UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

In the Matter of	)	
	)	Docket No. 50-275-OL
PACIFIC GAS AND ELECTRIC COMPANY	)	Docket No. 50-323-OL
	)	
Units 1 and 2 - Diablo Canyon Site	)	AMENDMENTS NOS. 75 AND 76

Pacific Gas and Electric Company hereby submits Amendments Nos. 75 and 76 to its application for an operating license for Units 1 and 2 at its Diablo Canyon Site. These amendments include material for Chapters 4, 4A, and 10 of the Hosgri Seismic Evaluation. For a brief description of the changes made by these amendments, see the Summary of Amendments 75 and 76 which precede the Removal and Insertion Instructions for the respective amendments.

Subscribed in San Francisco, California, this 5th day of February, 1979.

Respectfully submitted,

PACIFIC GAS AND ELECTRIC COMPANY

By BARTON W. SHACKELFORD
Barton W. Shackelford
Executive Vice President

JOHN C. MORRISSEY
MALCOLM H. FURBUSH
PHILIP A. CRANE, JR.
Attorneys for Pacific
Gas and Electric Company

By PHILIP A. CRANE, JR.
Philip A. Crane, Jr.

Subscribed and sworn to before me
this 5th day of February, 1979

THEODORA COOKE (SEAL)
Theodora Cooke, Notary Public in
and for the City and County of
San Francisco, State of California

My Commission expires January 28, 1981

7902080241

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

In the Matter of	)	
	)	Docket No. 50-275-OL
PACIFIC GAS AND ELECTRIC COMPANY	)	Docket No. 50-323-OL
	)	
Units 1 and 2 - Diablo Canyon Site	)	AMENDMENTS NOS. 75 AND 76
	)	

Pacific Gas and Electric Company hereby submits Amendments Nos. 75 and 76 to its application for an operating license for Units 1 and 2 at its Diablo Canyon Site. These amendments include material for Chapters 4, 4A, and 10 of the Hosgri Seismic Evaluation. For a brief description of the changes made by these amendments, see the Summary of Amendments 75 and 76 which precede the Removal and Insertion Instructions for the respective amendments.

Subscribed in San Francisco, California, this 5th day of February, 1979.

Respectfully submitted,

PACIFIC GAS AND ELECTRIC COMPANY

By Barton W. Shackelford
Barton W. Shackelford
Executive Vice President

JOHN C. MORRISSEY
MALCOLM H. FURBUSH
PHILIP A. CRANE, JR.
Attorneys for Pacific
Gas and Electric Company

By Philip A. Crane, Jr.
Philip A. Crane, Jr.

Subscribed and sworn to before me
this 5th day of February, 1979

Theodora Cooke
Theodora Cooke, Notary Public in
and for the City and County of
San Francisco, State of California

My Commission expires January 28, 1981

AMENDMENT 75

INSTRUCTION SHEET

(File this instruction sheet in the front of Volume 1 as a record of changes.)

The following instructions and check list are provided as a guide for the insertion of new pages for Amendment 75 to the Seismic Evaluation for Postulated 7.5M Hosgri Earthquake, of the operating license application for Units 1 and 2 Diablo Canyon Site. The new pages are marked "Amendment 75" and "(February 1979)" and contain both amended and supplementary material. This material is indicated by a vertical bar with the figure "75" inscribed in the adjacent margin of the page. Where such marks appear adjacent to a blank portion of a page, a deletion is indicated. Where pages have been changed only to reposition material, with no change in content, only the amendment number and the date are given.

For a brief description of the changes made by Amendment 75, see the SUMMARY of AMENDMENT 75 which precedes the "REMOVAL-INSERTION" INSTRUCTIONS.

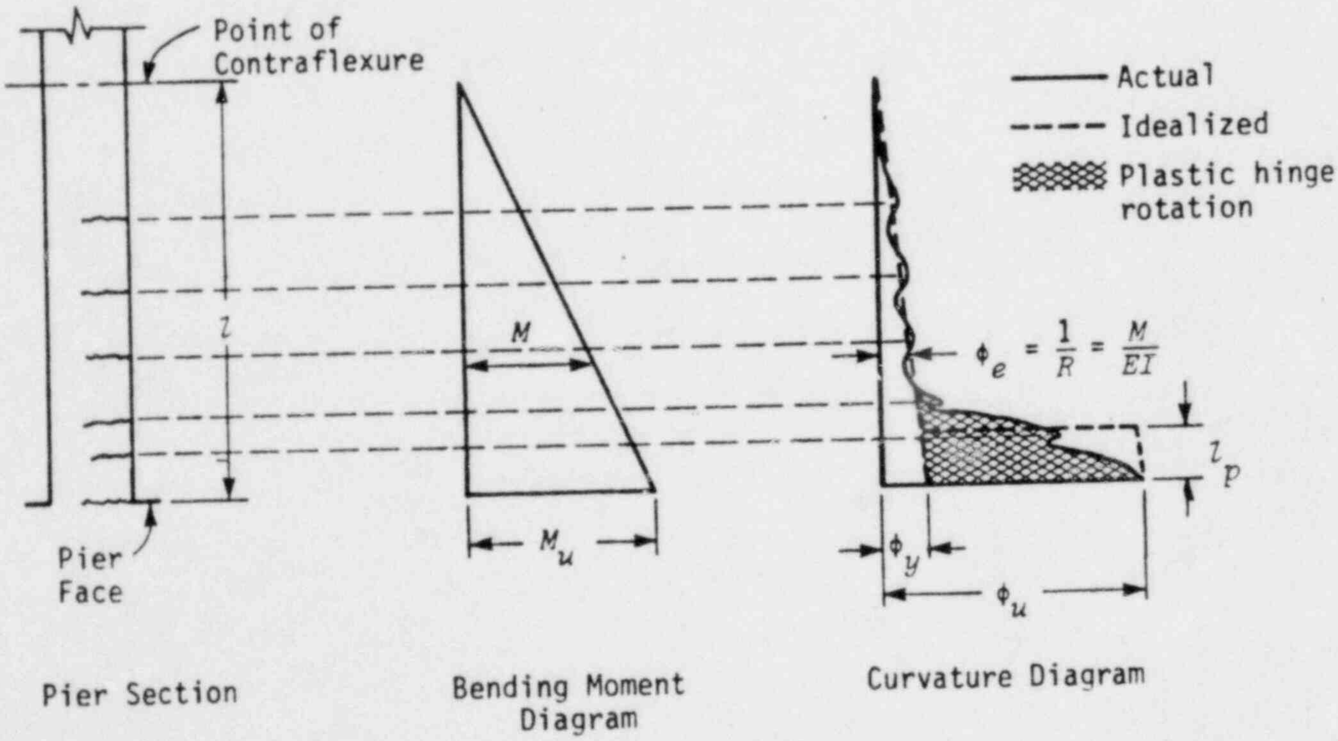
SUMMARY OF AMENDMENT 75

Location of Change	Comment
4A-iii through 4A-vi	Replaces Indices of Tables and Figures.
4A-9	Changes Figure numbers.
4A-16 through 4A-17a	Expands upon Polar Crane safety analysis discussion.
4A-23 through 4A-23f	Expands upon Polar Crane structural analysis discussion.
4A-24 through 4A-30	Expands upon Turbine Building Cranes discussion.
4A-36 through 4A-37	Expands Conclusions section.
Tables 4A-2, Sheet 4 of 8, Sheet 5 of 8	Deletes footnotes.
Tables 4A-5 through 4A-10	Makes title changes only.
Tables 4A-10A through 4A-10(0)	Adds new Polar Gantry Crane tables.
Figures 4A-2 through 4A-9	Makes title changes only.
Figures 4A-13 through 4A-20	Makes title changes only.
Figures 4A-22A through 4A-22B	Adds new figures.
Figures 4A-23A through 4A-23B	Adds new figures.
Figures 4A-24A through 4A-24H	Adds new figures.

REMOVAL - INSERTION INSTRUCTIONS

Remove	Insert Amendment 75 Material
Figure 4-333 (from Amendment 68)	Figure 4-333
Figure 4-333 (from Amendment 70)	Figure 4-334
Figure 4-334 (from Amendment 68)	Figure 4-336
Figure 4-334 (from Amendment 70)	Figure 4-337
4A-iii through 4A-vi	4A-iii through 4A-vi
4A-9	4A-9
4A-16 through 4A-17	4A-16 through 4A-17a
4A-23a through 4A-30	4A-23 through 4A-30
4A-36 through 4A-37	4A-36 through 4A-37
Table 4A-2, Sheets 4 of 8 and 5 of 8	Table 4A-2, Sheets 4 of 8 and 5 of 8
Tables 4A-5 through 4A-10	Tables 4A-5 through 4A-10
None	Tables 4A-10A through 4A-10(0)
Figures 4A-2 through 4A-9	Figures 4A-2 through 4A-9
Figures 4A-13 through 4A-20	Figures 4A-13 through 4A-20
None	Figure 4A-22A
None	Figure 4A-22B
None	Figure 4A-23A
None	Figure 4A-23B
None	Figures 4A-24A through 4A-24H

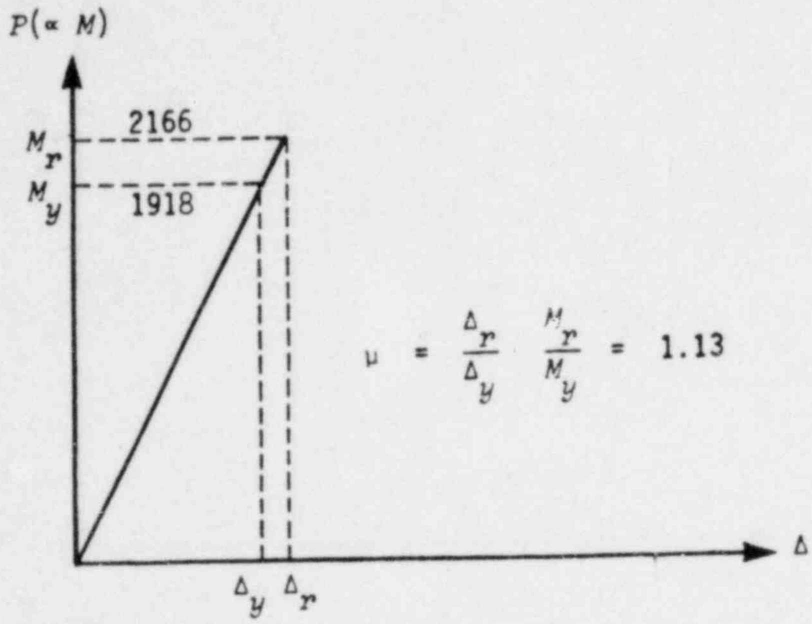
CURVATURE DUCTILITY REQUIREMENTS



$$\boxed{\frac{\phi_u}{\phi_y} = \frac{l^2(\mu - 1)}{3l_p(l - 0.5l_p)} + 1}$$

$$\text{where } \mu = \frac{\Delta_r}{\Delta_y} = \frac{\int_0^l x\phi_i dx}{\int_0^l x\phi_e dx}$$

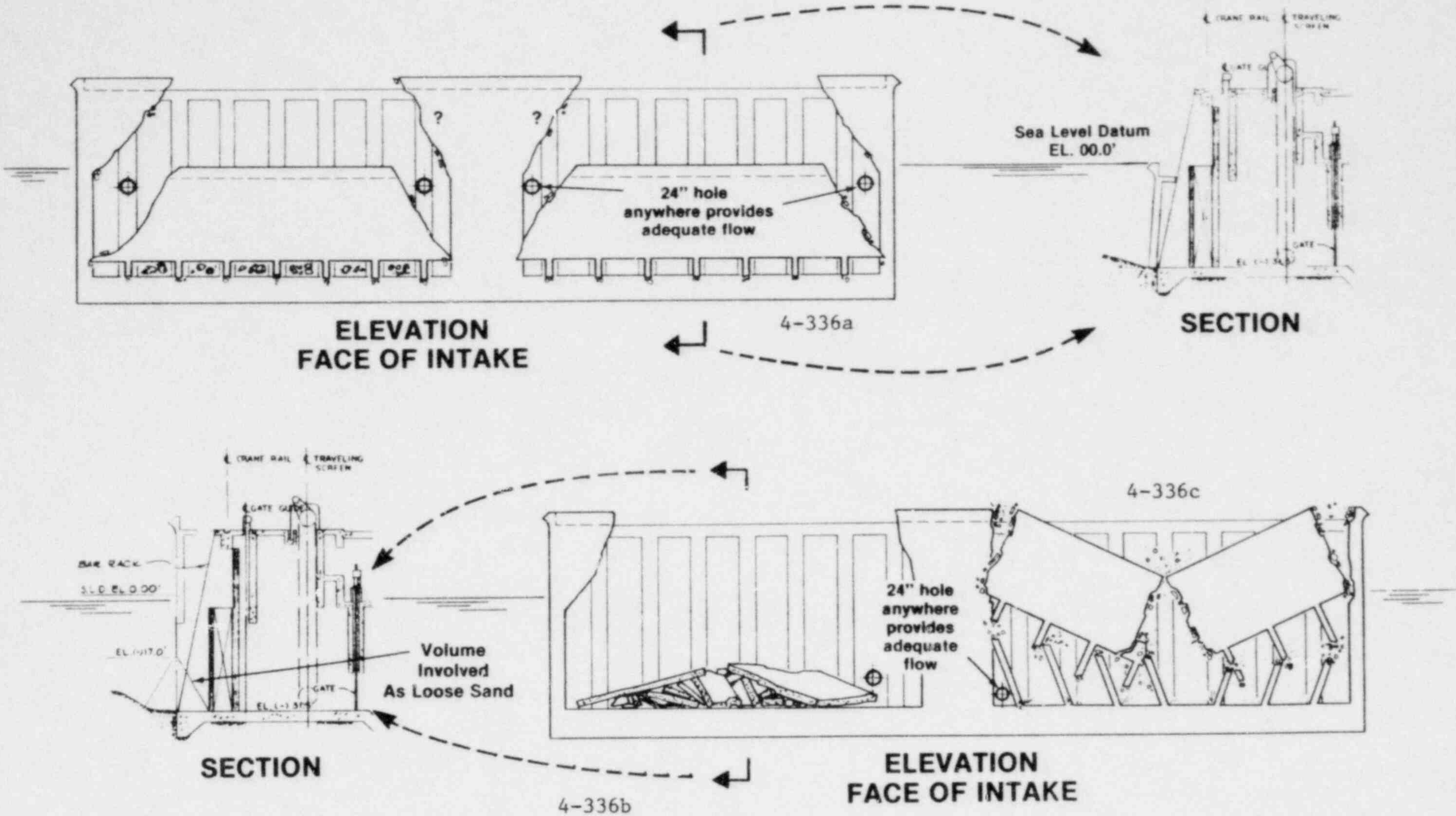
FIGURE 4-333



Displacement Ductility Factor, μ	Hinge Length ratio, l_p/l	Curvature Ductility Ratio, ϕ_u/ϕ_y
1.13	0.05	1.89
	0.10	1.45

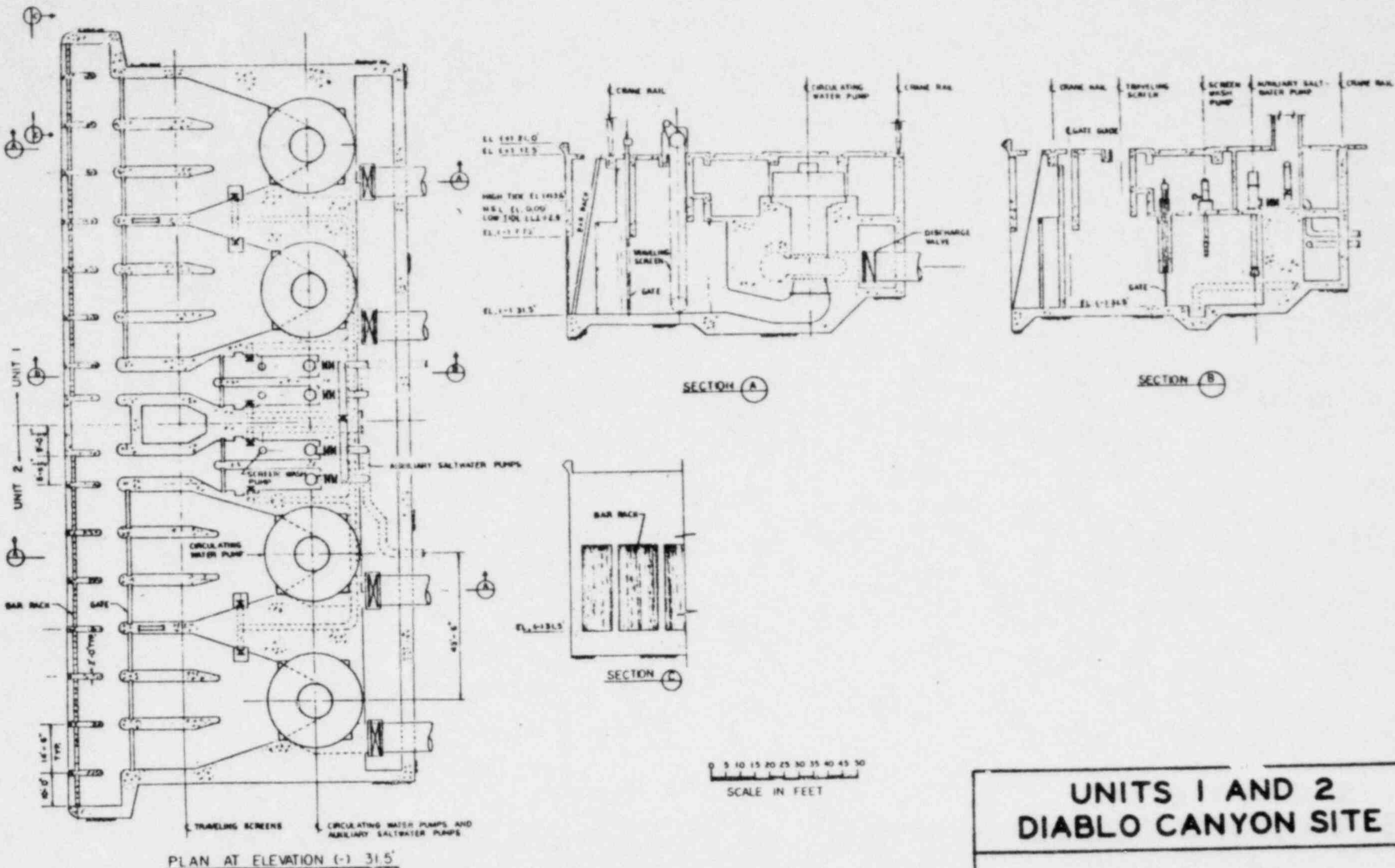
RESERVE ENERGY TECHNIQUE

FIGURE 4-334



UNITS 1 AND 2
DIABLO CANYON SITE

Figure 4-336
PATHWAY TO PUMPS



UNITS 1 AND 2
DIABLO CANYON SITE

FIGURE 4-337

ARRANGEMENT OF INTAKE STRUCTURE

INDEX OF TABLES

75

INDEX OF TABLES (Contd.)

INDEX OF FIGURES

75

INDEX OF FIGURES (Contd.)

75

The off-site radiological consequences of a postulated fuel handling accident inside the fuel handling building are mitigated by isolation of the building and venting through charcoal filters. The evaluation of the radiological consequences of such a postulated accident is presented in FSAR Sections 9.1 and 15.5. For damage of up to 15 freshly discharged assemblies the calculated exposures were below limits specified in 10 CFR 100.

4A.3.3 Structural Evaluation

Structural Criteria

Structural criteria used for the spent fuel pool cranes are the same as those described for the manipulator cranes.

Method of Analysis

Methods of analysis used are the same as those described for the manipulator cranes. Detailed mathematical models, response spectra, and other specific details used are those applicable to the spent fuel pool cranes. Sample finite element models are shown in Figures 4A-7, 4A-8 and 4A-9. The two 75
horizontal and one vertical response spectra are shown in Figures 4A-10, 4A-11 and 4A-12; these spectra were developed from the Newmark elastic spectra at elevation 140' of the auxiliary building. 7% damping is used because the crane structures are primarily of bolted steel construction; this is in accordance with NRC Regulatory Guide 1.61.

Results of Structural Evaluation

Maximum stress ratios for the typical structural members are given in Table 4A-6. All stress ratios are less than one. Thus, the structural members meet the structural criteria and are adequate during the postulated Hosgri event.

4A.5 POLAR CRANE

This section describes the methods, results and conclusions of the seismic evaluation of the Diablo Canyon polar cranes. The results of the safety evaluation support the conclusion that the polar cranes can be operated without undue risk to the health and safety of the public.

4A.5.1 Description

There are two polar cranes at the Diablo Canyon Plant, one located in each containment. These are gantry type cranes with trolleys.

The polar cranes are used for reactor head and equipment movement within the containment. The polar crane will not be used and will be maintained in the seismically locked condition during operational modes 1 (power operation) through 4 (hot shutdown). The polar cranes will be used only during modes 5 (cold shutdown) or 6 (refueling) when the primary system is below an average temperature of 200°F and there is at least a one percent shut down margin.

A discussion of the design and operation of the polar cranes is provided in Sections 1.2, 3.8 and 9.1 of the Diablo Canyon FSAR.

4A5.2 Safety Analysis

The safety-related items that could be potentially affected by a seismically induced failure of a polar crane are listed in Table 4A-3. A seismically induced failure of a polar crane which might result in damage to a safety-related item is very unlikely.

Stress and stability calculations discussed in the next subsection show that for both the seismically locked and unlocked condition, the polar cranes 75
remain stable with stresses within the prescribed acceptance criteria during the postulated Hosgri event. Thus the polar cranes can be safely operated without restriction or modification.

Results of preliminary structural analyses did not conclusively show that the polar cranes, in the unlocked condition, met the stress and stability criteria for all loading conditions. Thus in order to qualify the cranes, a safety analyses was performed evaluating the safety consequences of the seismic failure of a polar crane.

Results of further structural analyses discussed in the next subsection, now demonstrate the adequacy of the polar cranes for all conditions during the 75
postulated Hosgri event. The safety analysis, although no longer needed to qualify the cranes, is complete, supports the conclusions of the structural analyses, and provides added assurance of crane safety.

The safety analysis has shown that the crane is in the unlocked condition for only a small fraction of the lifetime of the plant. The crane can only be in the unlocked position when the reactor is shutdown (at least a one percent shutdown margin) and when the primary system is relatively cold (below an average temperature of 200°F). During this time there are two different paths for removing heat from the core. When the head is on the reactor vessel, either the RHR system or the steam generator may be used for heat removal. When the head is off the reactor vessel, either the RHR system or boiling and makeup may be used for heat removal. Even if all paths were temporarily lost, many hours would be available to re-establish one of the paths before fuel damage could occur. Thus, the plant is in a very stable and safe condition from both critical and core cooling standpoints.

In an effort to evaluate the effect on plant safety of hypothetical overturn- 75
ing of a polar crane, detailed reviews of plant layouts, including reviews of as-built drawings and site inspections, were performed. The intent of this effort was to identify safety-related items which might be adversely affected by overturning of the crane. These items have been identified in Table 4A-3. Also, the weights, frequencies, durations, and paths of all lifts have been

identified and are summarized in Table 4A-2. It is further noted that the crane is too large to enter the reactor cavity. The following paragraphs address the potential safety consequences from an unlocked crane tipping over or dropping a load on safety-related items.

Fuel

The only time that fuel would be unprotected is when the head is off of the reactor vessel and the upper internals package has been removed. Many of the items handled by a polar crane during period are large enough so they could not fit into the reactor vessel, which is just under 14 feet in diameter. Thus, only relatively small objects could fall into the vessel and only minor damage to the fuel would be expected.

Extensive safety analysis work has already been performed on fuel handling accidents inside the containment. The accident scenarios discussed in Section 15.4 of the Diablo Canyon FSAR would include damage to the fuel from an object being dropped into the reactor vessel.

The off-site radiological consequences of a postulated fuel handling accident inside the containment are mitigated by rapid containment isolation. The evaluation of the radiological consequences of such a postulated accident is presented in Section 15.5 of the FSAR. For all cases the calculated exposures were below limits specified in 10 CFR 100.

Reactor Vessel

For the drop of a large load, such as the reactor head assembly, it has been shown in Westinghouse WCAP-9198 that the integrity of the reactor vessel is maintained. Thus, the ability to cool the core is not impaired and the plant can be maintained in a safe condition.

Pressurizer

The pressurizer extends above and below the operating deck which is at the 140 foot elevation in the containment. The reinforced concrete operating deck varies from three to seven feet thick and provides protection for the lower part of the pressurizer. The upper part of the pressurizer is totally enclosed by reinforced concrete shield walls which are more than a foot thick.

Loads would not be lifted over the pressurizer. In the event the crane should tip, the shield walls extend considerably above the top of the pressurizer and would be expected to prevent pressurizer damage.

In the highly unlikely event that the pressurizer were damaged by a polar crane that tipped over, the plant could still be maintained in a safe condition. The primary system would be cold and most likely would be completely depressurized. A break of the primary system pressure boundary would, at worst, constitute a low energy break and would be much less severe than the full power LOCA for which the health and safety of the public has been assured. Potential damage to the pressurizer could not occur at a location which was less than 50 feet above the core, and thus, there would be no danger of the primary system water draining out and leaving the core uncovered. Also, additional water inventory would be available from such redundant sources as the primary water storage tank and the refueling water storage tank.

Primary System Piping

The primary system piping is located more than thirty feet below the operating deck in the containment. This piping is sufficiently protected by the operating deck and shield walls such that the probability of damage as a result of crane failure or overturning is very small. Nevertheless, should the primary system piping be damaged by a crane failure, the plant could still be maintained in a safe condition for the reason discussed previously under "Pressurizer".

Safety Injection Piping

The safety injection piping inside the containment is located at least 25 feet below the operating deck. It is sufficiently protected by the operating deck, shield walls, and piping restraints such that the probability of damage as a result of crane failure is highly unlikely. Nevertheless, should some safety injection piping be damaged by crane failure, the plant could still be maintained in a safe condition. There is a great deal of redundancy in the safety injection piping: there are four loops in the primary system and each loop has several safety injection lines which can supply water to the primary system. Even if some safety injection lines were disabled, water could still be supplied to cool the core. A breach of the primary system pressure boundary because of damage to safety injection piping would not preclude keeping the core cooled for the reasons discussed previously under "Pressurizer".

Steam Generators and Secondary System Piping

The steam generators and secondary piping are only partially protected by shield walls from a polar crane tipping over. However, in the unlikely event of a crane damaging a steam generator or secondary system piping, the plant can still be maintained in a safe condition.

During cold shutdown and refueling, steam and feedwater lines will be shut off and decay heat will be removed from the core through the RHR system. Additionally, it is noted that only one steam generator would be needed to remove decay heat. The energy and mass release from a steam generator under these shutdown conditions would not be sufficient to cause a significant pressurization of the containment.

The primary side tube bundles in the steam generator are low enough that they would be protected by shield walls as well as the upper dome of the steam generator. Even if the tube bundles were damaged, the core could still be cooled as explained previously under "Pressurizer".

Control Rod Drive Mechanisms (CRDM)

The tops of the CRDM's are sufficiently below the elevation of the operating deck to preclude damage in the unlikely event of a polar crane tipping over. Further, except during actual refueling operations, the missile shield would be in place, thereby further reducing the possibility of damaging the CRDM.

Nevertheless, in the unlikely event of the CRDM's being damaged, the plant could still be maintained in a safe condition. The primary system is relatively cold and would most likely be depressurized; thus, a breach of the primary system boundary at the CRDM seals would, at worst, constitute a low energy break which would not prevent removing heat from the core. Further, there would be at least a one percent shutdown margin from boric acid alone, so the displacement of control rods would not pose a critical problem.

Fan Coolers and Containment Spray System Piping

There are five fan coolers that are spaced around the periphery of the containment and two spray headers which are located at opposite ends of the containment. It is very unlikely that a polar crane would tip such that all five fan coolers or both spray headers would be damaged.

Even if all the fan coolers and both the spray headers were damaged the plant could still be maintained in a safe condition. During cold shutdown and refueling the primary system is relatively cold and would most likely be depressurized; thus, a breach of the primary system would not add enough mass or energy into the containment to significantly raise the pressure. Therefore, during cold shutdown and refueling, there are no safety function requirements for either the fan coolers or containment spray system, and damage to these systems during shutdown periods would not jeopardize plant safety.

Component Cooling Water System Piping

Component cooling water is supplied to the fan coolers which are located on the operating deck at the 140 foot level in the containment. Component cooling water is also supplied to the reactor coolant pumps, reactor support coolers, and to the letdown heat exchanger all of which are located considerably below, and are well protected by, the operating deck slab.

In the unlikely event that any of the lines for the component cooling water system were damaged by a polar crane tipping over, the damaged lines could be isolated by personnel present using manual valves that are located inside and outside the containment.

Any water lost from the system before the isolating valves were closed could be made up from several different sources. Even assuming that the component cooling water system were completely disabled, the plant could still be maintained in a safe condition. The auxiliary feed water system could be used to remove heat from the core via the steam generators if the reactor head were on. Boiling and makeup could be used if the head were off the reactor vessel.

Containment Wall and Equipment Hatch

It is unlikely that tipping of the polar crane would result in a severe enough impact to breach the reinforced concrete containment wall which is 3-1/2 to 4 feet thick. It is also unlikely that the crane would strike the equipment hatch.

In the unlikely event that the containment wall or equipment hatch was breached the plant could still be maintained in a safe condition with no undue risk to the health and safety of the public. Before personnel could enter the containment during cold shutdown and refueling the activity level in the containment would be very low. In addition to this low activity level there would not be significant pressure in the containment to drive activity through a breach.

4A.5.3 Structural Analysis

Structural Criteria

The structural criteria used are the same as those described for the fuel handling building crane.

Method of Analysis

Parked and Seismically Locked Condition

Methods of analysis used for the locked condition were similar to those described for the fuel handling building crane. Detailed mathematical models, response spectra and other specific details used are those applicable to the polar cranes. The finite element crane model is shown in Figure 4A-21. Horizontal and vertical response spectra used are shown in Figures 4A-23A and 4A-23B, respectively. These spectra correspond to the Newmark elastic floor response spectra for 4% damping at elevation 140' in the containment. Damping of 4% is used because the cranes are primarily welded structures. This is in acccordance with Regulatory Guide 1.61.

Unlocked Condition

For the unlocked condition, once the seismically-induced overturning moment exceeds the restoring moment (due to gravity), uplift of one side will occur and a rocking mode of response will prevail. The condition of free rocking represents one limiting situation while that of full fixity represents another. In reality, the existing crane system which includes seismic hold-down clamps will behave somewhere in between. Nonlinear analyses were performed to determine the effects of this response on the stability of the crane and the stresses in the individual structural members. 75

The polar cranes were modeled as two-dimensional nonlinear frame structures using the DRAIN-2D computer code. The structures consisted principally of beam-column elements. The support points were modeled as nonlinear gap elements.

Twc crane hold-down conditions were considered: 1) the "free" condition (an upper bound condition) which did not include the seismic hold-down clamps; and 2) the "tied" condition which included the seismic hold-down clamps.

In the first case, the gap elements developed compressive reactions but no tensile reactions. In the second case, a 1/2-in. gap was specified and then tensile forces corresponding to the hold-down capability of the clamps were allowed to develop. In this way, for both cases, the model was free to rock during the nonlinear dynamic response. Motion was input through an artificial rigid beam element. For the case with operating load, the cable was modeled as a nonlinear truss element with zero buckling strength in order to simulate impact effects of the cable-suspended load. The transverse and longitudinal nonlinear models are shown in Figures 4A-22A and 4A-22B, respectively. 75

The seismic input consisted of the acceleration histories developed for the 140-ft. elevation of the containment structure from the Newmark response spectra shown in Figures 4A-23A and 4A-23B.

Damping proportional to tangent stiffness was used in these nonlinear analyses. The coefficient $\beta = \lambda_1 T_1 / \pi = .0052$ corresponds to a transverse first-mode damping ratio of 3% for the linear response preceding uplift. The comparable value in the longitudinal direction was $\beta = 0.0081$.

Time increments, Δt, of .005 sec and .002 sec were used in the analyses. A value of .001 sec was often used to check the stability of these solutions.

Sensitivity analyses were undertaken to determine the effect of the gap element stiffness. Values of 1,000, 2,000, 4,000, 8,000, and 29,000 kip/in. were investigated.

The transverse model, incorporating the nonlinear gap and truss elements, was subjected to simultaneous horizontal and vertical seismic motions to obtain peak axial loads and transverse bending moments in the crane legs. The longitudinal model was subjected to the same motions to obtain peak 75
bending moments in the crane girders and longitudinal moments in the crane legs. The separate seismic effects were combined on an SRSS basis and added directly to gravity effects. Resulting stresses were compared with allowable values.

Results of Structural Analysis

Parked and Seismically Locked Condition

Results show that the polar cranes are structurally adequate in the parked and seismically locked condition during the postulated Hosgri seismic event. The cranes remain stable with stresses within the prescribed acceptance criteria.

The natural periods of vibration and participation factors for the longitudinal, transverse, and vertical dynamic analyses of the parked and seismically locked crane are summarized in Table 4A-10A. In accordance with the requirements of the NRC, only those modes with associated periods of vibration greater than or equal to 0.03 sec. (33 Hz) are considered significant for response computations. The funda- 75
mental frequencies of the system in the longitudinal, transverse, and vertical directions are 1.18 Hz, 4.46 Hz, and 6.66 Hz, respectively.

The predicted seismically induced displacements for the parked and seismically locked condition are shown in Table 4A-10B. The element and node numbers referred to in the tables correspond to the SAP IV computer model shown in Figure 4A-21. The maximum estimated displacements, relative to the base in the longitudinal, transverse and vertical directions are approximately 9 in., 1-1/2 in., and 1/2 in., respectively.

Maximum bending moments and axial loads for the crane legs, girders, end ties, and cross beams that result from the SRSS combined effects of the separate response spectrum analyses added directly to the dead load effects are shown in Table 4A-10C. The ratios of the computed bending moment and axial stresses to allowable values are shown in Table 4A-10D. For any member, the ratios are additive to obtain the combined stress effect. None of the combinations result in a ratio greater than 1.

Shear stresses were insignificant in all members.

The maximum support reactions are given in Table 4A-10E. These values represent the SRSS combined effects of the separate response spectrum analyses added directly to the dead load effects. The vertical reactions at the rail are compressive.

Unlocked Condition

Results for the fixed base analyses indicated excessive stresses in the hold-down anchorage system. Accordingly, two-dimensional nonlinear analyses of both the free and tied conditions were performed. Results of the nonlinear analyses demonstrate that the polar cranes can be safely operated without restriction or modification. 75

Free Condition - Analyses Allowing Free Uplift and Rocking Response

Preliminary energy balance analyses indicated that the rocking mode of response associated with the postulated Hosgri event was very stable. The energy required to cause overturning was almost six times the energy associated with the seismic motion.

Results from the more detailed response history nonlinear analyses confirmed that the rocking response was stable during the Hosgri event.

The predicted seismically-induced displacements for the unloaded and loaded condition are shown in Table 4A-10F. The element and node numbers referred to in the tables correspond to the SAP IV computer model shown in Figure 4A-21.

For the unloaded crane, maximum uplift was approximately 3 in. for the transverse excitation and 2-1/2 in. for the longitudinal excitation. Maximum relative horizontal displacements at the top of the crane (elevation 205 ft.) were approximately 10 in. in both the transverse and longitudinal directions.

For the 200-ton loaded condition, maximum uplift was approximately 4-1/2 in. in transverse rocking. There was no uplift associated with longitudinal response. Maximum horizontal displacements at the top of the crane were approximately 13 in. and 10 in. in the transverse and longitudinal directions, respectively. Typical response histories for the vertical displacement of each crane leg at the rail during rocking as a result of the postulated transverse and vertical seismic motions are given in Figures 4A-24A and 4A-24B. It can be seen that the crane uplifts several times with a peak uplift of slightly over 4 in. Corresponding horizontal displacement histories of the crane girder and the load are shown in Figures 4A-24C and 4A-24D, respectively. The maximum lateral displacement of approximately 13 in. is evident from Figure 4A-24C. Pendulum motion of the load with a peak displacement of nearly 75
18 in. is indicated in Figure 4A-24D.

Maximum bending moments and axial loads for the crane legs, girders, end ties, and cross beams that result from the SRSS combined effects of the separate components of seismic excitations added directly to the dead load effects for the unloaded and loaded condition are shown in Tables 4A-10G and 4A-10H. The ratios of the computed bending moment and axial stresses to allowable values are shown in Tables 4A-10I and 4A-10J. For any member, the total interaction ratio is the sum of that due to dead load and the SRSS combination of those due to the separate earthquake effects. None of the combinations result in a ratio greater than 1.

Shear stresses were insignificant in all members.

<u>Tied Condition - Analyses Incorporating Hold-Down System Failure Characteristics</u>

The effect of the hold-down system on the seismic response of the crane structure was evaluated.

Preliminary analyses based on energy considerations indicated that if the rail clamps became active after the initial 1/2-in. gap uplift, maximum total uplifts would be less than those for the situation with free uplift. Thus, the crane would remain stable during the postulated Hosgri event.

Results from the more detailed response history nonlinear analyses confirmed that the rocking response was stable during the Hosgri event. Maximum displacements are given in Table 4A-10K.

For the unloaded crane, maximum uplift was approximately 1-1/2 in. due to transverse and longitudinal rocking, respectively. Maximum horizontal displacements at the top of the crane (elevation 205 ft.) were approximately 7 in. and 9 in. in the transverse and longitudinal directions, respectively.

For the 200-ton loaded condition, maximum uplift was approximately 1 in. in transverse rocking. There was no uplift associated with longitudinal response. 75
Maximum horizontal displacements at the top of the crane were approximately 7-1/2 in. and 10 in. in the transverse and longitudinal directions, respectively.

Typical response histories for the vertical displacement of each crane leg at the rail during rocking as a result of the postulated transverse and vertical seismic motions are given in Figures 4A-24E and 4A-24F. It can be seen that the crane uplifts several times with a peak uplift of slightly less than 1 in.

Corresponding horizontal displacement histories of the crane girder and the load are shown in Figures 4A-24G and 4A-24H, respectively. The maximum lateral displacement of approximately 8 in. is evident from Figure 4A-24G. Pendulum motion with a peak displacement of approximately 16 in. is indicated in Figure 4A-24H.

Maximum bending moments and axial loads for the crane legs, girders, end ties, and cross beams that result from the SRSS combined effects of the separate components of seismic excitations added directly to the dead load effects for the unloaded and loaded conditions are shown in Tables 4A-10L and 4A-10M. The ratios of the computed bending moment and axial stresses to allowable values are shown in Tables 4A-10N and 4A10(O). For any member, the total interaction ratio is the sum of that due to dead load and the SRSS combination of those due to the separate earthquake effects. None of the combinations result in a ratio greater than 1. 75

Shear stresses were insignificant in all members.

4A.5.4 Results and Conclusions

The results of the seismic evaluation of the polar cranes demonstrate that the cranes without restriction or modification, comply with the NRC Staff's guidelines and can be operated without undue risk to the health and safety of the public. 75

4A.6 TURBINE BUILDING CRANES

This section describes the methods, results and conclusions of the seismic evaluation of the Diablo Canyon turbine building cranes. The results of this safety evaluation support the conclusion that the turbine building cranes can be operated without undue risk to the health and safety of the public.

4A.6.1 Description

There are two turbine building cranes at the Diablo Canyon Plant which are located in the turbine building. These bridge-type cranes have trolleys which travel in a direction perpendicular to the travel of the bridge. The cranes span the width of the turbine building and are approximately 40 feet above the operating deck of the turbine building.

The turbine building cranes are used for moving equipment during inspection and maintenance and may be used during plant operation. Analyses show that the cranes and turbine building are structurally adequate for loads of 100 tons or less during the postulated Hosgri event. The cranes will not be parked over the main steam lines. 75

A description of the design of the turbine building cranes is provided in Section 1.2 and Chapter 3 of the Diablo Canyon FSAR.

4A.6.2 Safety Analysis

The only safety-related items located in the turbine building are the diesel generators, 4KV switch gear, and component cooling water heat exchangers. A seismically induced failure of a turbine building crane which might result in damage to one of these safety-related items is very unlikely.

Stress and stability calculations discussed in the next subsection show that, for the unloaded and loaded (100 tons or less) conditions, the cranes remain stable and stresses in the cranes and turbine building remain within the prescribed acceptance criteria during the postulated Hosgri event.

Results of preliminary structural analyses showed that the cranes were adequate for loads up to 100 tons, but that the turbine building exterior columns were limited to crane loads of 15 tons or less. Rather than initiating building modifications, a safety analysis was performed to evaluate the safety consequences of the seismic failure of a turbine building crane.

Further structural analyses, discussed in the next subsection, identified the modifications necessary to qualify the turbine building for crane loads up to 100 tons. These modifications are underway. The safety analysis, although no longer necessary to qualify the cranes for operation during the postulated Hosgri event, is complete, supports the conclusions of the structural analyses, and provides added assurance of crane safety.

For the most part, heavy loads (greater than 15 tons) would only be lifted when a unit is shut down. During this time the primary system is cold and there are three different paths for removing heat from the core: via the RHR system or the steam generators or by boiling and makeup. Even if all paths were temporarily lost, many hours would be available to reestablish one of the paths before the core began to overheat.

In an effort to evaluate the effect on plant safety of a postulated seismic failure of the turbine building crane, detailed reviews of plant layout including reviews of as-built drawings and site inspections were performed. The intent of this effort was to identify safety related items which might be adversely affected by a seismic failure of the turbine building crane. These items have been identified in Table 4A-3. Also, for all lifts the lift weights, frequencies, durations, and paths have been identified and are summarized in Table 4A-2.

The following paragraphs address the potential safety consequences from seismic failure of a turbine building crane.

Component Cooling Water Heat Exchangers

It is very unlikely that a seismic failure of the turbine building crane would damage a component cooling water heat exchanger. There are two heat exchangers per unit, located along the east wall of the turbine building. Because they are directly under offices that are located on the operating deck, a crane should never have a load above these heat exchangers. The heat exchangers are on the 85 foot level and are more than 45 feet below the operating deck. They are protected by two reinforced concrete decks and by several walls. 75

Nevertheless, even in the unlikely event that both component cooling water heat exchangers for a unit were damaged, the plant could still be maintained in a safe condition. Component cooling water could be supplied from the undamaged unit to the damaged unit via a cross tie line, and so, heat could be removed from the core via the RHR system. In addition to heat removal through the RHR system, heat could also be removed from the core via the steam generators. There would be many days supply of water for the auxiliary feed water system. Heat could also be removed from the core by boiling and makeup if the head were off the reactor vessel.

Diesel Generators

It is very unlikely that a seismic failure of the turbine building crane would damage the diesel generators. The diesel generators are located along the west wall near the north and south end bays of the turbine building. The diesel generators are on the 85 foot level and are more than 45 feet below the operating deck of the turbine building. They are protected by two reinforced concrete decks and by several walls.

Nevertheless, even in the unlikely event that the diesel generators were damaged by the seismic failure of a turbine building crane, the plant could still be maintained in a safe condition. The diesel generators would only be needed if off-site power were unavailable. If that were the case, heat could be removed from the core via the steam generators or by boiling and makeup if the head were off the reactor vessel. There would be many days supply of feedwater which would allow sufficient time to restore off-site power or route power from the diesel generators in the undamaged unit.

4KV Switchgear

It is very unlikely that a seismic failure of the turbine building crane would damage the 4KV switchgear.

The switchgear is located near the north and south end bays of the turbine
building. The switchgear is on the 119 foot level and it is more than 20 feet
below the operating deck of the turbine deck. It is protected by a reinforced 75
concrete deck and by several walls.

In the unlikely event that the switchgear were damaged by the seismic failure of a turbine building crane, the plant could still be maintained in a safe condition. In addition to heat removal through the RHR system, heat could also be removed from the core via the steam generators or by boiling and makeup if the head were off the reactor vessel. There would be many days supply of water for the auxiliary feedwater system.

4A.6.3 Structural Analysis

Structural Criteria

The structural criteria used are the same as those described for the fuel handling building crane.

Method of Analysis

Methods of analysis used were similar to those described for the fuel handling building crane. Detailed mathematical models, response spectra, and other specific details used are those applicable to the turbine building cranes. The cranes were modeled as part of the building. Finite elements models for the linear and nonlinear analyses are shown in Figures 4A-25, 4A-26 and 4A-27. Horizontal spectra (Figures 4A-28 and 4A-29) for the crane/building model were the Blume (τ = 0.08) and Newmark (τ = 0.067) horizontal elastic spectra for 7% damping. The time histories corresponding to these spectra were increased by 10% to account for torsion. The vertical input spectrum (Figure 4A-30) for the crane/building model was 2/3 the Newmark 0.75g horizontal free-field response spectrum.

North-south dynamic analyses of the planar turbine building wall, both with and without the crane mass, were performed using the TABS computer code to obtain mode shapes, frequencies, and participation factors. This provided the input for a MATRAN analysis (mathematical manipulation) whereby a north-south response spectrum and time history was generated at elevation 180 ft., the crane rail. The crane model (Figure 4A-26) was then subjected to a response spectrum analysis using the derived response spectra at elevation 180 ft. (Figures 4A-31 and 4A-32) and structural damping of 4% for the unloaded crane to obtain north-south response. In accordance with Regulatory Guide 1.61, damping of 4% was used because the crane is primarily a welded structure. In this model, the total trolley mass was lumped on one girder for lateral response. Lateral framing action provided by the two crane girders and end ties was also considered.

Linear dynamic analyses of the crane/building model were performed using the SAP IV structural analysis computer code. The results were used in conjunction with the SPECTH computer code to obtain the acceleration time histories of the bridge girder support nodes at elevation 180 ft. (Figure 4A-33).

Nonlinear vertical analyses of the loaded crane were then performed using this motion as input to the DRAIN-2D computer code. The DRAIN-2D model for vertical analyses is shown in Figure 4A-27. Structural damping of 4% in the first two modes was adopted for these analyses.

The horizontal pendulum motion of the suspended load was determined using both the DRAIN-2D nonlinear time history analysis method and the SAP/SPECTH response spectrum method.

<u>Results of Structural Analysis</u>

Results of the linear and nonlinear analyses show that, except for a few structural modifications, the crane/building system is adequate during the 75
postulated Hosgri seismic event for the unloaded case and for an operational load up to 100 tons.

Minor structural modifications are necessary to transmit the horizontal and upward vertical forces directly from the trolley to the crane bridge girders and from the crane bridge girders to the crane runway girders. These minor modifications are currently underway and will be completed prior to operation. Sliding of a few inches can be expected along the trolley and crane runways during the postulated Hosgri earthquake.

Analysis also shows that structural modifications are necessary to qualify the turbine building exterior columns to allow the crane to carry a 100 ton load during the postulated Hosgri event. The modifications consist of strengthening 26 of the 54 exterior columns by welding additional material to the columns between elevations 130 feet and 150 feet. The modifications 75
are currently underway and will be completed prior to operation. Refer to Section 4.4.7 for further details of the modifications. When complete, these building modifications together with the above mentioned minor crane modifications, will allow unrestricted use of the turbine building cranes for loads up to 100 tons.

Predicted seismic-induced relative displacements for the unloaded and loaded 75
crane are summarized in Tables 4A-11 and 4A-12. The element and node numbers shown in the tables correspond to the computer model shown in Figure 4A-26. The maximum estimated displacements, relative to the crane supports, are approximately 2 in. and 5 in. in the north-south and vertical directions, respectively.

The ratio of the computed bending moment and axial stresses to allowable values for the main crane members with a 100 ton load are shown in Table 4A-13. For each member, earthquake effects were combined on an SRSS basis and added directly to the dead load effects to obtain the combined stresses. None of the combinations is greater than 1. 75

4A.6.4 Results and Conclusions

The results of the seismic evaluation of the turbine building cranes demonstrate that the cranes comply with the NRC Staff's guidelines. The cranes can be operated without undue risk to the health and safety of the public. Structural analysis shows that for the unloaded and loaded (100 tons or less) conditions, the cranes remain stable and stresses in the cranes and turbine building remain within the prescribed acceptance criteria during the postulated Hosgri event. The safety analysis supports the structural analyses 75
and demonstrates that a seismically induced failure of a turbine building crane does not preclude maintaining the plant in a safe condition.

4A.9 CONCLUSIONS

The seismic evaluation of the Diablo Canyon Plant cranes discussed in this chapter demonstrates that the plant cranes comply with the NRC staff's guidelines. The safety analysis demonstrates that the probability that a seismically induced crane failure would disable a safety-related item is very small, and that even in this unlikely event, the plant could be maintained in a safe condition. The seismic evaluation strongly supports the conclusion that the plant can be operated with use of the cranes and not pose undue risk to the health and safety of the public.

For the manipulator, spent fuel pool, polar and intake structure cranes,
structural analyses show that for the unloaded and loaded conditions the
cranes remain stable and stresses in the main structural members and joints
remain within the prescribed acceptance criteria during the postulated Hosgri 75
event. Exposure calculations show that in the unlikely event of a seismically
induced crane failure, the potential exposures would be below limits specified
in 10 CFR 100.

For the fuel handling building crane, structural analyses show that the crane 75
remains stable with stresses within the prescribed acceptance criteria during
the postulated Hosgri event for loads up to 15 tons. Exposure calculations
show that in the unlikely event of a seismically induced fuel handling
accident that potential exposure for damage of up to 15 freshly discharged
assemblies would be below limits specified in 10 CFR 100.

For the turbine building cranes, structural analyses demonstrate that the
cranes remain stable and stresses in the cranes and turbine building remain 75
within the prescribed acceptance criteria for loads of up to 100 tons during
the postulated Hosgri event. Additionally, extensive safety analysis work has
been presented that demonstrates seismically induced failure of a turbine
building crane would not preclude maintaining the plant in a safe condition.

In summary, the results of this seismic evaluation of the Diablo Canyon plant cranes demonstrate that operation of the plant using the cranes will not pose undue risk to the health and safety of the public. 75

TABLE 4A-2
SUMMARY OF CRANE OPERATION

CRANE	LIFTS	NUMBER OF COMPONENTS	LIFT WEIGHT	LIFT FREQUENCY	LIFT DURATION	LIFT PATH	SAFETY RELATED EQUIPMENT PASSED OVER	TIME PER YR. COMPONENT IS SUSPENDED OVER SAFETY RELATED EQUIPMENT
Fuel Handling Building Crane (Continued)	4. Miscellaneous pumps and equipment	Large	3 Tons	Continuous, as required	1 Hr	Throughout Hot Shop area of auxiliary building	Liquid hold up tanks, fuel in shipping containers, spent fuel pool heat exchangers, auxiliary feedwater pumps and fire water pumps	2080 Hrs
	5. RCP Motor	8	43.8 Tons	4 times per year	0.33 Hr	Within Hot Shop area of auxiliary building	Boric acid storage tanks, liquid hold up tanks, boric acid transfer pumps	1.33 Hrs
Spent Fuel Pool Cranes	1. Fuel	252	.85 Ton	504 per year	0.25 Hr	Between fuel transfer canal, spent fuel pool & delivery area at 115 ft. level	Fuel, spent fuel pool heat exchangers, auxiliary feedwater pumps and fire water pumps	63 Hrs
Turbine Building Bridge Cranes	1. H.P. turbine rotor	2	55 Tons	4 lifts every 4 years	0.5 Hr	40 ft west & 60 ft south	None	0
	2. H.P. blade rings	6	15 Tons	12 lifts every 4 years	0.5 Hr	60 ft south	None	0
	3. H.P. outer cover	2	85 Tons	4 lifts every 4 years	0.5 Hr	30 ft east & 165 ft north	None	0
	4. L.P. rotors	6	100 Tons	12 lifts in 4 yrs	0.5 Hr	1 lift moves 50 ft east & 50 ft south 2 lifts move 50 ft east & 100 ft to 170 ft north	None	0

75

TABLE 4A.-2
SUMMARY OF CRANE OPERATION

CRANE	LIFTS	NUMBER OF COMPONENTS	LIFT WEIGHT	LIFT FREQUENCY	LIFT DURATION	LIFT PATH	SAFETY RELATED EQUIPMENT PASSED OVER	TIME PER YR. COMPONENT IS SUSPENDED OVER SAFETY RELATED EQUIPMENT
Turbine Building Bridge Cranes (Continued)	5. L.P. outer cover	6	57.5 Tons	12 lifts in 4 yrs	0.5 Hr	0 to 50 ft east & 0 to 200 ft south	None	0
	6. L.P. cylinder cover #1	6	27.5 Tons	12 lifts in 4 yrs	0.5 Hr	30 ft east & 85 ft to 170 ft south	None	0
	7. L.P. cylinder cover #2	6	57.5 Tons	12 lifts in 4 yrs	0.5 Hr	2 lifts move 50 ft east & 100 ft to 170 ft north, 1 lift moves 50 ft east & 0 to 80ft south	None None	0 0
	8. FW pump turbine	4	7 Tons	1 lift per year	0.5 hr	From feedwater pump hatch to main equipment hatch	None	0
	9. Excitor housing	2	8.5 Tons	4 lifts every 3rd year	0.5 Hr	50 ft east & 40 ft south	None	0
	10. Generator rotor and excitor	2	200 Tons	4 lifts every 3rd year. The only 2 crane lift.	3 Hrs	90 ft north	None	0
	11. Mobile crane	1	20 Tons	20 lifts per year	0.5 Hr	To and from 85 ft level to 140 ft level	None	0
	12. Crane with no load	-	0	--	--	A few times a yr while a unit is in operation, the crane will be moved from parked position	Diesel generator and 4 kV switchgear, CCWHX	0.5

TABLE 4A-5

MANIPULATOR CRANE
MAXIMUM MEMBER STRESS RATOIS* 75

Member Description	Stress Ratio for Cases Analyzed**			
	A	B	C	D
Monorail Beam	.35	.32	.16	.16
Monorail Brackets	.15	.15	.15	.15
Monorail Columns	.44	.43	.45	.44
Monorail Bracing	.40	.30	.40	.39
Bridge Trucks	.19	.18	.21	.19
Back Girder	.46	.45	.44	.45
Bridge Drive Support	.90	.88	.75	.88
Front Girder	.25	.24	.42	.24
Trolley Trucks	.41	.40	.59	.40
Trolley Drive Support	.38	.37	.55	.37
Fuel Hoist Support	.40	.29	.43	.29
Mast Support Beam	.52	.41	.51	.40
Mast Support Tube	.11	.08	.11	.08
Tower Corner Angles	.26	.18	.26	.18
Tower Lacing Angles	.27	.21	.30	.21
Pulley Support Channels	.53	.20	.50	.20
Gripper Tube	.22	.22	.28	.22
Stationary Mast	.26	.19	.26	.19

---

* Stress Ratio is the ratio of calculated stress divided by the allowable.

TABLE [illegible]-6

SPENT FUEL POOL CRANE

SUMMARY OF THE STRESS RATIO IN MEMBERS* 75

Member Element #	Description of the Member	Stress Ratio From Interaction Formula	
		Normal Condition	Actual Faulted Condition
5	Top Horizontal Monorail (S 8x18.4)	0.010	0.560
65	Top Horizontal Monorail (S 8x18.4)	0.394	0.389
79	Top Horizontal Monorail (S 8x18.4)	0.393	0.392
62	Top Horizontal Beam of the Main Frame (S 12x31.8)	0.399	0.300
76	Top Horizontal Beam of the Main Frame (S 12x31.8)	0.386	0.298
39	Top Horizontal Beam of the Main Frame (S 12x31.8)	0.133	0.712
107	Top Horizontal Beam of the Main Frame (S 12x31.8)	0.107	0.456
18	Columns of the Main Frame (W 8x31)	0.243	0.499
21	Columns of the Main Frame (W 8x31)	0.318	0.544
121	Columns of the Main Frame (W 8x31)	0.330	0.545
35	Bottom Horizontal Beam of the Main Frame (2[12x25)	0.120	0.273
58	Bottom Horizontal Beam of the Main Frame (2[12x25)	0.079	0.250
97	Bottom Horizontal Beam of the Main Frame (2[12x25)	0.122	0.276
100	Main Frame Corner Bracing Member (W 4x13)	0.120	0.347
103	Main Frame Corner Bracing Member (W 4x13)	0.073	0.265
66	Top Frame Diagonal Bracing Member (L 3x3x3/8)	0.214	0.306
102	Bottom Frame Bracing (L 2x2x1/4)	0.079	0.955
140	Side Frame Diagonal Bracing Member (L 3x3x3/8)	0.178	0.270

*The highest stress ratio for typical member listed

TABLE 4A-7

FUEL-HANDLING BUILDING CRANE

MAXIMUM DISPLACEMENTS,

UNLOADED CASE

75

Nodal Point	Displacement (in.)	
	North-South Direction	Vertical Direction
71	0	0
85	0.099	-0.203
99	0.274	-0.355
113	0.346	-0.415
129	0.274	-0.355
144	0.099	-0.203
162	0	0

Notes:

1. All displacements are measured relative to ends of crane.
2. All nodal points refer to Figure 4A-14.

TABLE 4A-8 75

FUEL-HANDLING BUILDING CRANE

MAXIMUM DISPLACEMENTS,

LOADED CASE, 15 TONS

Nodal Point	Displacement (in.)	
	North-South Direction	Vertical Direction
71	0	0
85	0.116	-0.251
99	0.322	-0.448
113	0.407	-0.528
129	0.322	-0.448
144	0.116	-0.251
162	0	0

Notes:

1. All displacements are measured relative to ends of crane.
2. All nodal points refer to Figure 4A-14.

TABLE 4A-9

FUEL-HANDLING BUILDING CRANE
MAXIMUM STRESS RATIOS,
UNLOADED CASE

75

Element	$(\frac{f_{b_x}}{F_b})$ vert	$(\frac{f_{b_y}}{F_b})$ N/S	$(\frac{f_{b_x}}{F_b})$ DL	Total
3	0.06	0.04	0.04	0.11
5	0.11	0.08	0.08	0.22
7	0.15	0.12	0.11	0.30
9	0.15	0.12	0.11	0.30
11	0.11	0.08	0.08	0.22
13	0.06	0.04	0.04	0.11

Note:

All element numbers refer to Figure 4A-14.

Key

f_{b_x} - computed bending stress about x-axis

f_{b_y} - computed bending stress about y-axis

F_b - bending stress permitted in absence of axial force

TABLE 4A-10

FUEL-HANDLING BUILDING CRANE

MAXIMUM STRESS RATIOS,

LOADED CASE, 15 TONS

75

Element	$(\frac{f_{b_x}}{F_b})$ vert	$(\frac{f_{b_y}}{F_b})$ N/S	$(\frac{f_{b_x}}{F_b})$ DL	Total
3	0.07	0.04	0.06	0.14
5	0.13	0.10	0.11	0.27
7	0.18	0.14	0.14	0.37
9	0.18	0.14	0.14	0.37
11	0.13	0.10	0.11	0.27
13	0.07	0.04	0.06	0.14

Note:

All element numbers refer to Figure 4A-14.

Key

f_{b_x} - computed bending stress about x-axis

f_{b_y} - computed bending stress about y-axis

F_b - bending stress permitted in absence of axial force

TABLE 4A-10A

POLAR GANTRY CRANE

PERIODS OF VIBRATION AND PARTICIPATION FACTORS,

SEISMICALLY LOCKED (UNLOADED)

Node	Period (sec)	Participation Factor (%)		
		Longitudinal Direction	Transverse Direction	Vertical Direction
1	0.848	63.7	-	0.1
2	0.235	0.1	1.8	0.5
3	0.224	-	37.2	-
4	0.170	-	1.0	-
5	0.150	0.1	0.1	26.3
6	0.136	-	19.5	-
7	0.113	-	7.6	0.2
8	0.096	0.1	0.3	0.9
9	0.079	-	14.2	-
10	0.073	16.5	-	3.3
11	0.068	0.7	-	15.4
12	0.056	-	0.1	0.1
13	0.055	0.1	0.2	1.6
14	0.055	-	2.1	0.5
15	0.052	-	6.2	0.2
16	0.044	3.8	0.6	15.6
17	0.042	4.7	0.9	1.5
18	0.040	6.1	0.2	26.5
19	0.037	0.3	0.2	2.1
20	0.034	-	1.3	0.6
21	0.034	0.7	5.9	3.4
22	0.031	3.0	0.4	1.2

75

TABLE 4A-10B

POLAR GANTRY CRANE

MAXIMUM DISPLACEMENTS,

SEISMICALLY LOCKED (UNLOADED)

Nodal Point	Longitudinal Direction (in.)	Transverse Direction (in.)	Vertical Direction (in.)
1	-	-	-
5	1.48	-	0.01
11	1.48	-	0.01
13	4.87	0.04	0.03
15	6.99	0.06	0.04
19	8.52	0.02	0.06
25	8.52	0.01	0.04
27	8.97	0.15	0.07
31	9.21	0.35	0.07
37	9.21	0.63	0.35
41	9.21	0.98	0.51
43	9.21	0.30	0.36
45	9.21	1.28	0.58
49	9.21	0.30	0.34
50	9.21	1.38	0.60
52	9.21	1.29	0.58
54	9.21	0.99	0.51
56	9.21	0.60	0.35
60	9.21	0.21	0.06
64	9.21	0.21	0.04
67	8.94	0.10	0.05
71	8.50	0.02	0.05
77	6.97	0.04	0.04
79	8.50	0.01	0.02
81	4.86	0.03	0.02
85	1.48	-	0.01
91	-	-	-
93	1.48	-	0.01

Notes: 1. All displacements are measured relative to base of crane.
2. All nodal points refer to Figure 4A-21.

75

TABLE 4A-10C

POLAR GANTRY CRANE

MAXIMUM FORCES,

SEISMICALLY LOCKED (UNLOADED)

Element	Axial Force (kips)	Bending Moment About Axis 2 (kip-in.)	Bending Moment About Axis 3 (kip-in.)
4	410.4	32,100	2,700
6	397.5	68,400	7,600
9	347.3	82,000	4,300
10	343.4	89,900	9,300
11	126.4	14,800	18,200
12	197.7	91,000	23,100
15	177.6	44,000	17,500
19	184.0	89,200	19,400
20	276.1	89,300	9,700
21	280.2	81,700	10,400
24	314.7	68,400	4,900
26	328.0	13,800	1,900
59	44.7	1,700	300
62	205.4	8,100	12,000
69	156.4	3,300	7,500
72	29.8	1,300	900

Note: All element numbers refer to Figure 4A-21.

75

TABLE 4A-10D

POLAR GANTRY CRANE

MAXIMUM STRESS RATIOS,

SEISMICALLY LOCKED (UNLOADED)

	Interaction Ratios				
		Earthquake Component			
Element	Dead Load	Transverse	Longitudinal	Vertical	Total
4	0.05	0.10	0.27	0.05	0.34
6	0.05	0.14	0.57	0.05	0.64
9	0.05	0.24	0.58	0.05	0.68
10	0.05	0.18	0.58	0.04	0.66
11	-	0.18	-	-	0.18
12	0.01	0.21	0.27	0.01	0.35
15	0.04	0.18	-	0.07	0.23
19	0.01	0.17	0.30	0.01	0.35
20	0.03	0.14	0.58	0.04	0.63
21	0.03	0.17	0.58	0.04	0.64
24	0.04	0.11	0.57	0.05	0.62
26	0.03	0.09	0.26	0.05	0.31
59	-	0.06	-	-	0.06
62	-	0.32	-	-	0.32
69	-	0.19	-	-	0.19
72	-	0.06	-	-	0.06

75

Notes:
1. All element numbers refer to Figure 4A-21.
2. The total interaction ratio is the sum of that due to dead load and the SRSS combination of the separate earthquake effects.

TABLE 4A-10E

POLAR GANTRY CRANE

MAXIMUM SUPPORT REACTIONS,

SEISMICALLY LOCKED (UNLOADED)

Node	Support Reaction (kips)		
	Longitudinal	Transverse	Vertical
1	141	18	435
2	141	28	437
12	-	93	-
26	-	428	65
80	-	314	62
91	141	12	349
92	141	19	332
94	-	64	-

Note: All nodes refer to Figure 4A-21.

75

TABLE 4A-10F

POLAR GANTRY CRANE

MAXIMUM DISPLACEMENTS,

UNLOCKED - FREE

Condition	Nodal Point	Longitudinal Direction (in.)	Transverse Direction (in.)	Vertical Direction (in.)
Unloaded	1	-	-	2.66
	2	-	-	3.25
	19	9	7.14	2.66
	31	9.26	9.90	2.66
	41	9.26	9.92	2.49
	50	9.26	9.92	1.34
Loaded, 200 tons	1	-	-	3.07
	2	-	-	4.59
	19	9.69	9.33	3.07
	31	9.97	13.02	3.06
	41	9.97	13.04	3.02
	50	9.98	13.04	-2.96

75

Note: All nodes refer to Figure 4A-21.

TABLE 4A-10G

POLAR GANTRY CRANE

MAXIMUM FORCES,

UNLOCKED - FREE (UNLOADED)

Element	Axial Force (kips)	Bending Moment About Axis 2 (kip-in.)	Bending Moment About Axis 3 (kip-in.)
4	461	13,149	13,728
6	438	70,558	14,472
9	342	76,272	2,538
10	338	92,226	7,811
11	15	3,191	-
12	60	93,057	-
15	20	71,408	-
19	77	90,960	-
20	319	92,084	7,811
21	323	76,260	2,538
24	419	70,555	14,472
26	442	12,931	13,728
59	-	16,835	-
62	-	13,073	-
69	-	13,073	-
72	-	16,835	-

Note: All elements refer to Figure 4A-21.

75

TABLE 4A-10H

POLAR GANTRY CRANE

MAXIMUM FORCES,

UNLOCKED - FREE (LOADED)

Element	Axial Force (kips)	Bending Moment About Axis 2 (kip-in.)	Bending Moment About Axis 3 (kip-in.)
4	731	14,615	20,859
6	709	79,373	22,351
9	598	85,880	3,191
10	594	104,115	12,132
11	15	2,644	-
12	60	101,619	-
15	20	171,874	-
19	77	99,458	-
20	575	103,959	12,132
21	579	85,869	3,191
24	690	79,374	22,351
26	713	14,468	20,859
59	-	25,150	-
62	-	20,220	-
69	-	20,220	-
72	-	25,150	-

Note: All elements refer to Figure 4A-21.

75

TABLE 4A-10I

POLAR GANTRY CRANE

MAXIMUM STRESS RATIOS,

UNLOCKED - FREE (UNLOADED)

Element	Dead Load	Interaction Ratios			
		Earthquake Component			Total
		Transverse	Longitudinal	Vertical	
4	0.06	0.30	0.27	0.04	0.47
6	0.07	0.22	0.57	0.06	0.68
9	0.06	0.07	0.58	0.06	0.65
10	0.06	0.11	0.58	0.05	0.65
11	-	-	-	-	-
12	0.02	-	0.27	0.01	0.29
15	0.08	-	-	0.13	0.21
19	0.01	-	0.27	0.01	0.28
20	0.06	0.11	0.58	0.05	0.65
21	0.06	0.07	0.58	0.06	0.65
24	0.06	0.22	0.57	0.06	0.67
26	0.05	0.30	0.27	0.03	0.45
59	-	0.28	-	-	0.28
62	-	0.18	-	-	0.18
69	-	0.18	-	-	0.18
72	-	0.28	-	-	0.28

Notes: 1. All element numbers refer to Figure 4A-21.
2. The total interaction ratio is the sum of that due to dead load and the SRSS combination of the separate earthquake effects.

75

TABLE 4A-10J

POLAR GANTRY CRANE

MAXIMUM STRESS RATIOS,

UNLOCKED - FREE (LOADED)

Element	Dead Load	Interaction Ratios			
		Earthquake Component			Total
		Transverse	Londitudinal	Vertical	
4	0.11	0.46	0.27	0.05	0.65
6	0.15	0.35	0.57	0.12	0.83
9	0.15	0.10	0.58	0.12	0.75
10	0.15	0.19	0.58	0.12	0.77
11	-	-	-	-	-
12	0.04	-	0.27	0.04	0.31
15	0.24	-	-	0.28	0.52
19	0.04	-	0.27	0.04	0.31
20	0.15	0.19	0.58	0.11	0.77
21	0.14	0.10	0.58	0.12	0.74
24	0.14	0.35	0.57	0.12	0.82
26	0.10	0.46	0.27	0.05	0.64
59	-	0.42	-	-	0.42
62	-	0.28	-	-	0.28
69	-	0.28	-	-	0.28
72	-	0.42	-	-	0.42

75

Notes: 1. All element numbers refer to Figure 4A-21.
2. The total interaction ratio is the sum of that due to dead load and the SRSS combination of the separate earthquake effects.

TABLE 4A-10K

POLAR GANTRY CRANE

MAXIMUM DISPLACEMENTS,

UNLOCKED - TIED

Condition	Nodal Point	Longitudinal Direction (in.)	Transverse Direction (in.)	Vertical Direction (in.)
Unloaded	1	-	-	0.88
	2	-	-	0.81
	19	9	5.44	0.95
	31	9.26	6.97	0.95
	41	9.26	6.97	1.10
	50	9.26	6.98	-0.79
Loaded, 200 tons	1	-	-	0.85
	2	-	-	0.77
	19	9.75	5.97	0.90
	31	10.04	7.62	0.90
	41	10.05	7.63	-2.61
	50	10.05	7.63	-3.11

Note: All nodes refer to Figure 4A-21.

75

TABLE 4A-10L

POLAR GANTRY CRANE

MAXIMUM FORCES,

UNLOCKED - TIED (UNLOADED)

Element	Axial Force (kips)	Bending Moment About Axis 2 (kip-in.)	Bending Moment About Axis 3 (kip-in.)
4	696	13,149	35,325
6	680	70,558	37,891
9	402	76,272	2,846
10	398	92,226	21,874
11	15	3,191	-
12	60	93,057	-
15	20	71,408	-
19	77	90,960	-
20	379	92,084	21,874
21	383	76,260	2,846
24	661	70,555	37,891
26	677	12,931	35,325
59	-	42,486	-
62	-	35,728	-
69	-	35,728	-
72	-	42,486	-

Note: All elements refer to Figure 4A-21.

75

TABLE 4A-10M

POLAR GANTRY CRANE

MAXIMUM FORCES,

UNLOCKED - TIED (LOADED)

Element	Axial Force (kips)	Bending Moment About Axis 2 (kip-in.)	Bending Moment About Axis 3 (kip-in.)
4	957	14,615	40,245
6	934	79,373	42,683
9	626	85,880	3,259
10	622	104,115	24,079
11	15	2,644	-
12	60	101,619	-
15	20	171,874	-
19	77	99,458	-
20	603	103,959	24,079
21	607	85,869	3,259
24	915	79,374	42,683
26	938	14,468	40,245
59	-	48,700	-
62	-	39,593	-
69	-	39,593	-
72	-	48,700	-

75

Note: All elements refer to Figure 4A-21.

TABLE 4A-10N
POLAR GANTRY CRANE
MAXIMUM STRESS RATIOS,
UNLOCKED - TIED (UNLOADED)

Element	Dead Load	Interaction Ratios			
		Earthquake Component			Total
		Transverse	Longitudinal	Vertical	
4	0.06	0.70	0.27	0.04	0.81
6	0.07	0.54	0.57	0.06	0.86
9	0.06	0.08	0.58	0.06	0.65
10	0.06	0.26	0.58	0.05	0.70
11	-	-	-	-	-
12	0.02	-	0.27	0.01	0.29
15	0.08	-	-	0.13	0.21
19	0.01	-	0.27	0.01	0.28
20	0.06	0.26	0.58	0.05	0.70
21	0.06	0.08	0.58	0.06	0.65
24	0.06	0.54	0.57	0.06	0.85
26	0.05	0.70	0.27	0.03	0.80
59	-	0.71	-	-	0.71
62	-	0.50	-	-	0.50
69	-	0.50	-	-	0.50
72	-	0.71	-	-	0.71

75

Notes: 1. All element numbers refer to Figure 4A-21.
2. The total interaction ratio is the sum of that due to dead load and the SRSS combination of the separate earthquake effects.

TABLE 4A-10(0)

POLAR GANTRY CRANE

MAXIMUM STRESS RATIOS,

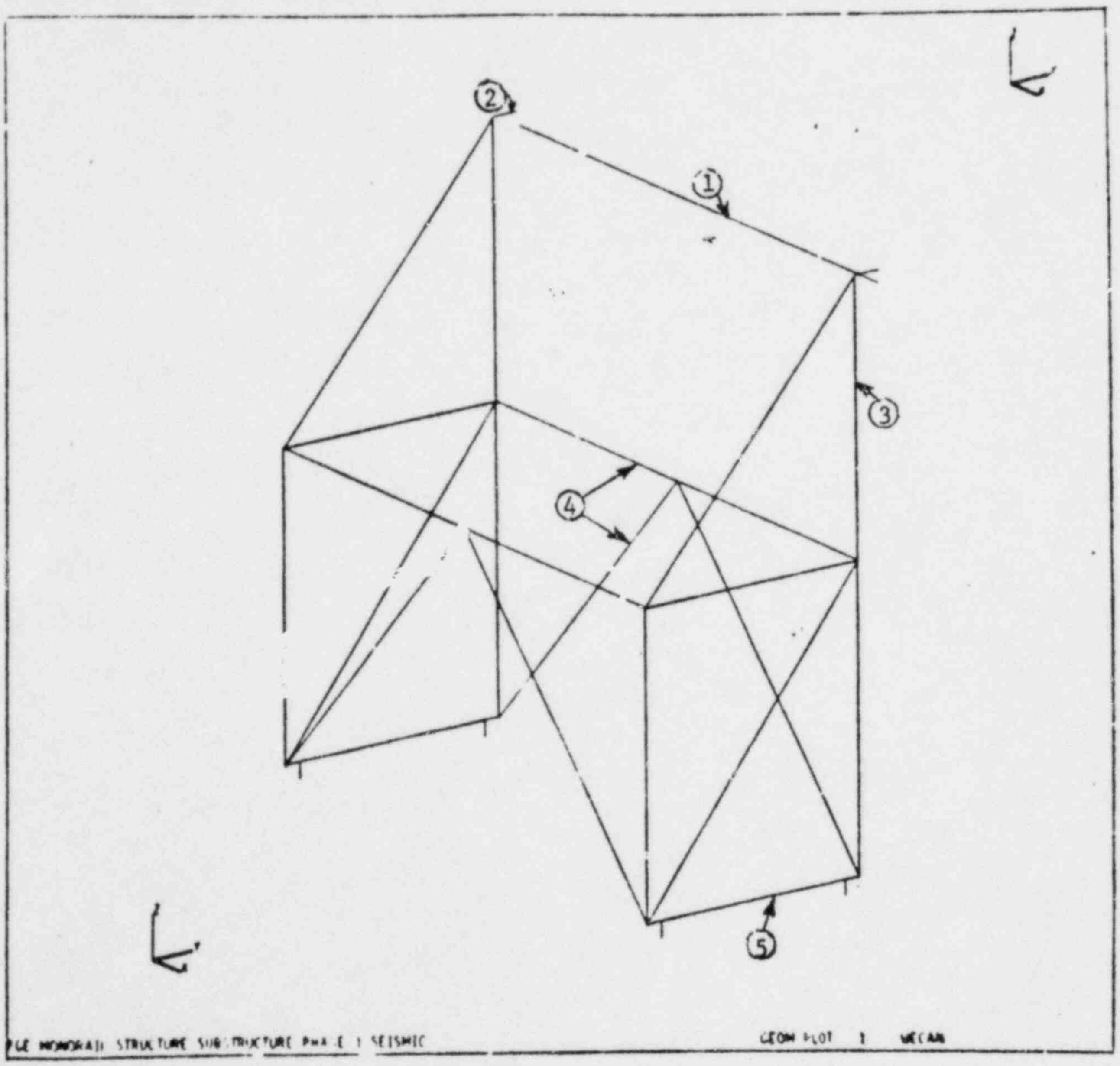
UNLOCKED - TIED (LOADED)

Element	Dead Load	Interaction Ratios			
		Earthquake Component			Total
		Transverse	Longitudinal	Vertical	
4	0.11	0.83	0.27	0.05	0.98
6	0.15	0.62	0.57	0.12	1.00
9	0.15	0.11	0.58	0.12	0.75
10	0.15	0.32	0.58	0.12	0.82
11	-	-	-	-	-
12	0.04	-	0.27	0.04	0.31
15	0.24	-	-	0.28	0.52
19	0.04	-	0.27	0.04	0.31
20	0.15	0.32	0.58	0.11	0.82
21	0.14	0.11	0.58	0.12	0.74
24	0.14	0.62	0.57	0.12	0.99
26	0.10	0.83	0.27	0.05	0.97
59	-	0.82	-	-	0.82
62	-	0.55	-	-	0.55
69	-	0.55	-	-	0.55
72	-	0.82	-	-	0.82

Notes: 1. All element numbers refer to Figure 4A-21.
2. The total interaction ratio is the sum of that due to dead load and the SRSS combination of the separate earthquake effects.

Manipulator Crane - Wecan Model

Monorail Structure

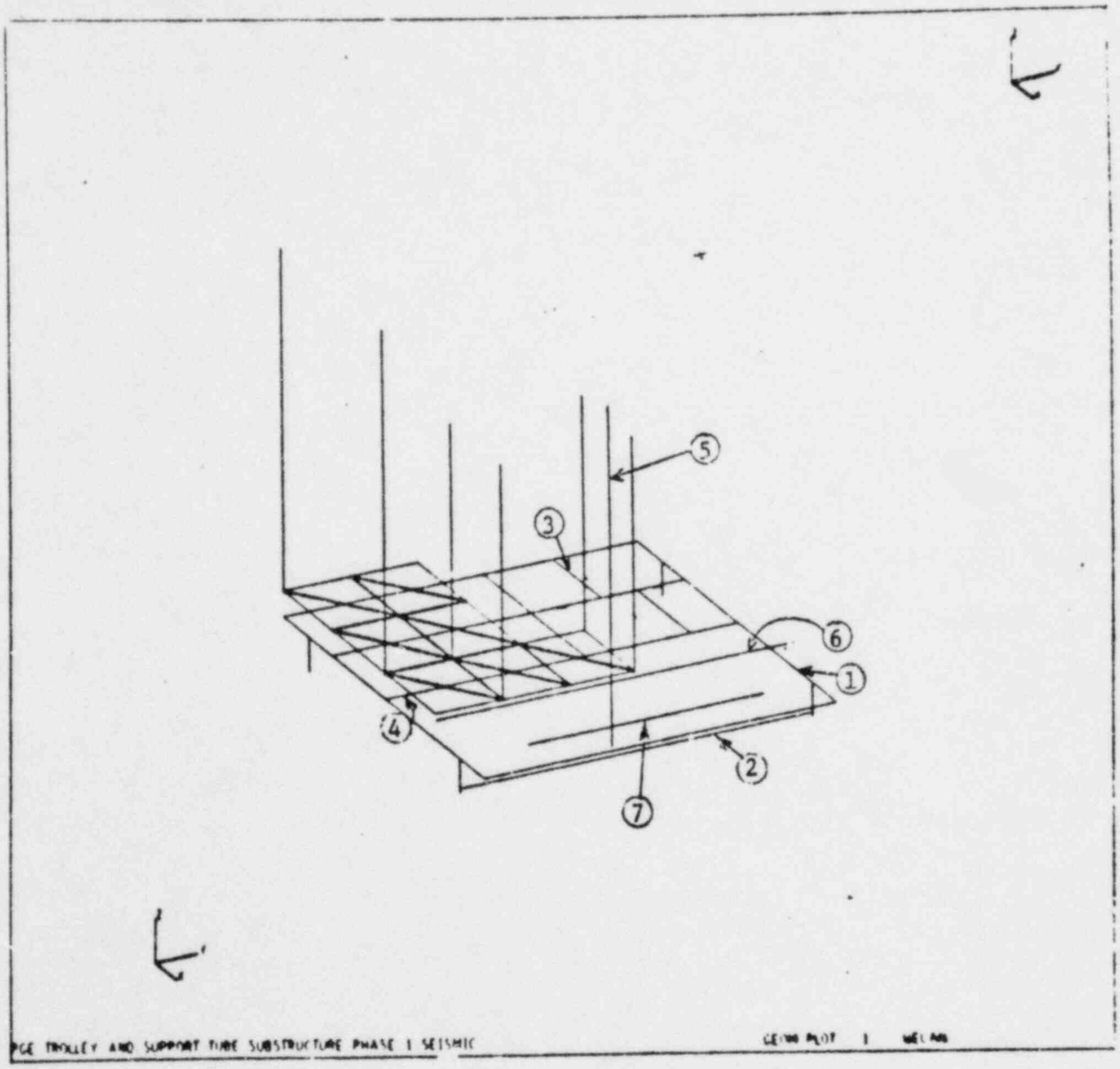


1. Monorail Beam
2. Monorail Brackets
3. Monorail Columns
4. Monorail Bracing
5. Bridge Trucks

FIGURE 4A-2

Manipulator Crane - Wecan Model

Trolley and Mast Support Tube

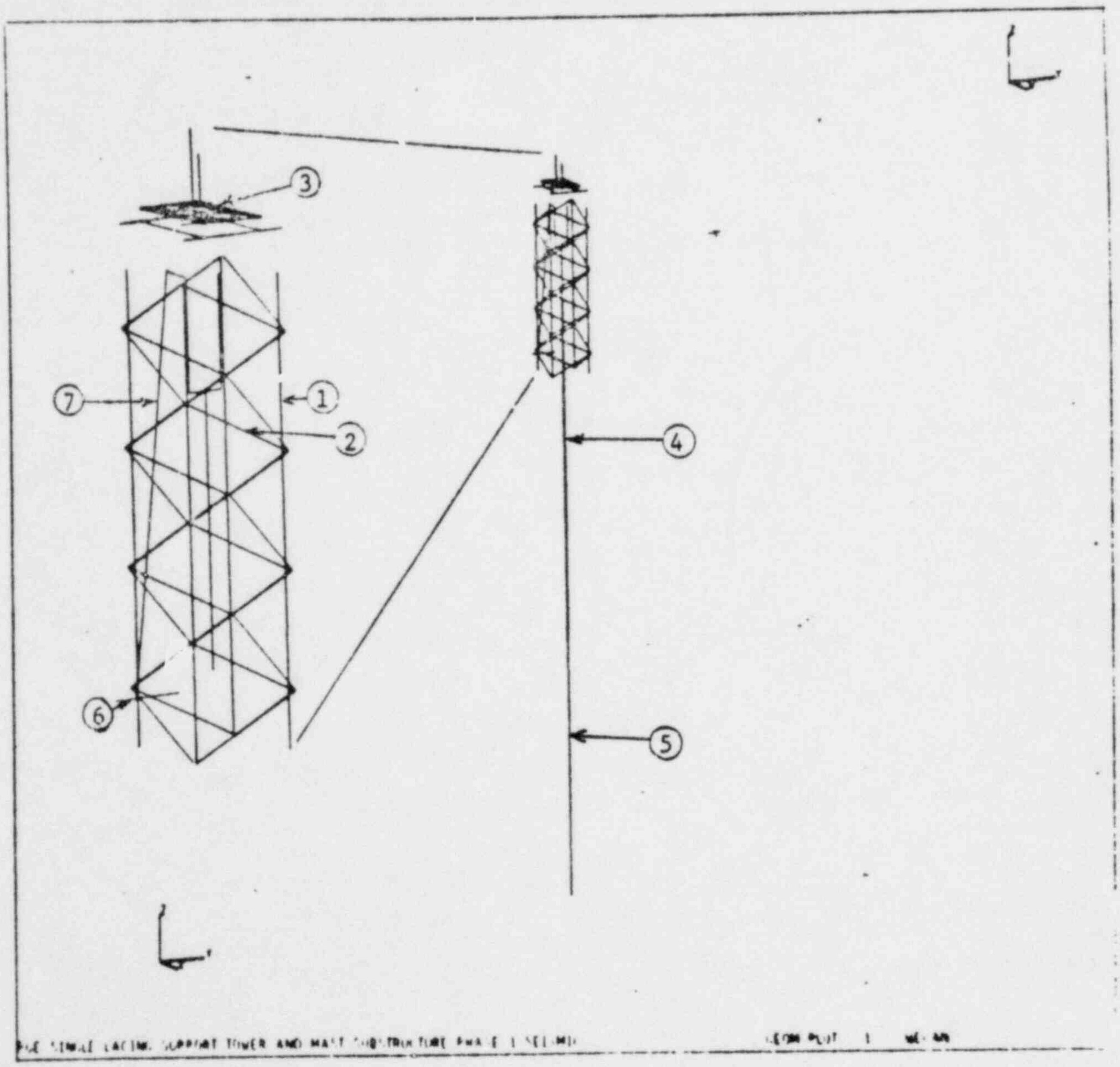


1. Trolley Trucks
2. Trolley Drive Support
3. Fuel Hoist Support
4. Mast Support Beam
5. Mast Support Tube
6. Floor Support
7. Trolley Drive

FIGURE 4A-3

Manipulator Crane - Wecan Model

Cable Support Tower and Mast



1. Tower Corner Angles
2. Tower Lacing Angles
3. Pulley Support Channels
4. Gripper Tube
5. Stationary Mast
6. Fuel Hoist
7. Cable

FIGURE 4A-4

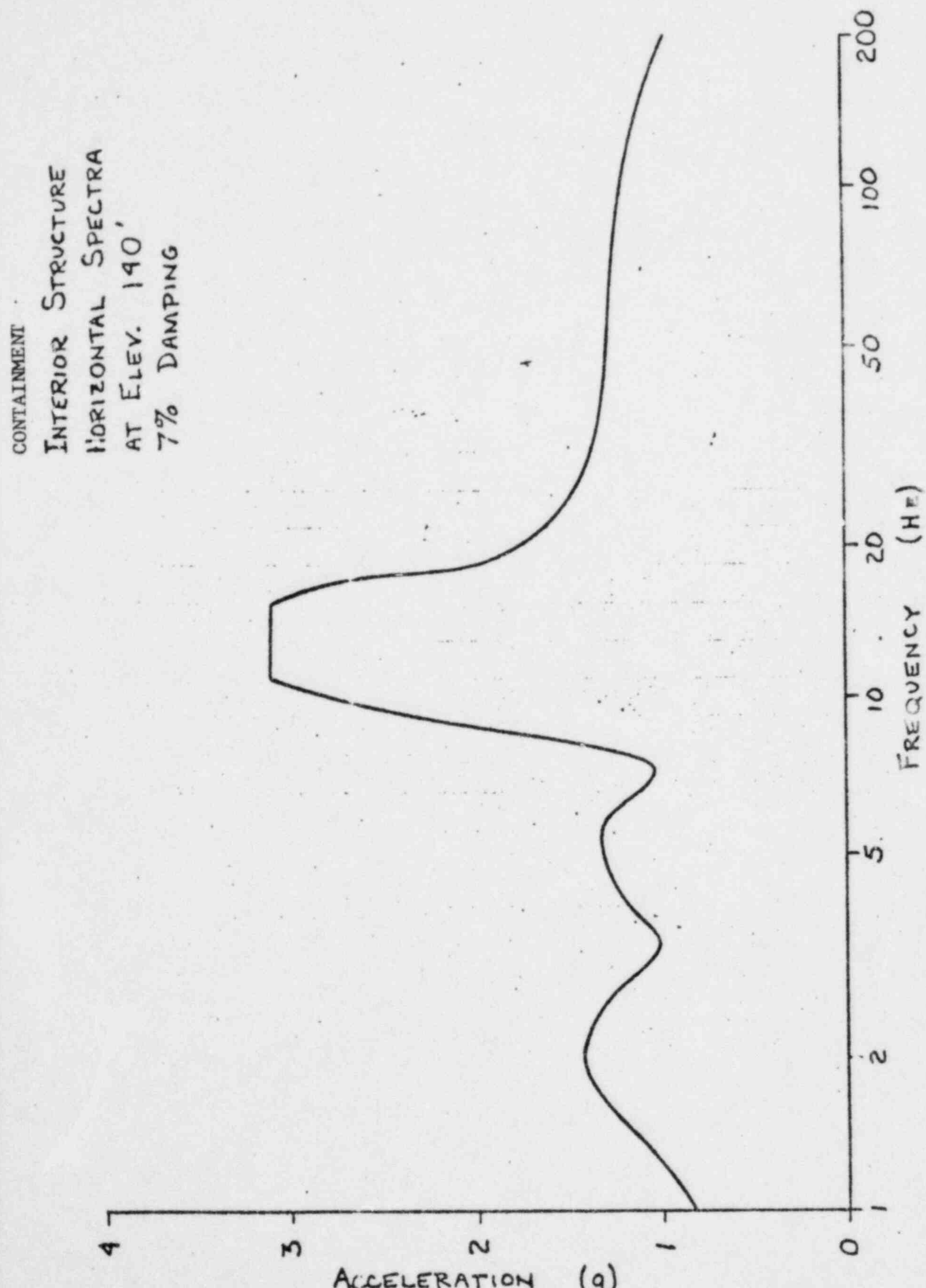

CONTAINMENT
INTERIOR STRUCTURE
HORIZONTAL SPECTRA
AT ELEV. 190'
7% DAMPING
ACCELERATION (g)
0
1
2
3
4
FREQUENCY (Hz)
1
2
5
10
20
50
100
200

FIGURE 4A-5

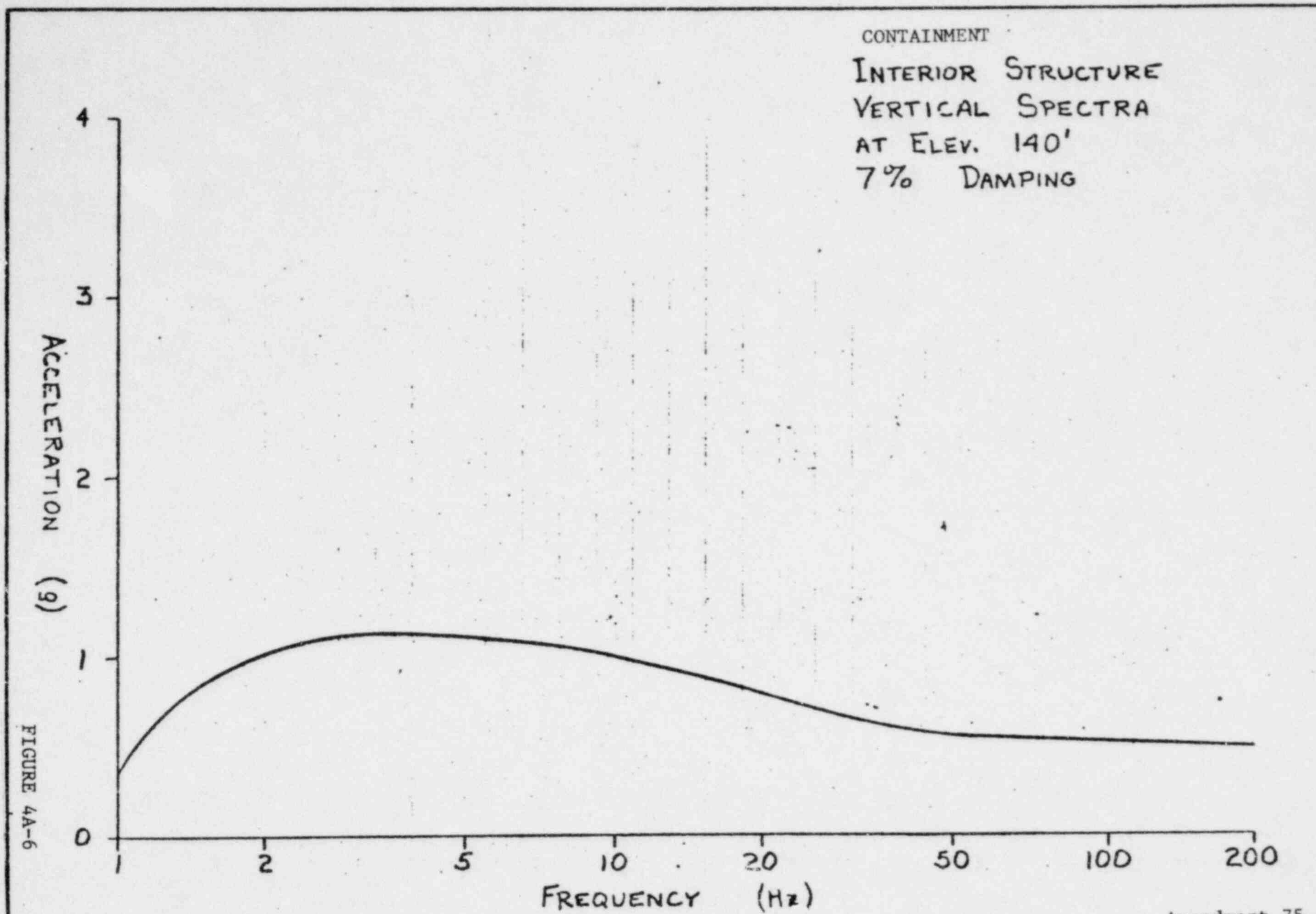
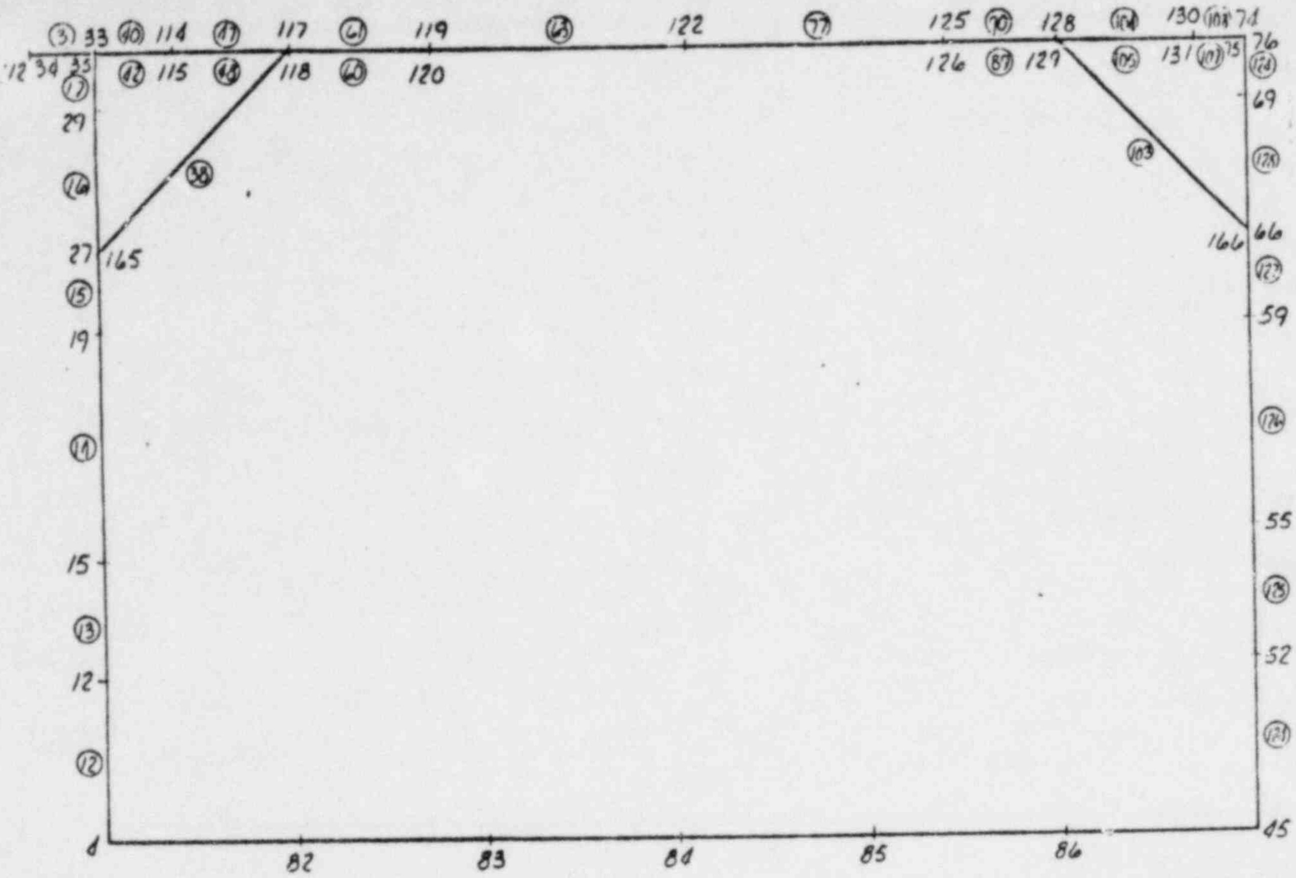
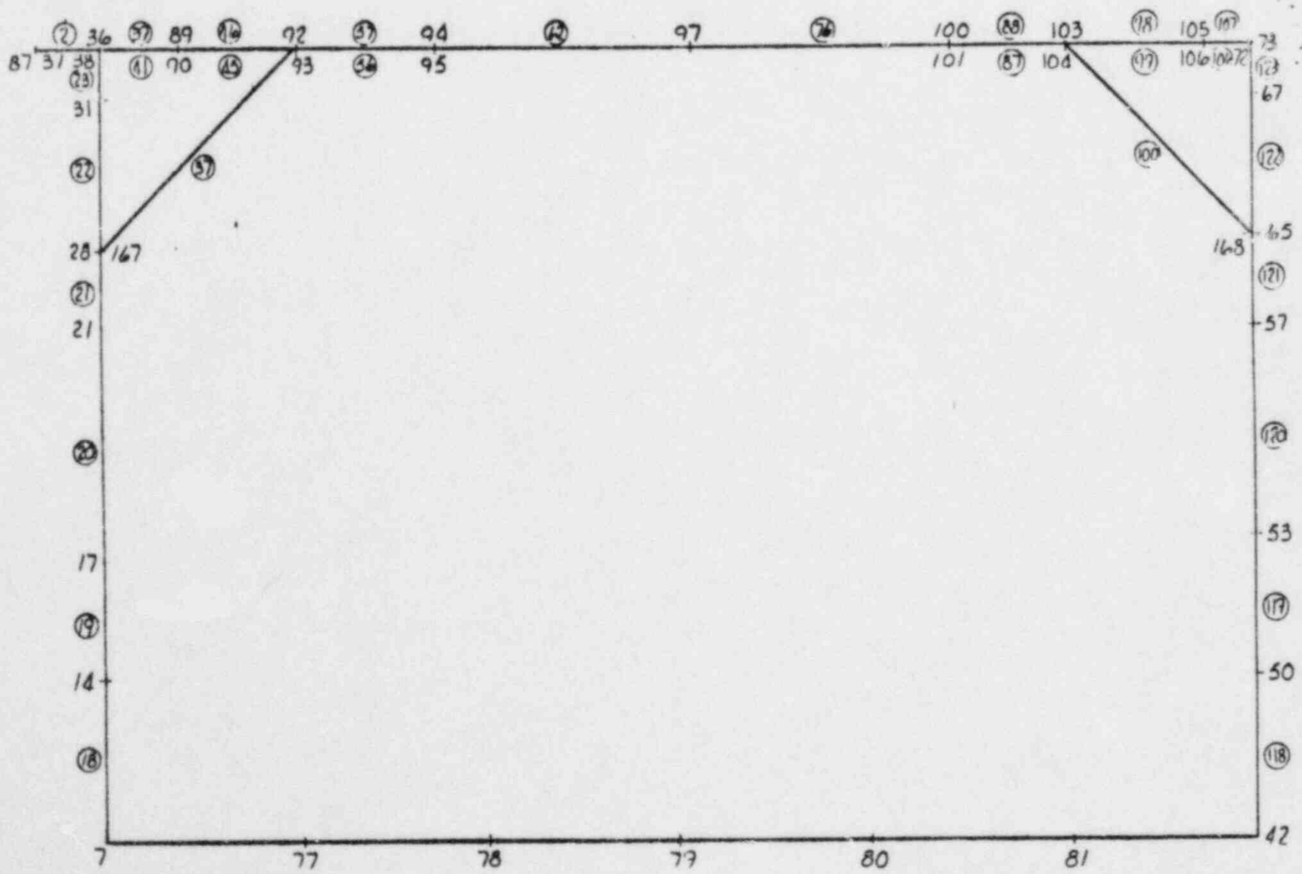


FIGURE 4A-6

WESTINGHOUSE ELECTRIC CORPORATION



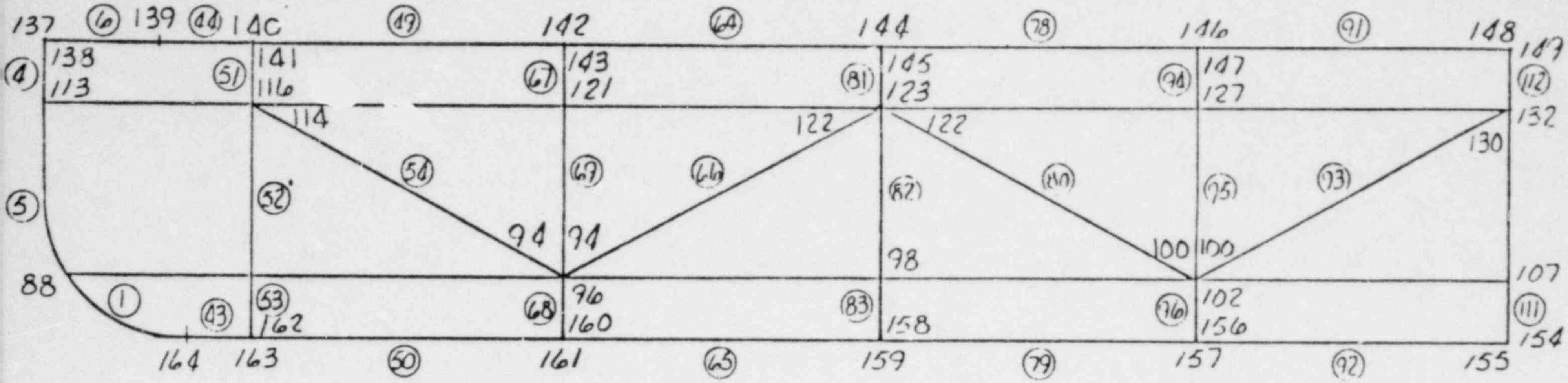
NORTH VIEW (FRONT SIDE)



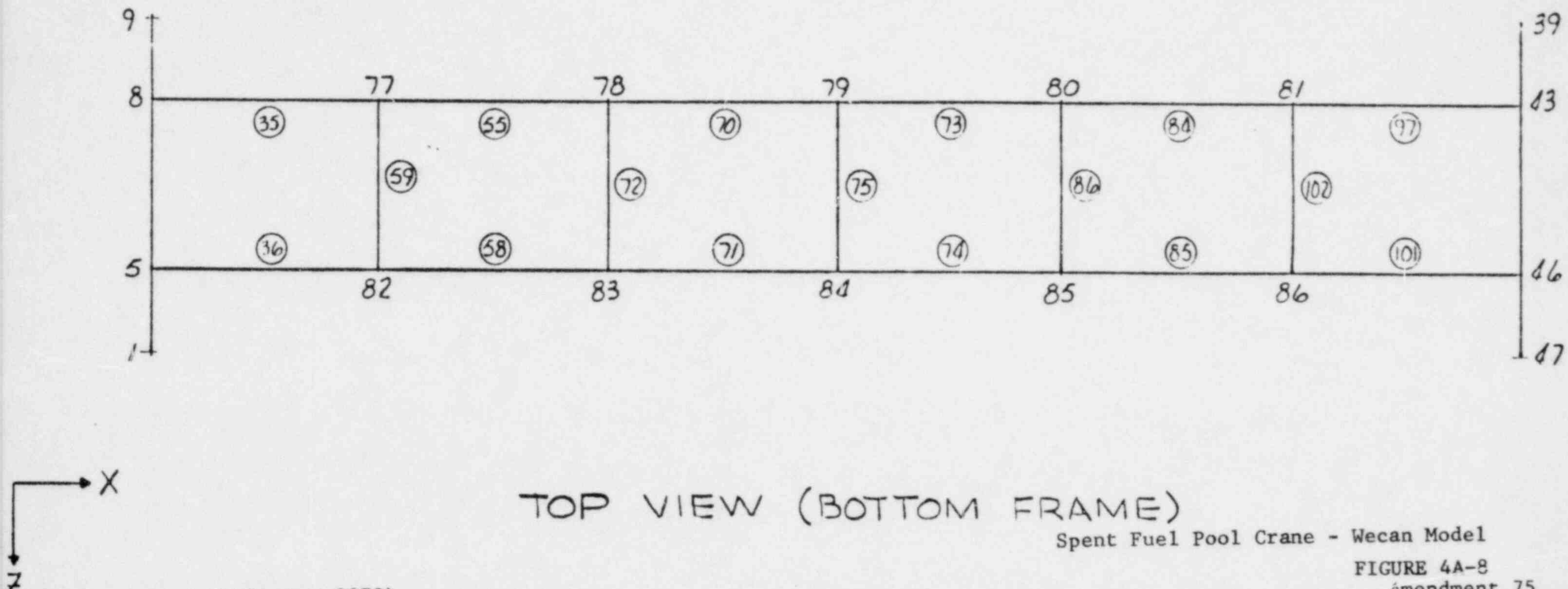
Spent Fuel Pool Crane - Wecan Model

NORTH VIEW (BACK SIDE)

FIGURE 4A-7



TOP VIEW (TOP FRAME)



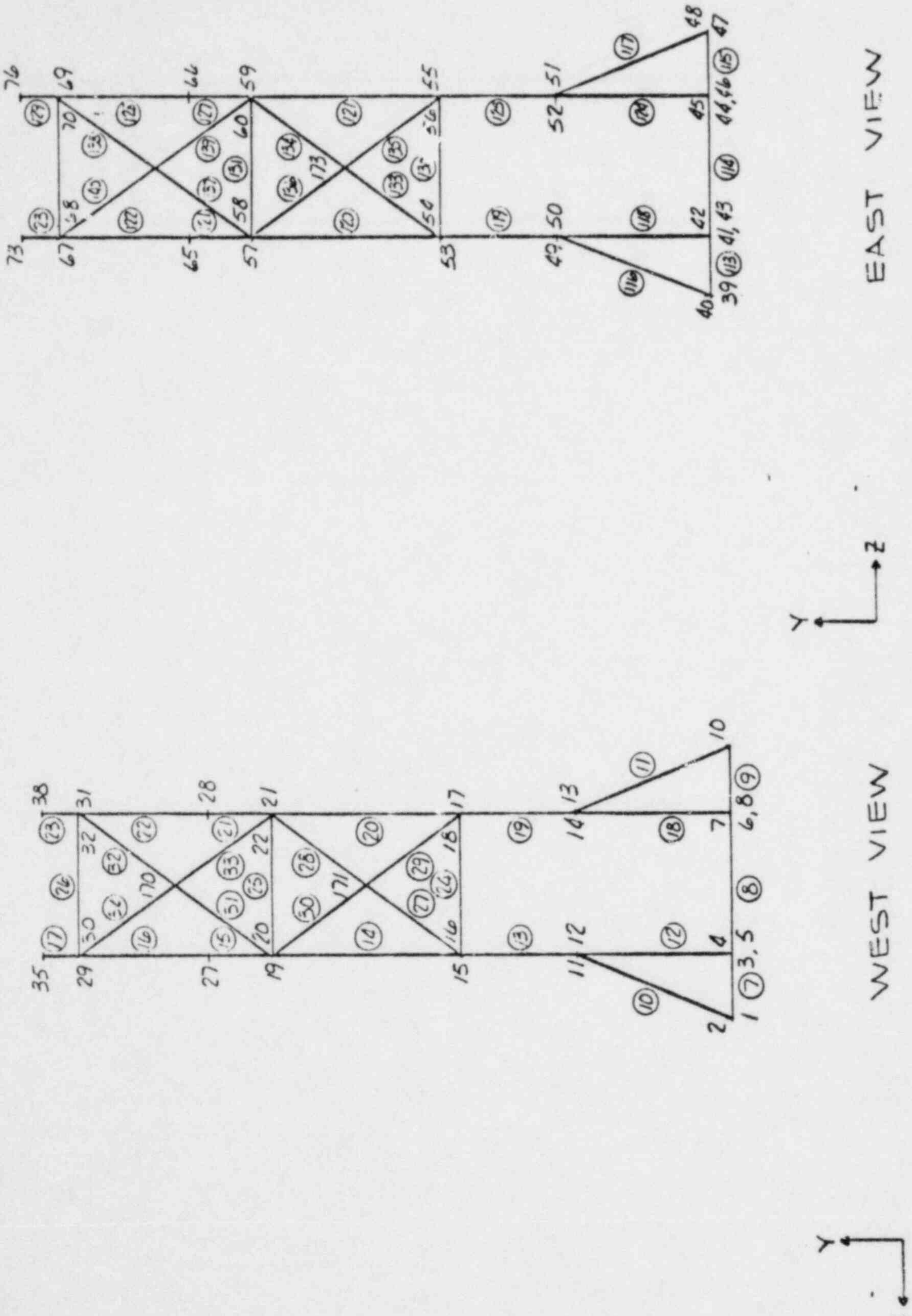
TOP VIEW (BOTTOM FRAME)

Spent Fuel Pool Crane - Wecan Model

FIGURE 4A-8

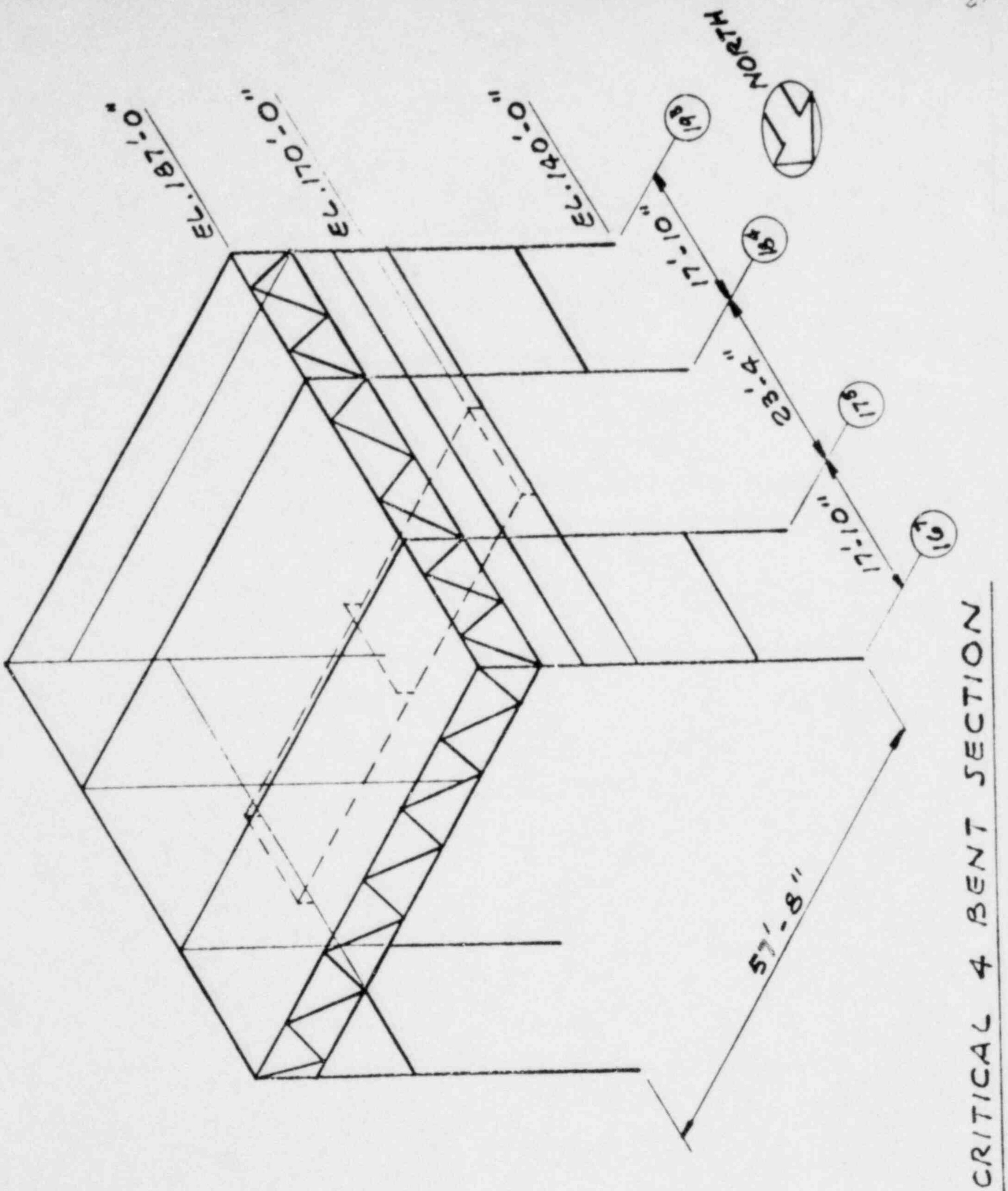
Amendment 75

(February 1979)



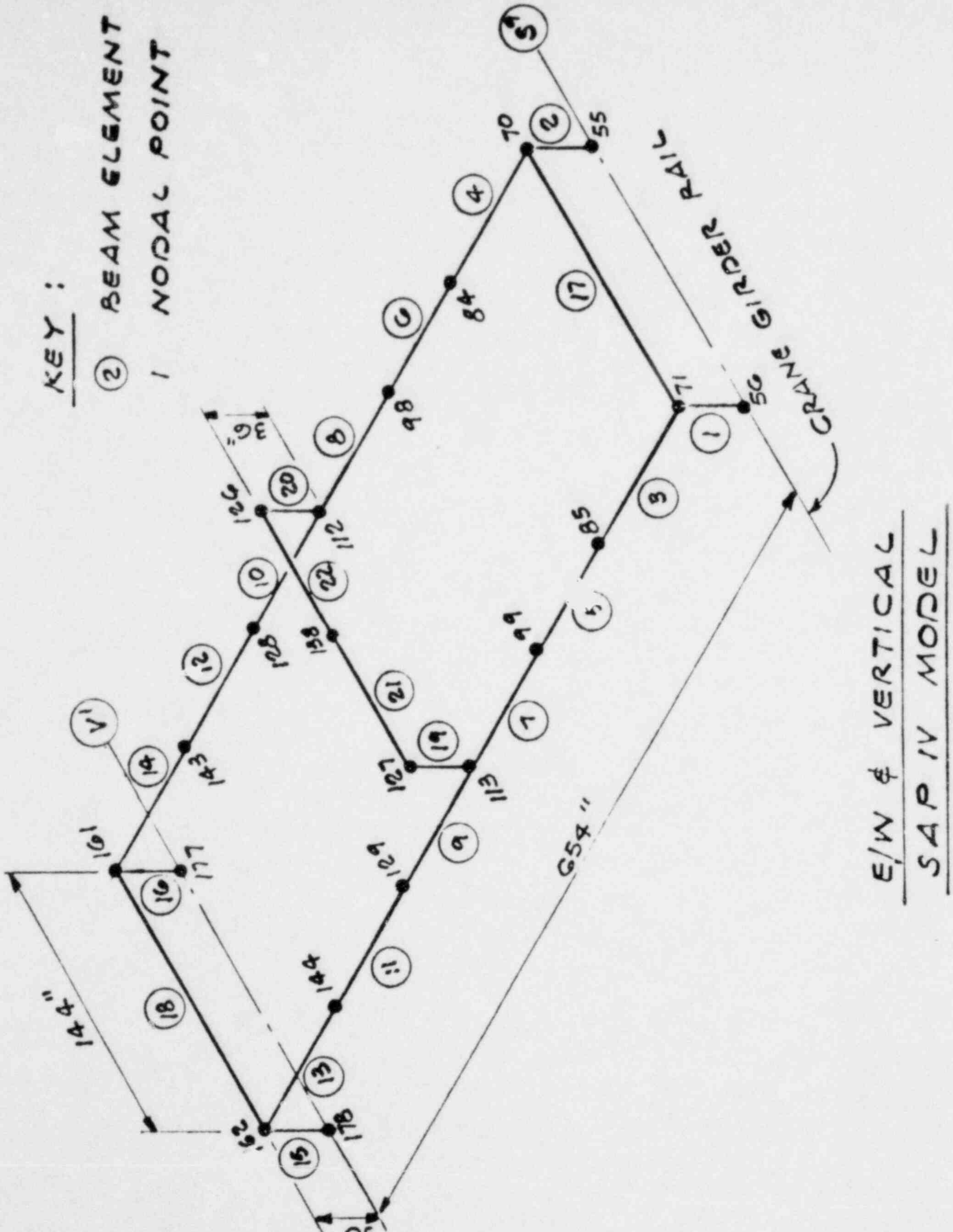
Spent Fuel Pool Crane - Wecan Model

FIGURE 4A-9



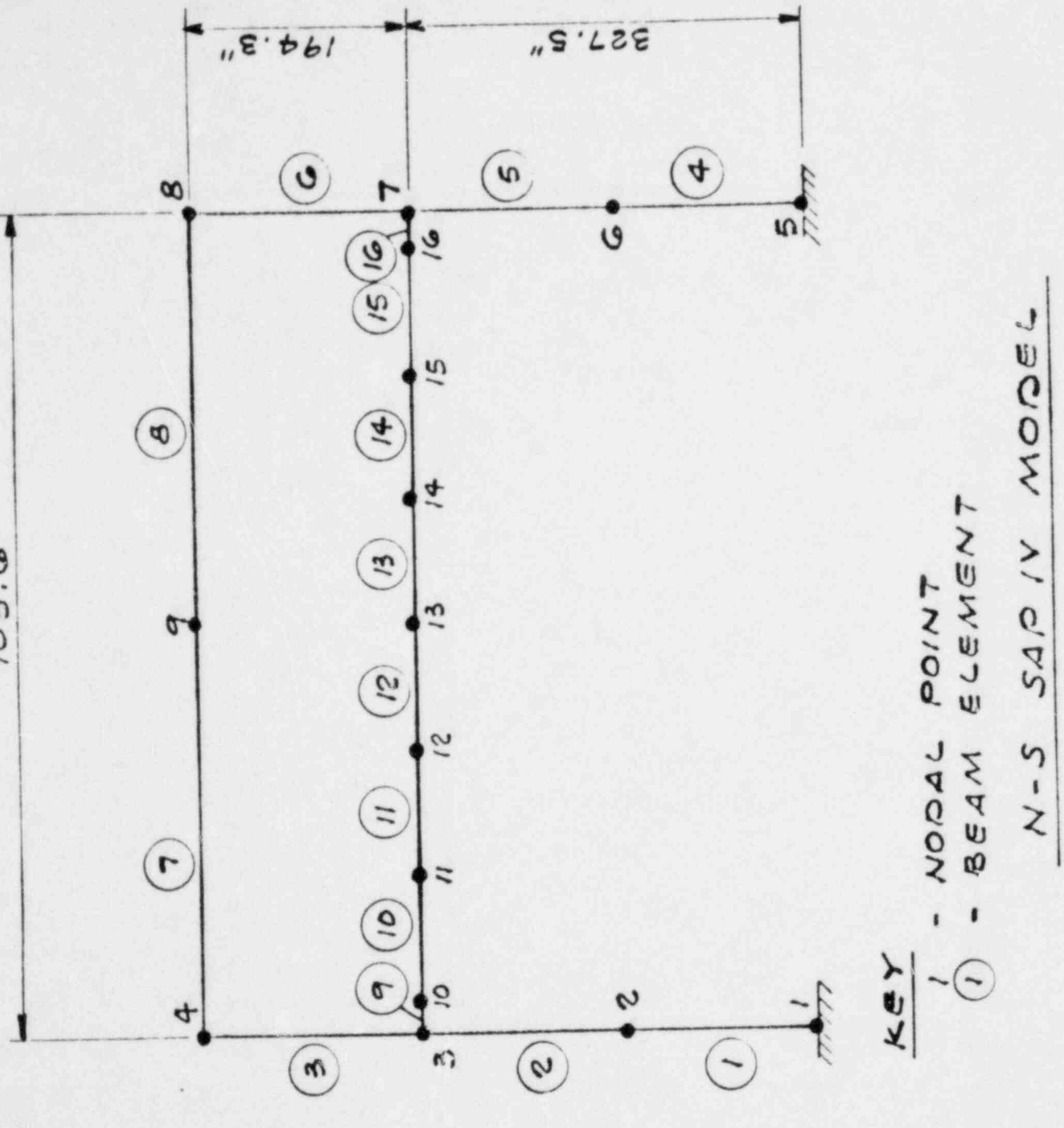
DIABLO CANYON
FUEL HANDLING BUILDING CRANE

FIGURE 4A-13



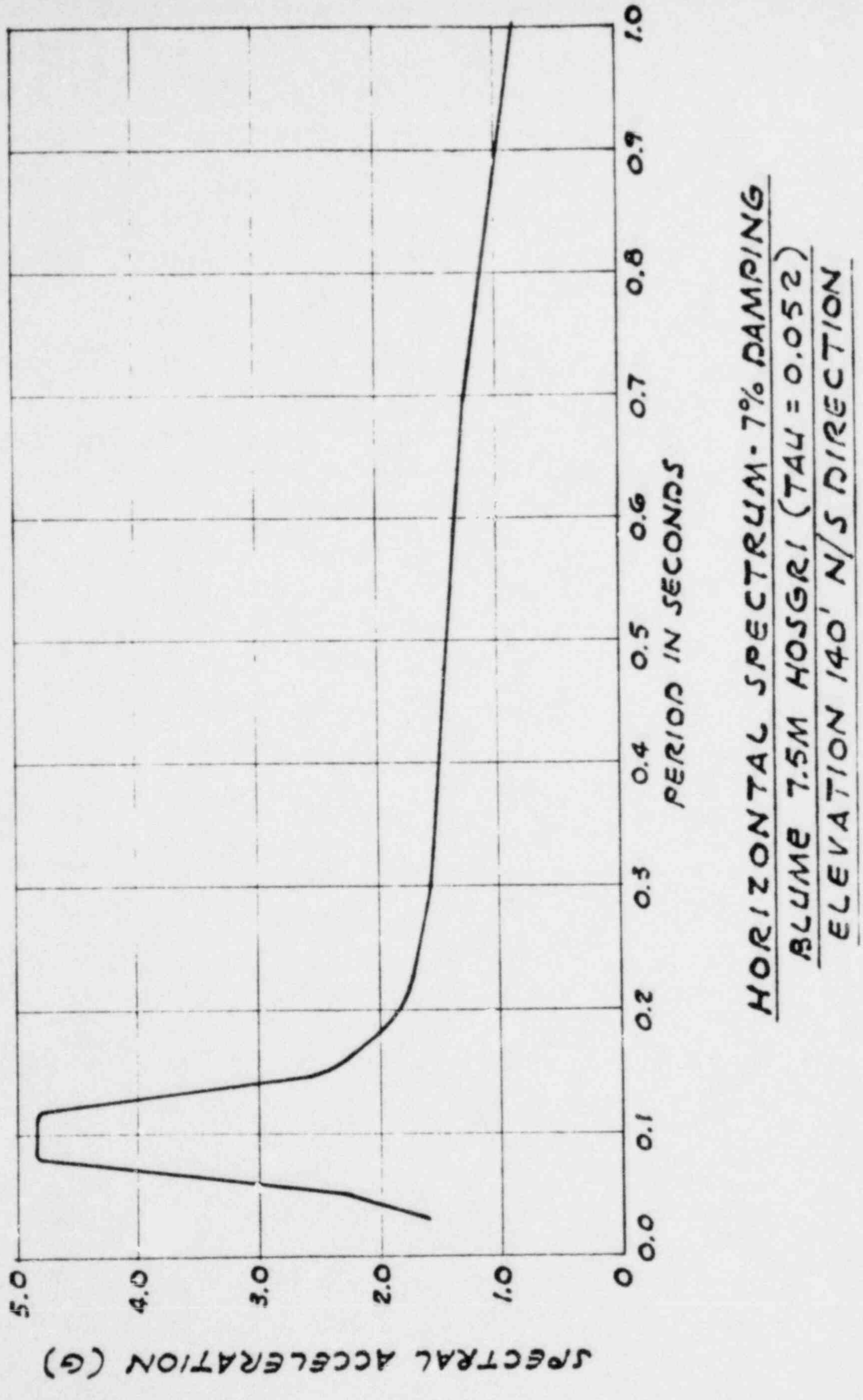
DIABLO CANYON
FUEL HANDLING BUILDING CRANE

FIGURE 4A-14



DIABLO CANYON
FUEL HANDLING BUILDING CRANE

FIGURE 4A-15

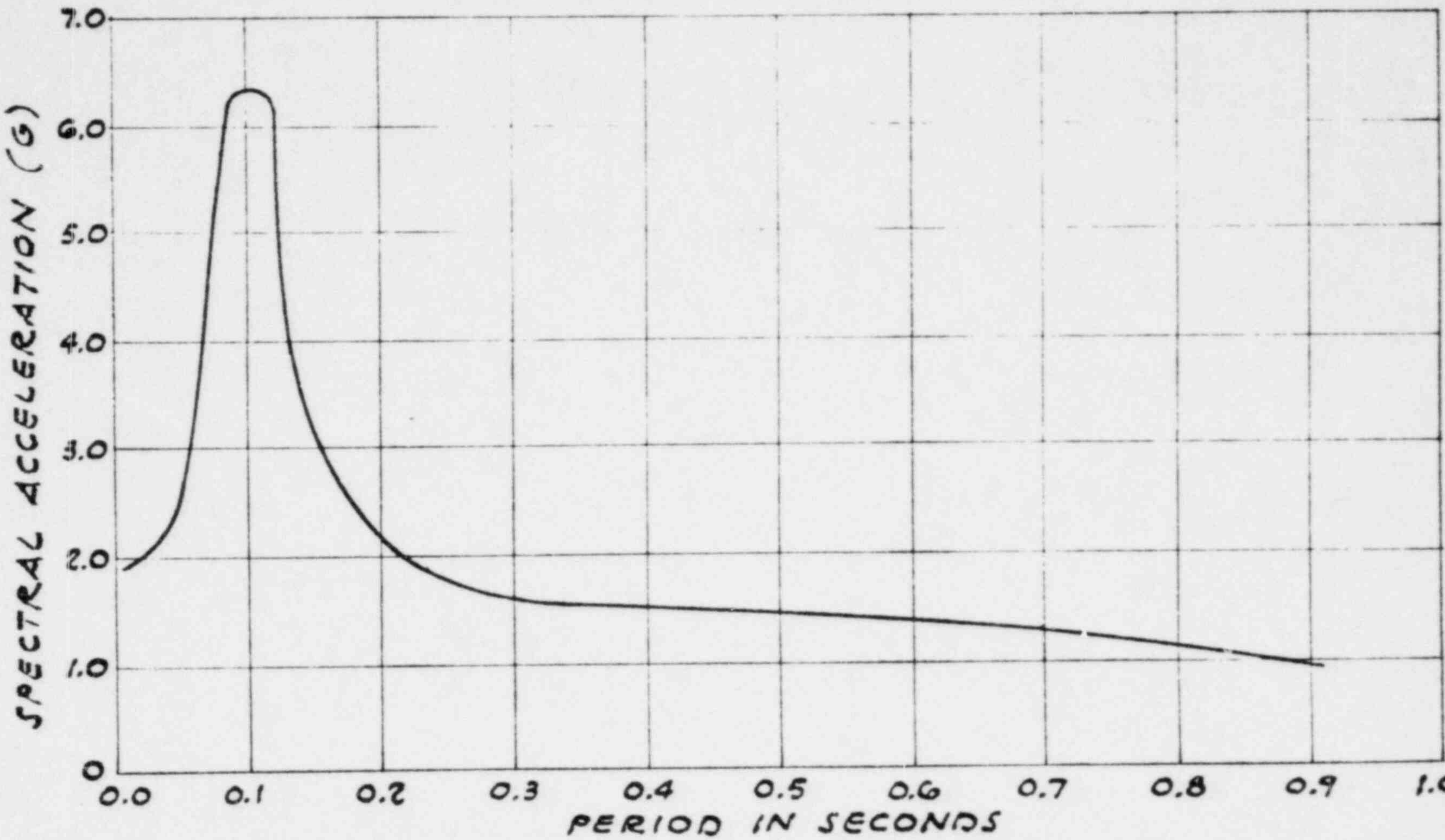


DIABLO CANYON
FUEL HANDLING BUILDING CRANE

FIGURE 4A-16

(February 1979)

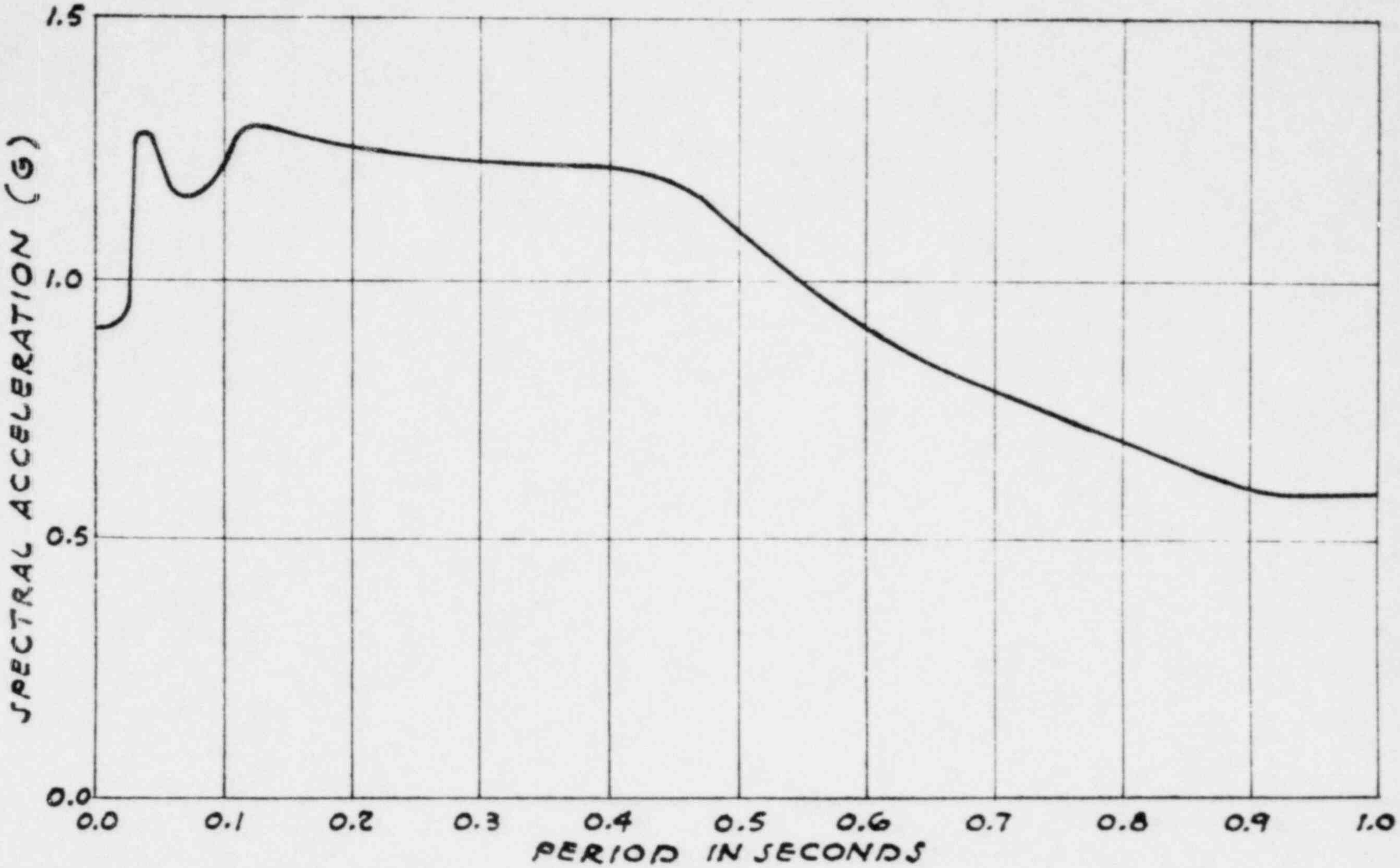
Amendment 75



HORIZONTAL SPECTRUM - 7% DAMPING
NEWMARK 7.5M HOSGRI (TAU = 0.052)
ELEVATION 140' E/W DIRECTION

DIABLO CANYON
FUEL HANDLING BUILDING CRANE

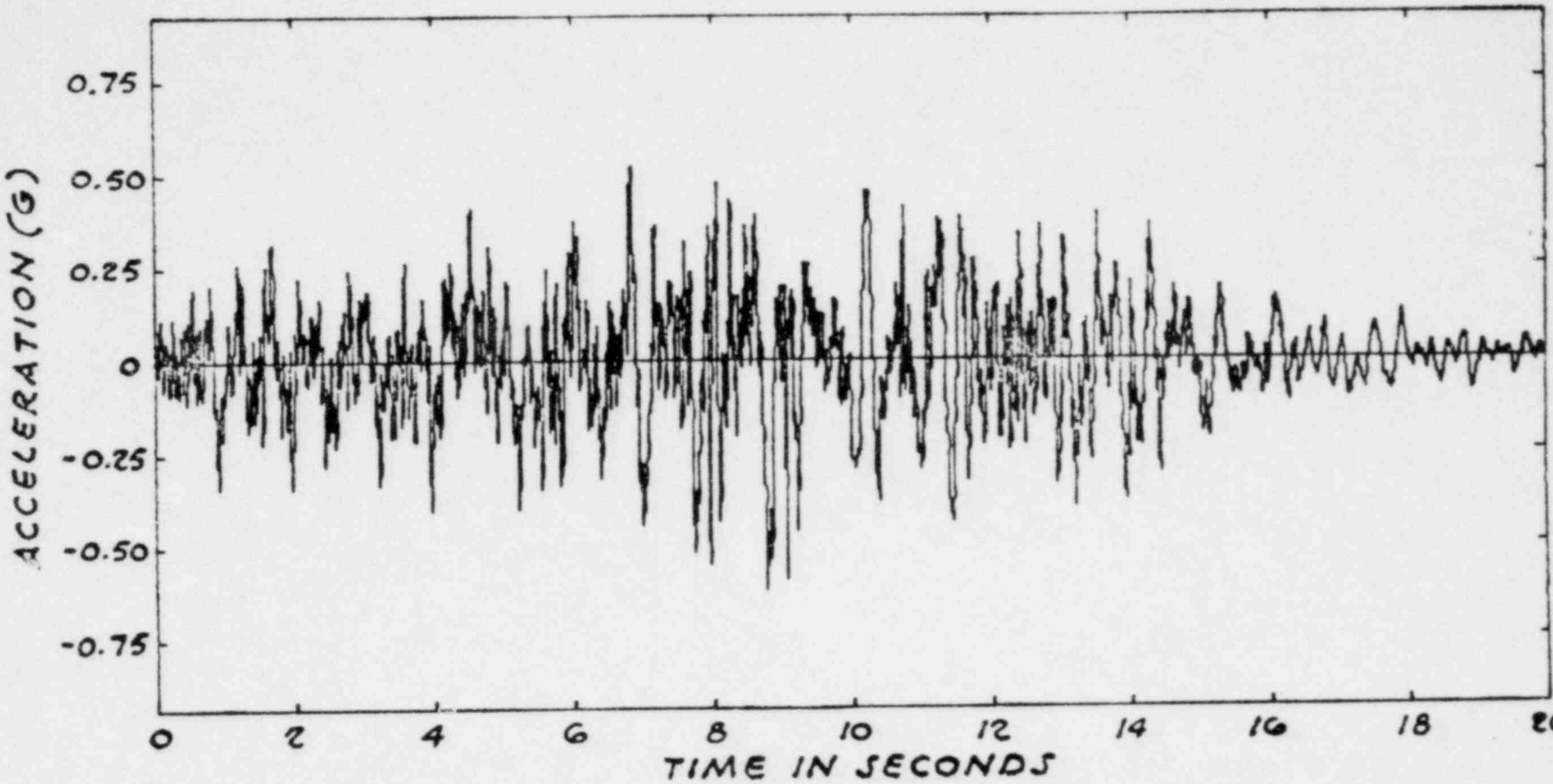
FIGURE 4A-17
Amendment 75
(February 1979)



VERTICAL SPECTRUM - 7% DAMPING
NEWMARK 7.5M HOSGRI (TAU = 0.0)
ELEVATION 140'

DIABLO CANYON
FUEL HANDLING BUILDING CRANE

FIGURE 4A-18
Amendment 75
(February 1979)

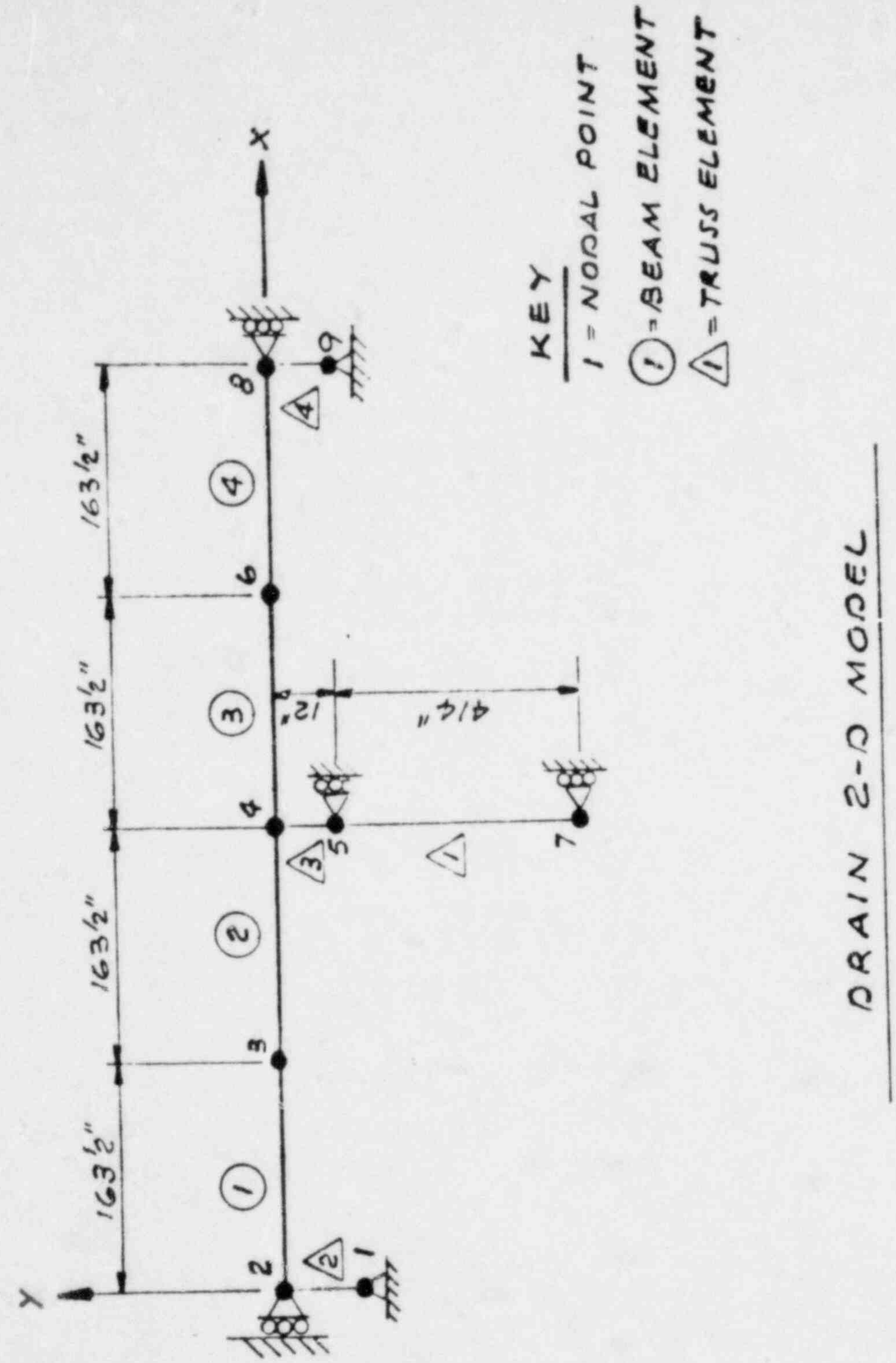


VERTICAL ACCELERATION TIME HISTORY
NEWMARK 7.5M HOSGRI (TAU = 0.0)
ELEVATION 170'

DIABLO CANYON
FUEL HANDLING BUILDING CRANE

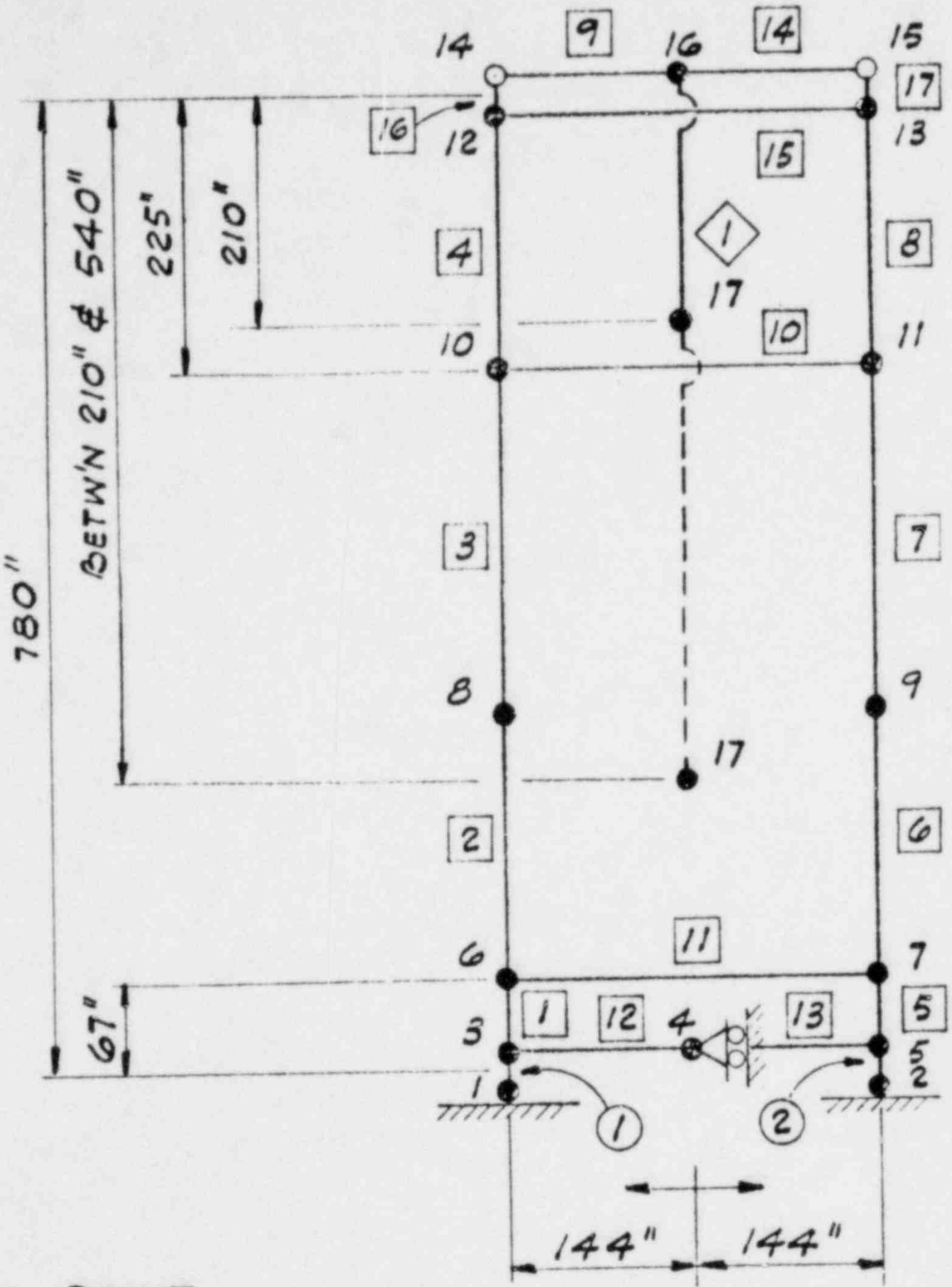
FIGURE 4A-19

(February 1979)
Amendment 75



DIABLO CANYON
FUEL HANDLING BUILDING CRANE

FIGURE 4A-20



KEY

1 NODAL POINT

◇1 TRUSS ELEMENT

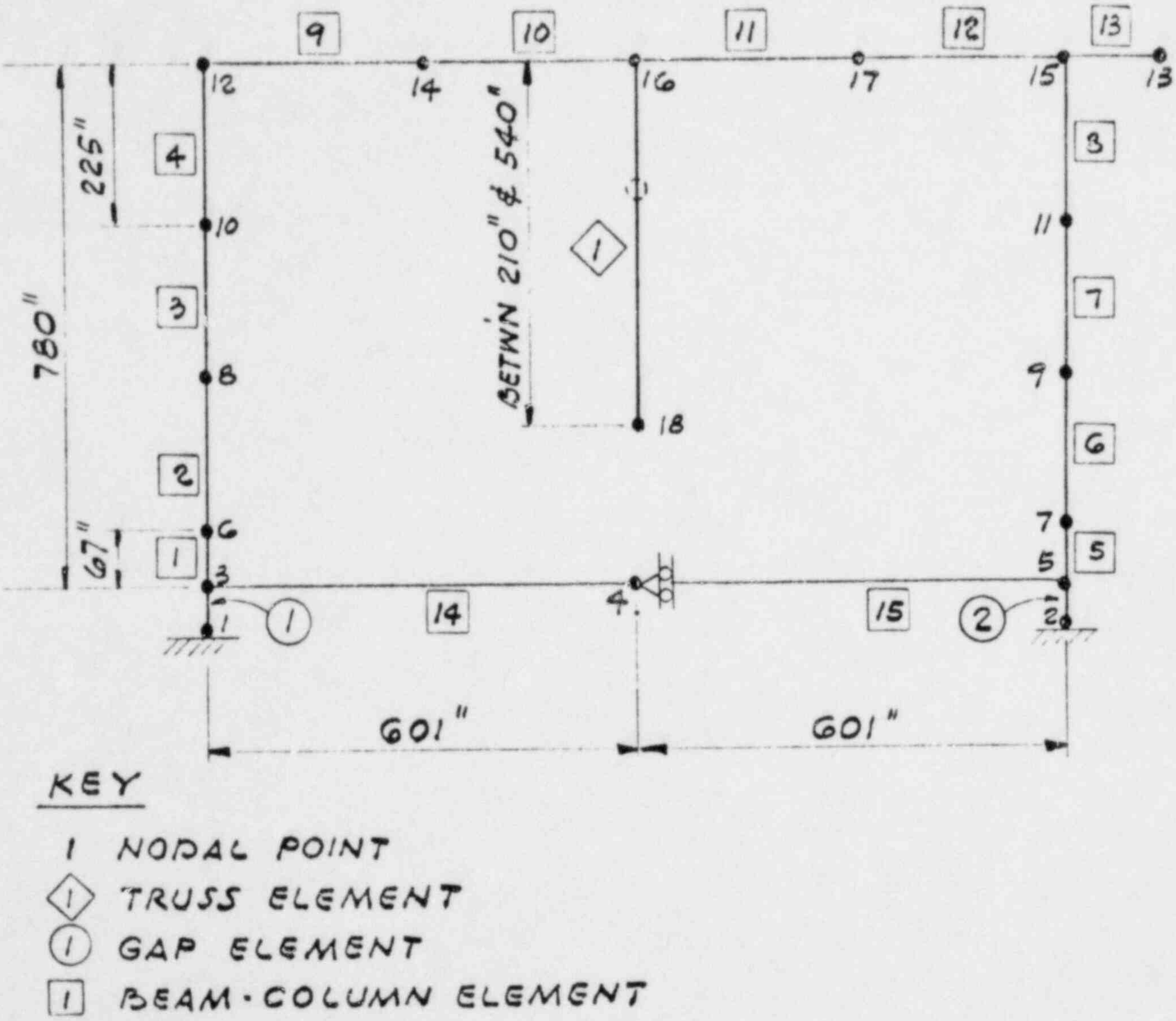
(1) GAP ELEMENT

[1] BEAM-COLUMN ELEMENT

TRANSVERSE NONLINEAR MODEL

DIABLO CANYON
POLAR GANTRY CRANE

FIGURE 4A-22A

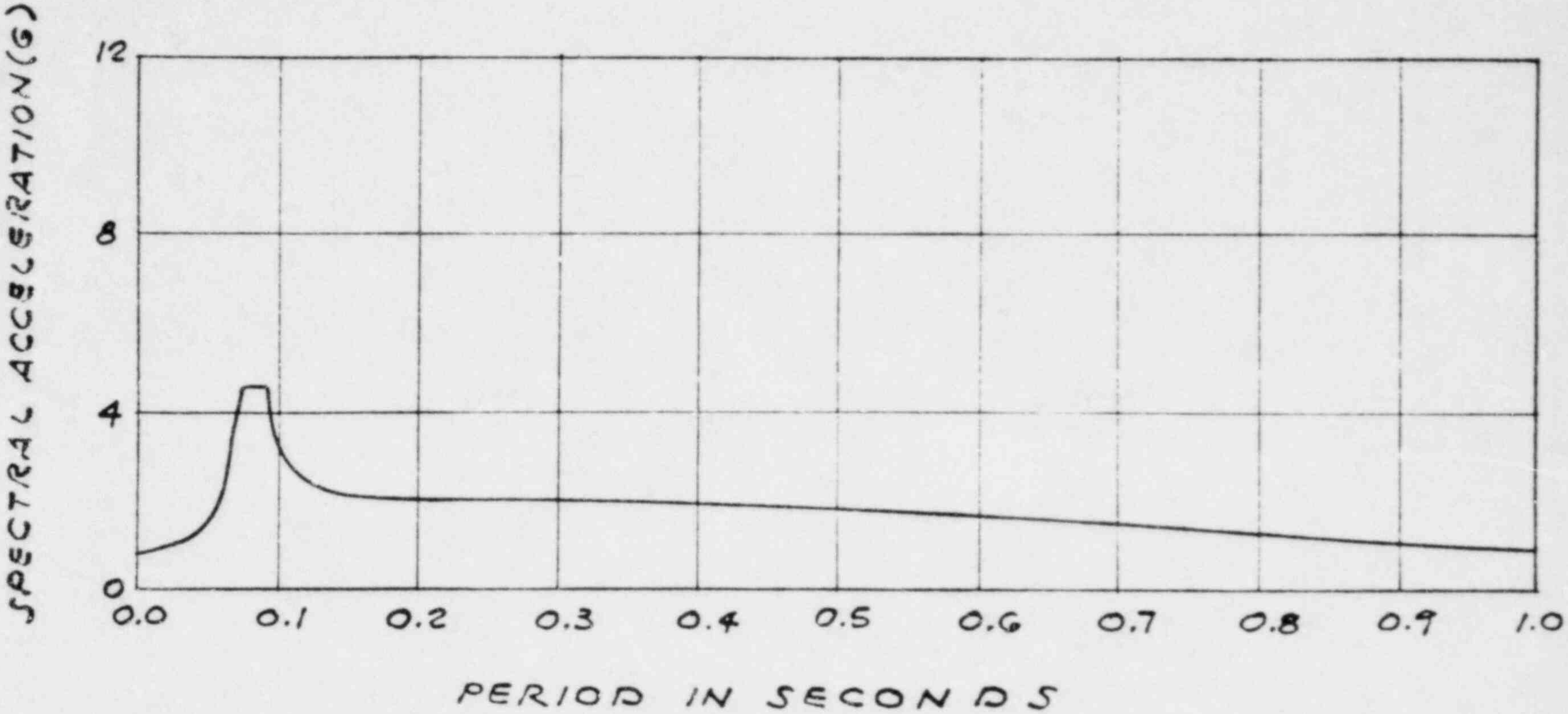


LONGITUDINAL NONLINEAR MODEL

DIABLO CANYON
POLAR GANTRY CRANE

FIGURE 4A-22B

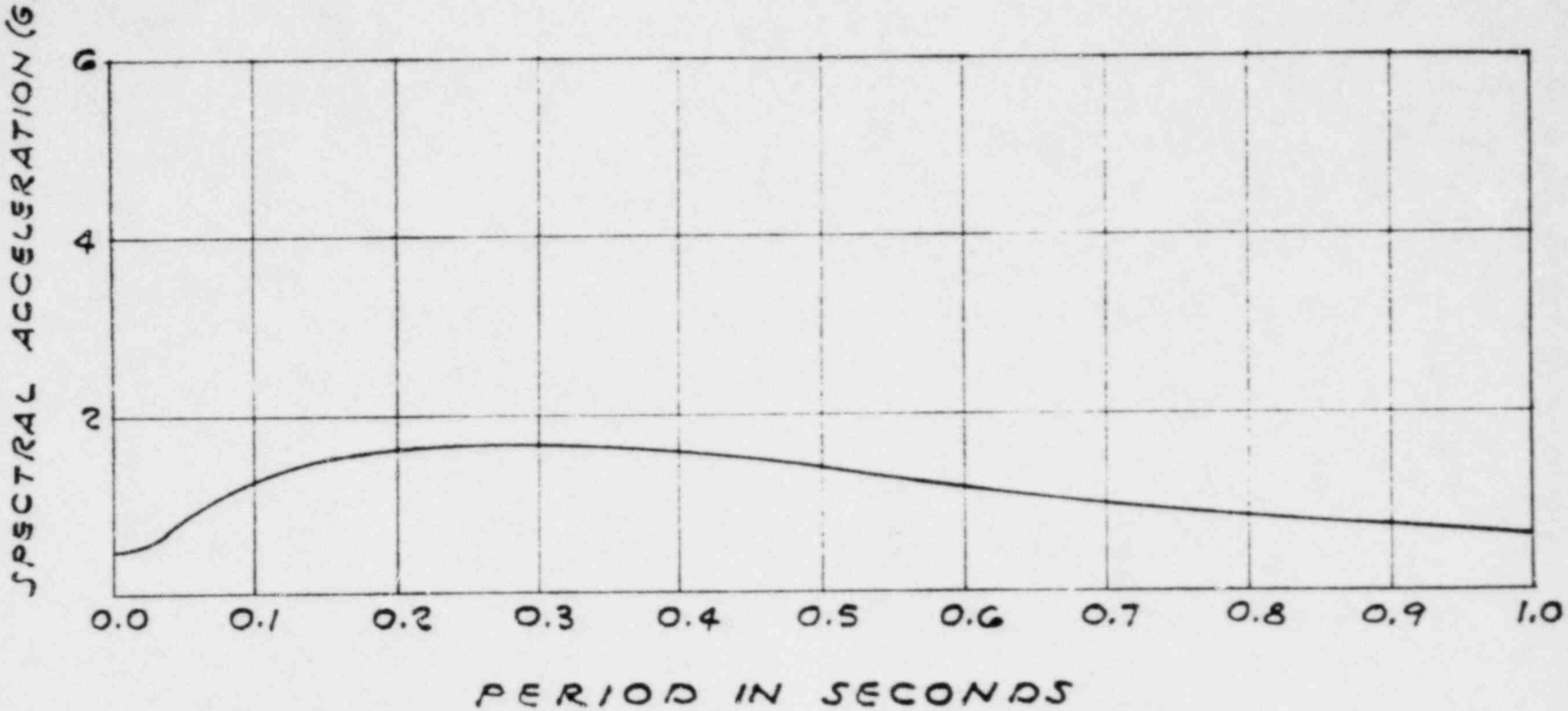
DIABLO CANYON
POLAR GANTRY CRANE



HORIZONTAL SPECTRUM - 4% DAMPING
NEWMARK 7.5M HOSGRI (TAU = 0.04)
ELEVATION 140'

FIGURE 4A-23A

DIABLO CANYON
POLAR GANTRY CRANE



VERTICAL SPECTRUM - 4 % DAMPING
NEWMARK 7.5 M HOSGRI (TAU = 0.0)
ELEVATION 140'

FIGURE 4A-23B

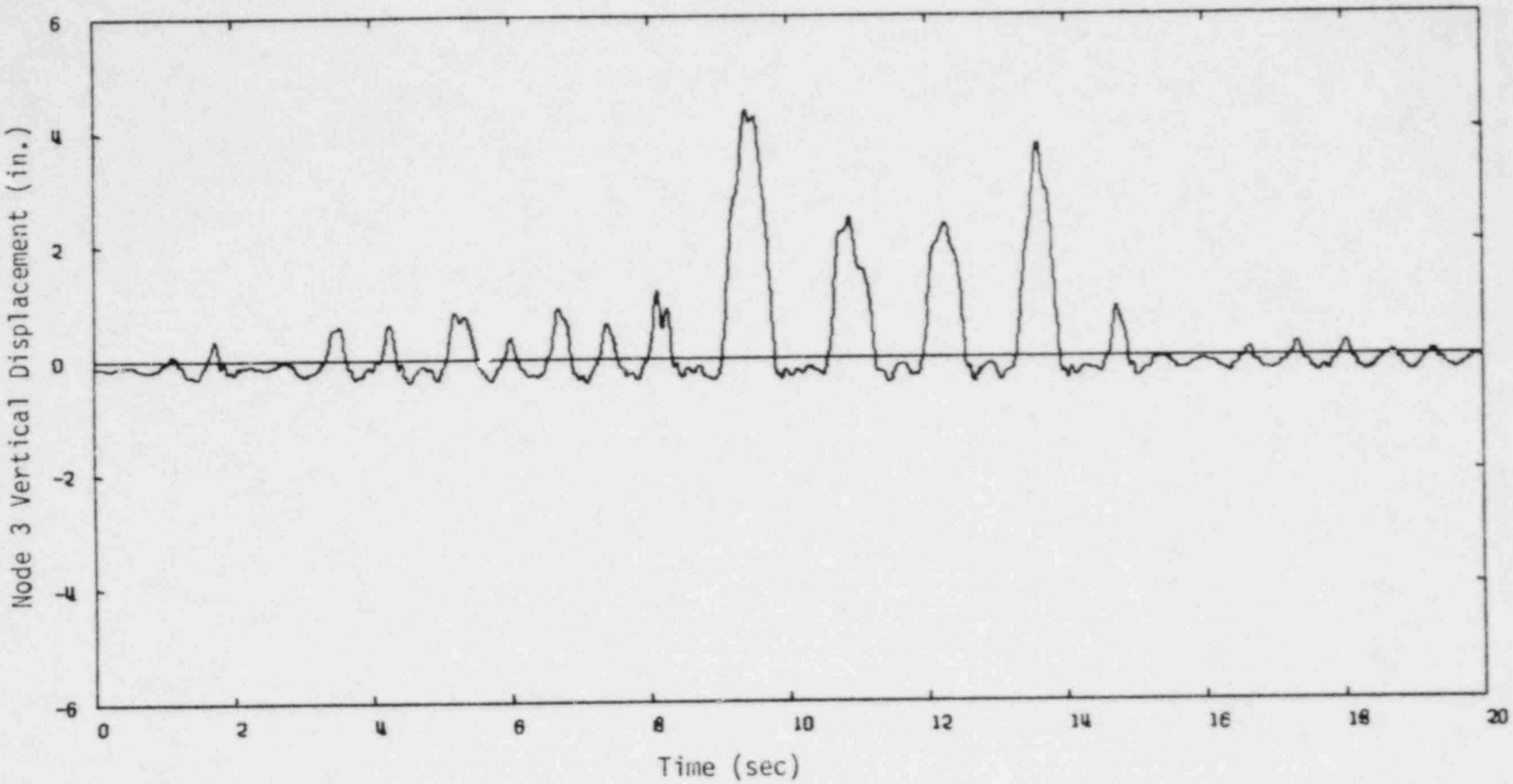


FIGURE 4A-24A VERTICAL DISPLACEMENT HISTORY OF ONE CRANE LEG AT RAIL (TRANSVERSE ROCKING): UNLOCKED AND LOADED CONDITION - FREE

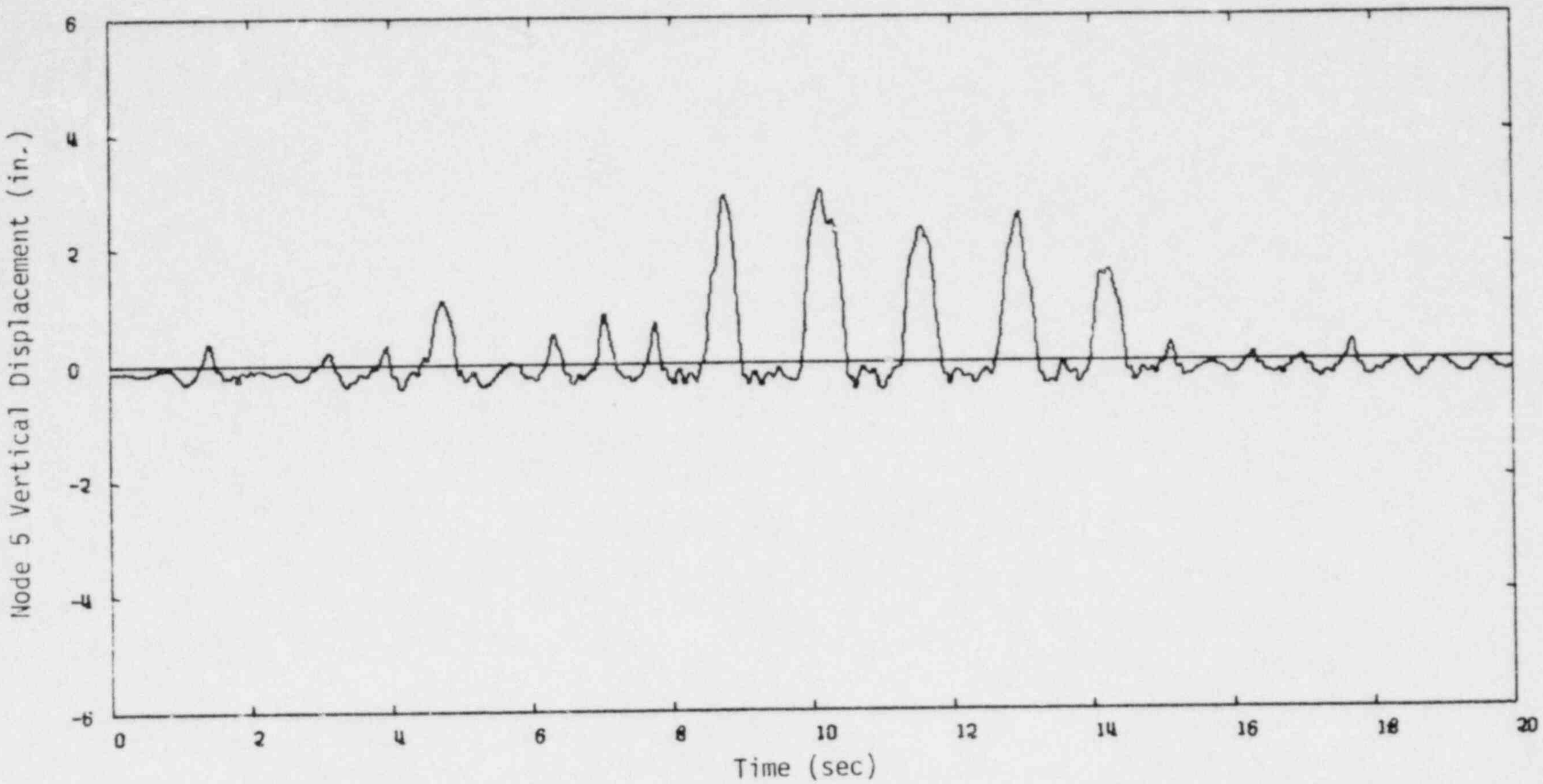


FIGURE 4A-24B VERTICAL DISPLACEMENT HISTORY OF OTHER CRANE LEG AT RAIL (TRANSVERSE ROCKING): UNLOCKED AND LOADED CONDITION - FREE

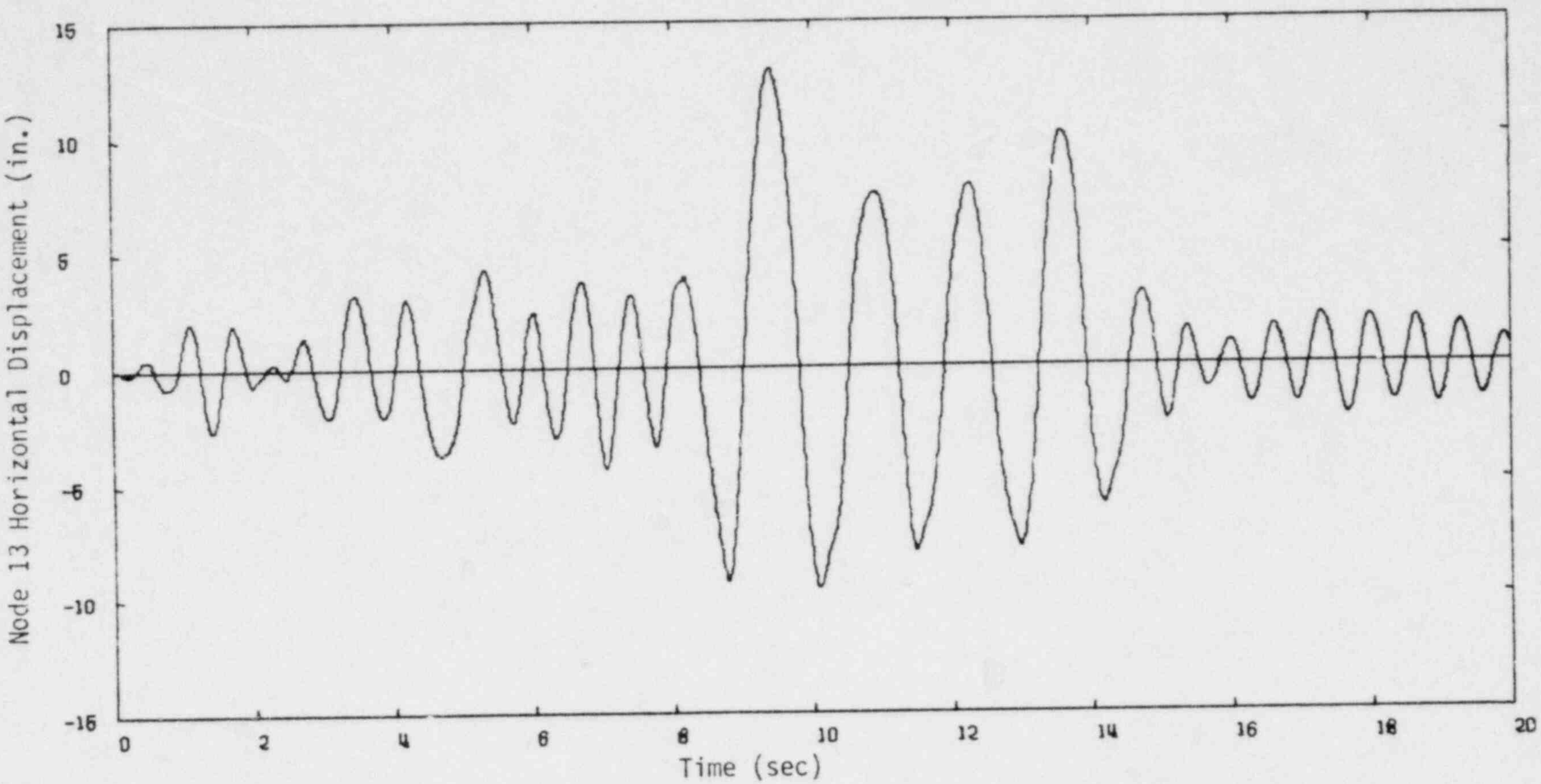
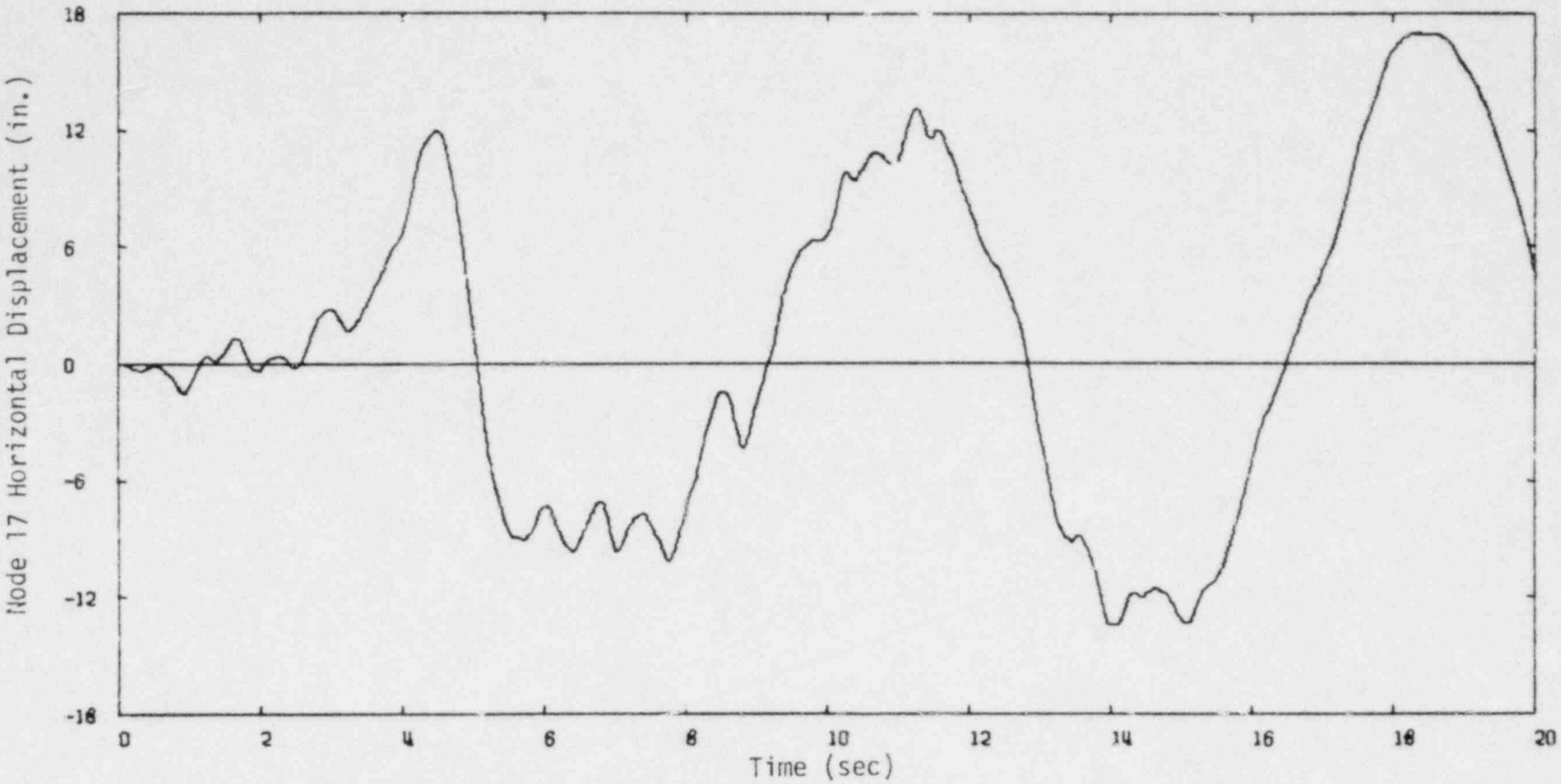


FIGURE 4A-24C HORIZONTAL DISPLACEMENT HISTORY OF CRANE GIRDER (TRANSVERSE ROCKING): UNLOCKED AND LOADED CONDITION - FREE



FIGURF 4A-24 D HORIZONTAL DISPLACEMENT HISTORY OF LOAD (TRANSVERSE ROCKING): UNLOCKED AND LOADED CONDITION - FREE

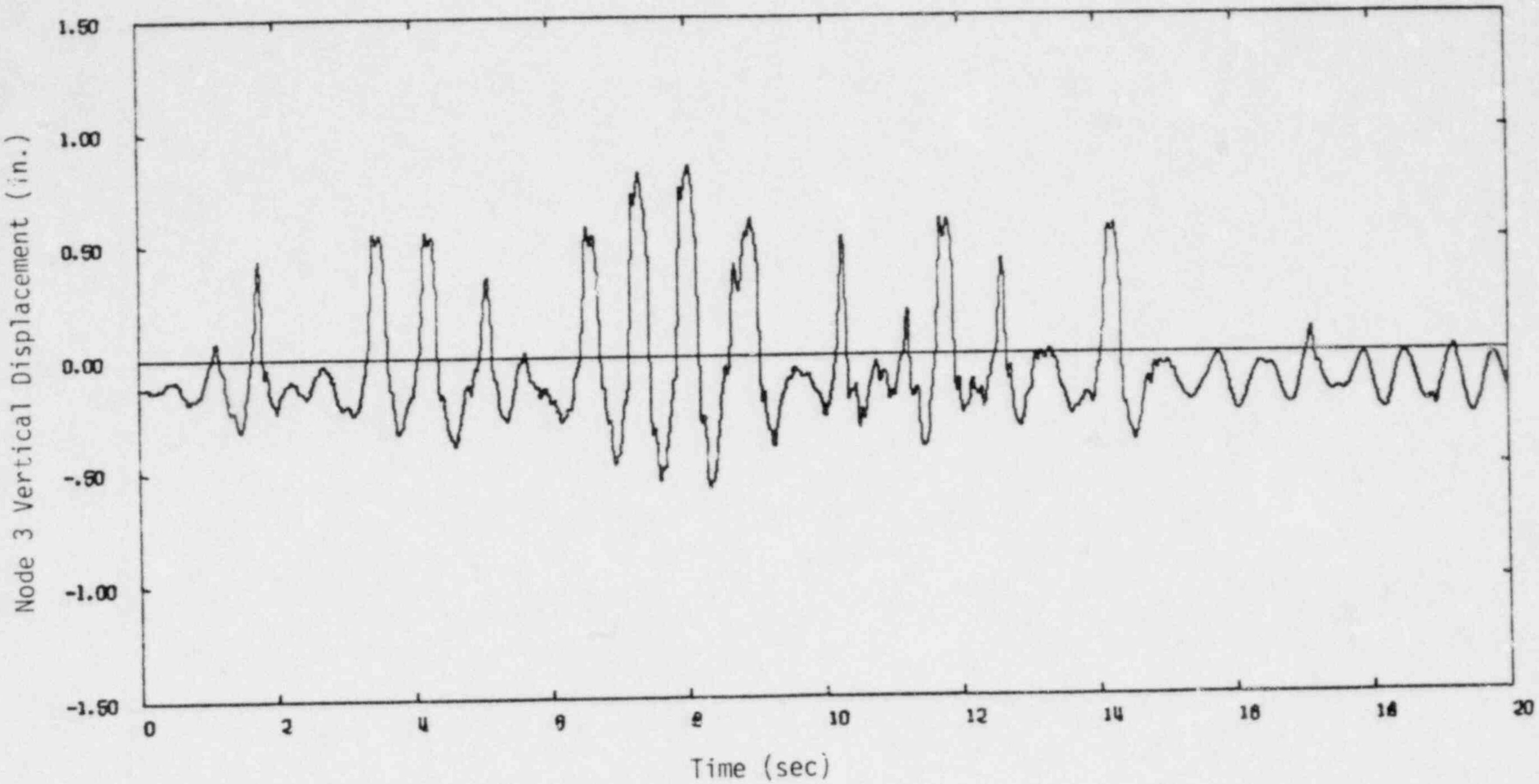


FIGURE 4A-24E VERTICAL DISPLACEMENT HISTORY OF ONE CRANE LEG AT RAIL (TRANSVERSE ROCKING): UNLOCKED AND LOADED CONDITION - TIED

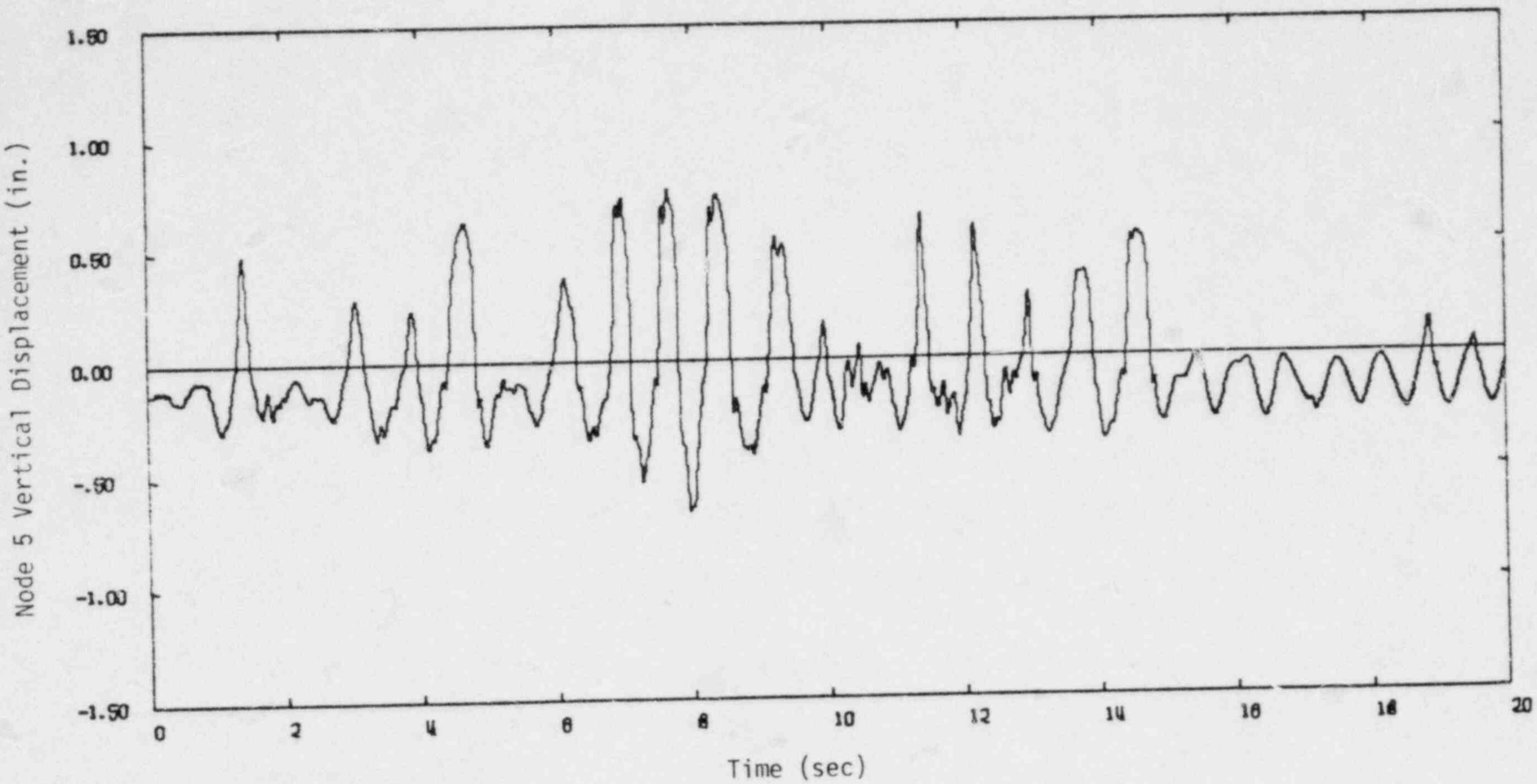


FIGURE 4A-24F VERTICAL DISPLACEMENT HISTORY OF OTHER CRANE LEG AT RAIL (TRANSVERSE ROCKING): UNLOCKED AND LOADED CONDITION - TIED

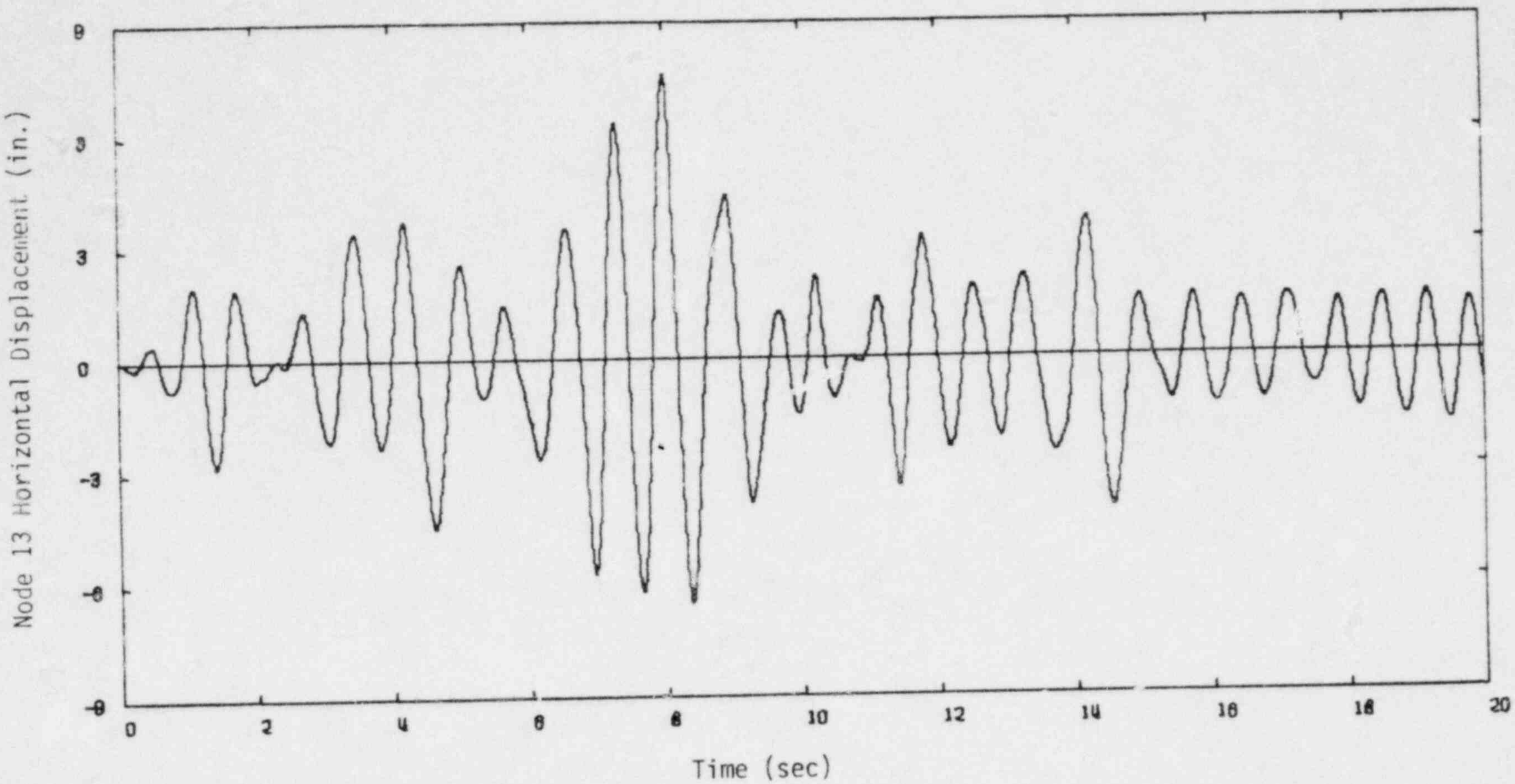


FIGURE 4A-24G HORIZONTAL DISPLACEMENT HISTORY OF CRANE GIRDER (TRANSVERSE ROCKING): UNLOCKED AND LOADED CONDITION - TIED

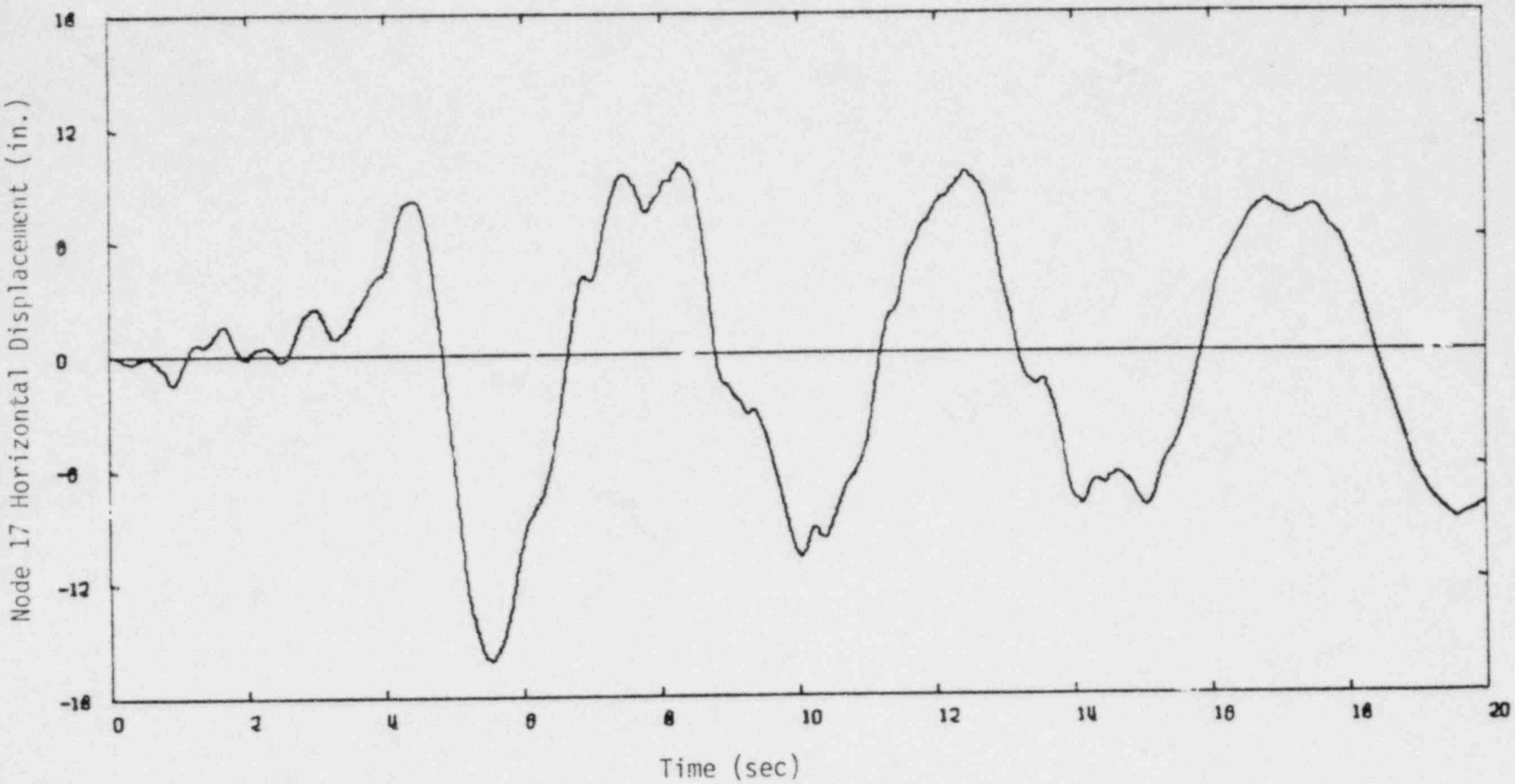


FIGURE 4A-24H HORIZONTAL DISPLACEMENT HISTORY OF LOAD (TRANSVERSE ROCKING): UNLOCKED AND LOADED CONDITION - TIED

AMENDMENT 76

INSTRUCTION SHEET

(File this instruction sheet in the front of Volume 1 as a record of changes.)

The following instructions and check list are provided as a guide for the insertion of new pages for Amendment 76 to the Seismic Evaluation for Postulated 7.5M Hosgri Earthquake, of the operating license application for Units 1 and 2 Diablo Canyon Site. The new pages are marked "Amendment 76" and "(February 1979)" and contain both amended and supplementary material. This material is indicated by a vertical bar with the figure "76" inscribed in the adjacent margin of the page. Where such marks appear adjacent to a blank portion of a page, a deletion is indicated. Where pages have been changed only to reposition material, with no change in content, only the amendment number and the date are given.

For a brief description of the changes made by Amendment 76, see the SUMMARY OF AMENDMENT 76 which precedes the "REMOVAL-INSERTION" INSTRUCTIONS.

SUMMARY OF AMENDMENT 76

Location of Change	Comment
10-33	Changes Test Results Section on Station Battery and Rocks.
10-37 through 10-39	Changes Test Results Section on DC 125/250 VDC Motor Control Center.
10-43 though 10-44	Changes Test Results Section on ITE DC Switchgear (125 Distribution Panelboard).
10-48 through 10-48a	Changes Test Results Section on Diesel Generators.
10-51 through 10-51a	Changes Test Results Section on Fire Pump Controllers.
10-56 through 10-57	Changes Section on Instrumentation Power AC Panelboards.
10-64a through 10-64b	Changes Test Results Section for Local Starters.
10-93	Changes Test Results Section on Safeguard Relay Boards.
10-101	Changes Test Results Section on Ventilating Control, Logic Cabinets.
10-103 through 10-103a	Changes Test Results Section on Ventilating Control, Relay Cabinets.
10-107 through 10-107a	Changes Test Results Section on Vital Load Centers.
10-111a through 10-111b	Changes Test Results Section on Vital Load Center Auxiliary Relay Panels.
10-126 through 10-127a	Changes Test Results Section on 4160-Volt Metal Clad Switchgear.

Location of Change	Comment
Figure 10-16A	Replaces Figure on Turbine Lube Oil Pump Motor Starter.
Figure 10-16C	Adds Figure on 125/250 Volt DC Turbine Lube Oil Pump Motor Starter.
Figure 10-17D	Adds Figure on Test Connections for Molded Case Circuit Breakers.
Figure 10-18G	Adds Figure on Diesel Generator Control Devices.
Figure 10-20E	Adds Figure on Local Starter LPF36.
Figure 10-25D	Adds Figure on 480 Volt Bus "G" Auxiliary Relay Panel.
Figure 10-26J	Adds Figure on Seismic Test Connections for Relays 27HHT1, 27HHT2, and 27XHT

REMOVAL-INSERTION INSTRUCTIONS

Remove	Insert Amendment 76 Material
10-33	10-33
10-37 through 10-38	10-37 through 10-38a
10-43	10-43 through 10-43a
10-48	10-48 through 10-48a
10-51	10-51 through 10-51a
10-56 through 10-57	10-56 through 10-57
10-64a through 10-64b	10-64a through 10-64b
10-93	10-93
10-101	10-101
10-103 through 10-104	10-103 through 10-104
10-107	10-107 through 10-107a
10-111a	10-111a through 10-111b
10-126 through 10-127	10-126 through 10-127a
Figure 10-16A	Figure 10-16A
None	Figure 10-16C
None	Figure 10-17D
None	Figure 10-18G
None	Figure 10-20E
None	Figure 10-25D
None	Figure 10-26J

The cells tested exhibited no damage and they have been returned to the Diablo Canyon Unit 2 Battery 2-1. Subsequently the ampere-hour capacity of the two cells was tested. The results of this test showed that the ampere-hour capacity of the cells were well within the limits set forth in IEEE 76 Standard 450-1975, IEEE Recommended Practice for Maintenance, Testing and Replacement of Large Stationary Type Power Plant and Substation Lead Storage Batteries.

10.3.4.6 Conclusions

Two C&D, Inc. LCU-27 station battery cells have been tested by multi-axis, multi-frequency seismic simulation as described in Wyle Report No. 58255, 4-19-78, pp. 240-254. These cells are identical to the other cells contained in the 6-60 cell station batteries in Diablo Canyon Units 1 and 2. The test results show that the test cells continued to supply DC power at the average load during and after seismic testing to the RRS based on the postulated 7.5M Hosgri event. The cells were not damaged by the test. Discharge testing following this seismic test will be completed at the Diablo Canyon Site by October 15, 1978; however, discharge and charging capability following a seismic event has previously been demonstrated on two identical LCU-27 cells tested earlier (see Wyle Report No. VL-762-02, August 4, 1976 (see Figure 10-15B, sheets 1 through 7).

On this basis it is concluded that the six Diablo Canyon station batteries are qualified for the postulated 7.5M Hosgri event in accordance with IEEE-Std 344-1975 and USNRC RG 1.100.

10.3.5.1.5 Test Results[1]

After mounting on the seismic test table, the starter was functionally tested by appling 125 VDC control power to the input of the starter breaker 72-2008, then manually closing this breaker. The manual switch on the test set-up was closed to provide a signal to start the motor. Contactor 42 energized, starting the time delay relay sequences. Upon completion of all contactors closing, the manual switch was returned to open and the motor starter returned to its motor tripped state.

During the 1st, 2nd, 3rd, and 4th OBE and SSE in the X-Y (east-west and vertical plant orientation) the starter was observed in its motor-tripped state. The timers, relays and contactors did not close or chatter to inadvertently start the motor starter sequences during the seismic test. The starter did not operate in its deactivated state during the 1st, 2nd, 3rd, and 5th OBE, and the 1st SSE in the Z-Y direction.

During the 5th OBE and the 2nd SSE in the X-Y direction, and the 4th, 5th, OBE's and 2nd SSE in the Z-Y direction, the manual switch was closed energizing contactor 42 and started the time delay contactor sequence. Upon completion of the sequence, the stop switch was opened releasing all the contactors. The entire sequence was completed before the end of each 30 second test.

Upon completion of the last SSE, the manual switch was again closed and the starter run through its sequence and again, deenergized.

The above seismic and functional testing verifies that this representative direct current motor starter was not inadvertently activated by the seismic shaking. Functionally, during a seismic event, the starter would remain off, would start the motor if switched on in the automatic position or manually, and would trip off if switched automatically or manually.

Table 10-5 shows a list of components contained in this starter and summarizes their functional performances during the seismic testing. 76

---

1. Detailed test results are contained in Wyle test report 58255, April 19, 1978, pp. 214-239 and Addendum 2. 76

The starter was further tested as required in the "Seismic Test Procedure for Diablo Canyon 125/250 VDC Turbine Lube Oil Pump Motor Starter" dated November 30, 1978. The testing program was extended into a full seismic qualification of the starter because its mounting to the shake table was improved over the mounting during the earlier test to represent better its actual field mounting. The electrical connections are shown in Figure 10-16A revised. The seismic requirements were the same as described in the "Test Criteria and Plan" paragraph 10.3.5.1.3 above. The required seismic test sequence is shown in Figure 10-16C. 76

The starter was subjected to a total of ten OBE and three SSE runs in the front to back orientation and five OBE and three SSE runs in the side to side orientation. All criteria and conditions described in 10.3.5.1.3 above and further described in the November 30, 1978 test procedure were met. At no time did the starter contacts chatter or close inadvertently. The contactors closed in the proper sequence and also opened without delay when switched during the runs.

The starter was operated before the test runs and again after the test runs. The switching sequences as recorded were identical to the switching sequences recorded during the test runs.

10.3.5.1.6 Conclusions

The results of the tests of the 250 VDC Turbine Lube Oil Pump motor starter subjected to a multi-axis, multi-frequency seismic simulation bounding the 7.5M Hosgri event have demonstrated that the test criteria specified above have been met.

Thus it is concluded that the 250 VDC Turbine Lube Oil motor starter is qualified for service in the Diablo Canyon plant for the 7.5M Hosgri event in accordance with IEEE-344-1975 and USNRC Regulatory Guide 1.100.

The 250 VDC Turbine Lube Oil Pump Motor Starter itself does not have a safety related function. However, inadvertant operation of anyone of its contactors could have an adverse affect on the plants 125/250VDC System; the reason for its seismic qualification requirement. The starter when tested, including the additional further testing, was exposed to a great number of simulated seismic events. It may serve as an example for determining effects of seismic events on electro mechanical equipment. Post test examination has shown that no physical or electrical damage was incurred; thus proving that plant electrical equipment of this general type has a high resistance to damage during seismic event. Therefore, it can be reasoned that electro mechanical equipment, which underwent seismic testing, can be used in safety related systems. 76

2a. (1) Closed auxiliary switch contacts remained closed.

(2) Open auxiliary switch contacts remained open (this contact is for alarm to Annunciator).

(3) Closed auxiliary switch contacts remained closed.

2b. Both Battery Charger Ammeters maintained 50 amperes. The Battery Charger Voltmeter and the 125 VDC Switchgear Bus Voltmeter maintained 132 VDC. Breaker did not trip to indicate loss of load.

2c. The SV relay picked up as the battery charger energized the switchgear with breakers 72-2100 and 72-2102 closed (125 VDC). At no time during the testing nor after the testing did the SV contact pick up except when the breakers or the battery charger was tripped off. SV contacts did not pick up during the energized time to indicate a drop in voltage below 112 VDC setting of the SV relay. The SV relay contact was monitored by Channel No. 4 of the chatter detector as shown on Figure 10-17B.

2d. If the breaker had tripped off the battery charger output would have dropped by the amount of load bank resistance lost with the open breaker.

2e. At no time by visual observation did the DC Switchgear nor the Battery Charger Voltmeter reading drop, when the switchgear and the Battery Charger were energized and the 125 VDC battery connected.

2f. The white light stayed on indicating bus potential.

Following the seismic tests, the SD-21 Distribution Panelboard was shipped back to Diablo Canyon Unit 2, its functional performance was tested and verified, and it was placed back in service in the plant.

Six molded case circuit breakers were further tested separately. The test requirements were defined in the "Seismic Test Procedure for Diablo Canyon 125 VDC Switchgear Distribution Panel, Molded Case Circuit Breakers, Addendum No. 1" dated December 20, 1978. The actual electrical test connections are shown in Figure 10-17D. Shunts were added to monitor the current flow thru the one set of circuit breakers rather than relying on the voltage drop across the ammeter and the current transformer in the 20A circuit breaker loop was omitted since the ammeter used could measure the current directly. An indicating light was added to demonstrate that 125 VDC voltage potential was present at all times during the test between the live parts of the molded case circuit breakers and their mounting base.

Two composite spectra were made up to be similar to the data on response plots pages 265-280 as referenced in the procedure. Machine limitations fell somewhat short of the desired spectra. For an added measure of assurance, a sine sweep was performed from 1 - 35 Hz at 3 g's input. The sweep was performed one axis at a time in the three axes. 76

No chatter was recorded as observed during the test runs neither on the closed and current carrying circuit breakers nor on the circuit breakers left open. The white potential indicating light remained lit during the test series indicating that no insulation breakdown had occurred.

The circuit breakers were tested for their overcurrent trip ranges upon return to the Diablo Canyon Site. They operated (tripped) within their acceptance time and current range.

10.3.5.2.6 Conclusions

A 125 VDC Distribution Panelboard (SD-21) from Diablo Canyon Unit 2 was tested by a multi-axis, multi-frequency seismic simulation described in Wyle Report No. 58255, April 19, 1978, pp. 255-280. This panelboard is identical to the other five 125 VDC Distribution Panelboards installed in

Devices from the subpanel were connected to appropriate power sources and monitored per Figure 10-18F. The devices are listed in Table 10-7.

10.3.6.6 Test Results

The test specimens demonstrated their abilities to withstand without compromise of structure or safety functions the simulated seismic environment of seismic random biaxial motion performed to the required response spectra. The output field current was visually monitored and did not fluctuate during the test sequences.

The equipment was further qualified by submitting the whole Diesel Generator Control Cabinet to a seismic qualification test. All devices met the conditions of the "Seismic Test Procedure for Diablo Canyon Diesel Generator Control Cabinet" dated November 30, 1978. The devices of the control cabinet were connected to 125VDC and 120VAC sources as shown on Figure 10-18G. Two pressure switches, PS 218 and PS 204, from the Diesel Generator Gauge Panel were added to the test. They were mounted rigidly to the shake table alongside the control cabinet. Air supplies were connected to the pressure switches and provisions were made to operate the pressure switches. They were switched during the test sequences when the electrical devices of the control cabinet were switched. Again, the equipment, structurally and electrically, met all requirements of the test procedure. The devices were operated prior to and after the seismic shake tests and their functions and timings were recorded. The tests demonstrated that all devices will operate as required during and after seismic events at a magnitude of the postulated Hosgri earthquake. Post test inspection did not reveal any physical damage. 76

The change of state of the Excitation Cubicle Devices was not demonstrated during the test runs. However, many tests of equipment with similar devices (relays) were performed which demonstrated that electro magnetic devices will change state on command without delay. Most of the test required much higher acceleration levels of the test machine than would be necessary for the Excitation Cubicle. Therefore, it can be reasoned that the relays within the Excitation Cubicle will also change state on command and further testing should not be required. It was demonstrated that the safety related devices of the Excitation Cubicle do not chatter or change state unintentionally during seismic events.

10.3.6.7 Conclusion

One Diesel Generator Excitation Cubicle and one Control Cabinet of Diablo Canyon Unit 2 were seismically tested by a multi-axis, multi-frequency seismic simulation described in WYLE Report Number 58255, dated April 19, 1978 and Addendum No. 2. The equipment contained devices representative of the contents of all Diablo Canyon Unit 1 and 2 Diesel Generator Control. Thus qualification will apply to all Diesel Generator Excitation Cubicles and Diesel Generator Control Cabinets. 76

The test results presented in section 10.3.6.6 above demonstrate that the test criteria are met, and thus that the equipment's safety function has been demonstrated during and after seismic testing to the RRS derived from the postulated 7.5M Hosgri event.

It is therefore concluded that the Diablo Canyon Units 1 and 2 Diesel Generator Excitation and Control Equipment are qualified for the postulated 7.5M Hosgri event in accordance with IEEE Standard 344-1975 and USNRC R.G. 1.100.

5. Run five OBE and two SSE tests (reduce pressure to actuate controller prior to one OBE and one SSE)

6. Rotate equipment 90 degrees on table and repeat steps 1 through 5.

7. Test equipment to verify proper operability prior to placing in service.

10.3.8.5 Test Results

No physical damage was observed as a result of the testing. Relays ICR, 3TR and the auxiliary contact of the main contactor demonstrated chatter during one SSE. As control power was available and no undesirable actuation occurred, the chatter presents no problem.

Functional testing has verified that the equipment is capable of starting the fire pump after the seismic test.

The Fire Pump Controller was further tested as described in the "Seismic Test Procedure for Diablo Canyon Fire Pump Contoller" dated December 29, 1978. During this test the controller chattered, closed and sealed itself in. The chatter and seal-in occurred during the front to back orientation SSE runs. It is believed that a minor modification in the mounting of the controller to the test machine, making it more rigid than it was during the first testing, caused the closure of the controller. However, inadvertent closure of the controller and start of the Fire Pump does not have an adverse effect on the fire protection system. No chatter of the main contacts of the controller has been recorded once it had closed or during the test run with the contactor energized and closed intentionally. The front to back orientation is the direction in which the controller is most susceptible to chatter during seismic events. In the light of the inadvertant closure of the controller during seismic testing in this orientation it was decided not to test the controller any further in this side to side orientation. It should be noted that the 76 equipment has experienced more than the minimum number of test runs, 5 OBE's and 1 SSE, in both axes during the first and second testing program. Thus meeting IEEE and NRC seismic qualification requirements. 76

10.3.8.6 Conclusions

One of two Fire Pump Controllers from Diablo Canyon was tested by a multi-axis, random frequency, seismic simulation as described in Wyle Test Re, rt 58255, pp. 217-224 and 229-234.

The test results in section 10.3.8.5 demonstrate that the test criteria specified in section 10.3.8.3 are met and thus that the equipment's safety function has been demonstrated during and after seismic testing to the RRS based on the postulated 7.5M Hosgri event. The inadvertent closure of the controller during test runs does not compromise its safety function. 76

It is therefore concluded that the Diablo Canyon Units 1 and 2 Fire Pump Controllers are qualified for the postulated 7.5M Hosgri event in accordance with IEEE Standard 344-1975 and NRC RG 1.100.

This equipment is located at the 115 foot elevation of the auxiliary building. Figure 10-5 presents a comparison of TRS and RRS. The RRS were developed from the Hosgri floor response spectra given in Chapter 4. At 9.5 Hz, the test frequency closest to the predominant frequency of the building, the ZPA test input level is 1.50g. This value is greater than the maximum Hosgri ZPA (1.16g horizontal) for the floor elevation where this equipment is located. The test vertical input accelerations were 2/3 of the horizontal. The Hosgri requirement for vertical floor acceleration at this location is 0.58g.

For this equipment, the significant resonances occur at 6 to 8 Hz for the side to side (N-S) direction and at 8 to 10 Hz and 14 to 16 Hz for the front to back (E-W) direction. As shown in the figure, the 7 Hz sine-beat test envelops the N-S spectrum from approximately 5.2 Hz to 8.1 Hz. The 9.5 Hz test envelopes the E-W spectrum at all frequencies above approxiered by testing at many frequencies with only three shown on the figure. As indicated in the figure, the overtest at 9.5 Hz is approximately 2.6 times the required spectrum.

Since the horizontal and vertical test ZPA exceed the required Hosgri ZPA, the equipment is qualified according to the requirements of IEEE-344-1971. In addition, the degree of conservatism compared to the RRS shows that the concluded that the static inverter is qualified for the Hosgri event.

10.3.11 INSTRUMENTATION POWER AC PANELBOARDS (B.O.P.)

The instrumentation power panelboards (AC) are mounted on reinforced concrete walls five feet above the 115 ft floor elevation of the Auxiliary Building. The panelboards were previously qualified for DDE accelerations (at the average elevation of 120 ft) of 1.19g east-west, 1.41g north-south and 0.27g vertical. (The front-to-back direction is north-south.) The panelboards are Federal Pacific Electric Company type NAIB with type NE circuit breakers. 76

In March 1976, PGandE's Department of Engineering Research, in situ tested one of the Instrument Power AC Panelboards, PY-22, (DER Report 7333,141-76), and determined that the panelboard (as a whole) and the panelback (as a component) have no natural frequency below 33 Hz, and that the mounting plate (above the breaker assembly) has a resonance frequency of 30 Hz. This mounting plate has been modified on all panelboards with horizontal centerline supports to the back panel per the recommendations in the above report. The circuit breaker assembly has no resonance below 33 Hz. Therefore, the circuit breakers would be subjected to the unamplified accelerations of the wall on which the panelboard is mounted. The wall mounting can resist up to 18g acceleration in any direction.

For the Hosgri 7.5M event, at the Instrument AC Power Panels, the floor accelerations are: 0.52g Horizontal and 0.56g Vertical. At a wall location 5 ft. above the floor at 115' Elevation these accelerations would be 1.00g and 0.6g respectively. In April 1975, Wyle Laboratories tested single pole and two-pole FPE type NE circuit breakers which are identical to those used in the Instrument AC Power Panels (Wyle Laboratory Report No. 53744-2). ZPA of these tests were (on the average) 2.8g horizontal and 1.5g vertical, applied simultaneously. The circuit breakers were monitored electrically during the Wyle tests and did not chatter or malfunction. Circuit breakers of essentially the same design were tested to acoustant 3g's at all frequencies between 0 and 35 Hz, as described in section 10.3.5, with no malfunctions. For these reasons it can be concluded that the Instrument Power AC Panelboards are qualified for a postulated 7.5M Hosgri event in accordance with IEEE-Standard-344-1975 and USNRC R.G. 1.100. 76

10.3.12 INSTRUMENT PANELS PIA, PIB, AND PIC (B.O.P.)

These instrument panels house various devices used to power balance of plant transmitters and perform the necessary signal conditioning of provide alarm functions and send linear signals to indicators on the main control board. The parameters involved are CCW flows and heat exchanger ΔP, and RWST level. These panels replace the original instrument rack, PGIR. Most of the components in them were originally in PGIR. The panels are mounted on reinforced concrete columns at about the 132 feet elevation, 131 feet west of the center of mass at this location.

Procedure:

1. Run three OBE tests with controller energized. Monitor main power contacts (use strip chart recorder) for contact openings.

2. Run two OBE tests with controller de-energized (strip chart recorder off).

3. Run one SSE test with controller de-energized (strip chart recorder off).

4. Run one SSE test with controller energized. Monitor main power contacts (use strip chart recorder).

5. Rotate equipment 90° on test table and repeat steps 1 through 4.

10.3.14.5 Test Results

All local starters met the test criteria specified in Section 10.3.14.3. All test results are reported in Wyle Laboratories Report 58255 as follows:

STARTER	CHATTER MONITORING	RRS/TRS
LPF 37	pp. 283-284	pp. 286-308
LPG 66	pp. 413-414	pp. 416-422
LPF 36	pp. 483-484	pp. 485-490

The above referenced results show that no contact chatter occurred of any auxiliary contacts or main power contacts when monitored. Strip chart records indicate no interruption of continuity through power contacts in the energized state. All Test Response Spectra (TRS) enveloped the Required Response Spectra (RRS).

Local Starter LPF-36 was further tested as required in the "Seismic Test Procedure for Diablo Canyon Local Starter LPF-36" dated December 1, 1978. The starter was connected to a 120V AC power supply and its main contact monitored on a direct readout recorder. Refer to Figure 10-20E. The control switch "S" was located on the test bench and enabled starter operation during the test runs. A second pole of the control switch was connected to the recorder to monitor the closing or opening command the starter had to follow. The starter contactor changed state without delay during the test runs when switch "S" was operated. No chatter of the contacts was recorded. The test results will be recorded in Wyle Laboratories Report 58255, Addendum 2. 76

10.3.14.6 Conclusion

Representative local starters were tested by a multi-axis multi-frequency seismic simulation described in Wyle Report 58255.

Based on the equipment tested and the test procedure employed, these qualification tests bound the seismic requirements for all local starters.

The test results described above show that the test criteria and the equipment's safety function have been demonstrated during and after seismic testing to the RRS based on the postulated 7.5 Hosgri event. Thus, it is concluded that the Diablo Canyon Unit 1 and 2 Local Starters are qualified for the postulated 7.5M Hosgri event in accordance wit IEEE Standard 344-1975 and USNRC R.G. 1.100.

10.3.15 MAIN CONTROL BOARD (NSSS AND B.O.P.)

10.3.15.1 Description of Equipment

The main control board is located in the control room at elevation 140' in the Auxiliary Building. It contains the control and indicating devices used by the operator to interface with the process control systems, and otherwise control the plant. It has two major structures: the control console, and the vertical boards.

The evaluation of the strain gage traces showed that the structural members of the relay board were exposed to stresses well within their design limits.

No physical damage to the relay board or its devices was observed.

The settings and performances of the protective relays, including the SA-1 diesel generator differential relay, were tested prior to the test runs and again verified after the test runs. No deviation was recorded.

The Agastat series 7000, Diesel Auto Transfer Timing Relay 62HH2, was checked for its calibration after the test runs. Using the same electrical connections described in paragraph 10.3.21.4g. above, the relay was switched and its timing recorded. The test was performed consecutively four times. The time delay was the same on the recorder printouts generated during the test runs and the recorder printouts generated after the test runs. This demonstrated that the timing of the relay was not affected by the seismic test. 76

10.3.21.6 Conclusion

Safeguard Relay Board H of Diablo Canyon Unit 2 was seismically tested by a multi-axis, multi-frequency seismic simulation described in Wyle Report Number 59255-1, dated August 22, 1978, pp. 92-138. This board contains devices representative of the contents of all Diablo Canyon Unit 1 and 2 Safeguard Relay Boards. Thus, qualification of this board will apply to all Diablo Canyon Safeguard Relay Boards.

The test results presented in Section 10.3.21.5 above demonstrate that the test criteria are met, and thus that the equipment's safety function has been demonstrated during and after seismic testing to the RRS derived from the postulated 7.5M Hosgri event.

It is therefore concluded that the Diablo Canyon Units 1 and 2 Safeguard Relay Boards are qualified for the postulated 7.5M Hosgri event in accordance with IEEE Standard 344-1975 and USNRC R.G. 1.100.

10.3.23.5 Test Results

The ventilation control logic was undamaged by the seismic testing, as verified by functional testing after completion of the seismic shaking. The typical outputs monitored maintained the proper relationship to the logic input during and after the tests. Change of state of the output relays was not demonstrated during the test runs. However relays, using reed contacts of similar design have been operated successfully during seismic test runs. For instance, relays K632AX and K632BX of the Vital 76
Load Center Auxiliary Relay Panels, paragraph 10.3.25A have been switched many times during seismic tests. It can be reasoned that low mass reed relay contacts will not change state under even severe seismic conditions.

10.3.23.6 Conclusions

The Ventilation Control Logic cabinet from Diablo Canyon Unit 2 was tested by a multi-axis, multi-frequency seismic simulation described in Wyle Report No. 58255, pp. 182-197. This Ventilation Control Logic Cabinet is identical to that installed in Diablo Canyon Unit 1.

The test results in section 10.3.23.5 demonstrate that the test criteria specified in section 10.3.23.3 are met and thus that the equipment's safety function has been demonstrated during and after seismic testing to the RRS based on the postulated 7.5M Hosgri event.

It is therefore concluded that the Diablo Canyon Units 1 and 2 Ventilation Control Logic Cabinets are qualified for the postulated 7.5M Hosgri event in accordance with IEEE Standard 344-1975 and NRC RG 1.100.

Five Operating Base Earthquakes (OBE) and two Safe Shutdown Earthquakes (SSE) were to be applied to the equipment in each axis. Required Response Spectra (RRS) developed for the plant location where the relay cabinet is mounted were used. Random bi-axial motion was to be applied to the equipment supports.

All testing was to be conducted in accordance with IEEE Standard 344-1975 and USNRC Regulatory Guide 1.100.

10.3.24.4 Test Procedure and Set-Up

A relay cabinet subpanel was removed from the plant and mounted to the shake table in the same manner as it is mounted in the field. (See Figure 10-25A.)

Fan control relays E1SR and S1SR are typical for safety related relays and were monitored for contact chatter. Each relay had one normally open (N.O.) and one normally closed (N.C.) contact connected to the chatter detector which was set at 2 milliseconds. Undervoltage relay 27-11UV also had one N.O. and one N.C. contact monitored for chattered. (See Figure 10-25B.)

The Test Response Spectrum (TRS) was developed which enveloped the RRS (see Wyle Report 58255, pages 150-156 and 162-168). Five OBE and three SSE test runs were then conducted. During two OBEs and one SSE the relays were energized. The subpanel was then rotated 90 degrees and the test runs repeated.

All relays were tested for satisfactory operation after the testing was completed.

10.3.24.5 Test Results

No physical damage was observed or detected and no relay contact chatter was detected in either the energized or deenergized state. All circuits and connections remained intact. The equipment was systematically checked out after the test and found to operate satisfactorily.

Change of state of the relays during the test runs was not demonstrated. However relays of identical design as the safety related relays of the Ventilation Control Relay Panel have been successfully operated during seismic test runs. For instance relays K632AX and K632BX of the Vital Load Center Auxiliary Relay Panels, paragraph 10.3.25A, have been switched many times during seismic tests. The reed contacts of these relays have such a low mass that differences in the required response spectra used for the testing of various equipment will not have an appreciable effect on the performance of these relays. 76

10.3.24.6 Conclusions

As a result of the above described testing which demonstrated satisfactory operation of the relay subpanel and the relays it can be concluded that the Ventilation Control Relay Cabinet is qualified to perform its safety function during and after a Hosgri fault seismic event.

10.3.25 VITAL LOAD CENTERS (B.O.P.)

The 480 volt type W motor control center consists of the following typical equipment: starters, breakers, relays, transformers, and indicating lights.

10.3.25.1 Description of Equipment

The Vital Load Centers (480 volt MCC, bus, F, G and H) consits of draw-out modules containing combination motor controllers or feeder breakers. These modules are arranged in vertical stacks with vertical stacks bolted together to make a line-up. Electrical bussing is provided both horizontally between stacks and vertically between modules. Each combination motor controller consists of a molded case magnetic-only circuit breaker, contactor and overcurrent relay. Feeder breakers are simply molded case thermal-magnetic circuit breakers. The Vital Load Centers are located at elevation 100' in the auxiliary building.

10.3.25.2 Safety Function

The Vital Load Centers must provide power on demand for Engineered Safety Features equipment. The major loads are electric motor operated valves and ventilation fans. In orderly accomplish this basic function, feeder breakers must remain closed, contactors must close on demand and remain closed, and overload relays must not spuriously operate to interrupt power inadvertently.

10.3.25.5 Test Results

With the exception of the anomalies discussed below, all Vital Load Center equipment met the test criteria specified in section 10.3.25.4 during and after the seismic testing while being operated per the test procedure described in 10.3.25.5 above.

During the initial tests it was determined that the draw-out modules required additional hold down brackets to eliminate excessive movement during the seismic testing. Hold down brackets where fabricated and utilized throughout the complete test sequence.

During one SSE one N.O. and one N.C. auxiliary contact on the size 4 controller chattered. Analysis determined that the auxiliary contacts are used only for indication. This chatter could at most result in momentary actuation of indicating lights. Momentary actuation of indicating lights during seismic shaking, with the contacts and indicating lights returning to proper status on cessation of the seismic motion has been judged not to have unacceptable impact on plant safety.

In addition, one N.C. contact chattered with the size 2 reversing controller deenergized. This effect has been analyzed and determined to present no degradation of any safety function. The primary reason for this is that all safeguards initiation signals are sealed-in until manually reset. Therefore, if the N.C. contact chattered and momentarily caused a motor operated valve to stop, (a fraction of a second) it would immediately resume travel as directed by the safeguards initiation signal.

Controllers of all sizes were tested at the power plant site and it was demonstrated that their mechanical configuration causes the normally open (N.O.) auxiliary contacts to close before the main power contacts. 76
Therefore it is concluded that if the N.O. contacts, monitored during seismic testing, did not chatter the associated main power contacts also did not chatter.

In the case of the size 4 controller, noted above, should the main power contacts chatter, chatter will not adversely affect the safety function of the controller or the connected motor. The nature of such chatter is that the contacts are closed for an extremely short time only; too short for motor acceleration. However inrush current across the controller contacts must be expected. The controllers are designed to interrupt inrush current 10,000 times and will survive chatter without degradation. The size 4 controllers are designed for motors up to 100 horsepower. The largest motor connected to a safety related bus in Diablo Canyon, however, is only 75 horsepower. Therefore, the controller will never have to interrupt the full motor inrush current its design permits. 76

The 480V motors are designed to withstand the thermal effects of inrush currents for much longer periods than chatter of the controller permits. Therefore, it can be reasoned that a motor will not be damaged by chatter of its controller.

10.3.25.6 Conclusions

A vertical section of the Vital Load Center was tested, with each NEMA size controller and representative circuit breakers installed, by a multi-axis, multi-frequency seismic simulation as described in WYLE Report No. 58255, pp. 318 to 410. Based on the components tested and the test procedure employed, these qualification tests are judged to be bounding for all Vital Load Center equipment.

10.3.25A.5 Test Results

All test response spectra (TRS) are given in WYLE Test Report 58255, pages 454 to 475. All relays performed satisfactorily, exhibited no chatter and maintained all connection and circuit integrity.

The relays were not switched during the seismic test runs. Agastat timers and other similar relays have been switched during other tests and have operated satisfactorily. In addition, the forces generated by the electro-magnetic operating coils exceed by many times the forces generated by seismic accelerations. Seismic forces are vibratory in nature and at very short intervals pass through zero and reverse in direction which would allow or aid in relay operation.

Auxiliary Relay Panel 2G, was further tested to demonstrate that typical relays operate, change state, during seismic events. Refer to "Seismic Test Procedure for Diablo Canyon Vital Load Center Auxiliary Relay Panels," dated December 22, 1978. During the pretest checkout of the electrical relay functions it was found that the normally closed (N.C.) contact of Relay K632AX and of the identical K632BX relay did not open on energization of the relays. These contacts are not used in the plant circuitry and for that reason had not experienced the normal operational check-out at the Diablo Canyon Site. The test then was conducted with Relay K632BX included. Of Relays K632AX and K632BX only the N.O. contacts, the contacts used in the Diablo Canyon Circuitry, were monitored. See Figure 10-25D. 76

All relays changed state on command during the test runs. The timing of the 2G2 SIS Timing Relay was within its design limits.

Later, when new N.C. contacts became available, the Auxiliary Relay Cabinet was tested again alongsite the Fan Cooler Motor Controller, Relay K632AX was connected to switch SI and both its N.O. and N.C. contacts were monitored. The relay and its contacts operated as required during the test runs.

No chatter of the monitored relay contacts was recorded throughout the test series. Refer to WYLE Test Report 58255, Addendum 2. 76

10.3.25A.6 Conclusion

As a result of the testing conducted as described in section 10.3.25A.4 and the results described above the Vital Load Center Auxiliary Relay Panels are seismically qualified, in accordance with IEEE Standard 344-1975 and USNRC Regulatory Guide 1.100, for service at the Diablo Canyon site.

- Run 16, Channel 2,
a-Contact of Auxiliary Switch, Breaker 52HH7 -

The spurious opening of this contact is of no significance. The auxiliary switch mechanism needed minor additional adjustment.

- Run 16, Channel 12, 4HH14 Start-Up Auto Close Relay -

Chatter of this relay by itself does not adversely affect a Class IE function. The test set-up was to demonstrate that the 27HHB1 Bus Undervoltage Relay would pick up 4HH14 on undervoltage (which was demonstrated during the test sequences).

- Run 17, Channel 7, 2HH9 Timing Relay -

See Run 8, Channel 7, above.

- Run 17, 27, and 22, Channel 11,
27ZHHB2 Bus Undervoltage Auxiliary Relay -

See Run 8, Channel 11, above.

- Runs 17, 19, 20, 27, 32, and 33, Channel 12,
4HH14 Start-Up Auto Close Relay -

See Run 16, Channel 12, above.

All protective relays were tested for their calibration and setpoints immediately before and after the seismic tests. The relay testers records show that none of the relay settings had changed or shifted and that the trip setpoints were still within the tolerances normally incurred in relay testing. 76

The 4160V switchgear and the associated relays met the test criteria specified in section 10.3 26.4 above during and after the seismic testing while being operated per the test procedure described in section 10.3.26.5 above. It is worthy of note that the equipment was subjected to more than the minimum number of test runs for qualification, demonstrating that there is a substantial margin in the equipment's resistance to seismic damage.

No physical damage to the switchgear structure or the associated devices was observed.

Maximum horizontal displacement of the structure was measured to be .55 inches; maximum vertical displacement was .2 inches.

As a result of this test the following actions will be taken:

a) Potential transformers on top of Cells 13 and 14 of all 4160V Class IE switchgear sections will be removed and relocated to a separate stand next to the respective switchgear. Electrically they will be wired to the switchgear as they were connected before.

b) Bus duct earthquake joints will be installed in all joints at the top of the Class IE switchgear sections. The test measurement will be used in the design criteria.

The functions of the Undervoltage Trip Relays 27HHT1 and 27HHT2 in conjunction with the Undervoltage Trip Auxiliary Relay 27XHHT were further tested in accordance with the "Seismic Test Procedure for Diablo Canyon 4160V Class 1E Switchgear Bus Undervoltage Relays." The test showed, that relay 27XHHT tripped, after the designed time delay of Relay 27HHT1, when bus undervoltage was simulated by switching off power to the potential coils of Relays 27HHT1 and 27HHT2 during the test runs. Refer to Figure 10-26J. Unexpected reset of Relay 27XHHT was caused by chatter of the normally open contact of Relay 27HHT2. This chatter was caused by rigid mounting of Cell Door H13 to the test fixture. Chatter of the normally open contact of the deenergized 27HHT2 relay did not occur when the switchgear was tested earlier. Then door H13 was mounted in its normal environment at the switchgear. Therefore, chatter of this contact during this test need not to be considered. Relay 27XHHT reset on command when power to the 27HHT1 and 27HHT2 prime relay potential coils was restored. The voltage relays were tested for their setpoints and timing immediately prior to and after the seismic test. Records show that the relays operated still within their calibration after the test. 76

10.3.26.6 Conclusion

A representative sample of the 4160V Class IE Switchgear of Diablo Canyon Unit 2 was seismically tested by a multi-axis, multi-frequency seismic simulation described in Wyle Report Number 58255-1 dated August 22, 1978, pp. 139-3[illegible]. Thus qualification of this sample will apply to all Diablo Canyon 4160V Class IE Switchgear.

The test results presented in section 10.3.26.6 above demonstrate that the test criteria are met, and thus that the equipment's safety function has been demonstrated during and after seismic testing to the RRS derived from the postulated 7.5M Hosgri event.

It is therefore concluded that the Diablo Canyon Units 1 and 2 4160V Class IE Switchgear are qualified for the postulated 7.5M Hosgri event in accordance with IEEE Standard 344-1975 and USNRC R.G. 1.100.

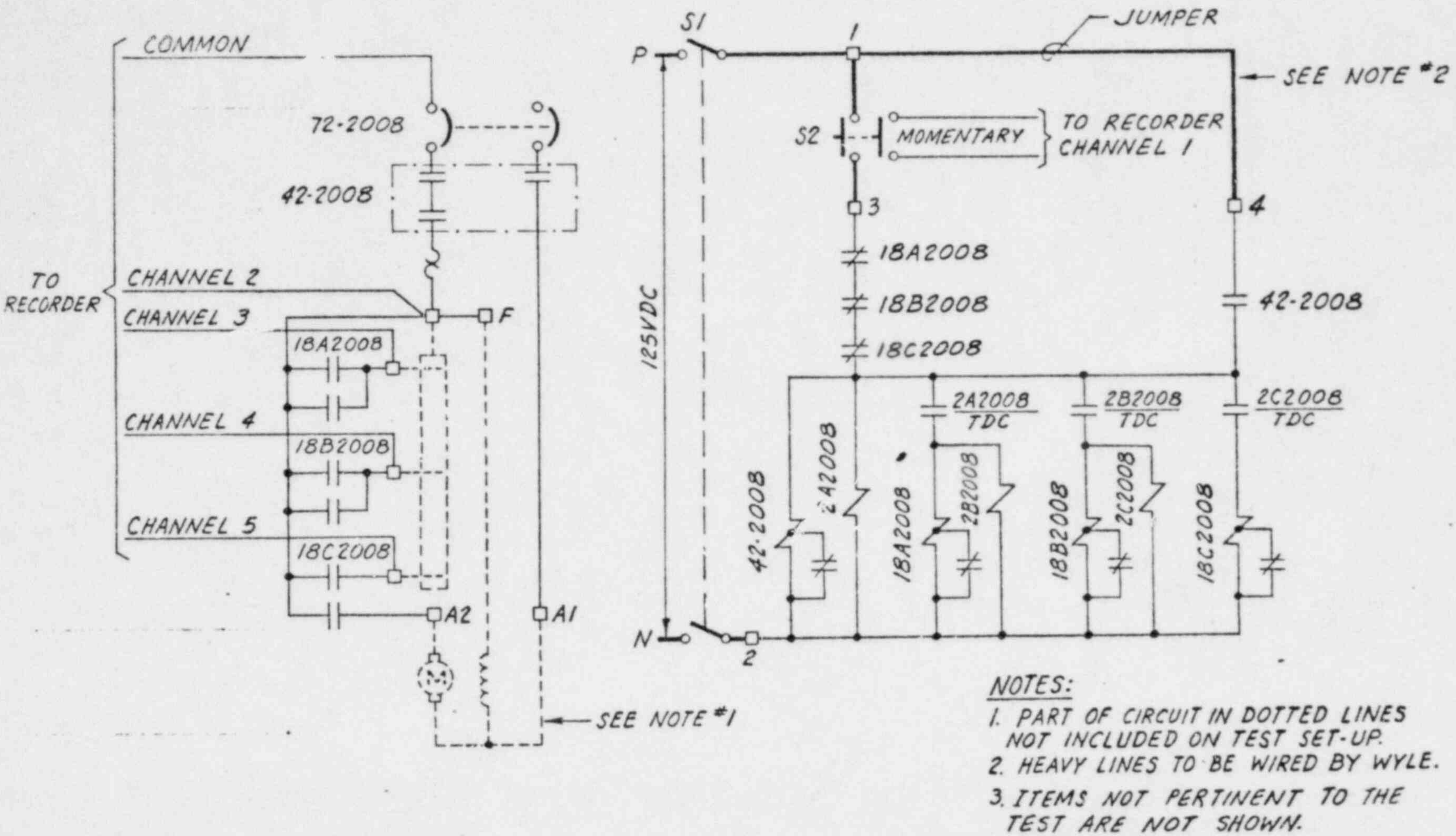


Figure 10-16A Turbine Lube Oil Pump Motor Starter, Seismic Test Schematic

SEISMIC TEST SEQUENCE*
FOR
125/250 VDC TURBINE LUBE OIL PUMP MOTOR STARTER

Front to Back Orientation

1) Sine Sweep Horizontal

2) Sine Sweep Vertical

3) Test Runs

Condition	Level	S1	S2	Remarks
1	OBE	X	0	Starter de-energized
2	"	X	mom. close after 5 sec.	Starter to close in 4 stages
3	"	X	0	Starter energized
4	"	mom. open after 5 sec.	mom. close after 10 sec.	Starter to open and then to close in 4 stages
-		mom. open betw. runs		Starter to open
5	"	X	0	Starter de-energized
6	SSE	X	0	" "
7	"	mom. open after 25 sec.	mom. close after 5 sec.	Starter to close in 4 stages on S1 and to open on S2
-		X	mom. close betw. runs	Starter to close in 4 stages
8	"	X	0	Starter energized

Side to Side Orientation

1) Sine Sweep Horizontal

2) Test Runs (Conditions 9 through 16)

Conditions 9 through 16 are the same as conditions 1 through 8 for the front to back orientation above.

* Retyped from Field Notes
X Denotes Switch closed
0 Denotes Switch open

Figure 10-16C 125/250 Volt DC Turbine Lube Oil Pump Motor Starter

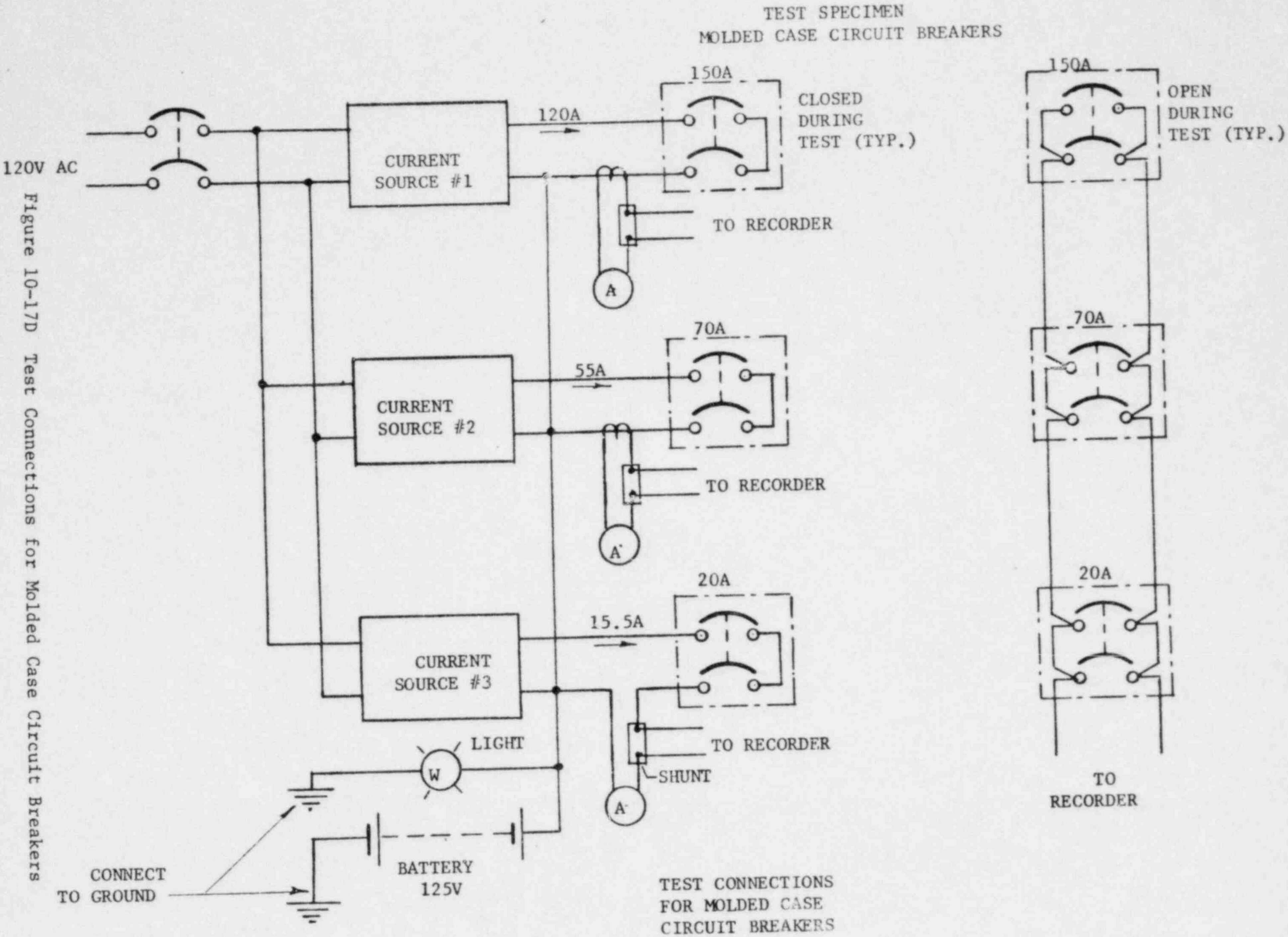


Figure 10-17D Test Connections for Molded Case Circuit Breakers

(February 1979)

Amendment 76

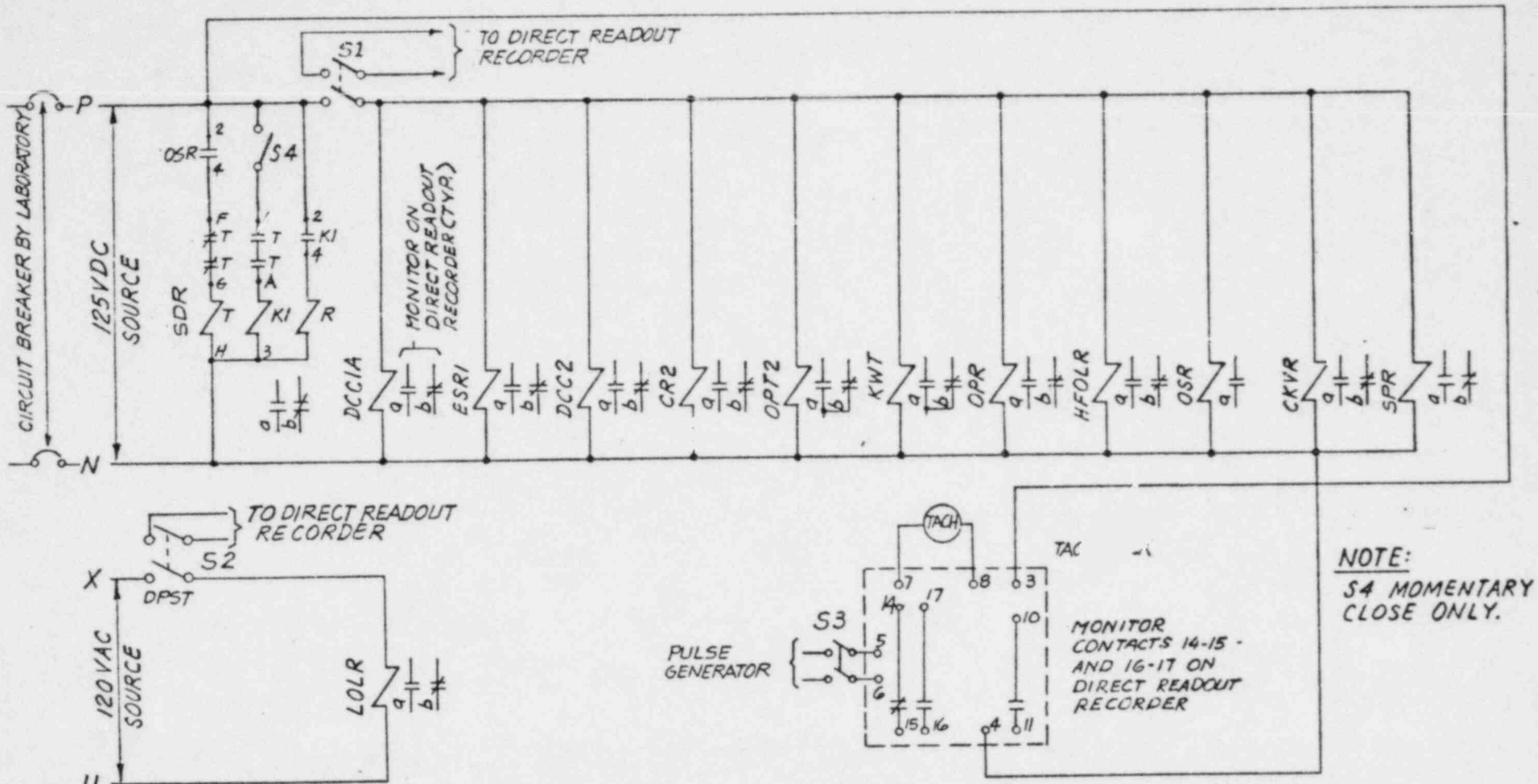


Figure 10-18G Diesel Generator Control Devices, Seismic Test Schematic

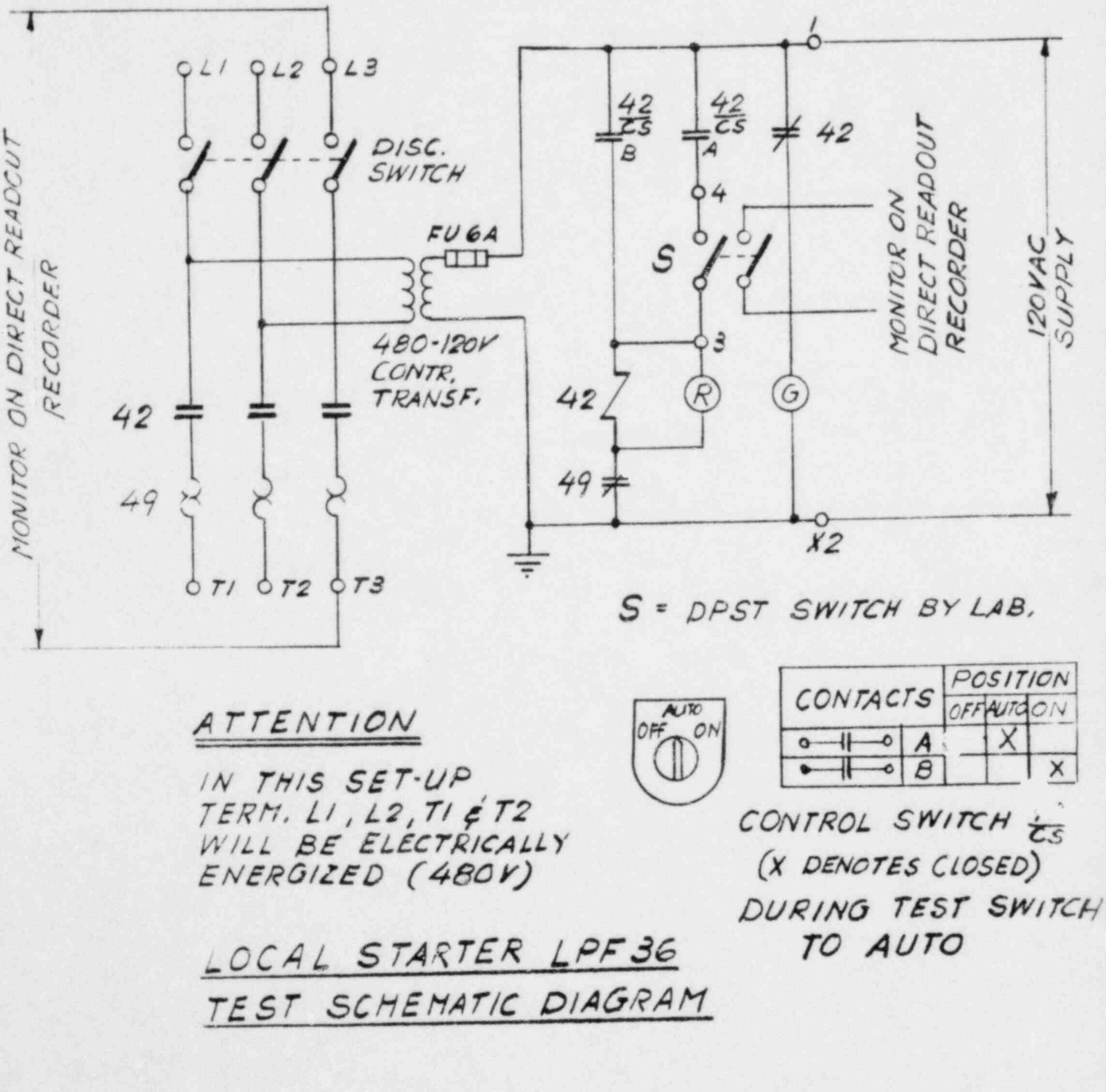


Figure 10-20E Local Starter LPF36, Test Schematic Diagram

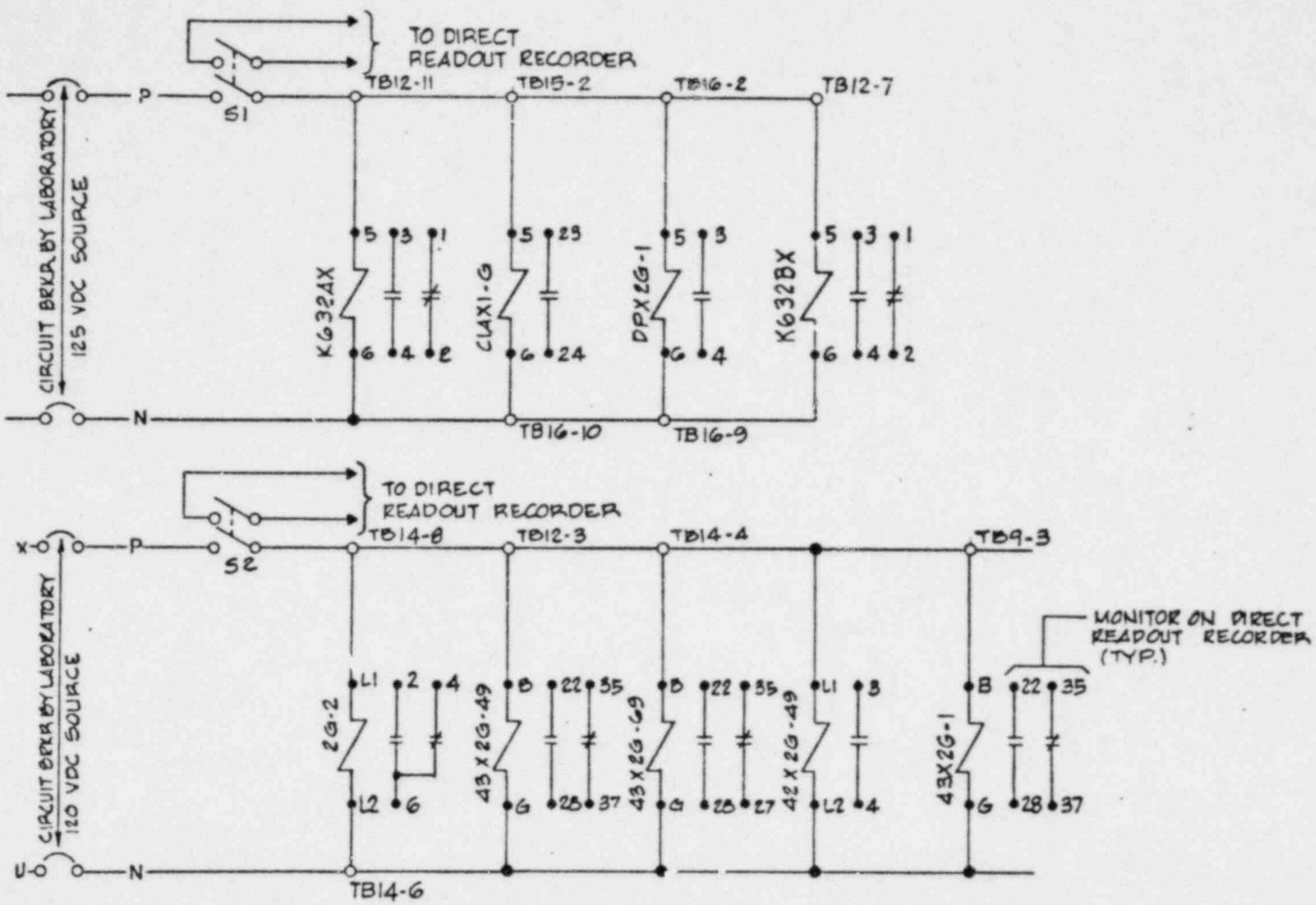


Figure 10-25D 480 Volt Bus "G" Auxiliary Relay Panel, Seismic Test Schematic

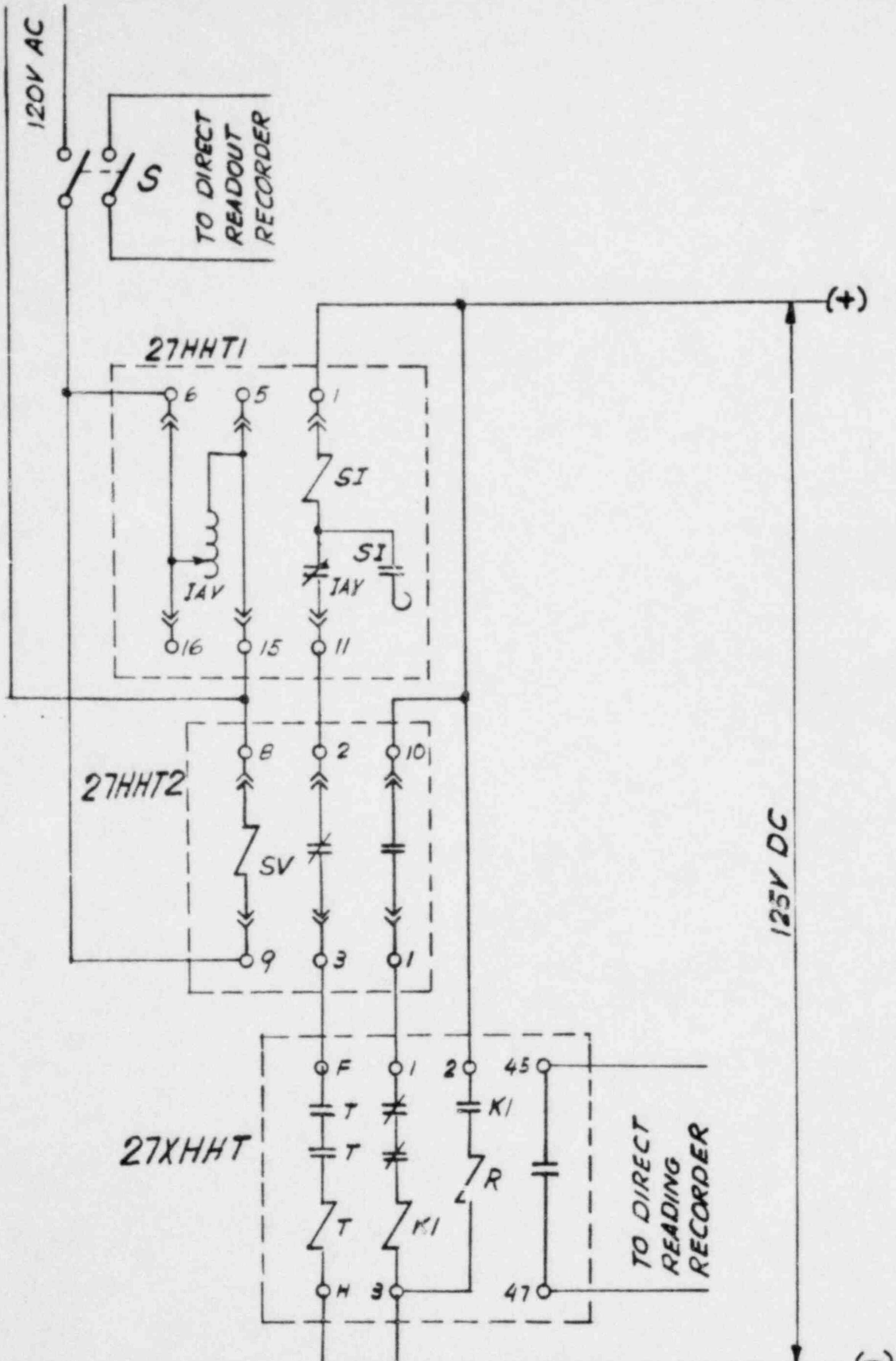


Figure 10-26J Seismic Test Connections for Relays 27HHT1, 27HHT2, and 27XHHT.