August 23, 1984

Docket Nos. 50-239/247/254/263/265/331

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MEMORANDUM FOR: Domenic B. Vassallo, Chief
Operating Reactors Branch #2
Division of Licensing

FROM: Byron L. Siegel, Lead Project Manager
Mark I Long Term Program

SUBJECT: TRIP SUMMARY - MARK I CONTAINMENT LONG TERM PROGRAM PLANT UNIQUE ANALYSIS REPORT (PUAR) EVALUATIONS

Re: Dresden Units 2/3, Quad Cities 1/2, Monticello and Duane Arnold

A meeting was held on August 9 and 10, 1984 in San Jose, California among Commonwealth Edison Company, Northern States Power Company, Iowa Electric Light and Power Company, NUTECH and its consultants, and the NRC and its consultants, the Brookhaven National Laboratory (BNL) and the Franklin Research Center (FRC). The purpose of the meeting was to discuss the staff's request for additional information related to its review of the licensees' PUARs. The meeting attendees are identified in Enclosure 1.

A copy of the vu-graphs presented by NUTECH during the meeting is contained in Enclosure 2. Based on the NUTECH presentations, only two issues were identified that required additional information.

For Monticello, the staff and its consultants requested the licensee to evaluate the effects of increasing the horizontal drag load volume to a value consistent with that used on other plans analyzed by NUTECH.

Related to the CMDOF computer code, used to calculate the coupling between the torus and torus-attached piping for Duane Arnold, the staff requested the licensee to provide examples of type B matrix data and the results of small and large piping analyses. The licensee is also going to identify the conservatisms in the analyses.

All the licensees will provide formal submittals of the information presented during the meeting.

Original signed by/

Byron L. Siegel, Lead Project Manager
Mark I Containment Long Term Program

Enclosures:
As stated

cc w/enclosures:
See next page

| | |
|---|---|
| DL:LB#2 | DL:ORB#2 |
| BSiegel:ajs | DVassallo |
| 08/ /84 | 08/22/84 |

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ENCLOSURE 1

ATTENDANCE LIST FOR AUGUST 9, 1984 MEETING

WITH CECO/NSP/IELP/NUTECH AND THE NRC TO DISCUSS

MARK I CONTAINMENT LTP PUARS SUBMITTED BY THE LICENSEES

| Name | Affiliation |
|---|---|
| B. Siegel | NRC/NRR/DL/LB#2 |
| H. Shaw | NRC/NRR/DE/MEB |
| Vu Con | Franklin Research Center |
| Aly A. Okaily | Franklin Research Center |
| Farouk Eltawila | NRC/NRR/DSI/CSB |
| George Bienkowski | Brookhaven National Laboratory/Princeton |
| John Lehner | Brookhaven National Laboratory |
| Bob Rybak | Commonwealth Edison Company |
| David Skolnik | Commonwealth Edison Company |
| Tim Bailey | Northern States Power Company |
| Terry Pickens | Northern States Power Company |
| Thomas Vogel | NUTECH/Minn |
| W. R. Butler | NRC/NRR/DSI/CSB |
| James W. Axline | NUTECH/SJO |
| Ben Acojido | NUTECH |
| Tom Mulford | NUTECH |
| Ron Wise | NUTECH |
| Vijay Kumar | NUTECH |
| Bob Lenhert | NUTECH |
| Jay Smith | NUTECH |
| R. H. Buchholz | NUTECH |

ENCLOSURE 2

## MARK I PLANT UNIQUE ANALYSIS REVIEW

## ATTENDEES --- AUGUST 10, 1984

| Name | Affiliation |
| --- | --- |
| B. Siegel | NRC/NRR/DL |
| H. Shaw | NRC/NRR/DE |
| Aly Okaily | Franklin Research Center |
| V. Con | Franklin Research Center |
| B. Rybak | Commonwealth Edison Company |
| D. Skolnik | Commonwealth Edison Company |
| Harry Shearer | Iowa Electric Light and Power Company |
| Billy W. Reid | Iowa Electric Light and Power Company |
| James W. Axline | NUTECH/SJO |
| Vijay Kumar | NUTECH/SJO |
| Jay Smith | NUTECH/SJO |
| Thomas Vogel | NUTECH |
| Terry Pickens | Northern States Power Company |
| B. Acojido | NUTECH/SJO |
| Tim Bailey | Northern States Power Company |
| R. H.Buchholz | NUTECH/SJO |

ENCLOSURE 3

# MARK I PLANT UNIQUE ANALYSIS REVIEW

## RESOLUTION OF NRC QUESTIONS

AUGUST 9-10, 1984

SAN JOSE, CALIFORNIA

## MEETING PURPOSE

- PROVIDE A RESPONSE TO THE NRC QUESTIONS DOCUMENTED ON THE NSP/CECo/IELP PLANT UNIQUE ANALYSIS REPORTS (PUARs)

- RESOLVE ALL ISSUES RELATED TO THE ABOVE QUESTIONS

THESE ACTIONS WILL FACILITATE ISSUANCE OF THE SERs BY THE END OF SEPTEMBER 1984.

# MARK I PLANT UNIQUE ANALYSIS REVIEW

## MEETING AGENDA

AUGUST 9, 1984

| | |
|---|---|
| 9:00 AM<br>BUCHHOLZ | MEETING OPENING & INTRODUCTION |
| | HYDRODYNAMIC LOADS |
| 9:15AM<br>SANCHEZ/<br>MULFORD | • MONTICELLO QUESTIONS<br>• DRESDEN/QUAD CITIES QUESTIONS |
| 11:30 AM | LUNCH |
| | HYDRODYNAMIC LOADS (CONT.) |
| 1:00PM<br>ALL | • DISCUSSION - SUMMARY OF HYDRODYNAMIC LOADS QUESTIONS |
| | STRUCTURAL/PIPING EVALUATION |
| 1:30PM<br>AXLINE/SMITH/<br>KUMAR/LEHNERT | • MONTICELLO QUESTIONS<br>• DRESDEN/QUAD CITIES QUESTIONS |
| 5:30PM | MEETING ADJOURNMENT |

# MEETING AGENDA

(CONT.)

AUGUST 10, 1984

| | |
|---|---|
| 9:00AM<br>BUCHHOLZ | MEETING OPENING |
| | STRUCTURAL/PIPING EVALUATION (CONT) |
| 9:15AM<br>AXLINE | • DUANE ARNOLD CLARIFICATIONS |
| 10:15AM<br>WEBER | • CMDOF DISCUSSION |
| 12:30PM | • DISCUSSION - SUMMARY OF STRUCTURAL QUESTIONS |
| 1:00PM | MEETING CLOSE |

# NRC CLARIFICATIONS ON
# DUANE ARNOLD ENERGY CENTER PUAR
# PIPING RESPONSE

ITEM 1:

- O PROVIDE PLOTS OF LONG AND TRUNCATED MODELS
- O TREATMENT OF BOUNDARY CONDITIONS

RESPONSE TO ITEM 1:

- O LONG MODEL UTILIZED FOR NON-MARK I
- O TRUNCATED MODEL UTILIZED FOR MARK I
- O COMPARISON OF TWO MODELS SHOWS GOOD COMPARISON
- O BOUNDARIES BEYOND 10% POINT, TREATED AS FICTITIOUS ANCHORS

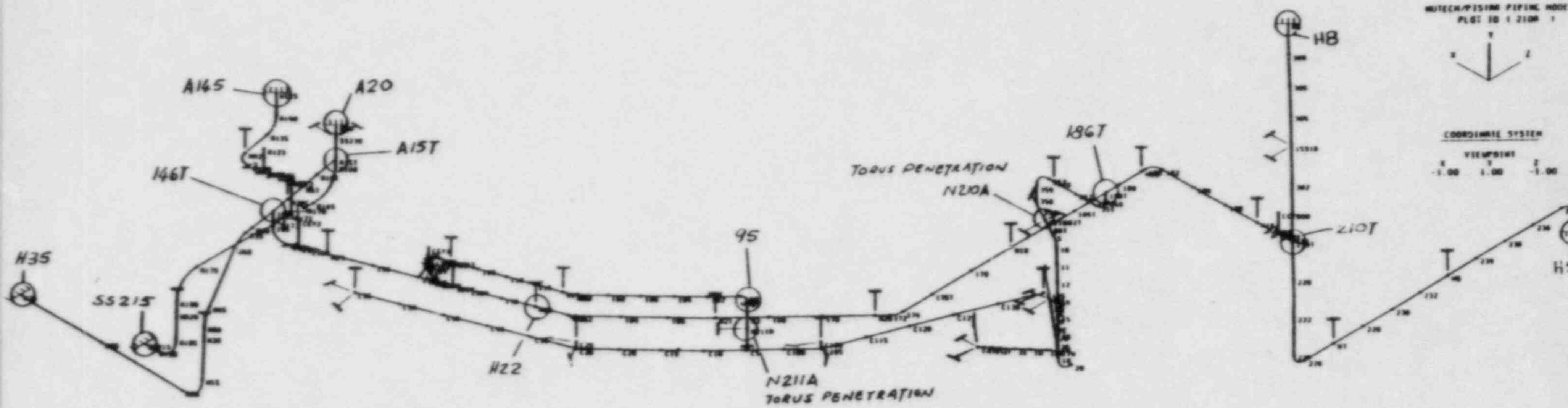


Figure 1

RHR AND CORE SPRAY DISCHARGE N210A/N211A
(Truncated Model)

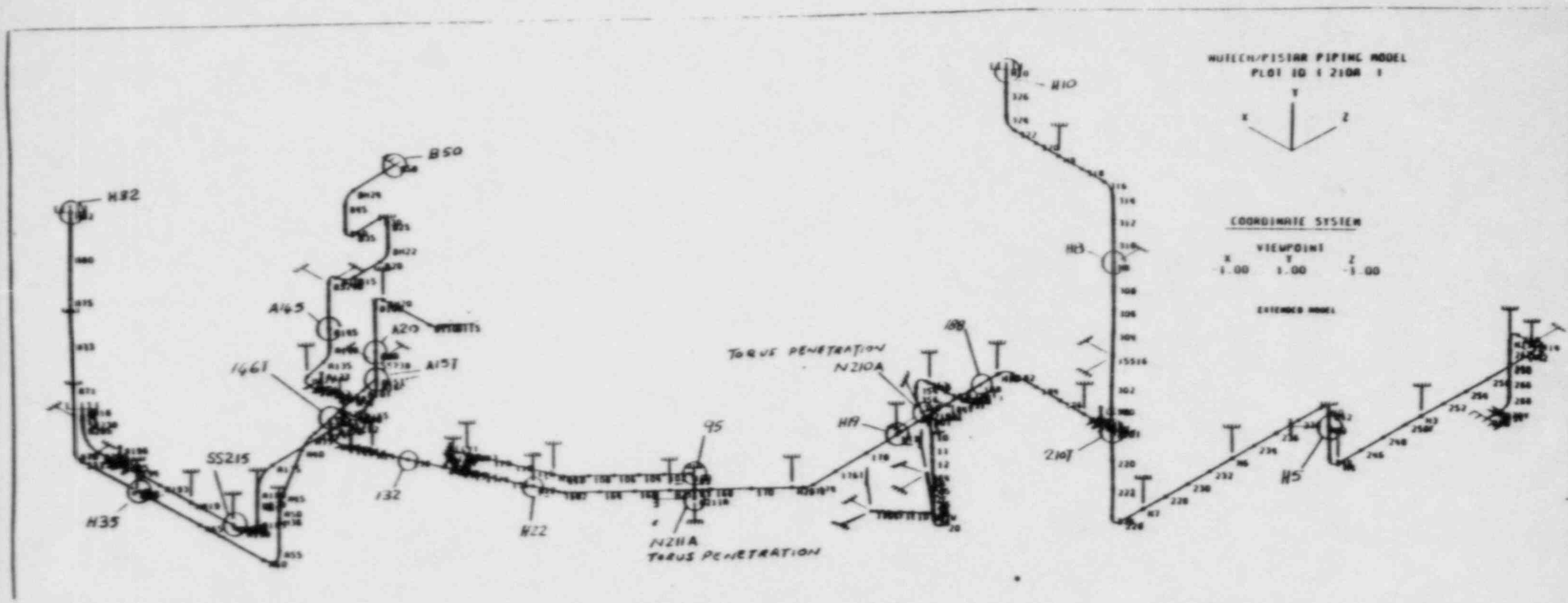


Figure 2

RHR AND CORE SPRAY DISCHARGE N210A/N211A
(Longer Mod-l)

Table 1

STRESSES DUE TO CO TORUS MOTION

| NODE | STRESSES IN LONG MODEL | STRESSES IN SHORTENED MODEL |
|---|---|---|
| A5T | .261E4 | .233E4 |
| H20C | .241E4 | .198E4 |
| A15T | .204E4 | .343E4 |
| 144 | .816E4 | .831E4 |
| H24 | .321E4 | .333E4 |
| 156 | .289E4 | .279E4 |
| H22 | .312E4 | .302E4 |
| 116 | .122E5 | .122E5 |
| 102 | .830E4 | .867E4 |
| 95 | .115E5 | .114E5 |
| 168 | .471E4 | .448E4 |
| 178 | .500E4 | .480E4 |
| H19 | .415E4 | .401E4 |
| 358 | .687E4 | .696E4 |
| N210A | .727E4 | .704E4 |
| 186T | .226E5 | .209E5 |
| 188 | .981E4 | .958E4 |
| 146T | .112E5 | .107E5 |

(Stresses in psi)

NRC CLARIFICATIONS ON
DUANE ARNOLD ENERGY CENTER PUAR
PIPING RESPONSE

ITEM 3A:

0 DESCRIPTION AND BACKGROUND FOR CMDOF

RESPONSE TO ITEM 3A:

0 ADDRESSED AS GENERIC ISSUE

# NRC CLARIFICATIONS ON
# DUANE ARNOLD ENERGY CENTER PUAR
# PIPING RESPONSE

ITEM 3B:

- O DESCRIBE IMPLEMENTATION OF TRANSFER FUNCTION METHOD
- O PROVIDE COMPARISON OF EXPLICIT VERSUS TRANSFER FUNCTION APPROACH

RESPONSE TO ITEM 3B:

- O UNCOUPLED TORUS AND PIPING EIGENVECTORS CALCULATED
- O APPLY WHITE NOISE INPUT, $W(\tau)$, TO TORUS
- O CMDOF UTILIZED TO GENERATE COUPLED PIPING RESPONSE, $R(\tau)$
- O DETERMINE FREQUENCY DOMAIN WHITE NOISE LOADING, $W(w)$, AND RESPONSE, $R(w)$ FROM $W(\tau)$ AND $R(\tau)$ USING FFT
- O CALCULATE TRANSFER FUNCTION, $T(w) = R(w)/W(w)$
- O TRANSFORM ACTUAL TIME HISTORY, $F(\tau)$, TO FREQUENCY DOMAIN, $F(w)$, USING FFT
- O MULTIPLY $F(w)$ BY TRANSFER FUNCTION TO OBTAIN FREQUENCY DOMAIN RESPONSE, $R(w) = F(w)*T(w)$
- O CALCULATE TIME HISTORY RESPONSE, $R(\tau)$, USING INVERSE FFT

TABLE I

| Example | | Response Type | Transfer Function Method | Explicit Method |
|---|---|---|---|---|
| 1. | Torus & piping system | Peak axial reaction at penetration (lb) | 14724 | 14300 |
| 2. | Torus | Acceleration in g, at Node 304 (DOF 3) | 2.18 | 2.16 |
| | | Acceleration in g, at Node 296 (DOF 3) | 2.30 | 2.25 |
| | | Acceleration in g, at Node 296 (DOF 2) | 2.28 | 2.22 |

# NRC CLARIFICATIONS ON

# DUANE ARNOLD ENERGY CENTER PUAR

# PIPING RESPONSES

ITEM $3_D$

- O SELECT TYPICAL PIPING SYSTEM AND DEMONSTRATE METHOD OF SELECTING CRITICAL FREQUENCIES

RESPONSE TO ITEM $3_D$:

- O CRITICAL FREQUENCY CHOSEN USING TRANSFER FUNCTION PEAKS

- O RHR AND CORE SPRAY LINE N210B/N211B

- O CRITICAL FREQUENCIES:

  16.60 HZ
  17.82 HZ

**CRITICAL FREQUENCY LIST BEFORE SORTING**

| FREQUENCY NUMBER | AVERAGE NORMALIZED TRANSFER FUNCTION PEAK VALUE | NUMBER OF TRANSFER FUNCTION PEAKS |
|---|---|---|
| 61 | .10380332E+00 | 2 |
| 62 | .21629307E+00 | 3 |
| 64 | .16695498E+00 | 9 |
| 65 | .25069015E+00 | 27 |
| 66 | .27872588E+00 | 24 |
| 67 | .15802724E+00 | 6 |
| 68 | .19380757E+00 | 10 |
| 69 | .29621517E+00 | 38 ← * |
| 70 | .21411773E+00 | 10 |
| 71 | .15225766E+00 | 4 |
| 73 | .21295619E+00 | 28 |
| 74 | .28260710E+00 | 30 ← * |
| 75 | .26136280E+00 | 17 |
| 76 | .26657321E+00 | 40 ← (2) |
| 77 | .12840306E+00 | 6 |
| 78 | .16775091E+00 | 7 |
| 79 | .18925974E+00 | 13 |
| 80 | .20860733E+00 | 11 |
| 81 | .16421185E+00 | 32 |
| 82 | .15300687E+00 | 7 |
| 84 | .22250208E+00 | 1 |
| 85 | .14490506E+00 | 15 |
| 86 | .15479945E+00 | 2 |
| 89 | .11918539E+00 | 4 |
| 90 | .13434632E+00 | 7 |
| 91 | .13841312E+00 | 2 |
| 93 | .13487135E+00 | 2 |
| 95 | .20243486E+00 | 2 |
| 96 | .16286111E+00 | 1 |
| 100 | .16573363E+00 | 2 |
| 101 | .11647898E+00 | 2 |
| 102 | .13337325E+00 | 10 |
| 103 | .18590594E+00 | 6 |
| 104 | .13828732E+00 | 5 |
| 105 | .13208351E+00 | 6 |
| 107 | .12878513E+00 | 1 |
| 111 | .19430448E+00 | 2 |
| 120 | .14901973E+00 | 1 |
| 125 | .15738691E+00 | 1 |
| 131 | .21103826E+00 | 2 |
| 156 | .10979069E+00 | 1 |

(1) BUBBLE FREQ. RANGE (frequency numbers 61 to 75)

**CRITICAL FREQUENCY LIST SORT BY PEAK VALUES**

| FREQUENCY NUMBER | AVERAGE NORMALIZED TRANSFER FUNCTION PEAK VALUE | NUMBER OF TRANSFER FUNCTION PEAKS |
|---|---|---|
| 69 | .29621517E+00 | 38 ← * |
| 74 | .28260710E+00 | 30 ← * |
| 66 | .27872588E+00 | 24 |
| 76 | .26657321E+00 | 40 ← (2) |
| 75 | .26136280E+00 | 17 |
| 65 | .25069015E+00 | 27 |
| 84 | .22250208E+00 | 1 |
| 62 | .21629307E+00 | 3 |
| 70 | .21411773E+00 | 10 |
| 73 | .21295619E+00 | 28 |
| 131 | .21103826E+00 | 2 |
| 80 | .20860733E+00 | 11 |
| 95 | .20243486E+00 | 2 |
| 111 | .19430448E+00 | 2 |
| 68 | .19380757E+00 | 10 |
| 79 | .18925974E+00 | 13 |
| 103 | .18590594E+00 | 6 |
| 78 | .16775091E+00 | 7 |
| 64 | .16695498E+00 | 9 |
| 100 | .16573363E+00 | 2 |
| 81 | .16421185E+00 | 32 |
| 96 | .16286111E+00 | 1 |
| 67 | .15802724E+00 | 6 |
| 125 | .15738691E+00 | 1 |
| 86 | .15479945E+00 | 2 |
| 82 | .15300687E+00 | 7 |
| 71 | .15225766E+00 | 4 |
| 120 | .14901973E+00 | 1 |
| 85 | .14490506E+00 | 15 |
| 91 | .13841312E+00 | 2 |
| 104 | .13828732E+00 | 5 |
| 93 | .13487135E+00 | 2 |
| 90 | .13434632E+00 | 7 |
| 102 | .13337325E+00 | 10 |
| 105 | .13208351E+00 | 6 |
| 107 | .12878513E+00 | 1 |
| 77 | .12840306E+00 | 6 |
| 89 | .11918539E+00 | 4 |
| 101 | .11647898E+00 | 2 |
| 156 | .10979069E+00 | 1 |
| 61 | .10380332E+00 | 2 |

**CRITICAL FREQUENCY LIST SORT BY NUMBER OF PEAKS**

| FREQUENCY NUMBER | AVERAGE NORMALIZED TRANSFER FUNCTION PEAK VALUE | NUMBER OF TRANSFER FUNCTION PEAKS |
|---|---|---|
| 76 | .26657321E+00 | 40 ← (2) |
| 69 | .29621517E+00 | 38 ← * |
| 81 | .16421185E+00 | 32 |
| 74 | .28260710E+00 | 30 ← * |
| 73 | .21295619E+00 | 28 |
| 65 | .25069015E+00 | 27 |
| 66 | .27872588E+00 | 24 |
| 75 | .26136280E+00 | 17 |
| 85 | .14490506E+00 | 15 |
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| 67 | .15802724E+00 | 6 |
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| 103 | .18590594E+00 | 6 |
| 105 | .13208351E+00 | 6 |
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| 89 | .11918539E+00 | 4 |
| 62 | .21629307E+00 | 3 |
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| 100 | .16573363E+00 | 2 |
| 101 | .11647898E+00 | 2 |
| 111 | .19430448E+00 | 2 |
| 131 | .21103826E+00 | 2 |
| 84 | .22250208E+00 | 1 |
| 96 | .16286111E+00 | 1 |
| 107 | .12878513E+00 | 1 |
| 120 | .14901973E+00 | 1 |
| 125 | .15738691E+00 | 1 |
| 156 | .10979069E+00 | 1 |

SELECTION OF CRITICAL FREQUENCY (SRV)

(1) SRV bubble frequency range = 4.04 Hz to 18.04 Hz (frequency number 17 to 75).

(2) Beyond the bubble frequency range.

*Critical frequencies = 16.6016 Hz (Frequency #69) and 17.8223 Hz (Frequency #74).

0*****************************

CRITICAL FREQUENCY LIST
AND CORRESPONDING
CRITICAL COMPONENTS

*****************************

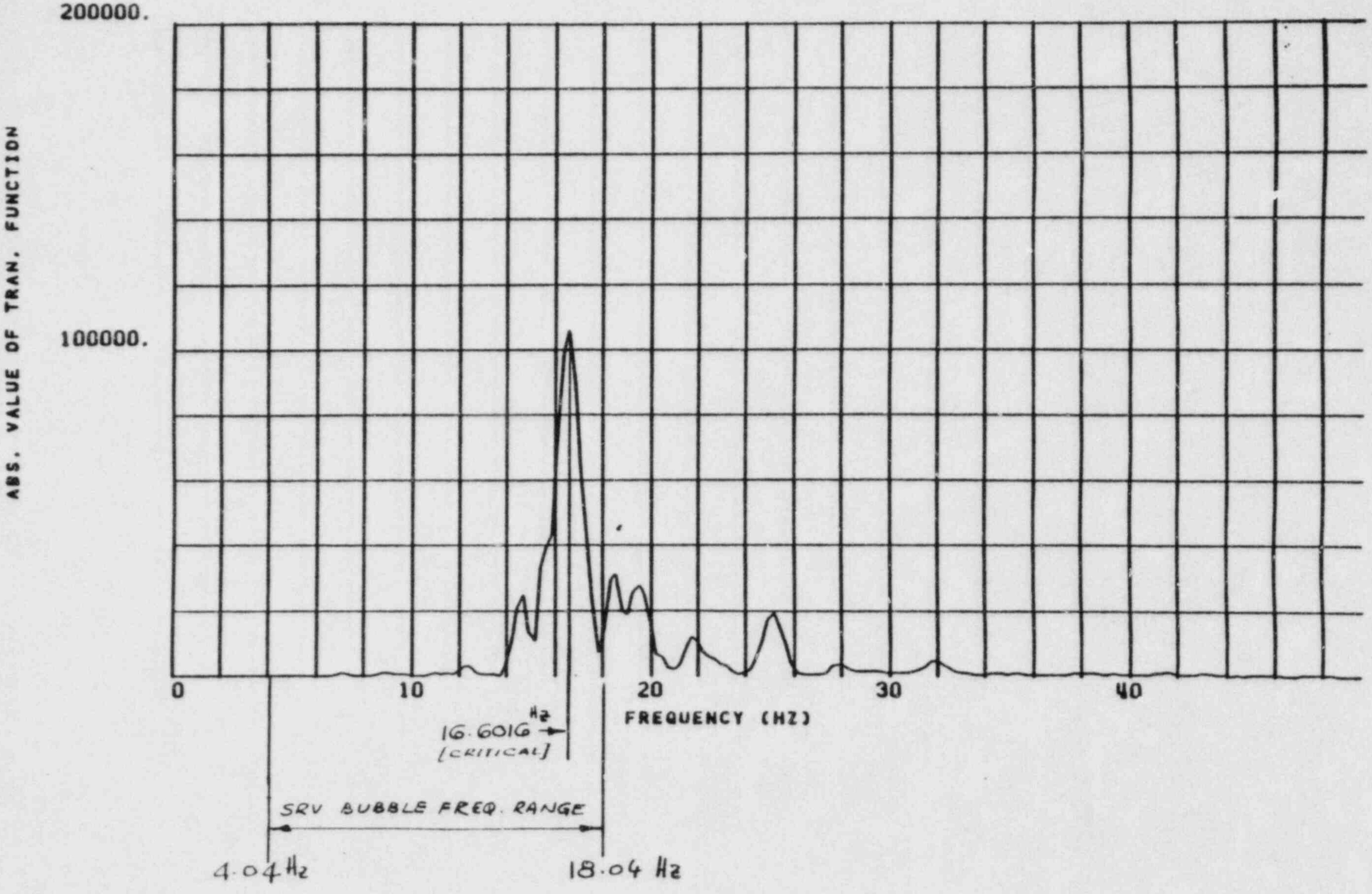
| COMPONENT | FREQ. NO. | FREQUENCY | RESPONSE TYPE | COMP | ELEM/NODE | IJNODE |
|---|---|---|---|---|---|---|
| 77 | → 69 | 16.6016 | STRESS | Y-MOME | 43 | 2 |
| 77 | 73 | 17.5782 | STRESS | Y-MOME | 43 | 2 |
| 77 | 76 | 18.3106 | STRESS | Y-MOME | 43 | 2 |
| 77 | 80 | 19.2871 | STRESS | Y-MOME | 43 | 2 |
| 78 | → 69 | 16.6016 | STRESS | Z-MOME | 43 | 2 |
| 78 | 75 | 18.0664 | STRESS | Z-MOME | 43 | 2 |
| 79 | → 69 | 16.6016 | STRESS | X-MOME | 46 | 1 |
| 79 | 76 | 18.3106 | STRESS | X-MOME | 46 | 1 |
| 79 | 79 | 19.0430 | STRESS | X-MOME | 46 | 1 |
| 79 | 90 | 21.7285 | STRESS | X-MOME | 46 | 1 |
| 81 | → 69 | 16.6016 | STRESS | Z-MOME | 46 | 1 |
| 81 | 76 | 18.3106 | STRESS | Z-MOME | 46 | 1 |
| 81 | 80 | 19.2871 | STRESS | Z-MOME | 46 | 1 |
| 83 | 62 | 14.8926 | STRESS | Y-MOME | 48 | 1 |
| 83 | → 69 | 16.6016 | STRESS | Y-MOME | 48 | 1 |
| 83 | 76 | 18.3106 | STRESS | Y-MOME | 48 | 1 |
| 83 | 79 | 19.0430 | STRESS | Y-MOME | 48 | 1 |
| 83 | 90 | 21.7285 | STRESS | Y-MOME | 48 | 1 |
| 83 | 104 | 25.1465 | STRESS | Y-MOME | 48 | 1 |
| 84 | → 69 | 16.6016 | STRESS | Z-MOME | 48 | 1 |
| 84 | 76 | 18.3106 | STRESS | Z-MOME | 48 | 1 |
| 84 | 80 | 19.2871 | STRESS | Z-MOME | 48 | 1 |
| 89 | 65 | 15.6250 | STRESS | Y-MOME | 49 | 1 |
| 89 | → 74 | 17.8223 | STRESS | Y-MOME | 49 | 1 |
| 90 | 67 | 16.1133 | STRESS | Z-MOME | 49 | 1 |
| 90 | → 74 | 17.8223 | STRESS | Z-MOME | 49 | 1 |
| 92 | 65 | 15.6250 | STRESS | Y-MOME | 49 | 2 |
| 92 | → 74 | 17.8223 | STRESS | Y-MOME | 49 | 2 |
| 93 | 67 | 16.1133 | STRESS | Z-MOME | 49 | 2 |
| 93 | → 74 | 17.8223 | STRESS | Z-MOME | 49 | 2 |
| ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ |

NODE 310T
OF ELEMENT 48

Using this table, a check is made to confirm that the selected frequencies are critical for the response components/locations in the system.

Also, the transfer functions are typically plotted to visually confirm the selection of the critical frequencies. As an example, the transfer function plots for the stress resultant moment component at Node 310T of element 48 are provided.

DUANE ARNOLD ENERGY CENTER
RHR CORE SPRAY RELIEF LINE N210B & N211B
FORCE TRANSFER FUNCTIONS
NODE (310T) Y-MOMENT



## CMDOF QUESTIONS

1. Request for CMDOF overview.

2. Why weren't larger models used in CMDOF verification?

3. How did NUTECH apply the Section 6 Guidelines?*

   - What cutoff frequency used?

   - How many torus and piping modes used?

4. How did NUTECH apply Appendix B.2* Modeling Guidelines?

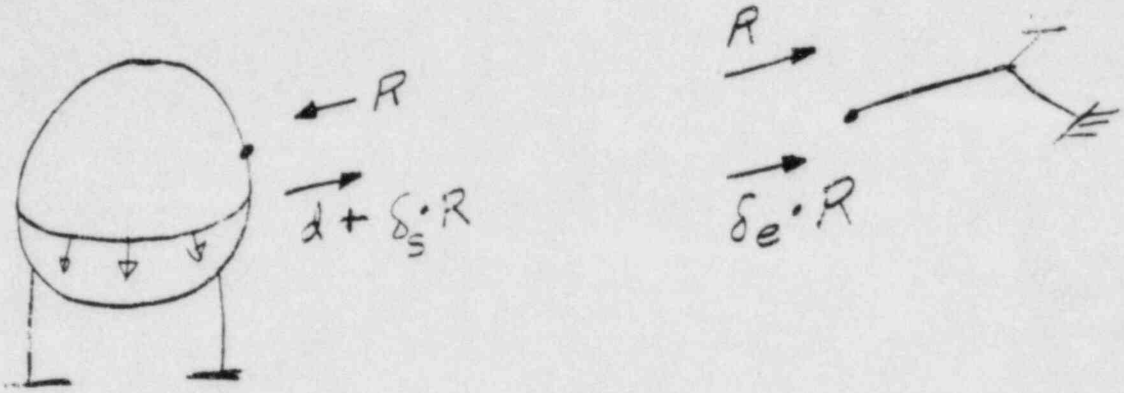
   - How many coupled DOF's?

   - Is torus model sufficiently accurate for CMDOF analysis?

---

*SMA Document 12101.03.R001, November 1980.

# STATIC COUPLING




$$d = (\delta_e - \delta_s) R$$

$$\delta_e = K_e R$$

$$\delta_s = -K_s R$$

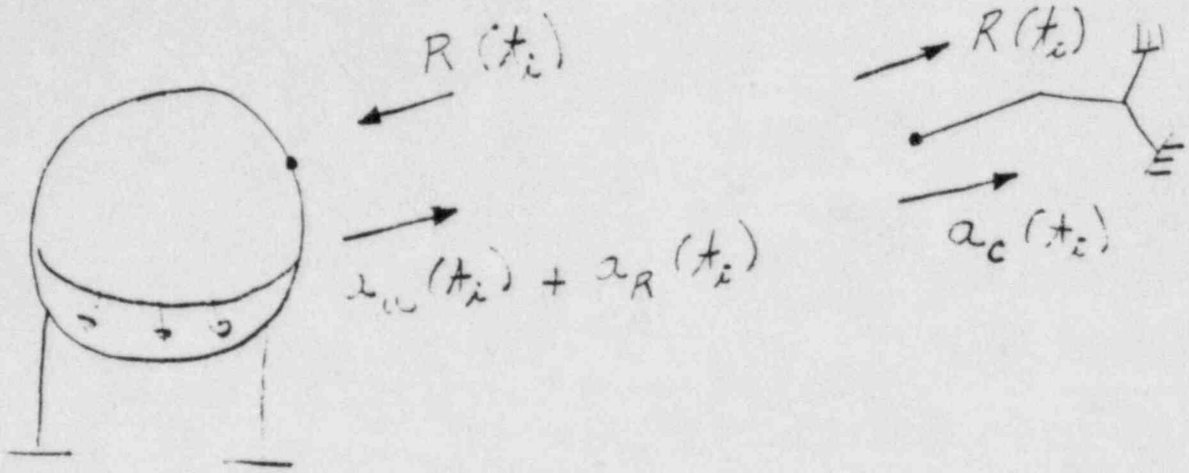
$d$ = uncoupled displacement

$R$ = reaction force

$\delta_s$ = structure (torus) displacement due to $R$

$\delta_e$ = equipment (piping) displacement due to $R$

# DYNAMIC COUPLING




$a_u(t)$ = uncoupled acceleration

$R(t)$ = Reaction force

$a_R(t)$ = torus acceleration due to $R(t)$

$a_c(t)$ = piping (coupled) acceleration due to $R(t)$.

$$a_u(t_i) + a_R(t_i) = a_c(t_i)$$

$$a_R(t_i) = f_1\left[R(t_i)\right]$$

$$a_c(t_i) = f_2\left[R(t_i)\right]$$

at every point $t_i$. At the outset, only the uncoupled response time histories defined by $a_{u_j}(t_i)$ are known at each time point $t_i$. The essence of this program is to determine the reaction $R_j(t_i)$ and reaction acceleration $a_{R_j}(t_i)$ for all NC attachment dof time point by time point so that compatibility and superposition are satisfied at every time point $t_i$.

## 2.3 STRUCTURE RESPONSE DUE TO EQUIPMENT REACTIONS

The reaction acceleration $a_{R_k}(t_i)$ for the structure at the equipment attachment node for dof k can be defined in terms of the reaction forces $R_j(t_i)$ by:

$$a_{R_k}(t_i) = \sum_{j=1}^{NC} \sum_{m=1}^{M_S} PF_{S_{j,m}} \cdot \phi_{S_{k,m}} \cdot \ddot{Y}_{j,m}(t_i) \qquad (2.2)$$

where NC represents the total number of coupling degrees-of-freedom considered, $M_S$ represents the total number of important structure modes, $PF_{S_{j,m}}$ is the uncoupled structure participation factor for mode m associated with an applied unit force/moment at dof j, and $\phi_{S_{k,m}}$ is the structural eigenvector for attachment dof k, for uncoupled structure mode m. The uncoupled structure m-th mode acceleration due to reaction $R_j(t_i)$ at dof j and time $t_i$ is given by:

$$\ddot{Y}_{j,m}(t_i) + 2\lambda_{S_m} \omega_{S_m} \dot{Y}_{j,m}(t_i) + \omega_{S_m}^2 Y_{j,m}(t_i) = -R_j(t_i) \qquad (2.3)$$

where $\lambda_{s_m}$ is the modal structural damping ratio and $\omega_{S_m}$ is the modal angular natural frequency for uncoupled structure mode m.

## CMDOF QA VERIFICATION PROBLEMS

| Example Problem | Number of DOF's | | Number of Coupled DOF's | Remarks |
|---|---|---|---|---|
| | Structure | Equipment | | |
| 1 | 5 | 4 | 3 | Equipment attached to structure at 3 locations |
| 2 | 5 | 2,3,4 | 3 | 3 separate equipment models attached to structure |
| 3 | 12 | 9 | 3 | 3 coupled DOF's at 2 locations |
| 4 | 1 | 1 | 1 | Ungrounded equipment |

# CMDOF VERIFICATION

- Fully-coupled models compared with substructured (CMDOF) models

  - All modes used in comparisons

  - Excellent results obtained

- NUTECH believes SMA verification applicable to larger models

  - CMDOF deals with modal data, not physical DOF's

  - Critical size parameter for CMDOF is number of <u>coupled</u> DOF's

  - For 30 versus 3 coupled DOF's, numerical accuracy not a concern where

$$A_{\Delta E_{k,j}} = \sum_{m=1}^{M_E} PF_{E_{j,m}} \cdot \phi_{E_{k,m}} \left[ 1 + 2\lambda_{E_m} \omega_{E_m} B_{22E_m} + \omega_{E_m}^2 B_{12E_m} \right] \quad (2.19)$$

The quantity $A_{\Delta E_{k,j}}$ represents the change in the equipment reaction acceleration at dof k due to a unit change in reaction/moment at attachment dof j during the time step.

The coupled acceleration for dof k is equal to:

$$a_{c_k}(t_i) = a^*_{ce_k}(t_i) + a_{\Delta c_k}(t_i) \quad (2.20)$$

In order to find the quantities $a_{\Delta R_k}(t_i)$ for the structure (Equation 2.7) and $a_{\Delta c_k}(t_i)$ for the equipment (Equation 2.18) for all NC attachment dof, the change in the coupling reactions $\Delta R_j(t_i)$ must be found for all dof at time step $t_i$. This may be done by setting Equation 2.10 equal to Equation 2.20 and solving for $\Delta R_j(t_i)$. Thus, for time step $t_i$:

$$\left[ \underline{B}_\Delta \right] \{ \Delta R \} = \{ C \} \quad (2.21)$$

where:

$$\{ \Delta R \} = \left[ B_\Delta \right]^{-1} \{ C \} \quad (2.22)$$

$$B_{\Delta_{k,j}} = A_{\Delta S_{k,j}} - A_{\Delta E_{k,j}} \quad (2.23)$$

$$C_k(t_i) = a^*_{ce_k}(t_i) - a^*_{cs_k}(t_i) \quad (2.24)$$

## CMDOF VERIFICATION

- EACH MARK I TAP CMDOF ANALYSIS CHECKED FOR REASONABLENESS OF RESULTS:
  - COUPLED AND UNCOUPLED FORCES, ACCELERATIONS, AND DISPLACEMENTS COMPARED
    - COUPLING BENEFIT USUALLY SEEN FOR LARGE OR STIFF PIPING
    - NO SIGNIFICANT BENEFIT FOR SMALL PIPING
    - NO EVIDENCE OF NUMERICAL INSTABILITY OR LOW FREQUENCY "DRIFT" IN DISPLACEMENTS

# CMDOF FREQUENCY RESPONSE CRITERIA

- Torus modes to 50 Hz used for uncoupled time histories and CMDOF analysis
  - Torus motions strongly centered around 18-25 Hz range
  - For $F_C$ = 35, NUTECH used torus modes up to 1.43 $F_C$
    - Exceeds $F_C$ = 1.3 recommended by SMA
- Piping modes up to 60 Hz used
  - Pseudo-mode for response greater than 60 Hz included

# ACCELERATION RESPONSE SPECTRUM, USING NEWMARK METHOD

X-209A ( NP. 27 , BF=13.4 HZ.) 1% Damping

ACCEL RESPONSE SPECTRUM AT NODE 27 LDOF 1 LC = 1

QAB$_I$ Fermi - Unit 2

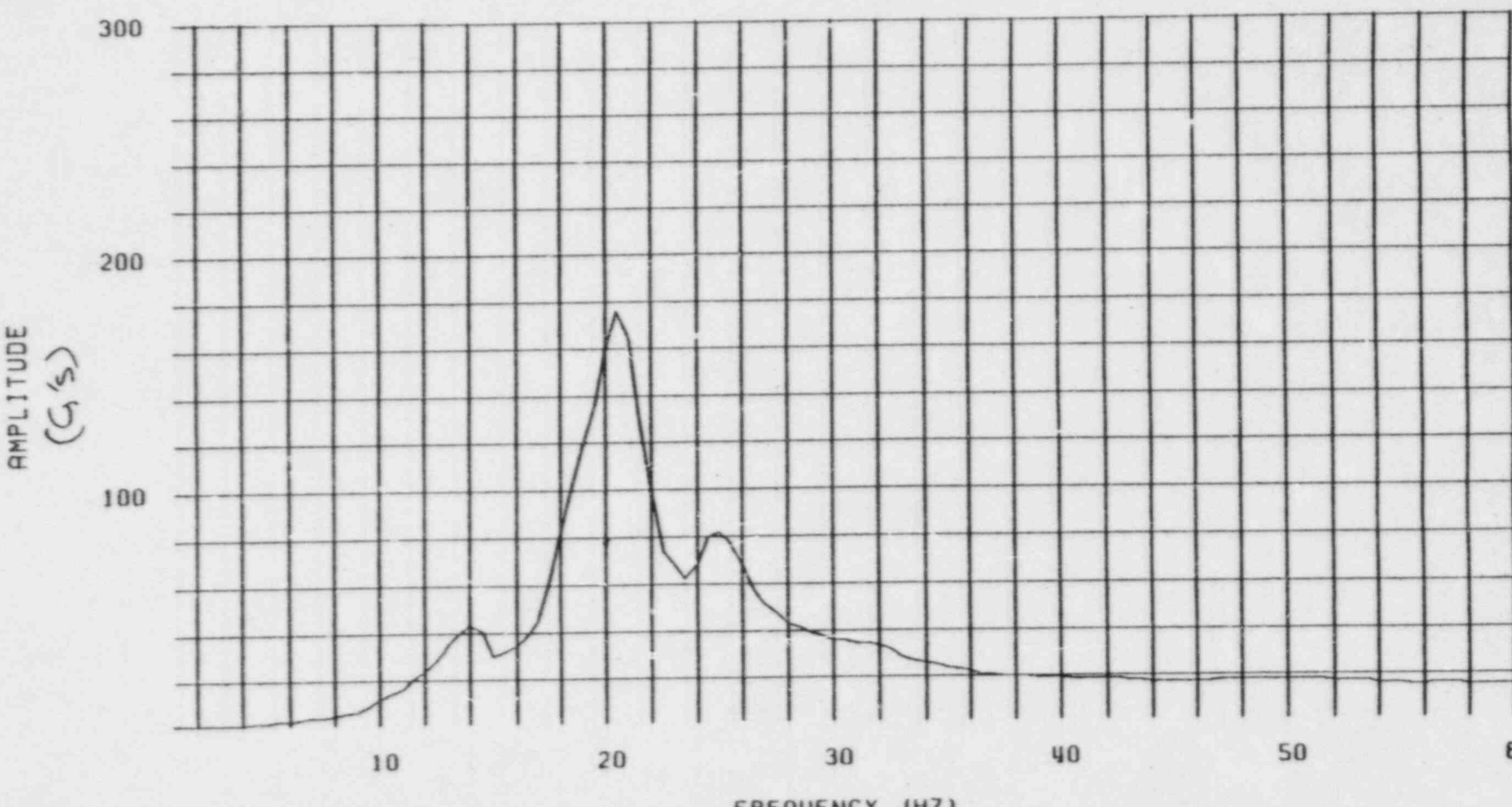



FIGURE 1

——— LEGEND

FILE NO. 50.0206.1041

REVISION 0 PAGE 6 of 9

PREPARED BY HK 4-28-83

CHECKED BY JAT 5-2-83

AFIIQIK 83/04/28 17.07.49

ACCELERATION RESPONSE SPECTRUM, USING NEWMARK METHOD
X-209A ( NP. 27 , BF=13.4 HZ.) 1% DAMPING
ACCEL RESPONSE SPECTRUM AT NODE 27 LDOF 2 LC = 1

QAB$_s$ Fermi-Unit 2

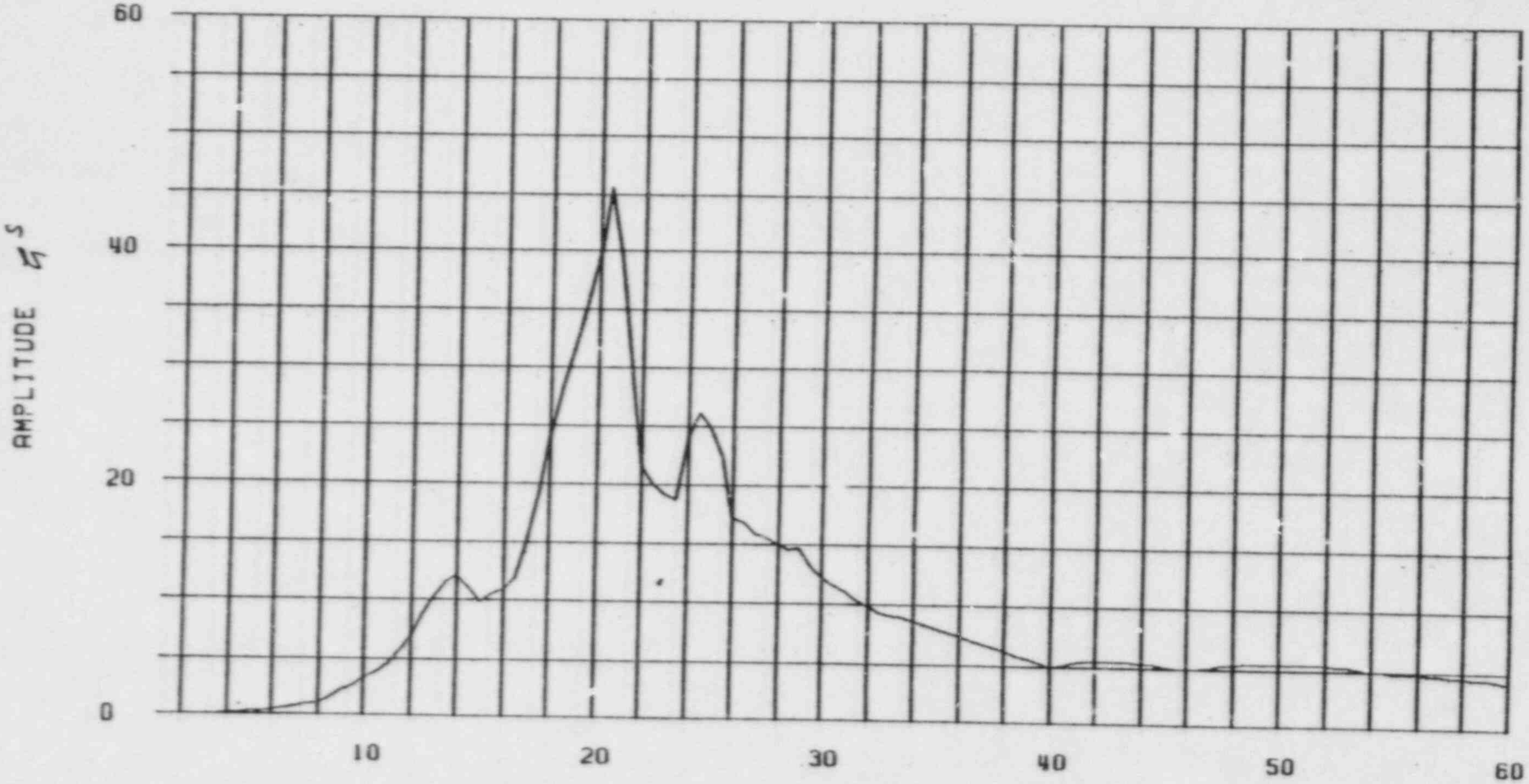



FIGURE 2

——— LEGEND

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PREPARED BY HK 4-28-83
CHECKED BY JET 5-2-83

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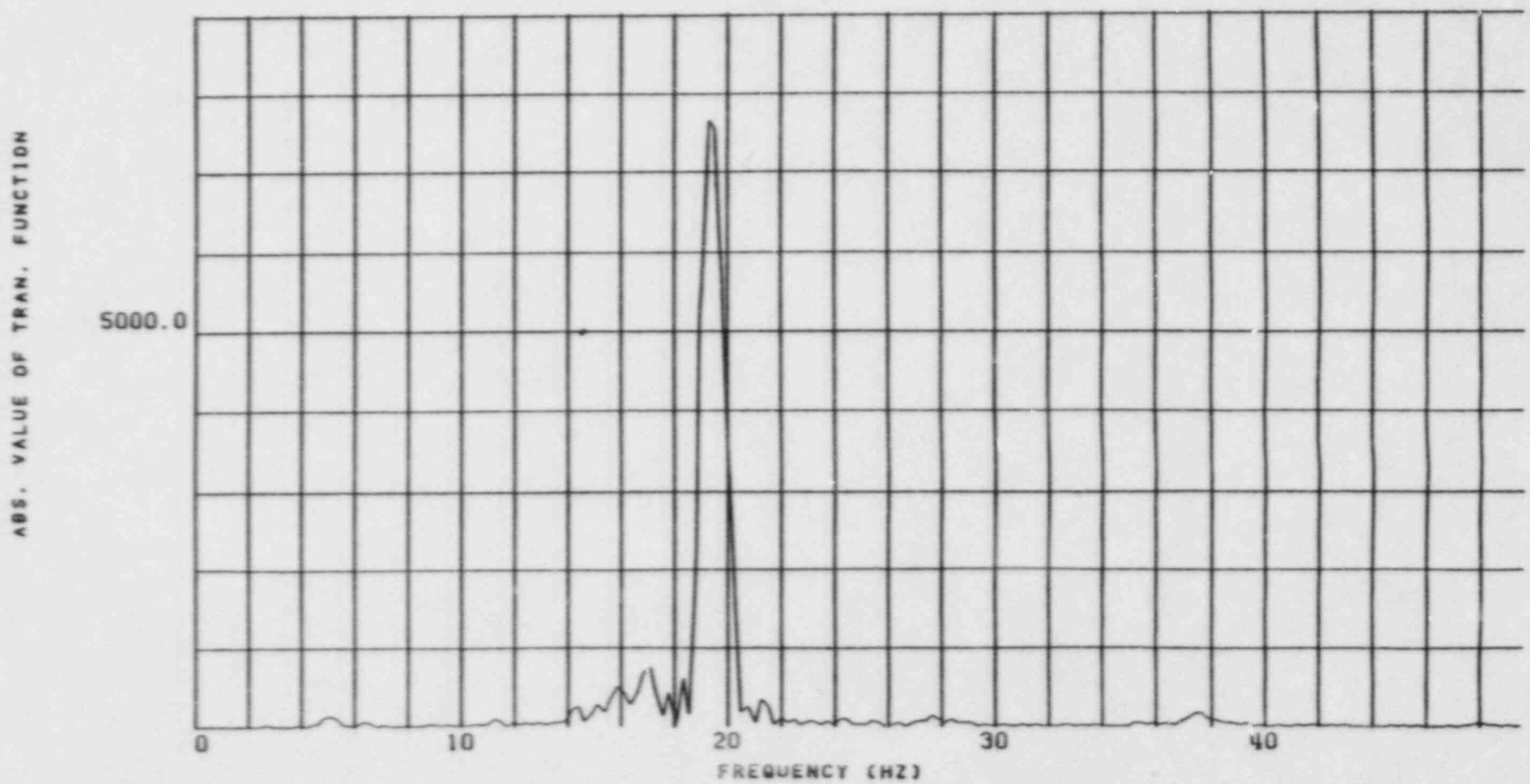
FILE NO. ____
REVISION 0 PAGE 7
PREPARED BY LW/8-10-82
CHECKED BY TYS/8-16-82

12

DUANE ARNOLD ENERGY CENTER
RHR CORE SPRAY RELIEF LINE N210B □ N211B
FORCE TRANSFER FUNCTIONS
NODE (212) X-MOMENT




FIGURE

## CMDOF MODELING TECHNIQUES

- Five coupled DOF's at each coupled node typically used

  - Rotation normal to torus (not defined for quad elements) not coupled

  - NUTECH studies showed longitudinal and circumferential rotations should be coupled

- Uncoupled torus motions calculated using modes up to 50 Hz

  - 40 to 50 torus modes typically used

  - Torus motion response predominantly in 18 to 25 Hz range

    - Modes in this range modelled with high accuracy

    - Higher modes modelled with adequate accuracy

# NRC QUESTION ON MONTICELLO PUAR HYDRODYNAMIC LOAD RESPONSES

## ITEM 1

- ACCELERATION VOLUMES FOR RING GIRDER
- IDENTIFY CHUGGING DOWNCOMERS AND PHASING
- PROVIDE LOCAL ACCELERATIONS

## RESPONSE TO ITEM 1

- NUREG-0661 METHOD INITIALLY USED TO CALCULATE ACCELERATION VOLUMES
- SRV AIR BUBBLE DRAG RESULTED IN AN EQUIVALENT PRESSURE OF APPROXIMATELY 195 PSI
- HIGHEST BUBBLE PRESSURE MEASURED AT MONTICELLO WAS 14 PSI
- ACCELERATION VOLUME DERIVED EMPIRICALLY BY DETERMINING PRESSURE AT RING GIRDER USING QBUBS02, THEN ADJUSTING SUBMERGED STRUCTURES PRESSURES TO BOUND QBUBS02
- DOWNCOMERS 2 AND 3 CHUGGING OUT-OF-PHASE


- ACCELERATIONS PER UNIT SOURCE STRENGTH

| SECTION NO. | $A_X$ | $A_Y$ | $A_Z$ |
|---|---|---|---|
| 7 | 0. | ~~1 84~~ 0.0178 | -0.01424 |
| 8 | -0.00039 | 0.00408 | -0.01316 |
| 9 | 0.18311E-9 | 0.18978E-8 | -0.01416 |
| 10 | 0. | -0.00601 | -0.01561 |

# NRC QUESTION ON MONTICELLO PUAR
# HYDRODYNAMIC LOAD RESPONSE

## ITEM 3

- o IS THE SAME RECTANGULAR BAY MODEL USED FOR CO, CHUGGING AND SRV SUBMERGED STRUCTURES LOADS AS FOR LOCA BUBBLE?
- o HOW ARE ASYMMETRIC LOADING CONDITIONS HANDLED?

## RESPONSE TO ITEM 3

- o RECTANGULAR BAY MODELS ARE THE SAME FOR MODELING TORUS CROSS-SECTION (MODEL E)
- o AS TABULATED BELOW, THE RECTANGULAR BAY MODELS DIFFER IN THE MODEL LENGTH

| STRUCTURE LOCATION | | BAY MODEL LENGTH |
|---|---|---|
| WITHIN BAY | LOCA AIR BUBBLE | ONE ACTUAL BAY |
| AT CENTER OF MODEL | C.O. | ONE CIRCUMFERENCE BASED ON MAJOR RADIUS |
| AT CENTER OF MODEL | CHUGGING | ONE CIRCUMFERENCE BASED ON MAJOR RADIUS |
| AT CENTER OF MODEL | SRV | ONE CIRCUMFERENCE BASED ON MAJOR RADIUS |

RECTANGULAR BAY MODELS FOR C.O., CHUGGING AND SRV SUBMERGED STRUCTURE LOADS ACCOMMODATE ASYMMETRIC LOADING CONDITIONS CONSERVATIVELY BECAUSE STRUCTURE IS LOCATED AT CENTER OF MODEL WHICH IS ONE CIRCUMFERENCE LONG.

RAS

## NRC QUESTION ON MONTICELLO PUAR
## STRUCTURAL AND PIPING RESPONSE

ITEM 5

- o DESCRIBE METHOD OF APPLICATION OF CALIBRATION FACTOR
- o PROVIDE NUMERICAL VALUES OF FACTOR
- o DESCRIBE EXTRAPOLATION OF FACTOR

RESPONSE TO ITEM 5

- o CALIBRATION FACTOR DEVELOPED USING TEST CONDITION ANALYSIS AND TEST RESULTS
- o DESIGN RESPONSES DEVELOPED USING SAME TECHNIQUES AS TEST CONDITION RESPONSES
- o CALIBRATION FACTOR APPLIED TO DESIGN RESPONSES AS PER NUREG-0661, SECTION 3.10.2.13
- o INDIVIDUAL SRV COMPONENT FACTORS RANGE FROM 1.59 TO 3.82
- o VENTHEADER SUPPORT AND DOWNCOMER FACTOR EQUALS 2.05

JWA

## NRC QUESTION ON MONTICELLO PUAR
## PIPING RESPONSE

### ITEM 6

- INCONSISTENCY BETWEEN FOOTNOTE AND TABLES

### RESPONSE TO ITEM 6

- FOOTNOTE MISLABELED
- TABLE 5-2.2-9 SHOULD BE TABLE 5-2.2-10
- TABLE 5-2.2-12 SHOULD BE TABLE 5-2.2-13

JWA

## NRC QUESTION ON MONTICELLO PUAR
## PIPING RESPONSE

ITEM 7

- o CLARIFICATION OF GEOMETRY DIFFERENCES BETWEEN SRVDL's
- o IDENTIFICATION AND BASIS FOR SELECTION OF ANALYZED CONFIGURATIONS

RESPONSE TO ITEM 7

- o ALL 8 SRVDL IN DRYWELL ARE DIFFERENT
- o ALL 8 SRVDL IN WETWELL ARE IDENTICAL
- o DRYWELL ANALYSIS PERFORMED FOR ALL 8 SRVDL INDIVIDUALLY
- o WETWELL ANALYSIS PERFORMED FOR ONE SRVDL (SRV-24)
- o SRV-24 WAS LINE INSTRUMENTED DURING IN-PLANT SRV TEST

JWA

## NRC QUESTION ON MONTICELLO PUAR
## PIPING RESPONSE

ITEM 8:

- o DESCRIPTION OF TECHNIQUE UTILIZED TO IMPLEMENT 10% RULE
- o DEMONSTRATE RESULTS OF IMPLEMENTATION

RESPONSE TO ITEM 8

- o 10% RULE ALLOWED IN NUREG-0661
- o ALL LDR LOADS CONSIDERED
- o ALL LOAD COMBINATIONS CONSIDERED
- o ALL SERVICE LEVELS CONSIDERED
- o 10% POINT CONSIDERED TO BE LOCATION BEYOND WHICH ALL STRESS RATIOS (CALCULATED TO ALLOWABLE) ARE LESS THAN 10%

JWA

# NRC QUESTION ON MONTICELLO PUAR
# PIPING RESPONSE

ITEM 10

- JUSTIFY USE OF SRV REDUCTION FACTOR OF 1.87 FOR ALL TAP LINES

RESPONSE TO ITEM 10

- PUAR MISLEADING
- FACTOR WAS NOT USED FOR ALL TAP, BUT ONLY SELECTIVELY
- RCIC TURBINE EXHAUST PIPING
  - LINE INSTRUMENTED DURING TEST
- RCIC AND HPCI TURBINE EXHAUST PENETRATIONS
  - GEOMETRIC SIMILARITIES

## NRC QUESTION ON MONTICELLO PUAR STRUCTURAL AND PIPING RESPONSE

### Item 11

- Certain components have stress ratios equal to 1.0
- Indicate conservatism in analysis

### Response to Item 11

- Loads developed in accordance with LDR
- Analytical methods in accordance with PUAAG
- Stress consistent with allowables
- Conservatisms described in Section 1-1.4 of PUAR

## NRC QUESTIONS ON DRESDEN/QUAD CITIES PUAR STRUCTURAL RESPONSES

ITEM 2:

- 0 USED DLF FOR EVALUATING SUBMERGED STRUCTURE LOADS
- 0 DESCRIBE HOW DLF'S ARE OBTAINED FOR RING GIRDER
- 0 PROVIDE CRITICAL FREQUENCIES AND MODE SHAPES FOR RING GIRDER

RESPONSE TO ITEM 2:

- 0 CRITICAL FREQUENCIES OBTAINED USING FINITE ELEMENT MODELS FOR IN-PLANE AND OUT-OF-PLANE DIRECTIONS
- 0 PUAR TABLE 2-2.4-1 SHOWS IN-PLANE FREQUENCY AND MASS PARTICIPATION. DOMINANT IN-PLANE FREQUENCY IS 18.87 HZ
- 0 TABLE 2-1 SHOWS OUT-OF-PLANE FREQUENCY AND MASS PARTICIPATION. DOMINANT OUT-OF-PLANE FREQUENCY IS 24.87 HZ

- DLF FOR CO AND CHUGGING SUBMERGED STRUCTURE. 50 HARMONICS OBTAINED USING THESE IN-PLANE AND OUT-OF-PLANE STRUCTURAL FREQUENCIES

- EQUIVALENT STATIC LOAD OBTAINED BY SUMMING ALL 50 HARMONICS

- FOR SRV AND LOCA SUBMERGED STRUCTURE LOADS BOUNDING DLF VALUES USED

ITEM 6:

0 SRV TORUS SHELL LOADS BASED ON MODIFIED ANALYTICAL MODEL CALIBRATED FROM IN-PLANT TESTS

0 PROVIDE NUMBER OF TESTS PERFORMED AT DRESDEN-2

0 PROVIDE COMPARISON OF OBSERVED AND PREDICTED SHELL PRESSURES

RESPONSE TO ITEM 6:

0 A TOTAL OF 8 TESTS CONDUCTED FOR VARIOUS CONDITIONS

0 TEST MATRIX SHOWN IN TABLE 6-1

0 COMPARISON OF OBSERVED AND PREDICTED SHELL PRESSURES DEMONSTRATES CONSERVATISM IN THE ANALYTICAL MODEL. SEE TABLES 6-2 AND 6-3

ITEM 7:

- 0 EXPLAIN HOW DLF FOR SRV DRAG LOADS IS DERIVED FROM DRESDEN IN-PLANT TESTS
- 0 PROVIDE DLF VALUES FOR RING GIRDER AND VENT HEADER SUPPORT COLUMNS
- 0 EXPLAIN HOW TEST INFORMATION IS EXTRAPOLATED TO DESIGN CONDITIONS

RESPONSE TO ITEM 7:

- 0 DLF FOR SRV DRAG LOADS CALCULATED USING MEASURED SRV BUBBLE PRESSURE TIME HISTORIES AS ALLOWED BY NUREG-0661.
- 0 BOUNDING DLF OF 2.5 FOR RESONANT CONDITIONS CALCULATED FROM THE MEASURED PRESSURE TIME HISTORIES IN MONTICELLO AND DRESDEN-2 TESTS
- 0 NUREG-0661 SECTION 3.10.2.13 PERMITS ACTUAL PRESSURE WAVE FORMS TO DETERMINE DLF AT RESONANT CONDITIONS TO BE APPLIED AT DESIGN CONDTIONS

ITEM 8:

- 0 ARE PUAR TABLES 3-2.2-15 (3-2.2-16) MISLABELED
- 0 PROVIDE VALUES USED IN PLANT UNIQUE ANALYSIS

RESPONSE TO ITEM 8:

- 0 THESE TABLES AND COLUMN HEADINGS ARE MISLABELLED IN PUAR
- 0 TABLES 8-1 AND 8-2 PRESENT THE CORRECTED VALUES USED IN PLANT UNIQUE ANALYSIS REPORT

## STRUCTURAL RESPONSES (CONT'D)

ITEM 9:

- ARE THE ENTRIES IN PUAR TABLE 3-2.2-3 FOR $F_1$ AND $F_2$ REVERSED
- IF NOT EXPLAIN

RESPONSE TO ITEM 9:

- ENTRIES IN PUAR TABLE 3-2.2-3 FOR $F_1$ AND $F_2$ ARE REVERSED
- LOADS WERE CORRECTLY APPLIED IN PLANT UNIQUE ANALYSIS

## NRC QUESTION ON MONTICELLO PUAR
## STRUCTURAL RESPONSE

ITEM 2

- SDOF MODEL IS JUDGED TO BE INADEQUATE FOR ANALYSIS OF RING GIRDER FOR SUBMERGED STRUCTURE LOADS. PROVIDE INFORMATION ON RING GIRDER MODE SHAPES ASSOCIATED WITH TWO CRITICAL FREQUENCIES (20 HZ AND 25 HZ) AND JUSTIFY USING THE SAME DLF FUNCTION OF FREQUENCY FOR LOADING IN ALL THREE DIRECTIONS.

RESPONSE TO ITEM 2

- DLF'S FOR SUBMERGED STRUCTURE LOADS WERE NOT CALCULATED BASED ON SDOF MODELS
- DLF'S BASED ON ANALYSIS OF SIMPLIFIED RING GIRDER F.E. MODEL FOR STEADY STATE SINUSOIDAL LOADING NORMAL TO RING GIRDER WEB
  - PRESSURE LOAD APPLIED NORMAL TO PLANE OF RING GIRDER
  - SINUSOIDAL LOADINGS VARIED FROM 1 TO 50 HZ
  - ALL RING GIRDER MODES BELOW 75 HZ WERE INCLUDED IN STEADY STATE ANALYSIS
  - DLF'S FOR EACH LOAD FREQUENCY WERE TAKEN AS THE RATIO OF BDC FLANGE LATERAL DISPLACEMENT FOR A STEADY STATE SINUSOIDAL LOADING TO BDC FLANGE LATERAL DISPLACEMENT FOR A STATIC LOADING
- MOST CONSERVATIVE DLF'S CALCULATED BY CONSIDERING DISPLACEMENT AND LOADING NORMAL TO RING GIRDER SINCE MODES BELOW 50 HZ EXHIBIT LARGEST DISPLACEMENTS IN THIS DIRECTION.

## NRC QUESTION ON MONTICELLO PUAR
## STRUCTURAL RESPONSE

ITEM 4

- JUSTIFICATION FOR MULTIPLE DOWNCOMER LATERAL LOADS USED IN PUA NOT TOTALLY CONVINCING
- PROVIDE NUMBER OF DOWNCOMERS USED FOR CRITICAL LOAD ON VENTHEADER UNDER SBA-II
- PROVIDE CONTRIBUTION OF CHUGGING LATERAL LOADS TO THE VENTHEADER MEMBRANE STRESS

RESPONSE TO ITEM 4

- AS PER NUREG 0661, SINGLE DOWNCOMER RSEL CONSERVATIVE FOR VENTHEADER AT DOWNCOMER INTERSECTION DURING CHUGGING
- TWO DOWNCOMERS LOADED IN THE SAME DIRECTION CONSERVATIVELY USED UNDER SBA-II
- TOTAL LOAD OF 21.48 KIPS CONSERVATIVELY APPLIED AS COMPARED TO SINGLE DOWNCOMER RSEL OF 11.81 KIPS
- CONTRIBUTION DUE TO 21.48 KIPS CHUGGING LOAD IS 51 PERCENT OF THE TOTAL VENTHEADER MEMBRANE STRESS
- ALLOWABLE STRESSES ARE 1.3 TIMES THE VALUES USED IN PUAR AS PER NUREG-0661
- CONSIDERABLE MARGIN EXISTS OVER THE ALLOWABLES

VK

## NRC QUESTION ON MONTICELLO PUAR
## STRUCTURAL RESPONSE

ITEM 9:

- WITH REFERENCE TO TABLE 5.2-2 OF THE PUA REPORT, PROVIDE REASONS FOR NOT CONSIDERING LOAD CASES WHICH INCLUDE POOL SWELL AND SAFE SHUTDOWN EARTHQUAKE (SSE).

RESPONSE TO ITEM 9

- SRV, CHUGGING, CO ARE INCLUDED IN SERVICE LEVEL B LOAD COMBINATIONS
  - $P_M \leq S_{MC}$
  - $P_L \leq 1.5\ S_{MC}$
  - $P_L + P_B + Q \leq 3.0\ S_{MI}$
- ALL POOL SWELL + SSE LOAD COMBINATIONS ARE SERVICE LEVEL C
  - $P_M \leq 1.0\ S_Y$
  - $P_L \leq 1.5\ S_Y$
  - EVALUATION OF $P_L + P_B + Q$ NOT REQUIRED
- INCREASE IN ALLOWABLE STRESSES FROM SERVICE LEVEL B TO SERVICE LEVEL C FAR EXCEEDS DIFFERENCES BETWEEN POOL SWELL + SSE AND SERVICE LEVEL B LOADS
- EVALUATION OF POOL SWELL + SSE NOT REQUIRED

JKS

# NRC QUESTIONS ON DRESDEN/QUAD CITIES PUAR HYDRODYNAMIC LOAD RESPONSES

ITEM 1:

- 0 ACCELERATION VOLUMES FOR RING GIRDER
- 0 IDENTIFY CHUGGING DOWNCOMERS AND PHASING
- 0 PROVIDE LOCAL ACCELERATIONS

RESPONSE TO ITEM 1:

- 0 SAME MODELING TECHNIQUE EMPLOYED TO CALCULATE ACCELERATION VOLUMES AS PRESENTED IN ENRICO FERMI PUAR AND ACCEPTED BY USNRC
- 0 FOR IN-PLANE DIRECTION . . .

  RING GIRDER MODELED AS I-BEAM

  $$V = [2.11 \pi A^2 + 2C (2A + B + C)] L A_W$$

  $V_{DRESDEN} = 17.30 \text{ FT}^3$ (SECTIONS 7-10)

  $V_{QUAD\ CITIES} = 7.19 \text{ FT}^3$ (SECTIONS 7-10)

0 FOR OUT-OF-PLANE DIRECTION . . .

RING GIRDER MODELED AS RECTANGLE

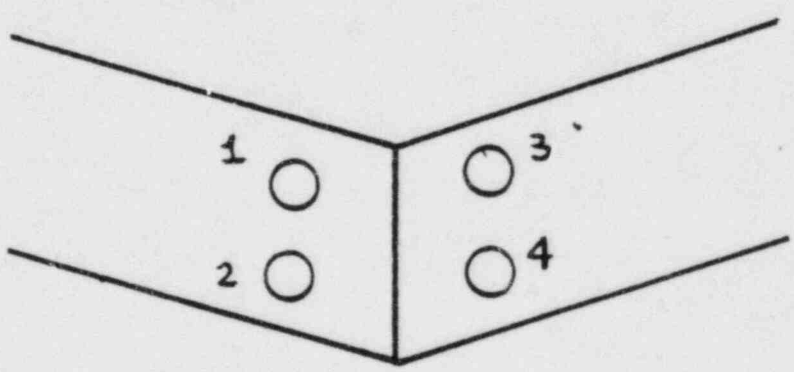
$V_{DRESDEN} = [1.33 \pi A^2 + (2B-C) C + 2AC] L A_W$

$V_{DRESDEN} = 59.85 FT^3$ (SECTIONS 7-10

$V_{QUAD CITIES} = [1.207 \pi A^2 + (2B-C) C + 2AC] L A_W$

$V_{QUAD CITIES} = 66.38 FT^3$ (SECTIONS 7-10)

0 FIVE POST CHUG CASES ANALYZED TO MAXIMIZE FORCES




1 & 3 IN-PHASE
1 & 3 OUT-OF-PHASE
2 & 3 IN-PHASE
3 & 4 IN-PHASE
3 & 4 OUT-OF-PHASE

## HYDRODYNAMIC LOAD RESPONSES (CONT'D)

| STRUCTURE LOCATION | LOAD | BAY MODEL LENGTH |
|---|---|---|
| WITHIN BAY | LOCA AIR BUBBLE | ONE ACTUAL BAY |
| AT CENTER OF MODEL | CO | ONE CIRCUMFERENCE BASED ON MAJOR RADIUS |
| AT CENTER OF MODEL | CHUGGING | ONE CIRCUMFERENCE BASED ON MAJOR RADIUS |
| AT CENTER OF MODEL | SRV | ONE CIRCUMFERENCE BASED ON MAJOR RADIUS |

∴ RECTANGULAR BAY MODELS FOR CO, CHUGGING AND SRV SUBMERGED STRUCTURE LOADS ACCOMMODATE ASYMMETRIC LOADING CONDITIONS CONSERVATIVELY BECAUSE STRUCTURE IS LOCATED AT CENTER OF MODEL, WHICH IS ONE CIRCUMFERENCE LONG.

0 ACCELERATIONS PER UNIT SOURCE STRENGTH FOR SEGMENT 7 AT DRESDEN

| CASE | AX | AY | AZ |
|---|---|---|---|
| 3-4 IN-PHASE | 0.465 | 0.394 | 0.609 |

ITEM 3:

- O IS THE SAME RECTANGULAR BAY MODEL USED FOR CO, CHUGGING AND SRV SUBMERGED STRUCTURES LOADS AS FOR LOCA BUBBLE?

- O HOW ARE ASYMMETRIC LOADING CONDITIONS HANDLED?

RESPONSE TO ITEM 3:

- O RECTANGULAR BAY MODELS ARE THE SAME FOR MODELING TORUS CROSS-SECTION (MODEL E)

- O AS TABULATED BELOW, THE RECTANGULAR BAY MODELS DIFFER IN THE MODEL LENGTH.

ITEM 4:

0 DESCRIBE MODEL USED TO CALCULATE POOL SWELL IMPACT AND DRAG LOADS ON SPHERICAL JUNCTION.

RESPONSE TO ITEM 4:

0 JUNCTION MODELED AS CYLINDERS WITH AXIS COINCIDENT WITH MAIN VENT

0 USED PROCEDURE FOR MAIN VENTS IN SECTION 2.6 OF APPENDIX A TO NUREG-0661

0 IN ADDITION TO IMPACT AND VELOCITY DRAG, ACCELERATION DRAG AND BUOYANCY CONSIDERED

0 VELOCITY DRAG CONSERVATIVELY CALCULATED USING $C_D=2$

## NRC QUESTIONS ON DRESDEN/QUAD CITIES PUAR

## PIPING RESPONSE

ITEM 5:

- 0 JUSTIFY PROCEDURE FOR CO HARMONIC PHASING FOR TAP
- 0 JUSTIFY USE OF SCALE FACTOR FOR ALTERNATE 4 OF CO SPECIFICATION

RESPONSE TO ITEM 5:

- 0 COMBINATION METHOD JUSTIFIED BY KENNEDY (SMA)
- 0 RANDOM PHASING AND 1.15 FACTOR RESULTS IN 50% NEP WITH 90% CONFIDENCE. TEST DATA IS BOUNDED
- 0 TEST CASE M-12 INCLUDED
- 0 M-12 WITH RANDOM PHASING AND 1.15 FACTOR BOUNDS ALTERNATIVES 1, 2 AND 3 WITH 1.3 FACTOR AND TEST DATA
- 0 M-12 WITH 1.15 FACTOR UTILIZED AS DESIGN LOAD