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PAULSON,W.A. Operating Reactors Branch 5

SUBJECT: Forwards responses to questions re 840402 application for amend to License DPR-18.Six proprietary oversize drawings encl.Aperture cards available at Central Files.
"see drawings"

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RG&E
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ROGER W. KOBER
VICE PRESIDENT
ELECTRIC & STEAM PRODUCTION

TELEPHONE
AREA CODE 716 546-2700

July 31, 1984

Director of Nuclear Reactor Regulation
Attention: Mr. Walter A. Paulson, Acting Chief
Operating Reactors Branch No. 5
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Subject: Responses to NRC Staff Questions
R. E. Ginna Nuclear Power Plant
Docket No. 50-244

Dear Mr. Paulson:

Attached are responses to NRC Staff questions concerning our Application for Amendment to Operating License of April 2, 1984.

Very truly yours,

Roger W. Kober

Roger W. Kober

Attachment

A001
1/1
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1. With regard to the friction between the rack and the support stand, please respond to the following:

   a. Explain why the case of = 0.2 only was investigated in the seismic analysis; discuss the effect of higher coefficients of friction upon the displacement and stress results.

   b. The support stand is composed of base support, shim, and floor plate which are not mechanically or metallurgically attached to each other. Explain how friction acts at the following interfaces between (i) rack and base support, (ii) base support and shim, and (iii) shim and floor plate. In addition, discuss how these interfacial frictions are simulated in the RACKOE model.

   c. Confirm whether the floor plate is mounted onto the surface in the fuel pool.

1a). The low friction factor case was run to determine maximum expected sliding distance. As the friction factor is increased, the sliding distance generally decreases, but reaction forces and therefore stresses increase. The limiting case is that in which the friction force is great enough to prevent relative motion between the rack and the pool floor altogether. This occurs for a friction factor of 0.5 - 0.6. In this case, the rack support is essentially fixed horizontally and it was so modelled. Since the purpose of the seismic analysis is to determine maximum displacements and maximum stresses, it is not considered necessary to include cases which result in neither.

1b). The computer model does not explicitly include either the base frame or shim plates. These are considered to be part of the base or ground for the rack. The only means of keeping the three items in their installed configuration is friction. For friction factors greater than 0.5 this is adequate; but if the friction factor is smaller, they will slide with respect to each other. For the lowest possible friction factor: (0.2 based on tests of SS on SS in water) the computer model predicts a maximum sliding distance of 0.08" for OBE and 0.51' for SSE loadings. Section 3.7.3 of the SRP Postulates 5 OBE events during the plant's lifetime, therefore the rack can displace 5 (0.08) = .44 inches horizontally with respect to the base frame. If friction between the base frame and shim plates is less than the friction between the rack and frame, the sliding will occur at ths interface; likewise if friction betwen the shims and floor plate is less, sliding will occur at this interface instead of the rack-support base frame interface. Therefore over the lifetime of the plant, either of the 3 items can displace horizontally with respect to the other a maximum distance of 0.9 inches.

The base frame has a top flange of 8" and the main load carrying element (the jackscrew housing) is a 6" diameter rod reinforced with 3 3/4" x 9" blocks. A vertical load with an eccentricity of 0.9 inches will not cause overstress in this element. The base plates are 11" x 11" and likewise will not be overstressed by the eccentricity.

1c). The floor plate is not welded to the liner on the pool floor.

2. With regard to the RACKOE model, please respond to the following:

a. Explain how the 2-D RACKOE model can be used to simulate the 3-D nonlinear structural behavior exhibited by the rack.

b. Discuss why the nonlinear behavior of friction between the rack and the support stand was not included in the model.

c. Explain how the model can be used to simulate a partially loaded rack.

d. There is only one hydrodynamic coupling mass between rack and fuel assembly as well as rack and wall. Discuss the effect of having five such masses in the model open the analysis results.

e. Elaborate on the procedure to include the gap between adjacent racks in the evaluation of hydrodynamic coupling mass between rack and wall.

2a). The seismic analysis of the racks is based on regulatory guide 1.92 "Combining Model Responses and Spatial Components In Seismic Response Analysis" which states that the "represented maximum value of a particular response...of a given element of a structure, system, or component subjected to the simultaneous action of the three components on the earthquake can be satisfactorily obtained by taking the SRSS of...the maximum response values from time-history dynamic analysis, to each of the three components calculated independently". This does not differentiate between linear and nonlinear structures. Additionally the major non-linearity in the rack structure (liftoff) is of very short duration, and so few of them occur in the time-history that it should not affect the maximum stresses. This is discussed more fully in the answer to question 3c.

2b). As explained in the response to question (1b.), the support base or base frame is not considered part of the rack model, but rather as part of "ground". Friction between the rack and support was therefore considered.

2c). A partially loaded rack would be modelled similarly to a full rack, the major differences being a reduction in the mass and stiffness of the nodes and beam representing the fuel assemblies. If the fuel assemblies were assumed to be concentrated in a specific area, the centroid of the rack and fuel would shift from the rack center to either side, resulting in unequal pedestal reactions in one direction and torsional effects in the other.

This case was not investigated because it wouldn't result in more severe seismic reactions than the fully loaded case. The fuel assemblies comprise a large percentage of the total rack mass (203,000/233,600 = 86% for standard fuel and 366,800/397,400 = 92% for the consolidated fuel) and a very small percentage of the rack stiffness (300 in^4 vs. 252.000 in^4). Since seismic forces are proportional to structural mass, the seismic reactions from a partially loaded rack would be less severe than for a full rack.

2d). The hydrodynamic masses are computed as a single value, but are actually the resultants of more or less uniformly distributed loads on the rack. The rack and fuel assemblies are also uniformly distributed stiffnesses and masses. These are modelled as 6 concentrated masses. This number of masses has been determined from experience as giving an adequate representation of the behavior of the distributed masses.

2e). The water in the rack - rack gap acts to force the racks in line to move in unison. If two racks were included in the model, they would be coupled to each other in the same manner the fuel is coupled to the racks, i.e., using hydrodynamic masses. Using case #13 from Fritz: M_H - Ph ^{3}b/12S, a 1" gap results in $M_H = 1.03 \times 10^6$ lbs. Since the racks are installed with a nominal zero gap, the actual hydrodynamic mass is much larger, virtually tying one rack to the other horizontally. The hydrodynamic mass does not, however, force the two racks to act compositely as a single rack, since the fluid cannot transmit the required shear. Rather, the movement is as shown on Figure 1, with one rack end displacing vertically with respect to the other at the interface.

If both racks are full of fuel, they will respond identically or "in-phase" to seismic excitation. One rack does not affect the other. The only external influence is then the hydrodynamic mass between the rack and wall. In this instance the gap between the racks and walls is identical on both sides and the effect on each rack is identical. But if consequently small, the rack close to the wall would, because of its greater hydrodynamic mass and consequent greater resistance to movement, would decrease the movement of the other (because of the hydrodynamic mass coupling the two).

This is reflected in the method used to calculate M_H^{rw} for for each rack, i.e., M_H^{rw} is calculated for each wall boundary, and the sum apportioned to each rack in line.

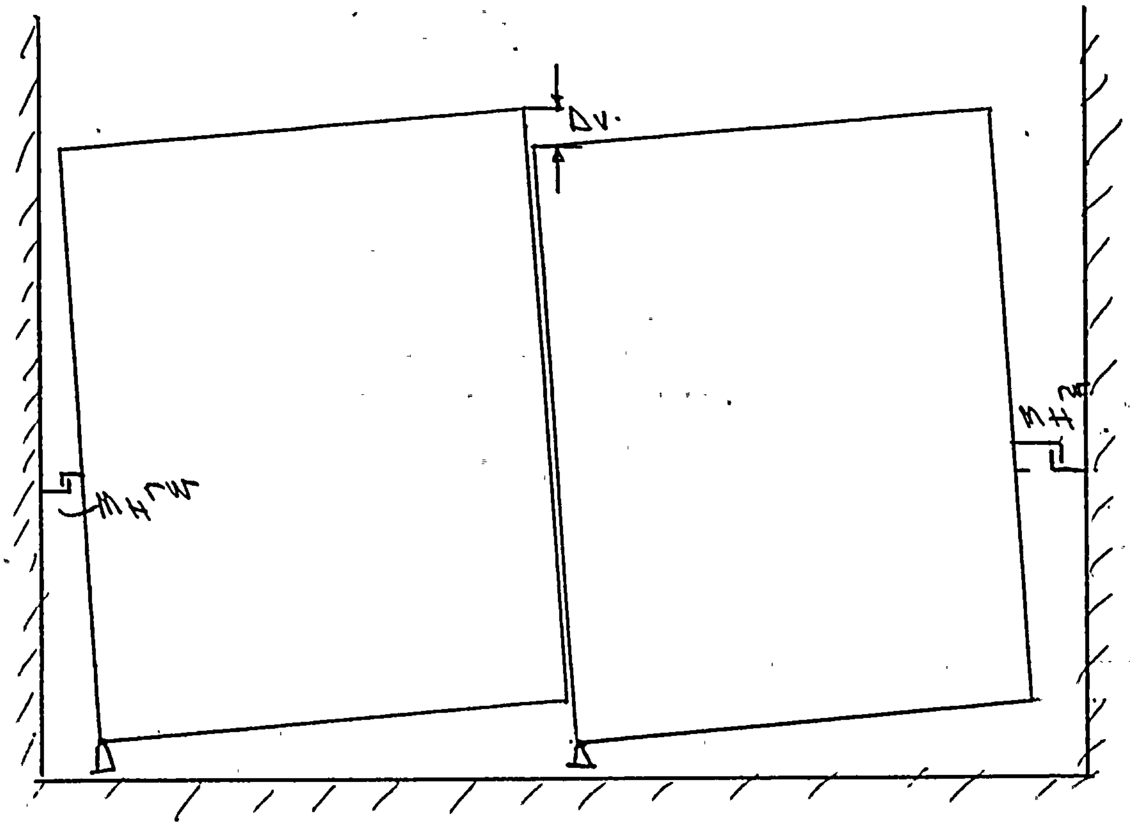


FIGURE 1:

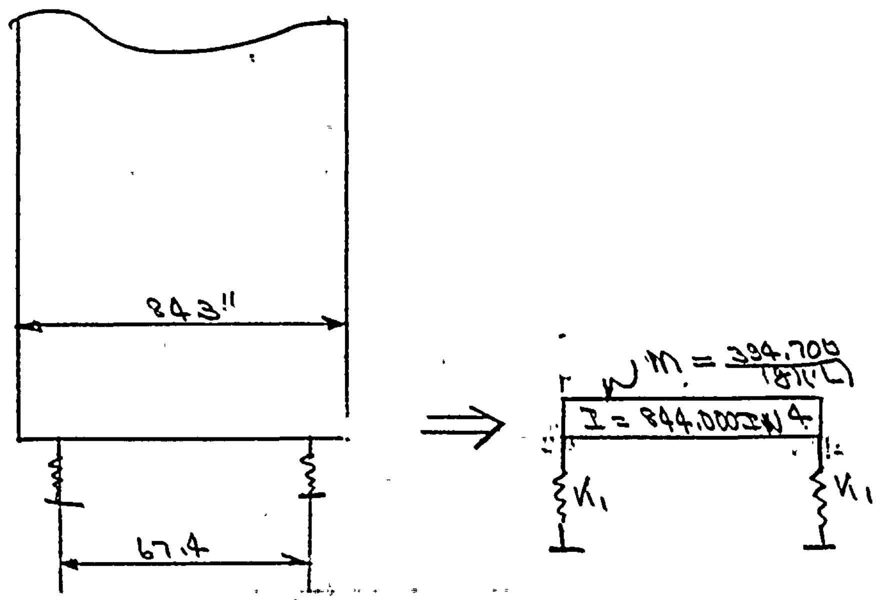


FIGURE 2

3. In the RACKOE model for liftoff analysis, please response to the following:

a. A single mass node was used to represent the rack and its contents. Discuss whether this simplified model is adequate to produce conservative results.

b. Indicate whether the following multiplication factors for seismic loads were used in the analysis:

1.1 for SSE
1.5 for OBE

c. Discuss whether this 2-D model is capable of simulating all possibilities of liftoff including the case of three supports off the pool liner.

3a). In either direction, the rack is a simply supported beam of distributed mass and stiffness supported by relatively soft springs (pedestals). Biggs, in "Introduction to Structural Dynamics" page 233 states that multidegree of freedom systems can be analyzed as a single DOF system provided that the natural periods of the elements are sufficiently different. He then suggests that these differ by at least a factor of 2. In this instance, the pedestals have a much longer period than the beam. They will respond slowly and the inertia forces along the beam due to the pedestal motion will be small compared to those due to the vibration or the beam itself, and hence will have little effect on the beam response.

The first element considered is a simply supported beam of distributed mass and stiffness (see figure 2). From Biggs, page 154 $f = \frac{W}{2\pi} = \frac{\pi}{2L^2}\sqrt{\frac{EI}{M}}$. I is the moment of inertia of of the rack, with height 159 inches and width of 14 boxes. I

$= 14\ (.18)\ (159)^3/12 = 844.000\ in^4$. L is the span length - taken as 67.4 inches in the east - west direction. The mass M = 394.700/(84.3)g = 4682/g lb/in.

f = 483 CPS

For the equivalent single DOF system:

$$f = \frac{1}{2\pi}\sqrt{\frac{kg}{W}}$$

$k = 2(2.7) \times 10^7) = 5.4 \times 10^7$ lb./in.
W = 394,700 lbs.

f = 36.6 CPS

Since the ratio of frequencies (483/36.6) = 13 is much greater than 2, the system is uncoupled and can be analyzed as a single DOF system.

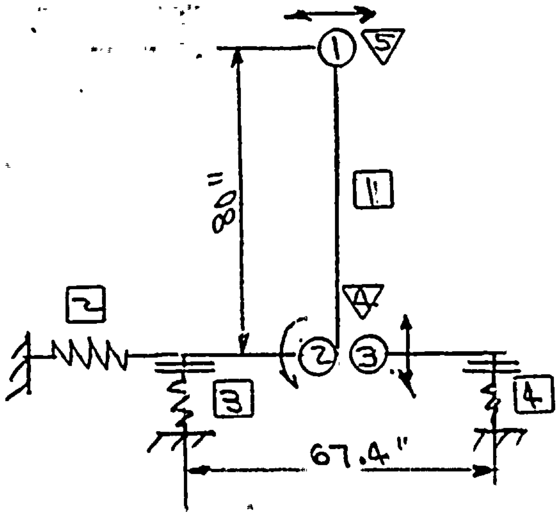
This does not insure that it is conservative, but it does show that values are representative. A simplified model of a rack with the liftoff capabilities was run as shown in figure 3. The base is modelled identically to that for the other runs in the report. i.e., assuming a rigid beam between pedestals. Additionally, a model (figure 4) was developed which include 5 vertical masses tied together with a beam with a moment of inertia equal to 844,000 in^4 and shear area = to 400 in^2. Resulting reactions are very similar:

	Single Mass	5 Masses
Max. Vertical Reaction	397.000 lbs.	384.000 lbs.
Max. Horizon Reaction	158.000 lbs.	155.000 lbs.
Max. Liftoff	.00877 in.	.00808 in.

UST & D DESIGN SERVICES, INC. U.S. TOOL & DIE, INC.

BY DiPaolo DATE 7/24/84 SUBJECT RG & E SECT. ____ SHEET ____ OF ____

CHKD. BY ____ DATE ____ RESPONSE TO NRC QUEST. PROJ. NO. 8369



○ MASS NODES (ACTIVE)

▽ REDUNDANT NODES

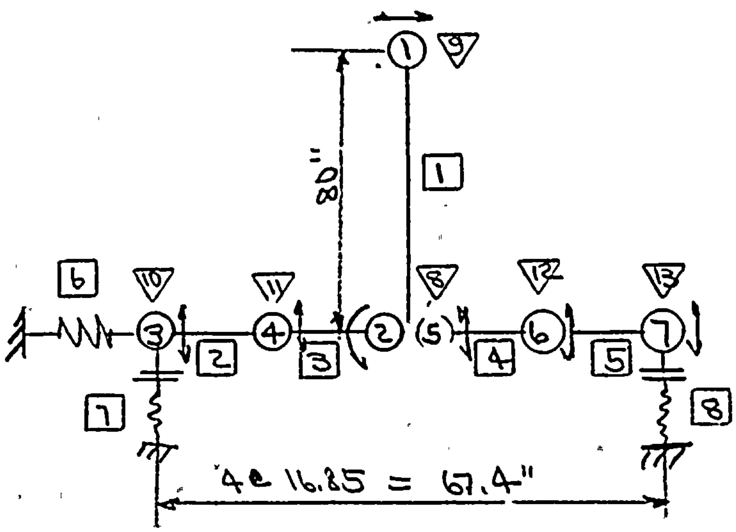
□ STRUCTURAL ELEMENTS.

DIRECTION OF DOF INDICATED BY ARROW

m_1 IS TOTAL MASS OF RACK = 389.000 LBS.

m_3 = 389.000 LBS.

FIGURE 3



m_1 = 389.000 LBS

$m_3 = m_4 = m_5 = \frac{389.000}{4}$

= 97.250 LBS.

$m_3 = m_7 = \frac{m_3}{2} = 48625$ LBS.

FIGURE 4

3b). The factors of 1.5 for OBE and 1.1 for SSE refer to factors of safety against sliding and tilting required by Appendix C of Section 3.8.4 of the Standard Review Plan. However, paragraph 6 of this appendix also states that "This position on factors of safety against sliding and tilting need not be met provided...it can be shown that any sliding and tilting motion will be contained within suitable geometric constraints such as thermal clearances and that any impact due to clearances is incorporated".

Computer results show a maximum sliding distance of 0.088 inches for OBE and 0.51 inches for SSE. Postulating 5 OBE events and 1 SSE event, the maximum distance the racks can slide is 5(.088) + .51 = 0.95 inches. The closest obstruction is the west wall which has an installed gap of 11.25 inches. The rack sliding and tilting will certainly not impact the wall, and a reduction of 1 inch in the rack-wall gap would have a mimimal effect on the Thermal-Hydraulic Analysis. It is, therefore, unnecessary to comply with these factors of safety.

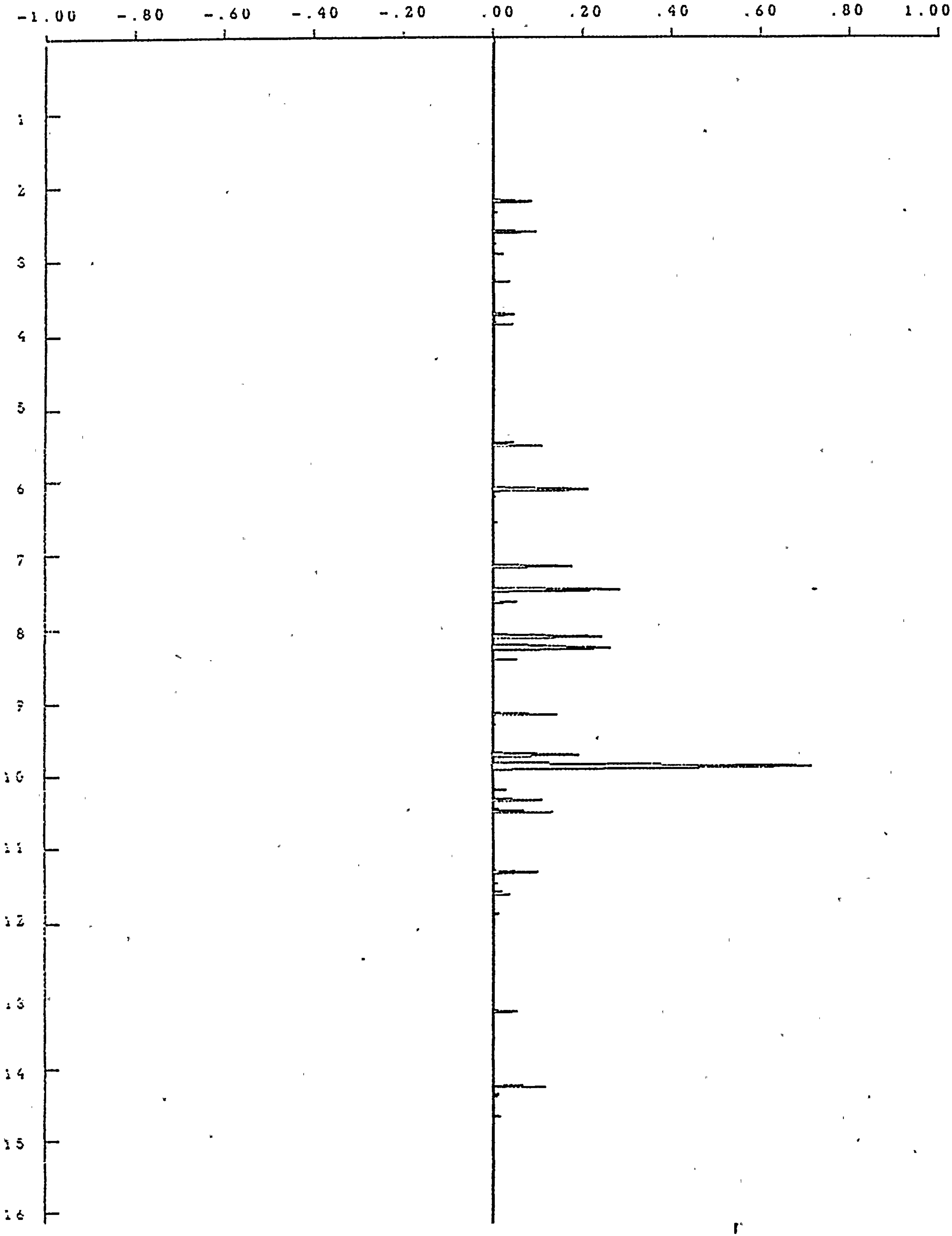
3c). The 2-d mode cannot explicitly model the case of 3 pedestals lifting off simultaneously.. However, liftoff occurs infrequently, and for short time periods (maximum of about .04 seconds). The probability that liftoffs occur simultaneously in both directions is very small. Using the philosophy spelled out in regulatory guide 1.92 for combining responses for codirectional seismic events using the SRSS method, the simultaneous occurrence of liftoffs in the two directions is sufficiently remote to be neglected.

An indication of the frequency and duration of liftoffs is shown by the enclosed plots of the right pedestal liftoffs for the rack filled with consolidated fuel, for SSE, east - west and north - south.

ROCHESTER GAS E-W LIFTOFF OF THE RIG[illegible] PEDESTAL

MAX. VALUE= .714E-01 AT TIME 9.86 MIN. VALUE= .000E 00 AT TIME .00

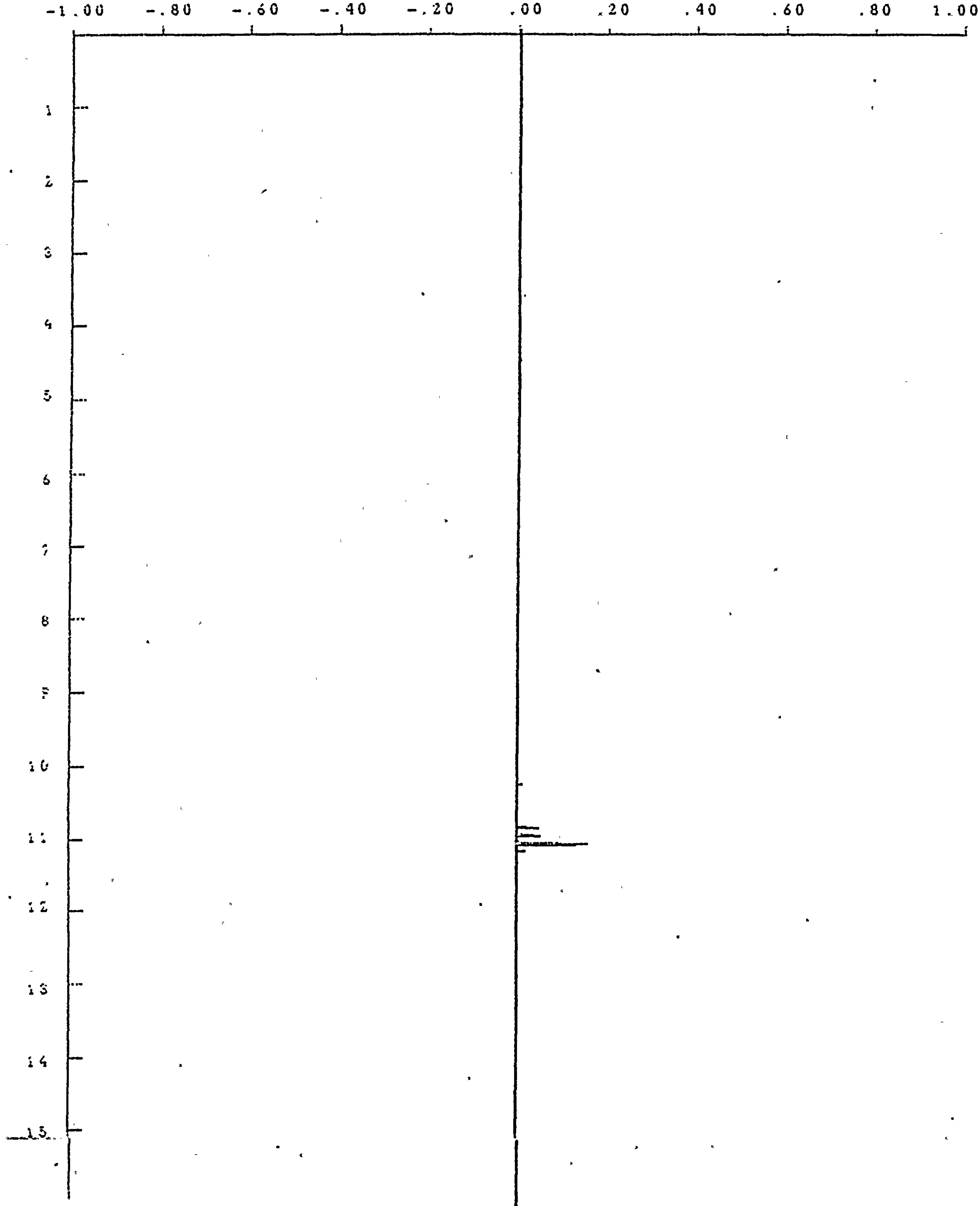
MULTIPLY VALUES BY 10**-1



ROCHESTER GAS N-S LIFTOFF OF THE RIGHT PEDESTAL

MAX. VALUE= .163E-01 AT TIME 11.04 MIN. VALUE= .000E 00 AT TIME .00

MULTIPLY VALUES BY 10**-1



4. Please provide design drawings for welds and support stands.

The following drawings are attached: Wachter and Associates 102-2, 102-8, 102-9 and 102-18.

These drawings provide information on the basic rack, box and support base construction. Drawings USTD 8369-2 and 8369-4 are attached to provide information on the modified configuration.

5. Please provide results of convergence study for explicit method of integration.

In our experience, any instability in the model shows up in the first second of a time history and is resolved by halving the time step. Subsequent reductions in the time step result in decreased seismic reactions and displacements. A brief study was conducted using the consolidated fuel model, maximum friction, north - south direction, SSE. The results are herein presented for 3 time steps; .001 sec., .0005 sec., and .00025 sec.

	Time Step (Sec.)		
	.001	.0005*	.00025
Max. Vertical Reaction	549,000	456,000	427,000
Max. Horizontal Reaction	293,000	239,000	240,000
Max. Vertical Liftoff	.042	.017	.015

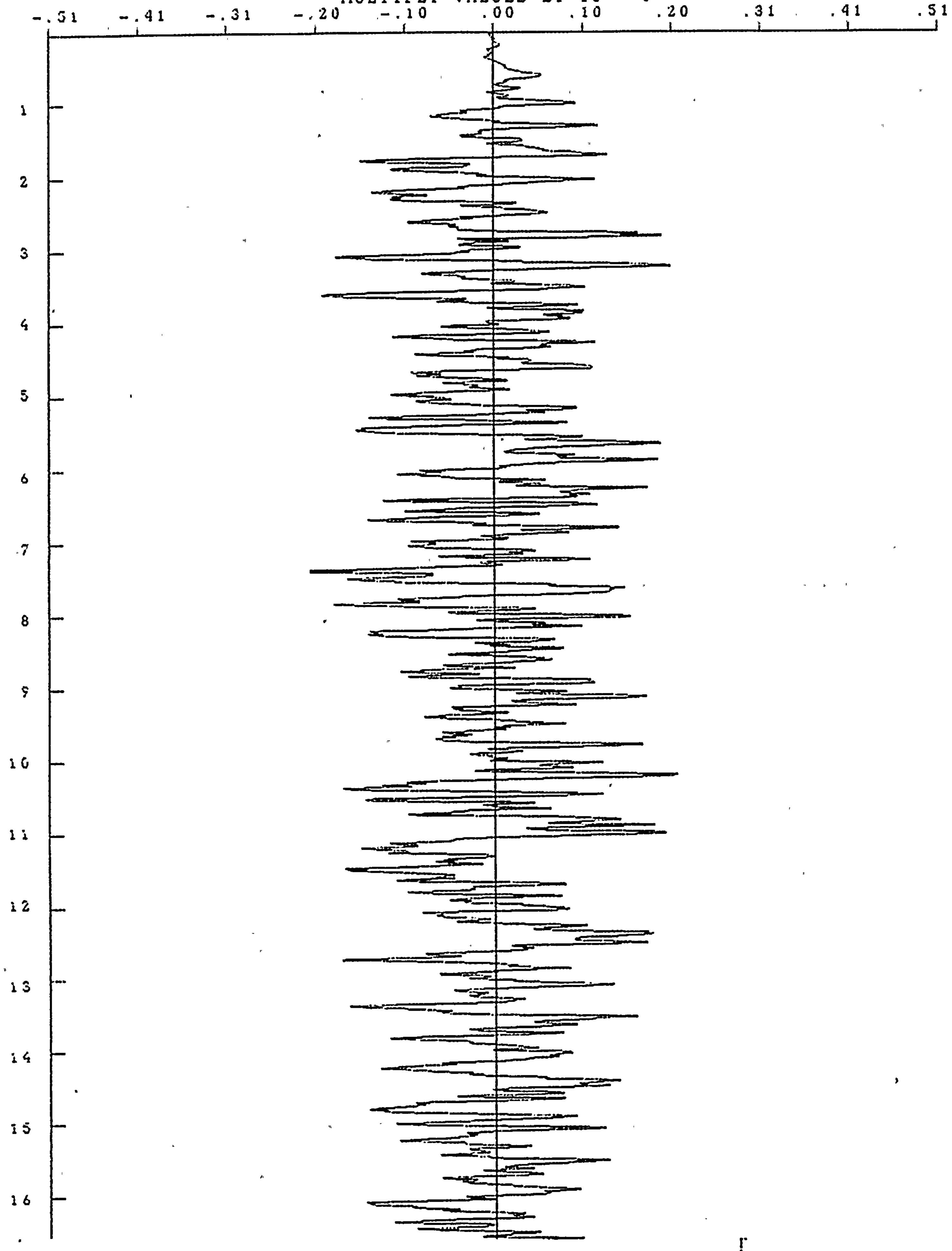
*Used throughout the analysis.

6. Please provide the E-W and N-S time history plots used in the seismic analysis.

The time history plots are attached.

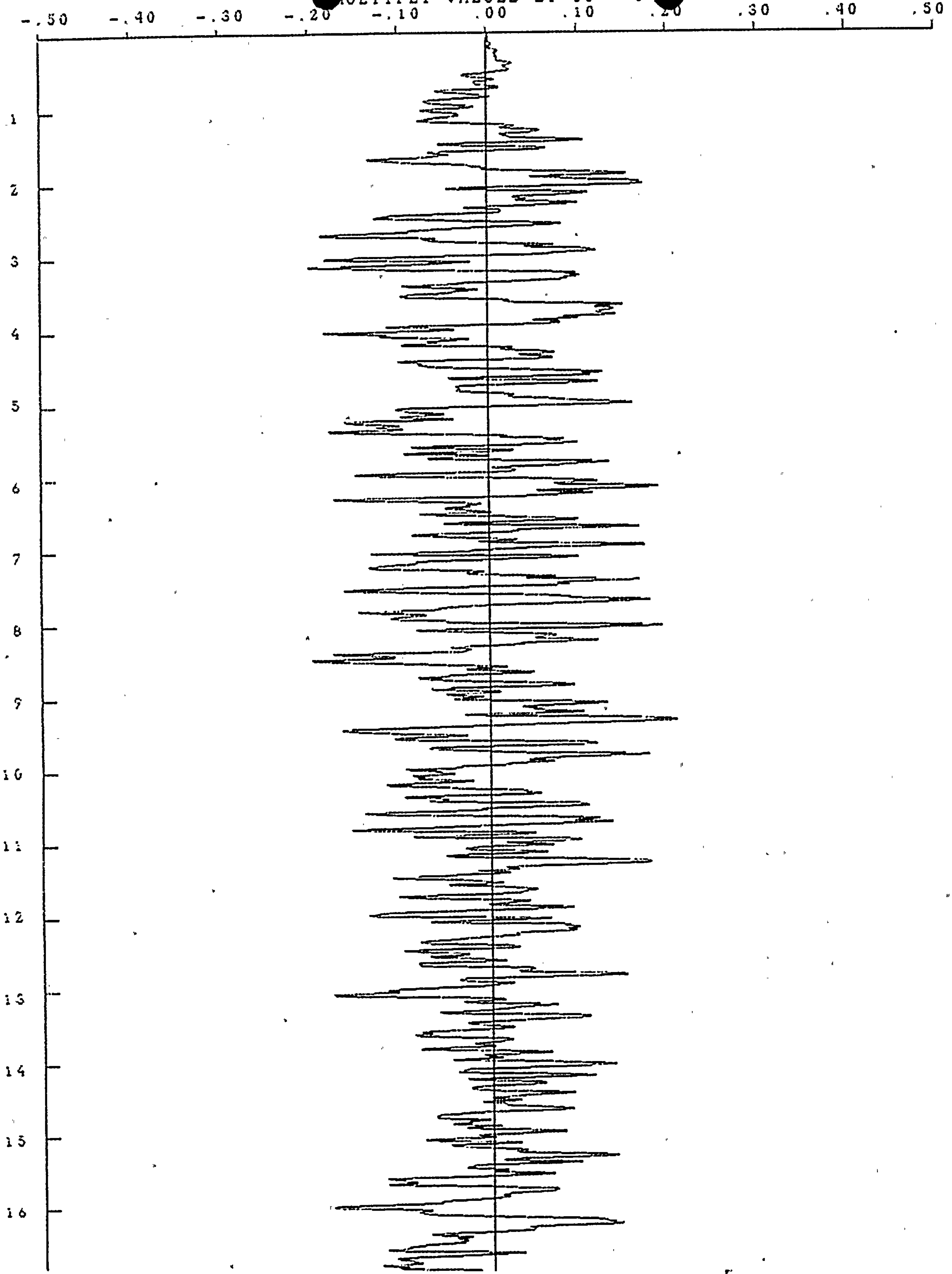
EARTH QUAKE NO.1 (NORTH SO[illegible]H) ACCELERATION TIME [illegible]STORY

MULTIPLY VALUES BY 10** 0



EARTH QUAKE NO. 2 (EAST WEST) ACCELERATION TIME HISTORY

MULTIPLY VALUES BY 10** 0



7. Please provide relevant structural drawings of the spent fuel pool with details of how the pool is supported, also the technical basis and justification for not performing structural analysis of the pool under anticipated increased loads.

The floor of the spent fuel pool is a stainless steel lined, 3 foot thick, reinforced concrete slab. The slab is founded on bedrock (Ginna FSAR, Section 2.8.3). The structure of the pool was evaluated for the original FSAR and again for the higher wall and floor loads associated with a subsequent rack replacement (Reference 1 of April 2, 1984 submittal to NRC). Because the rack will be modified to a free-standing design, only the increased concrete bearing stresses of the floor were evaluated. These were found to be acceptable.

8. There is no information provided for the local stresses and stability of the base support steel frames. Please submit the necessary information with the complete analysis and conclusions.

The rack base steel frames provide heavy members at each corner to carry the rack loads in compression. The racks are in contact with these bases only at the base corners because a 1" thick rack bottom plate is provided there, whereas the remaining rack bottom plates are only 1/2" thick. This results in 1/2" clearance elsewhere between the rack and base structure. Prior to this modification each corner load was carried through the corner structure to a 3" diameter jackscrew. The modification provides 11" square steel shims under the corner of the same thickness dimension as the amount of jackscrew extension. The rack load therefore is carried through the base corner structure to this 11" square area, or 121 sq. in. minus a 5" hole which is a clearance hole around the jackscrew. Net area is approximately 100 sq. in. The heavy corner members of the base consist of a 6 1/8" diameter bar, threaded internally for the 3" diameter jackscrew, and two 3 3/4" wide x 12" long plates which are welded at 90° to the 6 1/8" diameter bar. The net area in compression is approximately 115 sq. in. The maximum calculated vertical load for consolidated fuel storage is 283,000#, resulting in a very low stress of 2500 psi.

9. What are the technical basis and justifications for removing the four mounting bolts fastening each modified rack to its support base?

Four mounting bolts must be removed in order to remove each rack for the necessary modification work. The modified racks after reinstallation are to be free standing and are analyzed as such. Since the results from the conservative analysis show rack movement to be slight, there is no need to reinstall the bolts to tie each rack and base together.

10. Please elaborate on the leveling procedure used in the installation of racks to eliminate the possibilities of tilting and unbalanced placement of racks on the pool liner.

The racks as presently installed are level as they rest on their bases because the jackscrews in the bases were used to achieve this condition at the time of their installation. The procedure developed for this rack modification work provides that 11" square shims be installed under each rack corner, as noted in the answer to question 9, of the same thickness dimension as the amount of jackscrew extension below the base. Each base corner is to be individually treated in this manner so that the base will remain in the level condition. The rack which was removed for modification will be reinstalled on its same base resulting, therefore, in the same level condition as before.