANALYSIS
  - SUPPRESSION POOL MODEL
  - LOCAL POOL TEMPERATURE MODEL
  - SEVEN TRANSIENT EVENTS
- EVALUATION RESULTS
  - MAXIMUM BULK POOL TEMPERATURE = 179°F
  - MAXIMUM LOCAL POOL TEMPERATURE = 198°F
- POOL TEMPERATURE MONITORING SYSTEM
  - REDUNDANT MONITORS
  - CONTROL ROOM RECORDER
  - SEISMIC CATEGORY I SENSORS
  - ENVIRONMENTAL REQUIREMENTS

MEETING SUMMARY DISTRIBUTION

Docket File
NRC PDR
Local PDR
NSIC
ORB#2 Reading
ACRS-10

(w/ enclosures)

J. Heltemes
B. Grimes
DL Branch Chief
Project Manager
OELD
IE
NRC Participants

(w/enclosure 1 only)

cc: Licensee with short cc list (with Enclosure 1 only)

Mr. J. M. Pilant, Director
Licensing & Quality Assurance
Nebraska Public Power District
P.O. Box 499
Columbus, Nebraska 68601

Mr. J. M. Pilant
Nebraska Public Power District

cc:

Mr. G. D. Watson, General Counsel
Nebraska Public Power District
P. O. Box 499
Columbus, Nebraska 68601

Mr. Arthur C. Gehr, Attorney
Snell & Wilmer
3100 Valley Center
Phoenix, Arizona 85073

Cooper Nuclear Station
ATTN: Mr. L. Lessor
Station Superintendent
P. O. Box 98
Brownville, Nebraska 68321

Auburn Public Library
118 - 15th Street
Auburn, Nebraska 68305

Mr. Dennis Dubois
USNRC
Resident Inspector
P.O. Box 218
Brownville, NE 68321

John T. Collins
Regional Administrator, Region IV
U.S. Nuclear Regulatory Commission
611 Ryan Plaza Drive, Suite 1000
Arlington, Texas 76011