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New York Power Authority

John C. Brons
Executive Vice President
Nuclear Generation

September 15, 1989
IPN-89-058

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Mail Station P1-137
Washington, D.C. 20555

Subject: Indian Point 3 Nuclear Power Plant
Docket No. 50-286
Spent Fuel Pool Expansion (TAC No. 68233)

References:

1. Letter from Mr. J. C. Brons to the NRC, dated May 9, 1988, entitled: "Proposed Technical Specifications Regarding Spent Fuel Pool Storage Capacity Expansion."

2. Letter from Mr. J. C. Brons to the NRC, dated December 20, 1988, entitled: "Spent Fuel Pool Expansion (TAC No. 68233)."

Dear Sir:

The Authority met with the NRC on July 19, 1989, to discuss the proposed Indian Point 3 spent fuel pool expansion. The specific issues discussed concerned the seismic and mechanical analyses. The purpose of this letter is to provide clarifications and supplemental information to References (1) and (2) as discussed during the July 19, 1989 meeting and subsequent telephone conversations.

Attachment I to this letter contains the information regarding the seismic and mechnical analyses. Also included is information concerning the spent fuel pool wall adequacy to withstand the rack hydrodynamic pressure during a seismic event. Attachment II provides information regarding the open items from the July 19, 1989, meeting and an August 1, 1989, telephone conversation. Attachment III provides the results of the 1% damping case for a single 132 cell rack with regular (standard) fuel. Attachment IV contains a revised Table 4-3 of the Safety Analysis Report which was Enclosure 1 of Reference (1). Included as Attachment V is a page of the seismic report which was inadvertenly missing.

A001
1/1

8909280073 890915
PDR ADOCK 05000286
P PDC

Should you or your staff have any questions regarding this matter, please contact Mr. P. Kokolakis of my staff.

Very truly yours,

for John C. Brons
Executive Vice President
Nuclear Generation

cc: Resident Inspector's Office
Indian Point Unit 3
U.S. Nuclear Regulatory Commission
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ATTACHMENT I TO IPN-89-058

INFORMATION REGARDING THE SEISMIC AND MECHANICAL ANALYSES AND SPENT FUEL POOL WALL

NEW YORK POWER AUTHORITY
INDIAN POINT 3 NUCLEAR POWER PLANT
DOCKET NO. 50-286
DPR - 64

REFERENCE DOCUMENTS

1. "MECHANICAL REPORT, SPENT FUEL STORAGE RACKS, INDIAN POINT UNIT 3", 8721-00-0125 Rev 2, November 1988.

2. "THERMAL-HYDRAULIC REPORT, SPENT FUEL STORAGE RACKS, INDIAN POINT UNIT 3", 8721-00-0104 Rev 1, January 1988.

3. "SEISMIC ANALYSIS REPORT, SPENT FUEL STORAGE RACKS, INDIAN POINT UNIT 3", 8721-00-0033 Rev 3, November 1988.

4. "FORMULAS FOR STRESS & STRAIN", R. Roark, 5th Edition

5. "EXPERIMENTAL AND FINITE ELEMENT EVALUATION OF SPENT FUEL RACK DAMPING AND STIFFNESS", January 1988

(1) Q: Provide all supporting information to justify the increase in concrete allowable bearing stress above 3000 psi. If necessary, provide an alternate design for the floor plate over the leak chase so that bearing stress falls conservatively below the minimum allowable 3000 psi.

R: Due to the concern over use of a concrete bearing stress above 3000 psi, UST&D has revised its calculation for determining floor plate bearing stress. However, UST&D restates its position that 3000 psi is overconservative for:

a. 38" thick concrete slab
b. #8 rebar reinforcement
and c. concrete age over 28 days

Taking the above factors into account, a bearing stress above 3000 psi may be calculated. See Reference 3.

The more conservative, revised bearing stress calculation (using f_c1 = 3000 psi) results in a maximum factor of safety equal to 1.08. The following changes in the calculation were used:

1) A 45° spread to the bearing area used for vertical load distribution

and 2) The wet weight of the fuel and rack is used to calculate the factored loads. The previous Reference 2 analysis used the dry weights.

The resulting maximum bearing stress was 3320 psi, and the allowable stress is 3570 psi.

(2) Q: Provide in tabulated format all the computer seismic results, loads, displacements for the rack configurations run to date for NYPA.

R: See the Attached Tabulation

	A	B	C	D	E	F	G
RUN NO.	IP3EWCI	IP3NSCI	IP3ONSCIF	IP3OEWCIF	IP3EWCIF	IP3NSCIF	IP3NS
DB/CONFIRM	DB	DB	DB	DB	DB	DB	DB
RACK SIZE	132	132	132	132	132	132	132
FRICTION	.8	.8	.2	.2	.2	.2	.8
MULT/SINGLE	S	S	S	S	S	S	S
DIRECTION	EW	NS	NS	EW	EW	NS	NS
COMBINED	NO	NO	NO	NO	NO	NO	NO
WET/DRY	WET	WET	WET	WET	WET	WET	WET
FIGURE	2.1	2.1	2.1	2.1	2.1	2.1	2.1
REGION	2	2	2	2	2	2	2
CONSOL/NORM	CON	CON	CON	CON	CON	CON	NORM
TIME STEP	.0005	.0005	.0005	.0005	.0005	.0005	.0005
SYM/UNSYM	SYM	SYM	SYM	SYM	SYM	SYM	SYM
MULTI MASS	YES	YES	YES	YES	YES	YES	YES
SSE/OBE	SSE	SSE	OBE	OBE	SSE	SSE	SSE
DAMPING	4	4	4	4	4	4	4
GAP	---	---	---	---	---	---	---
DISPLACEMENT	.289	.276	.0114	.00126	.00348	.00306	.1928
MAX.PED FORCE ON 2 PED	289.	310.	238.	258.	295.	264.	191.
MAX. HORIZ. FORCE	89.	120.	---	---	---	---	840

	H	I	J	K	L	M	M
RUN NO.	IP3EWI	IP3NSIF	IP3EWIF	IP3NSIFO	IP3EWIFO	IP3EWRICI	IP3NSRICI
DB/CONFIRM	DB	DB	DB	DB	DB	DB	DB
RACK SIZE	132	132	132	132	132	80	80
FRICTION	.8	.2	.2	.2	.2	.8	.8
MULT/SINGLE	S	S	S	S	S	S	S
DIRECTION	EW	NS	EW	NS	EW	EW	NS
COMBINED	NO	NO	NO	NO	NO	NO	NO
WET/DRY	WET	WET	WET	WET	WET	WET	WET
FIGURE	2.1	2.1	2.1	2.1	2.1	2.1	2.1
REGION	2	2	2	2	2	1	1
CONSOL/NORM	NORM	NORM	NORM	NORM	NORM	CONS	CONS
TIME STEP	.0005	.0005	.0005	.0005	.0005	.0005	.0005
SYM/UNSYM	SYM	SYM	SYM	SYM	SYM	SYM	SYM
MULTI MASS	YES	YES	YES	YES	YES	YES	YES
SSE/OBE	SSE	SSE	SSE	OBE	OBE	SSE	SSE
DAMPING	.4	.4	.4	.4	.4	.4	.4
GAP	---	---	---	---	---	---	---
DISPLACEMENT	.295	.303	.155	.1280	.117	.167	.138
MAX.PED FORCE ON 2 PED	235.	163.	172.	162.	175.	206.	285.
MAX. HORIZ. FORCE	91.	---	---	---	---	52.8	105.5

	O	P	Q	R	S	T
RUN NO.	IP3EWR1CIF	IP3NSR1CIF	IP3EWR1I	IP3NSR1I	IP3EWR1IF	IP3NSR1IF
DB/CONFIRM	DB	DB	DB	DB	DB	DB
RACK SIZE	80	80	80	80	80	80
FRICTION	.2	.2	.8	.8	.2	.2
MULT/SINGLE	S	S	S	S	S	S
DIRECTION	EW	NS	EW	NS	EW	NS
COMBINED.	NO	NO	NO	NO	NO	NO
WET/DRY	WET	WET	WET	WET	WET	WET
FIGURE	2.1	2.1	2.1	2.1	2.1	2.1
REGION	1	1	1	1	1	1
CONSOL/NORM	CONS	CONS	NORM	NORM	NORM	CONS
TIME STEP	.0005	.0005	.0005	.0005	.0005	.0005
SYM/UNSYM	SYM	SYM	SYM	SYM	SYM	SYM
MULTI MASS	YES	YES	YES	YES	YES	YES
SSE/OBE	SSE	SSE	SSE	SSE	SSE	SSE
DAMPING	4	4	4	4	4	4
GAP	---	---	---	---	---	---
DISPLACEMENT	.0878	.0642	.161	.0938	.1197	.1454
MAX.PED FORCE ON 2 PED	218.	186.	197.	168.	148.	---
MAX. HORIZ. FORCE	---	---	51.	71.	---	1218.

	U	V	W	X	Y	Z
RUN NO.	IP3EWR1IFO	IP3NSR1IFO	IP3NSIH	IP3NSFE	IP3BSIHF	IP3NSE
DB/CONFIRM	DB	DB	DB	DB	DB	DB
RACK SIZE	80	80	132	132	132	132
FRICTION	.2	.2	.8	.2	.2	.8
MULT/SINGLE	S	S	S	S	S	S
DIRECTION	EW	NS	NS	NS	NS	NS
COMBINED	NO	NO	NO	NO	NO	NO
WET/DRY	WET	WET	WET	WET	WET	WET
FIGURE	2.1	2.1	2.1	2.1	2.1	2.1
REGION	1	1	2	2	2	2
CONSOL/NORM/EMPTY	NORM	NORM	NORM	EMPTY	NORM	EMPTY
TIME STEP	.0005	.0005	.0005	.0005	.0005	.0005
SYM/UNSYM	SYM	SYM	UNSYM	SYM	UNSYM	SYM
MULTI MASS	YES	YES	YES	YES	YES	YES
SSE/OBE	OBE	OBE	SSE	SSE	SSE	SSE
DAMPING	.4	.4	4	4	.4	.4
GAP	---	---	---	---	---	---
DISPLACEMENT	.0957	.1060	.1190	.82	.076	.052
MAX.PED FORCE ON 2 PED	130.	125.	161.	19.	107.	83.
MAX. HORIZ. FORCE	---	---	52.	---	---	23

	AA	AB	AC	AD	AE	AF	AG
RUN NO.	IP3NSL3	IP3IMP5	RACK3280	RACK3280F	RACK3280VF	RACK3280V	IP3NSR1I1
DB/CONFIRM	CONF	CONF	DB	DB	CONF	CONF	CONF
RACK SIZE	132	132	80	80	80	80	80
FRICTION	---	---	---	.2	.2	.8	.8
MULT/SINGLE	M	M	M	M	M	M	S
DIRECTION	NS	NS	NS	NS	NS	NS	NS
COMBINED	NO	NO	NO	NO	YES	YES	YES
WET/DRY	WET	WET	WET	WET	WET	WET	DRY
FIGURE	SEC5/P3	SEC5/P3	SEC6/P1	SEC6/P1	SEC6/P1	SEC6/P1	2.1
REGION	2	2	1	1	1	1	1
CONS/NORM/EMPTY	NORM	NORM	C,N,E	C,N,E	C,N,E	C,N,E	NORM
TIME STEP	.0005	.0005	.0005	.0005	.0005	.0005	.0005
SYM/UNSYM	F-1/2-F	F-1/2-F	Fc-Fn-E	Fc-Fn-E	Fc-Fn-E	Fc-Fn-E	SYM
MULTI MASS	NO	NO	YES	YES	YES	YES	YES
SSE/OBE	OBE	SSE	SSE	SSE	SSE	SSE	SSE
DAMPING	0.0	0.0	4	4	4	4	4
GAP	.25	1.5	1.5	1.5	1.5	1.5	---
IMPACT GAP	.25	1.5	1.5	1.5	.125	.125	---
DISPLACEMENT	.039/ .027/ .039	.196/ .235/ .196	INPUT ERROR	INPUT ERROR	.036/ .038/ .070	.0698/ -.065/ .056	
MAX.PED FORCE ON 2 PED	---	---	FUEL PROP	FUEL PROP	118/ 69.7/ 11.9	200/ 83. 145/ 40.	
MAX. HORIZ. FORCE	---	---			---	53./ -49.5/ 42.4	

(3) Q: Provide a computer run for determining the rack natural frequency <u>without</u> the K_{11} spring in the computer model. Compare rack motion to previous analysis.

R: The natural frequencies for conditions, (1) with the horizontal base K_{11} spring in the model and (2) without the base K_{11} spring. The results of the computer runs are attached and summarized below:

132-cell rack
consolidated fuel
NS excitation

Run 1 - with K_{11} spring
Run 2 - without K_{11} spring

	Run 1 (9-29-88)		Run 2 (4-10-89)	
Mode	NATURAL FREQ (H2)	MODEL PARTICIPATION	NATURAL FREQ (H2)	MODEL PARTICIPATION
1	.050	.176	.012	.007
2	.095	.191	.078	.202
3	2.935	.765	.124	.790
4	6.376	-.002	6.376	.000
5	15.078	-.014	14.922	-.001
6	15.974	-.033	15.494	-.001

(4) Q: Provide justification for use of 4% rack damping. Explain use of damping for 1% and 4%.

R: UST&D has based the use of internal structural damping on testing of the rack structure at the University of Akron. The test report is Reference 5, is listed in the seismic report as Reference (16) and is part of the public record after the STP licensing in 1988. The report indicates damping up to 18%, but only 4% was used for conservatism in the Indian Point 3 seismic analysis.

(5) Q: Summarize the expected difference between 2D and 3D seismic analysis. Which are more conservative and why?

SLIDING COMPARISON 2D VERSUS 3D

R: 2D Reference IP3 Seismic Report (runs with 0.2 friction - 2D; no vertical acceleration)

All deflections are in inches

IP3NSIF (8/17/87) MAX $\triangle$ = -0.303 at 4.76 sec
IP3EWI (8/17/87) MAX $\triangle$ = -0.155 at 2.21 sec

3D The following 3D run was for 15 sec real time with vertical acceleration

IP33DF (4/24/89) MAX $\triangle$ (NS) = -0.110 at 1.763 sec
" MAX $\triangle$ (EW) = 0.1581 at 2.22 sec

The following were for 5 sec real time
IP33DF NS & VERTICAL INPUT ONLY

(4/24/89) MAX $\triangle$ (NS) = - 0.252 at 3.85 sec

IP33DF EW & VERTICAL INPUT ONLY

MAX $\triangle$ (EW) = .1912 at 4.94 sec

The following was for EW and NS (NO VERTICAL)

MAX $\triangle$ (NS) = -.1117 at 4.76 sec
MAX $\triangle$ (EW) = .1606 at 2.22 sec

Note that the times for the maximum displacements are the same as for the 2D runs at the top. The EW displacement is about the same and the NS less.

It is concluded that the 2D runs give satisfactory displacements (actually somewhat greater than the 3D). The vertical acceleration has relatively little effect on the displacements.

(5) Continued:

LOAD COMPARISON 2D VERSUS 3D

The following are the pedestal loads for a 3D run representing 0.8 friction i.e. the base is restrained. The maximum loads on the pedestals and the times at which they occur are:

PEDESTAL	MAX LOADS (KIPS)	TIME
1	143.8	2.3335 sec.
2	164.0	2.136
3	128.8	2.198
4	129.7	2.415

The total horizontal loads (for all pedestals) are:

NS	83.2	KIPS	1.712 sec
EW	93.0	KIPS	2.64

The corresponding maximum forces from the 2D runs (using SRSS) are:

VERTICAL (1 PEDESTAL)		136.4 KIPS
HORIZONTAL	NS	84.1 KIPS
	EW	91.0 KIPS

(6) Q: Compute mechanical stresses with horizontal force acting to the right and left and equal to zero, to determine if our methodology of assuming horizontal force acting only to the right is conservative.

R: (a) To determine the maximum fusion weld stresses, three cases were considered in computer analysis, which are attached.

Case I included horizontal force acting to the right, at the base of pedestal.

Case II analysis used horizontal force, $F_H = 0$ and

Case III input was horizontal force F_H acting to the left, at the base of pedestal footing.

(b) The maximum stresses for each case are summarized below:

MAXIMUM STRESSES	CASE I HORIZONTAL FORCE TO THE RIGHT →	CASE II HORIZONTAL FORCE = 0	CASE III HORIZONTAL FORCE TO THE LEFT ←
SHEAR (τ MAX)	11.53 KSI	6.82 KSI	9.67 KSI
TENSILE (σ MAX)	16.14 KSI	8.46 KSI	15.22 KSI

CONCLUSION: When horizontal force is applied to the right and at the base of the pedestal, maximum stresses are induced in the structure. (Case I) The UST&D analysis has considered Case I stresses in the qualification of fusion welds, because it is more limiting than Case II or Case III.

(7) Q: Describe the fuel impact on the box wall and determine the resulting loading distribution and stress.

R: The 80-cell rack with standard fuel is considered for this analysis because of the maximum force on an individual fuel assembly during and East-West seismic event. The forces on an individual fuel assembly are computed in Table No. 3, Section 3 of the seismic report, Reference 2.

From Westinghouse fuel assembly outline Dwg. 1607E93, the grid impact dimensions were determined.

The summary of results is shown below:

FORCE ON INDIVIDUAL FUEL ASSEMBLY	= 276 LB
LOAD PER GRID	= 237 LB
THICKNESS OF BOX WALL	= 0.085 IN.
MAX STRESS ON THE BOX WALL	= 26.24 KSI
ALLOWABLE STRESS	= 28.8 KSI
FACTOR OF SAFETY	= 1.10

(8) Q: Document the thermal hot next to cold cell stress calculation or revise calculation to show individual weld stresses.

R: The maximum fusion weld thermal stresses have been calculated for Region 1 racks and standard fuel, placed in the cells 120-hours after reactor shutdown. The resulting temperature rise in the hot cell is calculated to be 26°F. With no fuel in the adjacent cell the water box temperature rise is calculated to be 10°F. Therefore, a net difference of 16°F exists between fuel cell and water box at the top of the rack. The thermal shear stress in the two top levels of fusion welds was calculated as 3857 psi. This stress was conservatively combined with the primary shear stress at the top of the racks for both Region 1 and Region 2 using consolidated fuel loads. The results are shown in Table I.

TABLE I

	SHEAR STRESSES, psi			
Region I	τ primary	τ thermal	τ total	*safety factor
Top of Rack	8,605	3,857	12,462	1.68
Bottom of Rack	10,000	0	10,000	2.1

	SHEAR STRESSES, psi			
Region II	τ primary	τ thermal	τ total	*safety factor
Top of Rack	7,715	3,857	11,572	1.81
Bottom of Rack	11,534	0	11,534	1.82

Adding the secondary shear thermal stresses to the primary shear stresses reduces the fusion weld shear stress safety factors from 2.1 to 1.68 for Region 1 and 1.82 to 1.81 for Region 2.

*NOTE: The allowable stress level was conservatively used as 21,000 psi although for addition of thermal stresses the allowable of 2Sy or 0.7Su (whichever is smaller) could have been used.

(9) Q: Explain the seismic analysis results that show more sliding for standard fuel than for consolidated fuel.

R: The summary of maximum movement at the base of the rack (response to NRC Question II.3) indicated that the 132-cell rack with standard fuel slid farther than the 132-cell rack with consolidated fuel.

The aforementioned result is predictable due to the differences in the horizontal coupling between the rack mass and the fuel mass when the two cases are compared. There is no mechanical coupling between the fuel and the rack. During accelerated motion the rack mass can translate horizontally independent of the fuel mass until the horizontal force overcomes the static friction force. This motion is only hindered by:

A) The closing of the gap between the fuel and the cell wall during translation.

B) The extent of the hydrodynamic coupling between the rack and fuel.

Therefore, standard fuel may be expected to slide a greater distance because: (1) less fluid coupling exists between the cell and the fuel and (2) the cell to fuel gap is greater for standard fuel.

A parametric study has been performed to support the conclusion above in which the gap between the fuel and the rack was varied for standard fuel while retaining the same fluid matrix coefficients. The results shown below indicate that the translation of the rack is reduced with decreased gap size and with decreased gap size the rack and fuel impact more frequently, thus imposing greater inertia and less travel for the rack-fuel system as opposed to the rack translating alone.

132-CELL STANDARD FUEL E-W
MAXIMUM DISPLACEMENT AS A FUNCTION
OF CELL TO FUEL GAP

CELL TO FUEL GAP	DISPLACEMENT
.21	.1545
.08	.0889
.01	.0634
.001	.000564

(10) Q: What are the maximum calculated hydrodynamic forces on the pool wall and the rack side?

1-R: The maximum hydrodynamic loading on the pool wall in the vicinity of the rack was determined and is supported by attached calculation. The design basis East-West single 132-rack math model was subjected to a SSE East-West seismic excitation. The wall forces were determined at the West wall. The rack to wall gap was 4.51".

Results: The hydrodynamic load acting on the (12 x 9.075" x 165") face of the pool wall is 1.1701 E5 kips which corresponds to an average pressure of 6.5 psi.

2-R: The maximum local rack stress due to hydrodynamic loading was determined and are supported by the attached calculation. The design basis East-West single 132-rack math model was subject to a SSE East-West seismic excitation. The wall forces were determined at the West wall. The rack to wall gap was 4.51".

The following localized stresses were examined:

1) The local wall buckling acting on the first row of cell walls.

2) Localized stress in the transverse outside wall.

The total load acting the face is 59.4 kips and corresponds to a pressure of 3.3 psi.

Results: The column stress in the first row of cells adjacent to the pressure boundary is 0.352 ksi. The factor of safety against buckling is 8.25.

The maximum bending stress developed in the transverse outside wall 18.8 ksi. The factor of safety is 1.91.

ATTACHMENT

SHEETS

RESPONSE TO QUESTION 1

U.S. TOOL & DIE, INC

BY a.t. DATE 04-11-89 SUBJECT NYPA REGION 2 SECT. ____ SHEET 1 OF 3

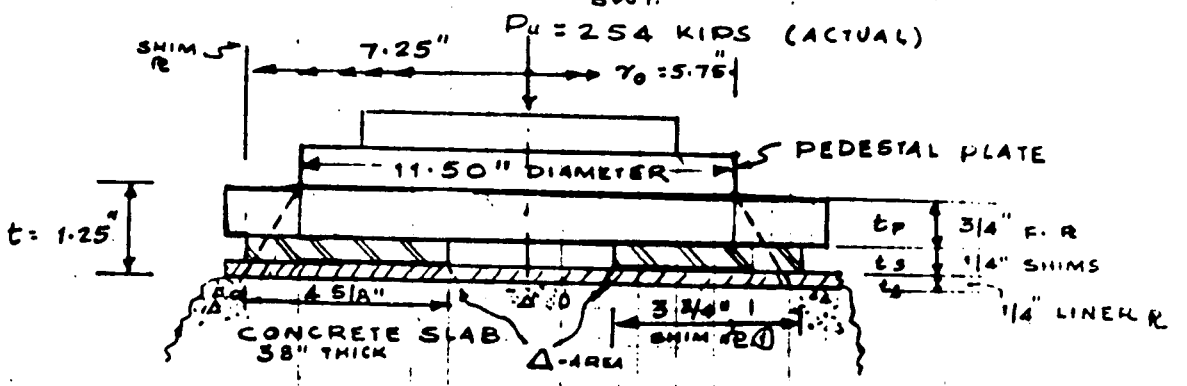
CHKD. BY PSS DATE 4-12-89 PLATE BEARING PROJ. NO 8721

DETERMINE CONCRETE BEARING STRESSES:

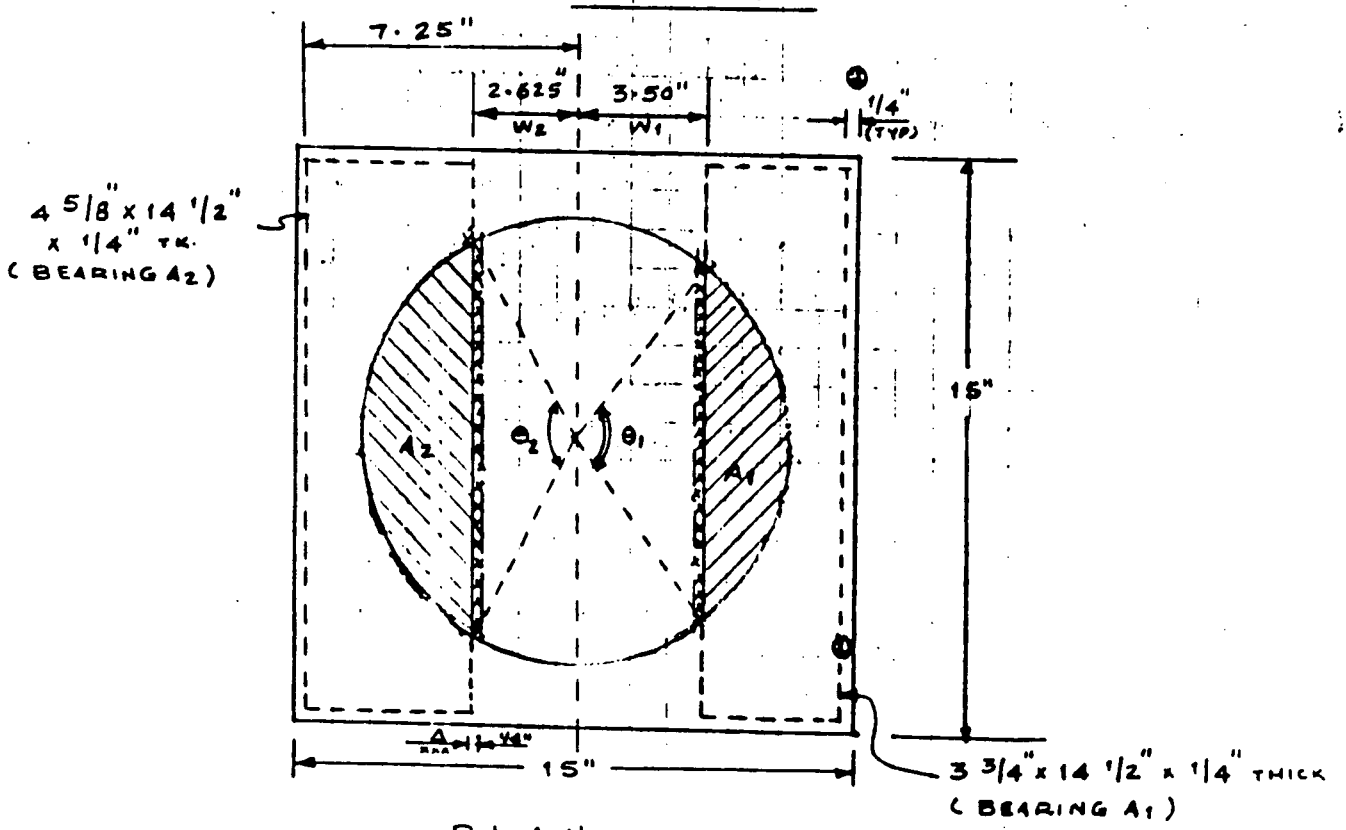
REF: UST&D DWGS. 8721-31 REV. 0
8721-35 REV. 0

PREVIOUSLY USED FACTORED (OBE) LOAD P_u = 273197 LB
(SECTION 4.2, Pg. 14A, MECH. REPORT)

ACTUAL P_u (OBE) = $1.4\left(\frac{368289\ LB}{4}\right) + 1.8(65856\ LB)$ = 254 KIPS
SWT. DYNAMIC



SECTION



PLAN

TYPE D PLATE

▨ BEARING AREA A_1, A_2.

▦ BEARING AREA Δ (A_3)

RESPONSE TO QUESTION 1

U.S. TOOL & DIE, INC.

BY a.t. DATE 04-11-89 SUBJECT NYPA REGION 2 SECT. ____ SHEET 2 OF

CHKD. BY PSS DATE 4-12-89 PLATE BEARING STRESSES PROJ. NO 8721

DIAMETER OF PEDESTAL PLATE = 11.50"

$r_o = 5.75"$

RADIUS OF BEARING (R)

$R = r_o + t(\tan 45°) = 5.75" + 1.25(1) = 7.0"$

$t = t_p + t_s + t_l = 0.75 + 0.25 + 0.25 = 1.25"$

$\theta = 2\cos^{-1}\left(\frac{W}{R}\right)$ FOR CIRCULAR SEGMENT
(RADIANS)

$W_1 = 7.25" - 3.75" = 3.50"$

$W_2 = 7.25" - 4.625" = 2.625"$

$\theta_1 = 2\cos^{-1}\left(\frac{3.50}{7.0}\right) = 120° \times \frac{\pi}{180} = 2.0944$ RADIANS

$\sin\theta_1 = 0.866$

$\theta_2 = 2\cos^{-1}\left(\frac{2.625}{7.0}\right) = 135.95° \times \frac{\pi}{180} = 2.373$ RADIANS

$\sin\theta_2 = 0.695$

AREA: $A = \frac{R^2}{2}(\theta - \sin\theta)$

$A_1 = \frac{(7.0)^2}{2}(2.0944 - 0.866) = 30.10$ IN.^{2}

$A_2 = \frac{(7.0)^2}{2}(2.373 - 0.695) = 41.11$ IN.^{2}

CONSIDER CROSS-HATCHED Δ-AREA FOR BEARING (A_3)

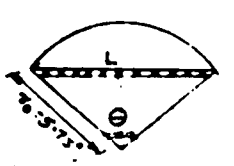
$t_\Delta = 1/4"$ (LINER) ∴ $r_\Delta = 0.25"(\tan 45°) = 0.25"$

$\theta_{\Delta_1} = \frac{\theta_1}{2} = \frac{120}{2} = 60°$

$L = 2\sqrt{b(d-b)}$; $b = r_o(1 - \cos\frac{\theta}{2})$

$d = 11.5"$

$r_o = 5.75"$



SEGMENT
REF. MARK'S HAND BOOK

$b_1 = 5.75(1 - \cos 60°) = 2.875"$

$L_1 = 2\sqrt{2.875(11.5 - 2.875)} = 9.96"$

$\theta_{\Delta_2} = \frac{\theta_2}{2} = \frac{135.95}{2} = 67.975°$

$b_2 = 5.75(1 - \cos 67.975°) = 3.594"$

$L_2 = 2\sqrt{3.594(11.5 - 3.594)} = 10.66"$

AREA: $A_3 = t_\Delta(L_1 + L_2) = 0.25"(9.96" + 10.66") = 5.16$ IN.^{2}

TOTAL BEARING AREA $= A_1 + A_2 + A_3$

$= (30.10 + 41.11 + 5.16) = 76.37$ IN.^{2}

RESPONSE TO QUESTION 1

U.S. TOOL & DIE, INC.

BY a.t DATE 04-11-89 SUBJECT REGION 2 SECT. SHEET 3 OF 3

CHKD. BY PSS DATE 4-12-89 CONCRETE BEARING STRESSES PROJ. NO 8721

FACTORED LOAD P_u = 254 KIPS. (OBE)

BEARING AREA A = 76.4 IN^2

BEARING STRESS $F_p = \frac{P_u}{A} = \frac{254^K}{76.4\ IN^2} = 3.32$ KSI

ALLOWABLE CONCRETE BEARING STRESS FOR f'_c = 3.0 KSI (CONS.), ϕ = 0.70 (CONSERVATIVE)

S_B ALLOWABLE = $0.85\,\phi\,(f'_c)\,2 = 1.19 \times 3$ KSI = 3.57 KSI.

F_p = 3.32 KSI. < S_B = 3.57 KSI ALLOW. O.K.

F.S. = 1.08.

FURTHERMORE,
THE CONCRETE SLAB IS 38" THICK.
IT IS REINFORCED WITH #8 BARS @ 12" c/c,
TOP & BOTTOM. CONCRETE COVER = 2"

PER ACI 349-85, SECTION 9.3.2(C)
ϕ MAY BE INCREASED LINEARLY TO 0.90
PROVIDED

$$\frac{(h - d' - d_s)}{h} > 0.70$$

Where h = 38", d' = 2.5", d_s = 2.5", f_y = 40 KSI

SUMMARY:

F_p = 3.32 KSI.

S_B = 3.57 KSI.

F.S. = 1.08 O.K.

RESPONSE TO QUESTION 3

0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0

NATURAL FREQUENCIES

2		3		5			
012	078	129	6.376	14.922	15.494	24.708	24.999
36.016	62.384	86.273	126.329	155.722	170.132		

NORMALIZED MODE SHAPES

-.6015E 00	.1421E-01	.8073E 00	-.2665E-02	-.7177E 00	-.9280E 00
.3837E-01	.0000E 00	-.7403E-01	.3200E 00	.9553E 00	.1000E 01
.1000E 01	.7627E 00				
-.6015E 00	.1421E-01	.8073E 00	.1151E-01	-.4936E 00	-.5600E 00
-.1814E 00	.0000E 00	.1649E 00	-.4034E 00	.4933E 00	-.2861E 00
-.2246E 00	-.8931E 00				
-.6015E 00	.1422E-01	.8073E 00	.2457E-01	-.1897E 00	-.1078E 00
.1675E 00	.0000E 00	-.3042E 00	-.3629E 00	-.5468E 00	-.8303E 00
.2491E 00	.1000E 01				
-.6015E 00	.1422E-01	.8073E 00	.1372E-01	.1734E 00	.1665E 00
.1636E 00	.0000E 00	.3050E 00	-.1770E 00	-.8835E 00	.5313E 00
.3320E 00	-.9740E 00				
-.6015E 00	.1423E-01	.8073E 00	-.2092E-01	.5004E 00	.5689E 00
-.1783E 00	.0000E 00	-.1642E 00	.5187E 00	-.5642E-01	.5452E 00
-.8017E 00	.7432E 00				
-.6015E 00	.1423E-01	.8073E 00	-.5635E-01	.7721E 00	.1000E 01
.3285E-01	.0000E 00	.7672E-01	.1000E 01	.1000E 01	-.7674E 00
.8087E 00	-.5494E 00				
.1000E 01	-.1665E 00	.1000E 01	.1000E 01	-.9474E 00	-.4437E 00
-.8837E 00	.0000E 00	.4312E 00	.2736E 00	.8098E 00	.8630E 00
.8792E 00	.6765E 00				
.6015E 00	.6605E-01	.9364E 00	.7595E-01	-.2131E 00	-.7006E 00
.1000E 01	.0000E 00	-.3925E 00	-.3556E 00	.4444E 00	-.2422E 00
-.7307E 00	-.8002E 00				
.2025E 00	.3001E 00	.8729E 00	-.5461E 00	.3379E-01	-.3857E 00
-.5428E 00	.0000E 00	-.1000E 01	-.5253E 00	-.4778E 00	-.7367E 00
.2230E 00	.9049E 00				
-.1762E 00	.9334E 00	.8093E 00	-.5553E 00	-.5515E-01	.3502E 00
-.5485E 00	.0000E 00	-.9773E 00	-.1573E 00	-.7773E 00	.4730E 00
.4769E 00	-.8006E 00				
-.5530E 00	.7667E 00	.7457E 00	.4016E-01	.2235E 00	.7142E 00
.7852E 00	.0000E 00	.6932E 00	.4620E 00	-.3787E-01	.4755E 00
-.7047E 00	.6679E 00				
-.7937E 00	.1000E 01	.6022E 00	.5536E 00	.1000E 01	.5113E 00
-.7054E 00	.0000E 00	-.4307E 00	.3510E 00	.8630E 00	-.8454E 00
.7162E 00	-.4900E 00				
.1537E-06	.1306E-06	-.2852E-06	-.3416E-04	.6850E-02	.9141E-02
-.4342E-03	.0000E 00	.1270E-02	-.2984E-01	.8326E-02	.4467E-02
.1011E-02	.1501E-02				
.0000E 00	.0000E 00	.0000E 00	.0000E 00	.0000E 00	.0000E 00
.0000E 00	.1000E 01	.0000E 00	.0000E 00	.0000E 00	.0000E 00
.0000E 00	.0000E 00				

MODAL PARTICIPATION FACTORS AND EFFECTIVE WTS (LBS)

1	.73706E-02	.70317E 03
2	.20237E 00	.27721E 05
3	.79047E 00	.33990E 06
4	.11745E-05	-.10277E 00
5	-.17797E-02	-.50956E 04
6	-.[illegible]E-02	-.67837E 04
7	.13274E-04	-.35203E 01

RESPONSE TO QUESTION 3

```
      0          0          0          0          0          0          0
      0          0          0          0          0          0          0
      0          0          0          0          0          0          0

NATURAL FREQUENCIES
      .050       .095      2.933      6.376     15.078     15.974     24.700     24
   32.0.6     62.374     86.372    126.406    153.777    170.154

NORMALIZED MODE SHAPES
  - .5274E-03  - .1147E-03   .8477E 00  - .3017E-02  - .4957E 00  - .9920E
   .6201E-01    .0000E 00   .7025E-01   .3208E 00   .9549E 00   .1000E
   .1000E 01    .7600E 00
  - .3479E-03  - .1131E-03   .8782E 00   .1103E-01  - .3846E 00  - .6379E
  - .1779E 00   .0000E 00  - .1630E 00  - .4027E 00   .4971E 00  - .2810E
  - .8195E 00  - .0950E 00
  - .5624E-03  - .1129E-03   .9094E 00   .2397E-01  - .1737E 00  - .2409E
   .1708E 00    .0000E 00   .3057E 00  - .6020E 00  - .5437E 00  - .3312E
   .2442E 00    .1000E 01
  - .5760E-03  - .1084E-03   .9405E 00   .1299E-01   .1202E 00   .1501E
   .1636E 00    .0000E 00  - .3047E 00  - .1759E 00  - .8864E 00   .5298E
   .5325E 00  - .9729E 00
  - .5970E-03  - .1060E-03   .9709E 00  - .2180E-01   .3482E 00   .5742E
  - .1787E 00   .0000E 00   .1636E 00   .5178E 00  - .5686E-01   .5460E
  - .8787E 00   .7410E 00
  - .6102E-03  - .9953E-04   .1000E 01  - .5736E-01   .4944E 00   .1000E
   .3017E-01    .0000E 00  - .7331E-01   .1000E 01   .1000E 01  - .9634E
   .8053E 00  - .5482E 00
   .1000E 01  - .2026E 00   .7309E 00   .1000E 01  - .9971E 00  - .7027E
  - .8785E 00   .0000E 00  - .4295E 00   .2943E 00   .3094E 00   .8659E
   .8791E 00   .6811E 00
   .7406E 00   .3799E-01   .7571E 00   .7558E-01   .3093E-01  - .6384E
   .1000E 01   .0000E 00   .6944E 00  - .3590E 00   .4477E 00  - .2377E
  - .7262E 00  - .8019E 00
   .4812E 00   .2705E 00   .7833E 00  - .5467E 00   .1962E 00  - .3140E
  - .5378E 00   .0000E 00  - .9991E 00  - .5245E 00  - .4773E 00  - .7377E
   .2.06E 00   .9049E 00
   .2210E 00   .5190E 00   .8096E 00  - .5561E 00  - .2476E 00   .2109E
  - .5463E 00   .0000E 00   .1000E 01  - .1563E 00  - .7773E 00   .4708E
   .4774E 00  - .8796E 00
  - .3768E-01   .7595E 00   .8360E 00   .4746E-01  - .5906E-01   .5904E
   .9017E 00   .0000E 00  - .6739E 00   .4628E 00  - .4026E-01   .4763E
  - .7823E 00   .6667E 00
  - .2971E 00   .1000E 01   .8625E 00   .9531E 00   .1000E 01   .7150E
  - .7052E 00   .0000E 00   .4295E 00   .8510E 00   .8630E 00  - .8445E
   .7131E 00  - .4889E 00
  - .4137E-06   .3659E-07   .7005E-03  - .3711E-04   .4436E-02   .9370E
  - .6633E-03   .0000E 00  - .1297E-02  - .2393E-01   .8257E-02   .4455E
   .1809E-02   .1809E-02
   .0000E 00   .0000E 00   .0000E 00   .0000E 00   .0000E 00   .0000E
   .0000E 00   .1000E 01   .0000E 00   .0000E 00   .0000E 00   .0000E
   .0000E 00   .0000E 00

MODAL PARTICIPATION FACTORS AND EFFECTIVE WTS (LBS)
   1   .17690E 00   .21518E 05
   2   .19112E 00   .26436E 05
   3   .76466E 00   .54540E 06
   4  - .24276E-03   .38379E 01
   5  - .4528E-01  - .26804E 05
   6  - .53500E-01  - .20882E 06
   7    .14901E-03  - .41469E 02
```

RESPONSE TO QUESTION 6

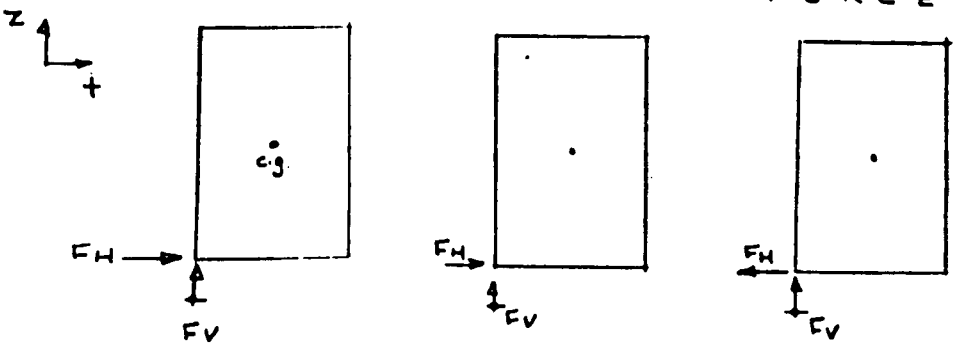
U.S. TOOL & DIE, INC

BY A.L. DATE 04-18-89 SUBJECT ADDITIONAL WORK TO SECT. NRC SHEET 1 OF 5

CHKD. BY WFS. DATE 4/22/89 SUPPORT RACK LICENSING PROGRAM PROJ. NO. 8721-31

PURPOSE: COMPUTE MECHANICAL STRESSES FOR FUSION WELDS, WITH HORIZONTAL FORCE ACTING TO THE RIGHT; TO THE LEFT; AND EQUAL TO ZERO, TO DETERMINE IF THE ASSUMPTION, USED IN THE MECHANICAL REPORT, IS CONSERVATIVE. (i.e. H. FORCE ACTING TO THE RIGHT PRODUCES THE MAX. STRESSES.

132-CELL RACK FORCE CONFIGURATION



	RIGHT (+ F_H)	$F_H = 0$	LEFT (− F_H)
CASE	I	II	III

VERIFICATION:

PLANE C-C (3-CELL SECTION) WITH OBE-LOADS IS CONSIDERED. SIX COMPUTER RUNS WERE MADE FOR 3 ABOVE CASES. FOR EACH CASE, LOADS ON E-W PLANE AND N-S PLANE HAVE BEEN ANALYZED.

CASE I, HORIZONTAL FORCE TO RIGHT

NORTH-SOUTH OBE LOADS ON E-W PLANE
F_H = +80210 LB. →

EAST-WEST OBE LOADS ON N-S PLANE
F_H = +59420 LB. →

$\tau_{MAX.}$ (SHEAR) = 11.53 KSI.
$\sigma_{MAX.}$ (TENSILE) = 16.14 KSI.
} REFER NRC, SHEET 3

CASE II, HORIZONTAL FORCE EQUALS ZERO

$F_H = 0$ } NORTH-SOUTH OBE LOADS ON EW-PLANE
EAST-WEST OBE LOADS ON NS-PLANE

τ_{MAX} = 6.82 KSI σ_{MAX} = 8.46 KSI

CASE III, HORIZONTAL FORCE TO LEFT

FH = -80210 LB. ← NORTH-SOUTH OBE LOADS ON E-W PLANE

FH = -59420 LB. ← EAST-WEST OBE LOADS ON N-S PLANE

$\tau_{MAX.}$ (SHEAR) = 9.67 KSI REFER NRC SHEET 4.

σ_{MAX} (TENSILE) = 15.22 KSI

SUMMARY:

HORIZONTAL FORCE ACTING TO THE RIGHT WILL PROVIDE THE MAXIMUM STRESSES.

τ_{MAX} = 11.53 KSI > $\tau_{MAX.}$ = 9.67 KSI > $\tau_{MAX.}$ = 6.82 KSI.
$F_H \rightarrow$ CASE I $\leftarrow F_H$ CASE III $F_H = 0$ CASE II

σ_{MAX} = 16.14 KSI > σ_{MAX} = 15.22 KSI σ_{MAX} = 8.46 KSI
→ ←

NOTE: COMPUTER RUNS ARE ATTACHED PAGES C-1 THRU C-12

SECTION 4.1: INTERNAL RACK WELD @ PLANE C-C (3-CELL SECTION), 132 CELL, CONSOLIDATED FUEL, REGION 2.
NORTH-SOUTH OBE LOADS ON E-W PLANE

OBE LOADS: CASE I.

$F_{Vt\,NS}$ = 268030 LB.
$F_{hZ\,NS}$ = 80210 LB. RIGHT.

REF. SEISMIC LOADS TABLE 2 REVISED

MAXIMUM OBE STRESSES, PLANE C-C

REF: FMTS FILES: IP132NCO.I3 (INPUT) & IP132NCO.03 (OUTPUT)
IP132ECO.I3 & IP132ECO.03 (OTHER DIRECTION)

$$\tau_{SHEAR} = \tau_{SWT} + \sqrt{(\tau_{NS})^2 + (\tau_{EW})^2 + (\tau_{VERT})^2}$$

$$\sigma_{TENSILE} = \sigma_{SWT} + \sqrt{(\sigma_{NS})^2 + (\sigma_{EW})^2 + (\sigma_{VERT})^2}$$

SHEAR (τ_S)

τ_{SWT} = 4041 PSI (BOTTOM)
$\tau_{N\text{-}S}$ = 6284 PSI (BOTTOM)
$\tau_{VERT} = (g \cdot 2/3)(\tau_{SWT}) = (0.53 \times 2/3)(4041)$ PSI
= 1428 PSI (BOTTOM)
OTHER DIRECTION: (IP132ECO.I3)
τ_{EW} = 1079 PSI

TENSILE (σ)

σ_{SWT} = 2078 PSI (TENSION BOTTOM)
σ_{NS} = 7091 PSI (COMP. BOTTOM)
$\sigma_{VERT} = (g \times 2/3)(\sigma_{SWT})$
$= (0.53 \times 2/3)(2078)$ PSI = 734 PSI (TEN. BOT)
OTHER DIRECTION: $\sigma_{EW} = 0$

$$\tau_S = 4041 + \sqrt{(6284)^2 + (1079)^2 + (1428)^2} = 10575 \text{ PSI (BOTTOM)}$$

$$\sigma = 2078 + \sqrt{(7091)^2 + 0 + (734)^2} = 9207 \text{ PSI (COMP. BOT)}$$

$$\tau_{MAX\,(SHEAR)} = \sqrt{\left(\frac{\sigma}{2}\right)^2 + (\tau_S)^2} = \sqrt{\left(\frac{9207}{2}\right)^2 + (10575)^2} = 11534 \text{ PSI (BOTTOM)}$$

SHEAR $\tau_{MAX.}$ = 11.53 KSI < 21.0 KSI ALLOW. O.K.

F.S. = 1.82

MAXIMUM TENSILE STRESS

$$\sigma_{MAX.} = \left(\frac{\sigma}{2} + \tau_{MAX.}\right) = \left(\frac{9207}{2} + 11534\right) = 16138 \text{ PSI (COMP. BOT)}$$

$\sigma_{MAX.}$ = 16.14 KSI < 18.0 KSI O.K.

F.S. = 1.12

U.S. TOOL & DIE, INC

BY a.t. DATE 04-19-89 SUBJECT CASE II SECT. NRC SHEET 4 OF 5
CHKD. BY WFS DATE 4/29/89 FH = 0 PROJ. NO. 8721-31

FUSION WELD STRESSES, PLANE C-C,
132 CELL RACK W/ CONSOLIDATED FUEL.
NORTH-SOUTH OBE LOADS ON E-W PLANE,
WITH HORIZONTAL FORCE $F_H = 0$.

INPUT OBE LOADS: F_V: 268030 LB.
F_H: 0. LB.

MAXIMUM OBE STRESSES, PLANE C-C

REF. FMTS FILE: TEST 3. & TEST 6.

$$\tau_{SHEAR} = \tau_{SWT} + \sqrt{(\tau_{NS})^2 + (\tau_{EW})^2 + (\tau_{VERT})^2}$$

$$\sigma_{TENSILE} = \sigma_{SWT} + \sqrt{(\sigma_{NS})^2 + (\sigma_{EW})^2 + (\sigma_{VERT})^2}$$

$$g_{OBE} = \frac{2}{3} g_{SSE} = \frac{2}{3}(.53) = 0.35333$$

SHEAR STRESSES (τ_S)

τ_{SWT} = 4041 PSI ↓ (BOT)
τ_{NS} = 1841 PSI ↓ (BOT)
τ_{VERT} = 0.35 x 4041 PSI
= 1428 PSI (BOT)
OTHER DIRECTION: TEST 5.
τ_{EW} = 1118 PSI

TENSILE STRESSES

σ_{SWT} = 2078 PSI (TENSION BOTTOM)
σ_{NS} = 946 PSI (TENSION BOTTOM)
$\sigma_{VERT} = (\frac{2}{3} g \times \sigma_{SWT})$ = .35333 x 2078 PSI
= 734 PSI (T-BOT)
OTHER DIRECTION: $\sigma_{EW} = 0$

$$\tau_S = 4041 + \sqrt{(1841)^2 + (1118)^2 + (1428)^2} = 6625 \text{ PSI (BOT)}$$

$$\sigma = 2078 + \sqrt{(946)^2 + 0 + (734)^2} = 3275 \text{ PSI (T-B)}$$

$$\tau_{MAX\ (SHEAR)} = \sqrt{\left(\frac{\sigma}{2}\right)^2 + (\tau_S)^2} = \sqrt{\left(\frac{3275}{2}\right)^2 + (6625)^2} = \underline{6824 \text{ PSI}}$$

MAXIMUM TENSILE STRESS

$$\sigma_{MAX.} = \left(\frac{\sigma}{2} + \tau_{MAX.}\right) = \left(\frac{3275}{2} + 6824\right) = \underline{8462 \text{ PSI}}$$

FUSION WELD STRESSES, PLANE C-C,
132 CELL RACK W/ CONSOLIDATED FUEL.
NORTH-SOUTH OBE LOADS ON E-W PLANE
WITH HORIZONTAL FORCE TO THE LEFT

OBE LOADS: FV = 268030 LB.
FH = -80210 LB.

MAXIMUM OBE STRESSES, PLANE C-C

REF. FMTS FILE: TEST2. & TEST6.

$$\tau_{SHEAR} = \tau_{SWT} + \sqrt{(\tau_{NS})^2 + (\tau_{EW})^2 + (\tau_{VERT})^2}$$

$$\sigma_{TENSILE} = \sigma_{SWT} + \sqrt{(\sigma_{NS})^2 + (\sigma_{EW})^2 + (\sigma_{VERT})^2}$$

SHEAR (τ_S)

$g_{OBE} = 2/3\, g_{SSE}$. where $g_{SSE} = 0.53$.

τ_{SWT} = 4041 PSI (BOT)↓

τ_{NS} = 2602 PSI (BOT) ↑

$\tau_{VERT} = (\frac{2}{3} \times 0.53)(\tau_{SWT})$

$= 0.35(4041) = 1428$ PSI (BOT)

OTHER DIRECTION: TEST6.

τ_{EW} = 2499 PSI.

TENSILE (σ)

σ_{SWT} = 2078 PSI (TENSION BOT)

σ_{NS} = 8984 PSI (TENSION BOT)

$\sigma_{VERT} = (\frac{2}{3} g)(\sigma_{SWT}) = .35(2078)$

$= 734$ PSI (T-BOT)

OTHER DIRECTION: $\sigma_{EW} = 0$

$$\tau_S = 4041 + \sqrt{(2602)^2 + (2499)^2 + (1428)^2} = 7921 \text{ PSI (BOTTOM)}$$

$$\sigma = 2078 + \sqrt{(8984)^2 + (0) + (734)^2} = 11092 \text{ PSI (TENSION BOT)}$$

$$\tau_{MAX\,(SHEAR)} = \sqrt{\left(\frac{\sigma}{2}\right)^2 + (\tau_S)^2} = \sqrt{\left(\frac{11092}{2}\right)^2 + (7921)^2} = \underline{\underline{9670 \text{ PSI}}}$$

MAXIMUM TENSILE STRESS

$$\sigma_{MAX} = \left(\frac{\sigma}{2} + \tau_{MAX}\right) = \left(\frac{11092}{2} + 9670\right) = \underline{\underline{15216}} \text{ PSI}$$

RESPONSE TO QUESTION 6

C-1

```
PROGRAM EMTS                                                          TESTF.
 INDIAN POINT 3. REGION 2. FILE.IP132NCO.13
 NORTH SOUTH OBE LOADS ON E-W PLANE                          CASE I
 132-CELL RACK. CONSOLIDATED FUEL                            HORIZONTAL →
 3-CELL SECTION (PLANE C-C)                                  RIGHT.
 EDITED 11-04-88
 DATE(MON/DAY/YEAR).  4/ 5/89                                NS-OBE
 TIME(HOUR.MIN.SEC). 11.51.40

NO. CELLS PITCH LENGTH HEIGHT PED.HEIGHT PED.OFFSET WEIGHT SUB. WEIGHT
    11.   9.073   99.0 165.7    11.630       .00     423062.   368289.

DYNAMIC FORCE CALCULATIONS
VERTICAL FORCE  NET VER. FORCE  HOR. FORCE  MOM. OF INERT.
     260030.        83886.       80210.      3413737.

ACCELERATIONS. HOR.(+RT)  VERT.(+UP)  ROT.(+CCW)
                 73.26      76.62      .9932

NUMBER OF CELLS IN SECTION:      3.0

SECTION MASS.   279. MOM. OF INERTIA:     701476.
MOMENT ARMS. VERT. TO PED. BOTTOM   94.47; HOR. TO PED.  13.61 TO FACE  13.

VERTICAL ACCELERATION OF CG OF SECTION. (+UP)     40.56

FORCES ON SECTION AT PEDESTAL: HORIZONTAL  VERTICAL
                               80210.      83886.
FORCES ON FACE.      AXIAL(+LEFT) SHEAR(+DOWN) MOMENT(+CW)
                       58335.       71773.       4761812.

BENDING STRESSES(Mc/I) TOP.  4841. BOTTOM: -4841.DIRECT STRESS(P/AW): -2251

STRESSES. (Mc/I+P/AW) TOP.    2590. BOTTOM:    -7091. SHEAR(+DOWN).      276

SHEAR FLOW AT BOTTOM     949. SHEAR STRESS(+DOWN)     3515.


SUBMERGED WEIGHT CALCULATIONS

NET VERTICAL FORCE: SUBMERGED WEIGHT
     104145.          368289.

SWT ACCELERATIONS. VERT(+UP)   -168.19  ROT(+CCW)   -2.692
VERTICAL FORCES ON SECTION. PEDESTAL  SUB. WEIGHT
                            104145.   100442.

VERTICAL ACCELERATION OF CG OF SECTION: (+UP)   -70.45
```

RESPONSE TO QUESTION 6

C-2

SHEAR FORCE(+DOWN). 104740. MOMENT(+CW). -2043732.

BENDING STRESS(Mc/I) TOP. -2078. BOTTOM. 2078. SHEAR(+DOWN) 4041

NO. CELLS TO TORQUE FACE. 3.00/12.00
SECTION MASS. 274. SECTION MOM. OF INERT.: 853434.2
TORQUE ON FACE(+CW). 847625. SHEARS: HOR.(+LEFT) 20053. VERT.(+DOWN) 20
ECCENTRICITY. .0 TORQUE ABOUT CENTROID(+CW): 847625.
SHEAR STRESSES. HOR. 1451. VERT. 1211. RESULT. 1890.

STRESS SUMMARY

	BOTTOM	TOP
DYNAMIC LOAD	σ_{NS}	
TENSILE	-7091.	2590.
SHEAR(+DOWN)	4234.	2767.
	τ_{NS}	
SUBMERGED WEIGHT		
TENSILE	2078.	-2078.
SHEAR(+DOWN)	4041.	4041.

TORQUE AND VERTICAL FORCE FROM MOTION IN OTHER DIRECTION
SHEAR STRESSES. HOR. 1451. VERT. 1211. RESULT. 1890.

RESPONSE TO QUESTION 6

C-3 TEST 4.

```
PROGRAM FMTS
 INDIAN POINT 3. REGION 2. FILE.IP132ECO.I3
 EAST-WEST OBE LOADS ON NORTH-SOUTH PLANE
 132-CELL RACK. CONSOLIDATED FUEL
 3-CELL SECTION (PLANE C-C)
 EDITED 11-04-88(PM)
 DATE(MON/DAY/YEAR).   4/ 5/89
 TIME(HOUR.MIN.SEC).  13: 9:55
```

OTHER DIRECTION
CASE I
HORIZONTAL →
RIGHT
EW-OBE

NO	CELLS	PITCH	LENGTH	HEIGHT	PED.HEIGHT	PED.OFFSET	WEIGHT	SUB WEIGHT
	12.	9.075	108.9	165.7	11.630	.00	423062.	368289

DYNAMIC FORCE CALCULATIONS

VERTICAL FORCE	NET VER. FORCE	HOR. FORCE	MOM. OF INERT.
252830.	68736.	57420.	3586552.

ACCELERATIONS.	HOR.(+RT)	VERT.(+UP)	ROT.(+CCW)
	54.27	62.78	.5216

NUMBER OF CELLS IN SECTION. 3.0

SECTION MASS. 274. MOM. OF INERTIA: 643038.
MOMENT ARMS. VERT. TO PED. BOTTOM 94.47. HOR. TO PED. 13.61 TO FACE 13.

VERTICAL ACCELERATION OF CG OF SECTION. (+UP) 41.48

FORCES ON SECTION AT PEDESTAL.	HORIZONTAL	VERTICAL
	57420.	68736.

FORCES ON FACE.	AXIAL(+LEFT)	SHEAR(+DOWN)	MOMENT(+CW)
	44565.	57382.	3561219.

BENDING STRESSES(Mc/I) TOP: 3320. BOTTOM: -3320.DIRECT STRESS(P/AW): -1577

STRESSES. (Mc/I+P/AW) TOP. 1743. BOTTOM: -4897. SHEAR(+DOWN): 203

SHEAR FLOW AT BOTTOM 610. SHEAR STRESS(+DOWN) 2072.

SUBMERGED WEIGHT CALCULATIONS

NET VERTICAL FORCE.	SUBMERGED WEIGHT
184145.	368289.

SWT ACCELERATIONS. VERT(+UP) -160.19 ROT(+CCW) -2.796

VERTICAL FORCES ON SECTION:	PEDESTAL	SUB. WEIGHT
	184145.	92072.

VERTICAL ACCELERATION OF CG OF SECTION: (+UP) -54.02

RESPONSE TO QUESTION 6

C-4

SHEAR FORCE(+DOWN). 106059. MOMENT(+CW). -2163590.

BENDING STRESS(Mc/I) TOP. -2017. BOTTOM. 2017. SHEAR(+DOWN). 3781

NO. CELLS TO TORQUE FACE. 3.00/11.00
SECTION MASS. 277. SECTION MOM. OF INERT.: 978153.2
TORQUE ON FACE(+CW). 425173. SHEARS. HOR.(+LEFT) 13505. VERT.(+DOWN) 15.
ECCENTRICITY. .0 TORQUE ABOUT CENTROID(+CW): 425173.
SHEAR STRESSES. HOR. 777. VERT. 749. RESULT. 1079.

STRESS SUMMARY

	BOTTOM	TOP
DYNAMIC LOAD		
TENSILE	-4097.	1793.
SHEAR(+DOWN)	4102.	2031.
SUBMERGED WEIGHT		
TENSILE	2017.	-2017.
SHEAR(+DOWN)	3781.	3781.

TORQUE AND VERTICAL FORCE FROM MOTION IN OTHER DIRECTION
SHEAR STRESSES. HOR. 777. VERT. 749. RESULT. 1079.

τ_{EW}

OTHER DIRECTION

→

RESPONSE TO QUESTION 6

C-S TEST 3.

CASE II

HORIZ. FORCE = 0

NS-OBE.

```
PROGRAM EMAS
 INDIAN POINT 3. REGION 2. FILE.IP132NCO.10
 NORTH SOUTH OBE LOADS ON E-W PLANE
 132-CELL RACK. CONSOLIDATED FUEL
 3-CELL SECTION (PLANE C-C)
 EDITED 11-04-88
 DATE(MON/DAY/YEAR). 4/ 3/89
 TIME(HOUR.MIN.SEC). 12. 6. 6

NO. CELLS PITCH LENGTH HEIGHT PED.HEIGHT PED.OFFSET WEIGHT SUB. WEIGHT
    11.    9.075    99.0 165.7    11.630       .00     423062.    368289.

DYNAMIC FORCE CALCULATIONS
VERTICAL FORCE  NET VER. FORCE  HOR. FORCE  MOM. OF INERT.
     269030.          83886.          0.       3413737.

ACCELERATIONS. HOR.(+RT)  VERT.(+UP)  ROT.(+CCW)
                    .00      76.62    -1.2265

NUMBER OF CELLS IN SECTION.      3.0

SECTION MASS.   279. MOM. OF INERTIA.     701496.
MOMENT ARMS. VERT. TO PED. BOTTOM   94.47; HOR. TO PED.   13.61 TO FACE   13.

VERTICAL ACCELERATION OF CG OF SECTION. (+UP)    121.14

FORCES ON SECTION AT PEDESTAL: HORIZONTAL  VERTICAL
                                       0.     83886.
FORCES ON FACE.      AXIAL(+LEFT) SHEAR(+DOWN) MOMENT(+CW)
                          0.        47713.        -931004.

BENDING STRESSES(Mc/I) TOP.   -946. BOTTOM.    946.DIRECT STRESS(P/AW):      0

STRESSES. (Mc/I+P/AW) TOP:     -946. BOTTOM:      946. SHEAR(+DOWN).       184

SHEAR FLOW AT BOTTOM        0. SHEAR STRESS(+DOWN)        0.


SUBMERGED WEIGHT CALCULATIONS

NET VERTICAL FORCE. SUBMERGED WEIGHT
     184145.          368289.

SWT ACCELERATIONS. VERT(+UP)    -168.19  ROT(+CCW)    -2.692
VERTICAL FORCES ON SECTION. PEDESTAL  SUB. WEIGHT
                            184145.    100442.

VERTICAL ACCELERATION OF CG OF SECTION. (+UP)    -70.45
```

RESPONSE TO QUESTION 6

C-6

SHEAR FORCE(+DOWN) 104740. MOMENT(+CW): -2043732.

BENDING STRESS(Mc/I) TOP -2070. BOTTOM. 2070. SHEAR(+DOWN) 4041.

NO. CELLS TO TORQUE FACE. 3.00/12.00
SECTION MASS. 274. SECTION MOM. OF INERT.: 853434.2
TORQUE ON FACE(+CW). -1046734. SHEARS: HOR.(+LEFT) 0. VERT.(+DOWN) 209
ECCENTRICITY. .0 TORQUE ABOUT CENTROID(+CW): -1046734.
SHEAR STRESSES. HOR. 837. VERT. 1306. RESULT. 1551.

STRESS SUMMARY

	BOTTOM	TOP
DYNAMIC LOAD	σ_{NS}	
TENSILE	946.	-946.
SHEAR(+DOWN)	1041.	1041.
	τ_{NS}	
SUBMERGED WEIGHT		
TENSILE	2070.	-2070.
SHEAR(+DOWN)	4041.	4041.

CASE II

$F_H = 0.$

NS-OBE

TORQUE AND VERTICAL FORCE FROM MOTION IN OTHER DIRECTION
SHEAR STRESSES. HOR. 837. VERT. 1306. RESULT. 1551.

RESPONSE TO QUESTION 6

C-7

```
PROGRAM EMTS
 INDIAN POINT 3. REGION 2. FILE.IP132ECO.13
 EAST-WEST OBE LOADS ON NORTH-SOUTH PLANE
 132-CELL RACK. CONSOLIDATED FUEL
 3-CELL SECTION (PLANE C-C)
 EDITED 11-04-88(PM)
 DATE(MON/DAY/YEAR). 4/ 5/89
 TIME(HOUR.MIN.SEC). 13.13:43
```

CASE II

$F_H = 0$

EW-OBE, Other Direction

```
NO. CELLS PITCH LENGTH HEIGHT PED.HEIGHT PED.OFFSET WEIGHT SUB. WEIGHT
    12.    9.075  108.9 165.7    11.630       .00     423062.   368289.

DYNAMIC FORCE CALCULATIONS
VERTICAL FORCE  NET VER. FORCE  HOR. FORCE  MOM. OF INERT.
     252330.        68736.          0.       3586562.

ACCELERATIONS. HOR.(+RT)  VERT.(+UP)  ROT.(+CCW)
                    .00      62.73    -1.0435

NUMBER OF CELLS IN SECTION:      3.0

SECTION MASS.    274. MOM. OF INERTIA.     643030.
MOMENT ARMS. VERT. TO PED. BOTTOM   94.47: HOR. TO PED.  13.61 TO FACE  13

VERTICAL ACCELERATION OF CG OF SECTION. (+UP)   105.39

FORCES ON SECTION AT PEDESTAL. HORIZONTAL  VERTICAL
                                     0.     68736.
FORCES ON FACE.      AXIAL(+LEFT) SHEAR(+DOWN) MOMENT(+CW)
                          0.        39867.        -807601.

BENDING STRESSES(Mc/I) TOP.  -753. BOTTOM.   753.DIRECT STRESS(P/AW):     0

STRESSES. (Mc/I+P/AW) TOP:    -753. BOTTOM.     753. SHEAR(+DOWN):      141

SHEAR FLOW AT BOTTOM       0. SHEAR STRESS(+DOWN)       0.

SUBMERGED WEIGHT CALCULATIONS

NET VERTICAL FORCE. SUBMERGED WEIGHT
     184145.        368289.

SWT ACCELERATIONS. VERT(+UP)   -168.17  ROT(+CCW)   -2.796
VERTICAL FORCES ON SECTION: PEDESTAL  SUB. WEIGHT
                            184145.     92072.

VERTICAL ACCELERATION OF CG OF SECTION: (+UP)   -54.02
```

SHEAR FORCE(+DOWN). 106359. MOMENT(+CW). -2133590.

BENDING STRESS(Mc/I) TOP. -2017. BOTTOM: 2017. SHEAR(+DOWN). 3781.

NO CELLS TO TORQUE FACE. 3.00/11.00
SECTION MASS. 299. SECTION MOM. OF INERT.. 970153.2
TORQUE ON FACE(+CW). -850602. SHEARS: HOR.(+LEFT) 0. VERT.(+DOWN) 15
ECCENTRICITY. .0 TORQUE ABOUT CENTROID(+CW): -850602.
SHEAR STRESSES. HOR. 598. VERT. 945. RESULT. 1118.

STRESS SUMMARY

	BOTTOM	TOP
DYNAMIC LOAD		
TENSILE	753.	-753.
SHEAR(+DOWN)	1411.	1411.
SUBMERGED WEIGHT		
TENSILE	2017.	-2017.
SHEAR(+DOWN)	3781.	3781.

TORQUE AND VERTICAL FORCE FROM MOTION IN OTHER DIRECTION
SHEAR STRESSES. HOR. 598. VERT. 945. RESULT. 1118.

τ_{EW}

OTHER DIRECTION

$F_H = 0$.

Case II.

RESPONSE TO QUESTION 6

C-9

TEST 2.

CASE III

FH TO LEFT

NS - OBE

```
PROGRAM IMTS
 INDIAN POINT 3. REGION 2. FILE.IP132NCO I3
 NORTH SOUTH OBE LOADS ON E-W PLANE
 132-CELL RACK. CONSOLIDATED FUEL
 3-CELL SECTION (PLANE C-C)
 EDITED 11-04-88
 DATE(MON/DAY/YEAR). 4/ 5/89
 TIME(HOUR.MIN.SEC). 12. 1: 7

NO. CELLS PITCH LENGTH HEIGHT PED.HEIGHT PED.OFFSET WEIGHT SUB. WEIGHT
    11.   9.075   99.0 165.7    11.630       .00    423062.   368289.

DYNAMIC FORCE CALCULATIONS
VERTICAL FORCE  NET VER. FORCE  HOR. FORCE  MOM. OF INERT.
     268030.         83886.     -80210.      3413737.
                                 Left

ACCELERATIONS. HOR.(+RT)  VERT.(+UP)  ROT.(+CCW)
               -73.26      76.62     -3.4462

NUMBER OF CELLS IN SECTION.     3.0

SECTION MASS.   277. MOM. OF INERTIA.    701476.
MOMENT ARMS. VERT. TO PED. BOTTOM   94.47; HOR. TO PED.  13.61 TO FACE  13.

VERTICAL ACCELERATION OF CG OF SECTION; (+UP)   201.71

FORCES ON SECTION AT PEDESTAL: HORIZONTAL  VERTICAL
                               -80210.     83886.
FORCES ON FACE.      AXIAL(+LEFT) SHEAR(+DOWN) MOMENT(+CW)
                      -58335.       23653.       -5523823.

BENDING STRESSES(Mc/I) TOP: -6734. BOTTOM:  6734.DIRECT STRESS(P/AW):  2251

STRESSES. (Mc/I+P/AW) TOP.   -4483. BOTTOM:    8984. SHEAR(+DOWN).      91

SHEAR FLOW AT BOTTOM    -949. SHEAR STRESS(+DOWN)   -3515.


SUBMERGED WEIGHT CALCULATIONS


NET VERTICAL FORCE. SUBMERGED WEIGHT
     184145.          368289.


SWT ACCELERATIONS. VERT(+UP)   -168.19  ROT(+CCW)   -2.692
VERTICAL FORCES ON SECTION. PEDESTAL  SUB. WEIGHT
                            184145.   100442.


VERTICAL ACCELERATION OF CG OF SECTION; (+UP)   -70.45
```

SHEAR FORCE(+DOWN). 104740. MOMENT(+CW). -2043732.

BENDING STRESS(MC/I) TOP. -2078. BOTTOM. 2078. SHEAR(+DOWN). 4041

NO. CELLS TO TORQUE FACE. 3.00/12.00
SECTION MASS. 274. SECTION MOM. OF INERT.: 053434.2
TORQUE ON FACE(+CW). -2941093. SHEARS. HOR.(+LEFT) -20053. VERT.(+DOWN) 20
ECCENTRICITY. .0 TORQUE ABOUT CENTROID(+CW). -2941093.
SHEAR STRESSES. HOR. 3125. VERT. 2205. RESULT. 3825.

STRESS SUMMARY

	BOTTOM	TOP
DYNAMIC LOAD	σ_{NS}	
TENSILE	8904.	-4403.
SHEAR(+DOWN)	-2602.	913.
	τ_{NS}	
SUBMERGED WEIGHT		
TENSILE	2078.	-2078.
SHEAR(+DOWN)	4041.	4041.

CASE III
TO left.
NS-OBE

TORQUE AND VERTICAL FORCE FROM MOTION IN OTHER DIRECTION
SHEAR STRESSES. HOR. 3125. VERT. 2205. RESULT. 3825.

RESPONSE TO QUESTION 6

C-11

CASE III

F_H TO LEFT

other DIRECTION EW-OCC

```
PROGRAM EHTS
 INC.AN POINT 3. REGION 2. FILE.IP132ECO.FS
 EAST-WEST OBE LOADS ON NORTH-SOUTH PLANE
 132-CELL RACK. CONSOLIDATED FUEL
 3-CELL SECTION (PLANE C-C)
 EDITED 11-04-88(PM)
 DATE(MON/DAY/YEAR). 4/ 5/89
 TIME(HOUR.MIN.SEC). 13.11.37

NO. CELLS PITCH LENGTH HEIGHT PED.HEIGHT PED.OFFSET WEIGHT SUB. WEIGHT
    12.    9.075  108.9 165.7    11.630       .00     423062.   368289.

DYNAMIC FORCE CALCULATIONS
VERTICAL FORCE  NET VER. FORCE  HOR. FORCE  MOM. OF INERT.
      252330.        68736.      -59420.      3586562.
                                   LEFT

ACCELERATIONS. HOR.(+RT)  VERT.(+UP)  ROT.(+CCW)
               -54.27      62.78    -2.6006

NUMBER OF CELLS IN SECTION.      3.0

SECTION MASS.    274. MOM. OF INERTIA:     643038.
MOMENT ARMS. VERT. TO PED. BOTTOM   94.47. HOR. TO PED.  13.61 TO FACE  13.

VERTICAL ACCELERATION OF CG OF SECTION: (+UP)    169.31

FORCES ON SECTION AT PEDESTAL: HORIZONTAL  VERTICAL
                                -59420.     68736.
FORCES ON FACE.      AXIAL(+LEFT) SHEAR(+DOWN) MOMENT(+CW)
                      -44565.       22392.       -5176423.

BENDING STRESSES(Mc/I) TOP. -4826. BOTTOM:  4826.DIRECT STRESS(P/AW).  1577

STRESSES. (Mc/I+P/AW) TOP.   -3249. BOTTOM:    6403. SHEAR(+DOWN):       79

SHEAR FLOW AT BOTTOM    -610. SHEAR STRESS(+DOWN)   -2072.


SUBMERGED WEIGHT CALCULATIONS

NET VERTICAL FORCE. SUBMERGED WEIGHT
      184145.          368289.


SUT ACCELERATIONS. VERT(+UP)   -168.19  ROT(+CCW)   -2.796
VERTICAL FORCES ON SECTION. PEDESTAL  SUB. WEIGHT
                            184145.     92072.

VERTICAL ACCELERATION OF CG OF SECTION: (+UP)    -54.02
```

RESPONSE TO QUESTION 6

C-12

SHEAR FORCE(+DOWN). 106059. MOMENT(+CW): -2163590.

BENDING STRESS(Mc/I) TOP. -2017. BOTTOM. 2017. SHEAR(+DOWN) 3781.

NO. CELLS TO TORQUE FACE. 3.00/11.00
SECTION MASS 299. SECTION MOM. OF INERT.. 978153.2
TORQUE ON FACE(+CW). -2126376. SHEARS: HOR.(+LEFT) -13505. VERT.(+DOWN) 15
ECCENTRICITY .0 TORQUE ABOUT CENTROID(+CW). -2126376.
SHEAR STRESSES. HOR. 1973. VERT. 1533. RESULT. 2499.

STRESS SUMMARY

	BOTTOM	TOP
DYNAMIC LOAD		
TENSILE	6403.	-3249.
SHEAR(+DOWN)	-1279.	792.
SUBMERGED WEIGHT		
TENSILE	2017.	-2017.
SHEAR(+DOWN)	3781.	3781.

TORQUE AND VERTICAL FORCE FROM MOTION IN OTHER DIRECTION
SHEAR STRESSES. HOR. 1973. VERT. 1533. RESULT. 2499.

TEW
Other DIRECTION
Case III
Left

RESPONSE TO QUESTION 7

NYPA - NRC

U.S. TOOL & DIE, INC.

BY a.t DATE 11-02-88 SUBJECT IMPACT BETWEEN SECT. NYPA SHEET 1 OF 1

CHKD. BY MB DATE 4-19-89 FUEL ASSEMBLY & CELL WALL PROJ. NO. 8721-31

THE MAXIMUM FORCE ON AN INDIVIDUAL FUEL ASSEMBLY DUE TO EW SEISMIC (SSE) = 276 LBS.

REFERENCE: SEISMIC REPORT, SECTION 3, TABLE #3, "SUMMARY OF RESULTS FOR 80-CELL RACK, 15x15 OFA (STANDARD FUEL), SET #2, E-W SSE @ 5th GAP ELEMENT. (pg. 7 of 8)

TOTAL NO. OF GAP ELEMENTS = 6.

THE ABOVE CASE IS THE MOST LIMITING FOR IMPACT BETWEEN THE FUEL ASSEMBLY AND THE CELL WALL.

PER WESTINGHOUSE DWG. 1607E93, SHT. 1 OF 1, FUEL ASSEMBLY OUTLINE:

NO. OF GRIDS = 7

SPACING = VARIABLE. (18.3" TOP, 24.582" BOTTOM AND THE INTERMEDIATE GRID SPACING = 26.19 INCHES.)

CONSIDER MAX. GRID SPACING = 26.19."

IMPACT GRID WIDTH = 8" & LENGTH = 1.5"

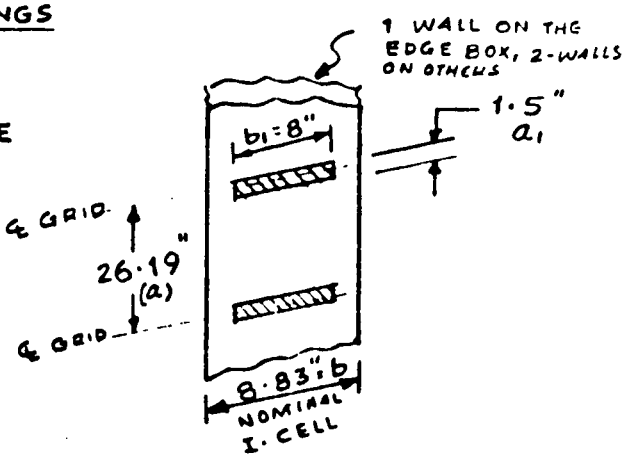
$$\text{LOAD } W = \frac{276^{LB} \times 6 \text{ GAP SPRINGS}}{7 \text{ GRIDS}}$$

$$W = 237 \text{ LB/GRID.}$$

FOR MAXIMUM STRESSES, ASSUME RECTANGULAR PLATE WITH ALL EDGES SIMPLY SUPPORTED & UNIFORM LOAD DISTRIBUTED OVER CENTRAL RECTANGULAR AREA.

REF: MECHANICAL REPORT 8721-00-0125

REF. #8 (ROARK, TABLE 26, FLAT PLATES WITH STRAIGHT BOUNDARIES & CONSTANT THICKNESS, CASE 1c, Page 387.)

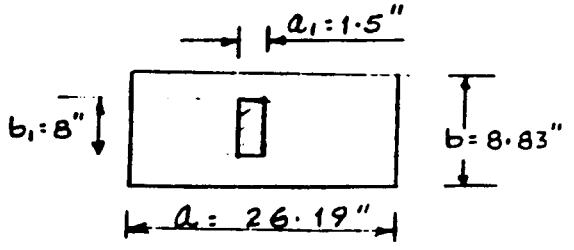


$$\text{MAX. } \sigma = \frac{\beta W}{t^2} \quad ; \quad W = 237 \text{ LB.} \quad t = 0.085" \text{ (CELL)}$$

$$\frac{a_1}{b} = \frac{1.5}{8.83} = 0.17$$

$$\frac{b_1}{b} = \frac{8}{8.83} = 0.91 \quad \& \quad \frac{a}{b} = 2.97$$

FROM TABLE, $\beta = 0.80 \approx$



RECTANGULAR PLATE. ALL EDGES SIMPLY SUPPORTED.

$$\text{MAX } \sigma = \frac{0.80 \times 237^{LB}}{(0.085^2 \text{ in})} = \underline{26.24 \text{ KSI}}$$

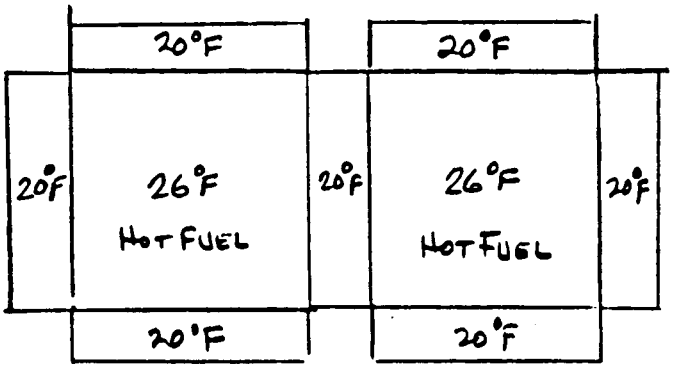
σ = 26.24 KSI < 0.60 Sy = 28.8 KSI, LEVEL D (TABLE 2.6.1 ALLOWABLES)

INTRODUCTION

Thermal stresses in cell walls will be developed when rack cells with hot fuel in them are adjacent to rack cells that are empty. The axial expansion of hot cell walls will be restrained by the cold cell walls causing a shear stress to be developed in the fusion welds holding the two walls together. Since the temperature distribution in the hot cells is approximately linear with elevation, the axial thermal shear stress distribution will also be linear, zero at the bottom of the rack and maximum at the top of the rack.

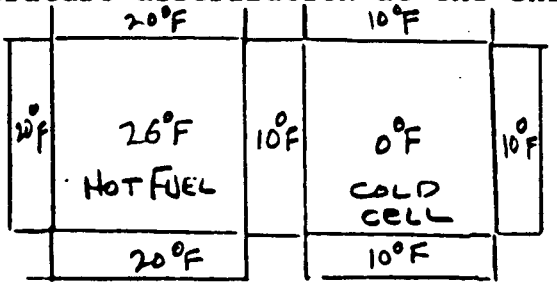
TEMPERATURE DISTRIBUTION

From the thermal analysis, Reference 1 UST&D report "Thermal Hydraulic Report - Spent Fuel Storage Racks Indian Point Unit No. 3 - 8721-0-0104 Rev 1" the maximum temperature rise in a fuel cell with regular fuel is 26.0°F for Region 1 racks. The adjacent water box temperature rise is 20.°F. (See Figure Below)



Hot fuel next to hot fuel, Region 1 relative temperatures at top of rack. Note, at bottom of rack the relative temperature is zero.

Its estimated that with an empty cell next to a hot cell, the relative temperature distribution at the exit will be as shown below.



Hot fuel cell next to cold cell. Region 1 relative temperatures at top of rack.

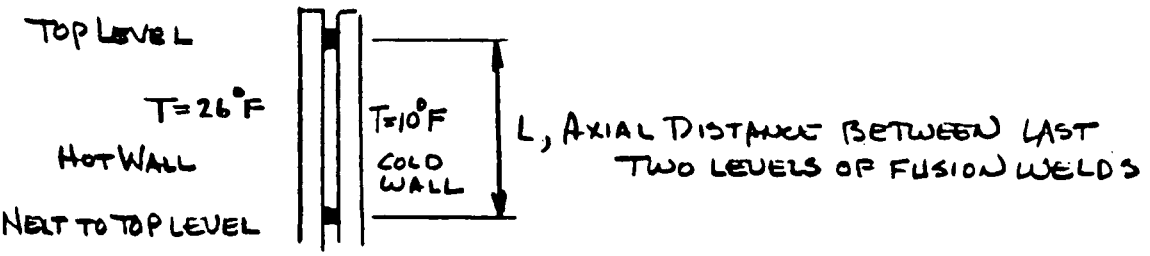
The maximum temperature difference occurs between the hot cell and the adjacent water box and is

$$\Delta T_{max} = 26^{o}F - 10^{o}F = 16^{o}F$$

at the top of the rack.

STRESS

The axial thermal expansion between the last two levels of fusion welds, between the hot wall and adjacent water box, will be:



Thermal Expansion of Hot Wall $\Delta L_{HOT\ WALL} = L \alpha \Delta T_{HOT}$, α = thermal expansion coefficient

Thermal Expansion of Cold Wall $\Delta L_{COLD\ WALL} = L \alpha \Delta T_{COLD}$

Relative free expansion $\overline{\Delta} L = \Delta L_{HOT\ WALL} - \Delta L_{COLD\ WALL}$

$$\overline{\Delta} L = L \alpha (\Delta T_{HOT} - \Delta T_{COLD})$$

Since the two walls are fastened together by the fusion welds, the net change in length will be $1/2\ \overline{\Delta} L$.

The compressive stress in the hot wall will be balanced by the tension developed in the colder wall.

$$\epsilon = 1/2\ \frac{\overline{\Delta} L}{L} \qquad \text{STRAIN IN WALL}$$

$$\sigma_T = \epsilon E \qquad \text{STRESS IN WALL}$$

$$\sigma_T = 1/2\ \alpha E\ (\Delta T_{HOT} - \Delta T_{COLD})$$

The stress in the cell wall will be balanced by a shear stress in two top fusion welds.

$$\sigma_T \text{ (AREA WALL)} = \tau \text{ (AREA FUSION WELDS)}$$

$$\sigma_T \quad (bt) = \tau \left(2 \frac{\pi}{4} d^2 \right)$$

WHERE b = WALL WIDTH
t = WALL THICKNESS
d = DIAMETER FUSION WELDS

HENCE

$$\tau = \frac{\sigma_{bt}}{\pi/_2 d^2}$$

THUS

$$\tau = 1/2 \alpha E (\Delta T_H - \Delta T_C) \frac{bt}{\pi/_2 d^2}$$

$$\tau = \alpha E (\Delta T_H - \Delta T_C) \frac{bt}{\pi/_2 d^2}$$

This shear stress in the fusion welds is maximum at the top of the rack and zero at the bottom of the rack and linear in between.

MAGNITUDE OF THERMAL STRESS

$$\tau = 9\text{x}10^{-6} \, {}^{in}/_{in} \, {}^{o}F \times 27.5\text{x}10^{6} \, {}^{lb}/_{in^2} \, \frac{(26^{o}F - 10^{o}F)}{\pi (.5)^2} \times 2 \, in^2 \, 9" \text{x} .085"$$

τ = 3857 psi AT TOP OF RACK

τ = 0 psi AT BOTTOM OF RACK

NOTE: This thermal stress is strictly for Region 1 with regular fuel. However, it will also be conservatively used for Region 1 & 2 with consolidated fuel.

COMBINING WITH PRIMARY STRESSES

The primary stresses for Region 1 & 2 will be combined with the thermal stresses.

τ_{ALL} = 21,000 psi

TABLE I

REGION I (OBE) SECTION C-C - CONSOLIDATED

	τ primary	τ thermal	τ total	safety factor
Top of Rack	8,605 *	3,857	12,462	1.68
Bottom of Rack	10,000	0	10,000	2.1

REGION I (OBE) SECTION C-C - CONSOLIDATED

	τ primary	τ thermal	τ total	safety factor
Top of Rack	7,715**	3,857	11,572	1.81
Bottom of Rack	11,534	0	11,534	1.82

FROM SECTION 4.1 - Page 54a MECHANICAL REPORT

* Top of Rack

$$\tau = 3{,}306 + 2/3\sqrt{(6.43E3)^2 + (1.318E3)^2 + (1.75E3)^2} = 7836 \text{ psi}$$

$$\sigma = 7{,}108; \quad \tau_{MAX} = \sqrt{(7836)^2 + \left(\frac{7108}{2}\right)^2} = 8605 \text{ psi}$$

FROM SECTION 4.1 - Page 32c MECHANICAL REPORT

** Top of Rack

$$\tau = 4{,}041 + \sqrt{(2769)^2 + (1079)^2 + (1428)^2} = 7338 \text{ psi}$$

$$\sigma = 2{,}078 + \sqrt{(2590)^2 + (734)^2} = 4770 \text{ psi}$$

$$\tau_{MAX} = \sqrt{(7338)^2 + \left(\frac{4770}{2}\right)^2} = 7715 \text{ psi}$$

CONCLUSIONS

Adding the secondary thermal stresses to the primary stresses reduces the shear safety factors for the fusion welds from 2.1 to 1.68 for Region 1 and 1.82 to 1.81 for Region 2.

RESPONSE TO QUESTION 10 (1)

U.S. TOOL & DIE, INC.

BY JMRB DATE 3/27/89 SUBJECT NYPA - NRC SECT. ____ SHEET 1 OF 2

CHKD. BY WDS DATE 3/27/89 HYDRODYNAMIC LOADING OF POOL WALL PROJ. NO. 8721-50

PURPOSE: TO DETERMINE THE HIGHEST HYDRODYNAMIC FORCE LOADING ON THE POOL WALL IN THE VICINITY OF THE RACK

METHOD: THE DESIGN BASIS EW SINGLE 132 RACK MATH MODEL IS SUBJECTED TO A SSE EW EXCITATION. THE WALL FORCES ARE RECORDED AT THE WEST WALL. THE RACK TO WALL GAP IS 4.51 INCHES

INPUT PARAMETERS ARE INCLUDED SUCH THAT FOR EACH TIME STEP THE HYDRODYNAMIC FORCE AT THE WEST WALL IS FOUND. THE ADDITION OF THESE PARAMETERS IS TRANSPARENT TO THE RACK RESPONSE

REFERENCE 8721-00-0033 PAGE 4-5

$$MH^{RW} = \frac{62.4}{1728}\frac{(165.4)^3}{12\,S}(9.15 \times 12) =$$

$$S = 4.5 \qquad M_H^{RW} = 332140$$

$$M_1^R = \frac{(9.15 \times 12)(9.15 \times 11)(165)62.4}{1728}(3+86/99.8)$$

$$= 254287$$

$$M_2^P = \frac{(9.15 \times 12 \times 395.5)}{1728}62.4(165) = 258746$$

M_1^R: Weight of water displaced by racks in row

M_2: Weight of water in pool, in the row, in absence of racks

U.S. TOOL & DIE, INC.

BY MRB DATE 3/27/89 SUBJECT NYPA - NRC SECT. ____ SHEET 2 OF 2
CHKD. BY W.B.J DATE 3/27/89 HYDRODYNAMIC LOADING OF POOL WALL PROJ. NO. 8721-10

$$F_{1,16} = F_{6,16} = \frac{332140}{10} + \frac{254287}{10} = 58643.$$

$$F_{2,16} \ldots F_{4,16} = 2 \times F_{1,16} = 117285$$

$$F_{1,17} = F_{6,17} = \frac{332140}{10} + \left(\frac{254287 + 258746}{10}\right) = 84517$$

$$F_{2,17} \ldots F_{4,17} = 2 \times F_{1,17} = 169035$$

RESULT (SEE ATTACHED OUTPUT)

THE HYDRODYNAMIC LOAD ACTING ON THE 12 X 9.075" X 165") FACE OF THE POOL WALL IS 1.170165 KIPS WHICH CORRESPONSE TO AVERAGE PRESSURE OF 6.5 PSI

THE FORCE ON THE POOL WALL (FOR EACH RACK MASS ELEMENT) IS

$$F = (\bar{M}_H^{rw} + \bar{M}_1^R)\ddot{x}_n - (\bar{M}_H^{rw} + \bar{M}_1^R + \bar{M}_2^P)\ddot{y}$$

where: $\ddot{x}_n$: the acceleration of element n

$\ddot{y}$: the acceleration of the pool wall

$\bar{M}_H^{rw}$, etc: Portion of M_H^{rw} applicable to mass element

$$m_{n,16} = \bar{M}_H^{rw} + \bar{M}_1^R$$

$$m_{n,17} = \bar{M}_H^{rw} + \bar{M}_1^R + \bar{M}_2^P$$

[illegible] CALCULATE POOL WALL FORCES
[illegible] EAST - WEST
[illegible] DAMPING (CONSOLIDATED FUEL)
[illegible] (HORIZONTAL - 303147. VERTICAL - 14.2383
[illegible] MARCH 15, 1989
[illegible] Spectrum [illegible] Indian Point # 3 (Fig H.3 1. 1% Damping)
DATE(MON/DAY/YEAR). 3/15/89
TIME(HOUR MIN.SEC) 14. 9.28

FORCES [illegible]
NRC

NUMBER OF MASSES 14
NUMBER OF REDUNDANTS 11
NUMBER OF FLEXIBLE ELEMENTS. 13
NUMBER OF TIME STEPS. 30000
PRINT INTERVAL. 30000
TIME STEP (SECONDS). .00050
INTERPOLATION STEPS. 20

EULERS METHOD USED

PERCENT OF CRITICAL DAMPING IN GAPS. 4.0
PERCENT OF CRITICAL DAMPING IN MODES.
4.0 4.0 4.0 4.0 4.0 4.0 4.0 4.0 4.0 4.0
4.0 4.0 4.0 4.0

NODAL MASSES AND DIRECTION FACTORS

NODE	WEIGHTS (POUNDS)	DIRECT. FACTORS
1	4103.	1.
2	4377.	1.
3	4399	1.
4	4377.	1.
5	4320.	1.
6	4731.	1.
7	39943.	1.
8	77836.	1.
9	79086.	1.
10	77836.	1.
11	79086.	1.
12	39743.	1.
13	351399900.	0.
14	423040.	0.

TOTAL WEIGHT IS 423061. POUNDS

NUMBER OF GAP ELEMENTS. 12

LEFT MASS	RIGHT MASS	CLEARANCE	STIFFNESS	DAMPING FACT.
1	7	.15	99371.	256.4
7	1	.15	99371.	256.4
2	8	.15	99371.	362.6
8	2	.15	99371.	362.6
3	9	.15	99371.	362.6
9	3	.15	99371.	362.6
4	10	.15	99371.	362.6
10	4	.15	99371.	362.6
5	11	.15	99371.	362.6
11	5	.15	99371.	362.6
6	12	.15	99371.	256.4
12	6	.15	99371.	256.4

MASSES ACTING VERTICALLY

NODE	LEFT STIFFNESS	RIGHT STIFFNESS	SUBMERGED WEIGHT	STATIC DEFLECTION
14	.1423E 08	.1423E 08	.3603E 06	.1294E-01

SEISMIC AMPLIFICATION FACTOR 1.00000

FORCES ARE OUTPUT FOR FOLLOWING STRUCT. ELEMENTS

1 ELEMENT NUMBER 1 STIFF. OPTION 1. 4 EFFECTS. GAP INDEX IS 0
28 00 334639.00 200.00 33.03 1.15
.5560E 08 -.5560E 08 .9197E 09 .9197E 09
-.5560E 08 .5560E 08 -.7177E 09 -.7177E 07
.9197E 09 -.9197E 09 .2985E 12 -.2681E 12
-.9197E 07 -.9197E 07 -.2681E 12 .2985E 12
1 2 13 1
0 0 0 1

2 ELEMENT NUMBER 11 STIFF. OPTION 0. 1 EFFECTS. GAP INDEX IS 0
.5081E 04
1
0

3 ELEMENT NUMBER 12 STIFF. OPTION 0. 2 EFFECTS. GAP INDEX IS 1
.1875E 11 .5145E 09
.5145E 09 .1423E 08
13 14
0 0

4 ELEMENT NUMBER 13 STIFF. OPTION 0. 2 EFFECTS. GAP INDEX IS 1
.1875E 11 -.5145E 09
-.5145E 09 .1423E 08
13 14
0 0

TIME. .0000 SEC.

NODE	ACCEL.(g)	VELOCITY(in/s)	DISP.(in,rad)	NODAL FORCE (lb,lb-in)	MAXIMUM DISP. (in,rad)
BASE	.0000E 00	.0000E 00	.0000E 00		
1	.0000E 00	.0000E 00	.0000E 00	.0000E 00	.0000E 00
2	.0000E 00	.0000E 00	.0000E 00	.0000E 00	.0000E 00
3	.0000E 00	.0000E 00	.0000E 00	.0000E 00	.0000E 00
4	.0000E 00	.0000E 00	.0000E 00	.0000E 00	.0000E 00
5	.0000E 00	.0000E 00	.0000E 00	.0000E 00	.0000E 00
6	.0000E 00	.0000E 00	.0000E 00	.0000E 00	.0000E 00
7	.0000E 00	.0000E 00	.0000E 00	.0000E 00	.0000E 00
8	.0000E 00	.0000E 00	.0000E 00	.0000E 00	.0000E 00
9	.0000E 00	.0000E 00	.0000E 00	.0000E 00	.0000E 00
10	.0000E 00	.0000E 00	.0000E 00	.0000E 00	.0000E 00
11	.0000E 00	.0000E 00	.0000E 00	.0000E 00	.0000E 00
12	.0000E 00	.0000E 00	.0000E 00	.0000E 00	.0000E 00
13	.0000E 00	.0000E 00	.0000E 00	.0000E 00	.0000E 00
14	-.3901E-04	.0000E 00	-.1294E-01	.3683E 06	-.1294E-01

FORCES IN GAP ELEMENTS(lb)

GAP ELEM. NO.	CONTACT FORCE	MAX CONTACT FORCE
1	.0000E 00	.0000E 00
2	.0000E 00	.0000E 00
3	.0000E 00	.0000E 00
4	.0000E 00	.0000E 00
5	.0000E 00	.0000E 00
6	.0000E 00	.0000E 00
7	.0000E 00	.0000E 00
8	.0000E 00	.0000E 00

	.0000E 00	.0000E 00
10	.0000E 00	.0000E 00
11	.0000E 00	.0000E 00
12	.0000E 00	.0000E 00

FLUID FORCES ON RACK WALL

MASS	FORCE	MAX. FORCE
1	.0000E 00	.0000E 00
2	.0000E 00	.0000E 00
3	.0000E 00	.0000E 00
4	.0000E 00	.0000E 00
5	.0000E 00	.0000E 00
6	.0000E 00	.0000E 00

FORCES IN DESIGNATED STRUCTURAL ELEMENTS(lb-in.lb)

	BEAM STR. FORCES	1	.0	.0	.0	.0
	ELEMENT STR. FORCES	2	.0			
	ELEMENT STR. FORCES	3	-6603509.0	-104136.2		
	ELEMENT STR. FORCES	4	6603509.0	-104136.2		
MAX	BEAM STR. FORCES	1	.0	.0	.0	.0
MAX	ELEMENT STR. FORCES	2	.0			
MAX	ELEMENT STR. FORCES	3	-6603509.0	-104136.2		
MAX	ELEMENT STR. FORCES	4	6603509.0	-104136.2		

LIFTOFF DISTANCES(INCHES)

NODE	LEFT	RIGHT	MAX. LEFT	MAX. RIGHT
14	.0000E 00	.0000E 00	.0000E 00	.0000E 00

AT TIME. 10.0000 SEC.

NODE	ACCEL (g)	VELOCITY(in/s)	DISP.(in.rad)	NODAL FORCE (lb;lb-in)	MAXIMUM DISP. (in;rad)
BASE	.4657E-09	-.4244E 00	-.7206E 01		
1	-.2904E-02	-.1770E 00	.5105E-02	-.2073E 03	-.2888E 00
2	-.2845E-02	-.1061E 00	.5240E-02	-.3666E 03	-.2972E 00
3	-.2804E-02	-.1935E 00	.5374E-02	-.2558E 03	-.3059E 00
4	-.2746E-02	-.2015E 00	.5541E-02	-.1762E 03	-.3146E 00
5	-.2611E-02	-.2107E 00	.5689E-02	-.2523E 03	-.3231E 00
6	-.2504E-02	-.2202E 00	.5832E-02	-.2505E 03	-.3313E 00
7	-.2238E-02	-.2522E 00	-.3563E-01	.5342E 02	.4693E 00
8	-.2307E-02	-.3979E 00	-.5564E-01	.7193E 02	-.4306E 00
9	-.2513E-02	-.5368E 00	-.2567E-01	-.5160E 02	-.4072E 00
10	-.2639E-02	-.6570E 00	.4233E-02	-.1360E 03	-.3777E 00
11	-.2312E-02	-.7516E 00	.3406E-01	-.3140E 02	.4210E 00
12	-.1614E-02	-.8320E 00	.6304E-01	.1359E 03	.4759E 00
13	.1030E-05	-.1057E-03	.3401E-05	.3647E 03	-.1973E-03
14	.0000E 00	-.4516E-05	-.1294E-01	.3603E 06	-.1294E-01

FORCES IN GAP ELEMENTS(lb)

GAP ELEM. NO.	CONTACT FORCE	MAX CONTACT FORCE
1	.0000E 00	.1200E 05
2	.0000E 00	.1603E 05
3	.0000E 00	.3702E 04
4	.0000E 00	.9153E 04
5	.0000E 00	.5374E 04
6	.0000E 00	.3329E 04
7	.0000E 00	.2703E 04
8	.0000E 00	.3712E 04
9	.0000E 00	.3064E 04
10	.0000E 00	.8213E 04
11	.0000E 00	.1405E 05
12	.0000E 00	.1307E 05

RESPONSE TO 10 (1)

AUTO FORCES ON RACK WALL

MASS	FORCE	MAX. FORCE
1	-.1703E 03	.1117E 05
2	-.3337E 03	.2272E 05
3	-.3239E 03	.2314E 05
4	-.3721E 03	.2351E 05
5	-.3062E 03	.2400E 05
6	-.1469E 03	.1237E 05

FORCES IN DESIGNATED STRUCTURAL ELEMENTS(lb-in,lb)

	BEAM STR. FORCES	1	-1355.5	1355.5	-126664.6	81823.0
	ELEMENT STR. FORCES	2	1573.1			
	ELEMENT STR. FORCES	3	-6620037.0	-102307.7		
	ELEMENT STR. FORCES	4	6747532.0	-105701.1		
MAX	BEAM STR. FORCES	1	80228.7	-80228.7	7448224.0	-4795104.0
MAX	ELEMENT STR. FORCES	2	-39006.1			
MAX	ELEMENT STR. FORCES	3	-10421220.0	-207097.6		
MAX	ELEMENT STR. FORCES	4	10377330.0	-205388.7		

LIFTOFF DISTANCES(INCHES)

NODE	LEFT	RIGHT	MAX. LEFT	MAX. RIGHT
14	.0000E 00	.0000E 00	.0000E 00	.0000E 00

SUMMARY FOR COMPLETE TIME HISTORY

NODE	MAXIMUM DISP(in,rad)	AT TIME
1	-.2888E 00	.2277E 01
2	-.2972E 00	.2297E 01
3	-.3059E 00	.2296E 01
4	-.3146E 00	.2296E 01
5	-.3231E 00	.2296E 01
6	-.3313E 00	.2296E 01
7	.4693E 00	.7624E 01
8	-.4306E 00	.7024E 01
9	-.4072E 00	.7024E 01
10	-.3777E 00	.7025E 01
11	.4210E 00	.8027E 01
12	.4759E 00	.8033E 01
13	-.1973E-03	.2294E 01
14	-.1294E-01	.1900E-01

FORCES IN GAP ELEMENTS

GAP ELEM NO.	MAX CONTACT FORCE(lb)	AT TIME
1	.1208E 05	.7026E 01
2	.1603E 05	.6522E 01
3	.8782E 04	.7027E 01
4	.9153E 04	.6521E 01
5	.5374E 04	.7050E 01
6	.3329E 04	.1219E 02
7	.2988E 04	.7134E 01
8	.3712E 04	.1217E 02
9	.3064E 04	.3575E 01
10	.8213E 04	.8106E 01
11	.1405E 05	.8502E 01
12	.1307E 05	.8095E 01

AUTO FORCES ON RACK WALL

MASS	MAX FORCE	TIME
1	.1117E 05	7.0300
2	.2272E 05	7.0300

RESPONSE TO 10 (1)

```
[illegible]E 05        7 0500
[illegible]E 05        7 0500
[illegible]E 05        7 0500
[illegible]E 05        7 0500
```

1.1701 E05 ; 6.5 PSI

```
FORCES IN DESIGNATED STRUCTURAL ELEMENTS(LB,LB-IN)
  MAX  BEAM STR  FORCES   1      00220.7     -00220.7    7440224.0   -4795184.0
TIME OF MAXIMUM FORCE            2.2750       2.2750      2.2945      2.2940
MAX  ELEMENT STR  FORCES   2     -09006.1
TIME OF MAXIMUM FORCE            2.2935
MAX  ELEMENT STR  FORCES   3  -10421220.0   -207097.6
TIME OF MAXIMUM FORCE            2.2940       2.2940
MAX  ELEMENT STR  FORCES   4   10377330.0   -205000.7
TIME OF MAXIMUM FORCE            2.0410       2.0410
MAXIMUM DEFLECTIONS
NODE        LEFT          RIGHT          TIME LEFT     TIME RIGHT
  1       00002.00      .00002.00          .0000          .0000

RUN TIME     0 HOURS- 32 MINUTES- 36 SECONDS
```

RESPONSE TO QUESTION 10 (2)

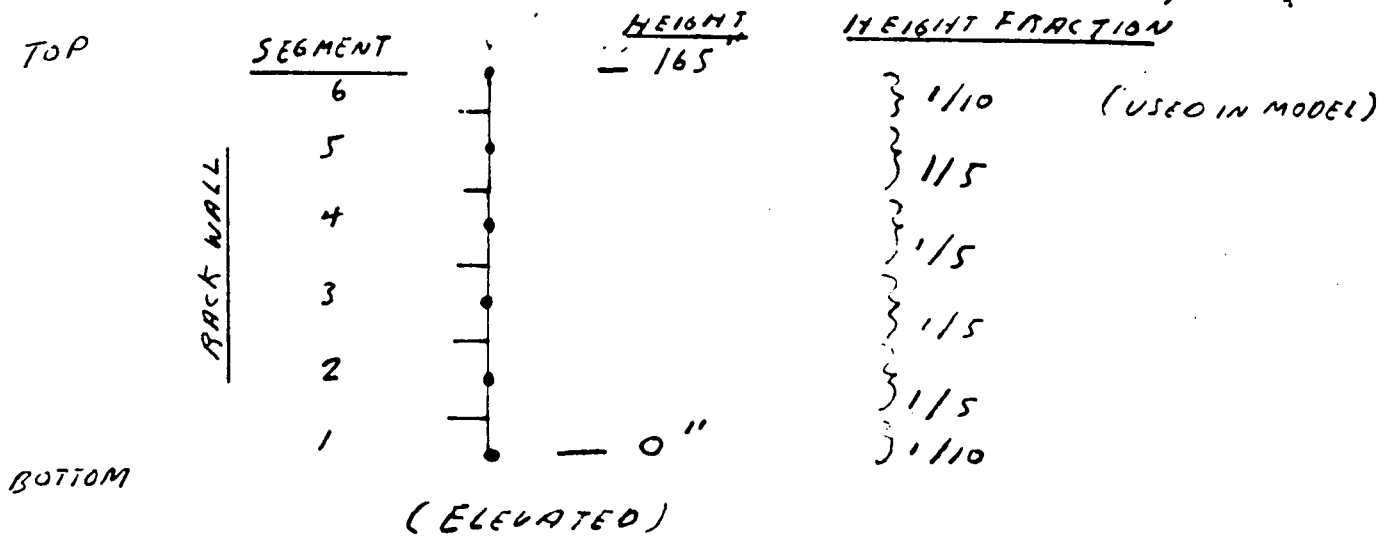
U.S. TOOL & DIE, INC.

BY MRG DATE 3/17/89 SUBJECT NYPA - NRC SECT. ___ SHEET 1 OF ___

CHKD. BY PS DATE 3/27/89 HYDRODYNAMIC WALL LOADING PROJ. NO. 8721-50

PURPOSE: TO DETERMINE THE LOCAL STRESSES INCURRED IN THE RACK DUE TO THE HYDRODYNAMIC LOAD ON THE RACK WALL, FROM RACKOE (132 CELL MODEL)

RESULTS; THE HYDRODYNAMIC LOAD ACTING ON THE (72" X 9.075" X 165") FACE OF THE RACK IS 59.4 KIPS (CONSERVATIVELY DETERMINED FROM) THIS 59.4 KIPS IS A THE MAXIMUM FORCE OF THE (IN THE RACKOE MODEL) 6 ELEVATION SEGMENTS MULTIPLIED BY 5.



THE LOCAL WALL BUCKLING STRESS ACTING ON THE FIRST ROW OF CELL WALLS IS CALCULATED USING THIS FORCE ASSUMING A UNIFORM DISTRIBUTION OVER THE FACE OF THE RACK

24 WALLS (.075 X 165) = AREA

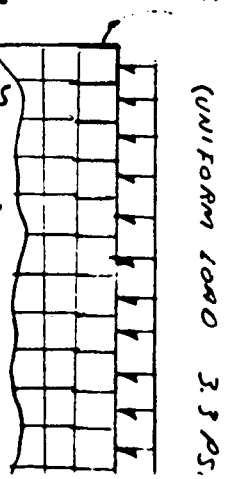
9.075 = LENGTH

$\sigma_{BUCKLING} = \frac{59.4 \text{ KIPS}}{336.6 \text{ IN}^2}$

$\sigma_{BUCKLING} = .176$ KSI

$\sigma_{BUCKLING}$ ALLOWABLE = 2.9 KSI REF 8721-00-0175 R

F.S. = 16.5



OUTER WALL

BUCKLING = 0.352 KSI

F.S = 8.25

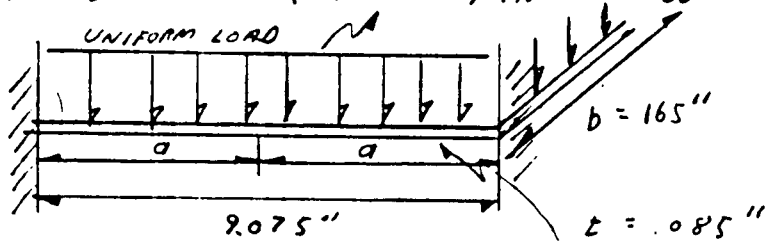
U.S. TOOL & DIE, INC.

BY JMRB DATE 3/17/89 SUBJECT N 9411 - NRC SECT. SHEET 2 OF
CHKD. BY PSV DATE 3/27/89 HYDRODYNAMIC WALL LOADING PROJ. NO. 8721-50

PURPOSE TO DETERMINE THE LOCALIZED STRESS IN TRANSVERSE OUTSIDE WALL DUE TO HYDRODYNAMIC LOADING.

THE 59.4 KIPS DIVIDED BY AREA, IS APPLIED TO A .085" PLATE OF LENGTH 165" and WIDTH 9.075" .0033 KIPS/IN² = w

BOX WALL ACTING AS A FLAT PLATE



CONSIDER BENDING IN PLATE

$$a/b = \frac{9.075/2}{165} = .0275$$

REF: PLATE FORMULAS : WILLIAM GRIFFEL CASE 88

FITTED CURVE → $K_x \approx .3333(a/b)^2$

TEST a/b	1/8	1/4	3/8	1/2
ESTIMATED	.0052	.0208	.0469	.0833
ACTUAL	.0052	.0209	.0476	.0852

FOR a/b = 0.0275

$K_x = .000252$

MAX MOMENT

$M_x = K_x(pb^2)$ $\quad M_{x_{MAX}} = .000252\ (.0033\ 165^2) = .02264$ KIPS

MAX STRESS

$S_{MAX} = \frac{6M}{t^2}$ $\quad S_{MAX} = \frac{6(.02264)}{(.085)^2} = 18.8\ KSI < 36\ KSI$

F.S = 1.91

RESPONSE TO 10 (2)

FORCES ON RACK WAL

[illegible] FILE TESLWCWFO
S2 SSE EAST - WEST
1% DAMPING (CONSOLIDATED FUEL)
[illegible] HORIZONTAL = 303147. VERTICAL = 14.2363
[illegible] MARCH 10, 1989
E-W SSE Spectrum Elev 34 -6" Indian Point # 3 (Fig H.3.1, 1% Damping)
DATE(MON/DAY/YEAR). 3/10/89
TIME(HOUR MIN.SEC). 11. 2.17

NUMBER OF MASSES. 14
NUMBER OF REDUNDANTS 11
NUMBER OF FLEXIBLE ELEMENTS. 13
NUMBER OF TIME STEPS. 30000
PRINT INTERVAL. 30000
TIME STEP (SECONDS). .00050
INTERPOLATION STEPS. 20

EULERS METHOD USED

PERCENT OF CRITICAL DAMPING IN GAPS. 4.0
PERCENT OF CRITICAL DAMPING IN MODES.
4.0 4.0 4.0 4.0 4.0 4.0 4.0 4.0 4.0 4.0
4.0 4.0 4.0 4.0

NODAL MASSES AND DIRECTION FACTORS

NODE	WEIGHTS (POUNDS)	DIRECT. FACTORS
1	4183.	1.
2	4399	1.
3	4399.	1.
4	4377.	1.
5	4320.	1.
6	4931.	1.
7	39943.	1.
8	79386.	1.
9	79086.	1.
10	79386.	1.
11	79086.	1.
12	39743.	1.
13	331399900.	0.
14	423060.	0.

TOTAL WEIGHT IS 423061. POUNDS

NUMBER OF GAP ELEMENTS. 12

LEFT MASS	RIGHT MASS	CLEARANCE	STIFFNESS	DAMPING FACT.
1	7	.15	99371.	256.4
7	1	.15	99371.	256.4
2	8	.15	99371.	362.6
8	2	.15	99371.	362.6
3	7	.15	99371.	362.6
9	3	.15	99371.	362.6
4	10	.15	99371.	362.6
10	4	.15	99371.	362.6
5	11	.15	99371.	362.6
11	5	.15	99371.	362.6
6	12	.15	99371.	256.4
12	6	.15	99371.	256.4

MASSES ACTING VERTICALLY

NODE	LEFT STIFFNESS	RIGHT STIFFNESS	SUBMERGED WEIGHT	STATIC DEFLECTION
14	.1423E 08	.1423E 08	.3603E 06	.1274E-01

RESONANCE AMPLIFICATION FACTOR 1.00000 RESPONSE TO 10 (2)

FORCES ARE OUTPUT FOR FOLLOWING STRUCT. ELEMENTS

```
1   ELEMENT NUMBER  1 STIFF. OPTION  1,  4 EFFECTS, GAP INDEX IS  0
      28 00 334607.00     200.00      33.00       1.15
  .3560E 08  -.3560E 08   .9197E 09   .9197E 09
 -.3560E 08   .3560E 08  -.7177E 09  -.7177E 09
  .9197E 09  -.9197E 09   .2905E 12  -.2601E 12
  .7177E 09  -.7177E 09  -.2601E 12   .2905E 12
      1     2    13     1
      0     0     0     1

2   ELEMENT NUMBER 11 STIFF. OPTION  0,  1 EFFECTS, GAP INDEX IS  0
  .308.E 06
      1
      0

3   ELEMENT NUMBER 12 STIFF. OPTION  0,  2 EFFECTS, GAP INDEX IS  1
  .1875E 11     .5165E 09
  .5165E 09     .1423E 08
     13    14
      0     0

4   ELEMENT NUMBER 13 STIFF. OPTION  0,  2 EFFECTS, GAP INDEX IS  1
  .1875E 11  -.5165E 09
 -.5165E 09   .1423E 08
     13    14
      0     0

TIME     .0000 SEC.
```

NODE	ACCEL.(g)	VELOCITY(in/s)	DISP.(in,rad)	NODAL FORCE (lb,lb-in)	MAXIMUM DISP. (in,rad)
BASE	.0000E 00	.0000E 00	.0000E 00		
1	.0000E 00	.0000E 00	.0000E 00	.0000E 00	.0000E 00
2	.0000E 00	.0000E 00	.0000E 00	.0000E 00	.0000E 00
3	.0000E 00	.0000E 00	.0000E 00	.0000E 00	.0000E 00
4	.0000E 00	.0000E 00	.0000E 00	.0000E 00	.0000E 00
5	.0000E 00	.0000E 00	.0000E 00	.0000E 00	.0000E 00
6	.0000E 00	.0000E 00	.0000E 00	.0000E 00	.0000E 00
7	.0000E 00	.0000E 00	.0000E 00	.0000E 00	.0000E 00
8	.0000E 00	.0000E 00	.0000E 00	.0000E 00	.0000E 00
9	.0000E 00	.0000E 00	.0000E 00	.0000E 00	.0000E 00
10	.0000E 00	.0000E 00	.0000E 00	.0000E 00	.0000E 00
11	.0000E 00	.0000E 00	.0000E 00	.0000E 00	.0000E 00
12	.0000E 00	.0000E 00	.0000E 00	.0000E 00	.0000E 00
13	.0000E 00	.0000E 00	.0000E 00	.0000E 00	.0000E 00
14	-.3901E-04	.0000E 00	-.1294E-01	.3603E 06	-.1294E-01

FORCES IN GAP ELEMENTS(lb)

GAP ELEM. NO.	CONTACT FORCE	MAX CONTACT FORCE
1	.0000E 00	.0000E 00
2	.0000E 00	.0000E 00
3	.0000E 00	.0000E 00
4	.0000E 00	.0000E 00
5	.0000E 00	.0000E 00
6	.0000E 00	.0000E 00
7	.0000E 00	.0000E 00
8	.0000E 00	.0000E 00

7	.0000E 00	.0000E 00
10	.0000E 00	.0000E 00
11	.0000E 00	.0000E 00
12	.0000E 00	.0000E 00

FLUID FORCES ON RACK WALL

MASS	FORCE	MAX. FORCE
1	.0000E 00	.0000E 00
2	.0000E 00	.0000E 00
3	.0000E 00	.0000E 00
4	.0000E 00	.0000E 00
5	.0000E 00	.0000E 00
6	.0000E 00	.0000E 00

FORCES IN DESIGNATED STRUCTURAL ELEMENTS(lb-in;lb)

	BEAM STR. FORCES	1	.0	.0	.0	.0
	ELEMENT STR. FORCES	2	.0			
	ELEMENT STR. FORCES	3	-6603509.0	-104136.2		
	ELEMENT STR. FORCES	4	6603507.0	-104136.2		
MAX.	BEAM STR. FORCES	1	.0	.0	.0	.0
MAX	ELEMENT STR. FORCES	2	.0			
MAX	ELEMENT STR. FORCES	3	-6603509.0	-104136.2		
MAX	ELEMENT STR. FORCES	4	6603507.0	-104136.2		

LIFTOFF DISTANCES(INCHES)

NODE	LEFT	RIGHT	MAX. LEFT	MAX. RIGHT
14	.0000E 00	.0000E 00	.0000E 00	.0000E 00

AT TIME. 15.0000 SEC.

NODE	ACCEL.(g)	VELOCITY(in/s)	DISP.(in;rad)	NODAL FORCE (lb;lb-in)	MAXIMUM DISP. (in;rad)
BASE	.4657E-09	-.4244E 00	-.7206E 01		
1	-.2704E-02	-.1770E 00	.5105E-02	-.2073E 03	-.2888E 00
2	-.2845E-02	-.1861E 00	.5240E-02	-.3666E 03	-.2972E 00
3	-.2804E-02	-.1935E 00	.5394E-02	-.2558E 03	-.3059E 00
4	-.2746E-02	-.2015E 00	.5541E-02	-.1762E 03	-.3146E 00
5	-.2611E-02	-.2109E 00	.5609E-02	-.2523E 03	-.3231E 00
6	-.2504E-02	-.2202E 00	.5832E-02	-.2505E 03	-.3313E 00
7	-.2288E-02	-.2522E 00	-.8563E-01	.5342E 02	.4693E 00
8	-.2307E-02	-.3979E 00	-.5564E-01	.7193E 02	-.4386E 00
9	-.2518E-02	-.5368E 00	-.2567E-01	-.5160E 02	-.4092E 00
10	-.2639E-02	-.6570E 00	.4233E-02	-.1360E 03	-.3777E 00
11	-.2312E-02	-.7516E 00	.3403E-01	-.3140E 02	.4210E 00
12	-.1614E-02	-.8320E 00	.6304E-01	.1359E 03	.4759E 00
13	.1038E-05	-.1357E-03	.3401E-05	.3647E 03	-.1993E-03
14	.0000E 00	-.4516E-05	-.1294E-01	.3603E 06	-.1294E-01

FORCES IN GAP ELEMENTS(lb)

GAP ELEM. NO.	CONTACT FORCE	MAX CONTACT FORCE
1	.0000E 00	.1200E 05
2	.0000E 00	.1603E 05
3	.0000E 00	.8782E 04
4	.0000E 00	.9153E 04
5	.0000E 00	.5374E 04
6	.0000E 00	.3329E 04
7	.0000E 00	.2708E 04
8	.0000E 00	.3712E 04
9	.0000E 00	.8064E 04
10	.0000E 00	.8213E 04
11	.0000E 00	.1405E 05
12	.0000E 00	.1367E 05

FLUID FORCES ON RACK WALL

MASS	FORCE	MAX FORCE
1	.9644E 02	-.5577E 04
2	.1070E 03	-.1140E 05
3	.1063E 03	-.1163E 05
4	.1024E 03	-.1109E 05
5	.1734E 03	-.1226E 05
6	.0310E 02	-.6307E 04

FORCES IN DESIGNATED STRUCTURAL ELEMENTS(lb-in,lb)

	BEAM STR. FORCES	1	-1555.5	1555.5	-126664.6	81823.8
	ELEMENT STR. FORCES	2	1573.1			
	ELEMENT STR. FORCES	3	-6620037.0	-102387.7		
	ELEMENT STR. FORCES	4	6747582.0	-135701.1		
MAX	BEAM STR. FORCES	1	80228.7	-80228.7	7440224.0	-4795184.0
MAX	ELEMENT STR. FORCES	2	-37006.1			
MAX	ELEMENT STR. FORCES	3	-10421220.0	-287097.6		
MAX	ELEMENT STR. FORCES	4	10377330.0	-285838.7		

LIFTOFF DISTANCES(INCHES)

NODE	LEFT	RIGHT	MAX. LEFT	MAX. RIGHT
14	.0000E 00	.0000E 00	.0000E 00	.0000E 00

SUMMARY FOR COMPLETE TIME HISTORY

NODE	MAXIMUM DISP(in.rad)	AT TIME
1	-.2883E 00	.2297E 01
2	-.2972E 00	.2297E 01
3	-.3037E 00	.2296E 01
4	-.3146E 00	.2296E 01
5	-.3281E 00	.2296E 01
6	-.3313E 00	.2296E 01
7	.4673E 00	.7624E 01
8	-.4386E 00	.7024E 01
9	-.4072E 00	.7024E 01
10	-.3777E 00	.7025E 01
11	.4210E 00	.8027E 01
12	.4709E 00	.8033E 01
13	-.1973E-03	.2274E 01
14	-.1294E-01	.1900E-01

FORCES IN GAP ELEMENTS

GAP ELEM. NO.	MAX CONTACT FORCE(lb)	AT TIME
1	.1208E 05	.7026E 01
2	.1603E 05	.6522E 01
3	.8782E 04	.7027E 01
4	.9153E 04	.6521E 01
5	.5374E 04	.7050E 01
6	.3329E 04	.1219E 02
7	.2980E 04	.7134E 01
8	.3712E 04	.1217E 02
9	.8644E 04	.8575E 01
10	.8213E 04	.8106E 01
11	.1405E 05	.8502E 01
12	.1307E 05	.8095E 01

FLUID FORCES ON RACK WALL

MASS	MAX FORCE	TIME
1	-.5577E 04	7.0300
2	-.1140E 05	7.0205

4	[illegible]	7.0500
5	-.1109E 05	7.0490
6	-.1226E 05	7.0473
7	-.0307E 04	7.0500

FORCES IN DESIGNATED STRUCTURAL ELEMENTS(lb,lb-in)

MAX BEAM STR FORCES	1	00220.7	-00220.7	7440224.0	-4795.84 0
TIME OF MAXIMUM FORCE		2.2750	2.2750	2.2945	2.2940
MAX ELEMENT STR. FORCES	2	-09006.1			
TIME OF MAXIMUM FORCE		2.2955			
MAX ELEMENT STR. FORCES	3	-10421220.0	-207097.6		
TIME OF MAXIMUM FORCE		2.2940	2.2940		
MAX ELEMENT STR. FORCES	4	10377330.0	-205008.7		
TIME OF MAXIMUM FORCE		2.0410	2.0410		

MAXIMUM DIFLOFFS

NODE	LEFT	RIGHT	TIME LEFT	TIME RIGHT
1	.0000E 00	.0000E 00	.0000	.0000

RUN TIME 0 HOURS- 32 MINUTES- 36 SECONDS

POOL WALL ADEQUACY

Q: Provide supporting evaluation of the adequacy of the pool walls to withstand the rack hydrodynamic pressure during a seismic event.

R: Shear and bending were evaluated for the interior wall (worst case) and both were found to be acceptable for 6.5 psig (maximum pressure). See the attached calculations for details (4 sheets of calculations).

EBASCO SERVICES INCORPORATED

BY C. SHIH DATE 3-10-89 SHEET 1 OF 1

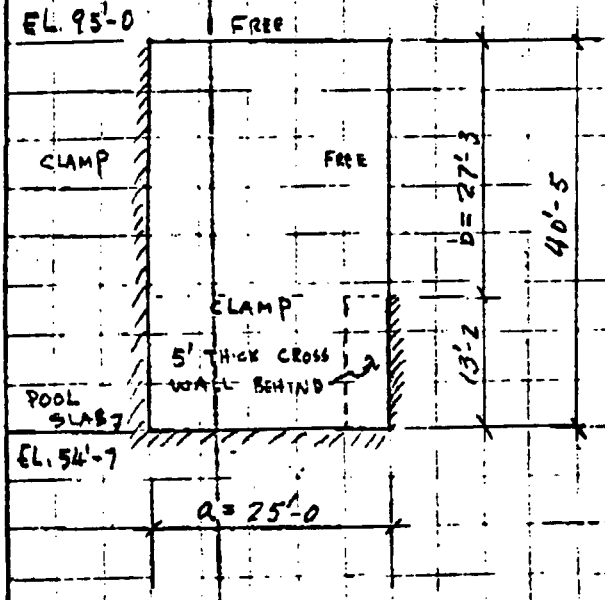
CHKD. BY DATE OFS NO. NYPA 6761.001 DEPT. NO. 550

CLIENT N Y POWER AUTHORITY

PROJECT INDIAN POINT UNIT NO. 3

SUBJECT SPENT FUEL POOL CAPACITY – FREQUENCY OF INTERIOR WALL

REFERENCE: FORMULA FOR NATURAL FREQUENCY AND MODE SHAPE BY ROBERT D. BLEVINS TABLE 11-4, CASE 9



FREQUENCY OF A RECTANGULAR PLATE WITH CLAMPED - FREE - FREE - CLAMPED BOUNDARY CONDITIONS IS OBTAINED FROM THE FORMULA:

$$f = \frac{\lambda^2}{2\pi a^2}\left[\frac{E h^3}{12\gamma(1-\nu^2)}\right]^{1/2}$$

$a = 25'$ $h = 5'$ (THICKNESS)

$b = 27.25'$

$a/b = 0.92$ $\lambda^2 = 6.942$ (FROM TABLE)

$\gamma = \mu h = \frac{150\ lb/ft^3}{32.2\ ft/sec^2} \times 5\ ft = 23.3$ (MASS PER UNIT AREA OF PLATE)

$\nu = .156$ (POISSON'S RATIO)

$E = 3.12 \times 10^3 \times 144 = 449.28 \times 10^6\ lb/ft^2$ (3000 PSI CONCRETE)

$$f = \frac{6.942}{2\pi(25)^2}\left[\frac{449.28\times10^6 \times 5^3}{12 \times 23.3\,(1-.156^2)}\right]^{1/2} = .00177\left[2.0587\times10^8\right]^{1/2}$$

$f = 25.4$ HERTZ, $T = \frac{1}{f} = .04$ SEC

FROM IP #3 SEISMIC GROUND RESPONSE SPECTRA, THE ZPA RANGE EXTENDS TO NATURAL PERIOD OF .06 SEC FOR 5% DAMPING (OR 16.6 HERTZ)

EBASCO SERVICES INCORPORATED

BY C. SHIH DATE 3-17-89 SHEET 1 OF 2

CHKD. BY P. K. Hsu DATE 3-17-89 OFS NO. 6761.001 DEPT. NO. 550

CLIENT NYPA

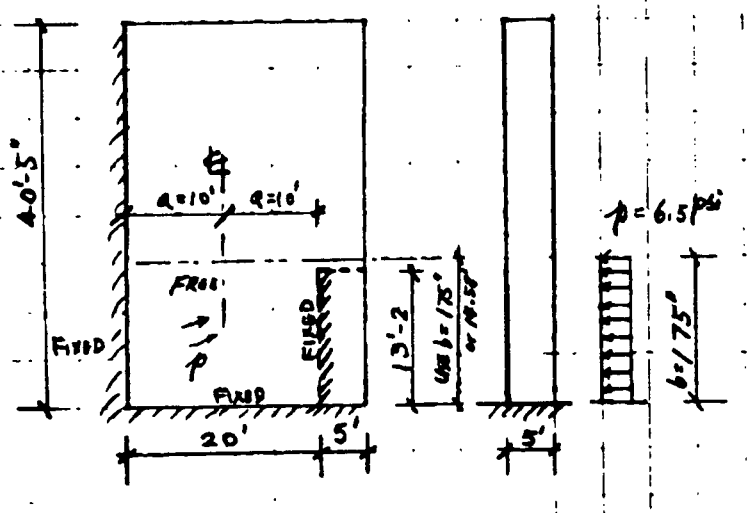
PROJECT IP #3

SUBJECT SPENT FUEL POOL CAPACITY EVALUATION — RACK HYDRODYNAMIC PRESSURE

EVALUATE POOL WALL DUE TO RACK HYDRODYNAMIC PRESSURE :

MAXIMUM PRESSURE = 6.5 psi (DUE TO SSE) BY U.S. TOOL & DIE

1) CHECK PRESSURE ON INTERIOR (FUEL TRANSFER CANAL) WALL :



FROM THE REFERENCED BOOK:

"MOMENTS AND REACTIONS FOR RECTANGULAR PLATES" BY U.S. DEPT OF THE INTERIOR BUREAU OF RECLAMATION ENGR. MONOGRAPH NO. 27, FIG. 1.

$a/b = 10/14.58 = 0.68$

USE $a/b = 0.75$

Maximum $M = .1212\, p b^2$

$M = .1212 \times 0.0065 \times 175^2$

$M = 24^{in\text{-}k}/in$

DUE TO OBE: $M = \frac{2}{3}(24)^{in\text{-}k/in} = 16^{in\text{-}k}/in$

FOR OBE COMBINATION (MOST CRITICAL) $0.75\,(1.4D + 1.7L + 1.9\,OBE + 1.7\,T_o)$:

ELEMENT 623 $M_{TOTAL} = \underset{(\text{ORIGINAL CAL})}{911} + 0.75 \times 1.9 \times \frac{2}{3}(24) = 911 + 23 = 934^{in\text{-}kip}/in$

$M_{CAPACITY} = 1017^{in\text{-}kip}/in$

$M.S. = (1017 - 934)/930 = .09$ O.K.

NOTE: GAP BETWEEN THIS WALL AND RACK IS 10.37", INSTEAD OF 4.10" WHICH DERIVED THE MAX. HYDRODYNAMIC PRESSURE OF 6.5 psi. THERE IS CONSERVATISM FOR PRESSURE LOAD USED HERE.

Great

BY C. SHIH DATE 3-17-89 SHEET 2 OF 2 (3)

CHKD. BY [illegible] DATE 3-17-89 OFS NO. 6761.001 DEPT. NO. 550

CLIENT NYPA

PROJECT IP #3

SUBJECT SPENT FUEL POOL CAPACITY EVALUATION - RACK HYDRODYNAMIC PRESSURE

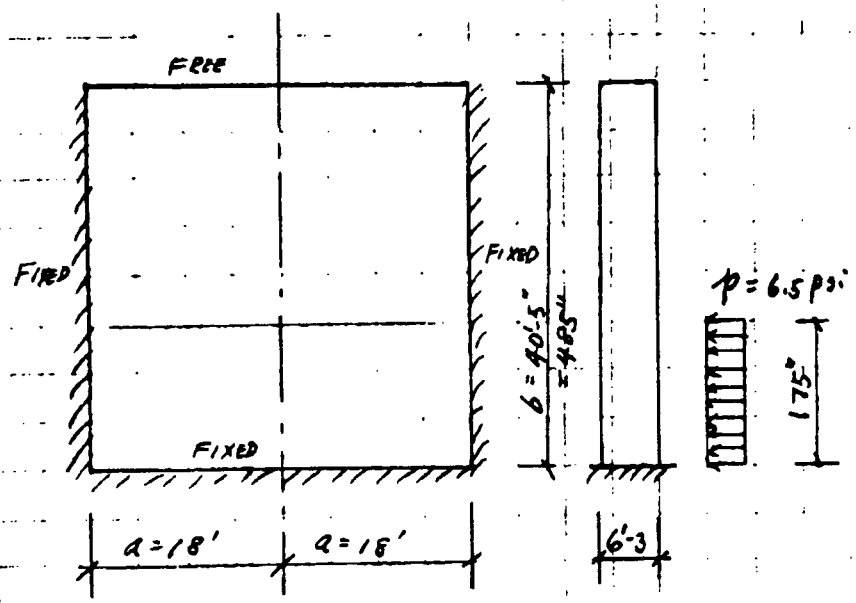
2) CHECK PRESSURE ON EXTERIOR WALL :

SELECT THE MOST CRITICAL WALL AMONG 4 EXTERIOR WALLS :

FOR EAST WALL : $a/b = 18/40.42 = 0.445$

USE $a/b = 0.5$

$175/485 = 0.36$ USE $1/3\ b$



FROM FIG 3 OF THE SAME REF

$M_{max} = .0247\ p b^2$

$= .0247 \times .0065 \times 485^2$

$= \underline{37.76\ ''k/in}$

$M_{OBE} = \frac{2}{3}(37.76) = \underline{25.17\ ''k/in}$

MAX EXTERIOR WALL MOMENT (ORIGINAL CAL) DUE TO OBE COMBINATION:

$M = 368\ ''k/in$

$0.75\,(1.4D + 1.7L + 1.9\ OBE + 1.7T_o)$:

$M_{TOTAL} = 368 + 0.75 \times 1.9 \times 25.17 = 368 + 36 = 404\ ''k/in$

$M_{CAPACITY} = 513\ ''k/in$

$M.S. = (513 - 404)/404 = 0.27$ O.K.

NOTE : GAP BETWEEN THIS WALL AND RACK IS 5.0 IN.

EBASCO SERVICES INCORPORATED

BY C. SHIH DATE 4-7-89 SHEET 1 OF 1

CHKD. BY P K Hunt DATE 4-7-89 OPS NO. 6761.001 DEPT. NO. 550

CLIENT NYPA

PROJECT INDIAN PT #3

SUBJECT SPENT FUEL POOL CAPACITY EVALUATION – RACK HYDRODYNAMIC PRESSURE

CHECK SHEAR DUE TO HYDRODYNAMIC PRESSURE ON FUEL TRANSFER CANAL WALL:

REACTION AT WALL BASE DUE TO 6.5 psi PRESSURE IS:

(a) interior wall: $R_y = 0.6725\, pb$ FROM FIG 1, SAME REFENCE BOOK

$= .6725 \times 6.5^{psi} \times 158''$

$= 690\ lb/in = .69\ k/in$ (SSE LEVEL)

FOR OBE LEVEL: $R_y = 2/3\,(.69) = .46\ k/in$

FOR MAX SHEAR OF THE WALL, USE SHEAR AT 'd' DISTANCE FROM THE MAT

i.e. ELEMENT 603 : $V_y = 3.063\ k/in$

FOR OBE COMBINATION: $0.75(1.4D + 1.7L + 1.9OBE + 1.7T_o)$

TOTAL SHEAR $= 3.063 + 0.75 \times 1.9 \times 0.46$

$= 3.063 + .656$

$= 3.72^k$

SHEAR CAPACITY $\phi V_n = 0.85 \times 2\sqrt{3000} \times 56.5 = 5.28\ k/in$

$\therefore$ TOTAL SHEAR $= 3.72 < 5.28\ k/in$ O.K.

(b) Exterior wall:

From Fig 3 of the ref $R_{y(max)} = 0.2905\, pb$

$= 0.2905 \times 6.5 \times 48'' = 915.8\ lb/in$

FOR OBE level $R_y = 2/3 \times 915.8 = 610.5\ lb/in = 0.61\ k/in$

element #214 for the case $V_y = 1.15\ k/in$

OBE load combination $= 0.75(1.4D + 1.7L + 1.9OBE + 1.7T_o)$

Total Shear $= 1.15 + 0.75 \times 1.9 \times 0.61$

$= 1.15 + 0.87 = 2.019\ k/in$

Shear allowable $\phi V_N = 0.85 \times 2 \times \sqrt{3000} \times 72.5 = 6.78\ k/in$

$\therefore$ Total shear $2.019\ k/in < 6.78\ k/in$ O.K

ATTACHMENT II TO IPN-89-058

OPEN ITEMS FROM THE JULY 19, 1989 MEETING
AND THE AUGUST 1, 1989 TELEPHONE CONVERSATION

NEW YORK POWER AUTHORITY
INDIAN POINT 3 NUCLEAR POWER PLANT
DOCKET NO. 50-286
DPR - 64

The specific UST&D action items are:

1) Provide a 80-cell results table, 0.2 friction, similar to 4.1.

2) Provide computer motion-time histories graphs for the full 15 seconds of seismic imput. Also provide the graphs for empty-full - if possible provide on the same page (3 graphs). Show <u>impact springs</u> on the computer model sketch.

3) For Table 4-2 and the motion history graph - locate 0.38 rack travel or identify top/bottom and rack number. Identify table data points on graphs.

4) Plot (graph) the 132-cell motion-history for 0.2 friction. If possible, put (3) racks on (1) graph.

5) For Table 2D - correct column F & G.

6) For Question 2D, explain the "inconsistency" in Table 1 OBE vs SSE (C vs F). Is the horizontal spring contributing? We may need to rerun the code or do a sensitivity study to provide an explanation.

7) For Question 2D, Table 5 - AE table needs to have the horizontal pedestal forces included.

8) Provide an additional 2D 132-cell multi-rack analysis similar to previous runs:

   (a) 1.0 inch hydraulic coupling, 1/32 physical gap
   (b) 2% internal damping
   (c) Standard fuel (1/2 full, full, empty)
   (d) Coefficient of friction: .2 and .8
   (e) EW direction
   (f) SSE imput
   (g) Output motion plots (15 seconds)
   (h) Output tables - maximum displacement

9) Based on 2D results (Item 8) provide a rack cell strength impact analysis using a buckling collapse strength (1.37 KSI). The impact area is to be defined as 1/2 rack wide by:

   a) for a top impact: 16-1/2 inch down
   b) for a mid impact: 33 inches down

   Also describe the increase in fusion weld stress and distribution.

10) Spring constant (k11), 132-cell rack, EW, NS

TABLE 4.1

MULTI-RACK ANALYSIS SUMMARY
(KIPS AND INCHES)

4% DAMPING
1/4" GAP

80 CELL
u = .8

COMPONENT	1/2 FULL RACK 1	FULL RACK 2	EMPTY RACK 3
AXIAL FORCE ON FOOT, KIPS	54.0	72.2	22.7
SHEAR FORCE ON FOOT, KIPS	19.5	13.8	11.2
RACK TO RACK IMPACT, LBS/LEVEL			
TOP	0	5,120	5,120
MIDDLE	0	3,102	3,102
BOTTOM	0	0	0
RACK TO WALL IMPACT, LBS	0	-	0
DISPLACEMENT, INCH			
TOP	0.16	0.13	0.26
BOTTOM	0.13	0.11	0.18

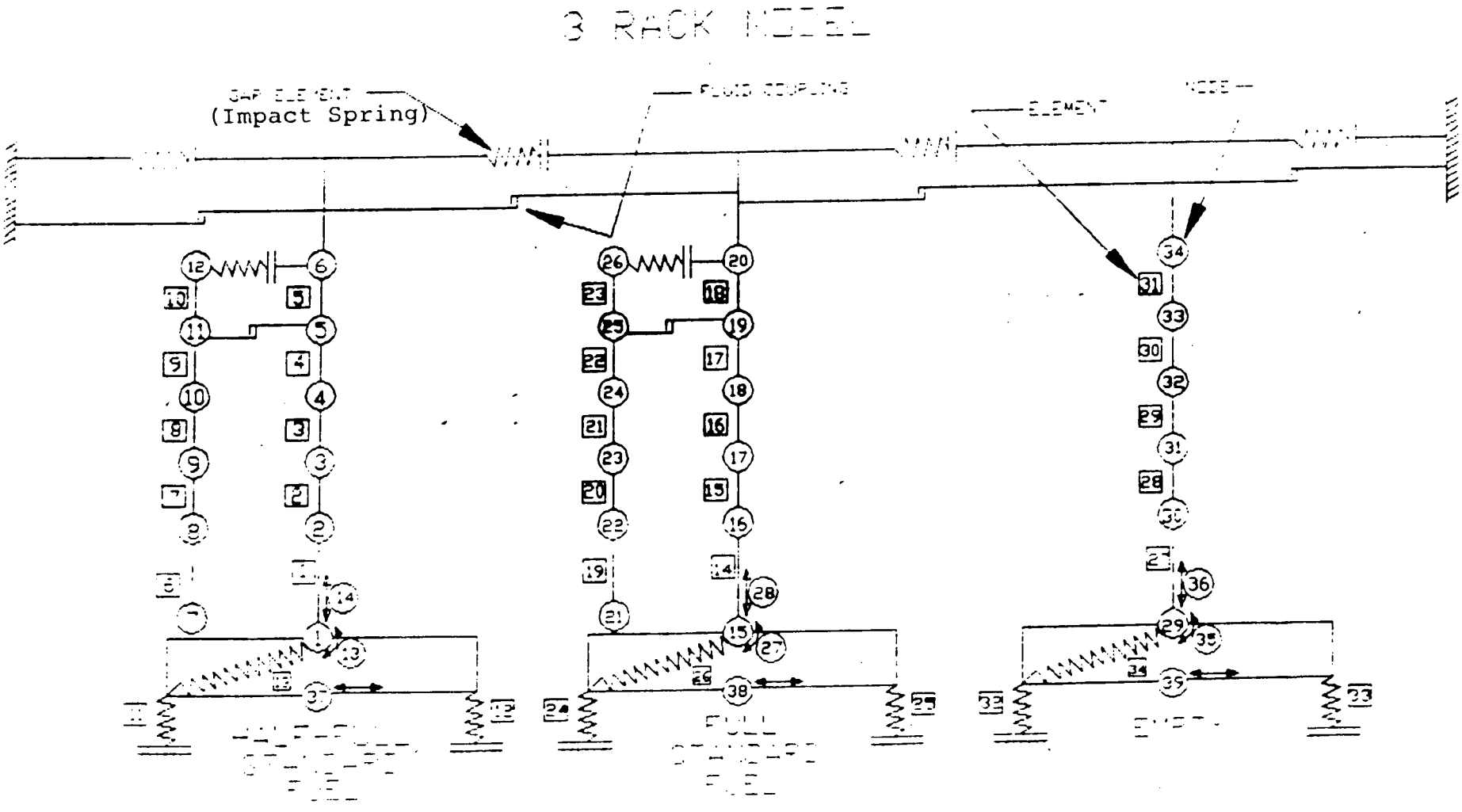
TABLE 4.1a

4% DAMPING
1/4" GAP

80 CELL
u = 0.2

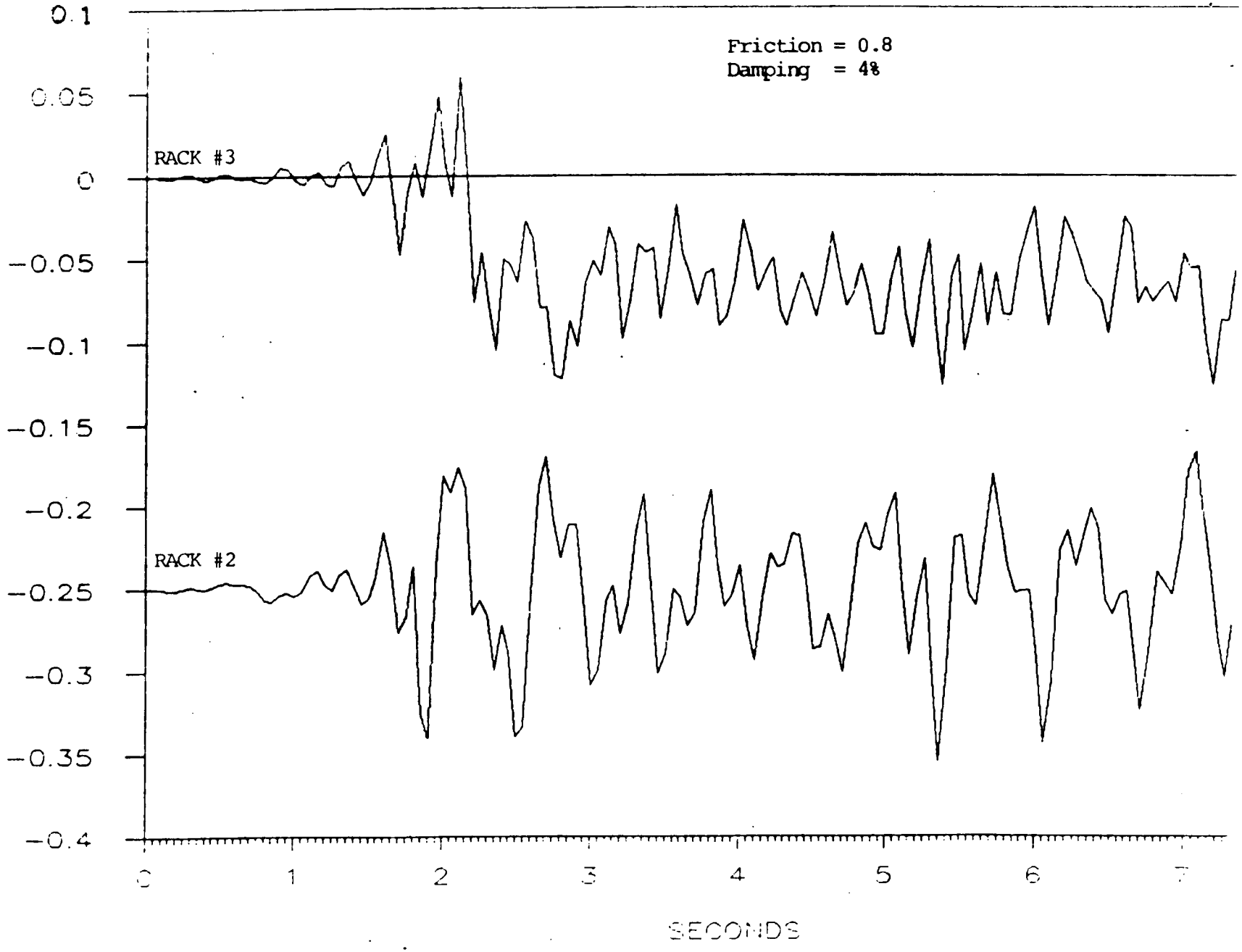
COMPONENT	1/2 FULL RACK 1	FULL RACK 2	EMPTY RACK 3
AXIAL FORCE ON FOOT, KIPS	42.8	62.5	16.8
SHEAR FORCE ON FOOT, KIPS	8.3	11.9	3.0
RACK TO RACK IMPACT, LBS/LEVEL			
TOP	1,914		
MIDDLE	3,461		
BOTTOM	3,781		
RACK TO WALL IMPACT, LBS	---		---
DISPLACEMENT, INCH			
TOP	.20	.16	.19
BOTTOM	.19	.14	.19

ITEM 2 (partial)



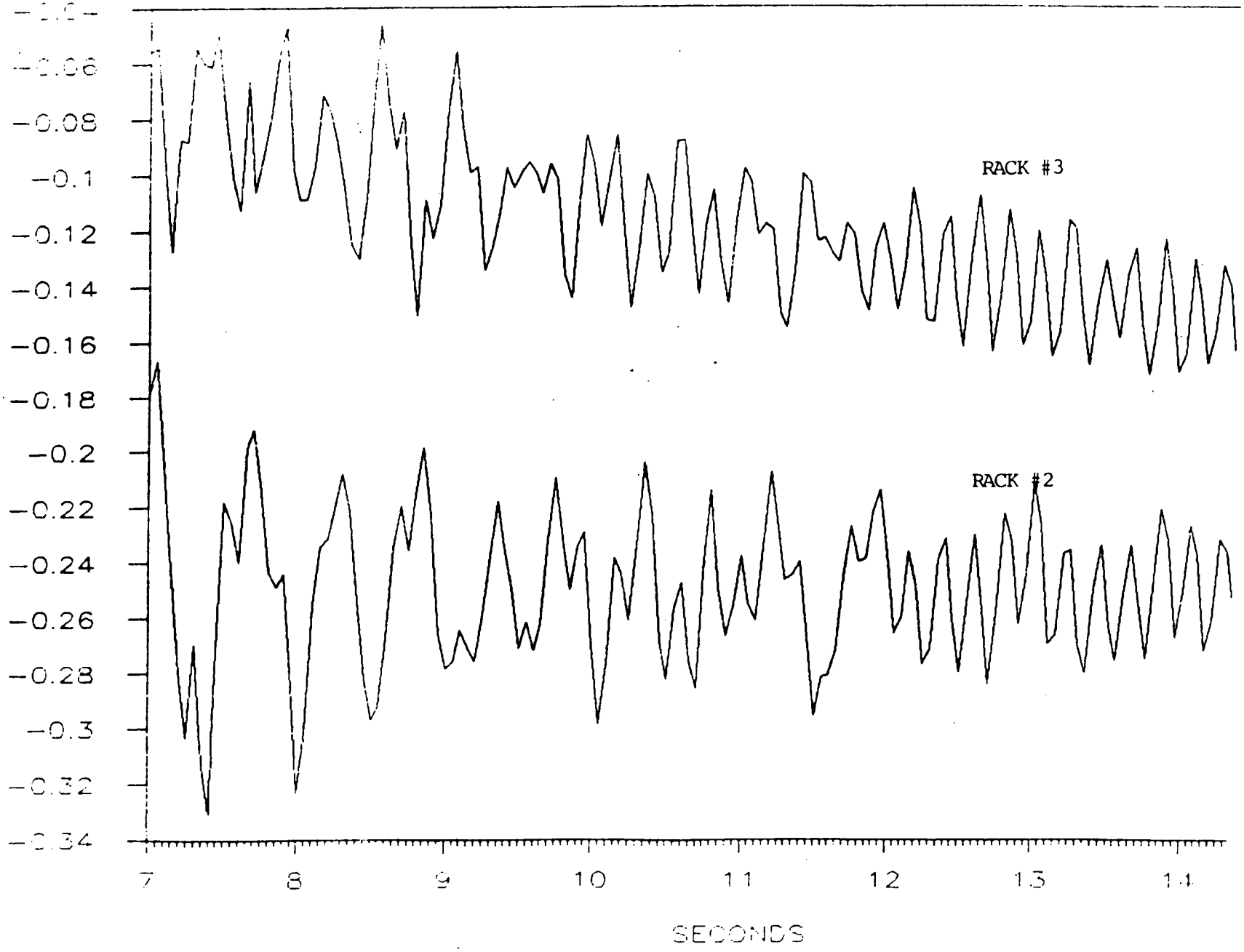
ITEM 2

REGION (1)
80-CEL CKS
Displacements of bot of Racks 2 and 3

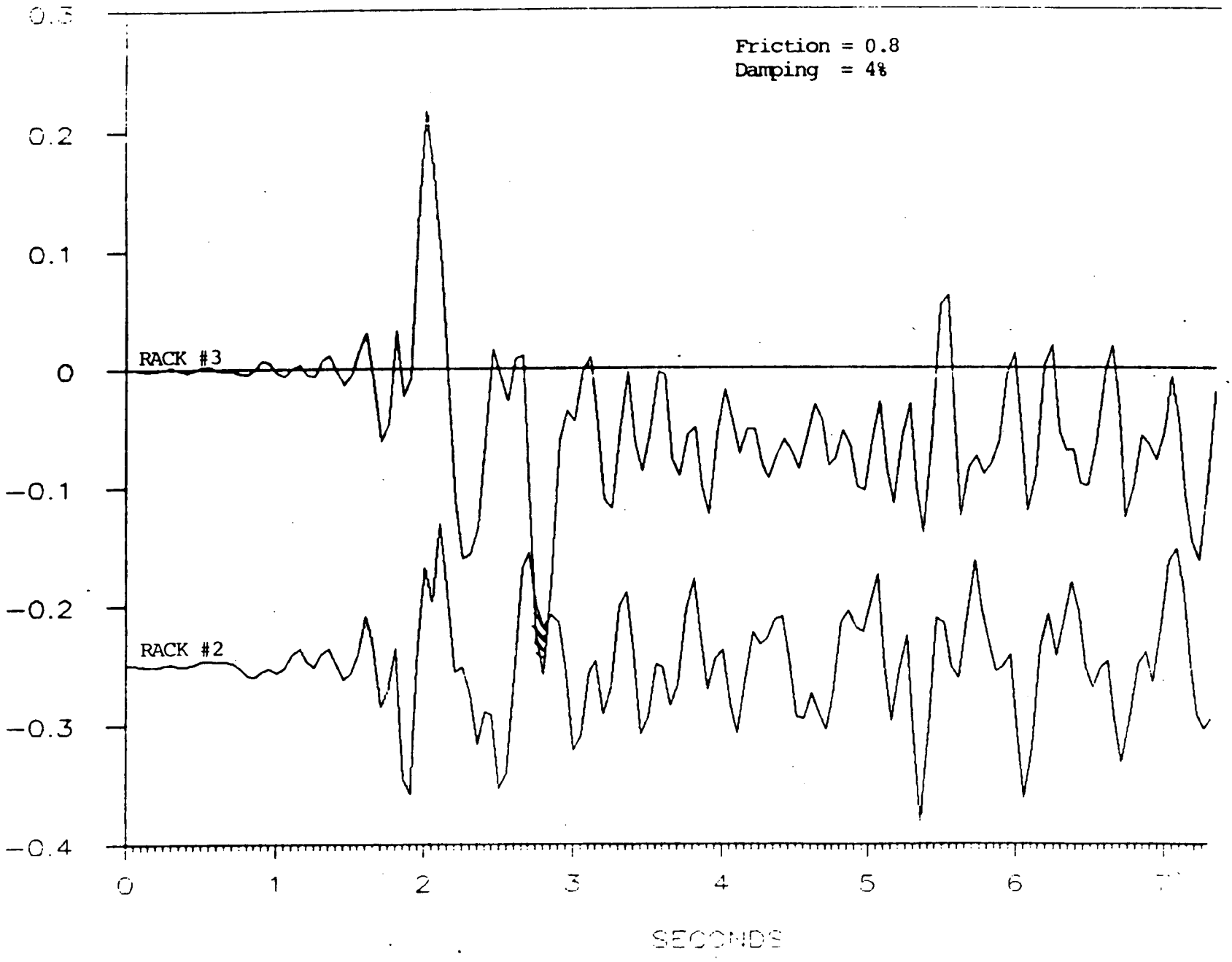


ITEM 2

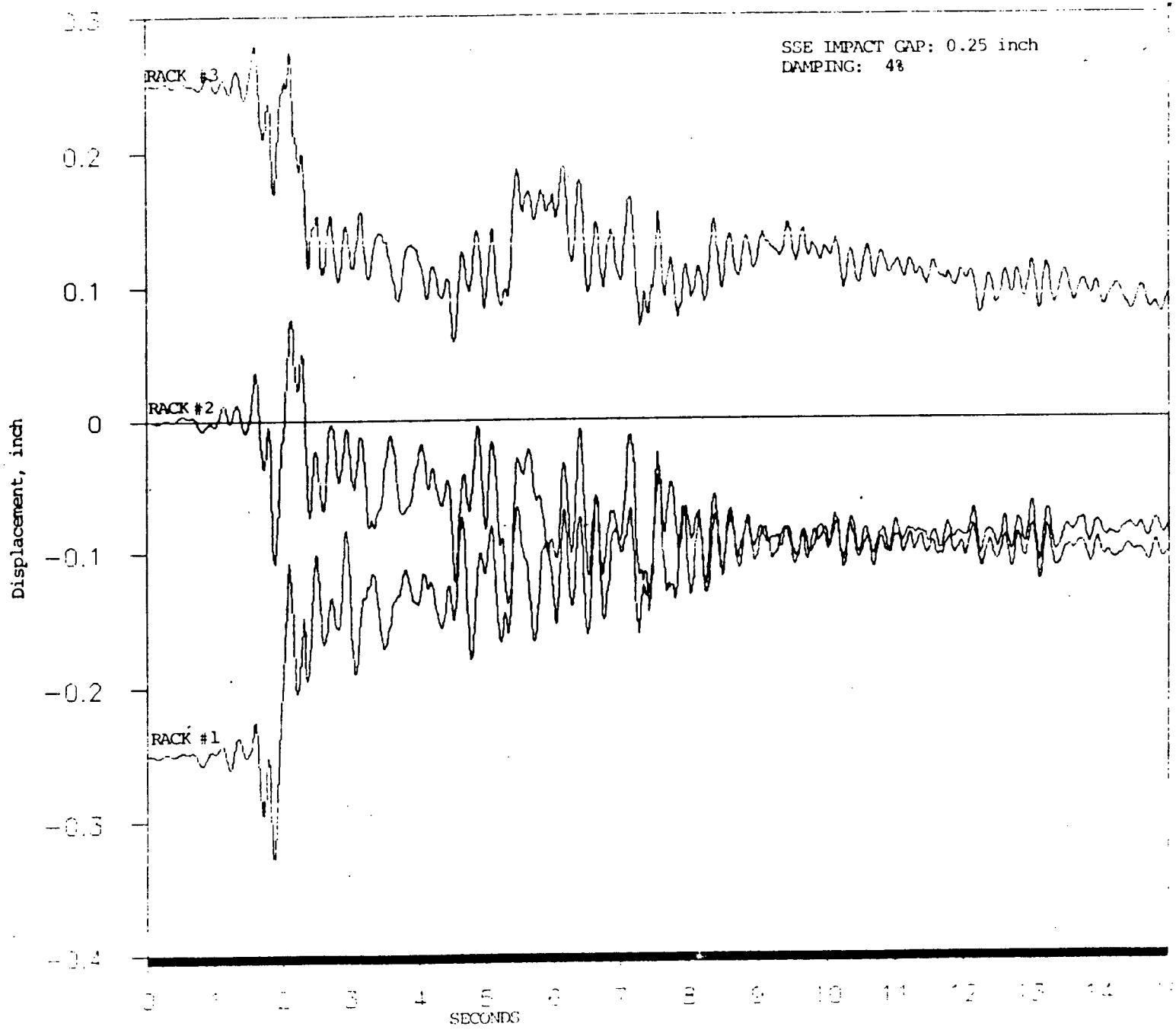
REGION (1)
80-CELL RACKS
Displacements of bo[illegible] of Racks 2 and 3



REGION (1)
80-CR RACKS
Displacements of of Racks 2 and 3

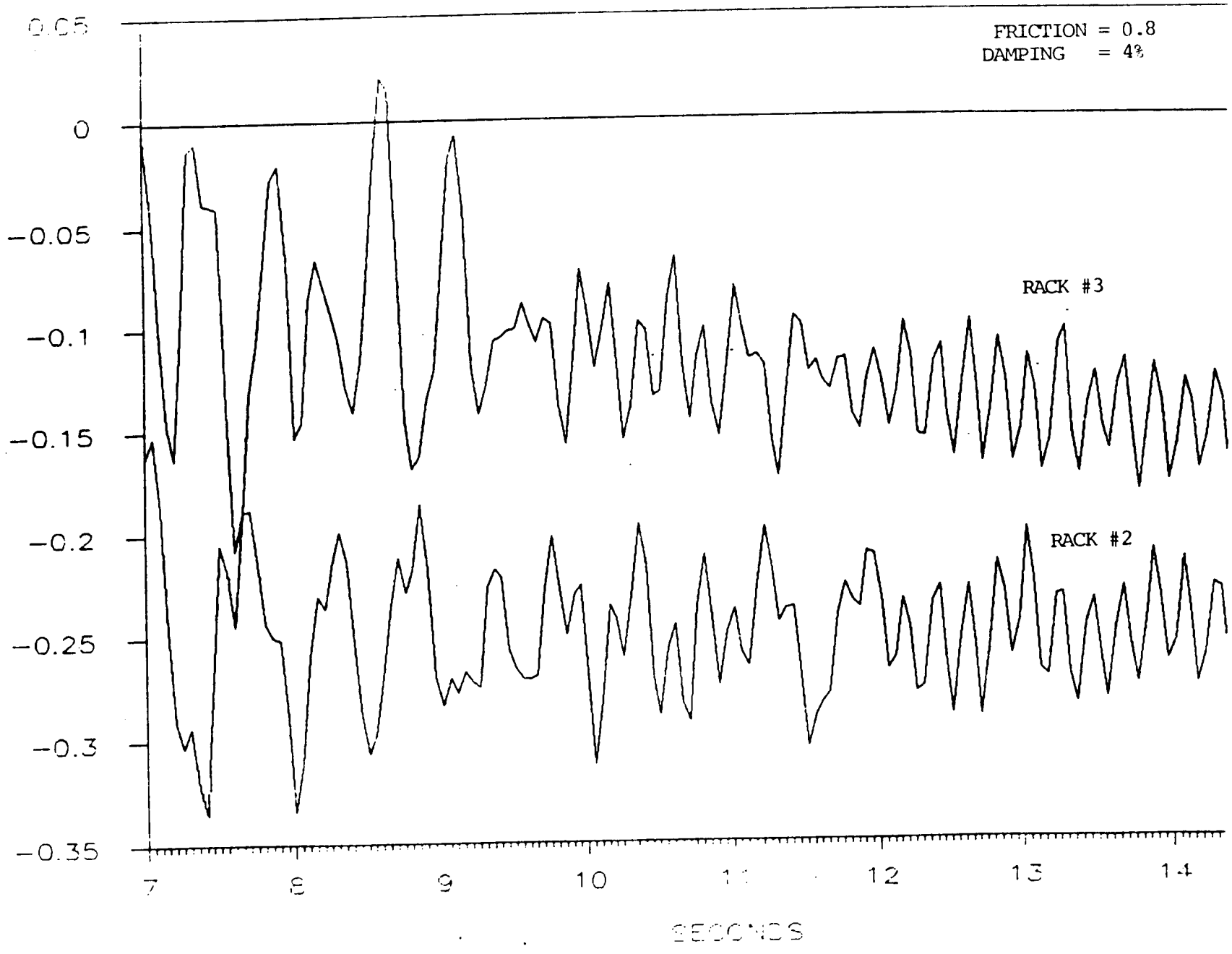


ITEM (4)


SSE IMPACT GAP: 0.25 inch
DAMPING: 4%
RACK #3
RACK #2
RACK #1
0.2
0.1
0
-0.1
-0.2
-0.3
Displacement, inch
SECONDS

ITEM 2

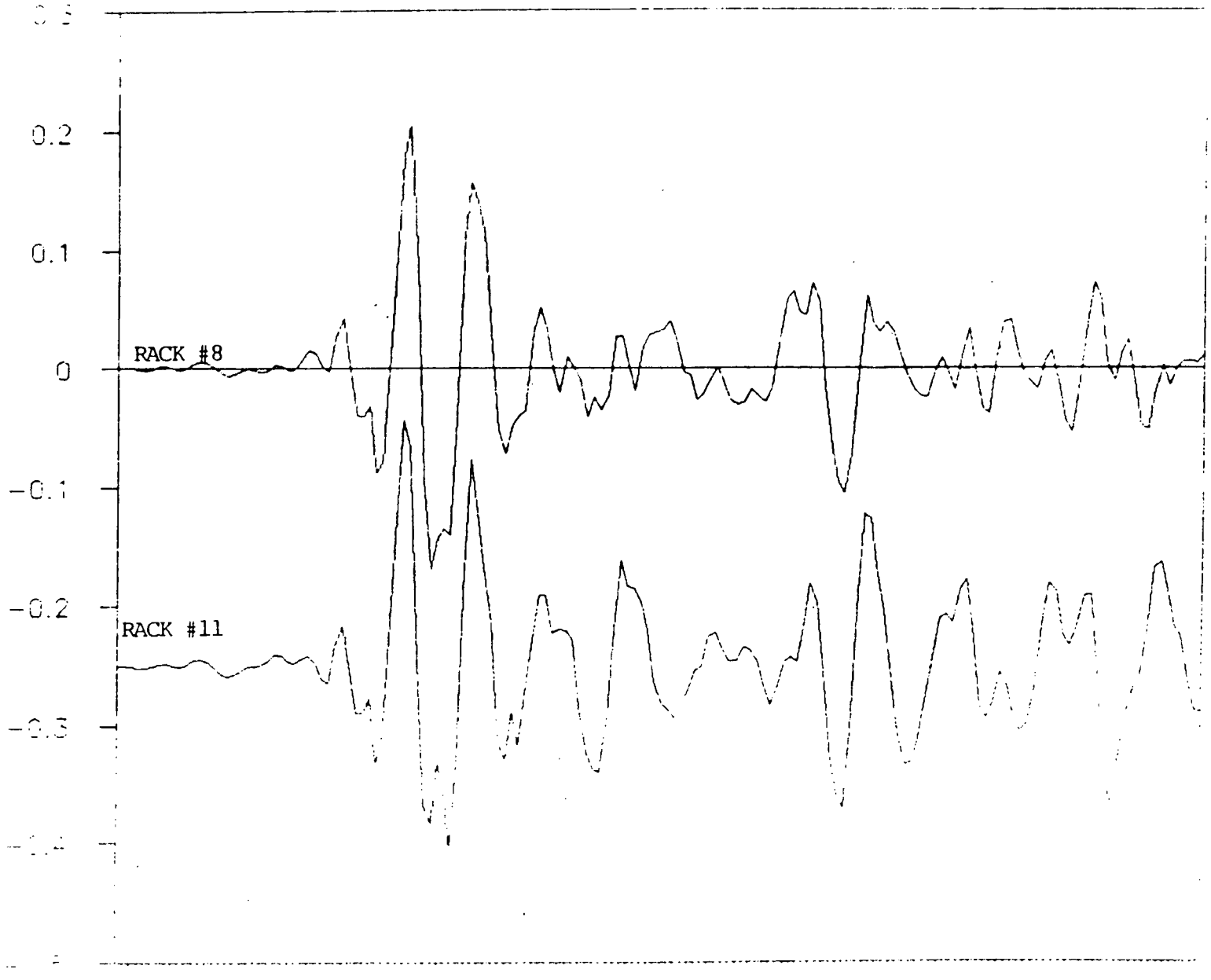
REGION (1)
80-CELL RACKS
Displacements of tops of Racks 2 and 3



ITE

REGI (2)
132 C ACKS
Displacement of bottoms o racks 11 and 8

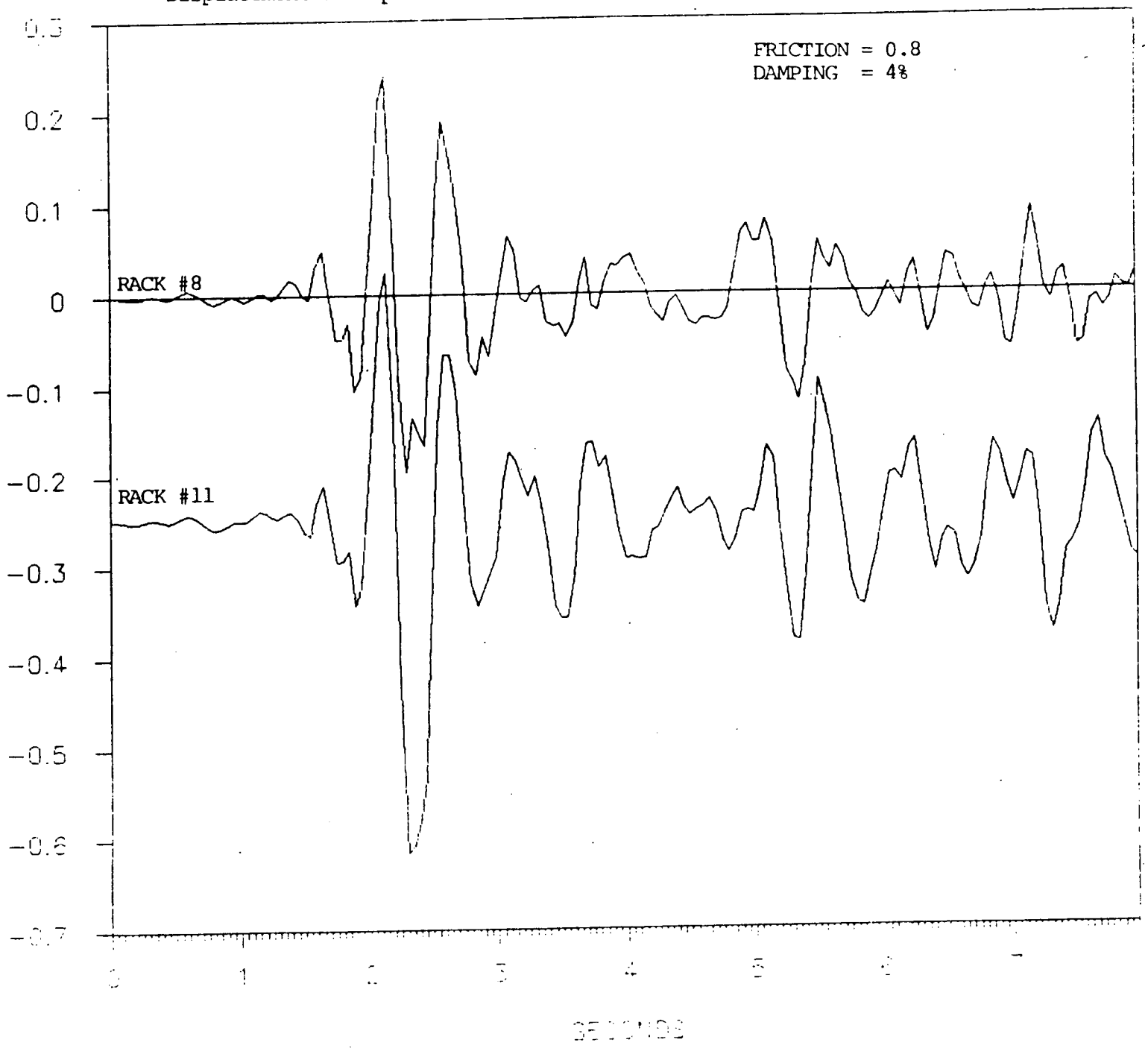
FRICTION = 0.8
DAMPING = 4



ITEM 2

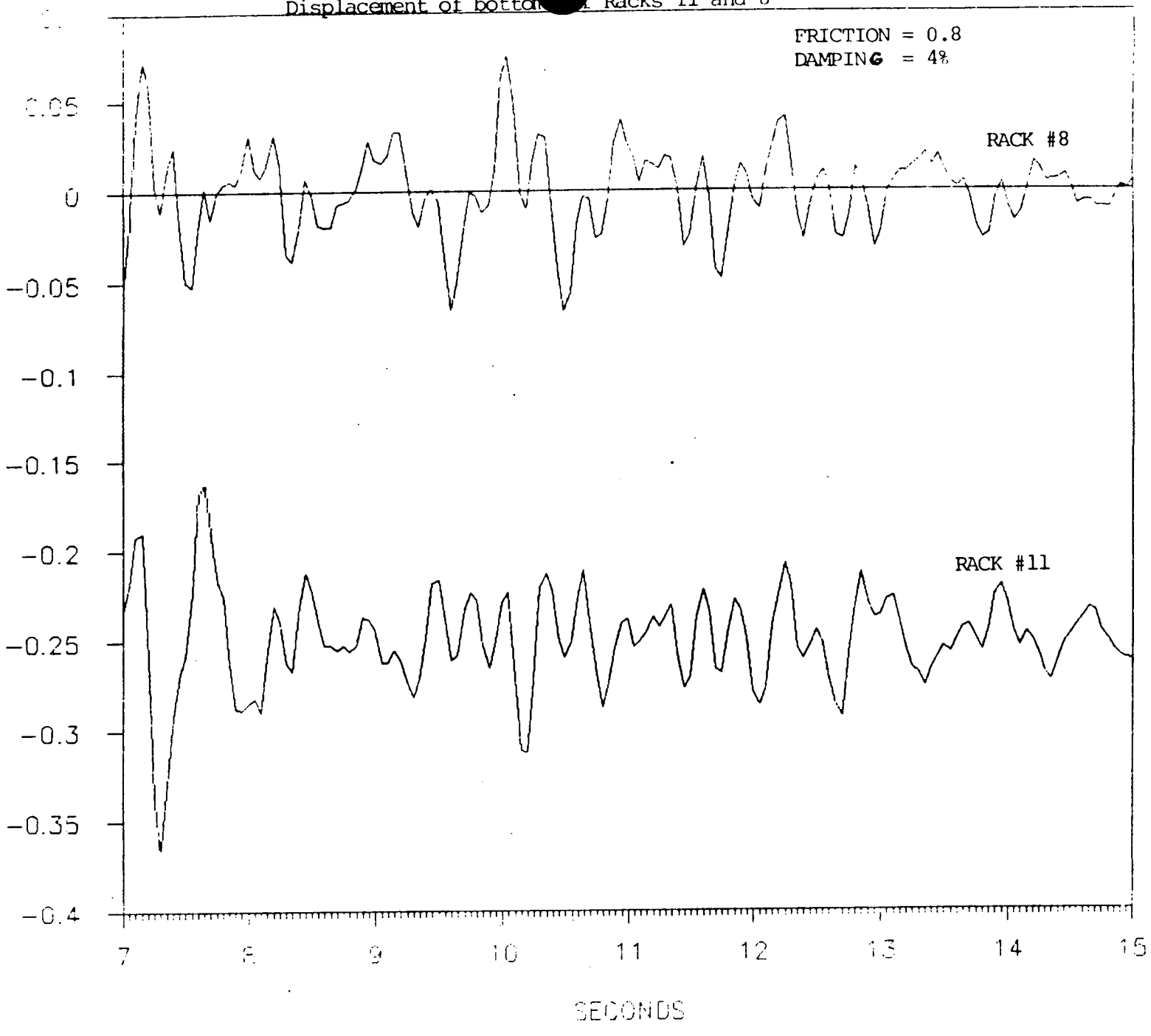
REGION (2)
132-CELL RACK

Displacement of tops of Racks 11 and 8



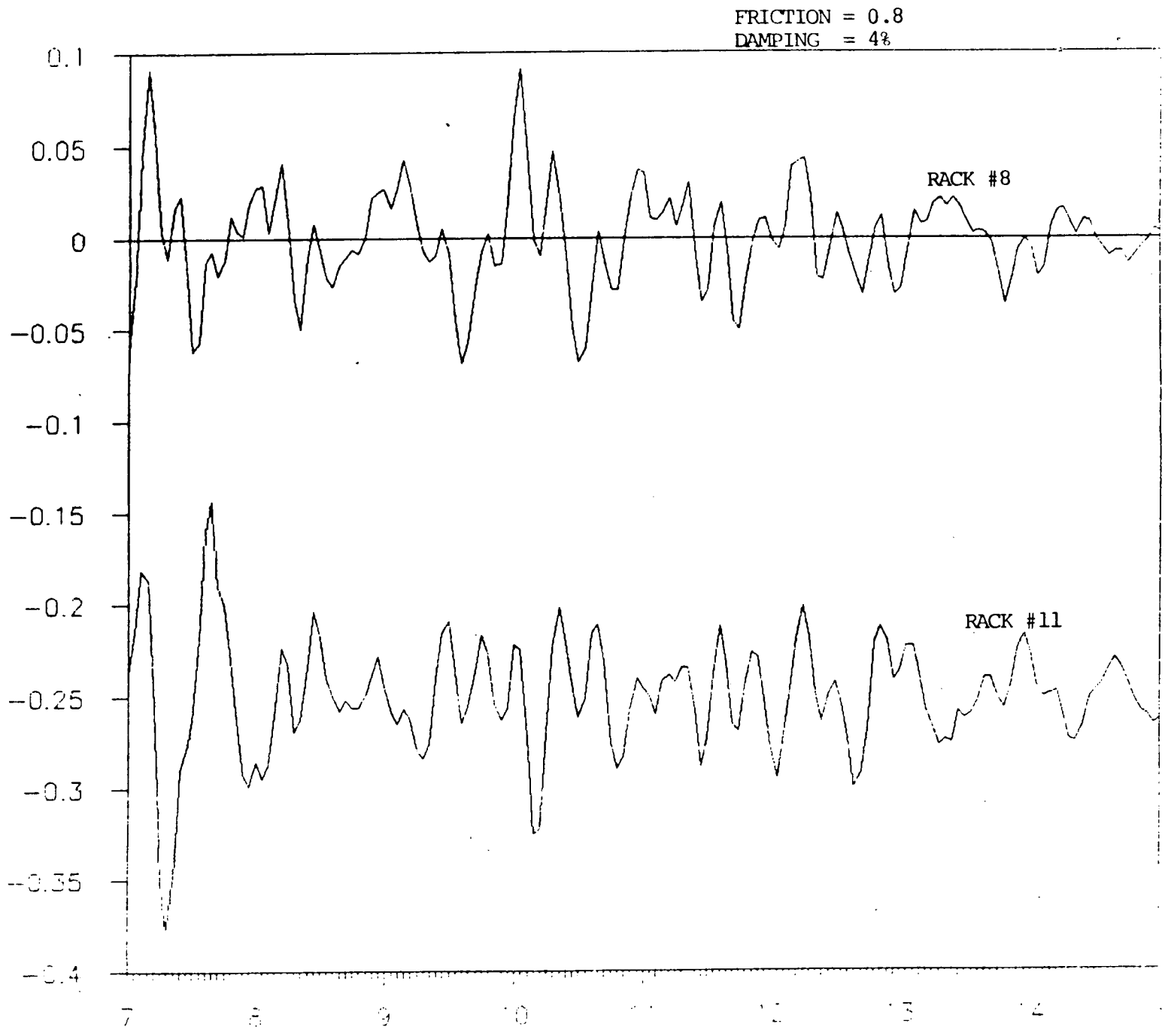
ITEM 2

REGION (2)
132 CELL RACKS
Displacement of bottom of Racks 11 and 8



ITEM 2

REGION (2)
132 L RACK
Displacement of t of Racks 11 and 8



ITEM 3

TABLE 4.2

MULTI-RACK ANALYSIS SUMMARY
(KIPS AND INCHES)

4% DAMPING
1/4" GAP

132-CELL
u = .8

COMPONENT	1/2 FULL RACK 11	FULL RACK 8	EMPTY RACK 5
AXIAL FORCE ON FOOT, KIPS	85.0	100.5	44.1
SHEAR FORCE ON FOOT, KIPS	34.2	31.5	35.3
RACK TO RACK IMPACT, LBS	0	0	0
RACK TO WALL IMPACT, LBS	0	0	0
DISPLACEMENT, INCH, TOP	-.38	.25	.40
BOTTOM	.22	.21	.21

TABLE 4.3

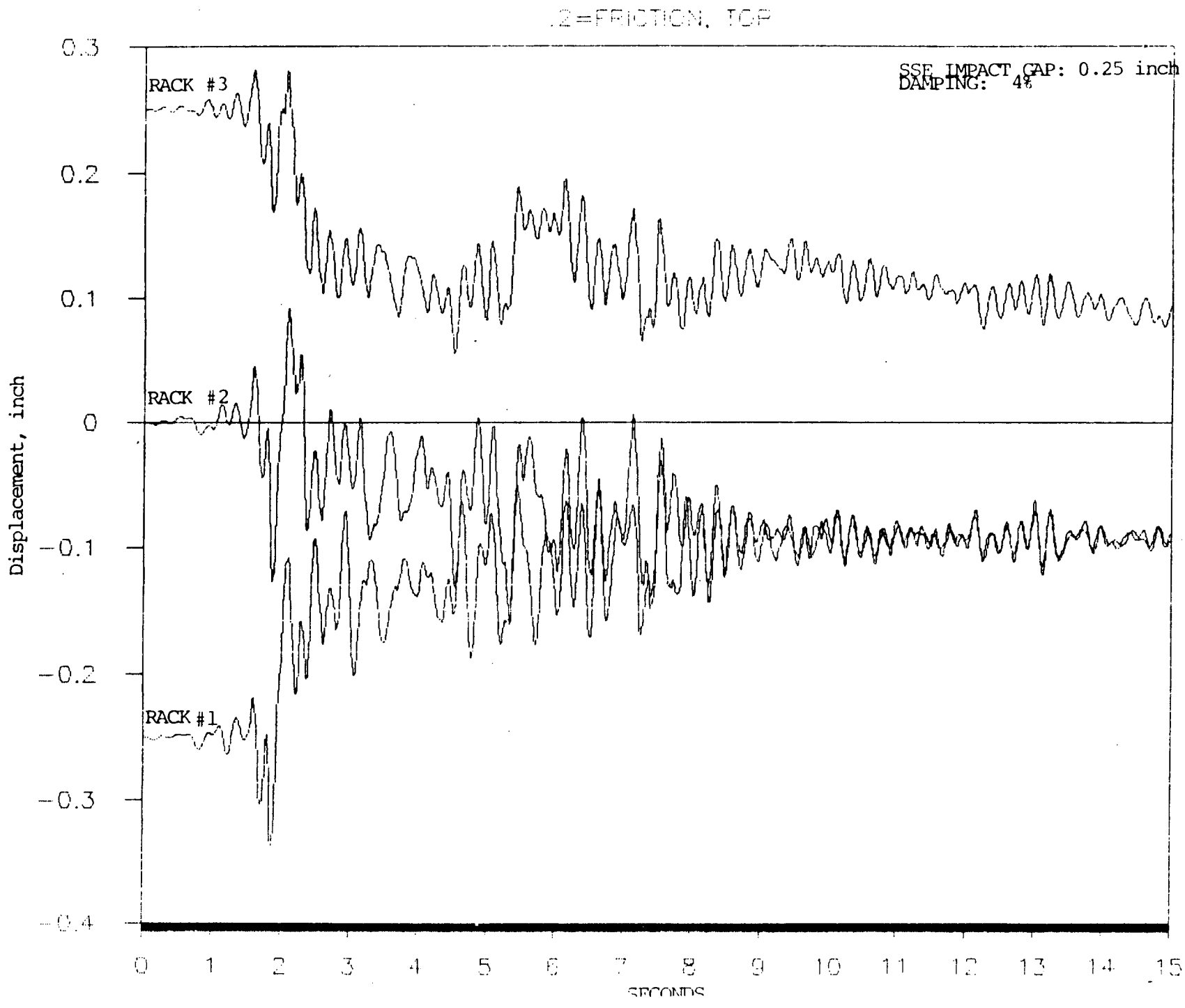
MULTI-RACK ANALYSIS SUMMARY
(KIPS AND INCHES)

4% DAMPING
1/4" GAP

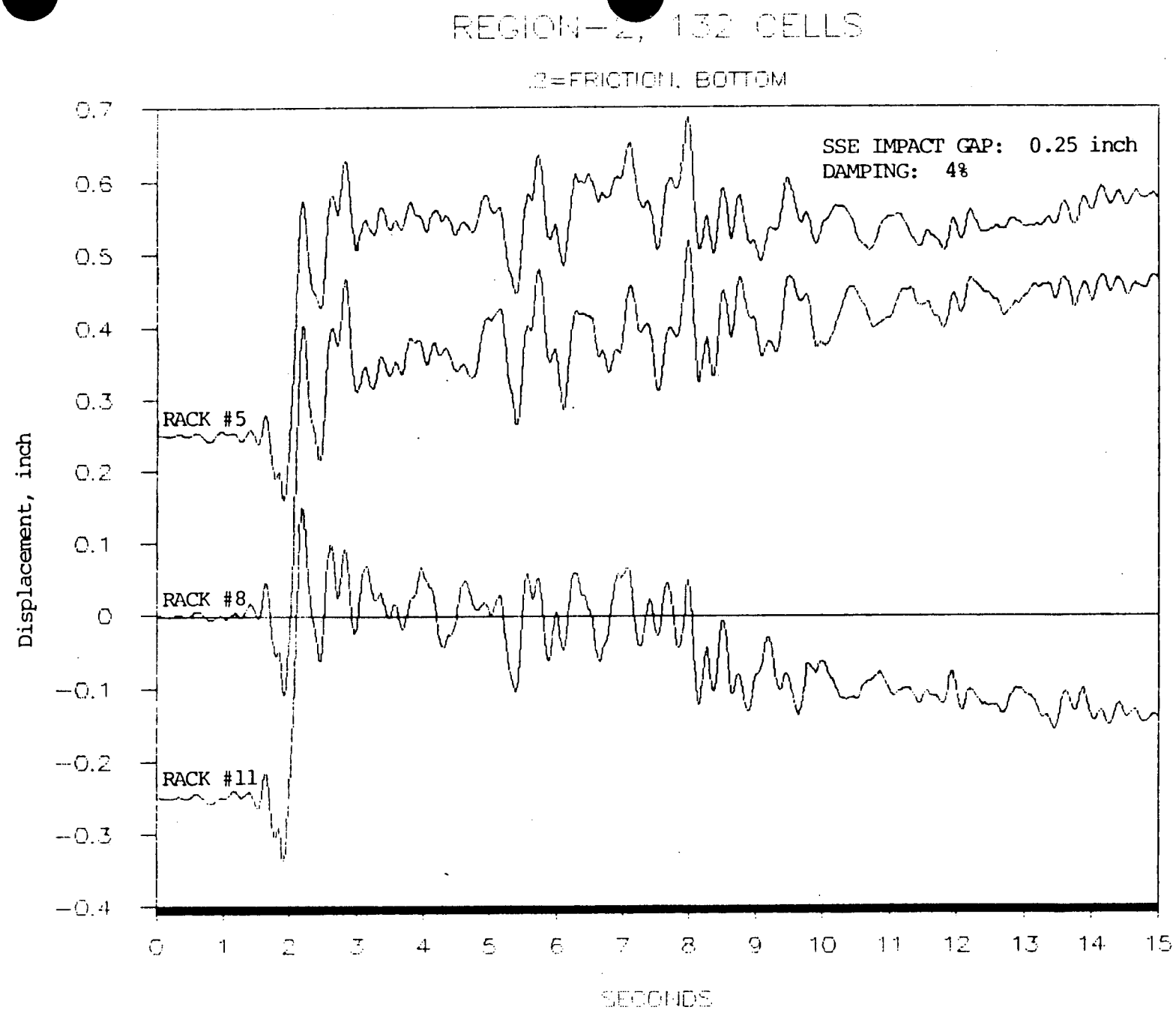
132-CELL
u = .2

COMPONENT	1/2 FULL RACK 11	FULL RACK 8	EMPTY RACK 5
AXIAL FORCE ON FOOT, KIPS	52.5	87.5	13.5
SHEAR FORCE ON FOOT, KIPS	10.1	17.2	2.4
RACK TO RACK IMPACT, LBS	0	-	0
RACK TO WALL IMPACT, LBS	0	-	0
DISPLACEMENT, INCH, TOP	0.40	0.53	0.44
BOTTOM	0.40	0.52	0.44

ITEM (4)


PE N-1, 80-CELL
.2=FRICTION, TOP
SSE IMPACT GAP: 0.25 inch
DAMPING: 4%
RACK #3
RACK #2
RACK #1
Displacement, inch
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
SECONDS

ITEM 4


REGION-2, 132 CELLS
.2=FRICTION, BOTTOM
SSE IMPACT GAP: 0.25 inch
DAMPING: 4%
RACK #5
RACK #8
RACK #11
Displacement, inch
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
SECONDS

ITEM 4

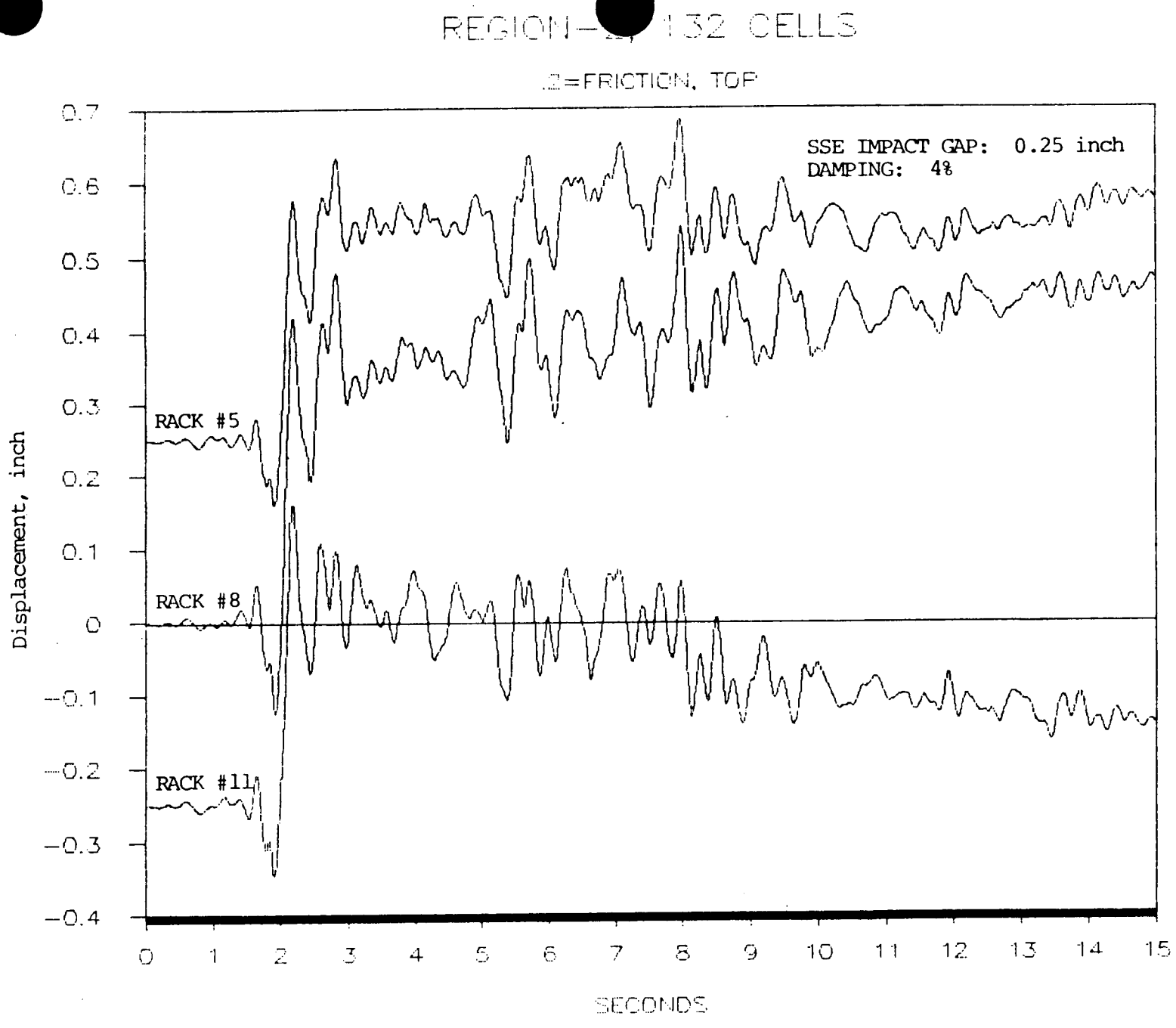

REGION-2, 132 CELLS
.2=FRICTION, TOP
SSE IMPACT GAP: 0.25 inch
DAMPING: 4%
RACK #5
RACK #8
RACK #11
Displacement, inch
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
SECONDS

TABLE 1 (cont)

	A	B	C	D	E	F	G
RUN NO.	IP3EWCI	IP3NSCI	IP3ONSCIF	IP30EWCIF	IP3EWCIF	IP3NSCIF	IP3NS
RACK TO WALL IMPACT	---	---	---	---	---	---	---
RACK TO WALL,INCH FLUID COUP,INCH	5.09/ 5.09	10.06/ **	10.06/ **	5.09/ 5.09	10.06/ **	10.06/ **	
RACK TO FUEL IMPACT GAP,INCH	0.15	0.15	0.15	0.15	0.15	0.15	.21
RACK TO FUEL FLUID COUP,INCH	0.15	0.15	0.15	0.15	0.15	0.15	*

* - Hydrodynamic mass based on Dong; conservative since proximity to wall not considered.

**- The gap is very large; an infinite coupling gap was used at South wall near cask area.

Item 6

The apparent discrepancy is that the displacement for the problem in Table 1 (2D) Column C, an OBE run, (0.0114 inch) was greater than for Column F, an SSE run (.00306 inch).

The computer study was done to determine the rack motion when loaded with consolidated fuel, since this was the design basis. The original runs were made on a Data General Computer which is no longer operational. The new runs were made on a COMPAQ computer. The following results were obtained:

SEISMIC INPUT	MAXIMUM DISPL.	MAXIMUM FRICTION
OBE = 2/3 (SSE)	-.000234	38,900
SSE	-.000170	58,350

Note that the maximum friction force for the OBE run is exactly 2/3 the maximum for the SSE. Further study showed this to be true for each time step, and it is concluded that for this case no sliding occurs and that the recorded displacement is accumulated round-off error. The other result, i.e. the forces, are essentially the same as for the original runs. These are for SSE (maximum values):

		(2) Left Ped	(2) Right Ped	Friction
Data General	(10/31/88)	264,440	262,261	58,190
Compaq	(8/01/89)	264,443	262,296	58,350

To further investigate the problem, runs were made with the input time history multiplied by 4 (AMP=4) and by 6 (AMP=6). The displacements for these are plotted, together with the base run (AMP=1), which to the scale plotted shows no displacement.

The question of the rack motion (maximum) being greater for the .8 coefficient case than the .2 coefficient case may be explained by the horizontal flexibility of the rack. Due to the modeling methods used in earlier models for the 0.8 coefficient of friction case (having a horizontal ground spring) and the 0.2 coefficient of friction case (without the ground spring), only the 0.2 coefficient case was used to determine rack sliding motion. The 0.8 coefficient case was essentially "tied down" by the horizontal ground spring, and output horizontal motion

included internal rack horizontal flexibility (sidesway). Therefore, with very small motions, rack flexibility motion for the 0.8 coefficient case will be large as is shown by the output data in question.

In conclusion, (2) computer problems have been identified in the data under question, but neither problem is serious. The very low numerical motion described by the data is below the level of computer accuracy, and is essentially zero. At higher time history input values, the SSE output is higher than OBE (2/3 SSE) values. For the 0.8 vs. 0.2 friction cases, modeling methods resulted in rack to ground motion lower than rack internal motion. This model method was and is acceptable for describing sliding with 0.2 and vertical motion with the 0.8 cases. In more recent computer applications, UST&D has removed the external horizontal ground spring to obtain true rack to ground horizontal displacement under the 0.8 coefficient case.

ITEM 6

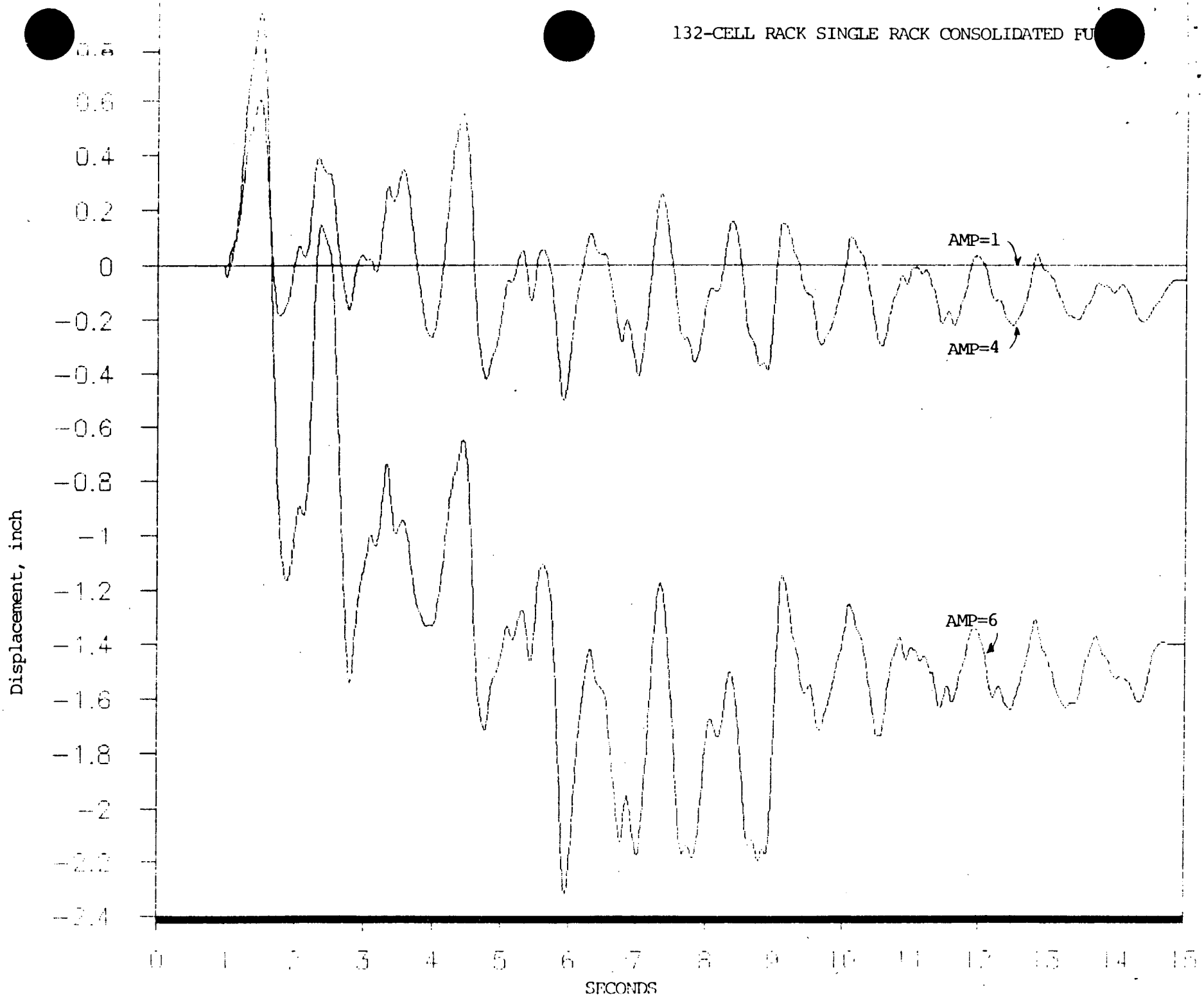

132-CELL RACK SINGLE RACK CONSOLIDATED FU
AMP=1
AMP=4
AMP=6
Displacement, inch
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-1.2
-1.4
-1.6
-1.8
-2
-2.2
-2.4
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
SECONDS

TABLE 5

	AA	AB	AE	AF	AG
RUN NO.	IP3NSL3	IP3IMP5	RACK3280VF	RACK3280V	IP3NSR1I1
DB/CONFIRM	CONF	CONF	CONF	CONF	CONF
RACK SIZE,#CELLS	132	132	80	80	80
FRICTION,COEFF	---	---	.2	.8	.8
MULT/SINGLE	M	M	M	M	S
DIRECTION	NS	NS	NS	NS	NS
COMBINED LOADS?	NO	NO	YES	YES	YES
WET/DRY	WET	WET	WET	WET	DRY
FIGURE,REF	SEC5/P3	SEC5/P3	SEC6/P1	SEC6/P1	2.1
REGION	2	2	1	1	1
CONS/NORM,FUEL	NORM	NORM	C,N,E	C,N,E	NORM
TIME STEP,SEC	.0005	.0005	.0005	.0005	.0005
SYM/UNSYM,FUEL	F-1/2-F	F-1/2-F	Fc-Fn-E	Fc-Fn-E	SYM
MULTI MASS MODEL	NO	NO	YES	YES	YES
SSE/OBE	SSE	SSE	SSE	SSE	SSE
DAMPING, %	0.0	0.0	.4	.4	.4
GAP	.25	1.5	1.5	1.5	---
IMPACT GAP	.25	1.5	.125	.125	---
DISPLACEMENT,INCH	.039/ .027/ .039	.196/ .235/ .196	.036/ .038/ .070	.0698/ -.065/ .056	
MAX.PED FORCE ON (2 PED),KIPS	---	---	118/ 69.7/ 11.9	200/ 83. 145/ 40.	
MAX. HORIZ. FORCE, KIPS	17.21/ 11.61/ 17.2	85.5/ -102.41 85.5	21.1/ 21.31/ 5.9	53./ -49.5/ 42.4	

ITEM 8 NYPA INDIAN POINT #3

MULTI-RACK ANALYSIS SUMMARY
(KIPS AND INCHES)

TABLE 1

132-CELL

DAMPING - 2%
EVENT - SSE
GAP,IN - 1/32
u - .8

COMPONENT	1/2 FULL RACK 11	FULL RACK 8	EMPTY RACK 5
AXIAL FORCE ON FOOT, KIPS	113.8	125	51.3
SHEAR FORCE ON FOOT, KIPS	36.7	37.3	41.0
RACK TO RACK IMPACT, LBS			
TOP	3,934	139	
MIDDLE	4,821	---	
BOTTOM	10,660	8,350	
RACK TO WALL IMPACT, LBS	---	---	
BOTTOM DISPLACEMENT, INCH	.38	.24	.56

TABLE 2

132-CELL

DAMPING - 2%
EVENT - SSE
GAP,IN - 1/32
u - 0.2

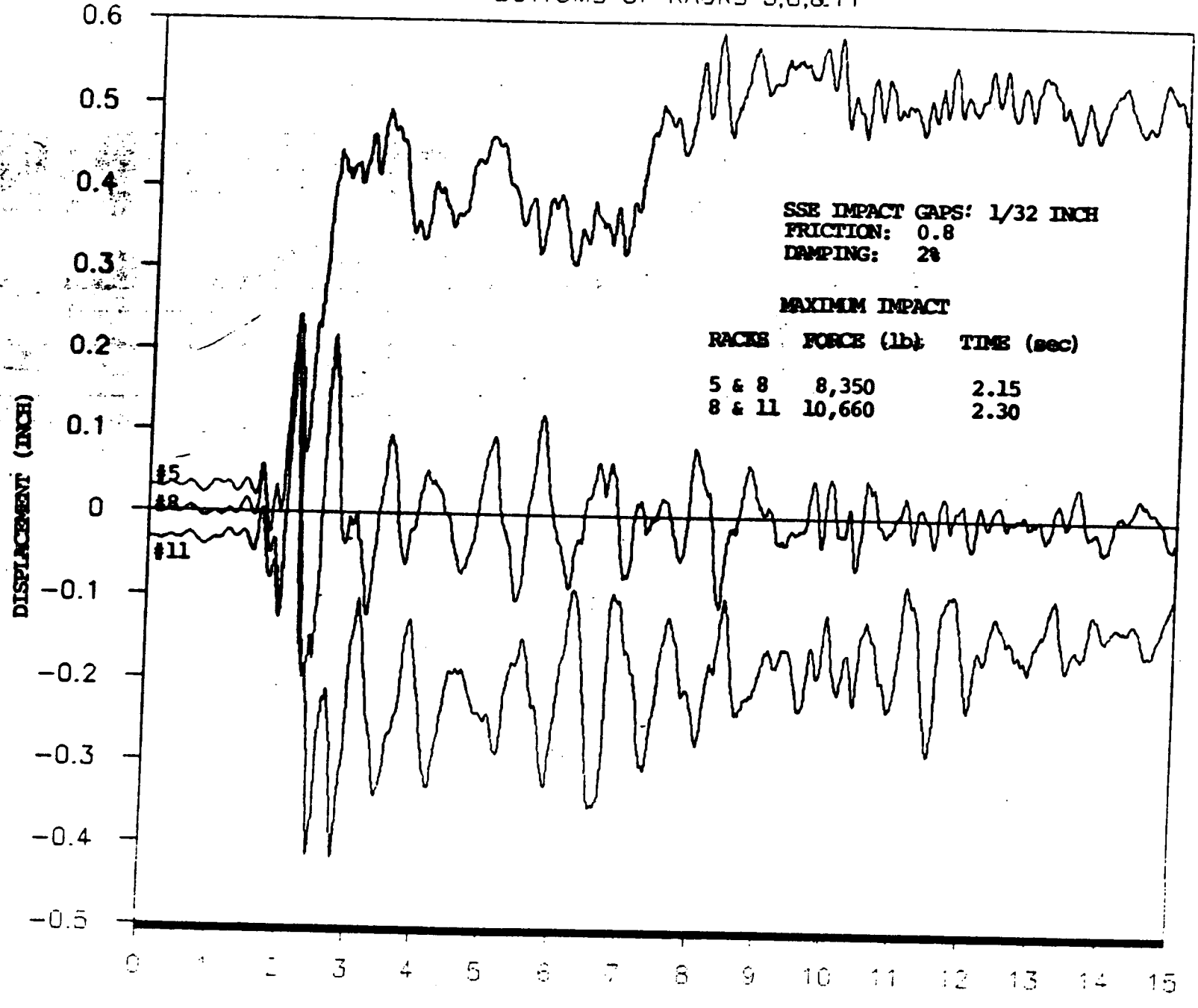
COMPONENT	1/2 FULL RACK 11	FULL RACK 8	EMPTY RACK 5
AXIAL FORCE ON FOOT, KIPS	53.8	83.7	16.4
SHEAR FORCE ON FOOT, KIPS	9.5	16.7	2.9
RACK TO RACK IMPACT, LBS			
TOP	9,922	9,543 *	
MIDDLE	17,080	16,080	
BOTTOM	11,990	11,270	
RACK TO WALL IMPACT, LBS	---	---	
BOTTOM DISPLACEMENT, INCH	.38	.41	1.34

* Inadvertently used 17,550 lb. in telephone discussion 8/1/89

M 8

REGION-2, 132-CELL RACKS

BOTTOMS OF RACKS 5,8,&11

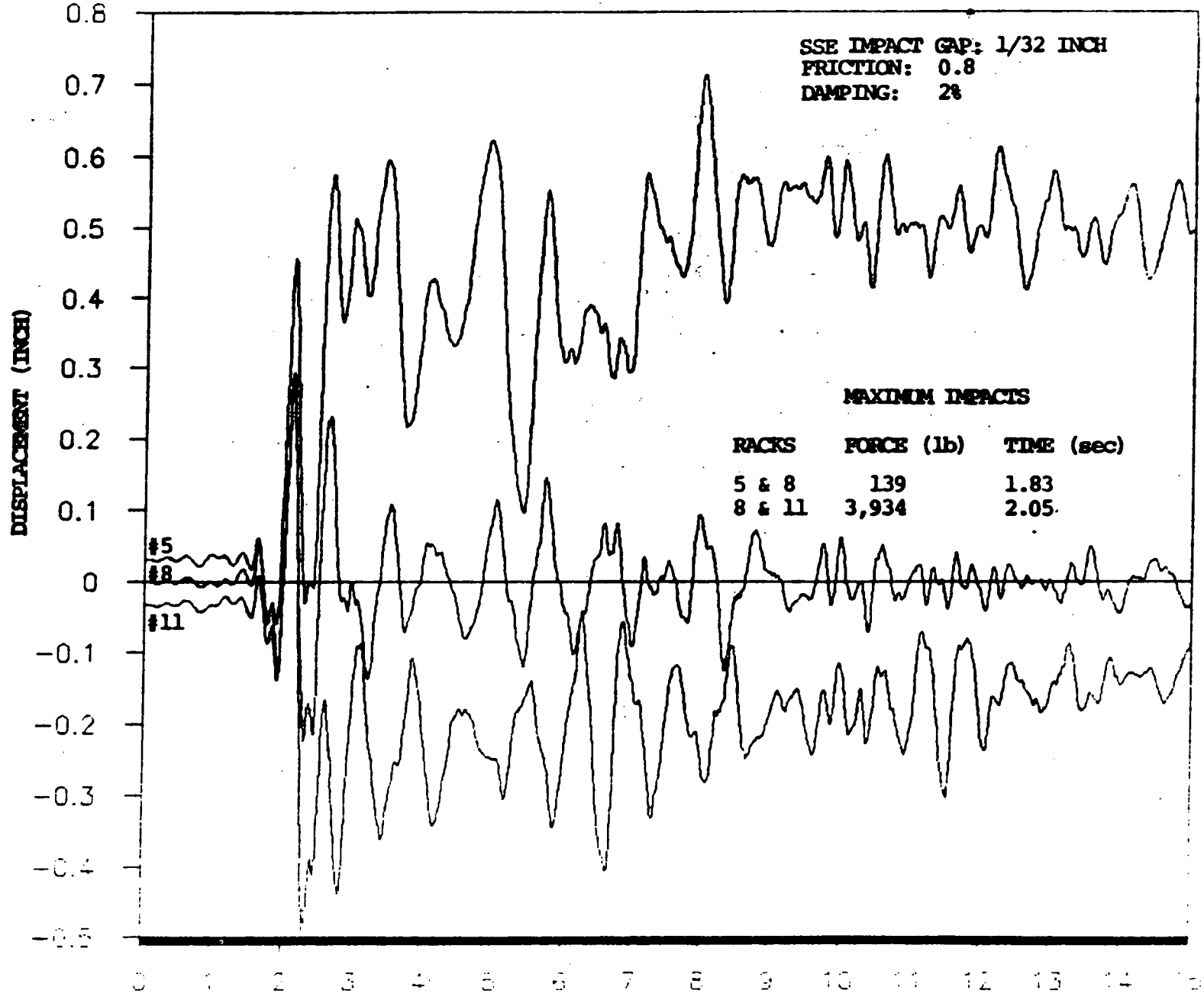


.8 FRICTION

ITEM 8

REGION-2, 132-CELL RACKS

TOPS OF RACKS 5,8,&11



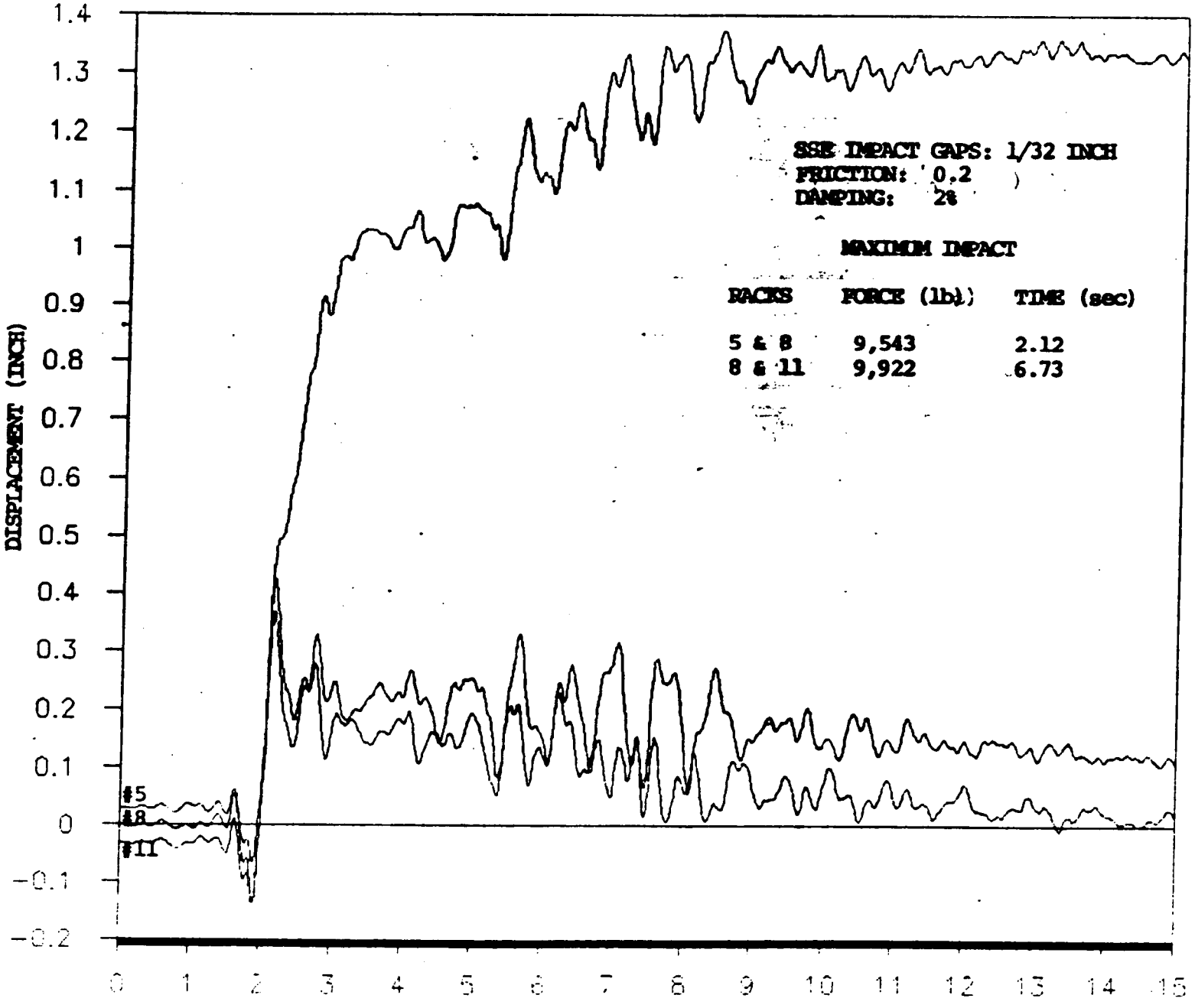
.8 FRICTION

ITEM

REGION-2, 132-CELL RACKS

TOPS OF RACKS 5,8,&11

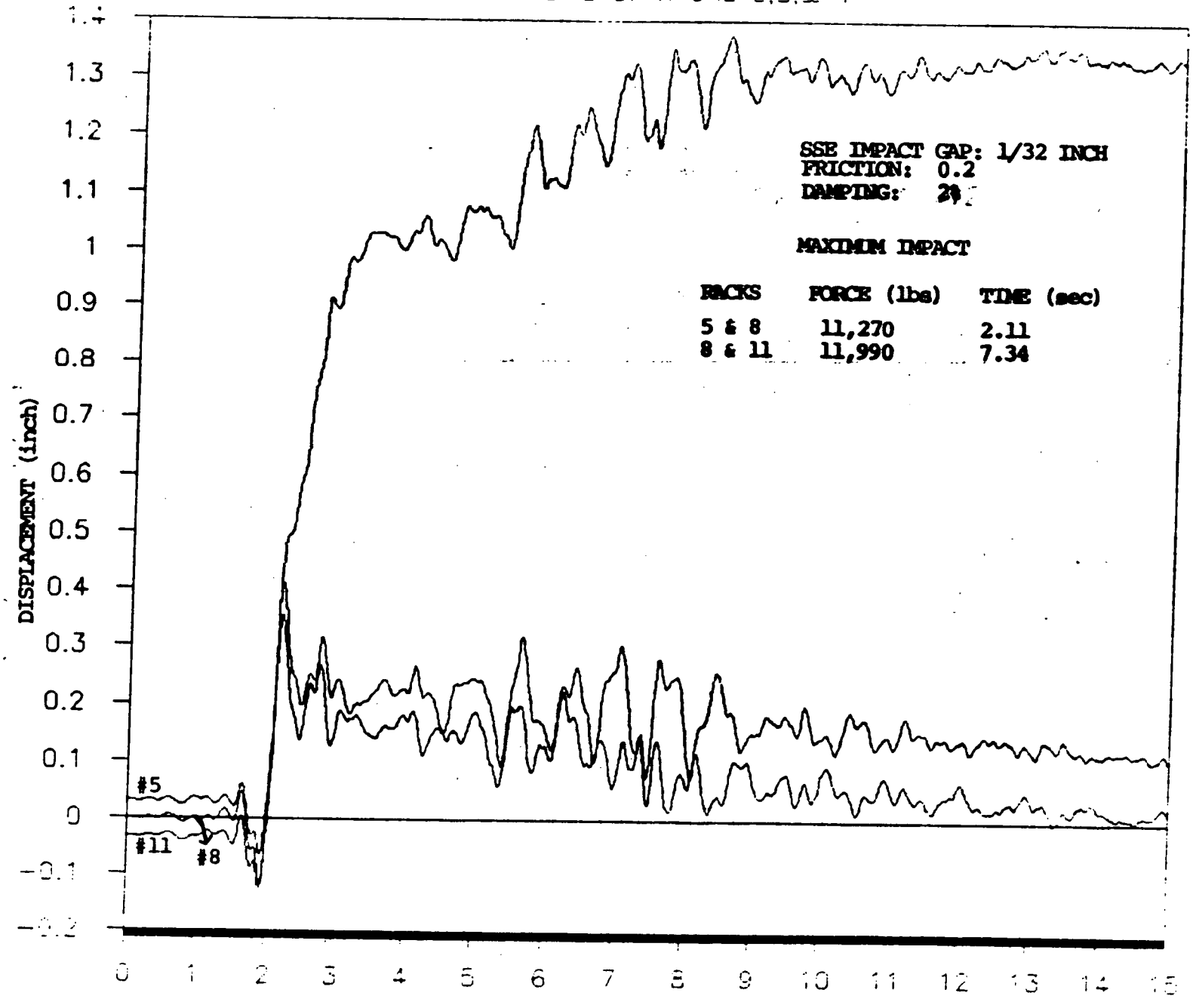
.2 FRICTION



ITEM 8

REGION-2, 132-CELL RACKS

BOTTOMS OF RACKS 5,8,&11



Item (9)

IMPACT ANALYSIS SUMMARY

132 CELL RACK
1/32" GAP
2% DAMPING
6 CELL IMPACT
BUCKLING ALLOWABLE = 1.37 KSI

	MAXIMUM IMPACT FORCE, LB	COMPRESSIVE STRESS, KSI	SAFETY FACTOR
TOP (16.5")	9,922 (0.2u)	0.59	2.32
MID SPAN (33"	17,080 (0.2u)	0.51	2.70

FUSION WELD STRESS DUE TO IMPACT *

1 LEVEL WELDS
11 BOXES

$\tilde{t}_{SHEAR}$ = 2297 PSI (TOP)

* This stress will be combined with single rack standard fuel case primary stress when analysis is completed.

ITEM 10

The horizontal spring constants, K11, for the original seismic model for the 132-cell rack in each direction are:

E-W = 308,100 LB/IN

N-S = 436,100 LB/IN

ATTACHMENT III TO IPN-89-058

RESULTS OF THE 1% DAMPING
CASE FOR A SINGLE 132 CELL RACK

NEW YORK POWER AUTHORITY
INDIAN POINT 3 NUCLEAR POWER PLANT
DOCKET NO. 50-286
DPR - 64

SUMMARY

132-CELL RACK

REG FUEL,SSE
1% DAMPING

LOADS ON TWO PEDESTALS, LBS

DIRECTION OF EVENT	VERT FVT	HORIZ FH
E-W	361,100	100,500
N-S	217,900	106,100

SRSS LOAD ON ONE PEDESTAL, LBS

FVT	FH
195,095	73,085

STRESS SUMMARY

	SSE	OBE
FUSION WELD,psi		
TOP	9,885	7,306
BOTTOM	13,797	9,523
THERMAL,psi		
TOP	3,857	3,857
BOTTOM	0	0
IMPACT,psi		
TOP	2,297*	0
BOTTOM	2,297*	0
COMBINED,psi		
TOP	16,039	11,163
BOTTOM	16,094	9,523
STRESS ALLOWABLE,psi	29,060	21,000
SAFETY FACTOR	1.80	1.88

* FROM 2% MULTI-RACK MODEL

ATTACHMENT IV TO IPN-89-058

REVISED TABLE 4-3 OF THE SAFETY ANALYSIS REPORT

NEW YORK POWER AUTHORITY
INDIAN POINT 3 NUCLEAR POWER PLANT
DOCKET NO. 50-286
DPR-64

TABLE 4-3 (Revised 8-15-89)

MAXIMUM STRESS RESULTS OF RACK STRUCTURAL ANALYSIS

			Region 1			Region 2		
			CONSOLIDATED FUEL, 4% DAMPING			REGULAR FUEL, 1% DAMPING		
Location	Cond.	Type	Actual (KSI)	Allowable (KSI)	Safety Factor	Actual (KSI)	Allowable (KSI)	Safety Factor
Maximum Cell to Cell Fusion Weld Stress:	OBE	Shear	10.0	21.00	2.10	11.16	21.00	1.88
		Bend	13.6	18.00	1.32	13.11	18.00	1.37
	SSE	Shear	13.3	29.06	2.19	16.09	29.06	1.80
		Bend	18.0	36.00	2.00	17.43	36.00	2.07
Cell Bottom Plate to Box Wall Weld Stress:	OBE	Shear	13.0	21.00	1.61	13.26	21.00	1.58
	SSE	Shear	16.5	29.06	1.76	18.52	29.06	1.57
Top Pedestal Plate to Cell Bottom Pl Weld:	OBE	Shear	12.7	21.00	1.65	4.07	21.00	5.15
	SSE	Shear	19.0	29.06	1.52	6.13	29.06	4.74
Pedestal Thread Stress Internal:	OBE	Shear	6.43	8.58	1.33	5.43	8.58	1.58
	SSE	Shear	8.15	10.73	1.31	7.17	10.73	1.49
External:	OBE	Shear	7.66	8.58	1.12	6.41	8.58	1.34
	SSE	Shear	9.71	10.73	1.10	8.46	10.73	1.27

ATTACHMENT V TO IPN-89-058

MISSING PAGE OF SEISMIC REPORT

NEW YORK POWER AUTHORITY
INDIAN POINT 3 NUCLEAR POWER PLANT
DOCKET NO. 50-286
DPR-64

TABLE # 1

IP3

SUMMARY OF RESULTS FOR 132 CELL RACK - 15X15 OFA

SET #1 - MAX. FORCES (KIPS)

DIR EVT	AT GAP ELEMENT# 1	2	3	4	5	6	PEDESTAL Fvt	Fhz
NS OBE								
EW OBE								
NS SSE	19.3	16.3	16.6	16.6	17.7	20	191	84.1
EW SSE	19.6	25.6	29.3	30.7	29.7	38.2	235	91

SET #2 - FORCES ON INDIVIDUAL F/A'S (LBS) AND PEDESTALS (KIPS)

NS OBE								
EW OBE								
NS SSE	146	123	126	126	134	152	96	42
EW SSE	148	194	222	230	225	214	118	46

SET #3 - MAX. FORCES AT BASE (LBS)

	Fvert	Fhoriz
NS OBE		
EW OBE		
VT OBE		
SRSS		
NS SSE	85147	84076
EW SSE	129325	91016
VT SSE	62582	
SRSS	272859	123906

SET #5 - MOVEMENT AT BASE (INS)

	ELASTIC	SLIDING	LIFTOFF
NS OBE			
EW OBE			
NS SSE	0.193	0.303	0
EW SSE	0.295	0.155	0.01

SET #4 - MAX. FORCES ON PEDESTAL (LBS)

NS OBE		
EW OBE		
VT OBE		
SRSS		
NS SSE	42574	42038
EW SSE	64663	45508
VT SSE	31291	
SRSS	136430.	61953

DWT= 316150 LBS.
BF = 24447 LBS.
SWT= 211703 LBS.

FRICTION FORCES
@ 0.2 FACTOR (LBS)
NSOBE = _____
EWOBE = _____
NSSSE = 42340
EWSSE = 42340