SEISMIC EVENT EVALUATION

REPORT

PERRY NUCLEAR POWER PLANT

DOCKET NOS. 50-440; 50-441

THE CLEVELAND ELECTRIC ILLUMINATING COMPANY

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1.0 INTRODUCTION

The purpose and scope of this report is to provide the results of The Cleveland Electric Illuminating Company seismic event evaluation for the Perry Nuclear Power Plant. The discussions contained herein provide the basis for CEI's conclusions that the January 31, 1986 earthquake in the vicinity of the Perry site:

1) did not adversely effect the plant structures, systems or components,
2) was within the design capability of the Perry Nuclear Power Plant, and
3) do s not change the licensing basis or conclusions regarding the site geology, seismology or design basis earthquake.

This evaluation report addresses the key issues related to the January 31 earthquake including the immediate response to the event, and the plant status and impact assessments following the earthquake. Detailed evaluations of the geological and seismological implications of this event and an analysis of the plant seismic design basis capabilities are presented. In addition, a description is provided of the confirmatory programs to monitor post seismic event activity, to continue the evaluations to identify any earthquake related effects, and to participate in generic industry studies.

2.0 SEISMIC EVENT OVERVIEW

Event

At approximately 11:48 a.m. on January 31, 1986, an earthquake occurred, which was located about 10 miles south of the Perry site and had a Richter magnitude of approximately 5.0. CEI implemented the Perry emergency plan in response to the seismic event as described in the attached chronology. A site area emergency was declared as a precautionary measure for site personnel accountability and for informational notification to local officials. Timely notifications were made and plant staff responded professionally and successfully implemented the plant procedures for this type of an event.

Plant Response and Assessments

Immediately following the earthquake, plant operations personnel were dispatched into the plant to survey for any major damage. The initial reports indicated no damage. Subsequently, a team of approximately 65 engineers and technicians was organized to perform a detailed walkdown of all plant areas. These inspections found no damage to any systems, structures or components. The hairline cracks in concrete walls that were observed have been reviewed and found to be typical of reinforced concrete structures which have not experienced seismic events. Numerous safety-related systems in operation or standby readiness continued to operate without incident.

Earthquake Analysis

Based on United States Geological Survey (USGS) recorded data, the earthquake of January 31, 1986 was centered about 10 miles south of the Perry Site and had a Richter magnitude of 4.96. This is a lesser magnitude than the earthquakes for which the Perry Plant has been analyzed and had substantially lower total energy content than the

Perry design response spectra. The January 31 earthquake is consistent with the previously established geology and historical seismicity of the region, as described in the Final Safety Analysis Report. The earthquake does not change the conclusions of the FSAR on the geology and seismicity of the site area.

Seismic Design Evaluation

Acceleration data taken from the in-plant seismic recorders showed recorded floor response spectra in certain locations outside the design spectra at high frequencies. The design spectra are based on a statistical envelope of historical earthquakes (84th percentile) and, therefore, some instances of recorded responses exceeding predicted floor responses are expected. The possibility of high frequencies outside the spectra has been evaluated at other nuclear plant sites and concluded to have insignificant effect on plant structure and components.

CEI analysis shows the high frequency accelerations involved are of a very short duration and the velocities are well below those which could cause damage even to non-engineered structures. The total energy associated with these high frequency accelerations is small, and therefore has no adverse impact on plant structures and equipment. Thus, the high frequency accelerations have no engineering significance and the effects of the earthquake experienced at Perry are well within the seismic capability of the plant.

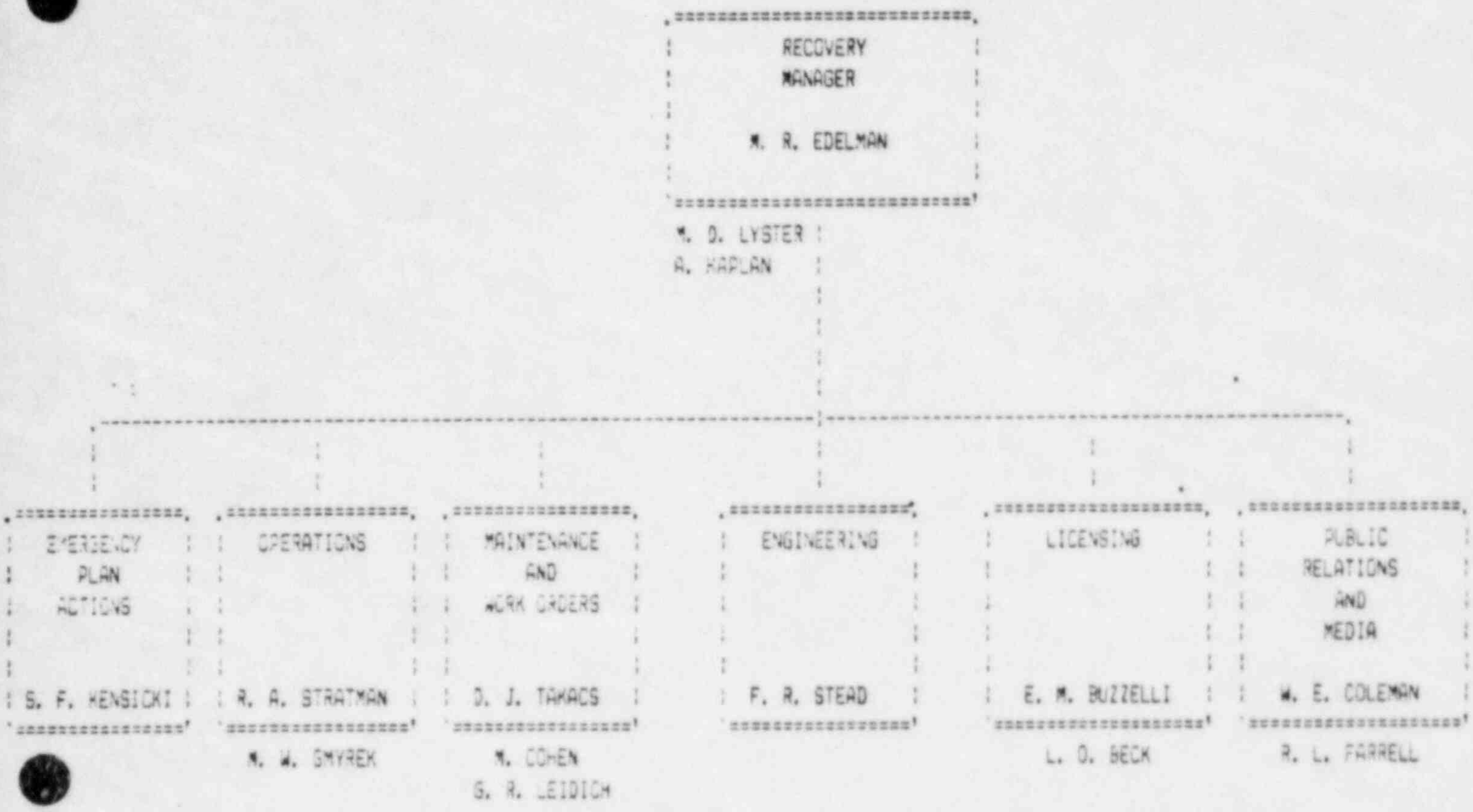
January 31, 1986 Earthquake

Chronological Summary of Events

Time of Occurrence	Event
11.46:42.3 (USGS data)	Seismic event occurs
1148	Control room reports nosie & vibration to to Systems Operation Center
1150	Main generator breaker reported open, isolating main and auxiliary transformer, automatically shifting to startup transformer. Auxiliary boiler trips noted Seismic alarms received in P680
1155	Trip of instrument air compressor noted
1200	Visual inspection of lower areas of Turbine Building, Auxiliary Building, Intermediate Building and transformer yard satisfactory
1201	Shift Supervisor sounds Plant Emergency Alarm
1204	Visual inspection of Turbine Building, Turbine Power Complex, Intermediate Building, Auxiliary Building and Control Complex satisfactory.
1206	Shift Supervisor delcares precautionary Site Area Emergency, makes Evacuation Announcement.
1211	Auxiliary boiler restarted
1216	Notifications to CEI emergency personnel pursuant to Emergency Plan began
1218	Initiated retrieval of seismic plates and magnetic tapes from seismic instrumentation
1219	Visual inspection of service water and emergency service water pump house satisfactory
1225-1240	Initial notifications of Site Area Emergency provided to Lake, Geauga and Ashtabula counties, the State of Ohio, Coast Guard, NRC
1230	Visual inspection of cooling towers and basins satisfactory
1232	Operational Support Center (OSC) activated

Time of Occurrence	Event
1235	Technical Support Center (TSC) activated
1251	Initial inspections of all Unit 1 and Common areas completed with satisfacory results, only minor problems noted.
1254	Visual inspection of suppression pool satisfactory
1257 - 1301	TSC completes precautionary Site Area Emergency Follow-up Notifications to Counties, State, Coast Guard
1300	Walkdown of all Unit 1 areas has finds no major equipment damage and noted minor flange leaks.
1302	Site Area Emergency downgraded to Alert
1303 - 1315	Initial Notification of downgrading to Alert made to Counties, State, Coast Guard and NRC.
1305	Three teams dispatched for additional system walkdowns; six maintenance teams dispatched to investigate equipment
1340 - 1401	Follow-up notification of Alert status provided to Counties, State, Coast Guard and NRC
1341	INPO contacted
1420	NRC - Bethesda and Region III concur on termination of emergency
1425	Termination of Emergency Event
1431 - 1442	Termination of Emergency Event reported to Counties, State, Coast Guard, & NRC.
1440	INPO notified of termination of Emergency Event
1531	Deactivated TSC.
1552	Seismic alarm P969 reset
1630	Recovery organization met to review seismic event, emergency response and confirmatory actions.

RECOVERY ORGANIZATION



3.0 PLANT STATUS AND IMPACT ASSESSMENTS

3.1 PLANT STATUS

Prior to the earthquake that occurred on January 31, 1986, numerous testing, calibration, and work completion activites were being conducted in preparation for fuel load. One major activity was preparation for the Division II Diesel Generator response time testing. As part of this work, all of the safety related components powered from the Division II Diesel were energized and in standby readiness. All of this equipment behaved normally through the event; that is, there were no spurious starts or alarms. Preparations were also underway to move the startup sources. This work had not yet begun when the seismic event occurred. The sources were never actually moved, and remained stored in the upper pools.

In support of the ongoing test and surveillance activities, a significant number of systems were in operation. In addition, numerous other systems were energized and in the standby mode. Lists of the specific safety and non-safety systems energized or operating prior to and during the earthquake are included as Tables 3.1 and 3.2. All of the operating safety-related systems continued to operate through the event. None of the safety-related systems in the standby mode experienced any spurious initiations.

As noted in Table 3.2, a large number of non-safety systems were operating or in the standby mode, and maintained their status throughout the event. Two non-safety items tripped on protective signals as intended by the design. These were the Unit 1 instrument air compressor, which tripped on high vibration, and the auxiliary steam boiler, which tripped due to actuation of one of its protective circuits. The instrument air compressor is a centrifugal machine that operates at greater than 40,000 rpm and as part of its protective devices has a very sensitive vibration switch. The auxiliary steam boiler has several protective circuits of which one tripped during the earthquake. The boiler was successfully restarted after the event.

The only other non-safety items of equipment that tripped during the earthquake were the Unit 1 main and auxiliary transformers, which tripped due to the closing of the generator protection relays. These relays although open at the time of the seismic event, did not have voltage applied as a result of an ongoing outage. Laboratory testing of these relays since the event has confirmed that the presence of voltage on the relays significantly increases the force required to close these relays. Had the voltage been supplied to these relays, they would not have closed during the event. This is substantiated by the fact that other similar open relays with voltage applied did not close during the event.

Investigation is ongoing to determine the cause of an indicated 1 1/2 inch increase in suppression pool level. No basis for a physical change in the water level has been identified. The water level transmitters were found to be out of calibration, though not enough to account for the entire indicated level increase. The same transmitters in other applications did not show any anomalous behavior.

In addition to the emergency plan actions previously discussed, immediately following the event the plant operators performed initial surveys of the plant. Areas visually inspected included the Transformer Yard, lower elevations of the Turbine, Auxiliary, Intermediate and Radwaste Buildings, as well as the Control Complex, Turbine Power Complex, Heater Bay and Water Treatment Building. The reports back to the Control Room indicated that the areas were found in satisfactory condition with no major damage. In addition, the General Supervisor of Operations and the Senior Operations

Coordinator made a specific survey of below grade areas. They found no unusual or abnormal conditions. Further steps taken to assess and evaluate the status of the plant included additional walkdowns by teams of plant maintenance personnel dispatched from the Operations Support Center.

3.3 PLANT IMPACT ASSESSMENT

As part of CEI's response to the earthquake, a team of approximately 65 engineers and technicians was organized on the evening of January 31 to perform systematic and thorough walkdowns of all plant areas. These walkdowns were performed using drawings of each area and checklists of components to inspect for any abnormal conditions. These included such items as piping, hangers, snubbers, valves, pumps, instrumentation and other components. The results of these walkdowns were recorded and compiled into a list of approximately 480 observations, many of which were later determined to be preexisting conditions. None of the observations involved structural damage to the plant or equipment. The 480 observations are typified by minor hairline cracks in concrete, burned out light bulbs and leaking valve or piping flanges, all of which are normal and expected conditions that would be identified in any comprehensive walkdown.

In the inspections that were conducted following the earthquake, plant personnel were instructed to document all unusual or abnormal conditions. Those conducting the inspections did not attempt to determine whether the conditions were the result of the earthquake; instead, discrepant conditions regardless of potential cause were documented to insure that the status of the plant following the earthquake would be fully documented for subsequent evaluation by engineering. Each of the observed discrepant conditions was subsequently evaluated by engineeering to determine whether the condition was caused by the earthquake and whether rework or repair was required. The engineering evaluation of the items concluded that 77% were preexisting conditions, and only two minor items, were directly attributable to the earthquake. The remainder, approximately 100 items, have been classified as indeterminate, i.e., it could not be definitively established that the condition existed prior to the earthquake. About 25% of the approximately 480 items will need rework or repair. (See Appendix E). These will be processed in accordance with a special procedure instituted in response to the earthquake.

A number of other inspections were also performed to determine the effect, if any, on specific plant structures and conditions. A site survey was performed to assess any impact of the earthquake on the site environs, and in particular on the shoreline bluff. No evidence of any earthquake impacts could be found.

A survey of settlement monitoring points was ordered to determine if the earthquake had any effect on building settlement. Monitoring points at various locations around the perimeter of the plant buildings are surveyed on a monthly basis to monitor building settlement. The results of the surveys were that the recorded movements were consistent with those measured in the past, including the amount of change from prior surveys and the absolute elevations. For example, a comparison of the Reactor Building reading with that of February 1985, found that the two readings were identical. Thus, it is concluded that the earthquake had no impact on building settlement. (See Appendix E).

A walkdown of Unit 1 Cooling Tower was performed to determine whether any damage had resulted from the earthquake. The areas inspected included the basin walls, tower columns and footers, internal support columns, baffle system, discharge pipe, and veil. While all inspections were done from ground level, any significant cracks in the veil would have been readily apparent since they would have been saturated by the previous day's rain. No structural damage was found in any area of the cooling tower. Water was observed seeping through the north and south vertical joints where the basin plume wall and pump house flume wall meet. Seepage at this joint has been noted in the past and stopped by the application of mastic material. (See Appendix E).

As part of the design program for the plant, seismic clearance criteria were established to assure that a seismic event would not cause any impact on a safety system either by causing swaying or by impact from a non-safety item. Instances of these criteria not being met are termed Seismic Clearance Violations (SCV's). SCV's are forwarded to engineering for evalution to determine whether repair is required. At the time of the earthquake, there were 29 SCV's that had been dispositioned for repair, where the repair had not yet been completed. Following the earthquake, inspectors were directed to reinspect these SCV's to determine whether the seismic event affected the SCV condition. These inspections found neither damage nor dimensional change. (See Appendix E).

As previously noted, the plant systems, both safety related and non-safety related, operated properly during and following the seismic event. Recognizing the sensitivity of electrical components to high frequency response, a detailed engineering study was undertaken to identify the number and types of electrical equipment that was energized during the earthquake. The components included motors, transformers, relays, switchgear breakers, switches, batteries, contacts, valve operators, chargers/inverters, meters, recorders, and transmitters. A wide variety of suppliers was represented. More than 70 separate systems were involved. The study showed that over 47,000 electrical components were energized and experienced no adverse effects in terms of spurious system actuation (See Appendix E).

TABLE 3.1

SAFETY RELATED SYSTEMS ENERGIZED DURING THE SEISMIC EVENT OF JANUARY 31, 1986

SYSTEM	DESCRIPTION
C11	Control Rod Drive
C41	Standby Liquid Control
C71	Reactor Protection System
D17	Plant Radiation Monitors
E12	Residual Heat Removal
E21	Low Pressure Core Spray
E22	High Pressure Core Sray
G41	Fuel Pool Cooling and Cleanup
M15	Annulus Exhaust Gas Treatment
M23	MCC, Switchgear, & Misc. Area HVAC
M24	Battery Room Exhaust
M25	Control Room HVAC
M26	Control Room Emergency Recirculation
M32	ESW Pumphouse Ventilation
M40	Fuel Handling Building Ventilation
M43	Diesel Building Ventilation
P11	Condensate Transfer and Storage
P22	Mixed Bed Demineralizer
P41	Service Water
P42	Emergency Closed Cooling
P43	Nuclear Closed Cooling
P45	Emergency Service Water
P47	Control Complex Chill Water
P49	ESW Screen Wash
P52	Instrument Air
P54	Fire Protection
C95	Emergency Response Information System
P51	Service Air
R14	110 VAC Vital Inverters
R22	Metalclad Switchgear
R23	480 V Load Centers
R24	Motor Control Centers
R25	Distribution Panels - 120, 208 & 480 volts
R42	D. C. System
R43	Standby Diesel Generator (SDG)
R45	SDG Fuel Oil
R46	SDG Jacket Water Coolant
R47	SDG Lube Oil
R61	Main Control Room Annunciator

TABLE 3.2

NON-SAFETY RELATED SYSTEMS
ENERGIZED DURING THE SEISMIC EVENT
OF JANUARY 31, 1986

SYSTEM	DESCRIPTION
F42	Fuel Transfer Equipment
G33	Reactor Water Cleanup
M11	Containment Vessel Cooling
M13	Drywell Cooling
M21	Controlled Access HVAC
M27	Computer Room HVAC
M35	Turbine Building Cooling & Ventilation
M36	Off-Gas Building Exhaust
M41	Heater Bay Ventilation
M45	Circulating Water Pump House Ventilation
N21	Condensate
N23	Condensate Filtration
N24	Condensate Demineralizers
N32	Turbine Control (EHC)
N71	Circulating Water
P20	Water Treatment
P21	Two Bed Demineralizer
P44	Turbine Building Closed Cooling
P55	Building Heating
P61	Auxiliary Steam
P62	Auxiliary Boiler Fuel Oil
P72	Plant Underdrain
C91	Process Computer
C94	Health Physic Computer
P56	Security
R11	Station Transformers
R15	Technical Support Center UPS
R36	Heat Tracing & Anti Freeze Protection
R44	SDG Starting Air
R51	Intra Plant Communications
R52	Maintenance & Calibration
R53	Exclusion Area Paging System
R57	Radio & In-Plant Antenna System
R71	Lighting
S11	Power Transformers
S41	Step Up Station

4.0 EARTHQUAKE ANALYSIS AND SITE SEISMICITY

An earthquake of magnitude 4.96 M_{blg} occurred on January 31, 1986 at 11 hours, 46 minutes, and 42.3 seconds approximately 11 miles (17.7 kilometers) south of the plant. The depth of the earthquake is presently calculated to be 6 miles (10 kilometers) deep and is located at 41.640° W and 81.098° N by the National Earthquake Information Center of the United States Geological Survey (USGS). This location is near the intersection of Highways 86 and 166 in Thompson Township, Geauga County. The location of this earthquake is shown on Figure 4.1 of this report. Earthquakes which have occurred within 200 miles in historical times, and an update for those occurring within 50 miles of the plant site are shown in Figures 4.2. and 4.3.

4.1 BACKGROUND GEOLOGICAL & SEISMOLOGICAL STUDIES RELATED TO THE PERRY NUCLEAR POWER PLANT

As required by the regulations governing the siting of nuclear power plants, a thorough study of the geological and seismological characteristics of the Perry Nuclear Power Plant site and its regional surroundings was made as part of both the Preliminary Safety Analysis Report (PSAR) and Final Safety Analysis Report (FSAR). The purpose of these investigations was to assure that the site was geologically suitable for the construction of a nuclear power plant and to provide a basis for the determination of a Safe Shutdown Earthquake (SSE) and the site ground motion resulting from the occurrence of such an earthquake. The information contained herein is summarized from the detailed discussions contained in Chapter 2 of the PSAR and FSAR, as reviewed and accepted by the NRC in the Safety Evaluation Reports and Supplements.

These studies were extensive, consisting of a compilation and analyses of published and unpublished literature; field geological checking and mapping including wide scale and local geophysical studies to characterize geological conditions at depth; borings; laboratory analyses; and detailed engineering analysis of the site foundation materials.

Based on these studies and following Appendix A of 10 CFR Part 100, a correlation of earthquakes to a particular fault or series of faults which would be designated as "capable" could not be made. In addition, no "large scale dislocation or distortion" of the earth's crust designated as a tectonic structure could be identified to which earthquakes could be correlated. Consequently, earthquakes were identified with a "tectonic province", representative of a region within which there is a relative consistency of geologic structural features.

To select the SSE, a Modified Mercalli Intensity of VII was chosen as the maximum intensity earthquake at the Perry site. This intensity corresponds to an acceleration value of 0.15g, based upon a number of developed relationships which relate peak accelaration to earthquake intensity values; the principal relationship was developed by Trifunac and Brady. (Trifunac, M.D. and Brady, A.G., 1975, on the Correlation of Seismic Intensity Scales with the Peaks of Recorded Strong Ground Motion: Bulletin of the Seismological Society of America, v. 65, No. 1, pp. 139-162). The response spectra representing the SSE were then developed by adopting a NRC Regulatory Guide 1.60 response spectral shape. The design response spectra are shown on Figures 4.4 and 4.5.

During the review of the FSAR, the NRC staff requested that site-specific spectra be constructed for the Perry site. In response to this request, site-specific response spectra were constructed using a set of ground motion accelerograms from actual earthquakes of magnitude range 5.3 ± .5 recorded on rock (to simulate the foundation conditions at Perry) at epicentral distances of 0 to 25 kilometers; this represents the earthquake "at the site" as required by Appendix A and is shown on Figure 4.6.

Eleven (11) earthquakes representing 22 components of motion were chosen. A subset of records accepted by the staff as representative of an Anna, Ohio type earthquake had an average magnitude of 5.53 ± .3 at an average distance of 8.5 miles (13.66 ± 4.5 kilometers). A smoothed 84 percentile of this data set fell below the design response spectra represented by a Regulatory Guide 1.60 spectra set at an acceleration of 0.15 g. These spectra are representative of free field data recorded at locations away from the influence of buildings and structures, and are shown on Figure 4.7.

4.2 REGIONAL GEOLOGY AND TECTONICS

The Perry site is located in the central part of Eastern Stable Platform Tectonic Province, characterized by an upper Precambrian crystalline basement and overlain unconformably by a sequence of Paleozoic sedimentary rocks. Basement rocks of this tectonic province comprise a complex sequence of high grade metamorphics and include: schists, gneisses, marbles, and granulites consolidated during the Grenville Orogeny (950 mya) onto the North American craton.

The basement rocks are overlain by a 5000' thick sequence of sedimentary rocks, Cambrian to Carboniferous in age, which dips less than 5^{o} to the south. (Fig. 4.8). Sedimentary rocks within this sequence of Paleozoic sediments includes shales, salt, sandstone, dolomites, and limestones. In the epicentral region the sedimentary sequence is approximately 2 kilometers thick with the main shock focus well within the crystalline basement.

A thin veneer, generally less than 100' of variable thick Pleistocene deposits, lies unconformably on the sedimentary sequence. These deposits include a lower till, dense and compact (approximately 30' thick) overlain by less compact till, lacustrine deposits and beach deposits.

Post consolidation tectonic deformation in the province includes the following structual elements. Paleozoic structures include broad upwarps: Cincinnati arch, Findlay arch, Kankakee arch, Ozark uplift, Nashville dome, and intervening Michigan and Illinois basins. Uplift and subsidence produced localized faulting and folding. The north northeast-trending Waverly arch of west central Ohio is the nearest upwarp structure.

Faults in the site region include:

- o Chatham sag faults
- o Peck fault, Howell-Northville anticline faults
- o Bowling Green fault
- o Anna Ohio faults
- o Cincinnati arch faults
- o Eastern Ohio faults
- o Western New York faults
- o Appalachian Plateau and Northern Valley and Ridge faults

Within the region only the Clarendon-Linden fault system in western New York is considered active.

4.3 SITE GEOLOGY

In conjunction with the PSAR and FSAR preparation and reviews, intensive geological and geotechnical investigations were conducted at the Perry site including:

- o test borings (maximum depth 730')
- o 42" drilled exploratory shafts
- o in-site testing, plate load tests
- o permeability determinations
- o piezometer installations
- o seismic analyses
- o seismic refraction and seismic shear wave determinations
- o geologic mapping of excavations, tunnels and trenches

Two bedrock structural styles were observed by Gilbert Commonwealth, NRC staff, USGS, and the Corps of Engineers. Gentle northeast-trending folds with two to three foot wavelength and 6" amplitude were attributed to depositional processes. Two larger folds and several related faults were also examined. The folds terminated below foundation grade. Faults with characteristic north over south directed motion become bedding plane detachments at depth. One to three inch thick gouge occurs in the fault zones. Absence of foreign materials, no recrystallization of country rock or crystallization within fault zone or adjacent fracture zones is interpreted to result from localized low temperature, relatively low stress deformation.

In summary, an approximately 45 foot thick layer, between excavation grade of the deepest onshore foundation excavations and the base of a boulder layer defining the bottom of structureless basal till, experienced deformation (folds, faults) including bedding detachment rotation and buckling, and slight upward thrusting. These features occur in glaciated terraine and are attributed to glacial loading, unloading and/or ice push mechanisms. Similar faulting was studied in the Warner Creek area with the same conclusions.

4.4 DEFORMATION - INTAKE AND DISCHARGE TUNNELS

Three minor low-angle north-northeast striking thrust faults occur in the intake and discharge tunnels to the north beneath Lake Erie. Displacements range between 0.5 and 2.5 feet, upward to the northeast.

Studies undertaken to define tunnel fault geometry included:

- o detailed mapping of tunnel walls
- o reconnaissance of lake bottom
- o lake shore reconnaissance
- o exploratory borings
- o borehole logging, offshore and onshore magnetic surveys
- o review of existing geophysical data
- o isotopic analyses of Lake Erie and fault seepage water

Studies to date fault included:

- o x-ray diffraction
- o clay mineralogic analysis
- o microcrack
- o consolidation of gouge

Miscellaneous studies included:

- o borehole stress
- o structure contour maps
- o interviews with knowledgeable Ohio geologists

Investigations of the vertical and lateral extent of faulting indicated that the faulting did not extend upward to the lake floor. Borings at the projected western shoreline intersection showed no faulting. Conclusions reached from detailed mapping of the tunnel faults, geophysical surveys, borings, and analysis of fault gouge and seepage included:

- o faults are genetically related; same fault or an echelon
- o faults confined in Chagrin shale; limited lateral and vertical extent
- o date of last motion is Pleistocene or older
- o motion sense indicates faults originated in northwest directed stress field, approximately 90^{o} from present stress field
- o possible mechanisms of nontectonic glacial origin include ice sheet traction, differential downwarp, differential rebound, surficial stress relief ("pop up")
- o geologic processes responsible for initiation and latest motion are nontectonic and no longer operative; therefore faults are not capable according to Appendix A to 10 CFR 100

4.5 CURRENT SEISMOLOGICAL AND GEOLOGICAL STUDIES

Immediately after the occurrence of the earthquake, CEI undertook a number of geological and seismological investigations to provide a thorough understanding of the earthquake and assess any impact on previous studies performed for the siting and licensing of the Perry Nuclear Plant.

In addition to the investigations undertaken by CEI, USGS, as well as various universities and private groups, have deployed instruments to study earthquake aftershocks.

Portable Seismographic Network

At the request of CEI, Weston Geophysical Corporation installed six portable analog seismographs (Sprengnether Instrument Co. MEG-800) in the epicenter area of the January 31, 1986 earthquake during the period from approximately 10 hours to 30 hours after the event.

These seismograph stations are located at the Perry Nuclear Plant and in the communities of Chardon, Chesterland, Middlefield, Hartsgrove, and Thompson. A seventh station was installed on February 4, 1986 in the town of Concord. This spatial distribution of the stations is designed to form a symmetrical array around the preliminary epicental area of the main shock, which was located in the basis of more distant stations. All instruments are operated continuously and all seismograms are recovered and analyzed daily. The purpose of this network is to obtain accurate locations of any recorded aftershocks, to refine the original location of the main shock, and to determine whether or not their occurrence reveals anything about the causative geologic structure.

Five other portable instruments integrated into this network are operated by Woodward-Clyde Consultants and deployed in a similar configuration to provide additional locationing capabilities.

Five small microearthquakes have been detected. The parameters of these earthquakes are located on the Table 4-1. Preliminary analyses indicate that the focal depths for these microearthquakes range from 2.3 to 8.9 kilometers. The largest of these microearthquakes, a magnitude 2.4 event on February 6, 1986, was the only event to be felt. These microearthquake locations are slightly to the west of the preliminary location of main shock provided by the National Earthquake Information Center.

Felt Intensity Investigation

A questionnaire survey is being conducted to evaluate the distribution of effects, including a general description of how people experienced the event and accounts of any damage that have been incurred. The questionnaires are being distributed using several parallel approaches to obtain broad coverage of the affected areas. Analysis and compilation of questionnaire results will be used to produce an "isoseismal map" or plot of intensity levels measured on the Modified Mercalli Scale. The purpose of such a map is to enable a comparison of effects of the present event with a well-known epicenter to the effects of some historical events located in the site area that have no well-determined instrumental epicenter.

Weston Geophysical personnel have been conducting personal interviews on perception and other effects of the earthquake in the epicenter region. Questionnaires have been distributed at establishments such as fire departments, grocery stores, schools, etc. with instructions to distribute these to persons near the earthquake epicenter. These reports will be used to recover information on the range of effects.

A preliminary evaluation of returned questionnaires indicates that most of the reports in the epicentral area are evaluated as representative of an Intensity VI on the Modified Mercalli Scale. Maximum observed or reported effects include a few instances of damaged chimneys above the roof line, cracks in concrete and cinder block walls, cracked or fallen plaster, and few broken windows. Some disturbances including silting of well-water have also been reported.

Geologic Studies

Weston Geophysical geologists have conducted preliminary reconnaissance of bedrock exposures in the epicentral area to determine whether or not any surface expression resulted from the earthquake. No significant expression of surface disturbance has been observed. Although several occurrences of minor rock slides and soil slumps have been documented and photographed, these are not considered unusual, since they occur in unstable, undercut steam banks where they could have been caused by ordinary weathering processes or induced vibratory ground motion from the earthquake.

Previously mapped fault locations on Paine Creek have been examined. No evidence of recent fault movement was observed. Also, no slumping or sliding of the steep slope was apparent. No evidence suggestive of a "capable fault" has been observed.

On-going work includes examination of other geological features, as well as an investigation of sites of unusual felt reports such as foundation damage and water-well disturbance. A field observation and evaluation of soil and rock conditions at such sites is being made to determine whether or not there is a correlation between the higher intensity values and geological conditions.

4.6 CONCLUSIONS REGARDING OF THE JANUARY 31, 1986 OHIO EARTHQUAKE

The earthquake, both as regards to magnitude and intensity, is below the maximum earthquake selected to represent the Safe Shutdown Earthquake. The intensity of the Safe Shutdown Earthquake was selected as intensity VII. It is estimated that the present earthquake is best represented by an intensity VI. The magnitude 4.96 M_{blg} of the January 1986 earthquake is below the magnitude of 5.3 ± 5, used in establishing the site specific response spectra.

Based on the initial data evaluation, it appears that the free field design response spectra constructed to represent the SSE may have been exceeded. An accelerogram at the foundation level of Unit 1 showed a peak acceleration of 0.18 g at approximately 20 Hz on the north-south component. The duration of the motion on foundation above the smoothed ground response spectra (SSE) is less than 0.1 second. Since both the Regulatory Guide 1.60 ground motion and the site-specific spectra represent a smoothed spectra at the 84th percentile for a number of strong motion accelerograms, exceedances above the smoothed spectra are not unexpected.

At the high frequency end of the spectra, where the 20 Hz exceedance exists, it is important to look at the other parameters of ground motion. The particle velocity associated with the 0.18 g. is 0.55 inch per second and the displacement is 0.004 inch. This velocity value would be far less than the 1 inch per second generally accepted by the US Bureau of Mines as the threshold of damage at the 20 Hz frequency: cracking of plaster walls, etc. to ordinary structures. (Siskind, D.E. et al., 1980, Structure Response and Damage Produced by Ground Vibrations from Surface Mine Blasting, Bureau of Mines RI 8507). Structural damage therefore is not a problem.

The area and region in which the January 31, 1986 earthquake occurred is one of low seismicity. Prior to 1986, the largest earthquake to occur within 50 miles of the site occurred in 1943. The 1986 Ohio earthquake is slightly larger in magnitude (4.9 vs. 4.7) and intensity (VI vs. V) than the March 9, 1943 earthquake which occurred approximately 12 miles west-southwest of the 1986 earthquake. Although somewhat larger than historical earthquakes within 50 miles of the plant site, it is smaller than those within 200 miles of the site, as well as those on which the plant design is based. This earthquake is consistent with the seismicity of the area and the area and region are still of low seismicity.

Geological investigations to date have not uncovered any evidence suggestive of a "capable fault" as defined in 10 CFR Part 100, nor has the investigation revealed a cause for any geological concern. The 1986 earthquake does not change the conclusions in the FSAR on the geology and seismology of the Perry site.

Table 4.1

RECENT EARTHQUAKES
IN THE SITE VICINITY

DATE	ORIGIN TIME (1)	LATITUDE	LONGITUDE	PRELIMINARY DEPTH (KM)	MAGNITUDE
22-JANUARY-1983	07:46:57.9	41°51.24'	81°11.46'	5	$2.7M_{bLg}$ (2)
31-JANUARY-1986	16:46:42.3	41°38.84'	81°05.30'	10	$4.9\ M_b$ (3)
01-FEBRUARY-1986	18:54:49.7	41°38.39'	81°09.99'	3.1	--
02-FEBRUARY-1986	03:22:49.1	41°38.37'	81°09.81'	2.3	--
03-FEBRUARY-1986	19:47:19.6	41°39.19'	81°10.27'	9	--
05-FEBRUARY-1986	06:34:02.4	41°39.93'	81°09.11'	6	--
06-FEBRUARY-1986	18:36:22.6	41°38.66'	81°09.80'	5	2.4

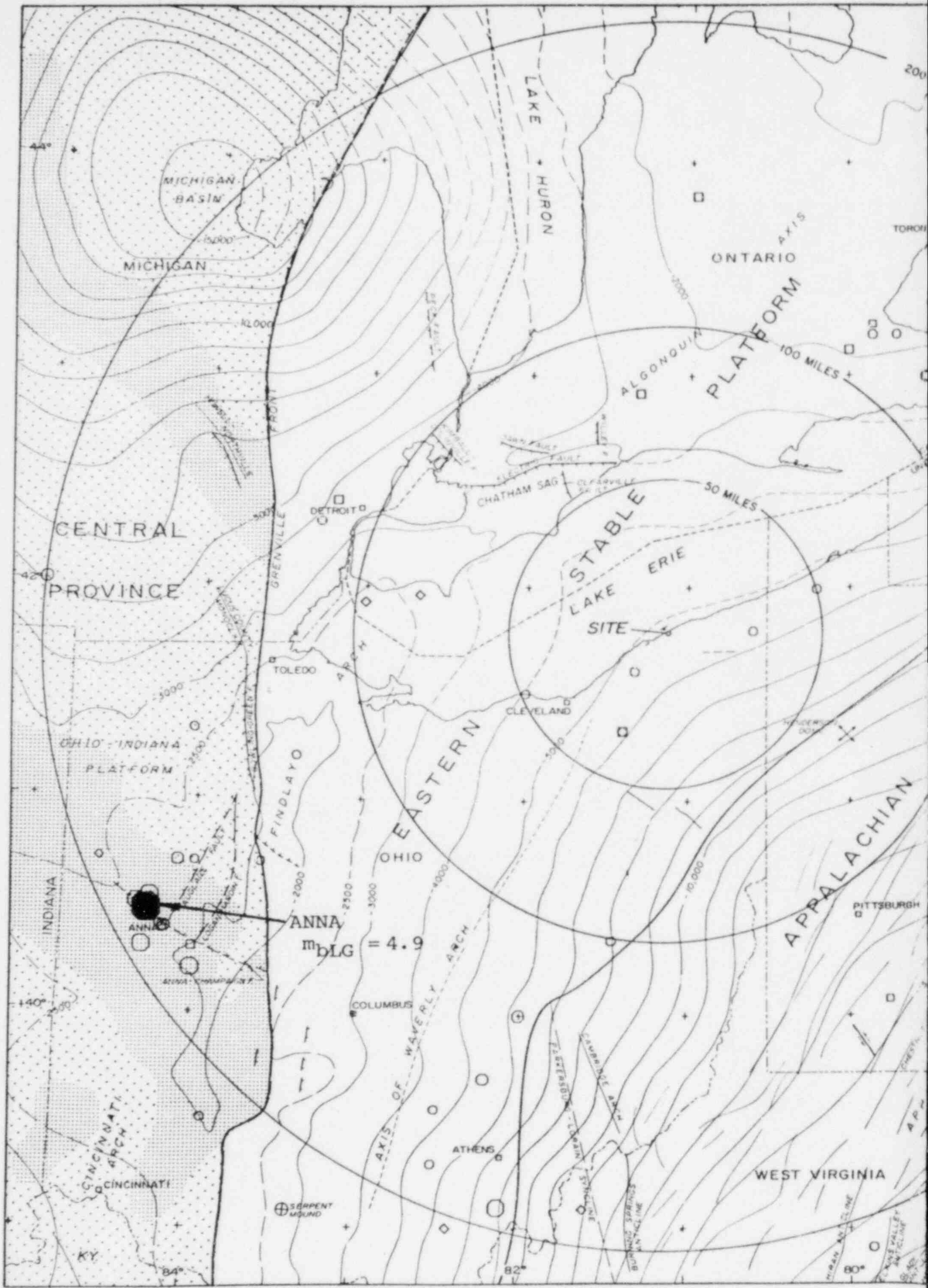
(1) UNIVERSAL Time Unless Noted As Local Time

(2) SOURCE: University of Michigan

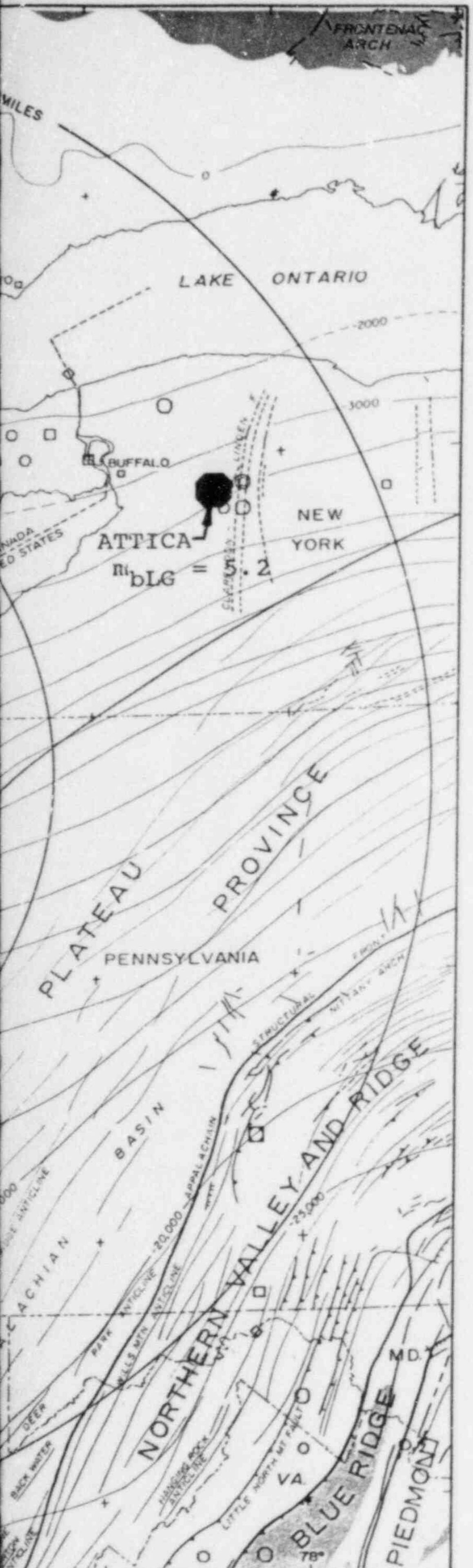
(3) SOURCE: National Earthquake Information Center (NEIC)

SITE
5 miles
10 miles
FEB. 5
FEB. 3
JAN 31
Mb 4.9
FEB. 6
Mb 2.4
FEB 1
FEB. 2
0
3 Mi

Figure 4.1



LAKE HURON
MICHIGAN BASIN
MICHIGAN
ONTARIO
ALGONQUIN
STABLE PLATFORM
100 MILES
50 MILES
CHATHAM SAG
DETROIT
CENTRAL PROVINCE
GRENVILLE FRONT
LAKE ERIE
SITE
TOLEDO
CLEVELAND
OHIO - INDIANA PLATFORM
FINDLAY ARCH
EASTERN
APPALACHIAN
OHIO
INDIANA
ANNA
$m_{bLG} = 4.9$
PITTSBURGH
COLUMBUS
AXIS OF WAVERLY ARCH
CINCINNATI ARCH
CINCINNATI
ATHENS
WEST VIRGINIA
SERPENT MOUND
KY
84°
82°
80°
44°
42°
40°



REGIONAL TECTONIC ELEMENTS

Grenvillian Basement - Ages around 950 million years (Shaded: Exposed, Non-patterned: Buried)

Keweenawan Basement - Ages around 1100 million years

Elsonian Basement - Ages around 1450 million years

-2000 Structure contours in feet drawn on the top of Precambrian basement surface.

Thrust fault—teeth on upper plate.

Normal fault - hatchures on downthrown side.

High angle fault. Inferred fault

Anticlinal axis Synclinal axis

Intensely disturbed "Cryptoexplosive" structure.

(Primary basement - structure sources: Bayley & Muehlberger, 1968; Hinze et al, 1975; Owens, 1967)

0 50 100 150 Miles
0 50 100 150 200 Kilometers

REGIONAL TECTONIC PROVINCES

PROVINCE BOUNDARY

EARTHQUAKES

MAGNITUDE (1930 through 1967)		MAGNITUDE (after 1-1-1968)	INTENSITY	
□	3.1-3.5	◇	○	V
□	3.6-4.2	◇	○	VI
□	4.3-4.7	◇	○	VII
			○	VIII

Figure 4.2

Am. 10 (11-29-82)

PERRY NUCLEAR POWER PLANT
THE CLEVELAND ELECTRIC ILLUMINATING COMPANY

Regional Tectonics - Earthquake Tectonic Provinces

Figure 2.5-59

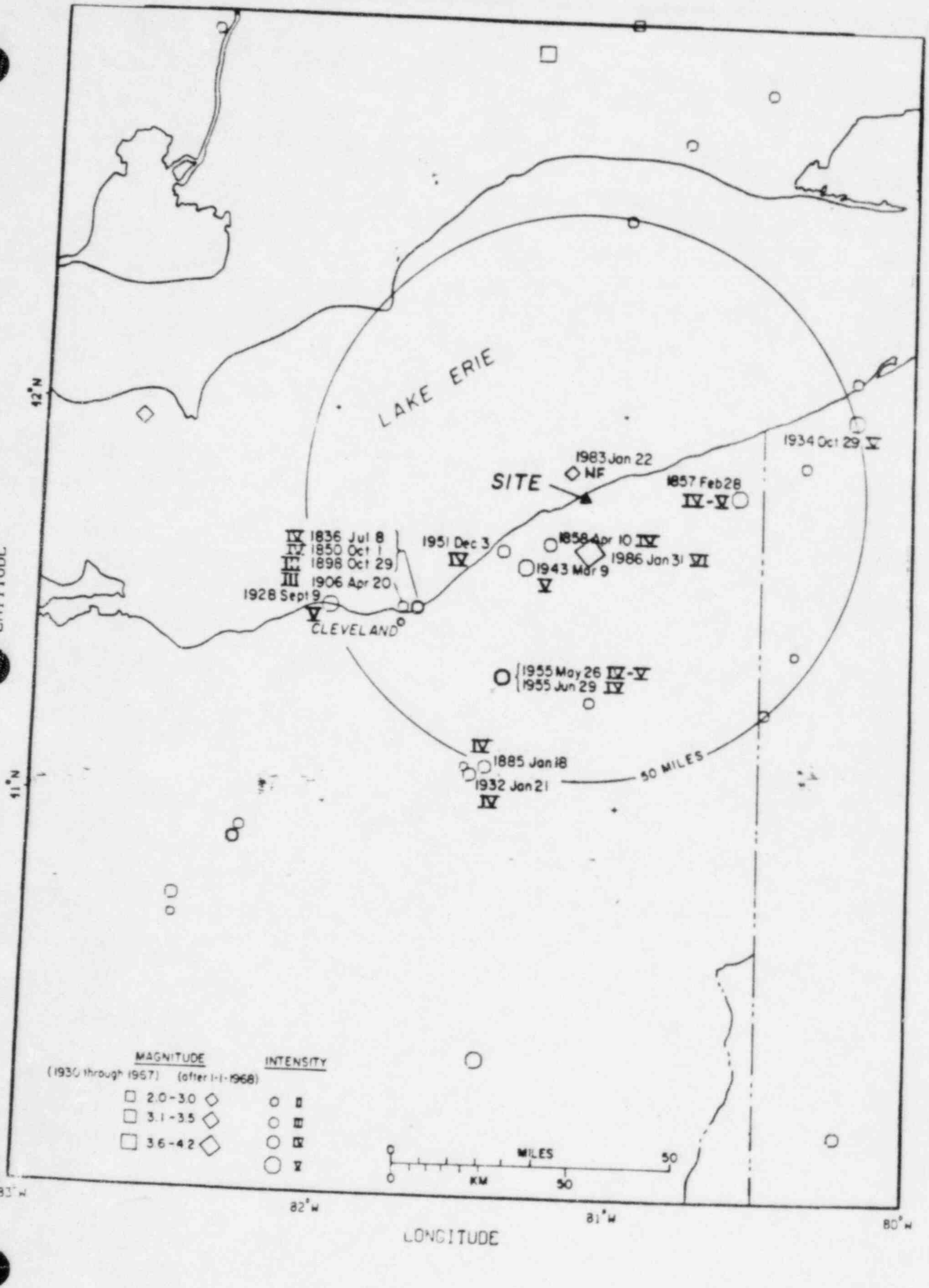

LAKE ERIE
SITE
1983 Jan 22
NF
1857 Feb 28
IV-V
1934 Oct 29 V
IV 1836 Jul 8
IV 1850 Oct 1
IV 1898 Oct 29
III 1906 Apr 20
1928 Sept 9
V
CLEVELAND
1951 Dec 3
IV
1858 Apr 10 IV
1943 Mar 9
V
1986 Jan 31 VI
1955 May 26 IV-V
1955 Jun 29 IV
IV
1885 Jan 18
1932 Jan 21
IV
50 MILES
42°N
41°N
40°N
83°W
82°W
81°W
80°W
LATITUDE
LONGITUDE
MAGNITUDE
(1930 through 1967)
(after 1-1-1968)
2.0-3.0
3.1-3.5
3.6-4.2
INTENSITY
II
III
IV
V
MILES
0
50
KM
0
50

Figure 4.3

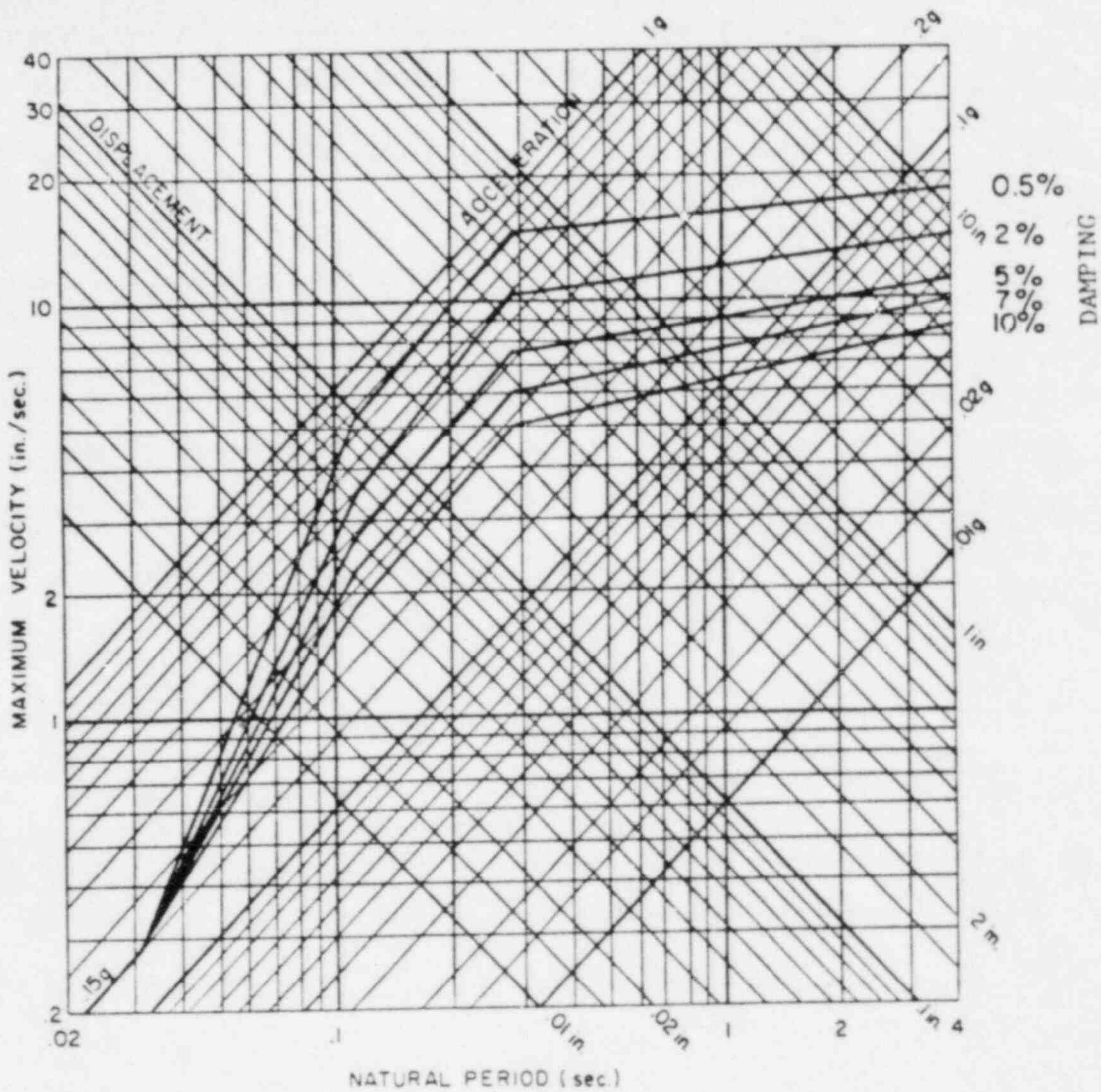


Figure 4.4

PERRY NUCLEAR POWER PLANT
THE CLEVELAND ELECTRIC ILLUMINATING COMPANY

Safe Shutdown Earthquake Design Response Spectra - Vertical Motion

Figure 3.7-2

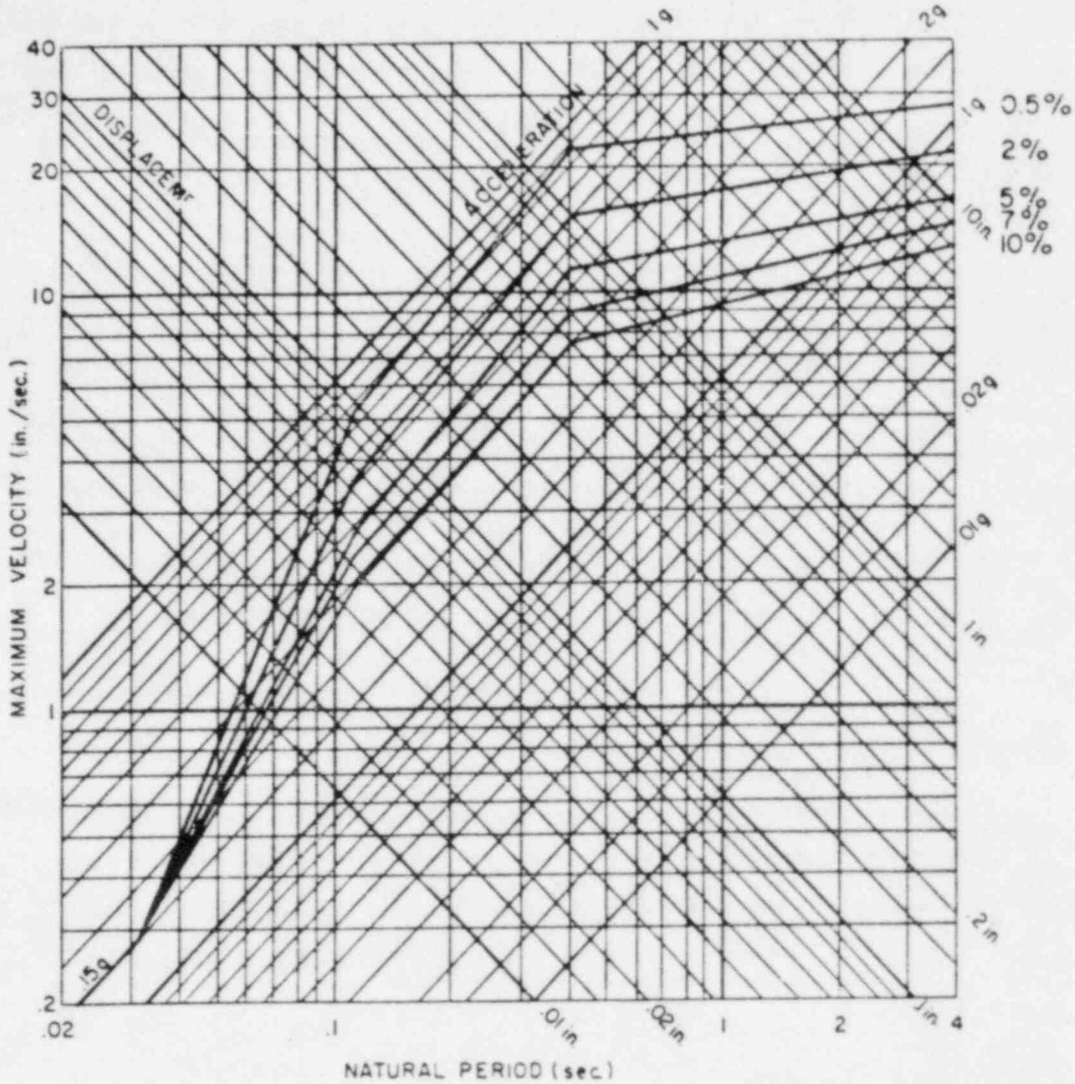
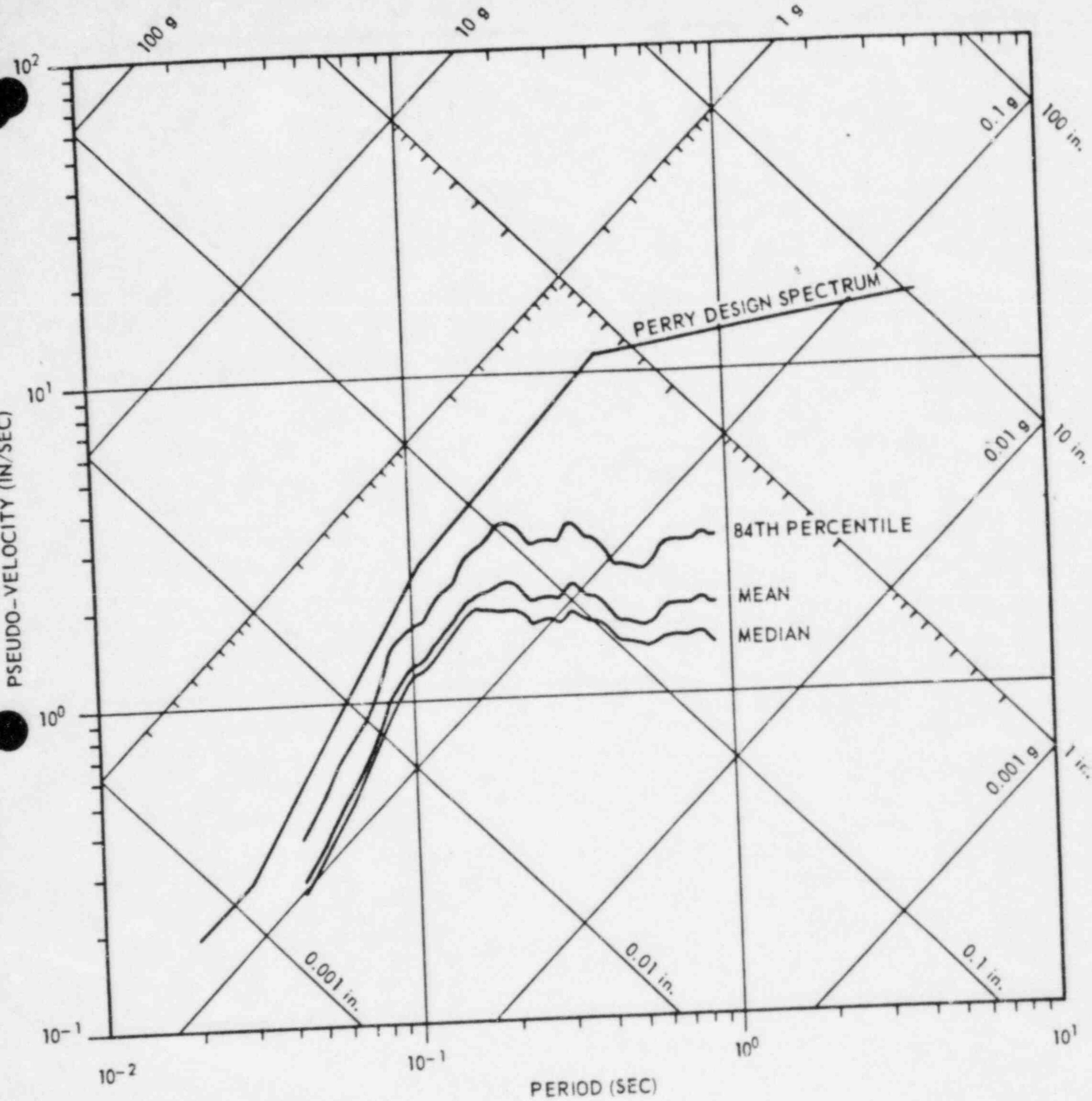


Figure 4.5

PERRY NUCLEAR POWER PLANT
THE CLEVELAND ELECTRIC
ILLUMINATING COMPANY

Safe Shutdown Earthquake
Design Response Spectra -
Horizontal Motion

Figure 3.7-1



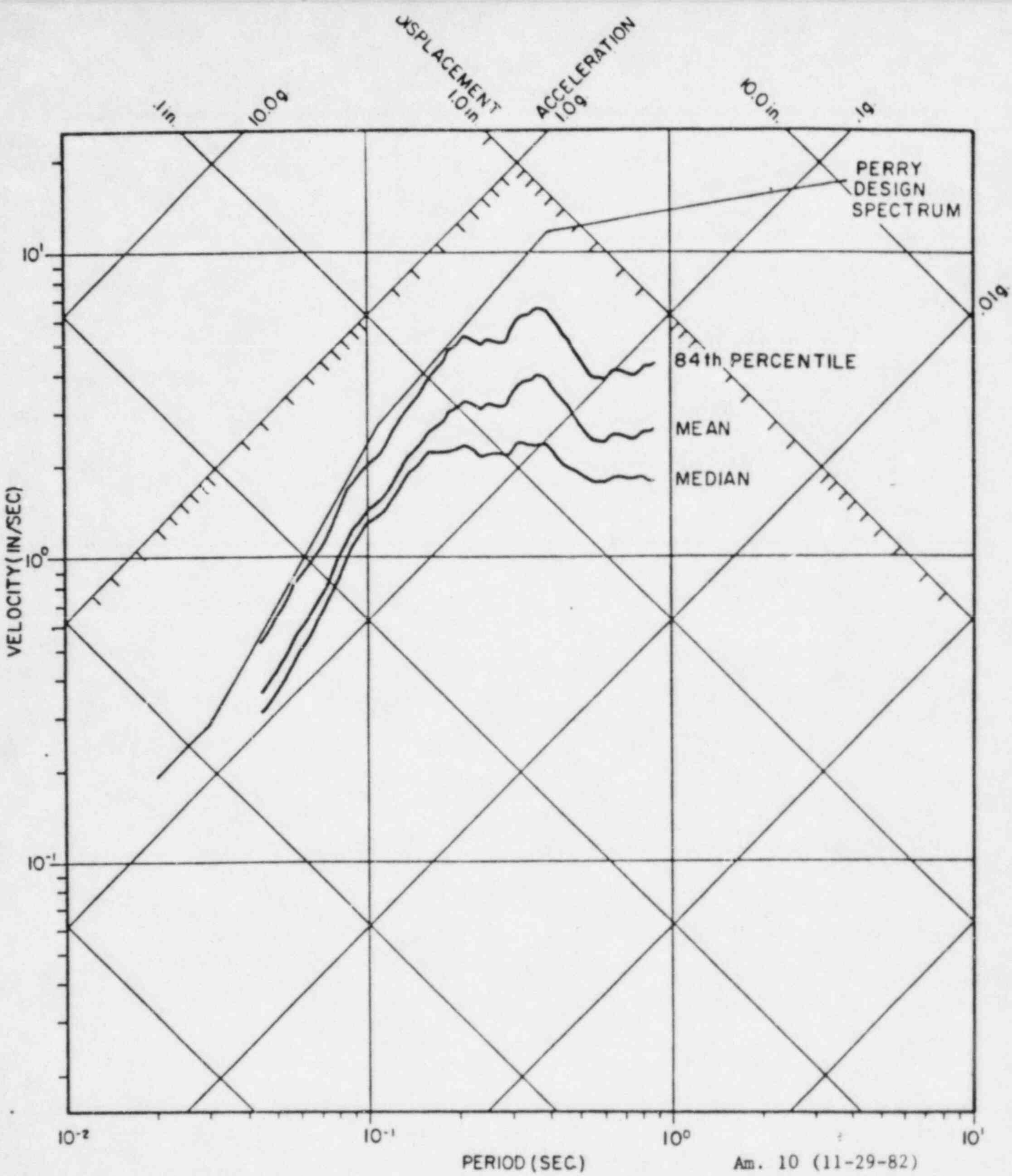
MEDIAN, MEAN AND 84TH PERCENTILE
RESPONSE SPECTRA FOR PERRY (ROCK) SITE.
(BASIC SUBSET, 5% DAMPING)

$m_{bLG} = 5.3 \pm .5$

Am. 10 (11-29-82)

PERRY NUCLEAR POWER PLANT
THE CLEVELAND ELECTRIC
ILLUMINATING COMPANY

Figure 230.6-2



Am. 10 (11-29-82)

MEDIAN, MEAN AND 84TH PERCENTILE
RESPONSE SPECTRA FOR PERRY (ROCK) SITE
(Basic Subset, Parkfield Included, 5% Damping)
$m_{bLG} = 5.53 \pm .3$

PERRY NUCLEAR POWER PLANT
THE CLEVELAND ELECTRIC
ILLUMINATING COMPANY

Figure 230.6-5

Q&R 2.5-40

Figure 4.7

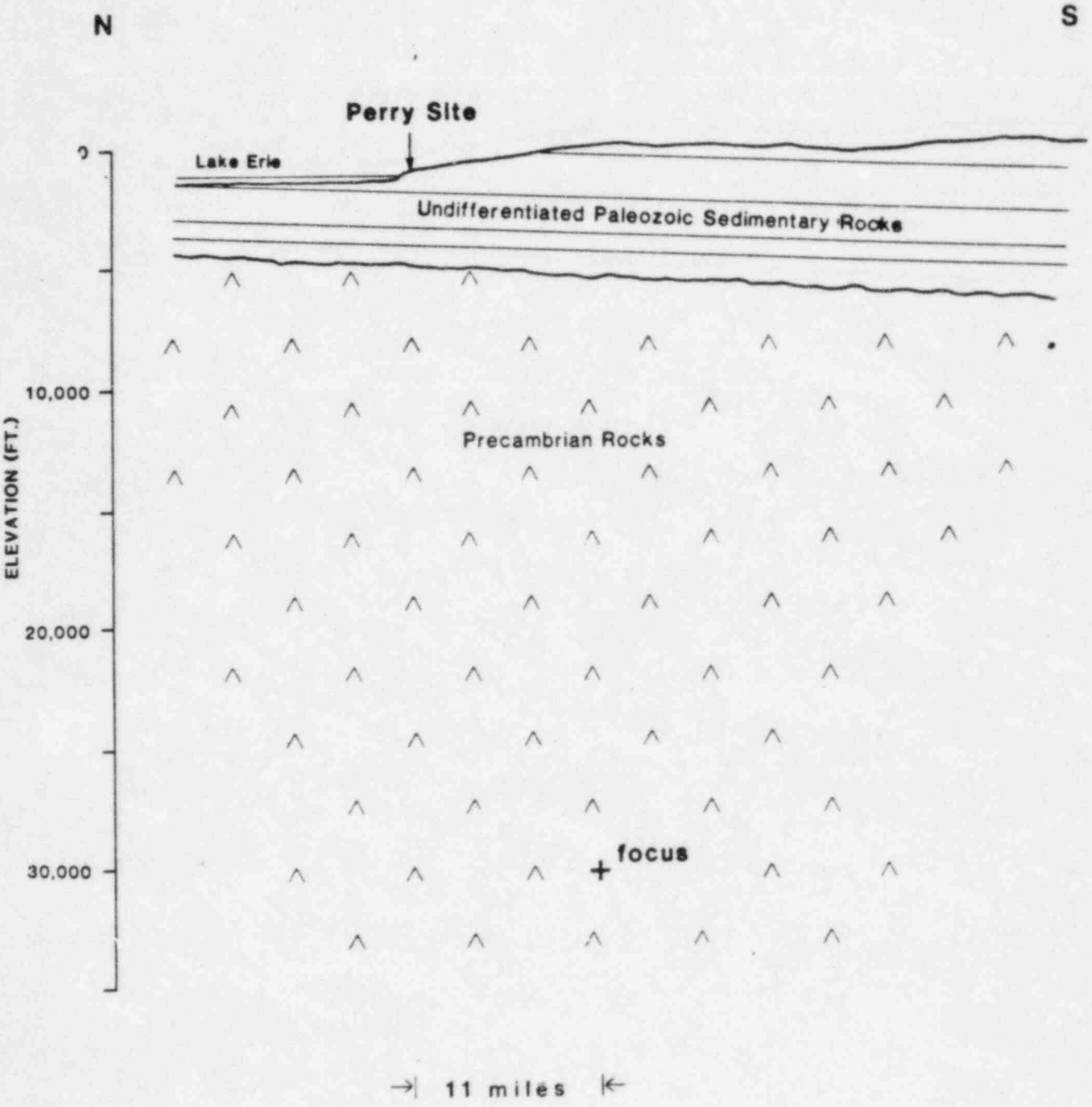

N
S
Perry Site
Lake Erie
Undifferentiated Paleozoic Sedimentary Rocks
Precambrian Rocks
focus
ELEVATION (FT.)
0
10,000
20,000
30,000
11 miles

Figure 4.8

5.0 SEISMIC INSTRUMENTATION DATA EVALUATION

Three different types of seismic monitoring instrumentation were used to record the 1986 Ohio Earthquake. Table 5.1 and Figure A through H and J delineate the specific instrument number, type and location. One type of instrument used is the Kinemetrics Model SMA-3 strong motion triaxial time-history accelerograph. This system detects and records three mutually perpendicular components of acceleration over the entire duration of the earthquake onto cassette magnetic tape. Power to the unit is supplied by internal rechargeable batteries which are kept in a charged state by 120 VAC line power. Two instruments of this type were used and were located on the Reactor Building Foundation Mat at an elevation of approximately 575 feet. Their latest calibration was December 1, 1985. See Appendix A for further instrumentation details and data tabulation.

The second type of instrumentation used was the Engdahl PSR 1200-H/V response spectrum recorder. This totally mechanical system also records three mutually perpendicular components of acceleration. The instrument used twelve reeds fabricated of varying lengths and weights of spring steel, one for each frequency (ranging from approximately 2 Hz to 25 Hz). A diamond-tipped stylus is attached to the free end of each reed to inscribe a permanent record of its deflection on one of twelve record plates. The record plates are made of aluminum and plated with successive layers of nickel, tin and lead-tin. This system is totally self-contained and requires no outside power source.

Four instruments of this type were used - two on the Auxiliary Building Foundation Mat and an elevation of approximately 568 feet, one at the Reactor Building Foundation Mat at an elevation approximately 575 feet, and one at the Reactor Building Inside Drywell Platform at an elevation of approximately 630 feet. Except for the one instrument located on the Reactor Building platform which was calibrated on January 30, 1986, all instruments of this type were calibrated during January 1985. See Appendix B for further instrumentation details and data tabulation.

The third type of instrument was the Engdahl PAR 400 peak accelerograph. This totally mechanical system records three mutually perpendicular components of peak local acceleration (i.e., the zero period acceleration). A diamond tipped scriber at the end of an amplifier arm records a permanent mark on a record plate made of aluminum and successive layers of nickel, gold and burnt gold. Again, this system is totally self-contained and requires no outside power source. Two instruments of this type were used and were located on the Auxiliary Building Foundation Mat at an elevation of approximately 568 feet and on the Reactor Recirculation Pump at the elevation of approximately 605 feet. The latest calibration date for the Auxiliary Building instrument was January 30, 1986, while the calibration date for the Recirculation Pump instrument was December 4, 1985. A third instrument of this type was out of service at the time of the earthquake because it was being recalibrated. See Appendix B for further instrumentation details and data tabulation.

All recorded data from the in-plant seismic instruments have been used in the evaluation.

PERRY NUCLEAR POWER PLANT UNIT NO. 1
SEISMIC MONITORING INSTRUMENTATION

TABLE 5.1

Instrument Number	Type	Manufacturer / Model Number	Location	References
D51-N101	(1)	Kinemetrics / SMA-3	Reactor Building Foundation Mat Elevation 575'–10" Azimuth 175°	Figures A and B
D51-N111	(1)	Kinemetrics / SMA-3	Reactor Building Containment Vessel Elevation 686'–0" Azimuth 174°	Figures A and C
D51-R120	(2)	Engdahl / PAR-400	Reactor Recirculation Pump (Inside Drywell, Reactor Building) Elevation 605'–0" (Approximately) Azimuth 145°	Figures A and D
D51-R130	(2)	Engdahl / PAR-400	OUT OF SERVICE	
D51-R140	(2)	Engdahl / PAR-400	Auxiliary Building Foundation Mat (HPCS Pump Room) Elevation 568'–4"	Figures A and E

1. Triaxial Time-History Accelerograph
2. Triaxial Peak Accelerograph
3. Triaxial Response Spectrum Recorder

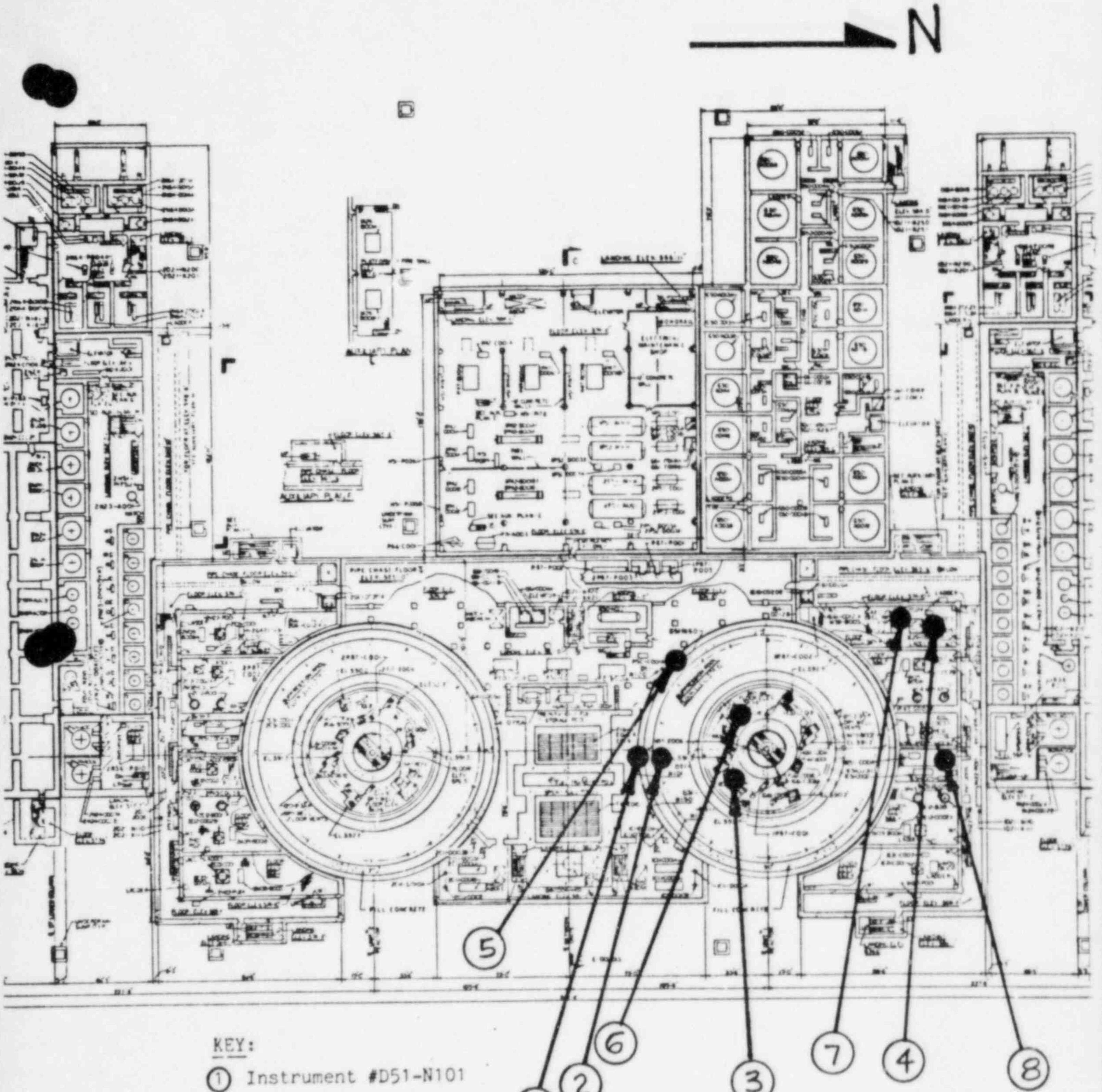
PERRY NUCLEAR POWER PLANT UNIT NO. 1
SEISMIC MONITORING INSTRUMENTATION

TABLE 5.1

Instrument Number	Type	Manufacturer / Model Number	Location	References
D51-R160	(3)	Engdahl / PSR-1200-H / V-12A	Reactor Building Foundation Mat Elevation 574'−10" Azimuth 225°	Figures A and F
D51-R170	(3)	Engdahl / PSR-1200-H / V	Reactor Building 630' Platform (Inside Drywell) Elevation 630'−1" Azimuth 238°	Figures A and G
D51-R180	(3)	Engdahl / PSR-1200-H / V	Auxiliary Building Foundation Mat (HPCS Pump Room) Elevation 568'−4"	Figures A and H
D51-R190	(3)	Engdahl / PSR-1200-H / V	Auxiliary Building Foundation Mat (RCIC Pump Room) Elevation 568'−4"	Figures A and J

1. Triaxial Time-History Accelerograph
2. Triaxial Peak Accelerograph
3. Triaxial Response Spectrum Recorder

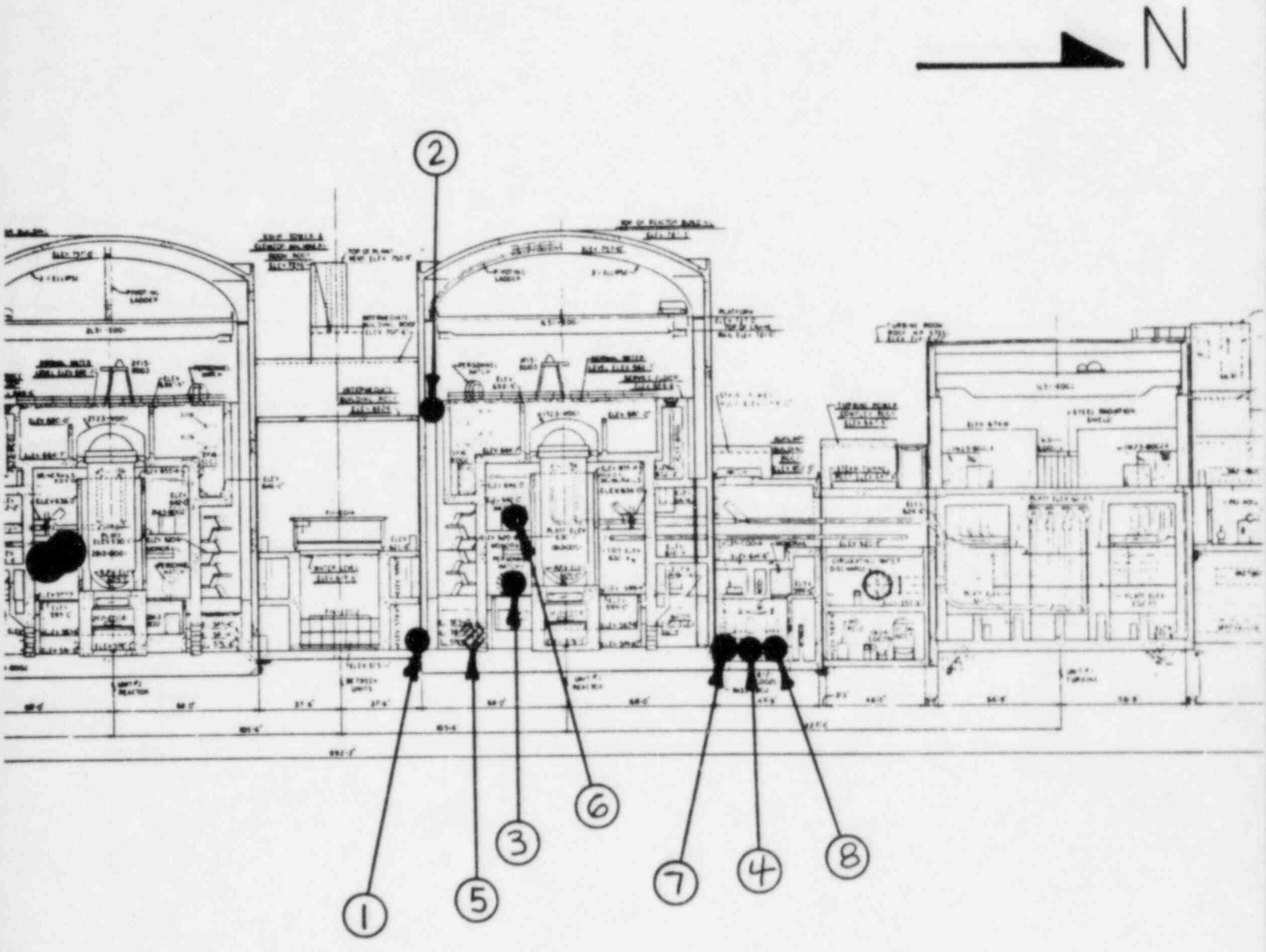
FIGURE A
Sheet 1 of 2



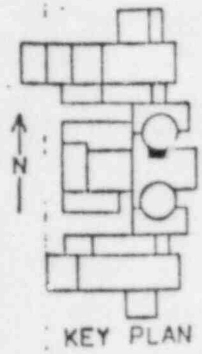
KEY:

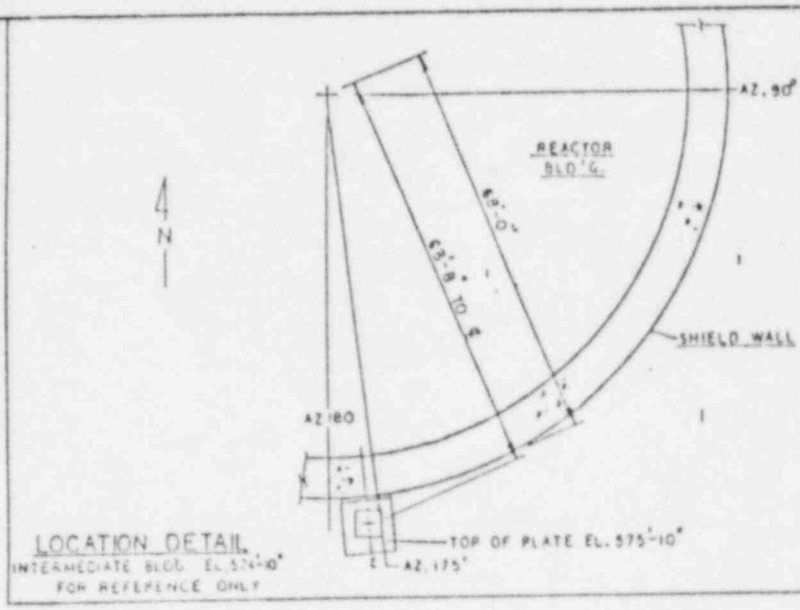
1. Instrument #D51-N101
2. Instrument #D51-N111
3. Instrument #D51-R120
4. Instrument #D51-R140
5. Instrument #D51-R160
6. Instrument #D51-R170
7. Instrument #D51-R180
8. Instrument #D51-R190

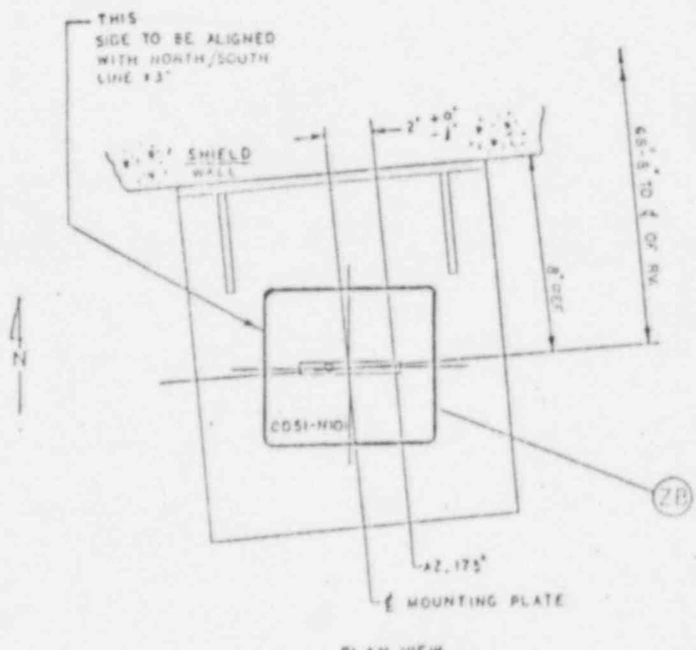
FIGURE A
Sheet 2 of 2



1. #D51-N101 R/B Foundation Mat, El. 575', Az. 175°
2. #D51-N111 R/B Containment Vessel, El. 686', Az. 174°
3. #D51-R120 Reactor Recirc Pump, El. 605', Az. 145°
4. #D51-R140 A/B Foundation Mat, El. 568'
5. #D51-R160 R/B Foundation Mat, El. 574' Az. 225°
6. #D51-R170 R/B Platform, El. 630' Az. 238°
7. #D51-R180 A/B Foundation Mat, El. 568'
8. #D51-R190 A/B Foundation Mat, El. 568'







PLAN VIEW
INSTRUMENT ORIENTATION DETAIL

THE FOLLOWING DOCUMENTS ARE APPLICABLE TO THIS I.F. PKG		
E.C.N.	F.V.A.	N.R.
N/A	N/A	N/A

[illegible]

REFER TO "REFERENCE DRAWINGS" FOR DESIGN NOTES & REFERENCES NOT COVERED BY THIS DRAWING

860213

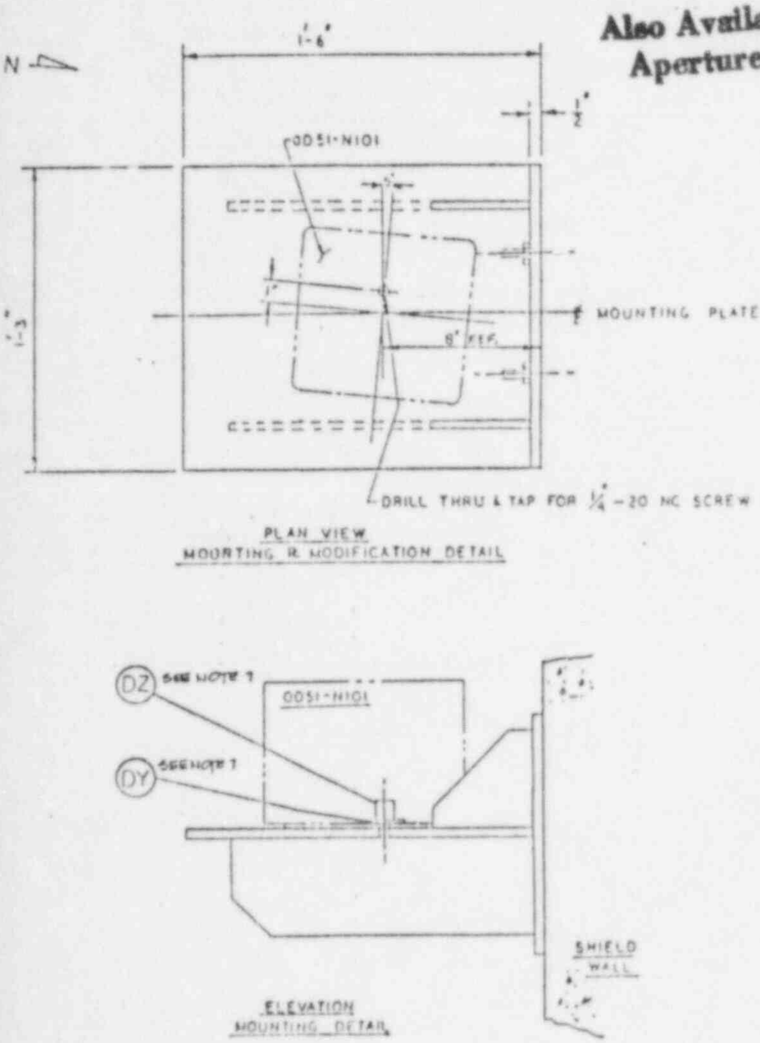
Figure B

TI APERTURE CARD

Also Available On Aperture Card

NOTES:

1) THIS DRAWING DEPICTS INSTRUMENT MOUNTING ONLY.
2) STRUCTURAL STEEL SPECIFICATION ASTM A-36.
3) UNLESS OTHERWISE SPECIFIED, ALL TOLERANCES WILL BE ± 1/8".
4) NON-SAFETY SEISMIC, MAINTAIN 18" SEPARATION BETWEEN ANY NON-SAFETY AND NON-SEISMIC IMPULSE LINES AND/OR DEVICES INSTALLED BY JCI.
5) MOUNTING BRACKET SUPPLIED AND INSTALLED BY OTHERS.
6) INSTRUMENT TO BE ALIGNED WITH NORTH/SOUTH LINE AS SHOWN ON THIS DRAWING.
7) MATERIAL SUPPLIED BY SP-49 AND INSTALLED BY SP-90.
8) THE FOLLOWING MEASUREMENT TOLERANCE SHALL APPLY TO AS-BUILT DIMENSIONS.
   - ± 1/16" FOR DIMENSIONS ≤ 1" (EXCEPT CLOSE CLEARANCE FOR ALL DIMENSIONS)
   - ± 1/4" FOR DIMENSIONS > 1" to 6'
   - ± 1/2" FOR DIMENSIONS > 6' to 3'
   - ± 1" FOR DIMENSIONS > 3'
   - INCLIN.................... ± 3°
9) ALL DIMENSIONS SHOWN ARE ACTUAL AS-BUILT DIMENSIONS. AS-BUILT DIMENSIONS HAVE BEEN VERIFIED BY JOHNSON CONTROLS INC.



PLAN VIEW
MOUNTING PL MODIFICATION DETAIL

ELEVATION
MOUNTING DETAIL

REFERENCE DOC	REV	QTY	ITEM	DESCRIPTION
D-814-661	D			
		1	Z8	0D51-N101 TIME HISTORY ACCELEROGRAPH
		1	DY	1/4 LOCK WASHER, CS
		1	DZ	1/4-20 X 1 1/4 LG. SOCKET HEAD CAP SCREW, CS

SYST 0D51
UNIT COMMON

HANGER

JOHNSON CONTROLS
SYSTEMS ENGINEERING & CONSTRUCTION DIV. POWER UNIT
PERRY NUCLEAR POWER PLANT UNITS 1 & 2

SEISMIC INSTRUMENTATION INSTALLATION DETAIL FOR 0D51-N101

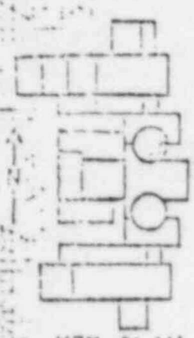
CONTRACT NO		DRAWING	SHT
0243-0001	SP-90	HF 0D51-N101	1

SCALE: NONE

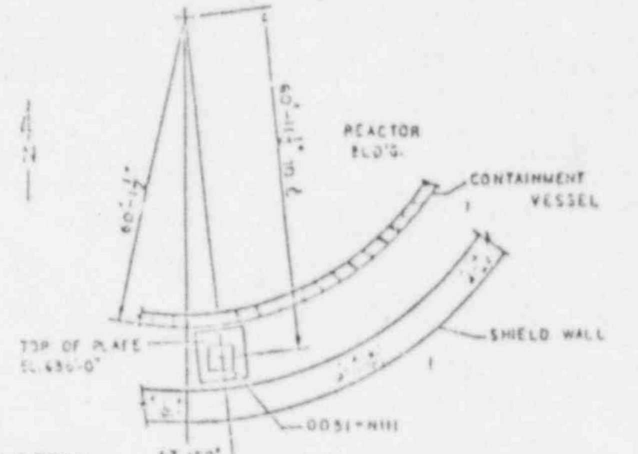
REV	DESCRIPTION
0	ORIGINAL ISSUE
1	AS BUILT 4549-548-396-1-0

CONSTRUCTION
RELEASED FOR
THE CLEVELAND ELECTRIC ILLUMINATING COMPANY
PERRY NUCLEAR POWER PLANT UNIT 1 & 2
GILBERT ASSOCIATES, INC.
ENGINEERS AND CONSULTANTS

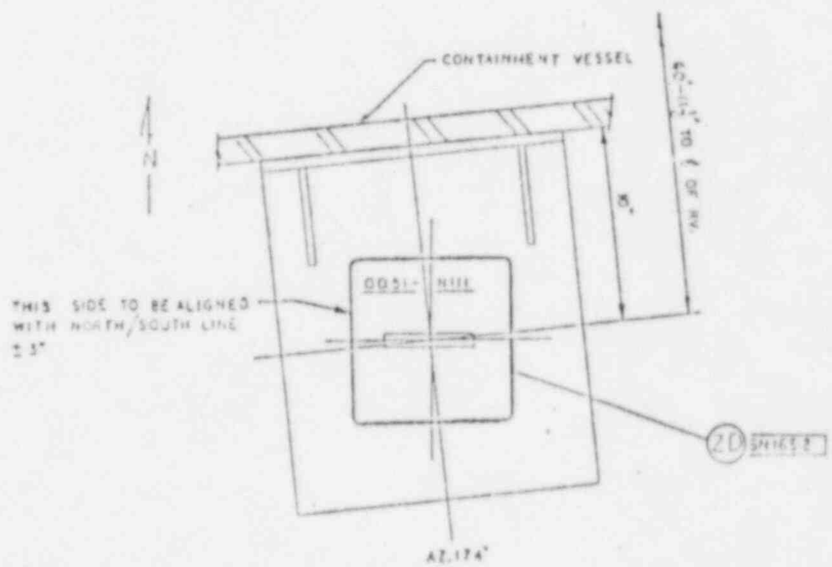
0199-02



KEY PLAN



LOCATION DETAIL
REACTOR BLD'G ANNULUS) EL.686'-0"
(FOR REFERENCE ONLY)

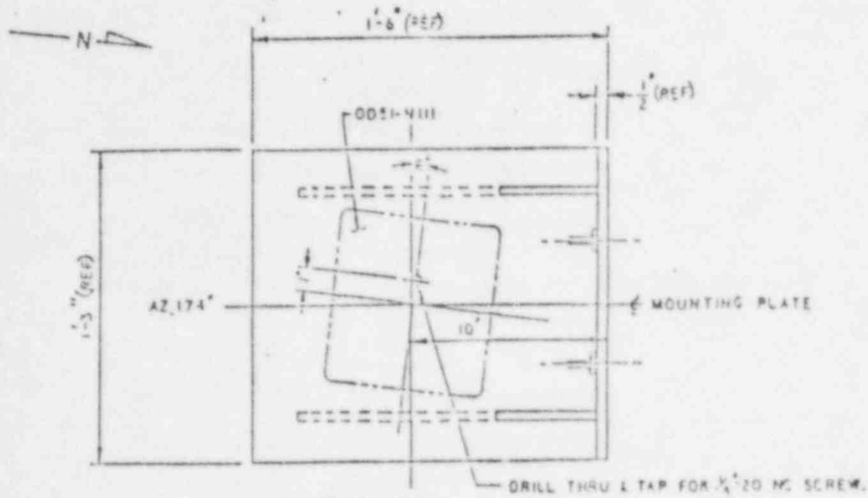


PLAN VIEW
INSTRUMENT ORIENTATION DETAIL

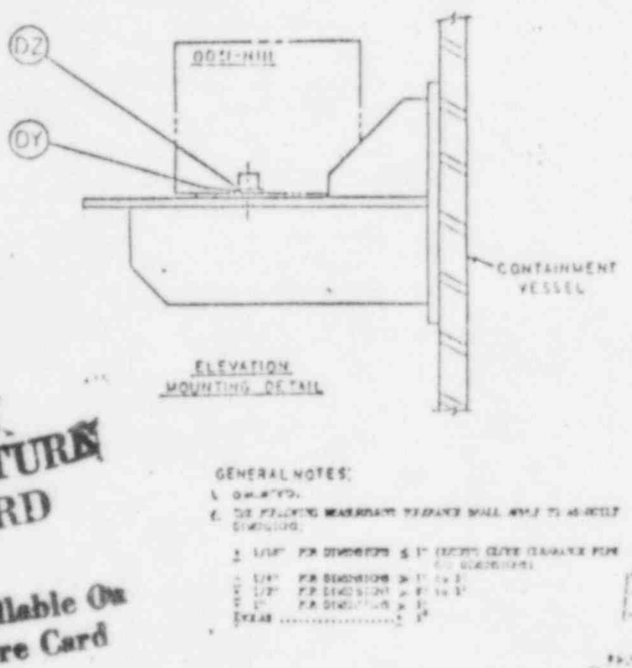
THE FOLLOWING DOCUMENTS ARE APPLICABLE TO THIS LEVEL		
ECN	F/A	NR
N/A	N/A	N/A

REFER TO APPROPRIATE DRAWINGS FOR DESIGN NOTES & REFERENCES NOT COVERED BY THIS DRAWING.

NOTES:



PLAN VIEW
MOUNTING & MODIFICATION DETAIL



ELEVATION
MOUNTING DETAIL

GENERAL NOTES:

ITEM CODE		
1	DY	
1	DZ	

JOHNSON CONTROLS®

REV	DESCRIPTION
0	ORIGINAL ISSUE
1	AS-BUILT

SEISMIC INSTRUMENTATION
INSTALLATION DETAIL FOR
0D51-N111

8243/001	90	0D51-N111

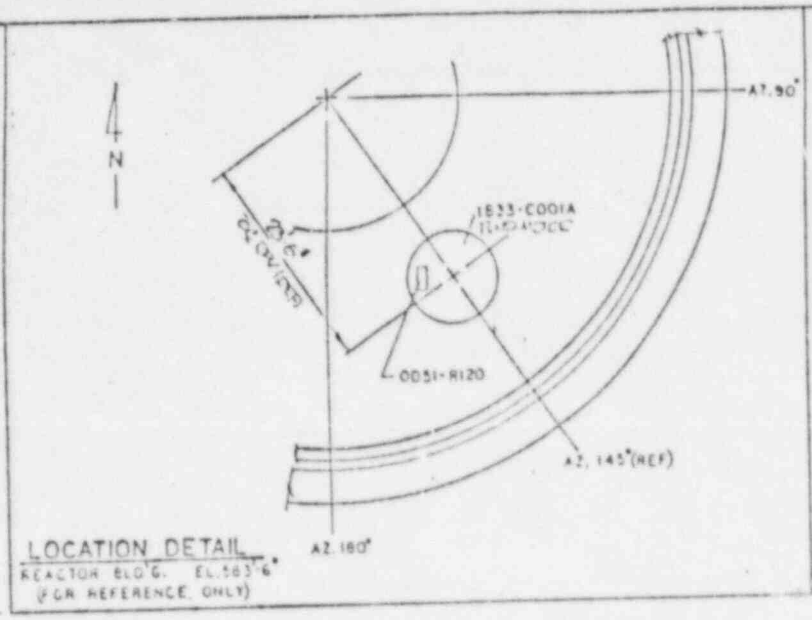
CONSTRUCTION

RELEASED FOR

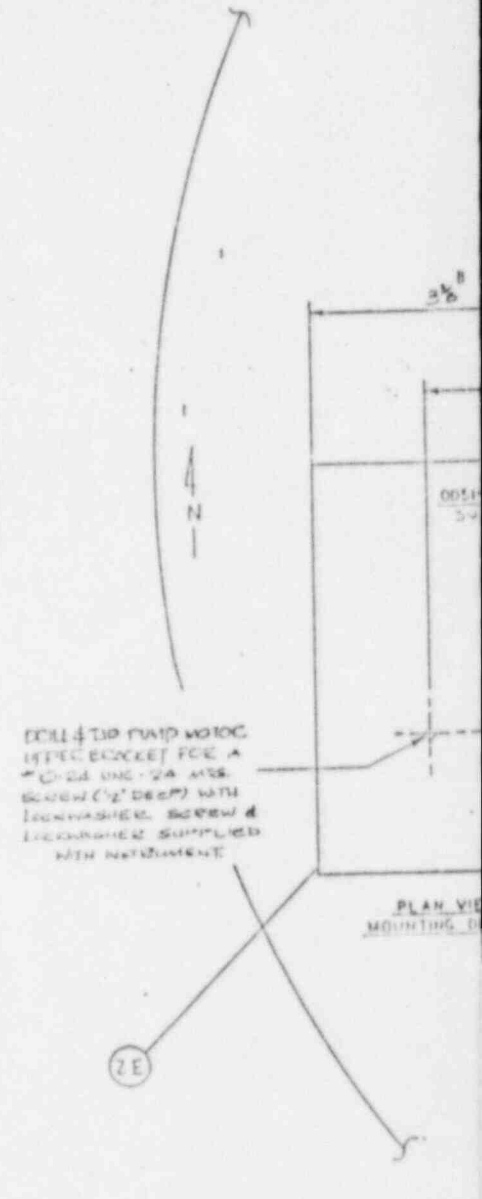
THE CLEVELAND ELECTRIC ILLUMINATING CO.

PERRY NUCLEAR POWER PLANT

8602130199-03



LOCATION DETAIL
REACTOR BLD'G. EL. 583'-6"
(FOR REFERENCE ONLY)



REFER TO "REFERENCE DRAWINGS" FOR DESIGN NOTES & REFERENCES NOT COVERED BY THIS DRAWING.

Figure [illegible]

NOTES:

1) THIS DRAWING DEPICTS INSTRUMENT MOUNTING ONLY.

2) UNLESS OTHERWISE SPECIFIED, ALL TOLERANCES SHALL BE ± 1/8".

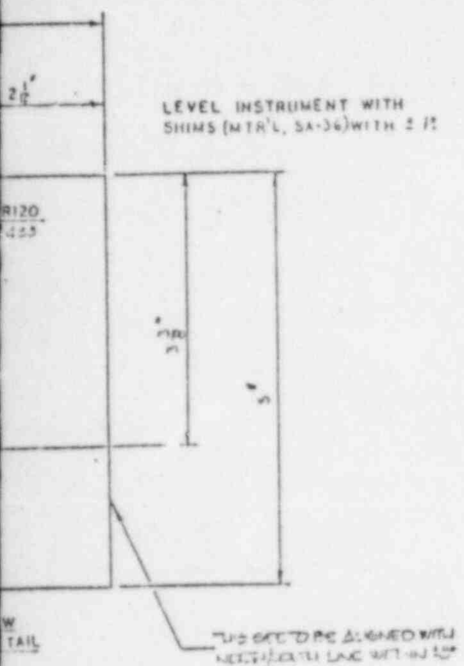
3) NON-SAFETY SEISMIC, MAINTAIN 18" SEPARATION BETWEEN ANY NON-SAFETY AND NON-SEISMIC IMPULSE LINES AND/OR DEVICES INSTALLED BY JCI.

4) PUMP AND LIFT FIXTURE SUPPLIED BY OTHERS.

5) INSTRUMENT TO BE ALIGNED WITH NORTH/SOUTH LINE AS SHOWN ON THIS DRAWING.

6) [illegible]

7) [illegible]



REFERENCE DOC	REV	QTY	ITEM	DESCRIPTION
D 814-663	D			
SYSTEM D51				
UNIT COMMON				
AREA REACTOR				
		1	TE	OD51-R120 PEAK ACCELERATION RECORDER

BILL OF MATERIALS

HANGER

JOHNSON CONTROLS®

SYSTEMS ENGINEERING & CONSTRUCTION DIV. POWER UNIT

PERRY NUCLEAR POWER PLANT UNITS 1 & 2

TITLE: SEISMIC INSTRUMENTATION INSTALLATION DETAIL FOR OD51-R120

8243-0001 | SP-90 | I/F OD51-R120

SCALE NONE

ISSUE

RECEIVED JUN 27 1985

REVIEW PENDING

THE CLEVELAND ELECTRIC ILLUMINATING COMPANY

PERRY NUCLEAR POWER PLANT UNIT 1 & 2

CONSTRUCTION

RELEASED FOR

DATE

GILBERT ASSOCIATES, INC.

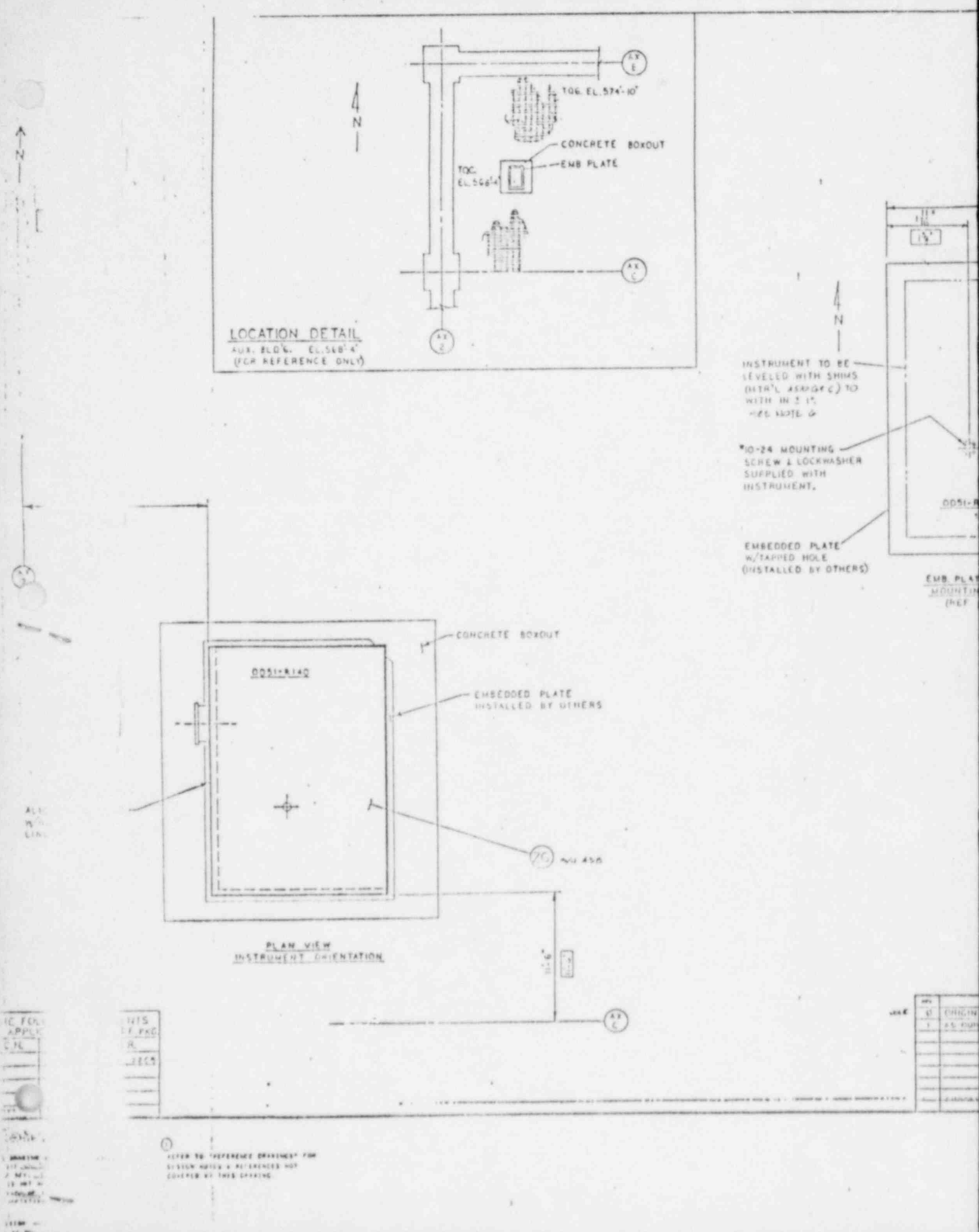
REACTOR BUILDING

D-514-663

TI APERTURE CARD

Also Available On Aperture Card

9602130199-04



TOC. EL.574'-10"
CONCRETE BOXOUT
EMB PLATE
TOC. EL.566'-4"
LOCATION DETAIL
AUX. BLD'G. EL.568'-4"
(FOR REFERENCE ONLY)
INSTRUMENT TO BE LEVELED WITH SHIMS (MTR'L ASM/GR C) TO WITH IN ± 1°. SEE NOTE 6
#10-24 MOUNTING SCREW & LOCKWASHER SUPPLIED WITH INSTRUMENT.
EMBEDDED PLATE W/TAPPED HOLE (INSTALLED BY OTHERS)
CONCRETE BOXOUT
0051-R140
EMBEDDED PLATE INSTALLED BY OTHERS
PLAN VIEW
INSTRUMENT ORIENTATION
REFER TO "REFERENCE DRAWINGS" FOR DESIGN NOTES & REFERENCES NOT COVERED BY THIS DRAWING.

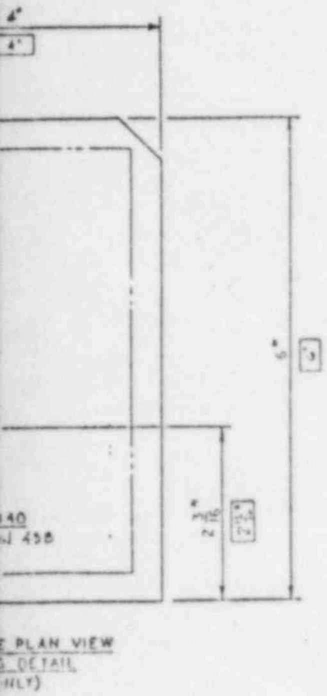
Figure E

NOTES:

1) THIS DRAWING DEPICTS INSTRUMENT MOUNTING ONLY
2) ALL CONSTRUCTION TOLERANCES WERE ±1/8" UNLESS SHOWN OTHERWISE IN PARENTHESES
3) NON-SAFETY SEISMIC, MAINTAIN 18" SEPARATION BETWEEN ANY NON-SAFETY AND NON-SEISMIC IMPULSE LINES AND/OR DEVICES INSTALLED BY JCI.
4) EMBEDDED PLATE SUPPLIED AND INSTALLED BY OTHERS.
5) INSTRUMENT TO BE ALIGNED WITH NORTH/SOUTH LINE AS SHOWN ON THIS DRAWING.
6) SHIM MATERIAL IS A570 GR C., LEVEL TOLERANCE WILL GOVERN SHIM THICKNESS.
7) THE FOLLOWING MEASUREMENT TOLERANCE SHALL APPLY TO AS-BUILT DIMENSIONS;

   ± 1/16" FOR DIMENSIONS ≤ 1" (EXCEPT CLOSE CLEARANCE PIPE GAP DIMENSIONS)
   ± 1/4" FOR DIMENSIONS > 1" to 6"
   ± 1/2" FOR DIMENSIONS > 6" to 2'
   ± 1" FOR DIMENSIONS > 2'
   ANGLES .... ± 3°

8) ALL DIMENSIONS SHOWN IN BOXES ARE ACTUAL AS-BUILT DIMENSIONS. AS-BUILT DIMENSIONS HAVE BEEN MEASURED AND VERIFIED BY JOHNSON CONTROLS, INC.



REFERENCE DOC	REV	QTY	ITEM	BILL OF MATERIALS DESCRIPTION
C815-663	D			
SYSTEM 0D51		1	26	0D51-R140 PEAK ACCELERATION RECORDER SH 458
UNIT COMMON				
BLDG AUX				

HEADER / ITEM / WELD / HANGER

JOHNSON CONTROLS®
SYSTEMS ENGINEERING & CONSTRUCTION DIV. POWER UNIT

PERRY NUCLEAR POWER PLANT UNITS 1 & 2

SEISMIC INSTRUMENTATION INSTALLATION DETAIL FOR 0D51-R140

CONTRACT NO 8243-0001 | SP-90 | DWG NO 1IF 0D51-R140 | REV 1

SCALE NONE

DESCRIPTION						
... ISSUE						
... 4549-51B-401-1-0						

CONSTRUCTION RELEASED FOR

DATE

GILBERT ASSOCIATES, INC.

THE CLEVELAND ELECTRIC ILLUMINATING COMPANY

PERRY NUCLEAR POWER PLANT UNIT 1 & 2

AUXILIARY BUILDING

ENVIRONS MONITORING SYSTEM

D-814-663-906

PRINTED
PERRY NUCLEAR POWER PLANT
FEB 06 1985
UNCONTROLLED

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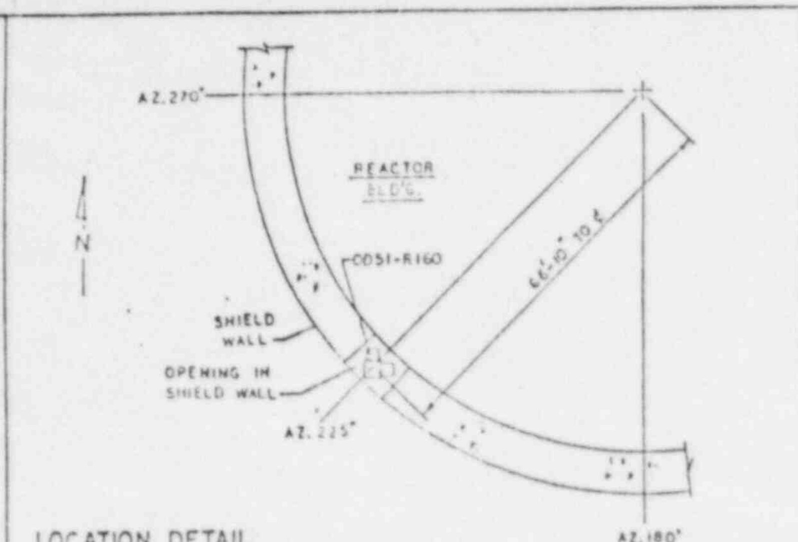
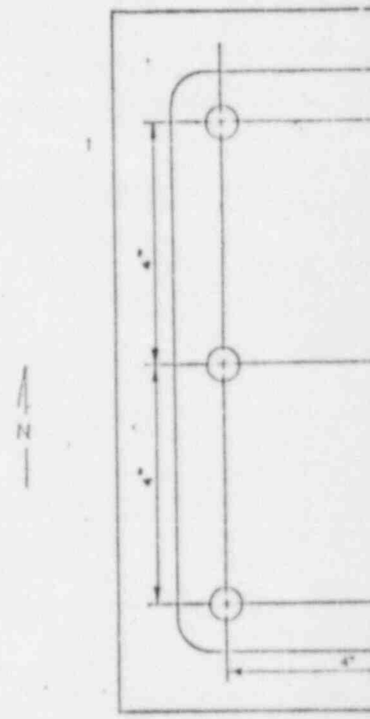
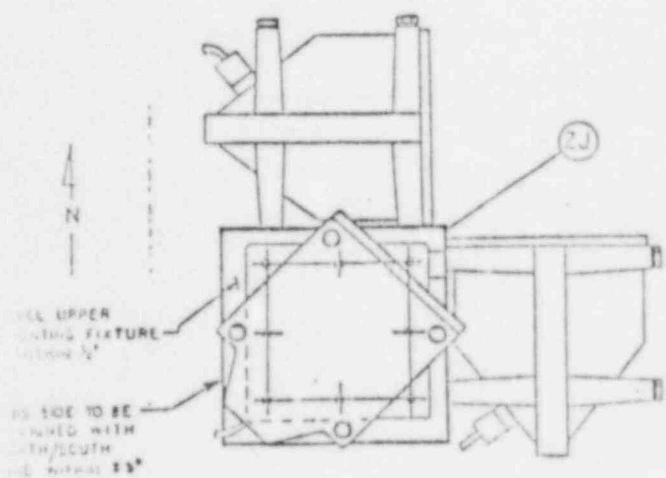
8602130199-05

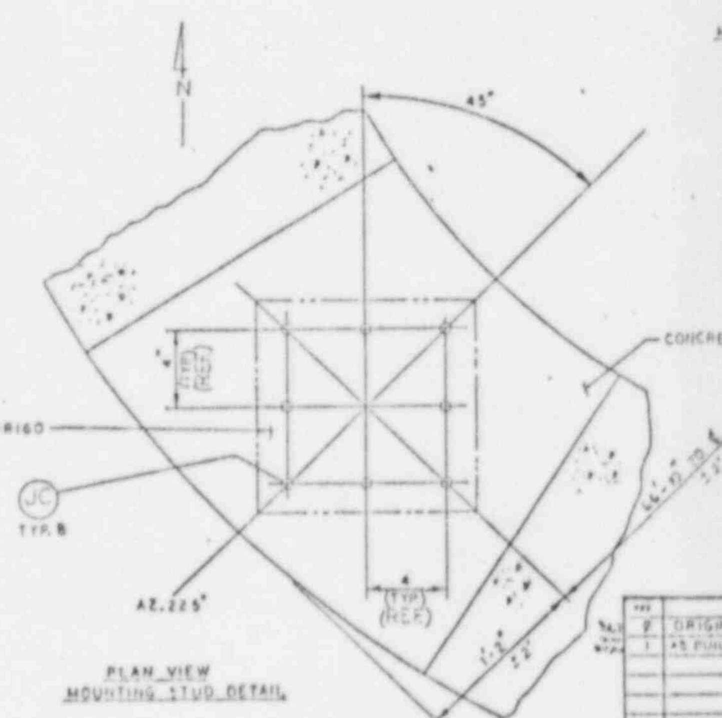


LOCATION DETAIL
REACTOR SHIELD WALL EL. 574'-10"
FOR REF. ONLY





PLAN VIEW
TRIAXIAL PEAK SPECTRUM RECORDER
ORIENTATION DETAIL



PLAN VIEW
MOUNTING STUD DETAIL

① REFER TO "REFERENCE DRAWINGS" FOR DESIGN NOTES & REFERENCES NOT COVERED BY THIS DRAWING.

Figure 8

NOTES:

1) THIS DRAWING DEPICTS INSTRUMENT MOUNTING ONLY.

2) UNLESS OTHERWISE SPECIFIED, ALL TOLERANCES WERE ± 1/8".

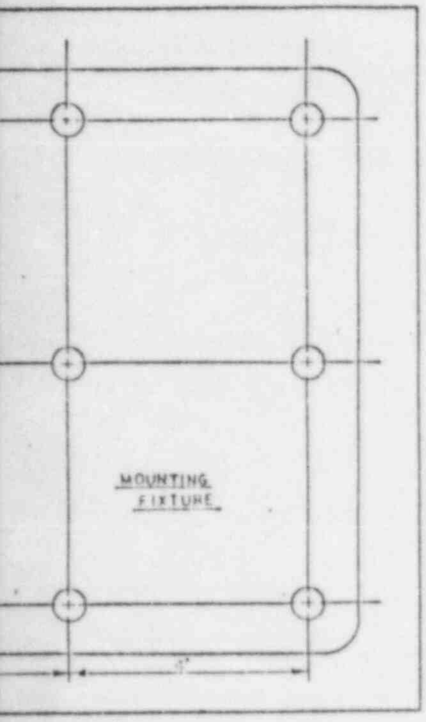
3) NON-SAFETY SEISMIC, MAINTAIN 18" SEPARATION BETWEEN ANY NON-SAFETY AND NON-SEISMIC IMPULSE LINES AND/OR DEVICES INSTALLED BY JCI.

4) INSTRUMENT TO BE ALIGNED WITH NORTH/SOUTH LINE AS SHOWN ON THIS DRAWING.

5) THE FOLLOWING MEASUREMENT TOLERANCE SHALL APPLY TO AS-BUILT DIMENSIONS:

± 1/16" FOR DIMENSIONS ≤ 1" (EXCEPT CLOSE CLEARANCE PIPE GAP DIMENSIONS)
± 1/4" FOR DIMENSIONS > 1" to 6"
± 1/2" FOR DIMENSIONS > 6" to 3'
± 1" FOR DIMENSIONS > 3'
ANGLES ± 3°

6) ALL DIMENSIONS SHOWN ARE ACTUAL AS-BUILT DIMENSIONS. AS-BUILT DIMENSIONS HAVE BEEN VERIFIED BY JOHNSON CONTROLS INC.



PLAN VIEW
MOUNTING DETAIL

REFERENCE DOC	REV
D814-663	D

QTY	ITEM	DESCRIPTION
1	27	0D51-R160 TRIAXIAL RESPONSE SPECTRUM RECORDER/SWITCH
1	28	3/8" x 5" LG HVY HEX BOLT W/NUT & WASHER

SYSTEM 0D51
UNIT COMMON
BLDG REACTOR

HANGER

JOHNSON CONTROLS®
SYSTEMS ENGINEERING & CONSTRUCTION DIV. POWER UNIT

PERRY NUCLEAR POWER PLANT UNITS 1 & 2

SEISMIC INSTRUMENTATION INSTALLATION DETAIL FOR 0D51-N160

8243-0001 | SP. 90 | I/F 0D51-R160 | 1

SCALE NONE

ISSUE
E49-218-403-1-0

JUN 27 1985

CONSTRUCTION
RELEASED FOR
DATE

THE CLEVELAND ELECTRIC ILLUMINATING COMPANY
PERRY NUCLEAR POWER PLANT UNIT 1
REACTOR BUILDING

GILBERT ASSOCIATES, INC.
ENGINEERS AND CONSULTANTS

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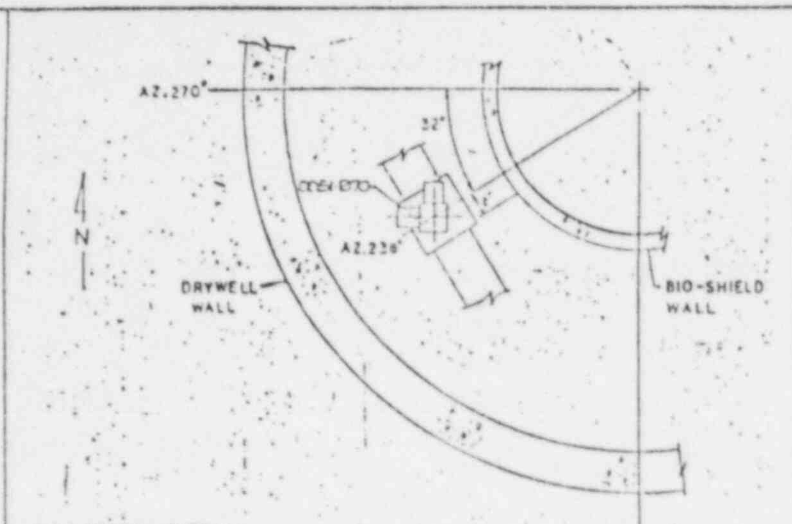
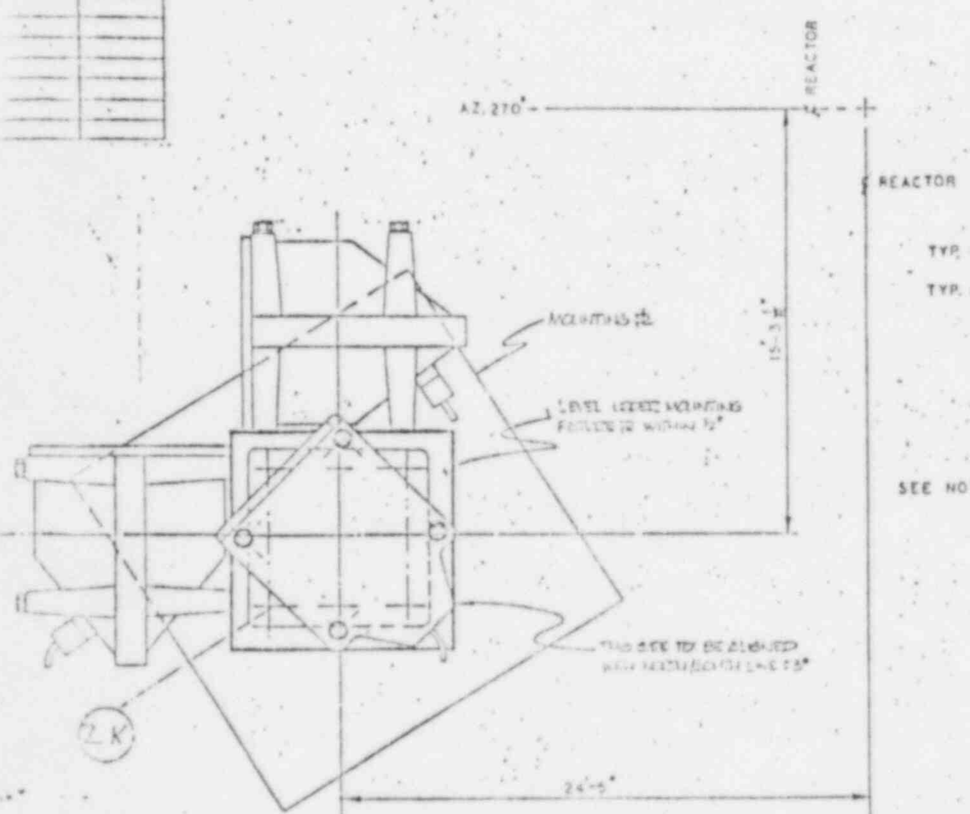
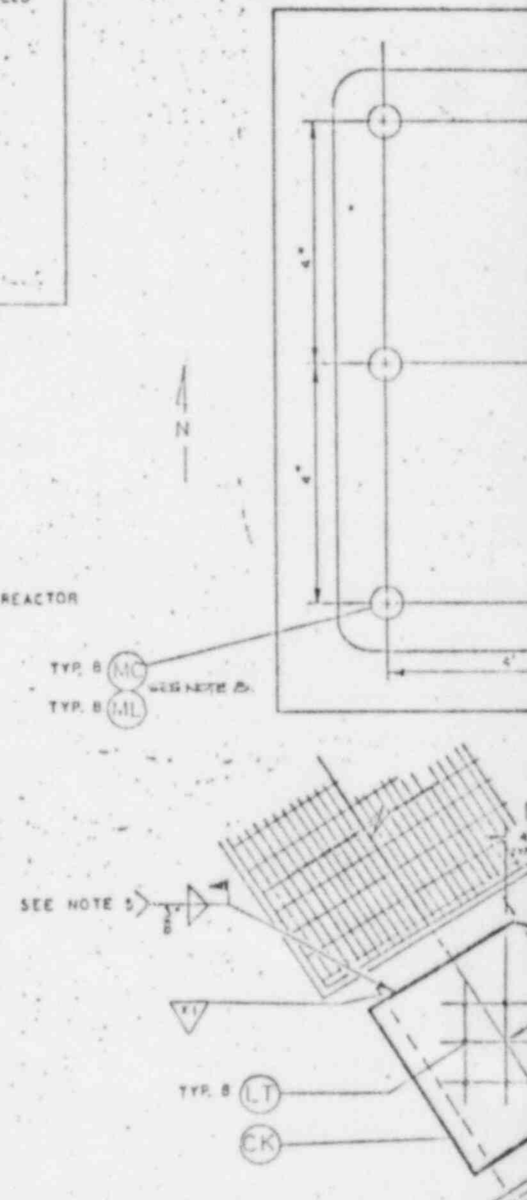


LOCATION DETAIL
REACTOR BLD'G. EL. 630'-1"
(FOR REFERENCE ONLY)



PLAN VIEW
TRIAXIAL PEAK SPECTRUM RECORDER ORIENTATION DETAIL



PLAN VIEW
MOUNTING PLATE WITH STUD DETAIL

REFER TO REFERENCE DRAWINGS FOR DESIGN NOTES & REFERENCES NOT COVERED BY THIS DRAWING.

12) ALL DIMENSIONS SHOWN IN BOXES ARE ACTUAL AS-BUILT DIMENSIONS. AS-BUILT DIMENSIONS WERE FIELD MEASURED AND VERIFIED BY JOHNSON CONTROLS, INC.

NOTES:

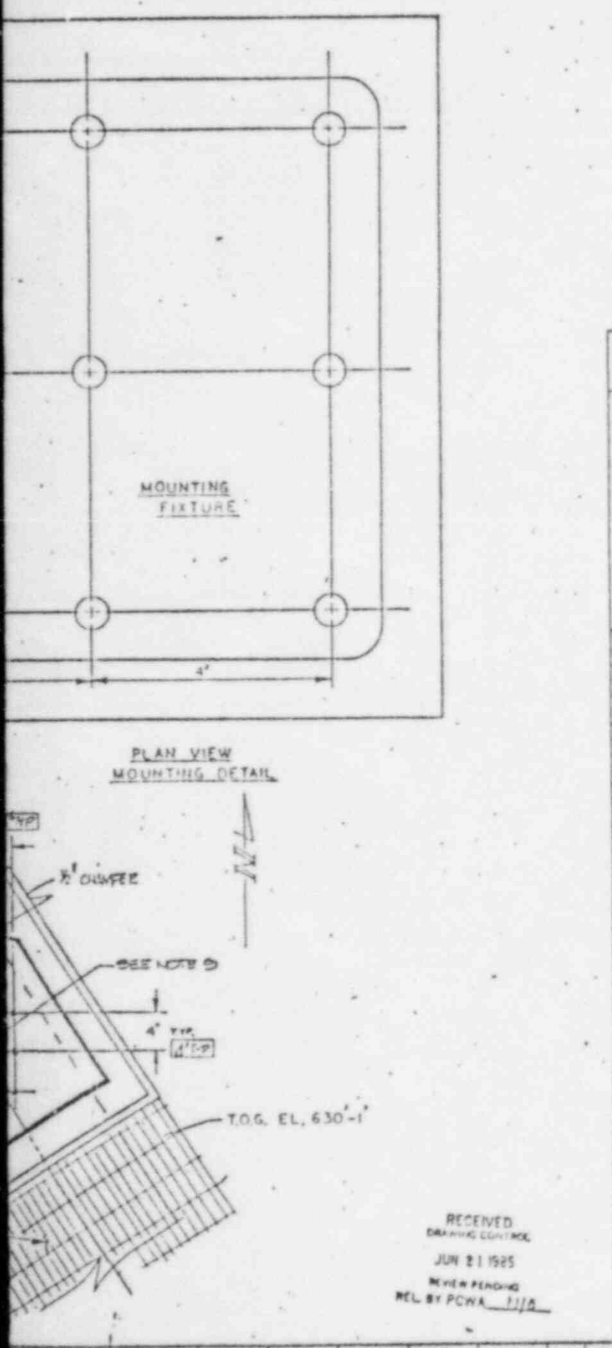
1) STUDS TO BE WELDED TO STEEL PLATE IN ACCORDANCE WITH GAS-1007.
2) THIS DRAWING DEPICTS INSTRUMENT MOUNTING ONLY.
3) STRUCTURAL STEEL SPECIFICATION: ASTM A-36.
4) UNLESS OTHERWISE SPECIFIED, ALL TOLERANCES WERE ± 1/8".
5) ALL WELDING ON THIS DRAWING, EXCEPT STUDS, SHALL BE PERFORMED PER THE FOLLOWING PROCEDURE:

   WPS-101C-PGPP WELD NO. X1

6) NON-SAFETY SEISMIC, MAINTAIN 18" SEPARATION BETWEEN ANY NON-SAFETY AND NON-SEISMIC IMPULSE LINES AND/OR DEVICES INSTALLED BY JCI.
7) INSTRUMENT TO BE ALIGNED WITH NORTH/SOUTH LINE AS SHOWN ON THIS DRAWING.

a) TORQUE NUT TO 15 FT·LBS
b) STUD PATTERN TO BE CENTERED ON EXISTING STEEL BEAM
c) MOUNTING PLATE SHALL HAVE STAMPED ON FACE OF PL. PARALLEL TO NELSON STUDS IN LETTERS 1/2" OR LARGER AS SHOWN - "PLANT NORTH →"

11) THE FOLLOWING MEASUREMENT TOLERANCES APPLY TO AS-BUILT DIMENSIONS:
± 1/16" FOR DIMENSIONS ≤ 1" [illegible]
± 1/4" FOR DIMENSIONS > 1" TO [illegible]
± 1/2" FOR DIMENSIONS > [illegible] TO [illegible]
± 1" FOR DIMENSIONS > [illegible]
ANGLES .... ± 2°



REFERENCE DOC	REV	QTY	ITEM	DESCRIPTION
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				TUBING
				VALVE
				VALVE
				TEE
				ELL
				UNION
				ADAPTER
				CONNECTOR
				NIPPLE
				PLUG CAP
		1		[illegible] TRIAXIAL RESPONSE SPECTRUM RECORDER
		6		1/2" x 1 1/2" LG NELSON STUD [illegible]
		8		1/2" HEX NUT [illegible]
		8		1/2" FLAT WASHER [illegible]
		1		PLATE 1" THK. [illegible]

SYSTEM: D51
UNIT: COMMON
BLDG: REACTOR

BULKHEAD
WELD
HANGER

RECEIVED
DRAWING CONTROL
JUN 21 1985
REVIEW PENDING
REL BY PCWA N/A

JOHNSON CONTROLS®
SYSTEMS ENGINEERING & CONSTRUCTION DIV. POWER UNIT

PERRY NUCLEAR POWER PLANT UNITS 1 & 2

TITLE: SEISMIC INSTRUMENTATION INSTALLATION DETAIL FOR 0D51-R170

CONTRACT NO. 8243-0001 | SP. 90 | DRAWING NO. 1-0D51-R170 | REV 1

DESCRIPTION	DWN/DATE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]AL ISSUE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

CONSTRUCTION
DATE | RELEASED FOR | ENGR

THE CLEVELAND ELECTRIC ILLUMINATING COMPANY
PERRY NUCLEAR POWER PLANT UNIT 1
REACTOR BUILDING

GILBERT ASSOCIATES, INC.
ENGINEERS AND CONSULTANTS

PRINTED
[illegible]
FEB [illegible] 1986

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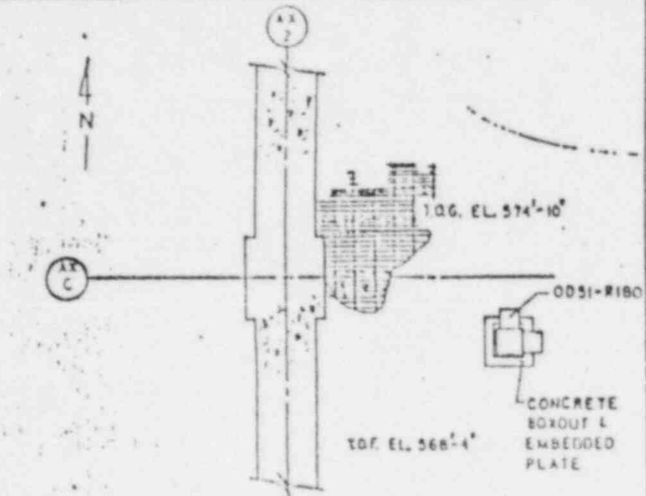
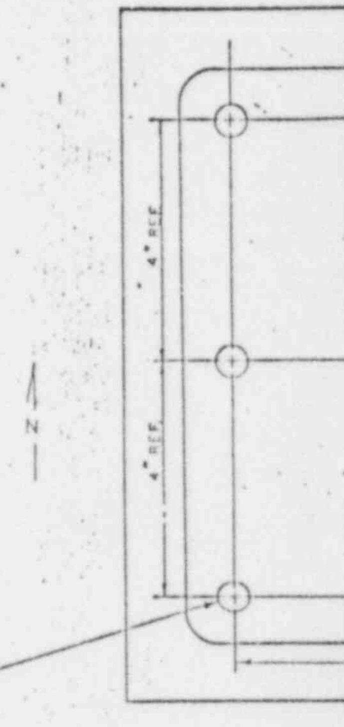
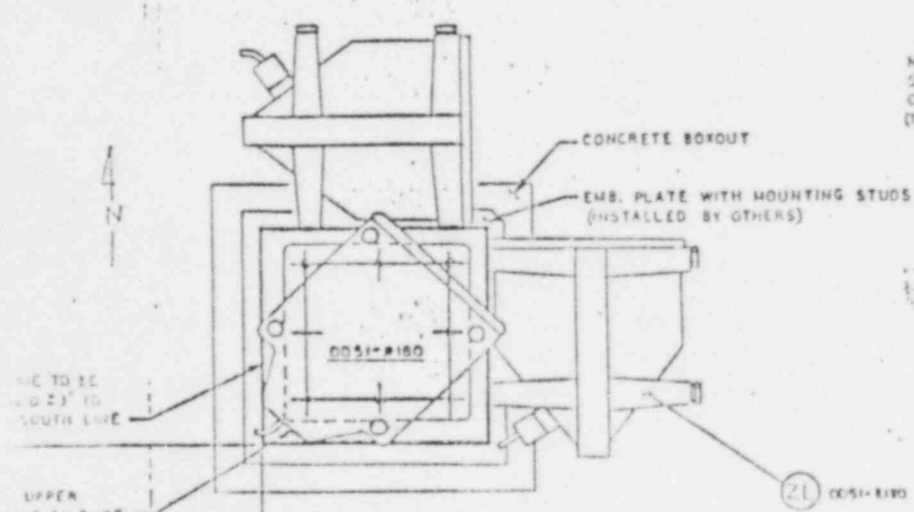


LOCATION DETAIL
AUX. BLD'G. EL. 568'-4"
(FOR REFERENCE ONLY)



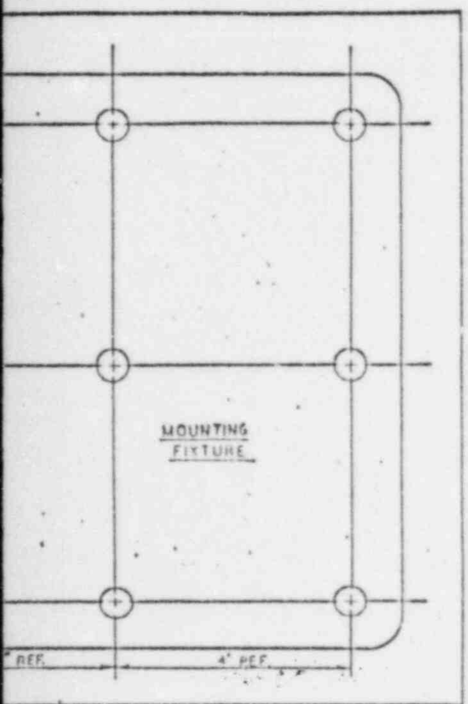


PLAN VIEW
TRIAXIAL PEAK SPECTRUM RECORDER
ORIENTATION DETAIL

THE FOLLOWING DOCUMENTS ARE APPLICABLE TO THIS I/F PACKAGE

ECN	FVA	NR	TSR
N/A	N/A	N/A	N/A

① REFER TO REFERENCE DRAWINGS FOR DESIGN NOTES & REFERENCES NOT COVERED BY THIS DRAWING.



PLAN VIEW
MOUNTING DETAIL

NOTES:

1) THIS DRAWING DEPICTS INSTRUMENT MOUNTING ONLY.
2) UNLESS OTHERWISE SPECIFIED, ALL TOLERANCES WILL BE ± 1/8". FOR INSTALLATION ONLY
3) NON-SAFETY SEISMIC, MAINTAIN 18" SEPARATION BETWEEN ANY NON-SAFETY AND NON-SEISMIC IMPULSE LINES AND/OR DEVICES INSTALLED BY JCI.
4) EMBEDDED PLATE SUPPLIED AND INSTALLED BY OTHERS.
5) INSTRUMENT TO BE ALIGNED WITH NORTH/SOUTH LINE AS SHOWN ON THIS DRAWING.
6) SHIM AS REQUIRED, MATERIAL TO BE SA-36
7) ALL DIMENSIONS SHOWN IN BOXES ARE ACTUAL AS-BUILT DIMENSIONS. AS-BUILT DIMENSIONS HAVE BEEN MEASURED AND VERIFIED BY JOHNSON CONTROLS, INC.
8) THE FOLLOWING MEASUREMENT TOLERANCE SHALL APPLY TO AS-BUILT DIMENSIONS:

± 1/16" FOR DIMENSIONS ≤ 1" (EXCEPT CLOSE CLEARANCE FITS AND [illegible])
± 1/4" FOR DIMENSIONS > 1" to 1'
± 1/2" FOR DIMENSIONS > 1' to 3'
± 1" FOR DIMENSIONS > 3'
ANGLES .... ± 3°

REFERENCE DOC.	REV.	QTY.	P/N	DESCRIPTION
0D14-E63	D			
SYSTEM 0D51				
UNIT COMMON				
		1	21	0D51-R180 TRIAXIAL RESPONSE SPECTRUM RECORDER

BULKHEAD / PIPE / WELD / HANGER

JOHNSON CONTROLS®
SYSTEMS ENGINEERING & CONSTRUCTION DIV. POWER UNIT

PERRY NUCLEAR POWER PLANT UNITS 1 & 2

SEISMIC INSTRUMENTATION INSTALLATION DETAIL FOR 0D51-R180

CONTRACT NO.		DRAWING NO.	REV.
8243-0001	SP-90	IIF 0D51-R180 -	1

SCALE NONE

DESCRIPTION	DATE
ORIGINAL ISSUE	
INT. 4549-546-405-1-D	

JUN 27 1985

CONSTRUCTION
RELEASED FOR
THE CLEVELAND ELECTRIC ILLUMINATING COMPANY
PERRY NUCLEAR POWER PLANT UNIT 1 & 2
AUXILIARY BUILDING

GILBERT ASSOCIATES, INC.
ENGINEERS AND CONSULTANTS

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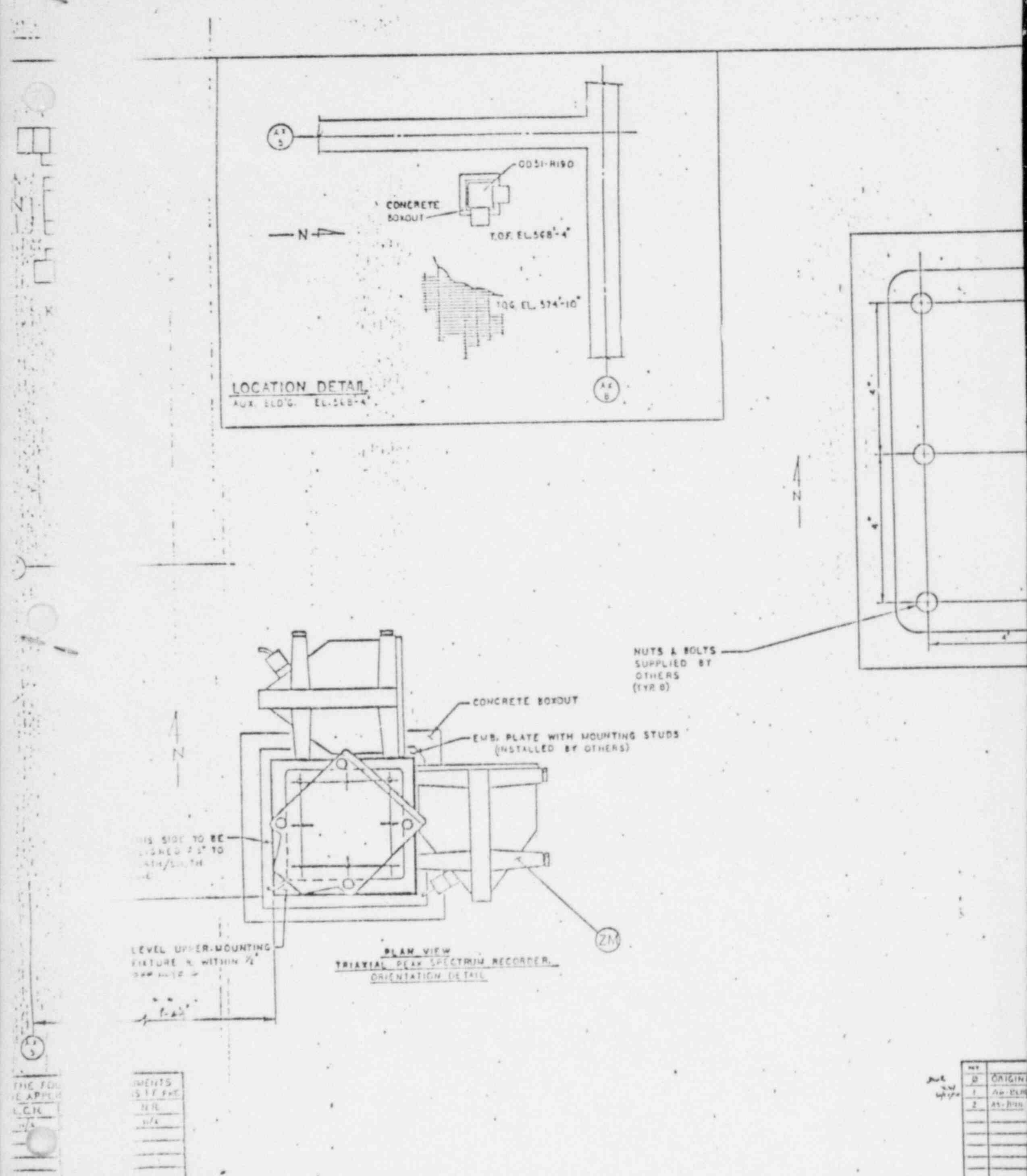
APERTURE
CARD

Also Available On
Aperture Card

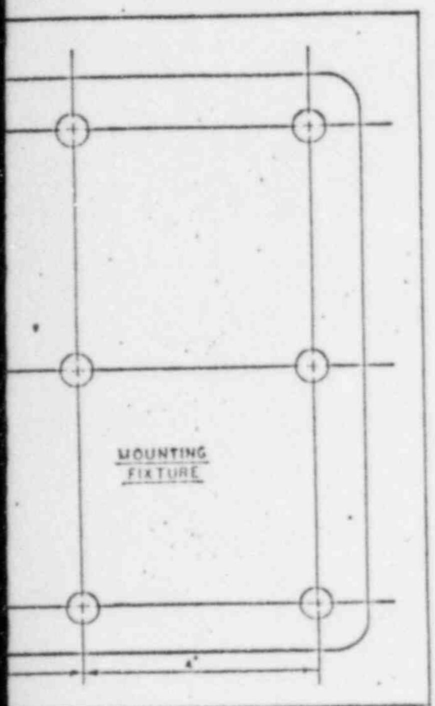
8602130199-08



REFER TO "REFERENCE DRAWINGS" FOR DESIGN NOTES & REFERENCES NOT COVERED BY THIS DRAWING.

NOTES:

1) THIS DRAWING DEPICTS INSTRUMENT MOUNTING ONLY.
2) ALL CONSTRUCTION TOLERANCES WITH ± [illegible] IN PARENTHESIS.
3) NON-SAFETY SEISMIC, MAINTAIN 18" SEPARATION BETWEEN ANY NON-SAFETY AND NON-SEISMIC IMPULSE LINES AND CA DEVICES INSTALLED BY JCI.
4) EMBEDDED PLATE SUPPLIED AND INSTALLED BY OTHERS.
5) INSTRUMENT TO BE ALIGNED WITH NORTH/SOUTH LINE AS SHOWN ON THIS DRAWING.
6) SHIM AS REQUIRED, MATERIAL TO BE SA-36
7) ALL DIMENSIONS SHOWN ARE ACTUAL AS-BUILT DIMENSIONS. AS-BUILT DIMENSIONS HAVE BEEN VERIFIED BY JOHNSON CONTROLS INC.
8) THE FOLLOWING MEASUREMENT TOLERANCES APPLY TO AS-BUILT DIMENSIONS:
± 1/16" FOR DIMENSIONS ≤ 1" (EXCEPT CLOSE CLEARANCE PIPE CAP DIMENSIONS)
±1/4" FOR DIMENSIONS > 1" to 1'
±1/2" FOR DIMENSIONS > 1' to 3'
±1" FOR DIMENSIONS > 3'
ANGLES .... ± 3



PLAN VIEW
MOUNTING DETAIL

REFERENCE DOC	REV	QTY	ITEM	DESCRIPTION
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				TUBING
				VALVE
				VALVE
				TEE
				ELL
				UNION
SYSTEM 0D51				ADAPTOR
UNIT COMMON				CONNECTOR
				NIPPLE
				PLUG CAP
		1	7H	0D51-R190 TRIAXIAL RESPONSE SPECTRUM RECORDER

BULKHEAD
PEN
WELD
HANGER

RECEIVED
DRAWING CONTROL
JUN 27 1985
REVIEW PENDING
REL. BY [illegible]

2

DESCRIPTION	DWN/DATE	PE/DATE	[illegible]	[illegible]	[illegible]	CHK/DATE
L ISSUE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
T 4549-548-406-1-A	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4549-548-406-1-0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

JOHNSON CONTROLS®
SYSTEMS ENGINEERING & CONSTRUCTION DIV. POWER UNIT
PERRY NUCLEAR POWER PLANT UNITS 1 & 2

SEISMIC INSTRUMENTATION
INSTALLATION DETAIL FOR
0D51-R190

8243-0001 | SP-90 | I/F 0D51-R190 | 2
SCALE NONE

CONSTRUCTION
DATE | RELEASED FOR | ENGR
THE CLEVELAND ELECTRIC ILLUMINATING COMPANY
PERRY NUCLEAR POWER PLANT UNIT 1 & 2
AUXILIARY BUILDING D51
GILBERT ASSOCIATES, INC.
ENGINEERS AND CONSULTANTS

PRINTED
[illegible]
FEB [illegible]
UNCONTROLLED

Figure

8602130199-09

6.0 PLANT SEISMIC DESIGN EVALUATION

The seismic design basis for the Perry Nuclear Power Plant is established by requirements in 10 CFR Part 100, Appendix A and NRC Regulatory Guide 1.60. These regulations require nuclear plant structures and safety class systems and components to be designed to withstand loads induced by a "Safe Shutdown Earthquake" (SSE) for the particular site. The SSE is the strongest earthquake in terms of magnitude of vibratory ground motion that is ever expected to occur at a particular site. The SSE is the design basis earthquake considered for plant licensing. A second seismic event also considered in designing nuclear plants is the "Operating Basis Earthquake" (OBE). The OBE is the strongest earthquake considered likely to occur at a particular site and is at least one-half of the SSE. Operations may resume following an earthquake which exceeds the OBE after demonstrating that no functional damage has occurred to safety-related plant features. (10 CFR Part 100, Appendix A, III(c), V(a)).

The SSE can be described by means of a "response spectrum," which depicts the maximum acceleration, velocity or displacement response to an input excitation (here the SSE) at a specified damping value for single degree-of-freedom oscillators of varying natural frequencies. The high frequency end of a response spectrum indicates the "zero period acceleration" (ZPA) associated with the event. The ZPA is equal to the maximum ground acceleration of the SSE itself.

In the design of any plant, it is difficult to predict the exact shape of postulated earthquake acceleration time-histories and associated ground response spectra. Appendix A of 10 CFR Part 100 therefore requires an expected SSE to be developed by statistically combining the response spectra from multiple historical earthquakes. Following this guideline, the NRC has provided in Reg. Guide 1.60 standardized response spectra that can be used in lieu of spectra developed for each site (see Fig. 6.1). These standardized spectra were derived by normalizing and combining spectra calculated from numerous sets of historically recorded acceleration time-histories. From these sets of spectra, smoothed response curves (acceleration, velocity and displacement) were generated at a level equal to one standard deviation greater than the mean of the responses. This method provides an 84% level of statistical confidence that responses at any particular frequency will not be exceeded by any future event.

Thus, in lieu of having to develop site-specific SSE ground response spectra, the standardized response spectra of Reg. Guide 1.60 can be used. The standardized spectra need only be scaled up or down to reflect the effective maximum ground accelerations (i.e., ZPA's) expected for the SSE at that site. The SSE design response spectra are used to dynamically analyze a lumped-mass model of the power plant structures.

6.1 DESIGN OF THE PERRY PLANT

The Perry design response spectra were derived by using the standard response spectra of Reg. Guide 1.60 scaled to a ZPA of 0.15 g determined for the Perry site. These spectra served as the design response spectra at the foundation elevations for use in designing the plant buildings.

From these spectra, a simulated SSE time-history of ground accelerations was developed for each directional component (N-S, E-W, and vertical). The conservatism of these simulated time-histories was checked and confirmed by assuring that the response spectra generated from the simulated time-histories envelop the Reg. Guide 1.60 design response spectra (see Fig. 6.2).

Seismic Category I structures were analyzed by applying the simulated time-histories to a lumped-mass model of the entire structure, as shown in Figure 6.3. From this analysis, time-history accelerations at each floor elevation were also derived. These time-histories were then used to derive response spectra for each floor of each main building. The floor response spectra were used in designing the safety class equipment, components, and systems.

In addition to the conservatism included in the derivation of response spectra, there were numerous other conservatisms included in the overall structural design of the Perry structures, systems and components. Examples of some of the more significant conservatisms are as follows:

1. Broadening the Envelope of Floor Response Spectra

   Frequency bands of floor responses spectra were artifically broadened (typically by 15%) to account for possible frequency variations. Responses used for design were thus overestimated for systems having more than one dominant frequency falling into the broadened frequency bands of the floor response spectra.

2. Equipment Qualification by Test

   Equipment qualified by shake table testing used time-histories simulated from the floor response spectra. The simulated time-histories were generated in such a way that their calculated response spectra envelop the broadened floor response spectra, which in turn already envelop the original design response spectra. The conservatism of the time-histories is increased by this "envelope on top of an envelope" process. Moreover, this process results in simulated time-histories with maximum accelerations much higher than the ZPA's of the floor response spectra.

3. Strain Hardening Not Accounted For and Static Allowables Used for Dynamic Load

   In equipment design, material is assumed to behave linearly up to the yield point, then to deform continuously to collapse when the external load is maintained. All material used in equipment design exhibits characteristics of strain hardening. This means that resistance to deformation increases after the deformation exceeds the yield point. Furthermore, even if no strain hardening is assumed, the material can resist dynamic loads having peak values higher than the yield strength through the absorption of energy in the plastic region.

4. Loading Combinations

The plant was designed to withstand loading combinations with a very low probability of simultaneous occurrence. For example, some load combinations included seismic loads, hydrodynamic loads, and loads due to a hypothetical loss of coolant accident. This results in design capability well above the loads associated with seismic alone.

5. Allowable Stresses

Computed seismic stresses used in design were considered to be primary, non-self-limiting stresses instead of secondary stresses with a self-limiting nature. The actual behavior of seismic stresses is somewhere between a primary and secondary nature. Consideration of seismic stresses as primary stresses results in overestimated values used for design.

6. Damping Values

Conservative damping values were employed at Perry pursuant to NRC Regulatory Guide 1.61. The recent ASME code case N-411 allows increased damping values to be used in the design of nuclear power plant piping systems.

One example of just how significant these types of design conservatisms are is the response of the El Centro Steam Plant (in California) to the 1979 Imperial Valley earthquake. The El Centro Steam Plant was designed to withstand a 0.2 g static lateral load. The recorded peak horizontal load at the site was 0.5 g. The station tripped when station power was lost. One unit was restored to service in 15 minutes and another one in 2 hours. According to calcuations performed by Lawrence Livermore Laboratories, the actual loads experienced by the plant were 2 to 9 times higher than the design values. The plant, however, suffered essentially no damage. The El Centro case shows that an engineered structure can indeed resist seismic loads many times higher than their design values.

6.2 EVALUATION OF THE JANUARY 31 EARTHQUAKE

The USGS determined the magnitude of the January 31, 1986 earthquake to be M_b = 4.9 with an epicenter at about 11 miles (17.6 Km.) south of the Perry Power Plant site. This is of much less magnitude than the earthquake for which the plant was designed (the SSE) and contained substantially lower total energy than the Perry SSE Evidence of the low energy content of the January 31 earthquake is shown by a comparison of the acceleration time-histories it induced at various elevations with the corresponding design acceleration time-histories. (See Figs. 6.4 through 6.9). The time-histories used for design are 22 seconds long and of sustained high magnitude (strong motion). By contrast, the January 31 time-histories are about 5 seconds long and contain strong motion in only less than a one-second interval (total) of the event.

A comparison of Figures 6.1 and 6.10 gives a further indication of the low energy content of the January 31 earthquake. These figures show that the Reg. Guide 1.60 spectra used for design have much broader frequency contents than those of the recorded earthquake, which contain strong motion only at high frequencies. The design earthquake therefore contains much greater total energy.

The maximum relative displacements from the recorded time-histories of the recorded earthquake are shown in Table 6.1. A comparison of the total square-root-of-the-sum-of-the-squares (SRSS) recorded relative displacements with the SSE and OBE values shows that the recorded displacements were all far below those values. For example, the overall relative displacement shown in the Table is 0.36 cm for the SSE and 0.10 cm for the actual event. Since stresses in the structures are proportional to relative displacements, and the recorded relative displacements were far less than the SSE design values, the stresses induced by the 1986 earthquake were all well within design capabilities.

Table 6.2 compares the structural response ZPA's of the recorded data with those of the SSE and OBE. The SRSS comparison indicates that the recorded values of the 1986 earthquake vary from significantly below OBE values to 74% of SSE values, except at elevation 686 feet of the Reactor Building Containment Vessel. At that location, the N-S and Vertical acceleration components exceed SSE values, while the E-W acceleration component is less than the SSE value. However, the recorded relative displacements are far less than their design values, as shown in Table 6-1. In addition, recorded response spectra accelerations show that the design response spectra accelerations in certain instances were exceeded at the high frequency end of the spectra. At lower frequencies (at or below approximately 14 Hz) the recorded accelerations are all well under the design values (see response spectra comparisons in Appendix D).

The measurement of accelerations outside the predicted responses at the high frequency ends of certain response spectra has no engineering significance. This is explained by the interrelationships among the frequencies, accelerations, velocities, and displacements associated with a seismic event. In general, high frequency acceleration responses have correspondingly low velocity and displacement responses. The 1986 earthquake accelerations occurred at very high frequencies. Therefore, despite some recorded maximum acceleration responses which exceeded SSE values at higher frequencies, corresponding velocities and displacements (and resulting stresses) were nevertheless acceptably low.

As discussed, the significant indicators of structural stresses are the relative displacements, and Table 6.1 indicates that relative displacements (and thus stresses) caused by the 1986 earthquake were very small. This is consistent with the high frequency nature of the disturbance. The high frequencies combined with the short duration resulted in an earthquake that contained very low total energy compared to the SSE.

The maximum recorded velocity at the top of the Reactor Building foundation mat during the 1986 earthquake was 0.87 inches/sec (2.21 cm/sec). This can be compared with the Bureau of Mines (BOM) velocity threshold for no damage to non-engineered buildings, which is 1 inch/sec (2.54 cm/sec). This shows that the BOM considers it acceptable for blasting work to induce velocity waves in nearby residential housing foundations that are greater than the maximum velocities induced by the 1986 earthquake at the Perry Plant. This example helps provide perspective on just how low the velocities and energy content of the 1986 event were.

As discussed earlier in this report, extensive plant inspections have indicated that no structural damage resulted form the 1986 earthquake. This is as expected based upon the low energy, short duration, and low velocity and displacemnt of the event. Although some hairline cracks in the structural concrete were documented during plant walkdowns, this does not constitute damage. Reinforced concrete structures are expected to show hairline cracks. Regardless of their cause, such cracks have no effect on the strength and integrity of the structures. Moreover, such cracking is judged not to be attributable to the 1986 earthquake because of the low magnitude of the event.

Section 7.5 of IEEE 344 "Recommended Practices for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations," was employed at Perry. This standard recognizes that short duration/high frequency/low energy input motions will not cause significant structural stresses. Instead, it requires qualification by long duration/broad band frequency/high energy testing to provide conservatism.

As discussed earlier in this report, all energized plant equipment functioned during this event as designed. To confirm the lack of impact of the high frequency accelerations on plant equipment, CEI is comparing the qualification data for equipment listed in Table 6.3 against recorded response spectra. Although still ongoing, the evaluation to date shows that the original conservatism in the equipment qualification was more than adequate to accqmodate the recorded event.

6.3 EVALUATION OF SPECIFIC DATA

In light of the above discussion, recorded responses at particular locations can be evaluated. At all four instrument locations recording response spectra, SSE design spectra are all well above the recorded spectra in the frequency range of 1 Hz to 14 Hz (see Figs. D1 through D12). These figures compare recorded data with the appropriate design spectra at adjacent elevations. These figures also compare the data from different types of seismic instrumentation at the same elevation.

At higher frequencies, the design spectra are exceeded by recorded values in certain cases. However, the corresponding displacements based on recorded data are all extremely small (on the order of several one-hundredths of an inch) at 20 Hz. These extemely low displacements conform to the above analysis demonstrating that the stresses at higher frequencies are insignificant despite acceleration exceedences.

In evaluating all the spectra data recorded at the various locations, it was noted that the acceleration responses at the Reactor Building Platform outside the Biological Shield Wall varied from the general pattern of responses recorded at the other three locations. The recorded N-S and E-W acceleration components for this location are all well-enveloped by the entire range of the SSE spectra while the recorded vertical acceleration component exceeds the SSE spectra at the high frequency end (see Figure D-9). This response may be due to the fact that this particular Engdahl PSR-1200 instrument is located near multiple supports and piping system snubbers and components. Actuation of snubbers or local loads induced by nearby components may thus have influenced the recorded vertical response. Such impacts would be of a local, secondary nature. Regardless, the low energy, short duration, high frequency nature of the event indicates that these accelerations had no structural significance. Indeed, the recorded displacement spectrum value is only 0.023 inches (0.06 cm) at 25 Hz at this location.

In general, the high frequency acceleartion content of ground motion will be filtered out by buildings and thus will not appear at higher elevations. This is due in part to the low participation factor generally associated with modes at the higher frequencies. This phenomenon is exhibited by the responses recorded at the Reactor Building mat and elevation 686 feet of the Reactor Building Containment Vessel. A very high frequency p-wave was recorded at the Reactor Building foundation mat. The time-histories shown in Figures 6.4 through 6.9 indicate that this p-wave (appearing during the first second or so of the time-histories) was filtered out by the building and did not appear at elevation 686 feet.

There was a response in the range of 20 Hz that was transmitted to the higher elevations. The explanation for this involves the structural characteristics of the buildings on the Reactor Building foundation mat. The Reactor Building consists of multiple structures sitting on a common foundation mat--a concrete shield building, steel containment vessel, concrete drywell wall, and biological shield wall. The structural response of each building influences the responses of the others. The frequencies, mode shapes and participation factors of the two most dominant vibration modes are at roughly 4 Hz and 18.4 Hz, as shown in Figures 6.11 through 6.13. These two dominant frequencies correspond to the peaks at 4 Hz and 20 Hz on the recorded spectra for the Reactor Building at the mat and elevation 686 feet. The input motion at 20 Hz (corresponding to the s-wave) was amplified by this latter mode with some rigid body motion. The 20 Hz input was thus not filtered out but did appear at the higher elevation. As discussed, the acceleration peaks at 20 Hz at this location correspond to very small relative displacements and thus are not significant in an engineering sense.

6.4 CONCLUSION

The 1986 Ohio earthquake was a low energy, high frequency, short duration, low velocity, and small displacement event. As a result of these characteristics and the above discussions, the 1986 earthquake had no adverse effects on the Perry structures, systems, or components, and no changes to the Perry seismic design basis are required.

TABLE 6.1

Comparison of Design Displacements[1] VS Recorded Displacements[1]

(Expressed in centimeters/one inch = 2.54 cm)

		COLUMN 1	COLUMN 2	COLUMN 2 minus COLUMN 1
		Reactor Building Foundation Mat Elevation 574′–10″ SMA-3 (Kinemetrics) D51-N101	Reactor Building Containment Vessel Elevation 686′ SMA-3 (kinemetrics) D51-N111	Relative Displacements for the Containment Vessel
NS	Recorded	0.09	0.17	0.08
	SSE	0.044	0.28	0.24
	OBE	0.023	0.17	0.15
EW	Recorded	0.16	0.21	0.05
	SSE	0.044	0.28	0.24
	OBE	0.023	0.17	0.15
VERT.	Recorded	0.05	0.07	0.02
	SSE	0.02	0.37	0.017
	OBE	0.013	0.022	0.009
SRSS[2]	**Recorded**	—	—	**0.1**
	SSE	—	—	**0.34**
	OBE	—	—	**0.21**

1 Displacements based on same time-step to determine relative displacements

2 Square-root-of-the-sum of the squares

TABLE 6.2

Comparison of Design ZPA's[1] VS Recorded ZPA's

(Expressed in g values)

		Auxiliary Building Foundation Mat Elevation 568' PAR 400 (Engdahl) D51-R140	Reactor Building Foundation Mat Elevation 574'–10" SMA–3 (Kinemetrics) D51-N101	Reactor Building Recirculation Pump Elevation 605' PAR 400 (Engdahl) D51-R120	Reactor Building Platform Elevation 630' Inside Drywell PSR 1200 (Engdahl) D51-R170	Reactor Building Containment Vessel Elevation 686' SMA–3 (Kinemetrics) D51-N111
NS	Recorded	.17	.18	.32	.09	.55
	SSE	.17	.18	1.06	.48	.40
	OBE	.10	.10	.86	.40	.24
EW	Recorded	.06	.10	.11	.16	.18
	SSE	.20	.18	1.06	.48	.40
	OBE	.10	.10	.86	.40	.24
VERT.	Recorded	.03	.11	.05	Note 2	.30
	SSE	.20	.18	.47	.28	.24
	OBE	.10	.10	.38	.16	.15
SRSS[3]	**Recorded**	**.18**	**.23**	**.34**	**Note 2**	**.65**
	SSE[4]	**.33**	**.31**	**1.57**	**.73**	**.62**
	OBE	**.17**	**.17**	**1.27**	**.59**	**.37**

1. Zero period acceleration of structural response
2. ZPA indeterminable from available data
3. Square-root-of-the-sum of the squares
4. Licensing basis is SSE

TABLE 6.3

EQUIPMENT LIST AT AUXILIARY BUILDING ELEVATION 568'

1H22P0001	LPCS	Instrument Rack	
1H22P0017	RCIC	Instrument Rack	
1H22P0018	RHR	Instrument Rack	A
1H22P0021	RHR	Instrument Rack	B
1H22P0055	RHR	Instrument Rack	C
1C61N0001		Differential Press Transmitter	
1E12N0007A,B		Differential Press Transmitter	
1E12N0015A,B,C		Differential Press Transmitter	
1E12N0026A,B		Pressure Transmitter	
1E12N0028		Pressure Transmitter	
1E12N0050A,B		Pressure Transmitter	
1E12N0051A,B		Pressure Transmitter	
1E12N0052A,B,C		Differential Press Transmitter	
1E12N0055A,B,C		Pressure Transmitter	
1E12N0056A,B,C		Pressure Transmitter	
1E12N0058 C		Pressure Transmitter	
1E21N0003		Pressure Transmitter	
1E21N0050		Pressure Transmitter	
1E21N0051		Flow Transmitter	
1E21N0052		Pressure Transmitter	
1E21N0053		Pressure Transmitter	
1E21N0054		Pressure Transmitter	
1E31N0075A		Pressure Transmitter	
1E31N0077A		Pressure Transmitter	
1E31N0083A,B		Pressure Transmitter	
1E51N0003		Differential Press Transmitter	
1E51N0050		Pressure Transmitter	
1E51N0051		Differential Press Transmitter	
1E51N0053		Pressure Transmitter	
1E51N0055A,B,E,F		Pressure Transmitter	
1E51N0056A, E		Pressure Transmitter	
1E12C002A	RHR	Pump & Motor	
1E12C002B	RHR	Pump & Motor	
1E12C002C	RHR	Pump & Motor	
1E21C001	LPCS	Pump & Motor	
1E22C001	HPCS	Pump & Motor	

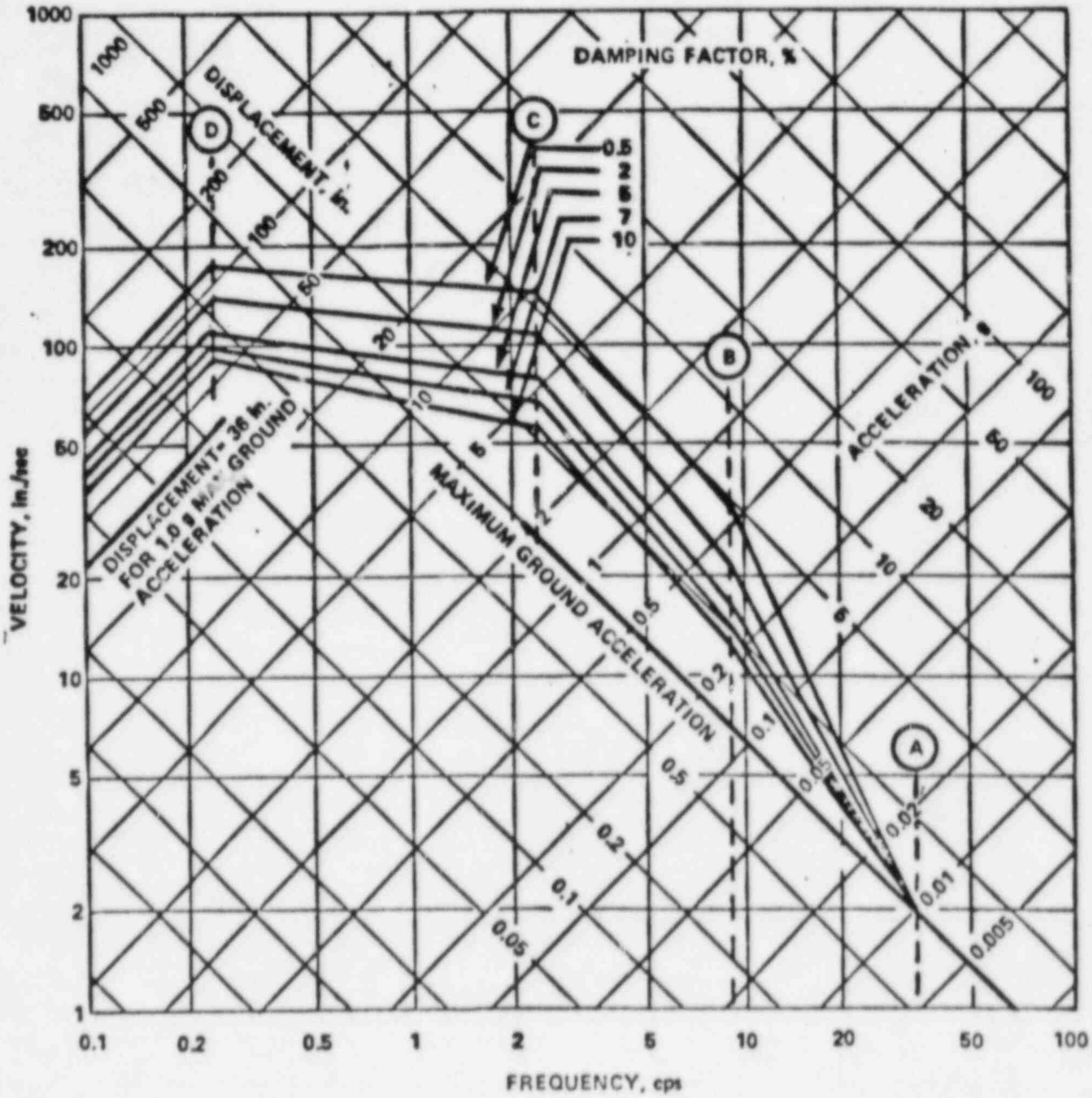
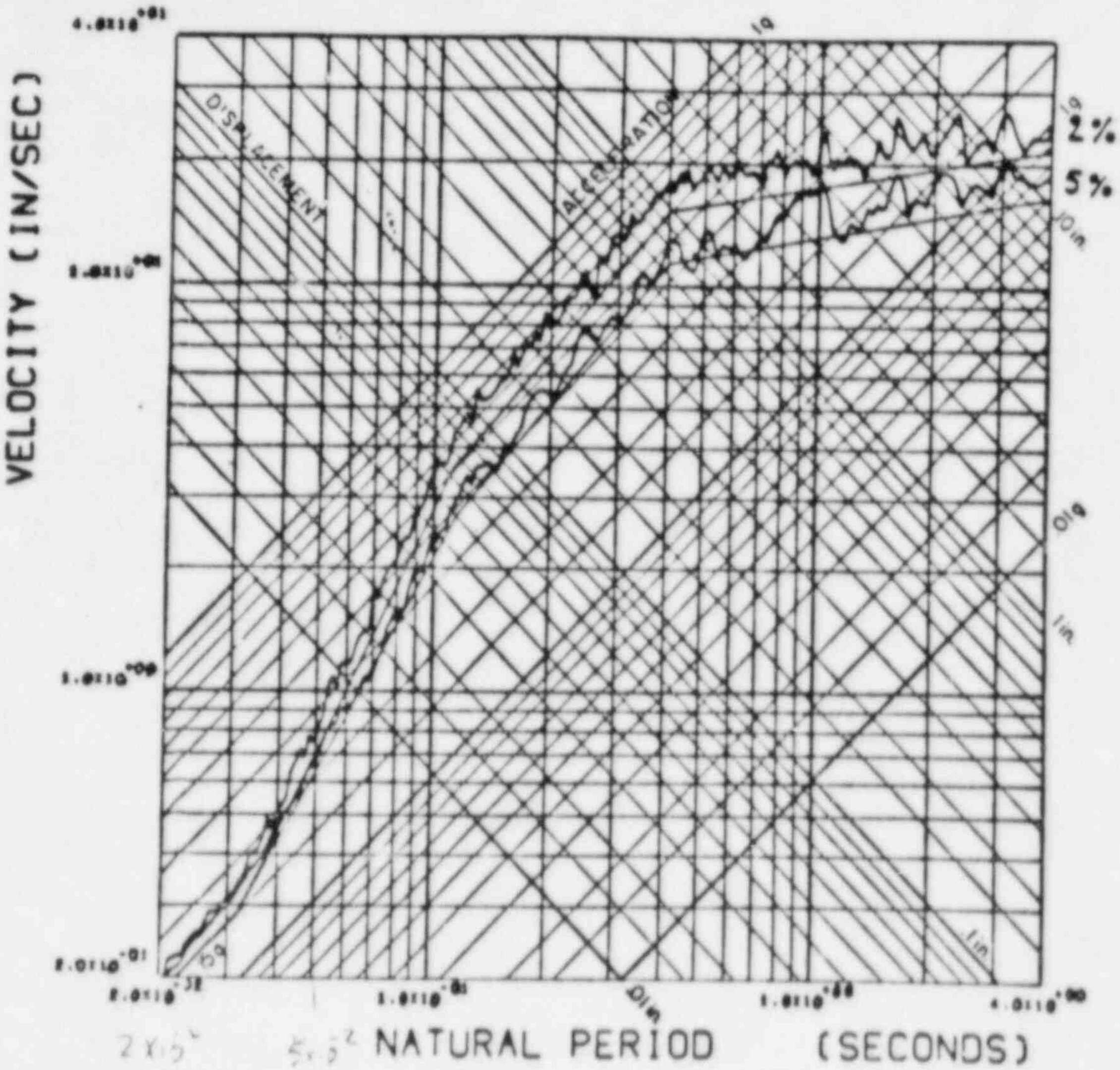


FIGURE 1. HORIZONTAL DESIGN RESPONSE SPECTRA – SCALED TO 1g HORIZONTAL GROUND ACCELERATION

Figure 6.1



PERRY NUCLEAR POWER PLANT
THE CLEVELAND ELECTRIC ILLUMINATING COMPANY

Response Spectra - Horizontal Motion H1 (2% and 5% Damping)

Figure 3.7-5

Figure 6.2

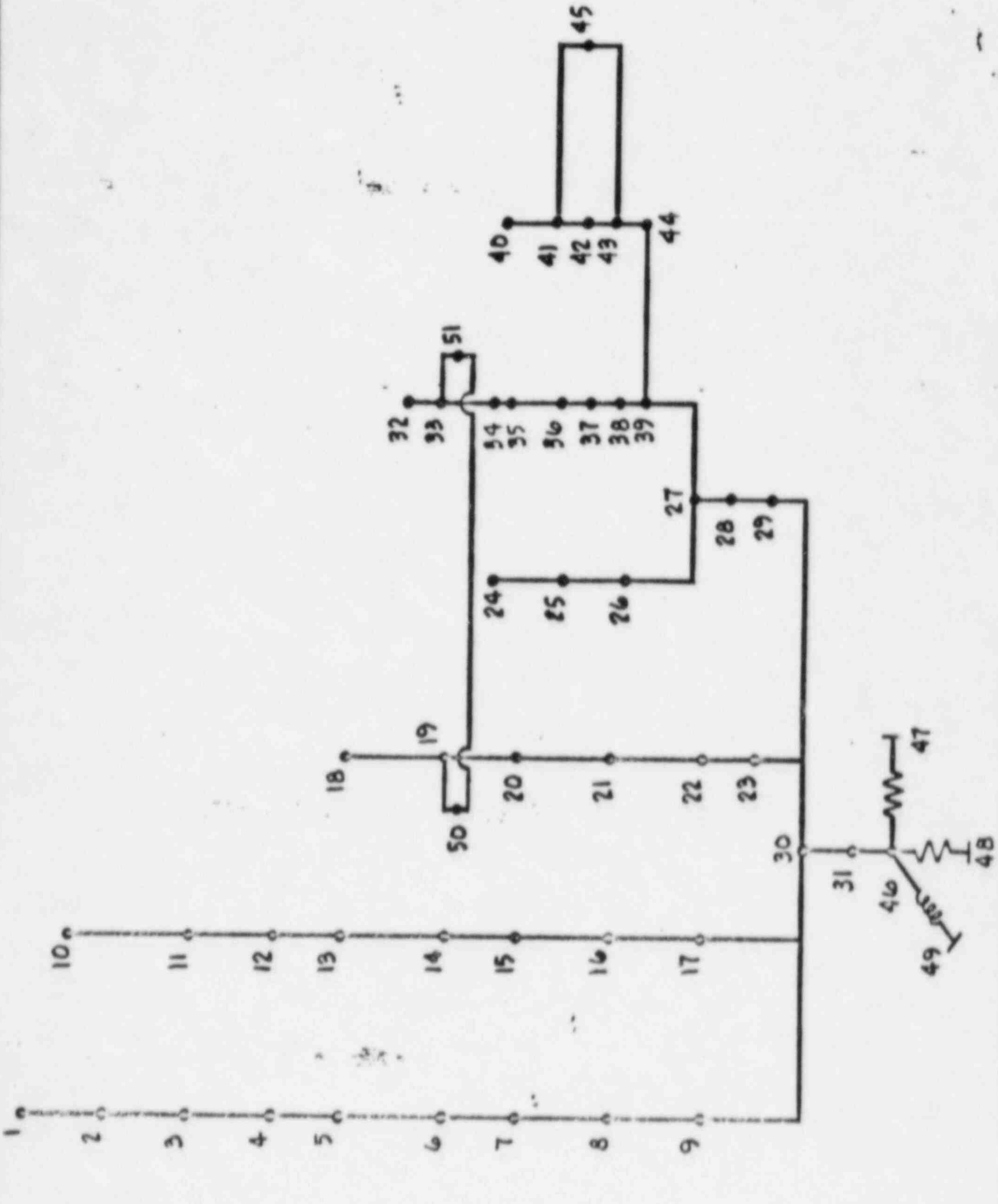

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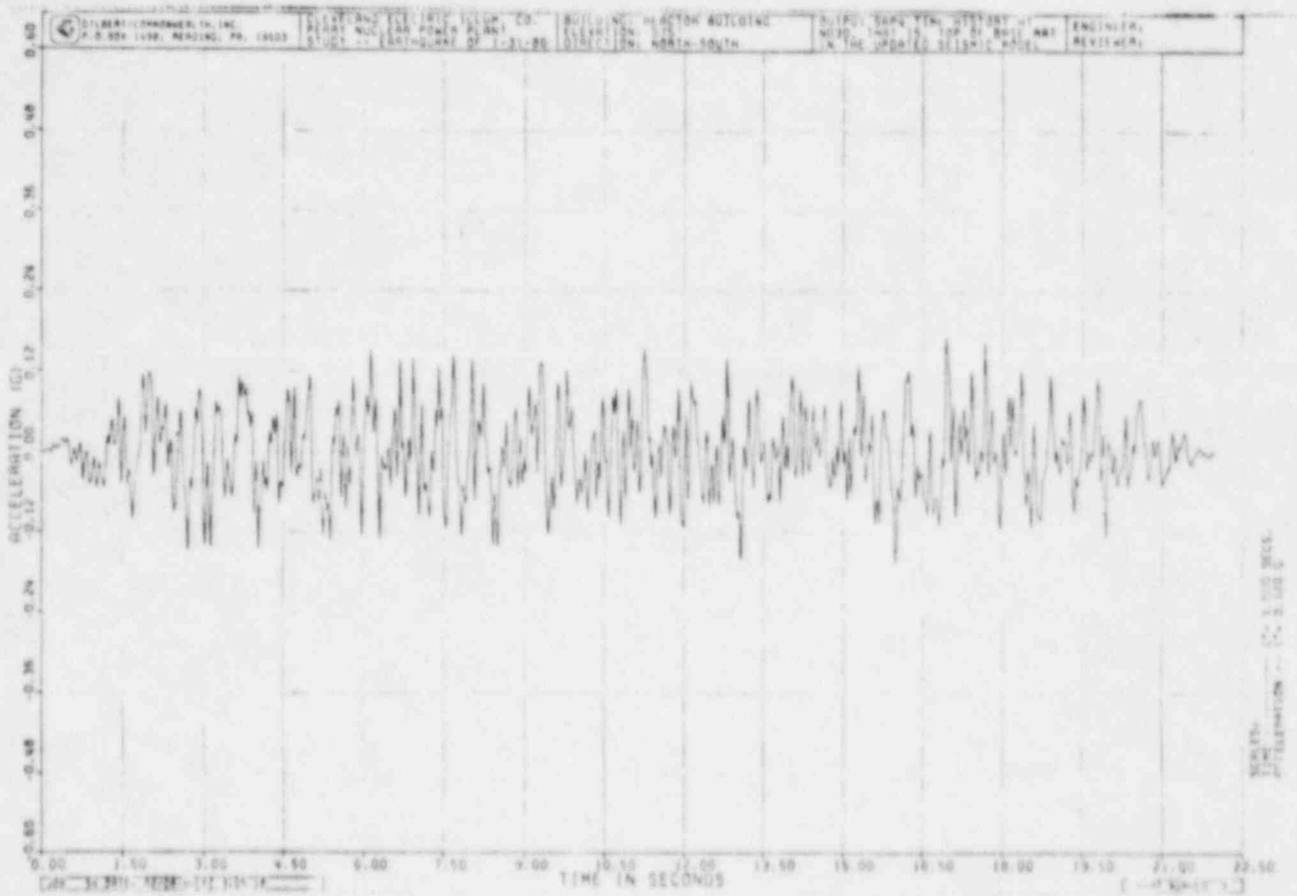
Figure 6.3



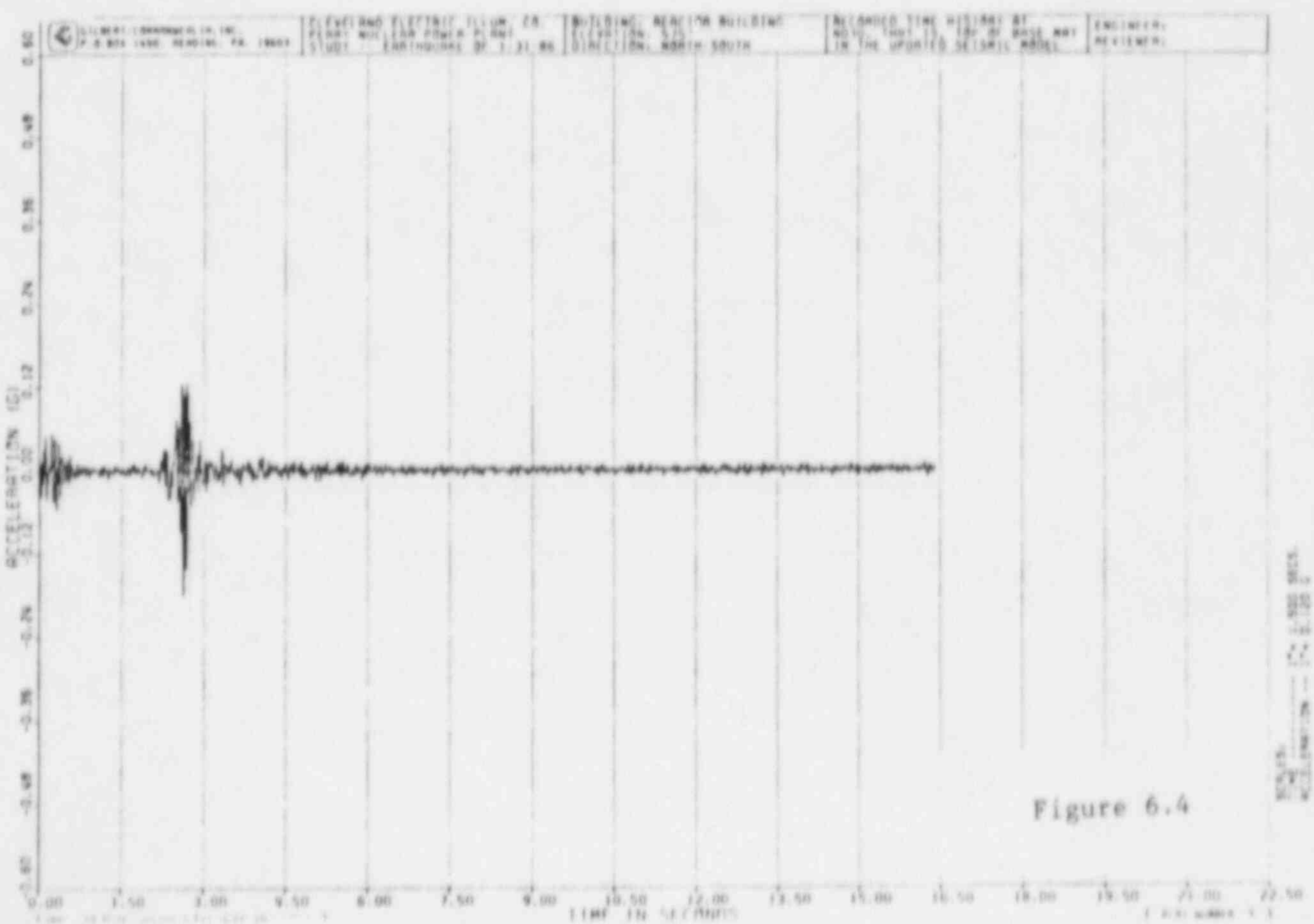
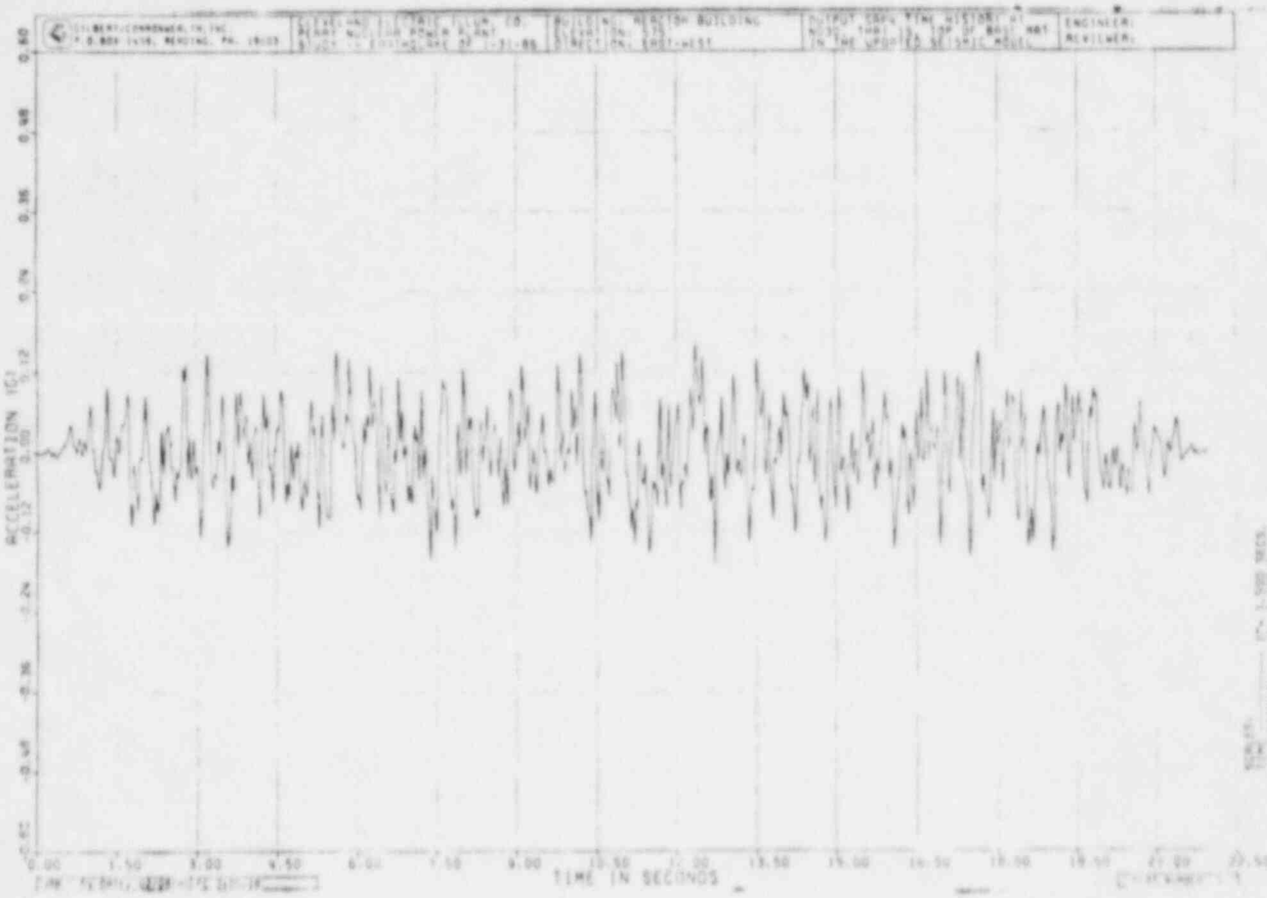


Figure 6.4



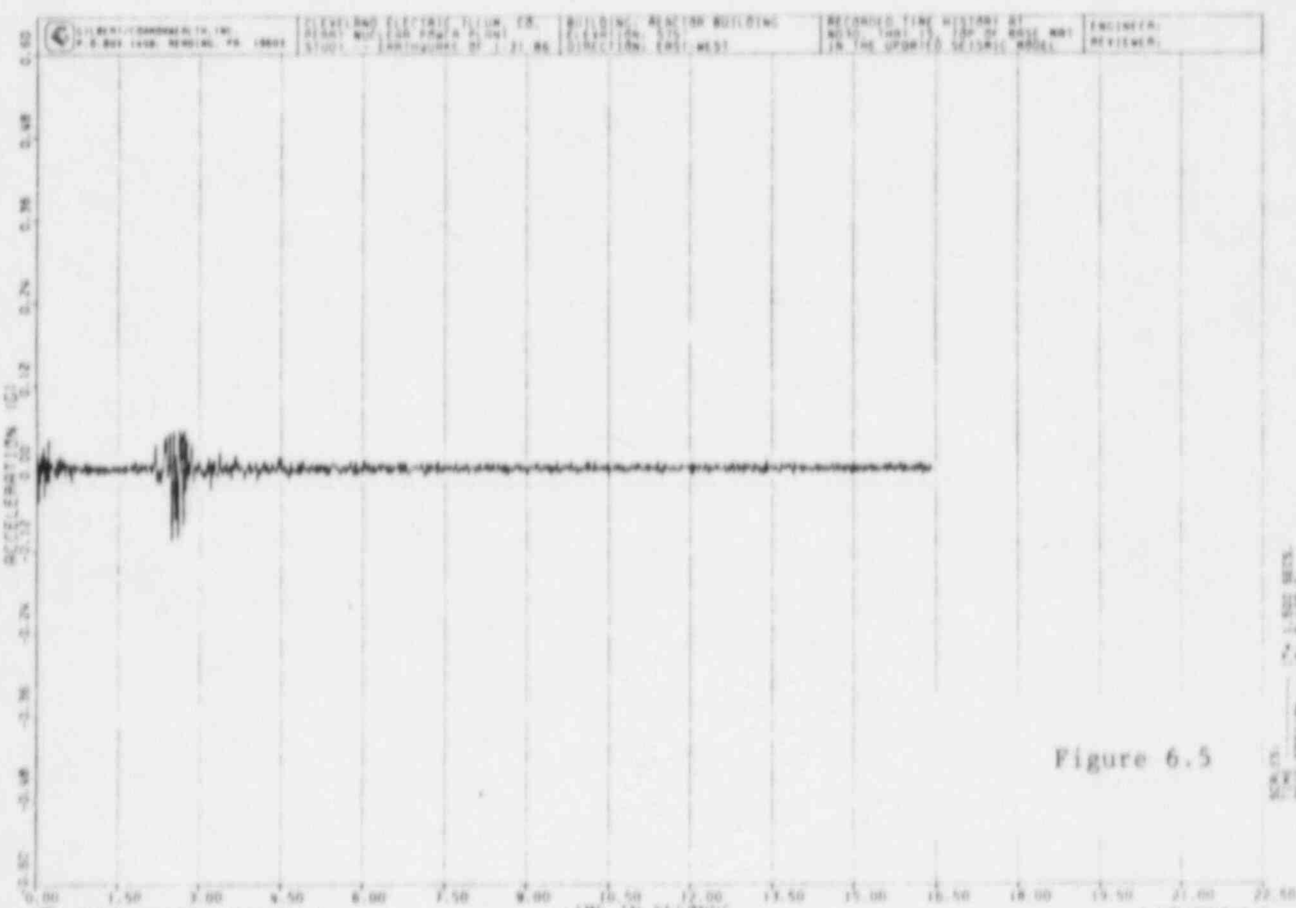
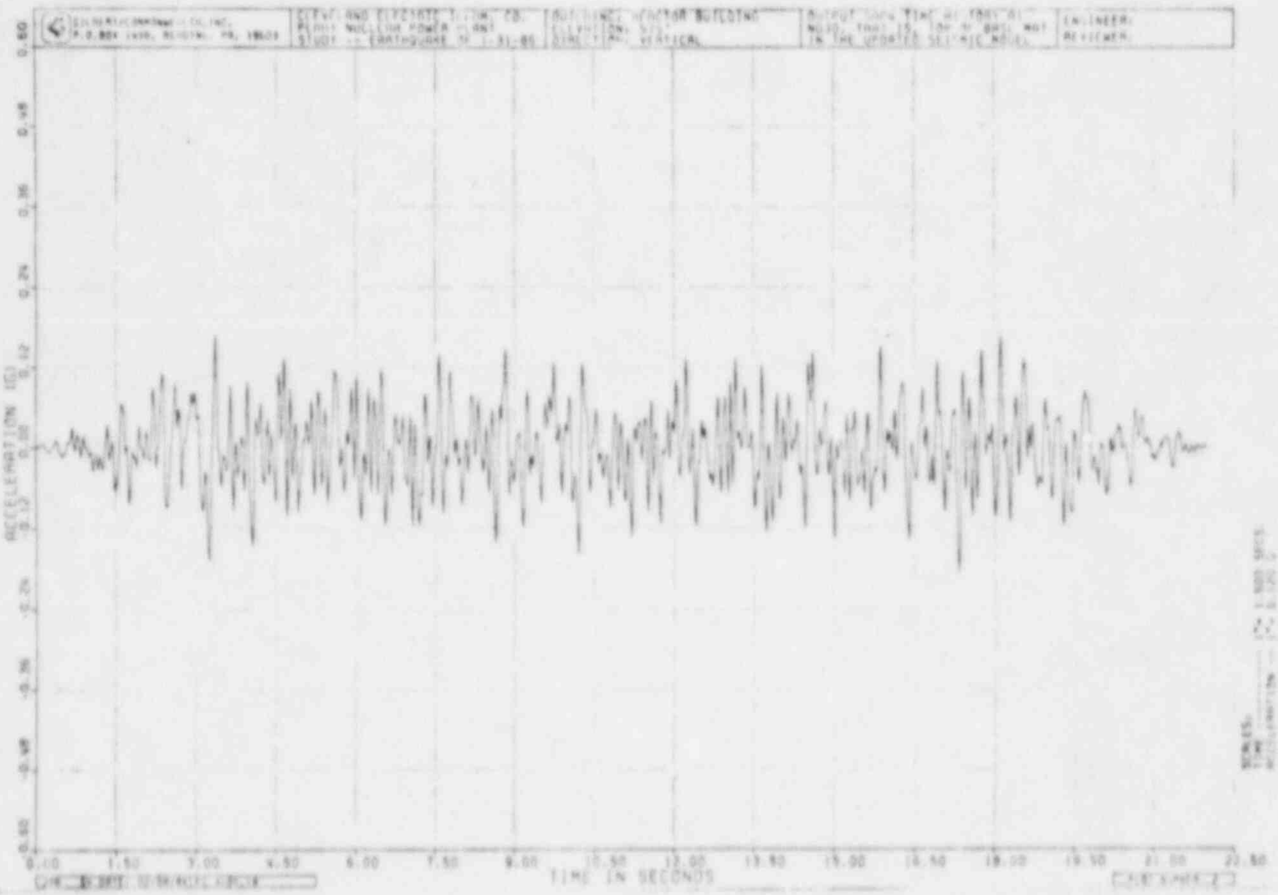


Figure 6.5


ACCELERATION (G)
TIME IN SECONDS

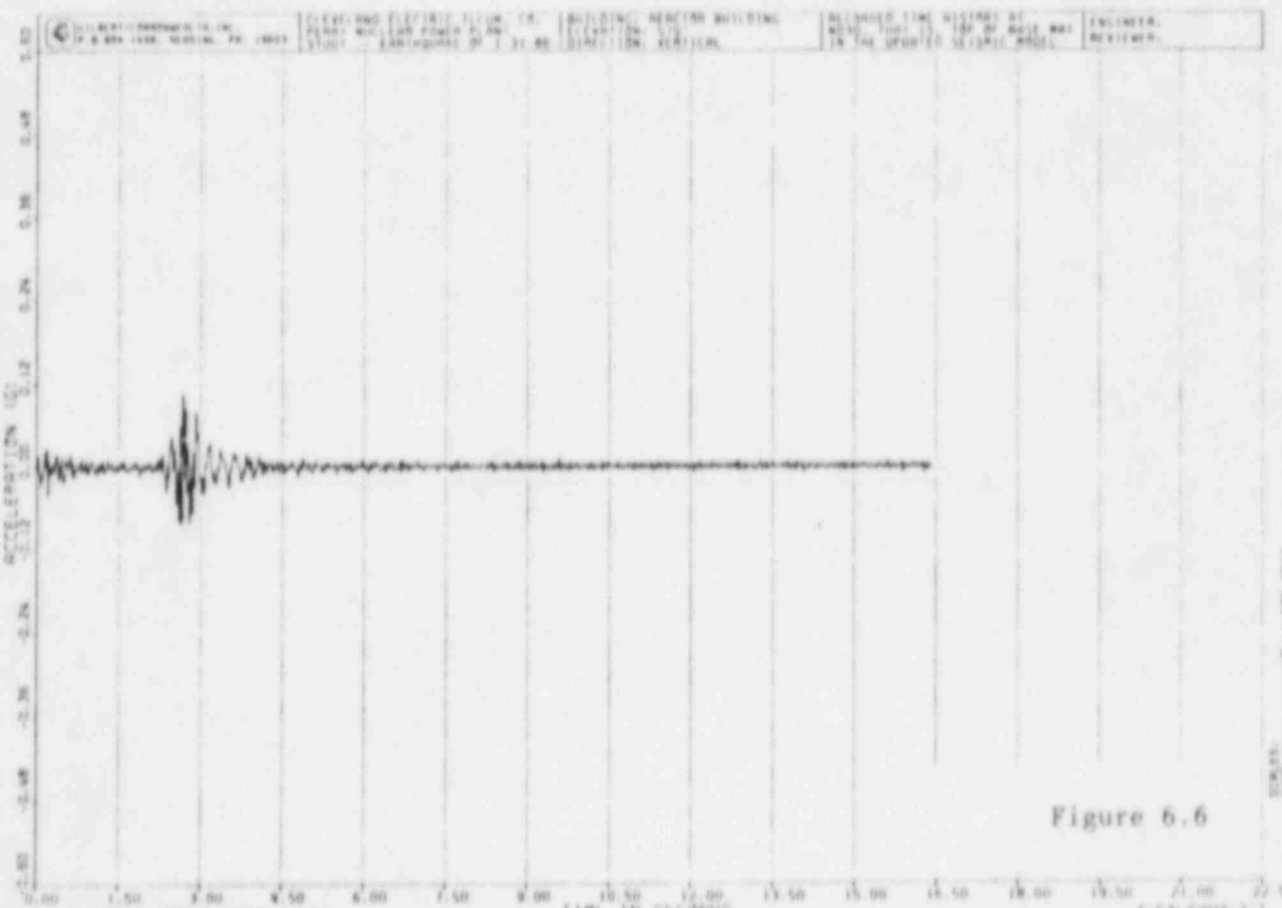

ACCELERATION (G)
TIME IN SECONDS

Figure 6.6

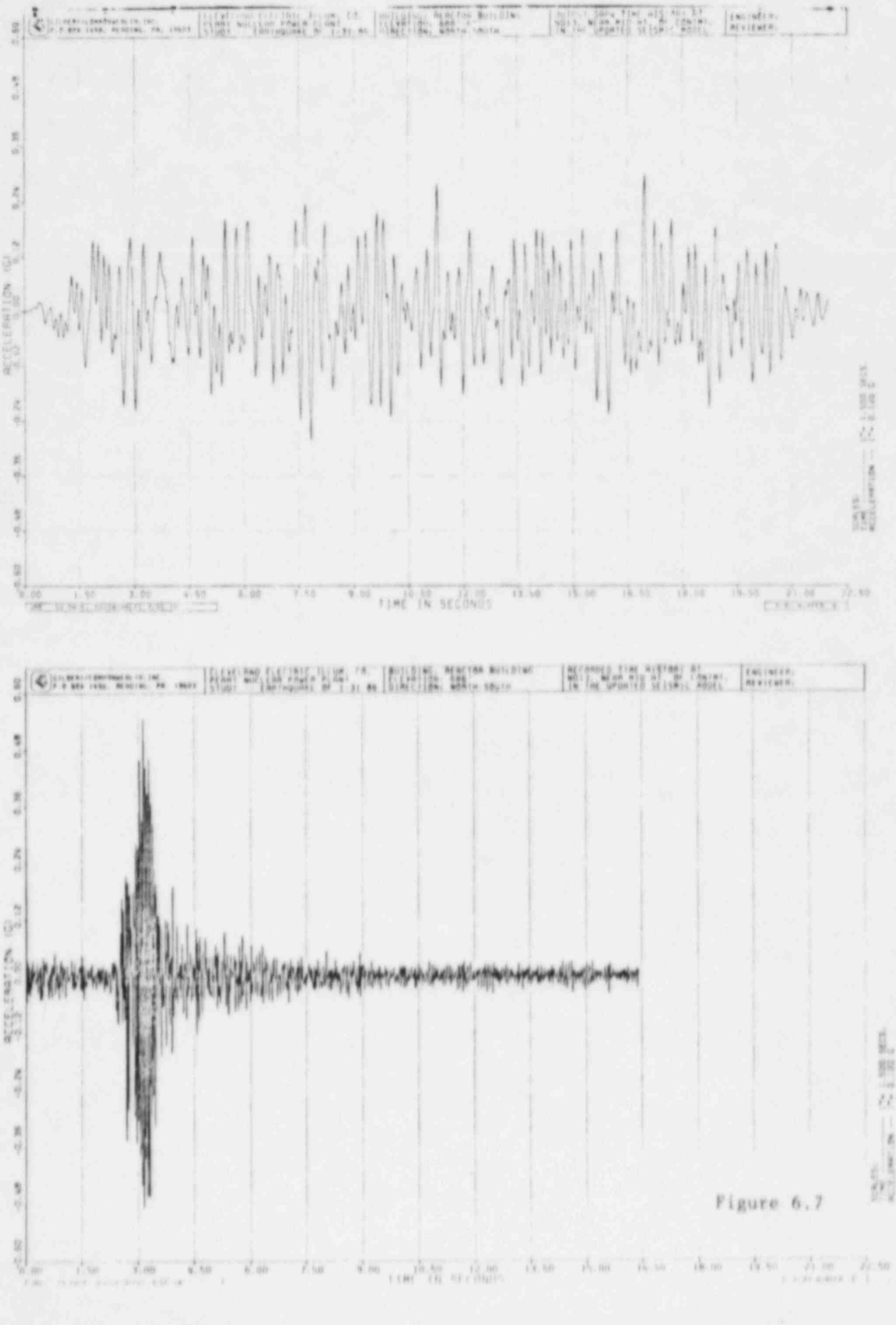
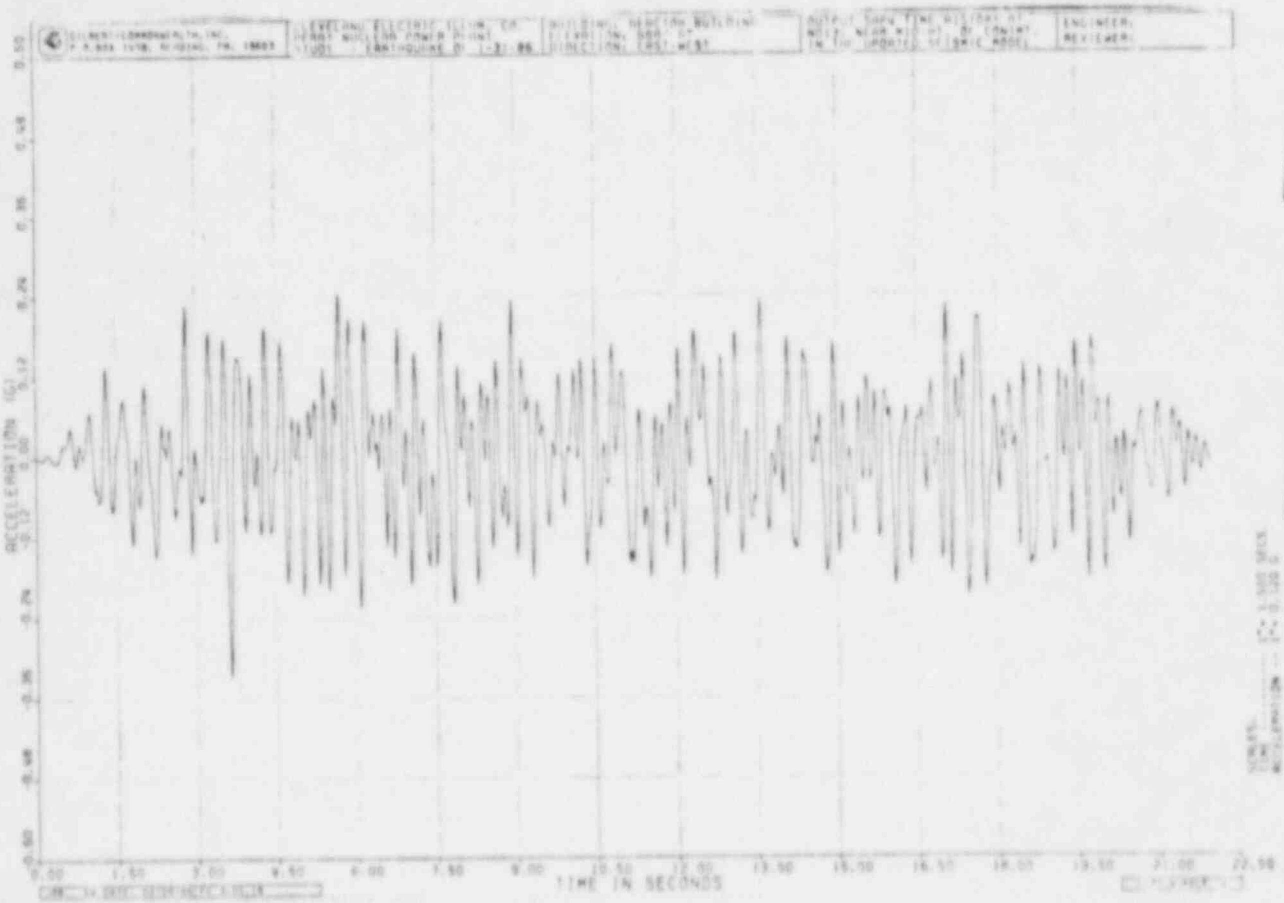

ACCELERATION (G)
TIME IN SECONDS
ACCELERATION (G)
TIME IN SECONDS

Figure 6.7


CLEVELAND ELECTRIC ILLUM. CO.
PERRY NUCLEAR POWER PLANT
BUILDING: REACTOR BUILDING
DIRECTION: EAST-WEST
ENGINEER:
REVIEWER:
ACCELERATION (G)
TIME IN SECONDS

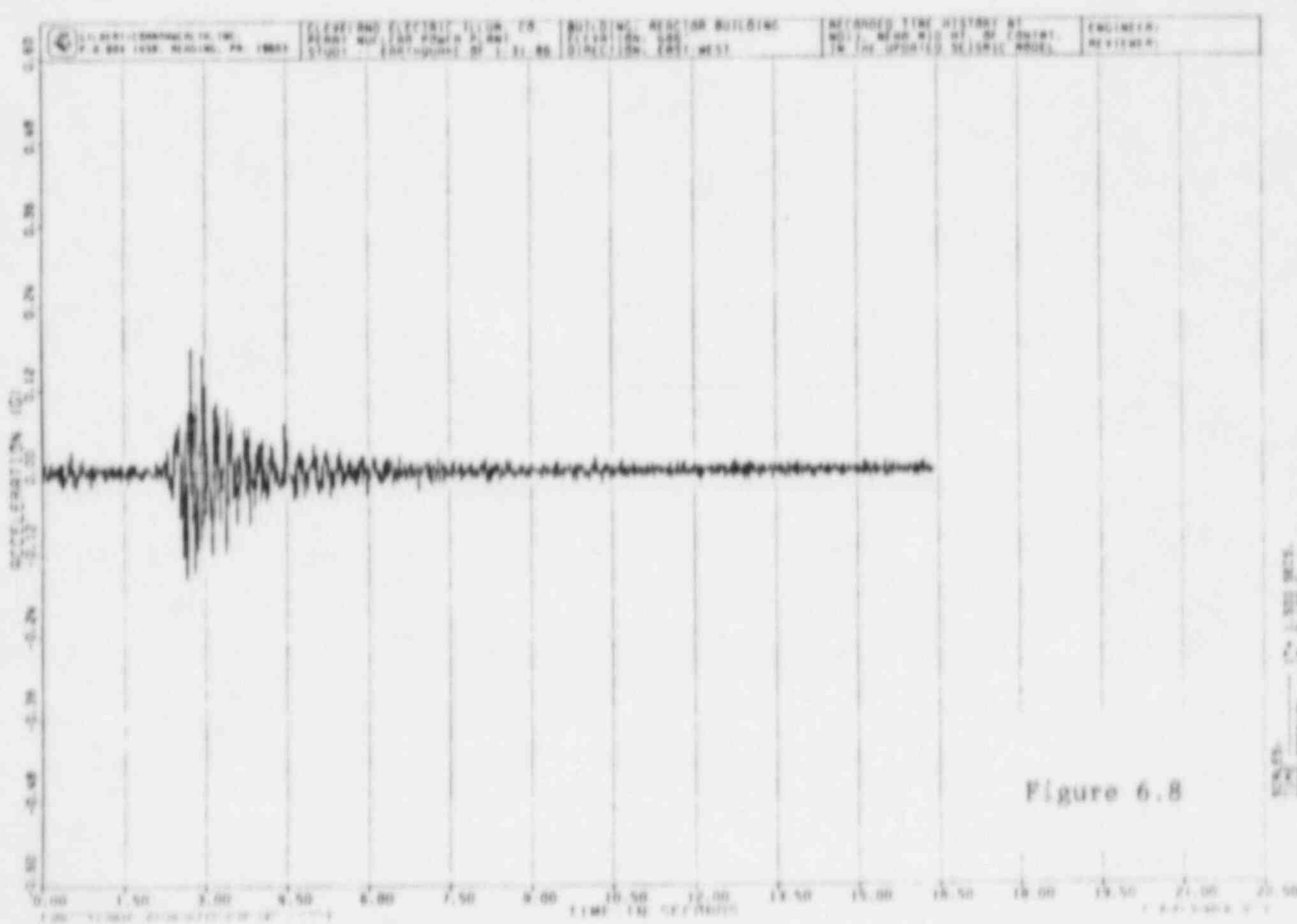

CLEVELAND ELECTRIC ILLUM. CO.
PERRY NUCLEAR POWER PLANT
BUILDING: REACTOR BUILDING
DIRECTION: EAST-WEST
ENGINEER:
REVIEWER:
ACCELERATION (G)
TIME IN SECONDS

Figure 6.8

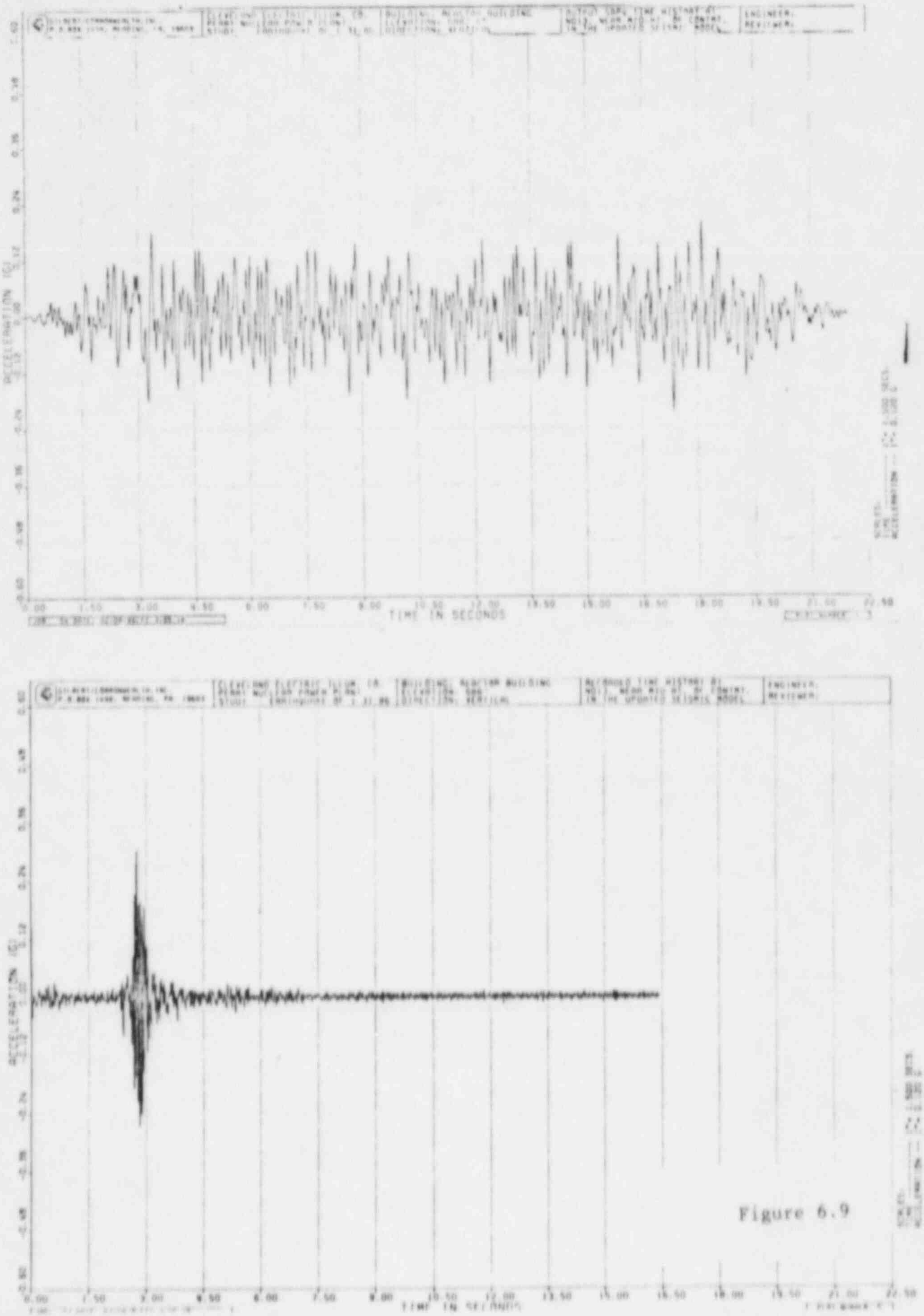

ACCELERATION (G)
TIME IN SECONDS
ACCELERATION (G)
TIME IN SECONDS

Figure 6.9

ML 5.0 EARTHQUAKE JANUARY 31, 1980

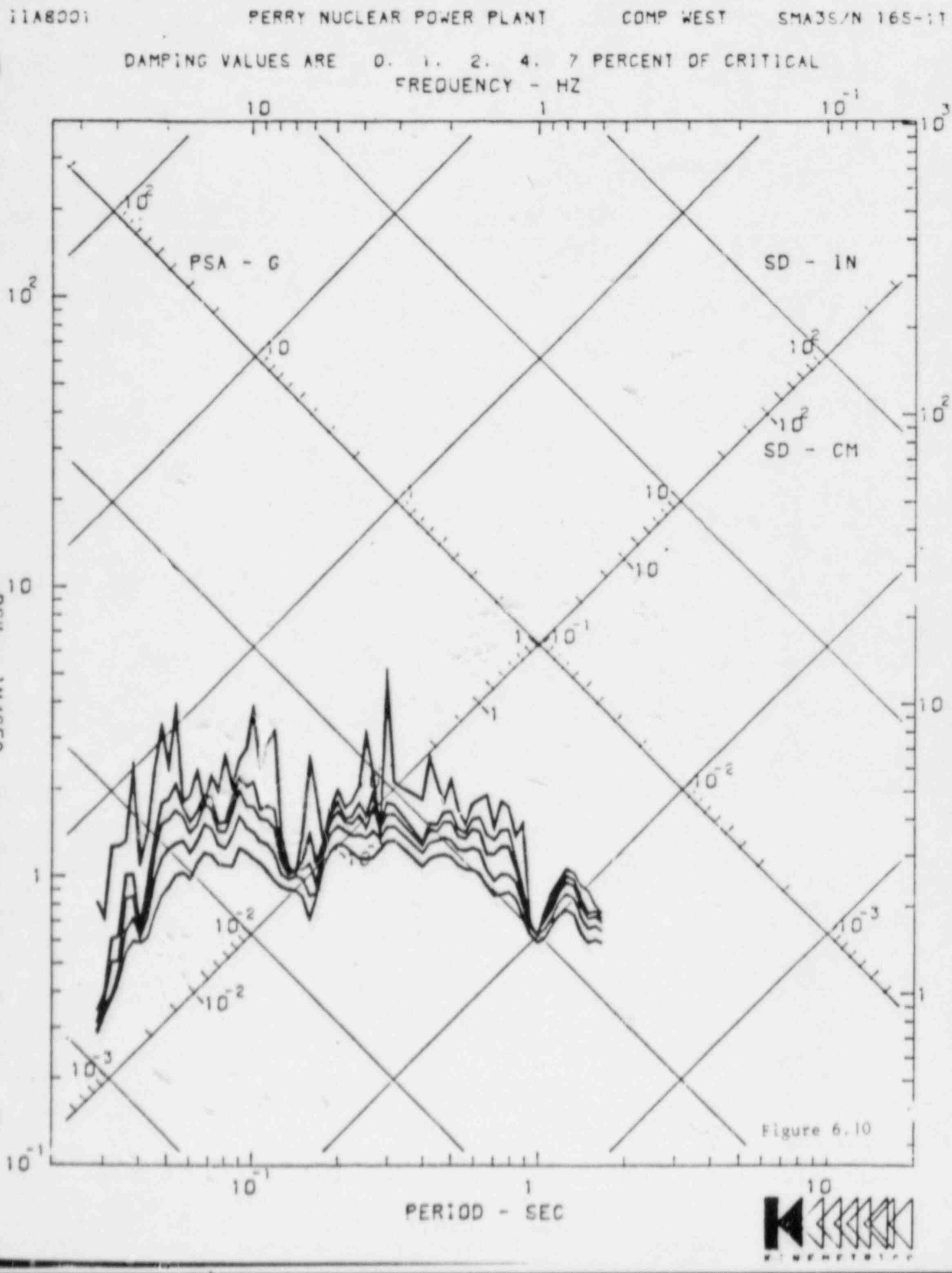
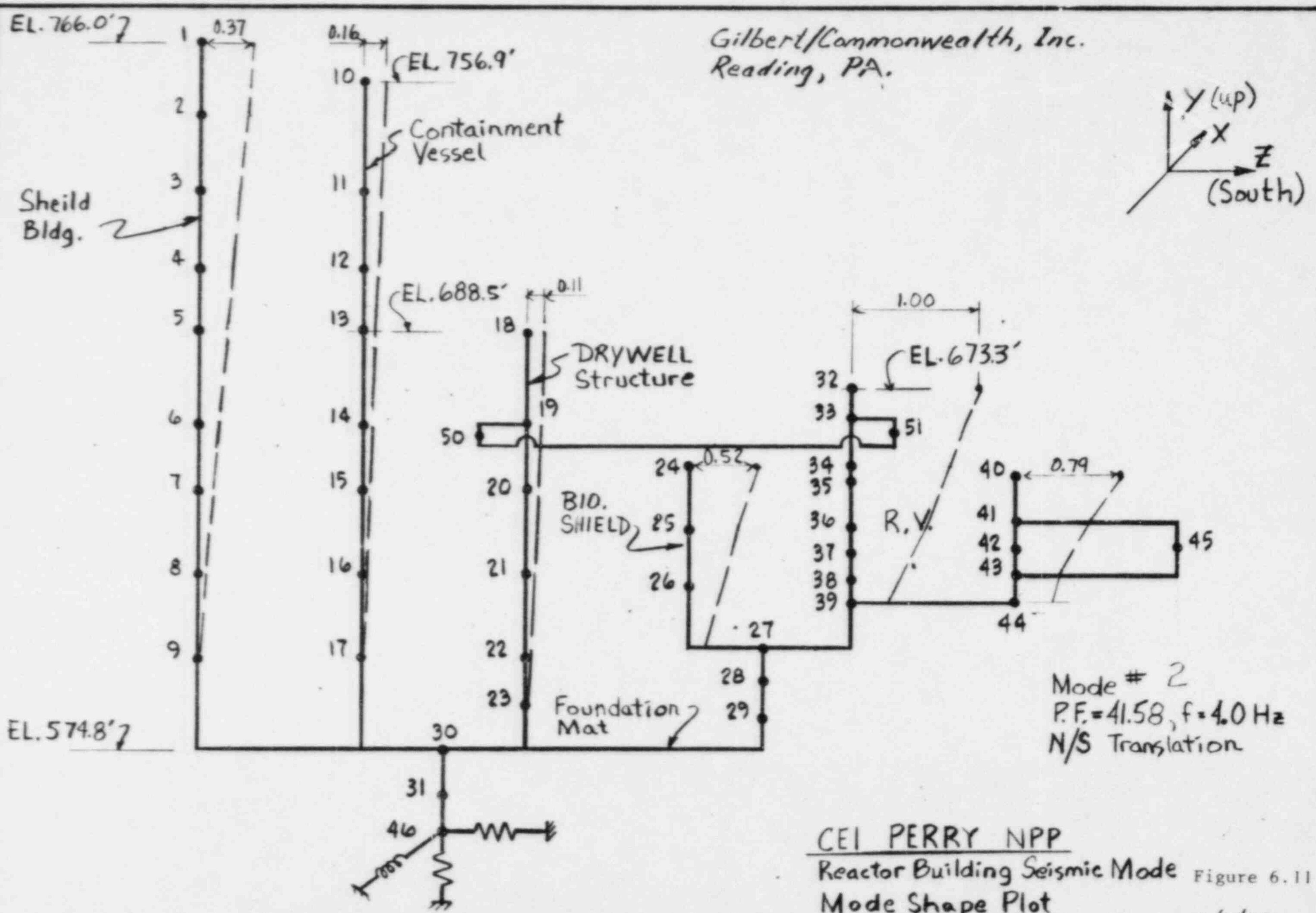


Figure 6.10



CEI PERRY NPP

Reactor Building Seismic Mode

Mode Shape Plot

Figure 6.11

2/9/86 WS

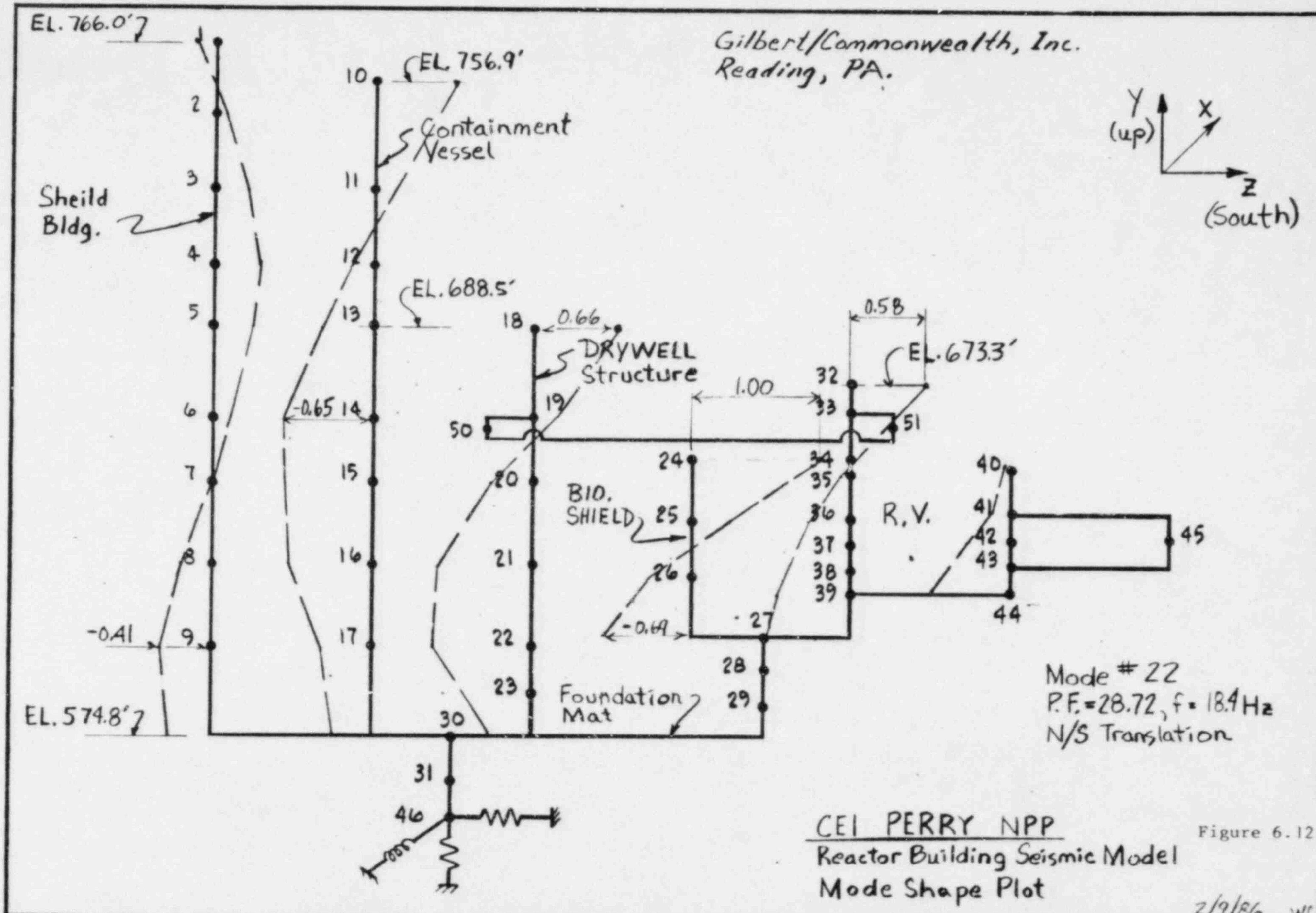
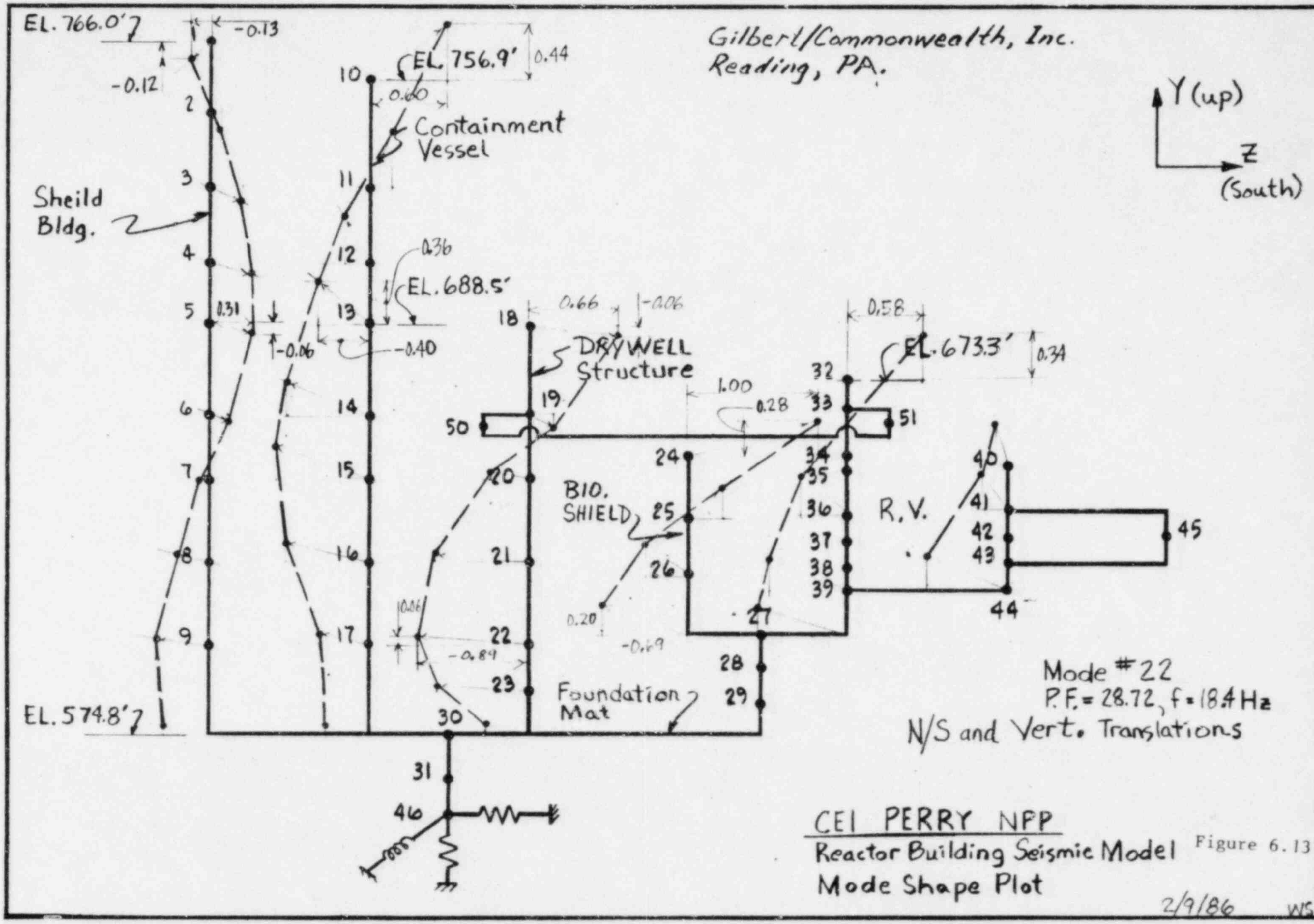

Gilbert/Commonwealth, Inc.
Reading, PA.
EL. 766.0'
EL. 756.9'
Containment Vessel
Sheild Bldg.
EL. 688.5'
0.66
DRYWELL Structure
0.58
EL. 673.3'
1.00
-0.65
-0.41
-0.69
BIO. SHIELD
R.V.
Y (up)
X
Z (South)
Foundation Mat
EL. 574.8'
Mode # 22
P.F. = 28.72, f = 18.4 Hz
N/S Translation
CEI PERRY NPP
Reactor Building Seismic Model
Mode Shape Plot
2/9/86 WS

Figure 6.12


Gilbert/Commonwealth, Inc.
Reading, PA.
Y (up)
Z
(South)
EL. 766.0'
-0.13
-0.12
EL. 756.9'
0.44
0.60
Containment Vessel
Sheild Bldg.
0.36
EL. 688.5'
0.31
-0.06
-0.40
0.66
-0.06
0.58
DRYWELL Structure
EL. 673.3'
0.34
1.00
0.28
BIO. SHIELD
R.V.
0.20
-0.69
0.06
-0.89
Foundation Mat
EL. 574.8'
Mode # 22
P.F. = 28.72, f = 18.4 Hz
N/S and Vert. Translations
CEI PERRY NPP
Reactor Building Seismic Model
Mode Shape Plot
2/9/86
WS
Figure 6.13

7.0 CONFIRMATORY PROGRAMS

Within hours of the earthquake, CEI's geophysical consultant had set up seismographs in the area of the epicenter to monitor any aftershocks. These remain in place at this time and the monitoring will continue until it is determined that no further aftershocks are anticipated. In addition, CEI is cooperating with the U.S. Geological Survey and others who are studying the earthquake.

CEI has instituted a specific procedure (OM19A: GTI-003) to ensure proper documentation, review, and reporting of all potentially earthquake related conditions in the plant. Under the procedure, all of the items identified within 24 hours following the seismic event have been documented as Earthquake Inspection Team Items ("EITI's"). Engineering has evaluated each EITI to determine whether the item was a direct result of the earthquake. The results of the evaluation are shown in Appendix E. The two EITI's determined to have been caused by the earthquake, and those with an "indeterminate" cause (i.e., where it cannot be definitively established that the condition existed prior to the earthquake), were identified and documented as discussed above. None of these items is associated with any plant structural damage. It is anticipated that minor rework or repair will be done on some of the items in accordance with CEI's normal program to correct nonconforming conditions. CEI's procedure provides that all potentially earthquake related EITI's will be maintained in the "as found" condition until reviewed by CEI and released by the NRC.

New Work Requests (WR's) (for conditions other than those already covered by EITI's), are also being reviewed in accordance with CEI's new procedure for earthquake related items.

Engineering evaluation results for these items are being documented and tracked. As with the EITI's, any potentially earthquake related conditions associated with new WR's are being maintained in the as-found condition until reviewed by CEI and released by the NRC. CEI has not identified any plant structural damage associated with potentially earthquake related items identified on new WR's.

On a longer term basis, CEI is participating in several industry efforts to study the effects of seismic events on nuclear plants. The organizations performing these studies include the Seismic Owners Group (SOG), the Seismic Qualification Utilities Group (SQUG), and Electric Power Research Institute (EPRI).

These industry groups are examining various gneneric seismic issues which have been under consideration by the NRC. For example, SOG has been focusing on eastern seismicity hazard analysis, with EPRI managing the program effort. SOG will review the Perry earthquake as part of this work. SQUG has focused its effort on the seismic qualification of electrical equipment. SQUG intends to review the Perry data presented in this report, and will integrate this information into their studies. EPRI has been supporting SQUG by sponsoring projects to resolve issues associated with equipment qualification, focusing on test data, adequacy of equipment anchorages, and post earthquake investigation programs.

These industry groups all visited the site shortly after the seismic event. A SOG/EPRI team installed in-plant and field instruments within a day of the seismic event to collect aftershock data. An SQUG team conducted a plant walkdown. The team informed CEI that the seismic event at Perry was much smaller than others they have evaluated (Coalingo, Chile, Mexico City, Morgan Hill), and that the SQUG data base generated from these previous earthquakes would predict no damage from the Janaury 31, 1986 earthquake. This prediction was confirmed by the group's plant walkdown. The EPRI equipment qualification program manager concluded that Perry's response to the seismic event was properly handled. The Perry experience will be used in EPRI's development of generic post-earthquake investigation methods.

8.0 SUMMARY AND CONCLUSIONS

The seismic event which occurred on January 31, 1986 has been thoroughly studied and its effects on the Perry Nuclear Power Plant analyzed in detail. The earthquake itself was of smaller magnitude and intensity than the postulated earthquake which was used as the basis for the plant seismic design. The occurrence of the 1986 earthquake does not change any of the conclusions previously reached as to the geology and seismology of the site. Consideration of this event does not result in any change in the Safe Shutdown Earthquake licensing basis for the Perry plant.

The earthquake confirmed the adequacy of the plant's seismic design. The plant structures and equipment were essentially unaffected by the earthquake. The large number of safety and non-safety related systems which were operating or energized at the time of the earthquake responded in accordance with their design. Extensive plant walkdowns and inspections revealed no structural or equipment damage.

The seismic characteristics of the earthquake have been reviewed and compared the plant's seismic design. The high frequencies which typified the 1986 earthquake are of no significance with regard to the adequacy of the plant's design. In contrast to the seismic design basis, the earthquake was of short duration, with low energy, low velocities and small displacements. Although certain of the recorded response spectra exceeded the design response spectra in the high frequency range, such exceedances are consistent with the analytical methods of Regulatory Guide 1.60 and are of no engineering significance. In the frequency range of significance for plant structural design (below 14 Hz), recorded spectra are far below the design response spectra for Perry.

The January 31, 1986 earthquake, in effect, constituted a proof test of Perry's seismic design. By any standard the Perry Nuclear Power Plant passed that test. The earthquake presents no new information which would change the previously accepted licensing basis for the plant.

APPENDIX A

STRONG-MOTION DATA FROM THE PERRY NUCLEAR POWER PLANT SEISMIC INSTRUMENTATION KINEMETRICS

ML 5.0 EARTHQUAKE

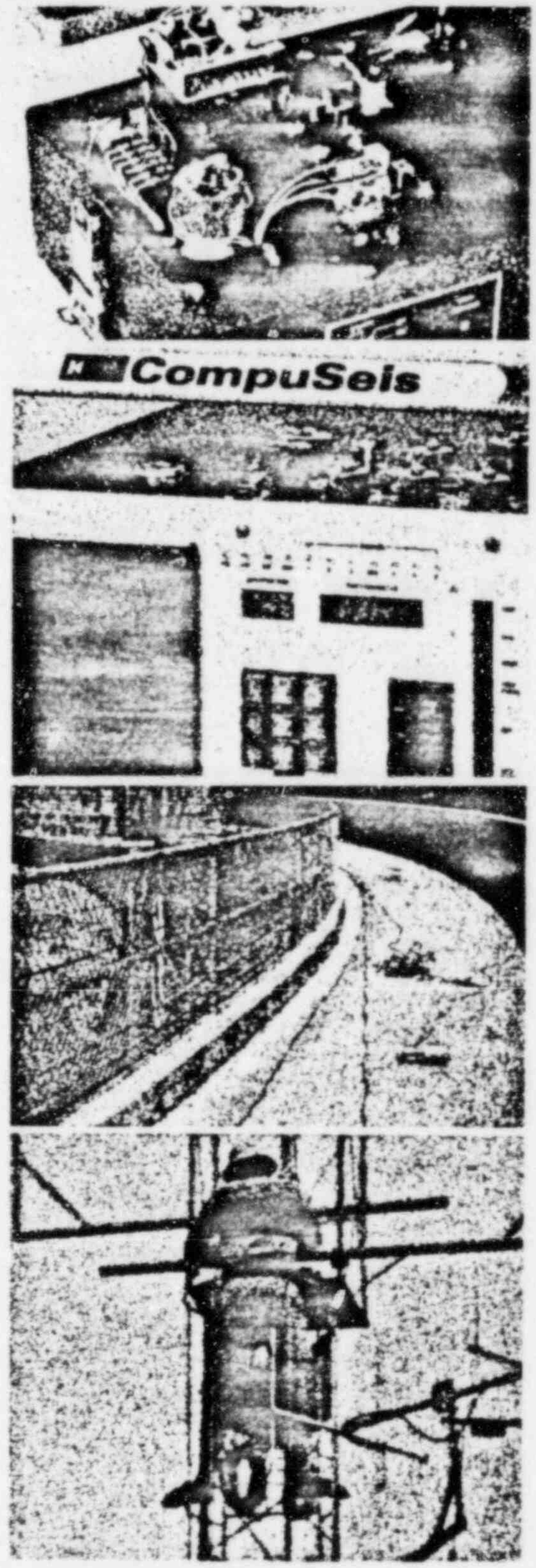
JANUARY 31, 1986

STRONG-MOTION DATA

from the

PERRY NUCLEAR POWER PLANT

SEISMIC INSTRUMENTATION



February 3, 1986

KINEMETRICS

STRONG-MOTION DATA REPORT

for the

M_L 5.0 EARTHQUAKE

of

1147 EST, JANUARY 31,1986

PERRY, OHIO

RECORDED ON THE

PERRY NUCLEAR POWER PLANT

STRONG MOTION ACCELEROGRAPHS

for

Cleveland Electric Illuminating Company

Requisition No. NED-E-860006

by

Kinemetrics/Systems
222 Vista Ave.
Pasadena, CA 91107

Sales Order C-K6028

February 4, 1986

TABLE OF CONTENTS

1.0 INTRODUCTION

On January 31, 1986, a (M_L 5.0) local earthquake was recorded by the strong-motion instrumentation at Perry Nuclear Power Plant, Perry, Ohio. The FM analog magnetic tape cassette records from two Kinemetrics Model SMA-3 accelerographs were retrieved from the instruments and provided to Kinemetrics for analysis.

This report describes the processing of these strong-motion records and presents the results. Included are the uncorrected accelerograms, corrected acceleration, velocity and displacement time series, and response spectra.

2.0 INSTRUMENTATION

2.1 Model SMA-3 Accelerograph

The SMA-3 is a multi-channel, centralized recording, FM analog magnetic tape accelerograph system designed to detect and record strong local earthquakes and record the three orthogonal acceleration signals on cassette tape. The SMA-3 remains in a standby mode until its vertical trigger detects an earthquake. The trigger then actuates recording in less than .10 seconds.

The force balance accelerometers in the SMA-3 have a nominal natural frequency of 50 Hz and damping of 65% critical, providing flat (-3dB) response from DC to 50 Hz. The nominal sensitivity of each of the three channels is 2.5 volts/g with a full scale response of 1.0g. The dynamic range of the accelerograph is nominally 40 dB, giving it a resolution of approximately .01g.

The trigger in the SMA-3 has a flat (-3dB) response from 1 to 10 Hz and a nominal trigger level of 0.01g.

Power is supplied to the SMA-3 by internal rechargeable batteries. These batteries are kept in a charged state by 120 VAC line power.

2.2 Calibration Data

The three Model SMA-3 accelerographs which recorded the event were factory calibrated in January, 1985, and the sensors were recalibrated for sensitivity by the Perry NPP personnel in December of 1985. These most current calibration data are given in Table 1 below.

Ser. No.	Channel	Sens., v/g	Nat. Freq., Hz	Damping % critical
165-1	long	2.48	52.3	65
	tran	2.49	53.7	65
	vert	2.47	50.6	64
165-2	long	2.48	52.6	67
	tran	2.48	52.2	72
	vert	2.65	50.5	66

TABLE 1: Calibration Data

3.0 DATA PROCESSING

Data from the Model SMA-3 accelerographs were played back using a Kinemetrics Model SMP-1 Playback System through a Data Compenstor, digitized using a Kinemetrics Model DDS-1105 Digital Data System and processed as described in Kinemetrics' Aplication Note No. 7 "Conditioning and Correction of Strong Motion Data on Analog Magnetic Tapes", appended to this report.

3.1 Digitization

The magnetic tapes were digitized using the DDS-1105. The 1024 Hertz FM time reference recorded on channel 4 of the cassette is output from the SMP-1 and divided down by four (256 Hz ± deviation) and used as the timing signal for the digital conversion time interval. The multiplexed uncorrected time series are written on 9-track computer-compatible tape.

3.2 VOL1 Processing

The digitized data were demultiplexed and scaled to acceleration units using the Table 1 calibration data. The mean was then subtracted from each acceleration time history. The new time histories were then written in a Kinemetrics' VOL1-format disk file.

The three uncorrected acceleration time histories from each SMA-3 record were then plotted; these plots are included in the data section of this report.

3.3 VOL2 Processing

The recorded accelerograms were then instrument and baseline corrected using Kinemetrics' VOL2 program. This program is based upon the VOL2 program developed at Caltech (Trifunac and Lee, 1973). No major modifications to the original VOL2 algorithms have been made.

The data were bandpass filtered using Ormsby filters. The low-pass filter had a cut-off frequency of 35 Hz and a termination frequency of 40 Hz. The high-pass filter had a cutoff frequency of 0.625 Hz and a termination frequency of 0.4 Hz.

Output of this program consists of a plot of corrected acceleration, velocity and displacement for each component of recorded data. These plots are presented in the data section of this report.

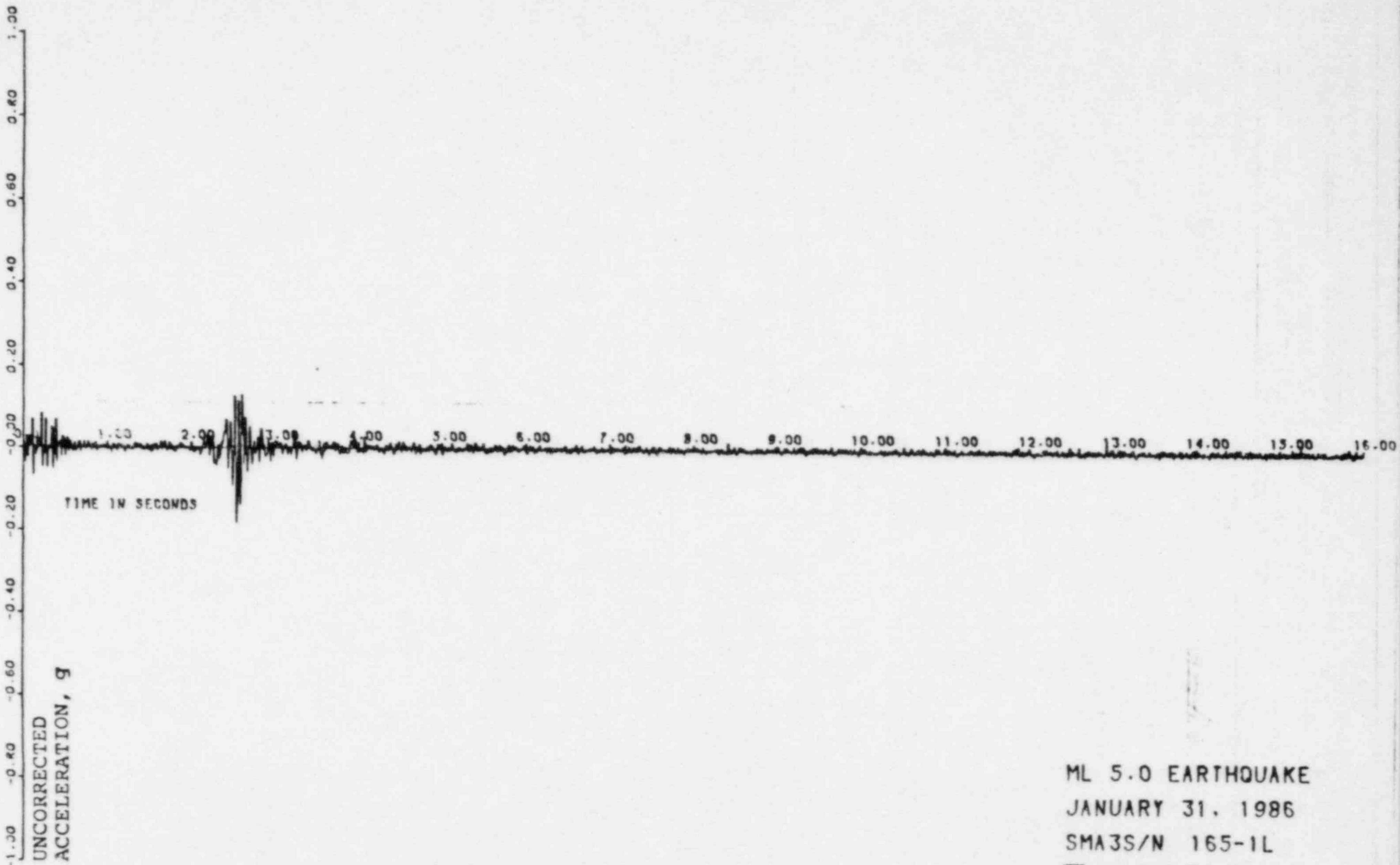
3.4 VOL3 Processing

Linear response spectra were calculated from the corrected acceleration time histories using the algorithms developed by Trifunac and Lee. Response spectra were calculated for damping ratios of 0, 1, 2, 4, and 7 percent. The period range of these spectra was 1.68 to 0.0283 seconds (0.59 to 35.4 Hz) with oscillator response calculated at 1/24 th octave intervals.

Two types of plots were produced and are included in the data section of this report. The first type is the traditional tripartite log-log plot of pseudo-velocity vs. period. The second is a linear plot of velocity response and Fourier spectrum vs. frequency.

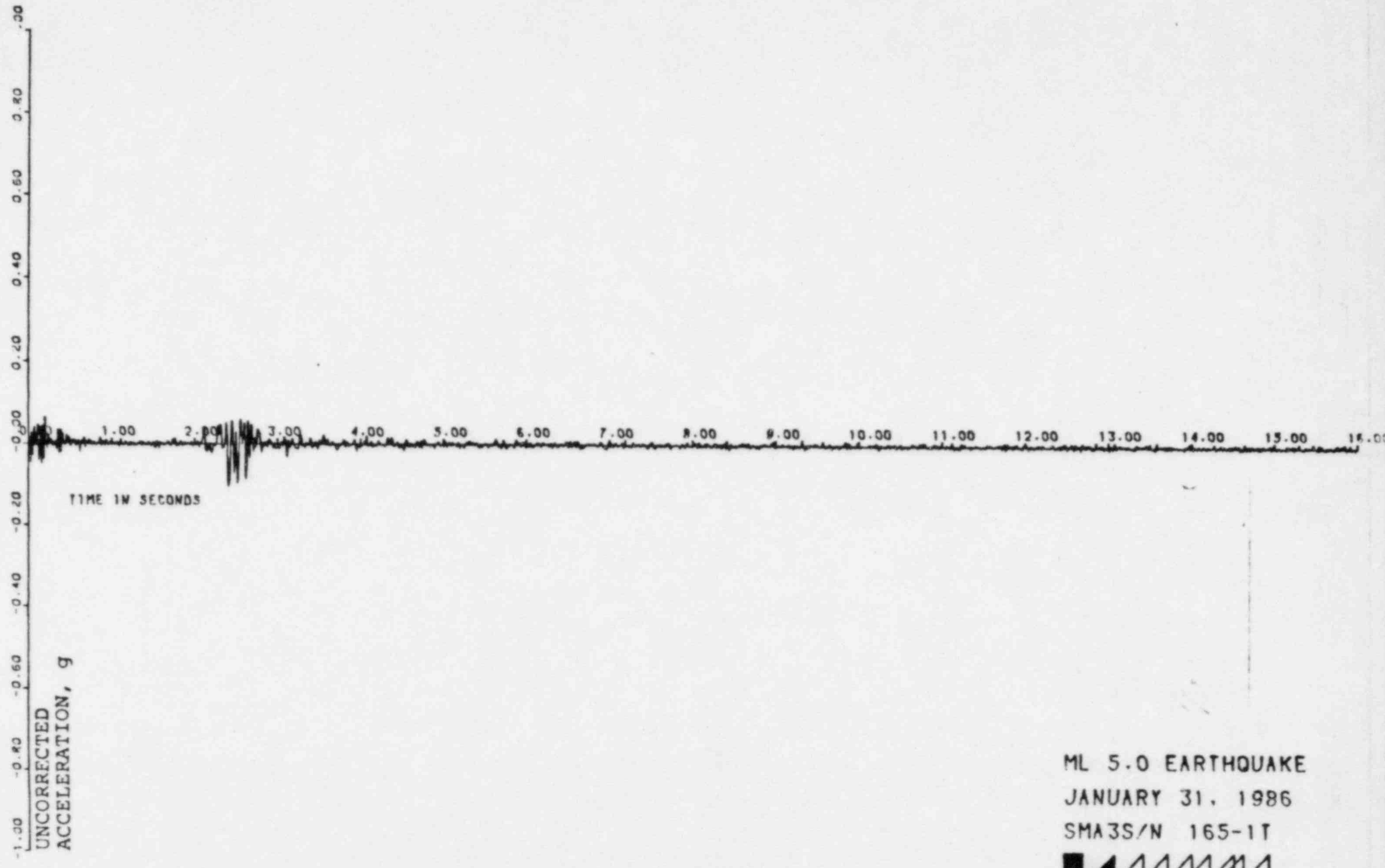
Reactor Building Foundation, Elevation 575 Ft.

SMA-3 Serial Number 165-1
Tag Number D51-N101
Longitudinal Channel - South Orientation
Transverse Channel - West Orientation
Vertical Channel - Up Orientation



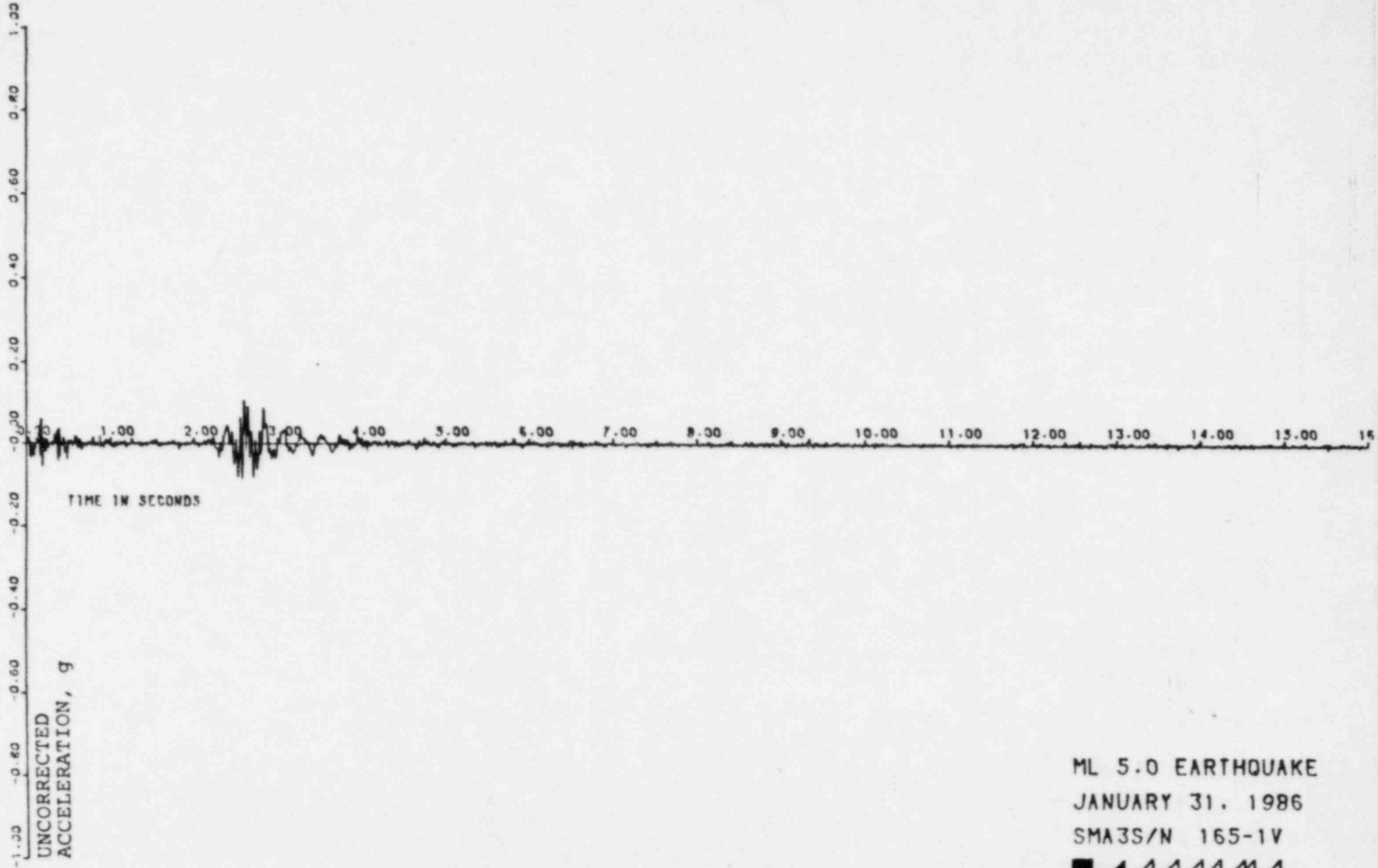
ML 5.0 EARTHQUAKE
JANUARY 31, 1986
SMA3S/N 165-1L

KINEMETRICS



ML 5.0 EARTHQUAKE
JANUARY 31, 1986
SMA3S/N 165-1T

KINEMETRICS



ML 5.0 EARTHQUAKE
JANUARY 31, 1986
SMA3S/N 165-1V

KINEMETRICS

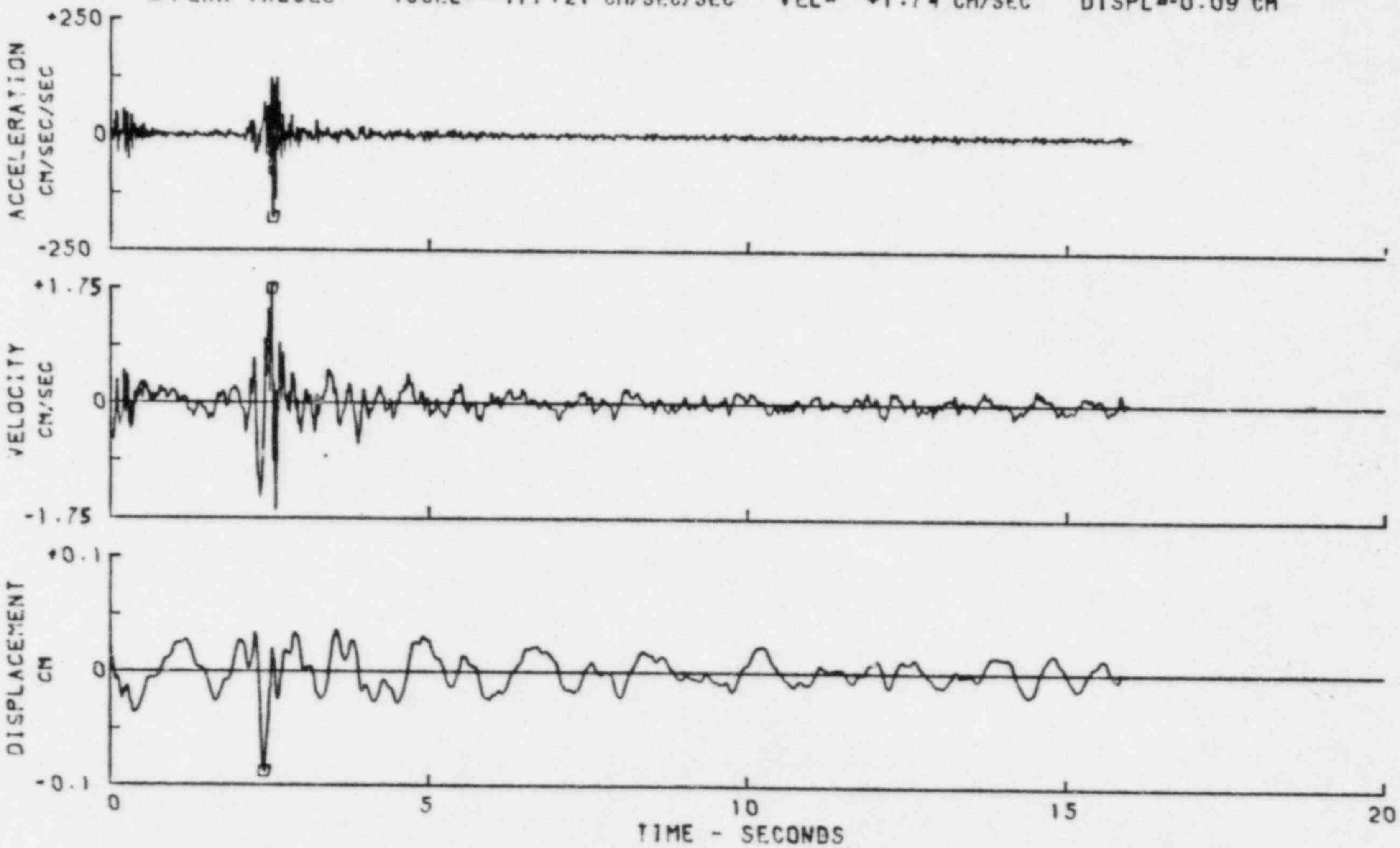
KINEMETRICS

ML 5.0 EARTHQUAKE JANUARY 31. 1986

11A8001 PERRY NUCLEAR POWER PLANT COMP SOUTH SMA3S/N 165-1L

ACCELEROGRAM IS BAND-PASS FILTERED BETWEEN 0.400- 0.625 AND 35.00- 40.00 HERTZ

◻ PEAK VALUES: ACCEL= -177.21 CM/SEC/SEC VEL= +1.74 CM/SEC DISPL= -0.09 CM



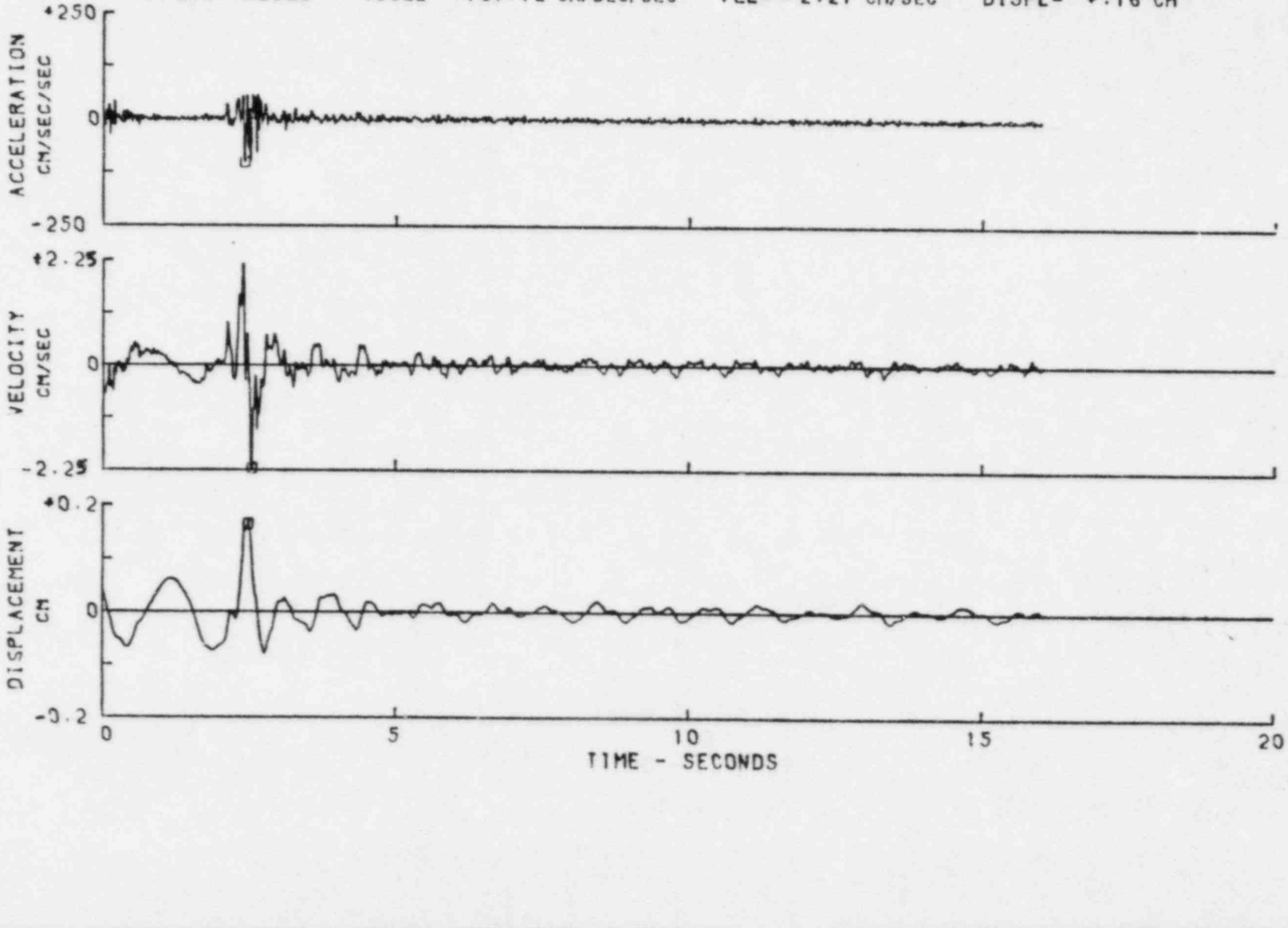
KINEMETRICS

ML 5.0 EARTHQUAKE JANUARY 31, 1986

11A8001 PERRY NUCLEAR POWER PLANT COMP WEST SMA3S/N 165-1T

ACCELEROGRAM IS BAND-PASS FILTERED BETWEEN 0.400- 0.625 AND 35.00- 40.00 HERTZ

□ PEAK VALUES: ACCEL= -101.12 CM/SEC/SEC VEL= -2.21 CM/SEC DISPL= +.16 CM



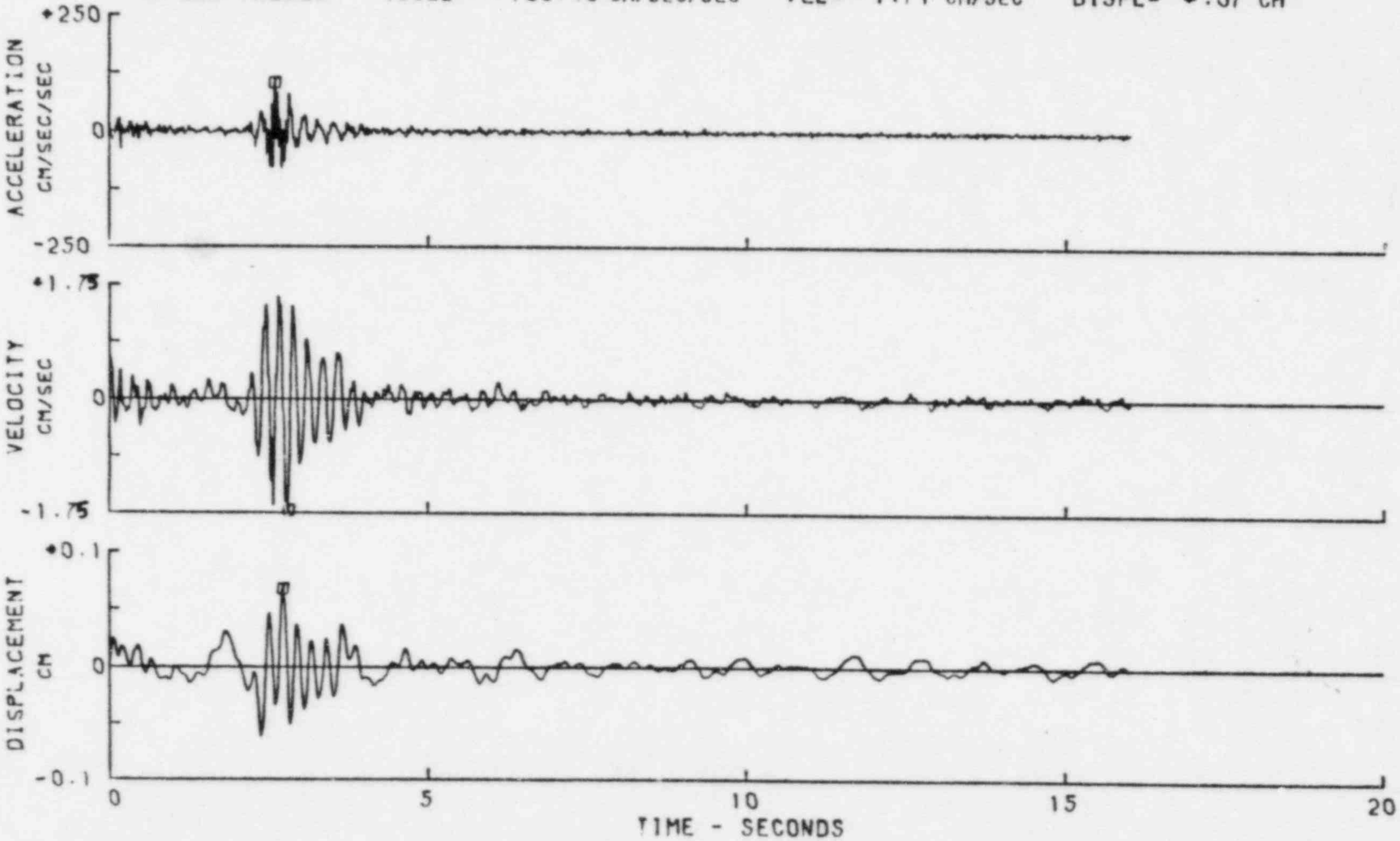
KINEMETRICS

ML 5.0 EARTHQUAKE JANUARY 31, 1986

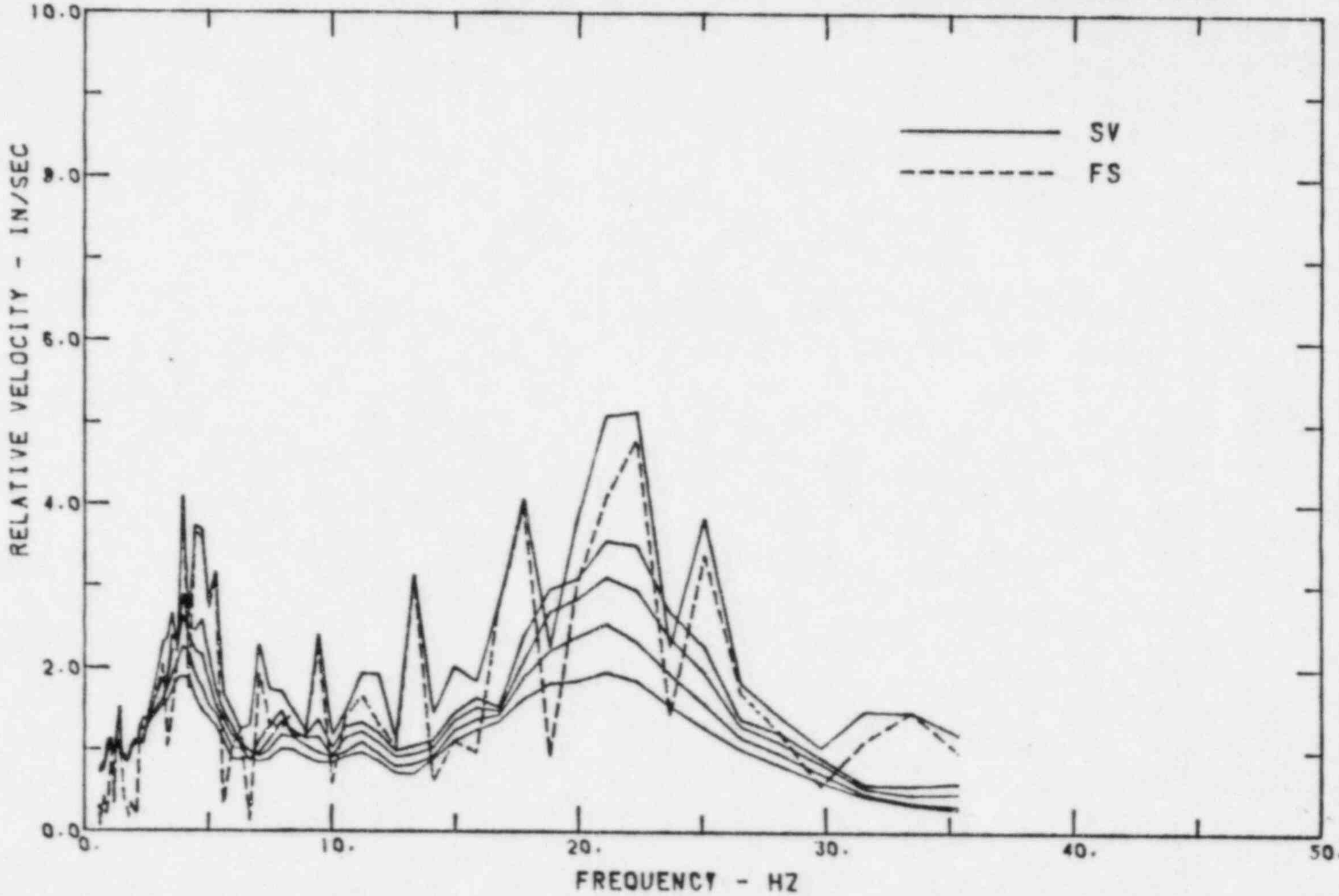
11A8001 PERRY NUCLEAR POWER PLANT COMP UP SMA3S/N 165-1V

ACCELEROGRAM IS BAND-PASS FILTERED BETWEEN 0.400- 0.625 AND 35.00- 40.00 HERTZ

□ PEAK VALUES: ACCEL= +103.46 CM/SEC/SEC VEL= -1.71 CM/SEC DISPL= +.07 CM

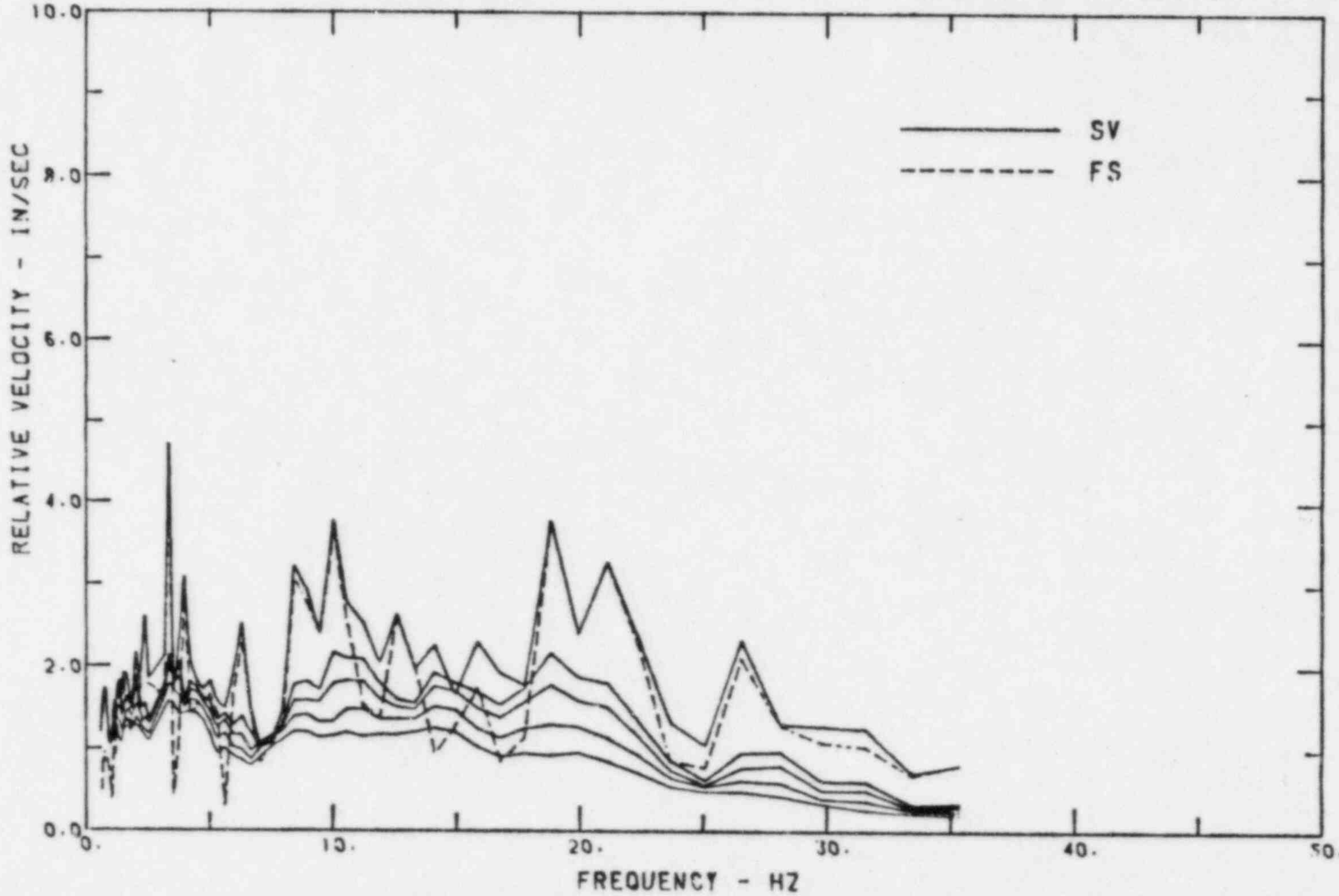


RELATIVE VELOCITY RESPONSE SPECTRUM
ML 5.0 EARTHQUAKE JANUARY 31, 1986
11A8001 PERRY NUCLEAR POWER PLANT COMP SOUTH SMA3S/N 165-1L
DAMPING VALUES ARE 0, 1, 2, 4, 7 PERCENT OF CRITICAL



KINEMETRICS

RELATIVE VELOCITY RESPONSE SPECTRUM
ML 5.0 EARTHQUAKE JANUARY 31, 1986
11A8001 PERRY NUCLEAR POWER PLANT COMP WEST SMA3S/N 165-1T
DAMPING VALUES ARE 0. 1. 2. 4. 7 PERCENT OF CRITICAL



KINEMETRICS

RELATIVE VELOCITY RESPONSE SPECTRUM

ML 5.0 EARTHQUAKE JANUARY 31, 1986

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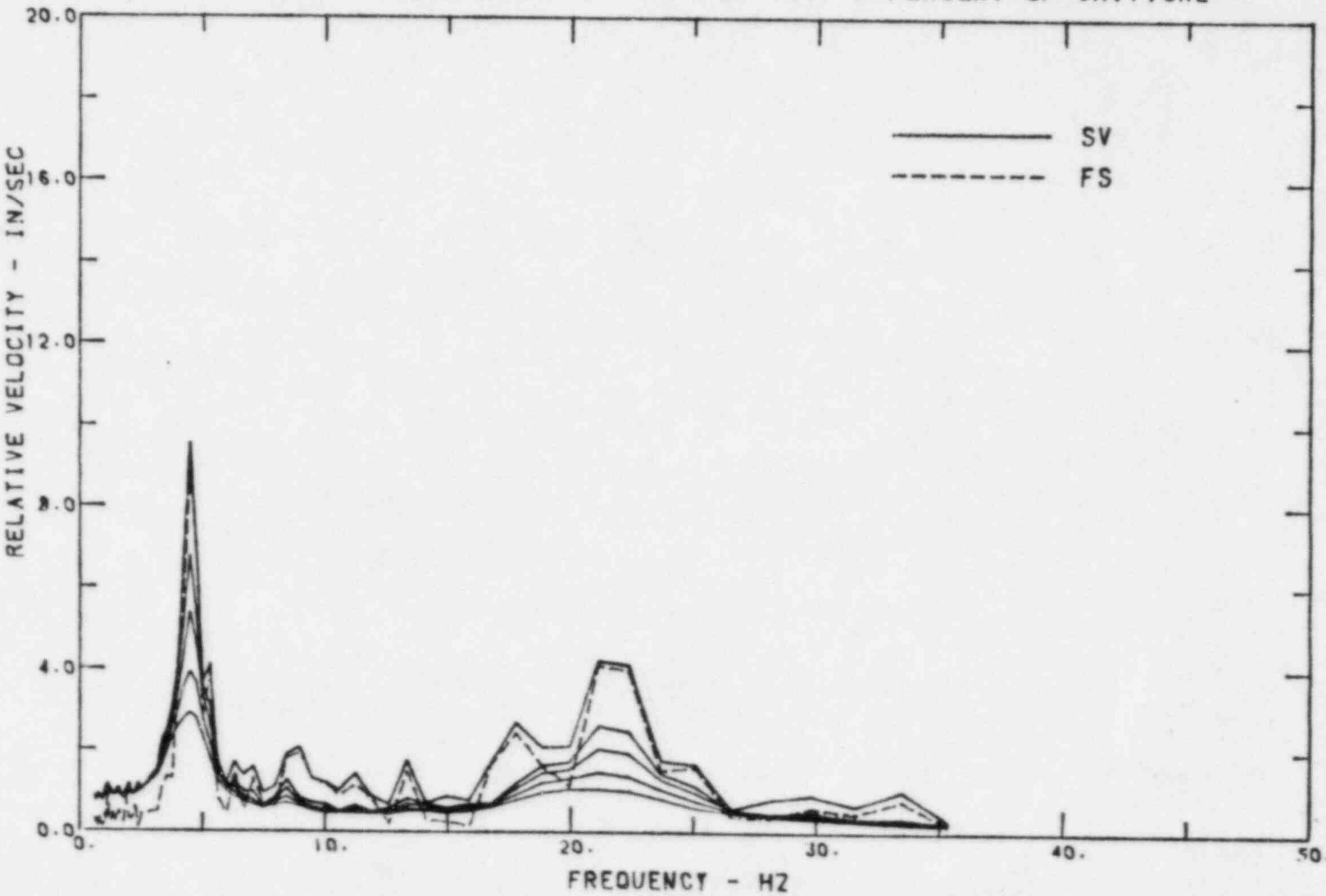
DAMPING VALUES ARE 0, 1, 2, 4, 7 PERCENT OF CRITICAL



KINEMETRICS

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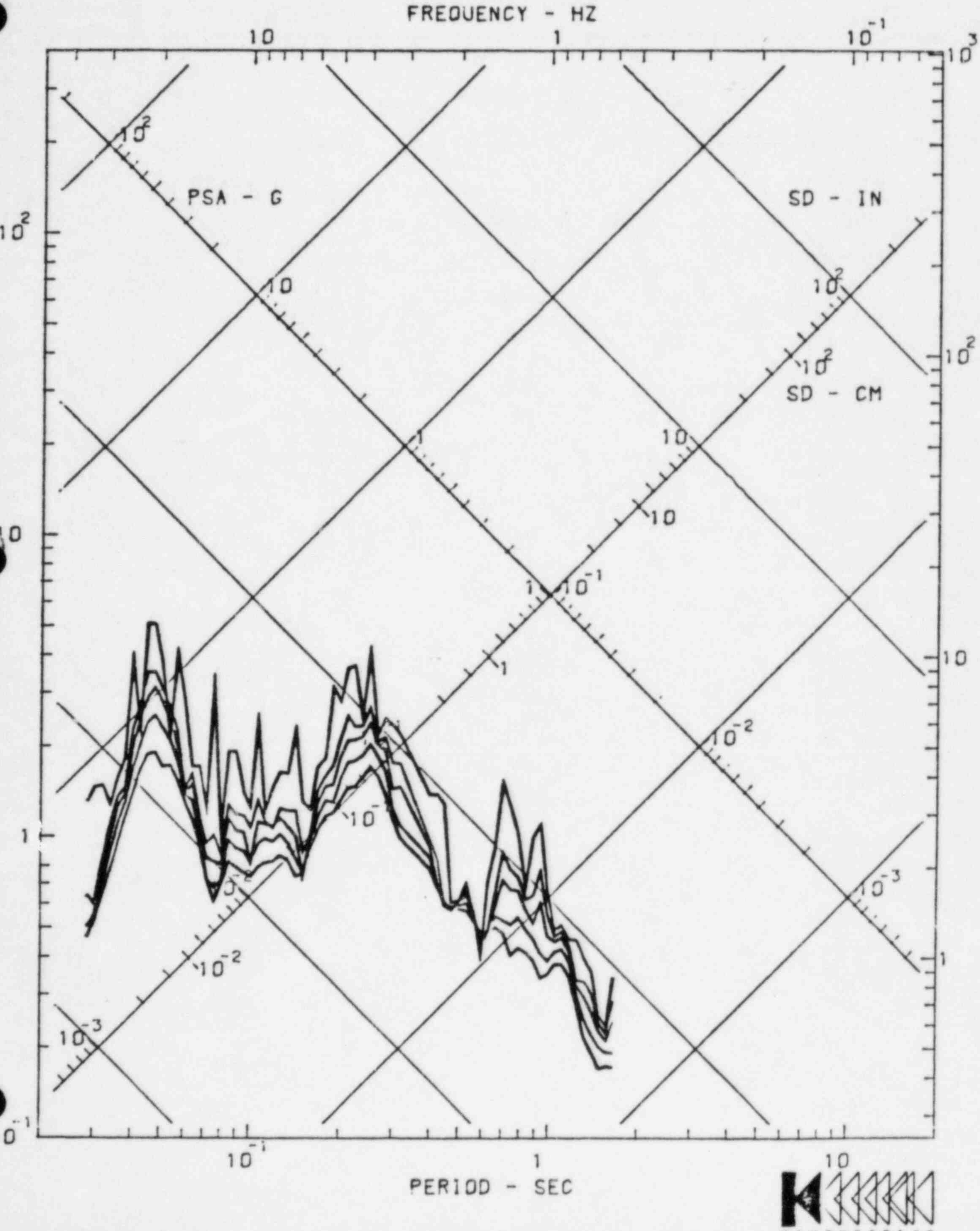

ML 5.0 EARTHQUAKE JANUARY 31, 1986

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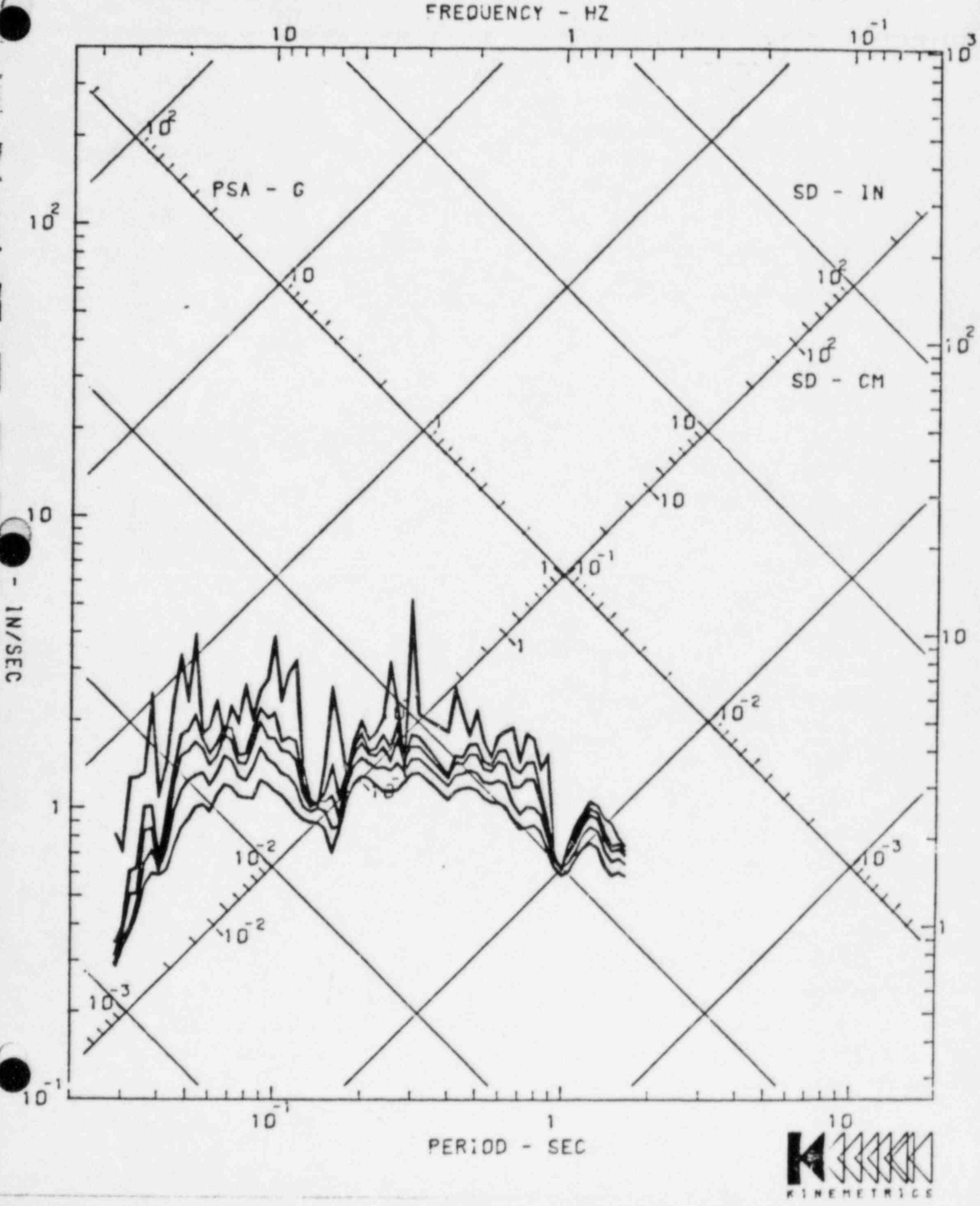

ML 5.0 EARTHQUAKE JANUARY 31, 1986

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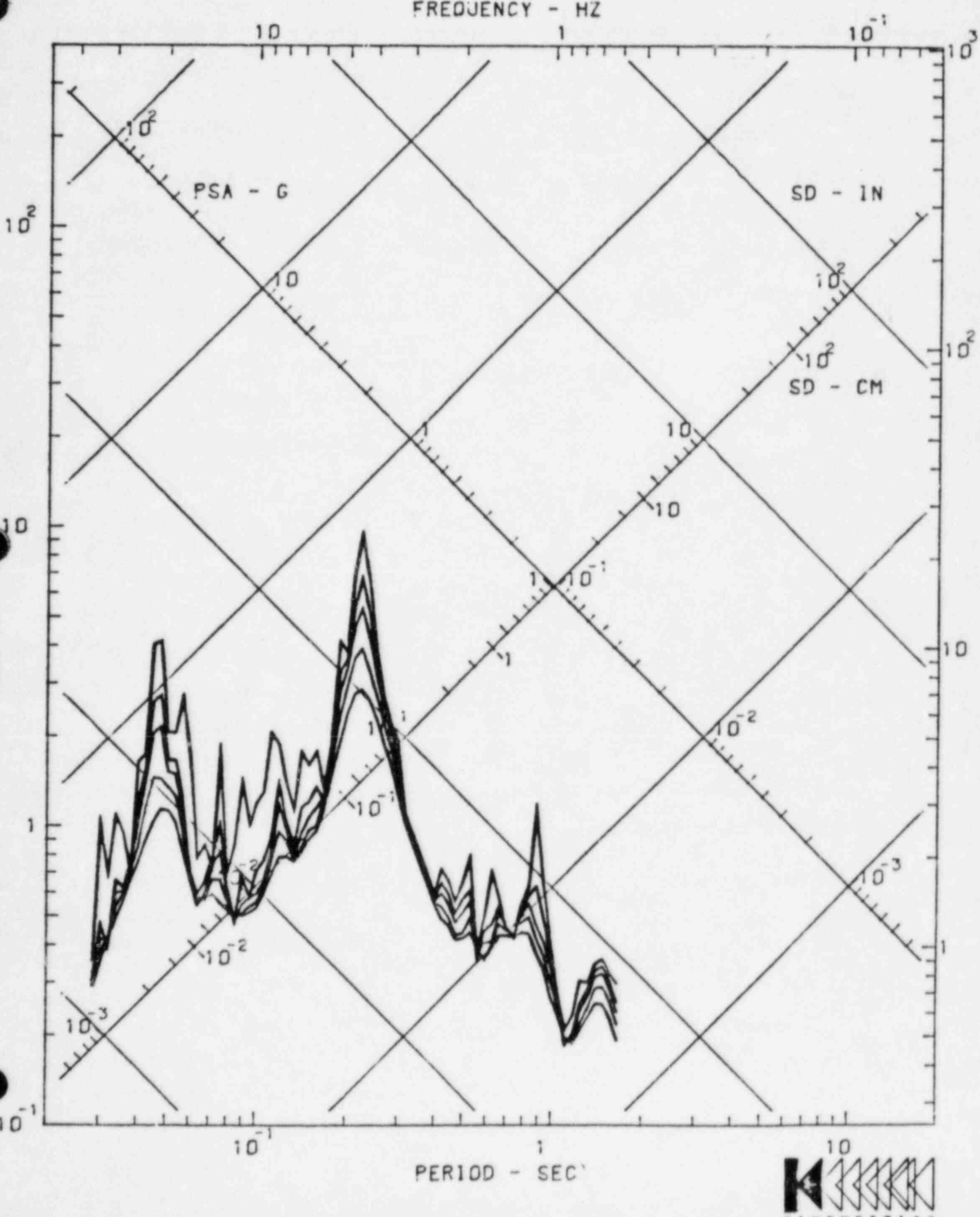
DAMPING VALUES ARE 0, 1, 2, 4, 7 PERCENT OF CRITICAL



ML 5.0 EARTHQUAKE JANUARY 31, 1986

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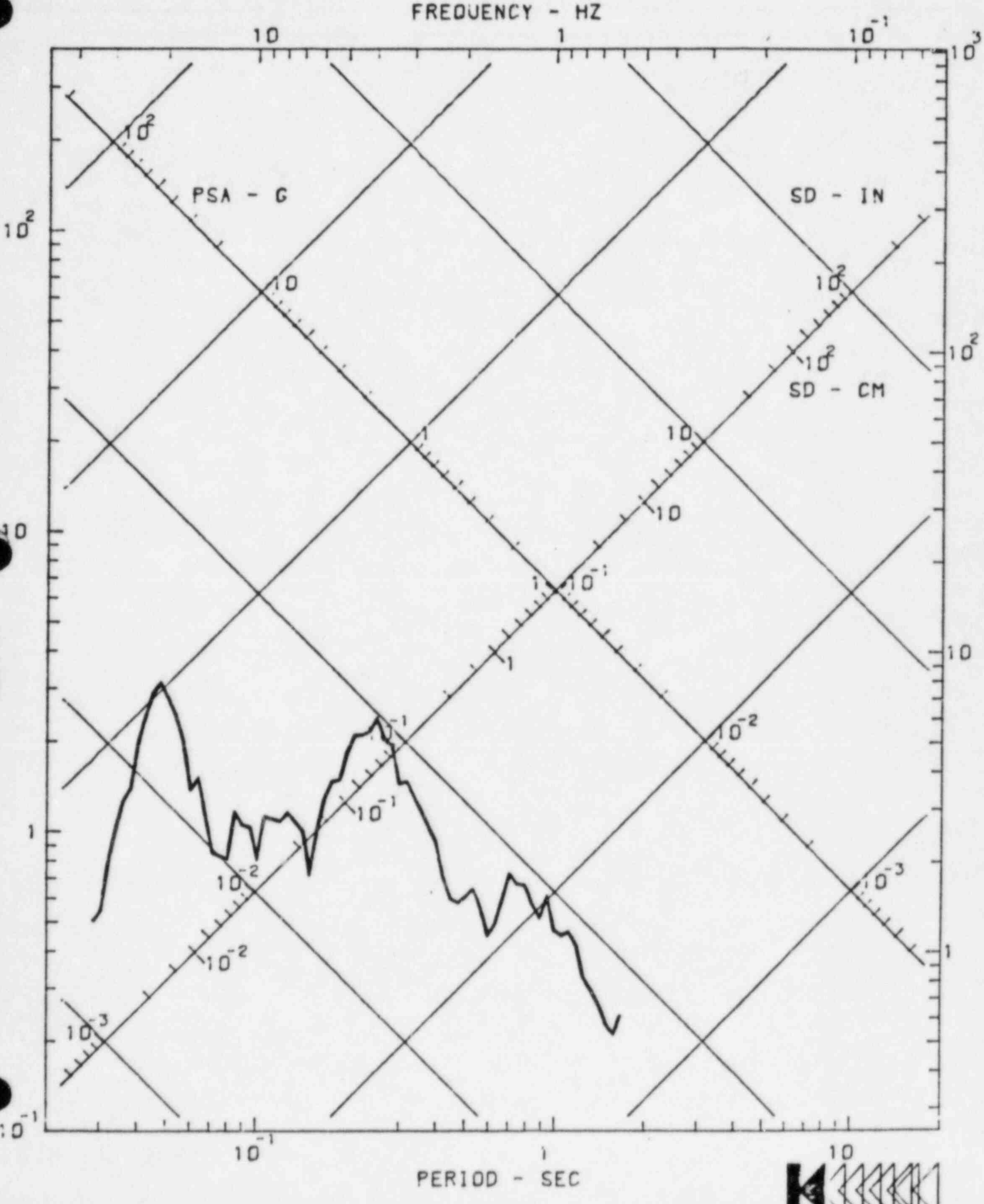
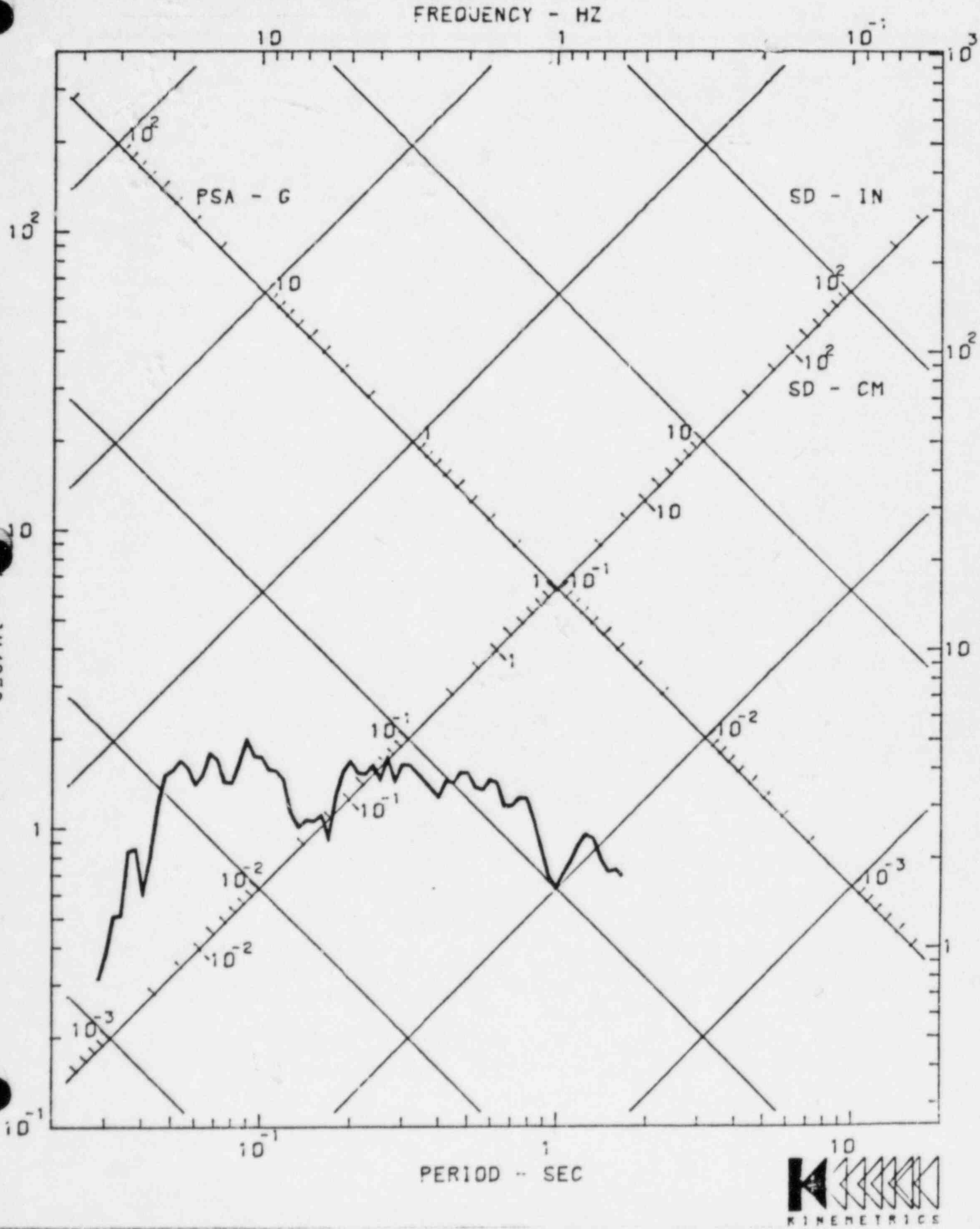
DAMPING VALUES ARE 2 PERCENT OF CRITICAL



ML 5.0 EARTHQUAKE JANUARY 31, 1986

11AB001 PERRY NUCLEAR POWER PLANT COMP WEST SMA3S/N 165-1T

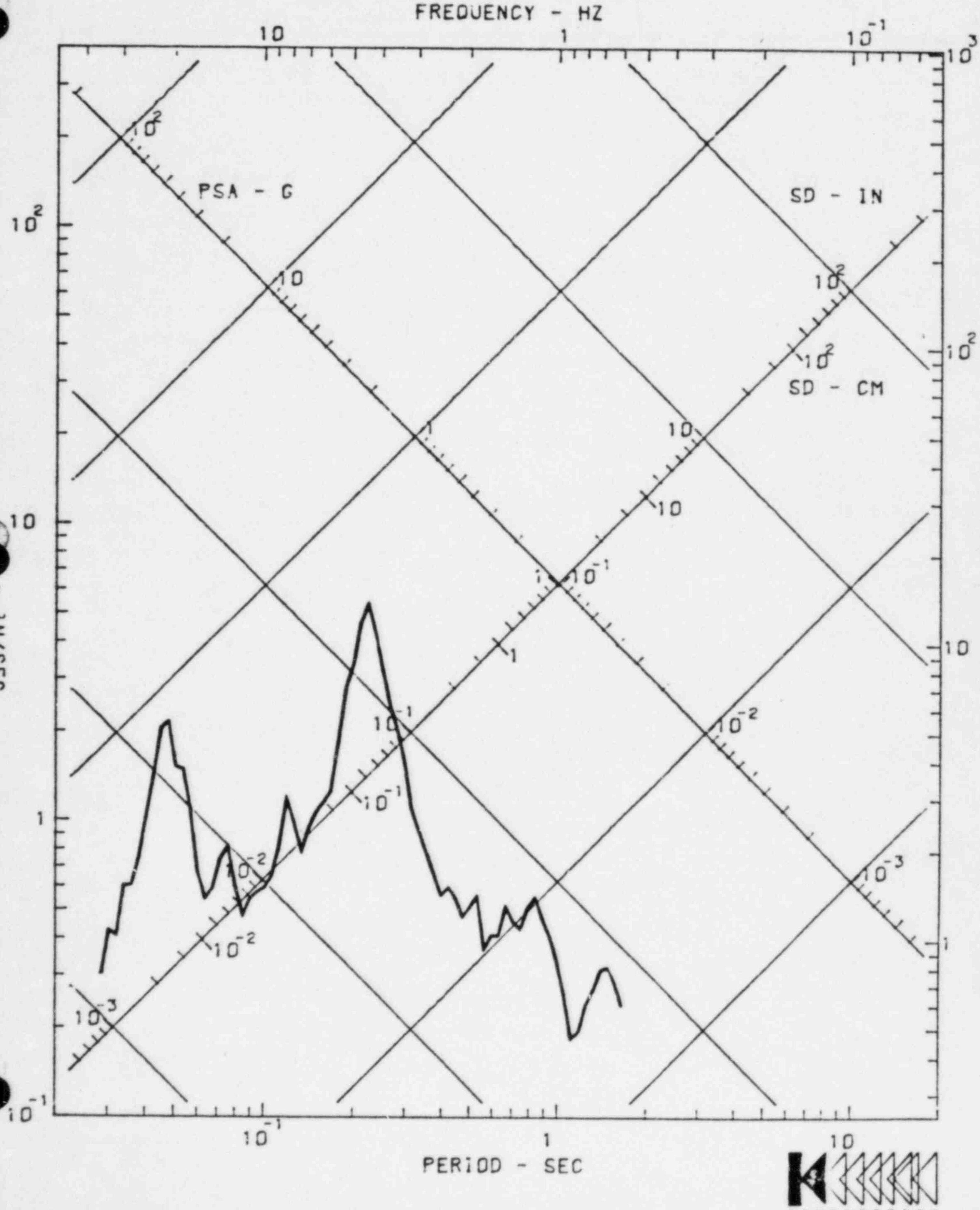
DAMPING VALUES ARE 2 PERCENT OF CRITICAL



ML 5.0 EARTHQUAKE JANUARY 31, 1986

IIA8001 PERRY NUCLEAR POWER PLANT COMP UP SMA3S/N 165-1V

DAMPING VALUES ARE 2 PERCENT OF CRITICAL



KINEMETRICS

ML 5.0 EARTHQUAKE JANUARY 31, 1986

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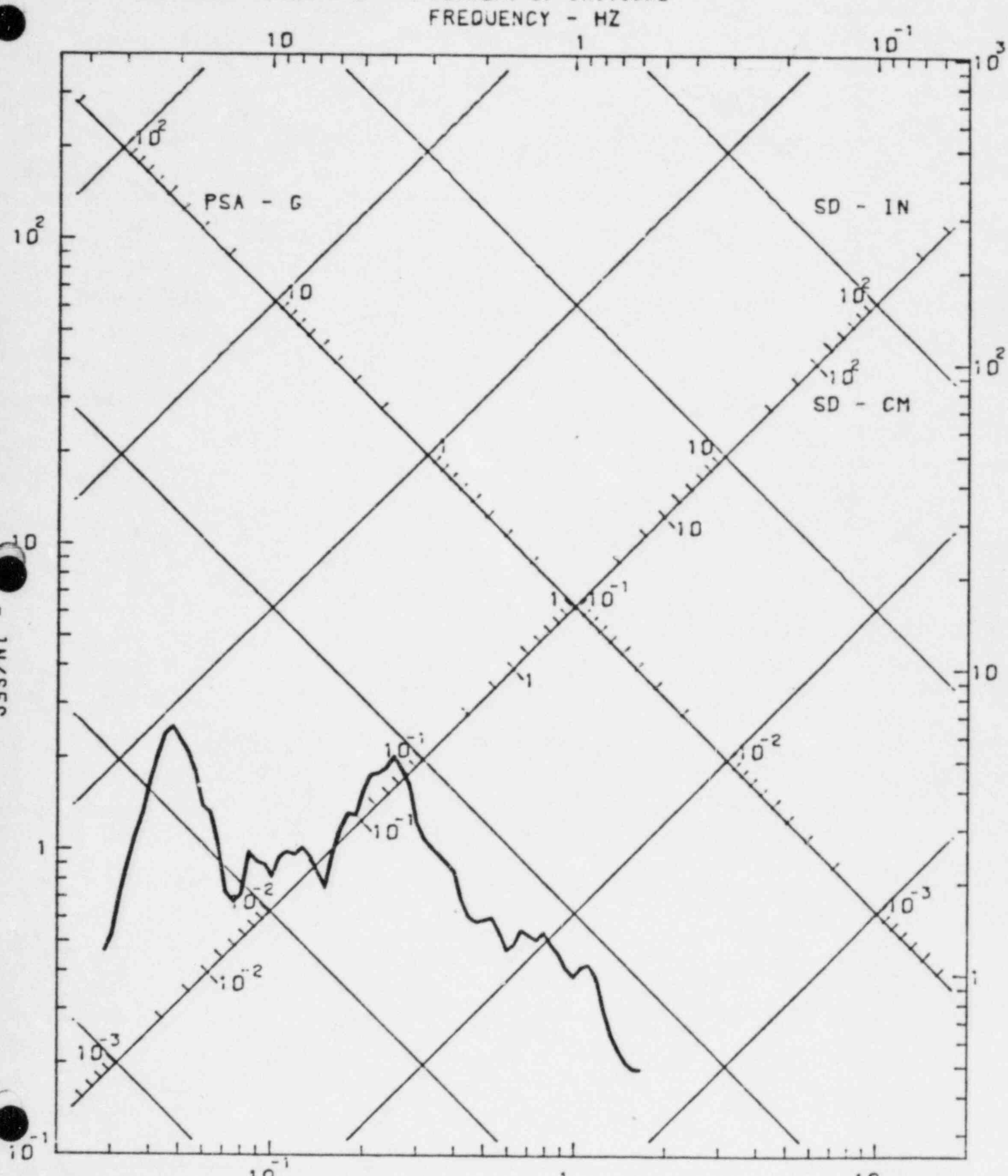
DAMPING VALUES ARE 4 PERCENT OF CRITICAL



KINEMETRICS

ML 5.0 EARTHQUAKE JANUARY 31, 1986

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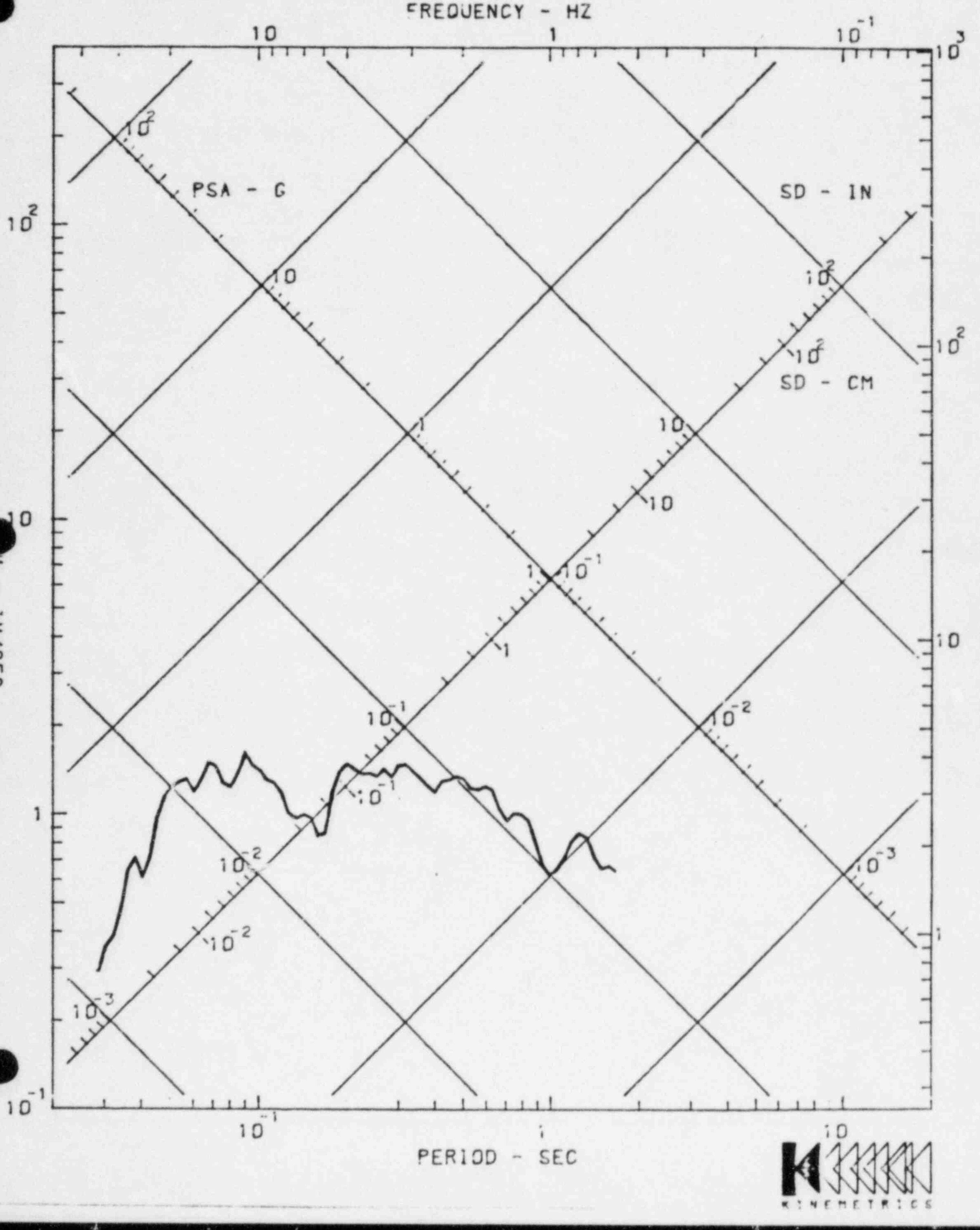
DAMPING VALUES ARE 4 PERCENT OF CRITICAL



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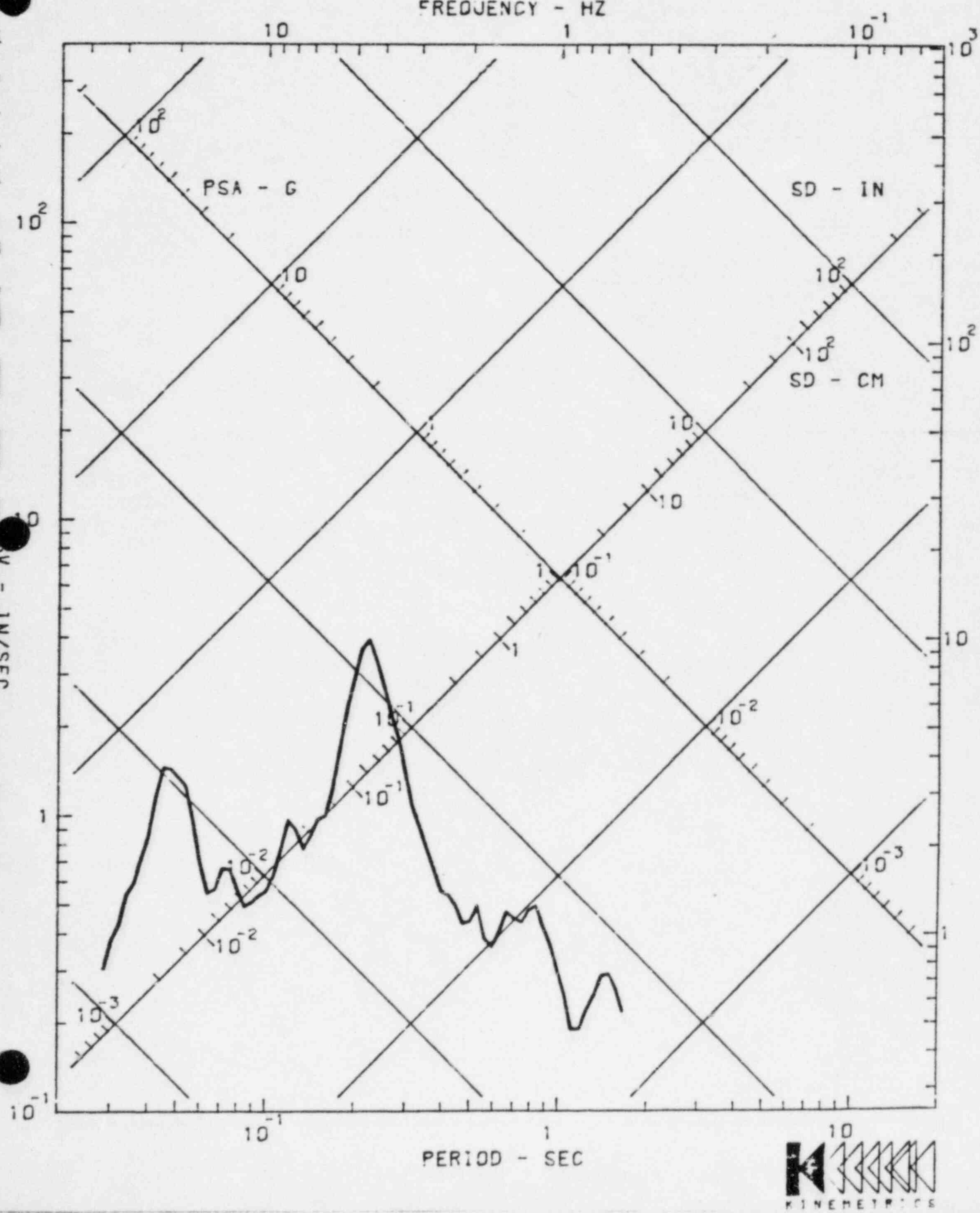
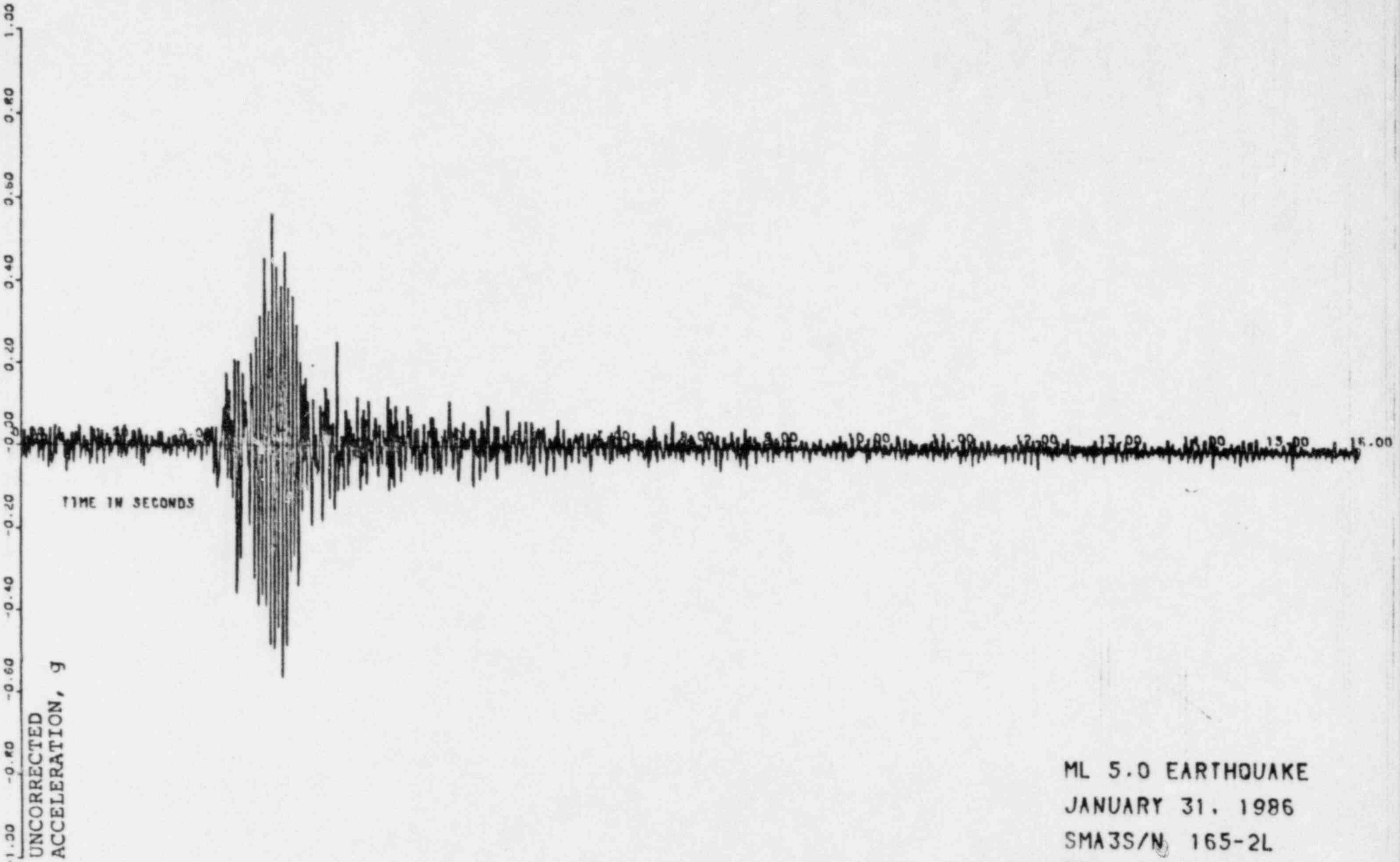
IIA8001 PERRY NUCLEAR POWER PLANT COMP UP SMA3S/N 165-1V

DAMPING VALUES ARE 4 PERCENT OF CRITICAL



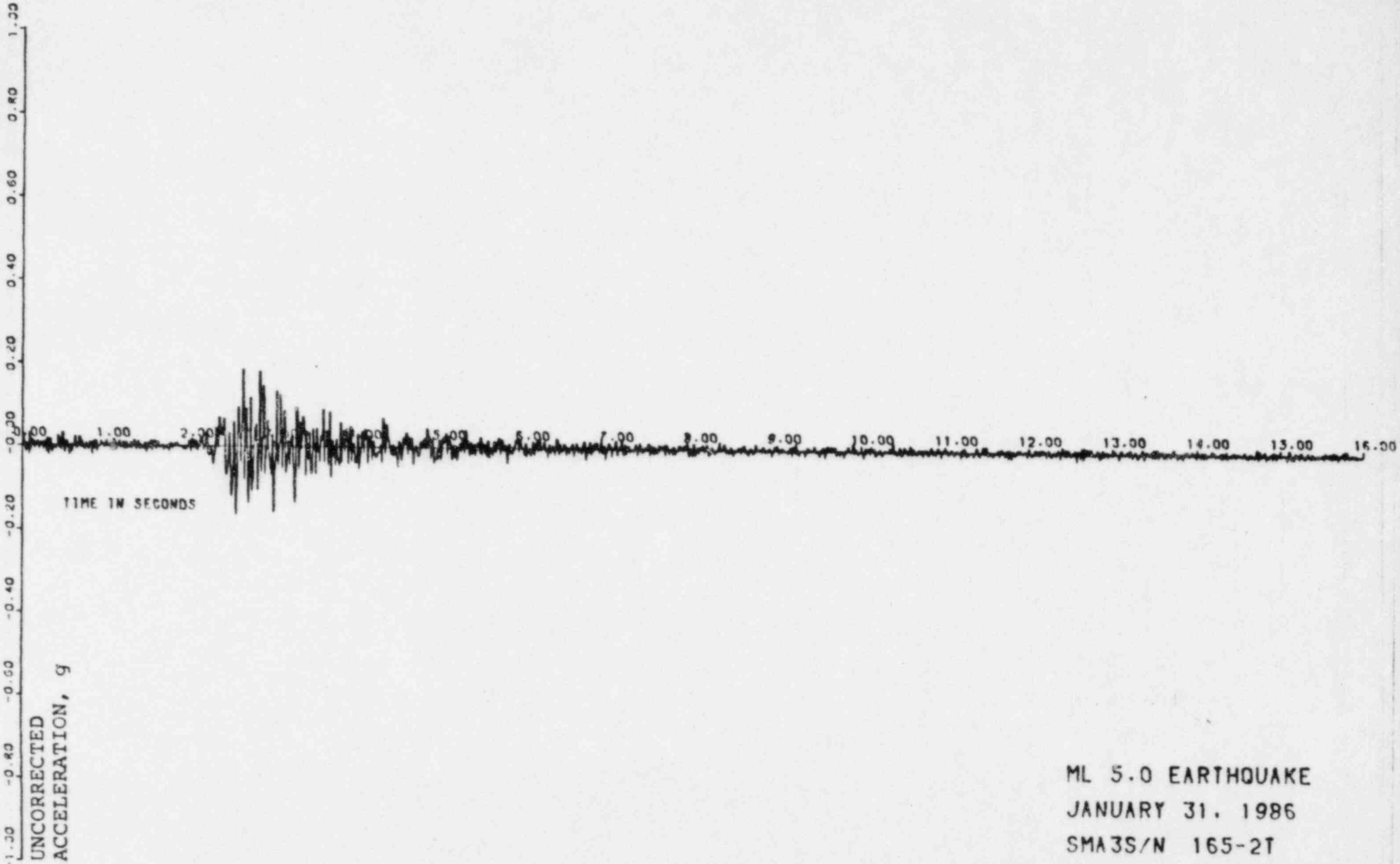
Containment Vessel Annulus, Elevation 682 Ft.

SMA-3 Serial Number 165-2
Tag Number D51-N111
Longitudinal Channel - South Orientation
Transverse Channel - West Orientation
Vertical Channel - Up Orientation



ML 5.0 EARTHQUAKE
JANUARY 31, 1986
SMA3S/N 165-2L

KINEMETRICS



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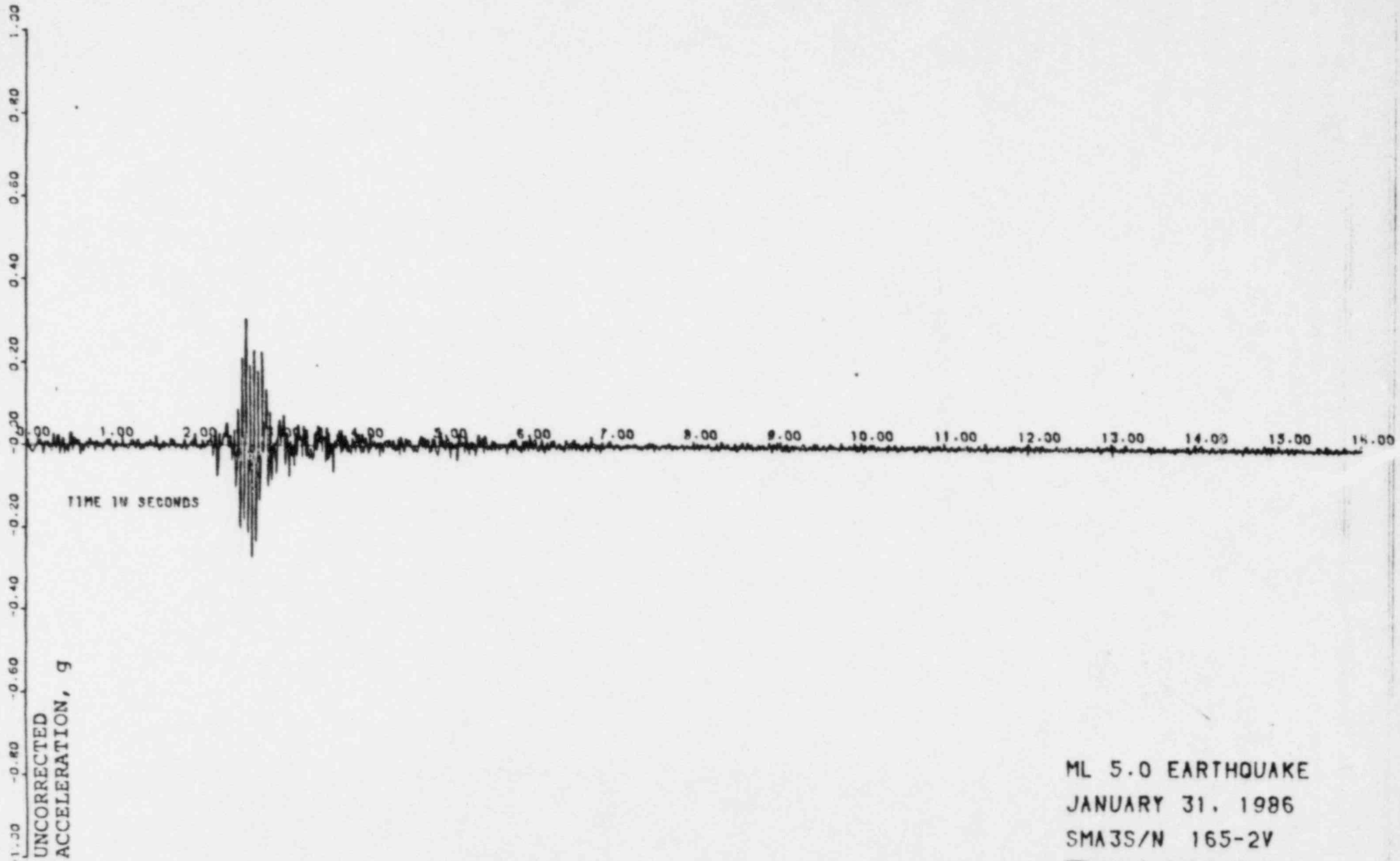


ML 5.0 EARTHQUAKE
JANUARY 31, 1986
SMA3S/N 165-2V

KINEMETRICS

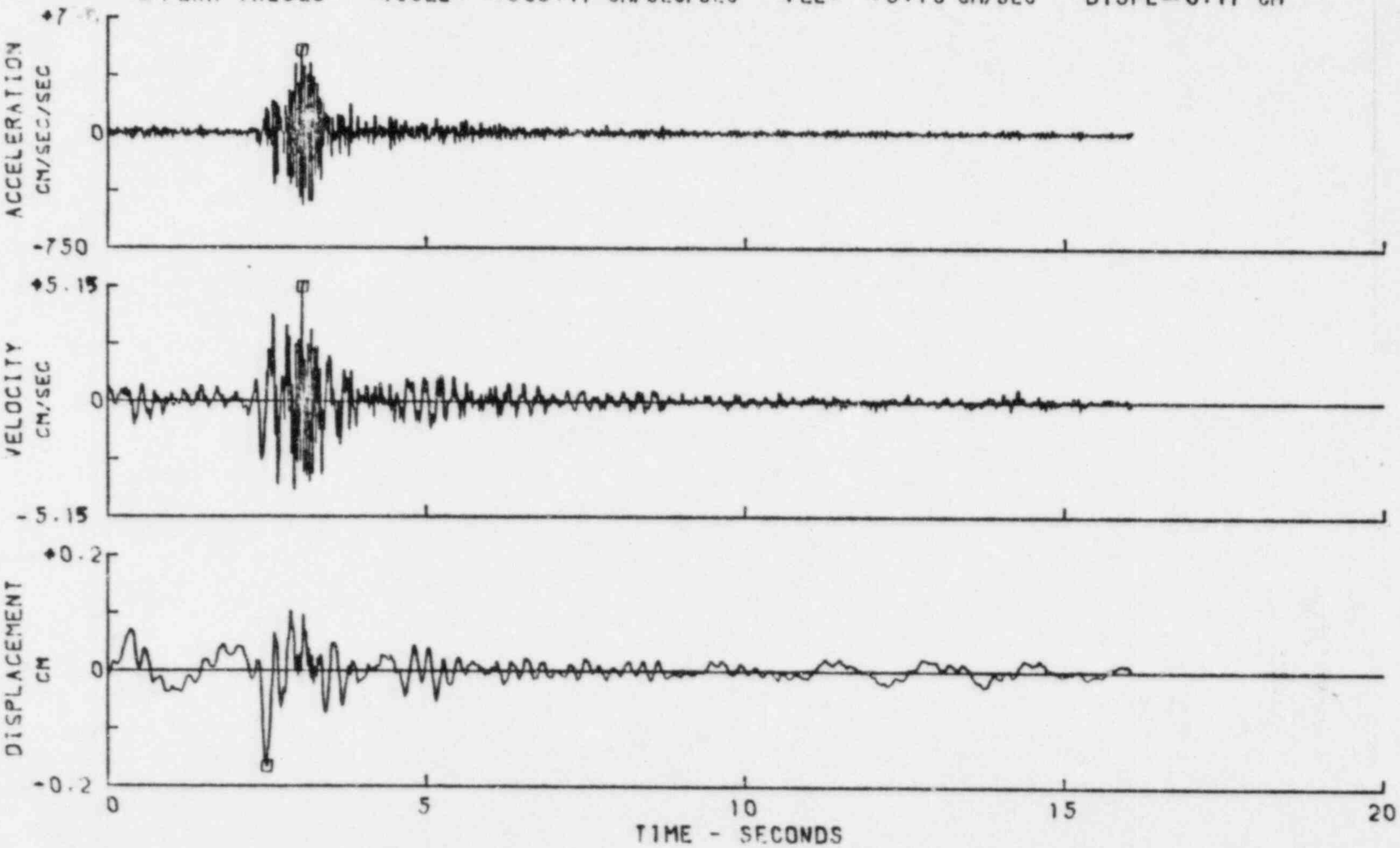
KINEMETRICS

ML 5.0 EARTHQUAKE JANUARY 31, 1986

11A8002 PERRY NUCLEAR POWER PLANT COMP SOUTH SMA3S/N 165-2L

ACCELEROGRAM IS BAND-PASS FILTERED BETWEEN 0.400- 0.625 AND 35.00- 40.00 HERTZ

□ PEAK VALUES: ACCEL= +535.17 CM/SEC/SEC VEL= +5.13 CM/SEC DISPL=-0.17 CM



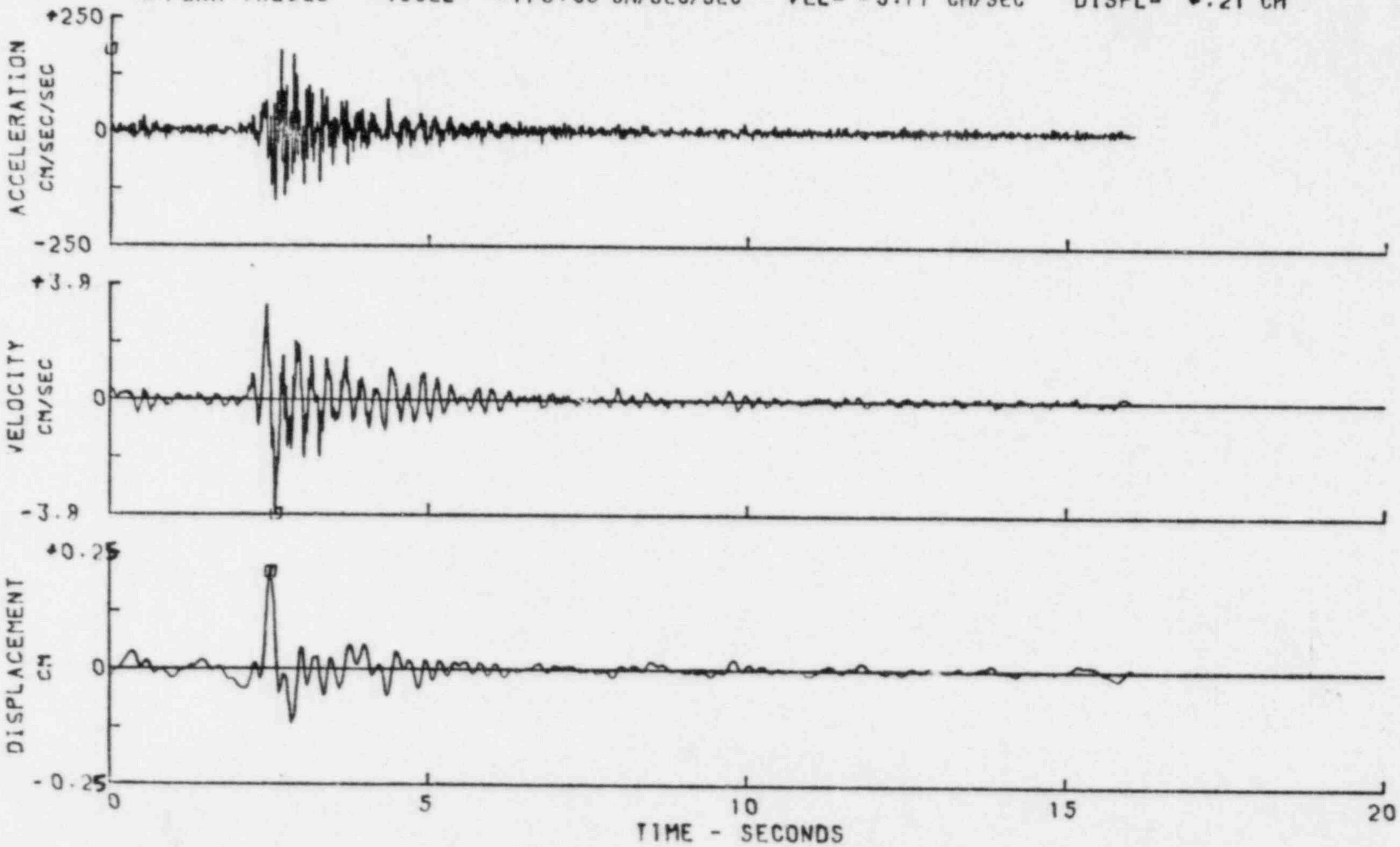
KINEMETRICS

ML 5.0 EARTHQUAKE JANUARY 31, 1986

11A8002 PERRY NUCLEAR POWER PLANT COMP WEST SMA3S/N 165-2T

ACCELEROGRAM IS BAND-PASS FILTERED BETWEEN 0.400- 0.625 AND 35.00- 40.00 HERTZ

▢ PEAK VALUES: ACCEL= +178.35 CM/SEC/SEC VEL= -3.77 CM/SEC DISPL= +.21 CM



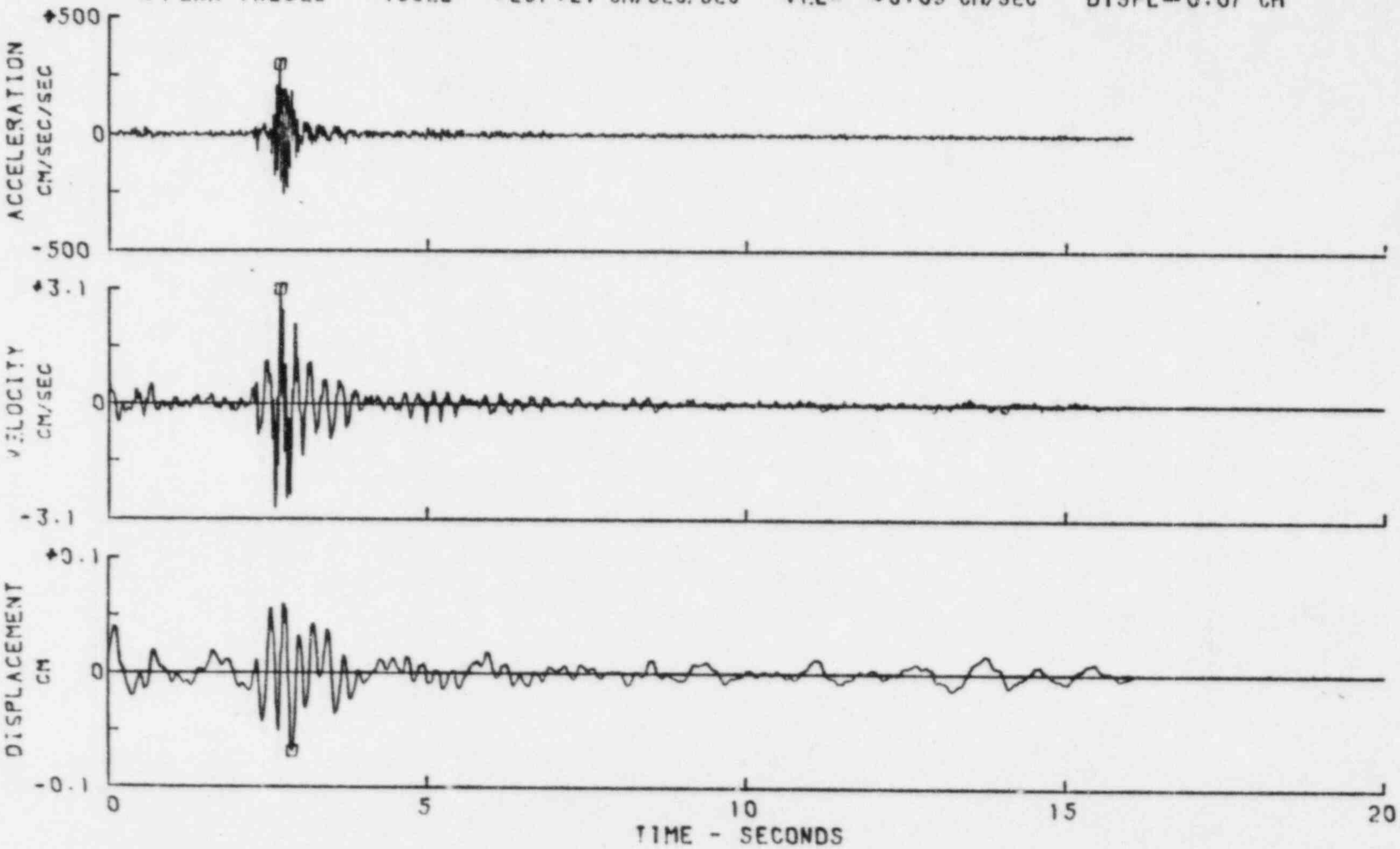
KINEMETRICS

ML 5.0 EARTHQUAKE JANUARY 31, 1986

11A8002 PERRY NUCLEAR POWER PLANT COMP UP SMA3S/N 165-2V

ACCELEROGRAM IS BAND-PASS FILTERED BETWEEN 0.400- 0.625 AND 35.00- 40.00 HERTZ

□ PEAK VALUES: ACCEL= +297.21 CM/SEC/SEC VEL= +3.09 CM/SEC DISPL=-0.07 CM

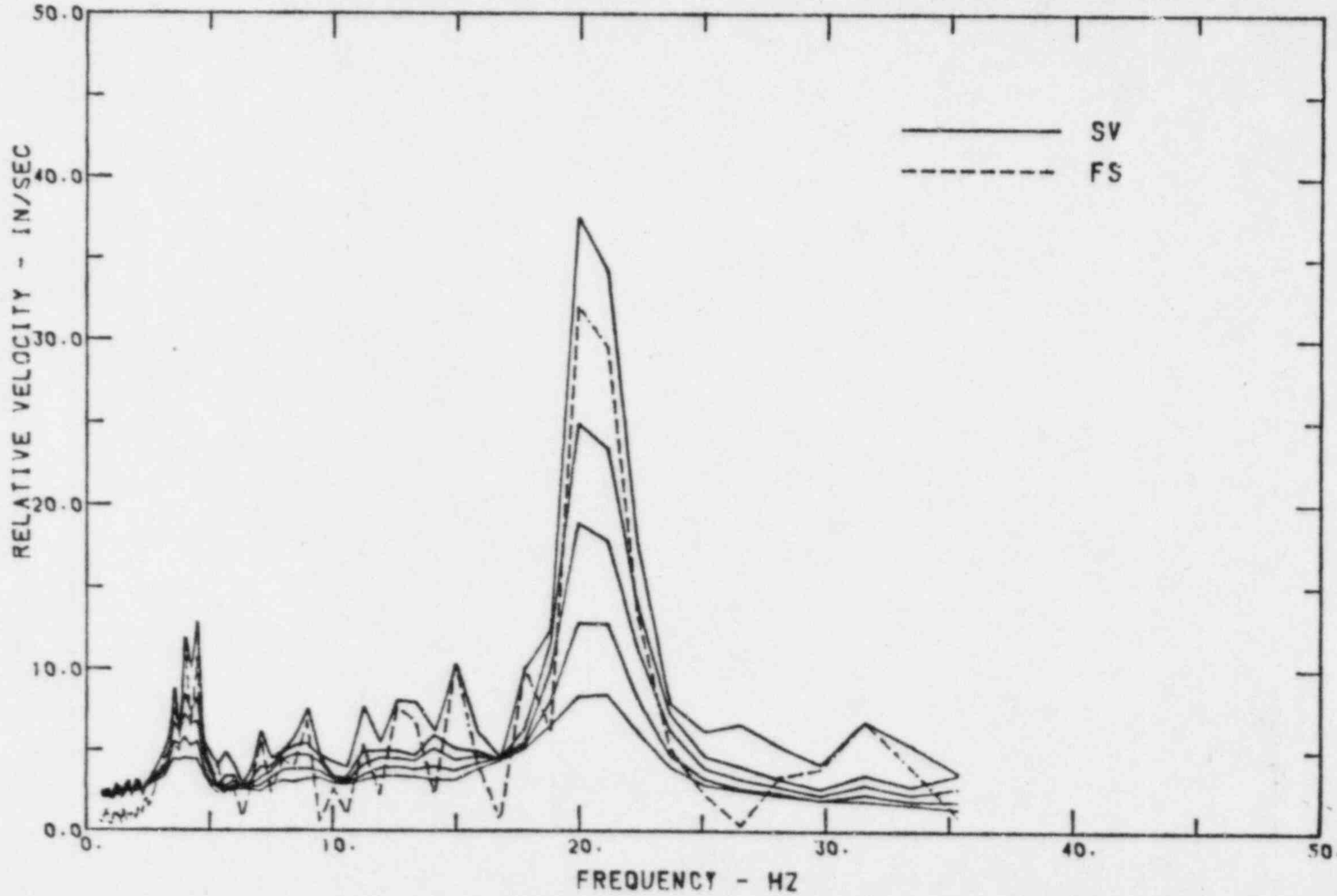


RELATIVE VELOCITY RESPONSE SPECTRUM

ML 5.0 EARTHQUAKE JANUARY 31, 1986

11A8002 PERRY NUCLEAR POWER PLANT COMP SOUTH SMA3S/N 165-2L

DAMPING VALUES ARE 0, 1, 2, 4, 7 PERCENT OF CRITICAL



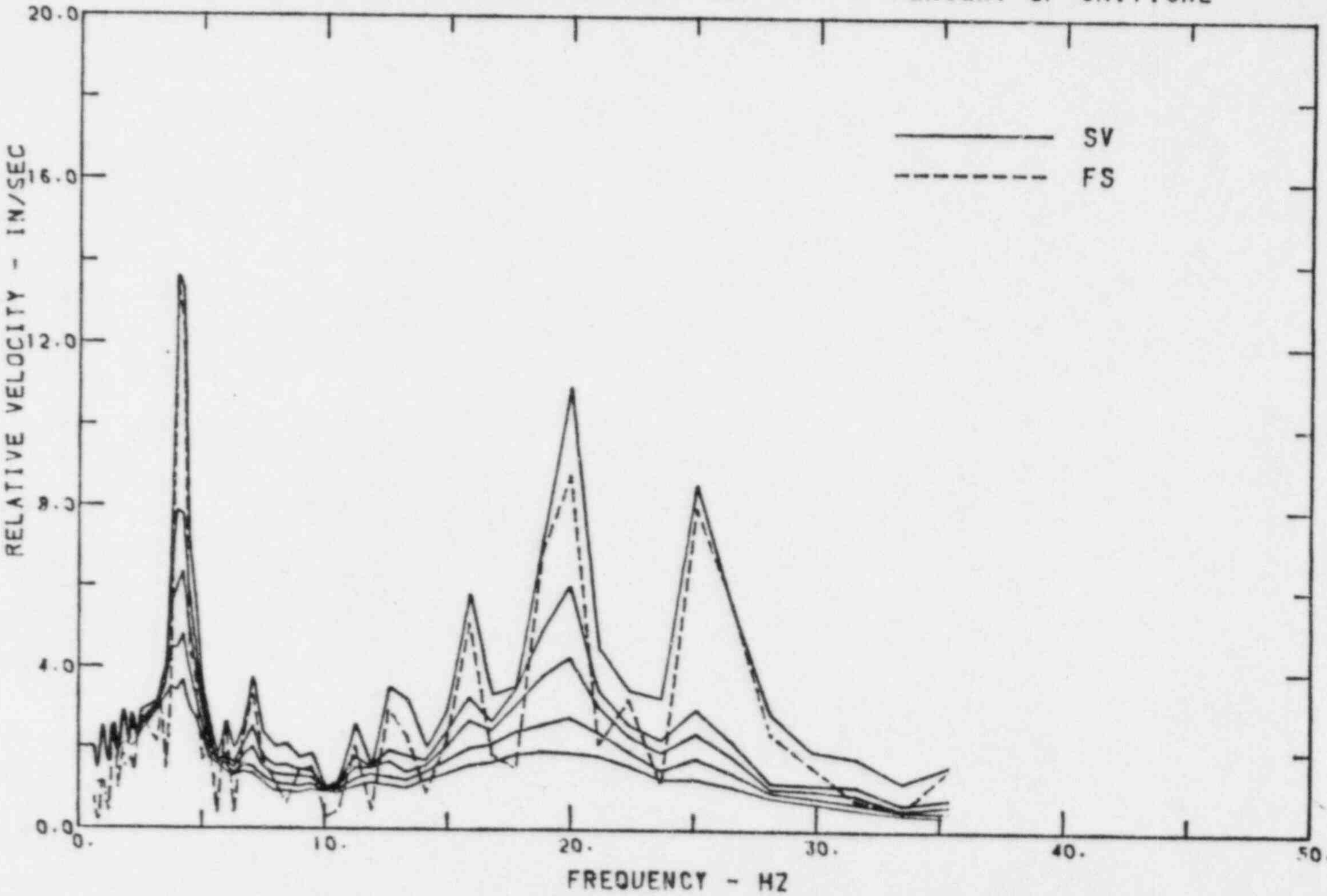
KINEMETRICS

RELATIVE VELOCITY RESPONSE SPECTRUM

ML 5.0 EARTHQUAKE JANUARY 31, 1986

11A8002 PERRY NUCLEAR POWER PLANT COMP WEST SMA3S/N 165-2T

DAMPING VALUES ARE 0. 1. 2. 4. 7 PERCENT OF CRITICAL



KINEMETRICS

RELATIVE VELOCITY RESPONSE SPECTRUM

ML 5.0 EARTHQUAKE JANUARY 31, 1986

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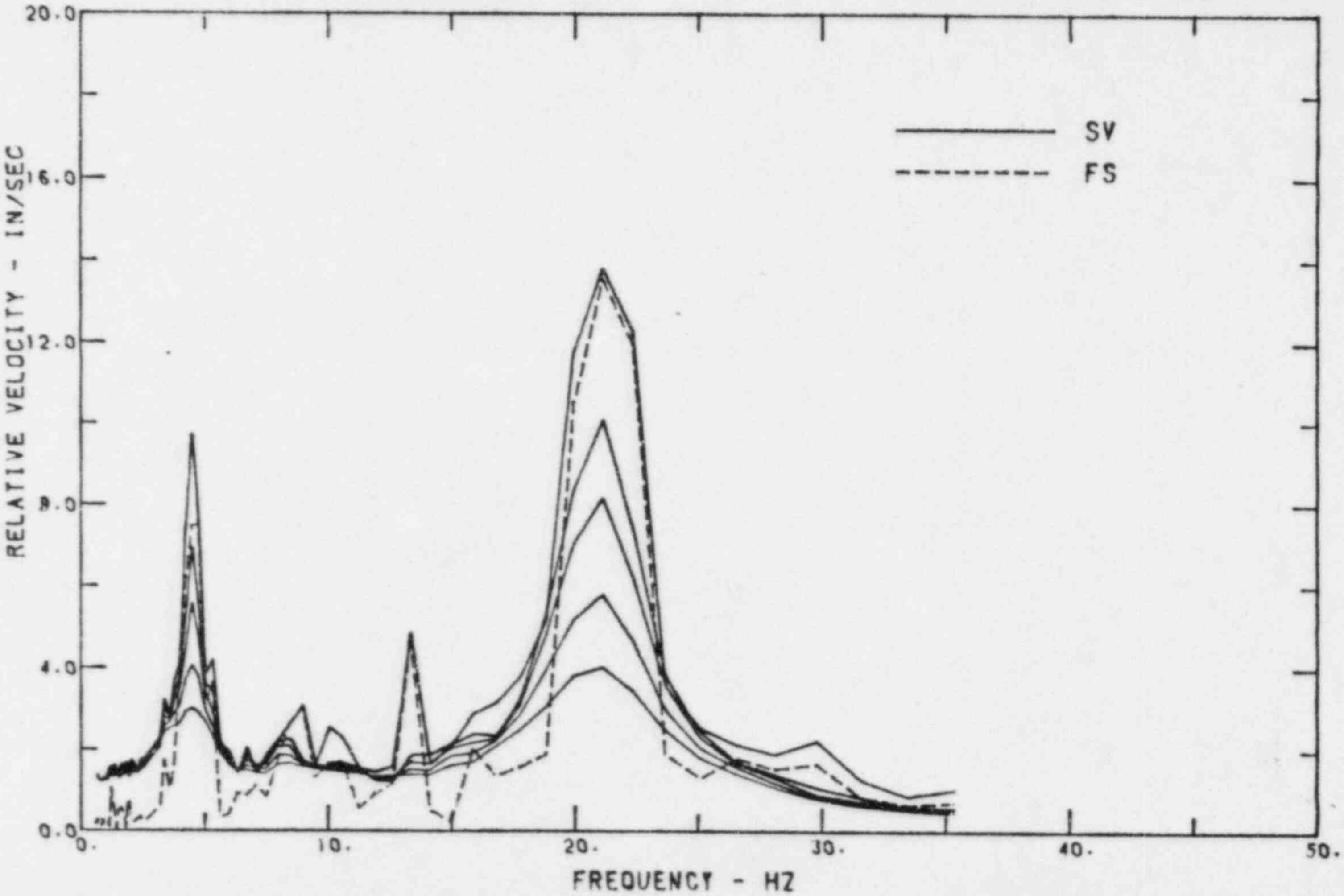
DAMPING VALUES ARE 0. 1. 2. 4. 7 PERCENT OF CRITICAL



KINEMETRICS

ML 5.0 EARTHQUAKE JANUARY 31, 1986

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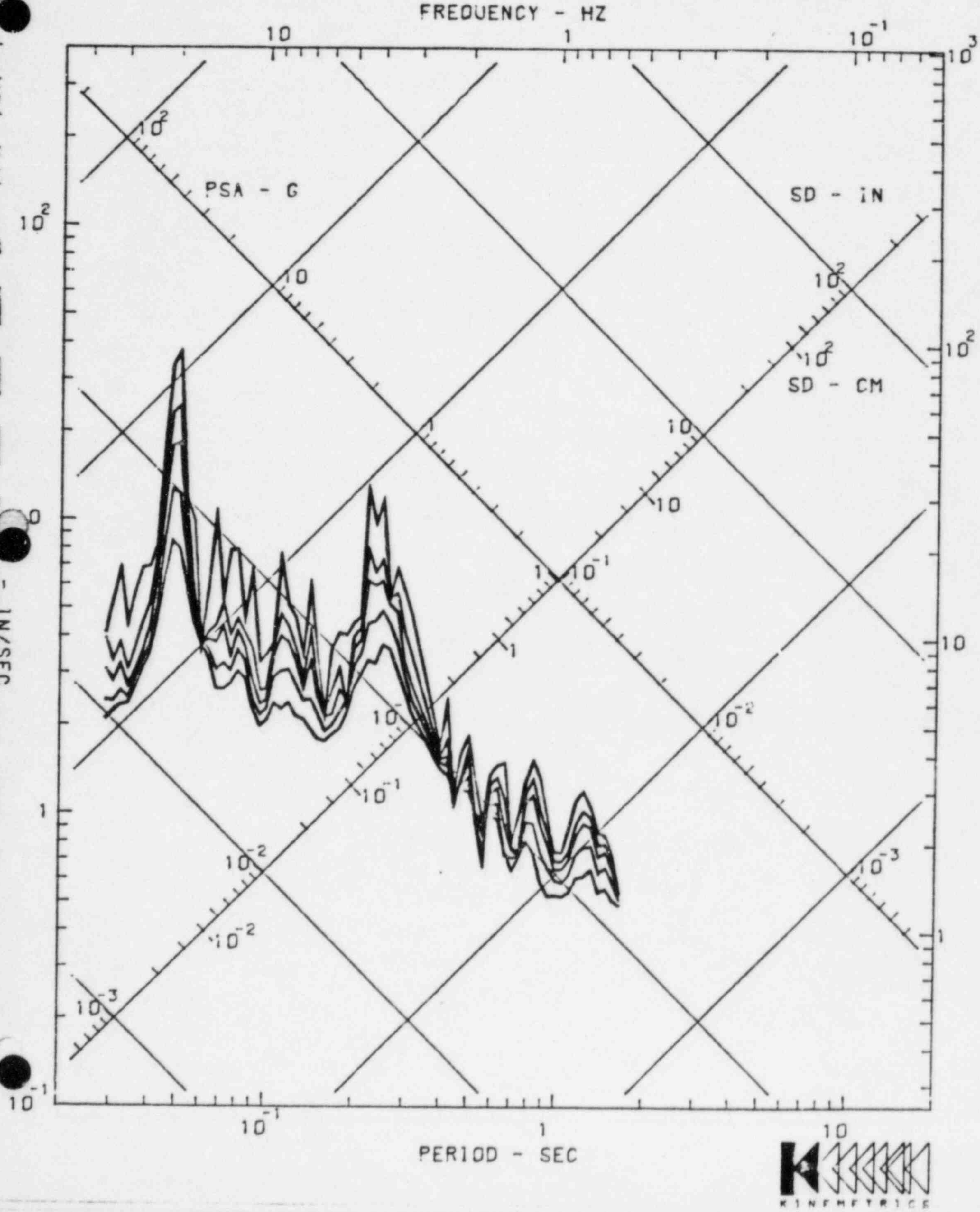
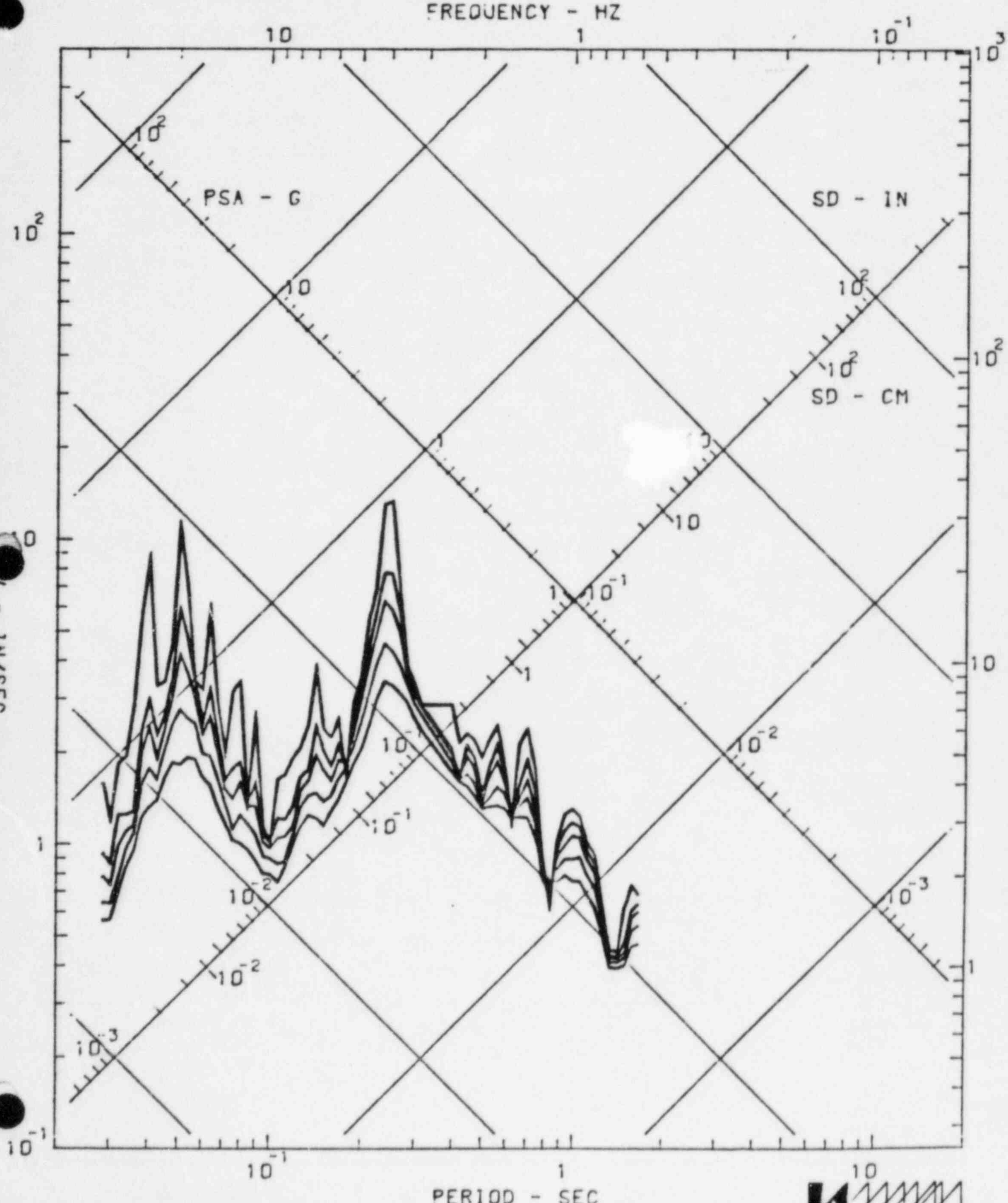
DAMPING VALUES ARE 0. 1. 2. 4. 7 PERCENT OF CRITICAL



ML 5.0 EARTHQUAKE JANUARY 31, 1986

IIA8002 PERRY NUCLEAR POWER PLANT COMP WEST SMA3S/N 165-2T

DAMPING VALUES ARE 0. 1. 2. 4. 7 PERCENT OF CRITICAL

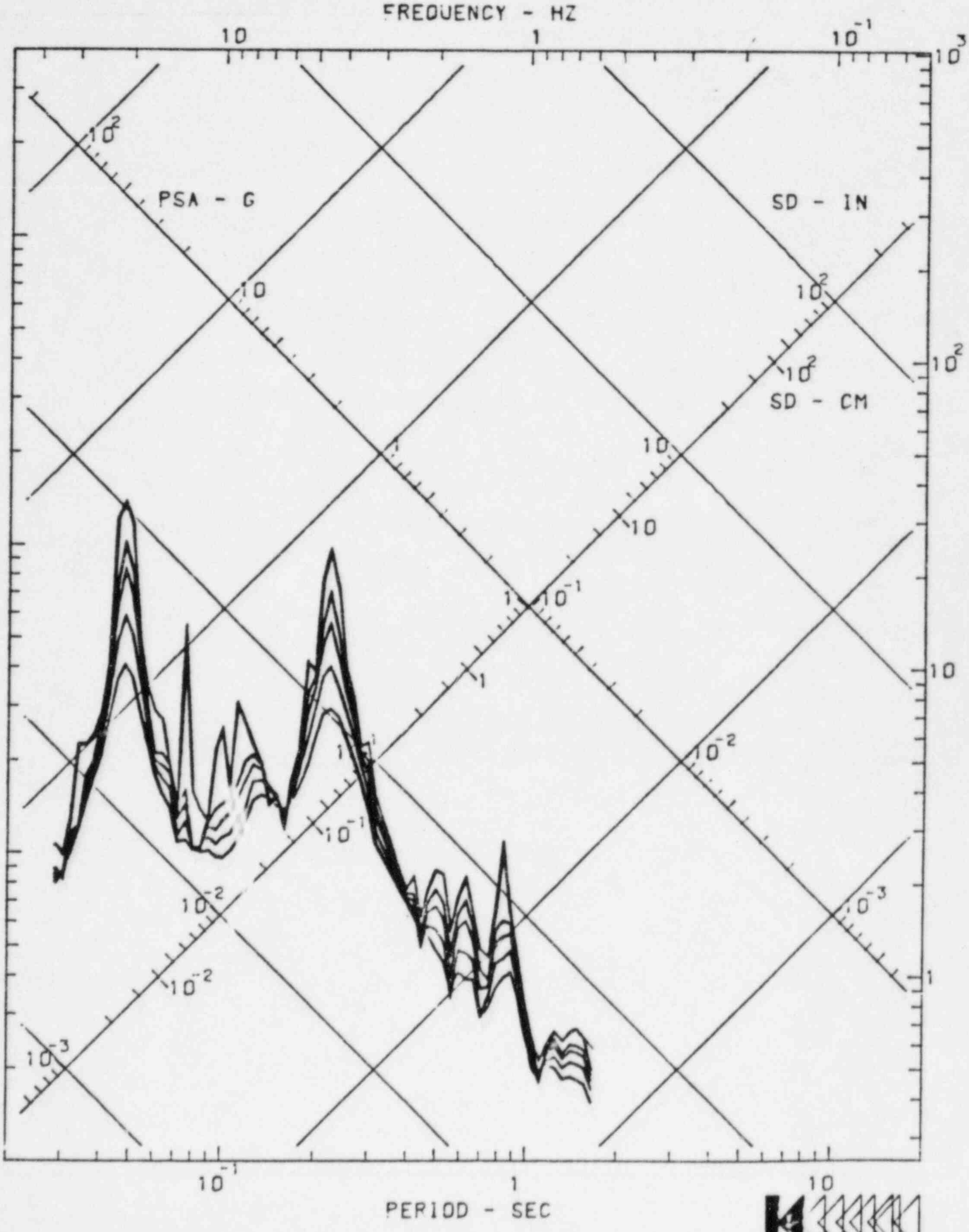


KINEMETRICS

ML 5.0 EARTHQUAKE JANUARY 31, 1986

11A8002 PERRY NUCLEAR POWER PLANT COMP UP SMA3S/N 165-2V

DAMPING VALUES ARE 0. 1. 2. 4. 7 PERCENT OF CRITICAL

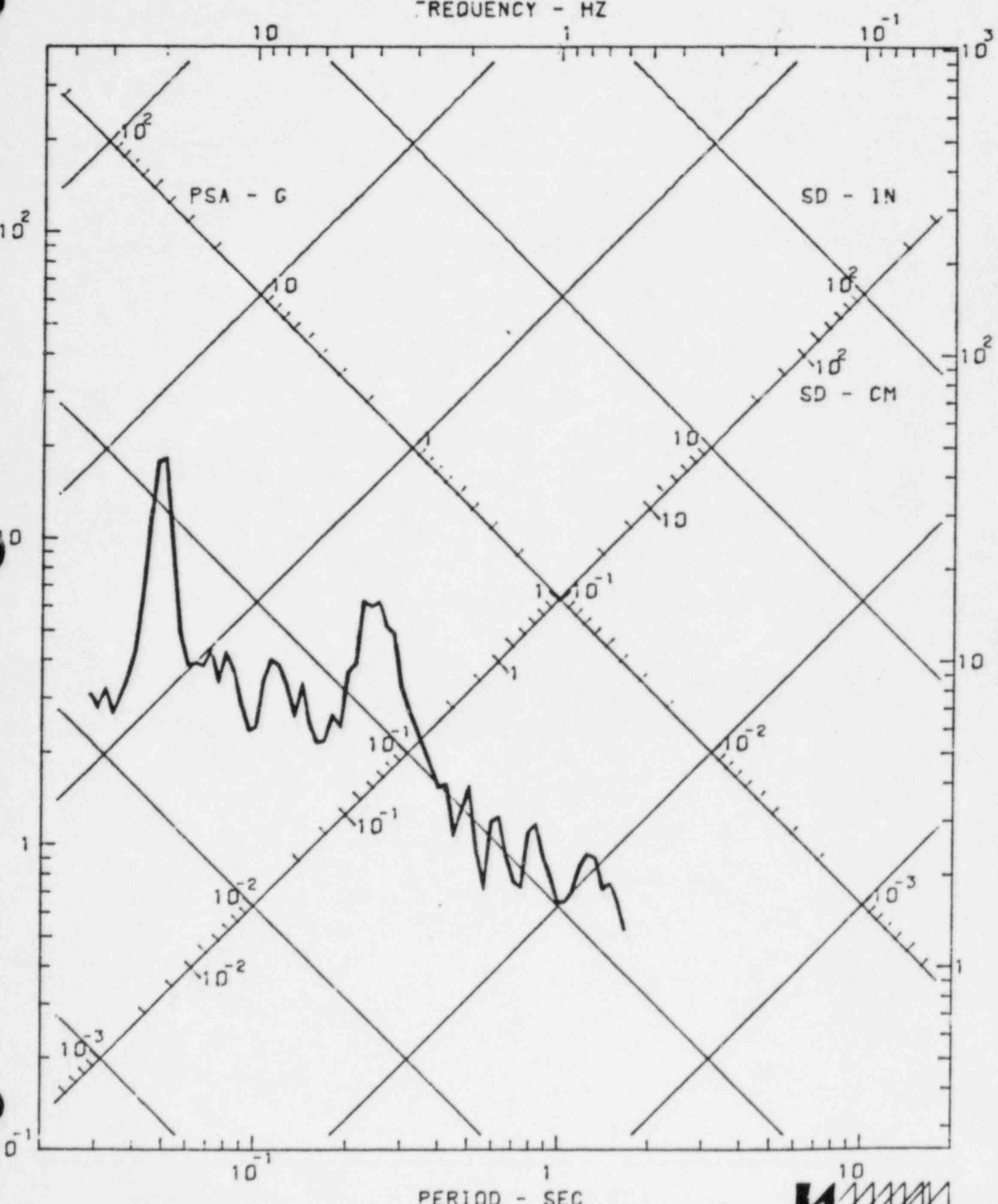


KINEMETRICS

ML 5.0 EARTHQUAKE JANUARY 31, 1986

11A8002 PERRY NUCLEAR POWER PLANT COMP SOUTH SMA3S/N 165-2L

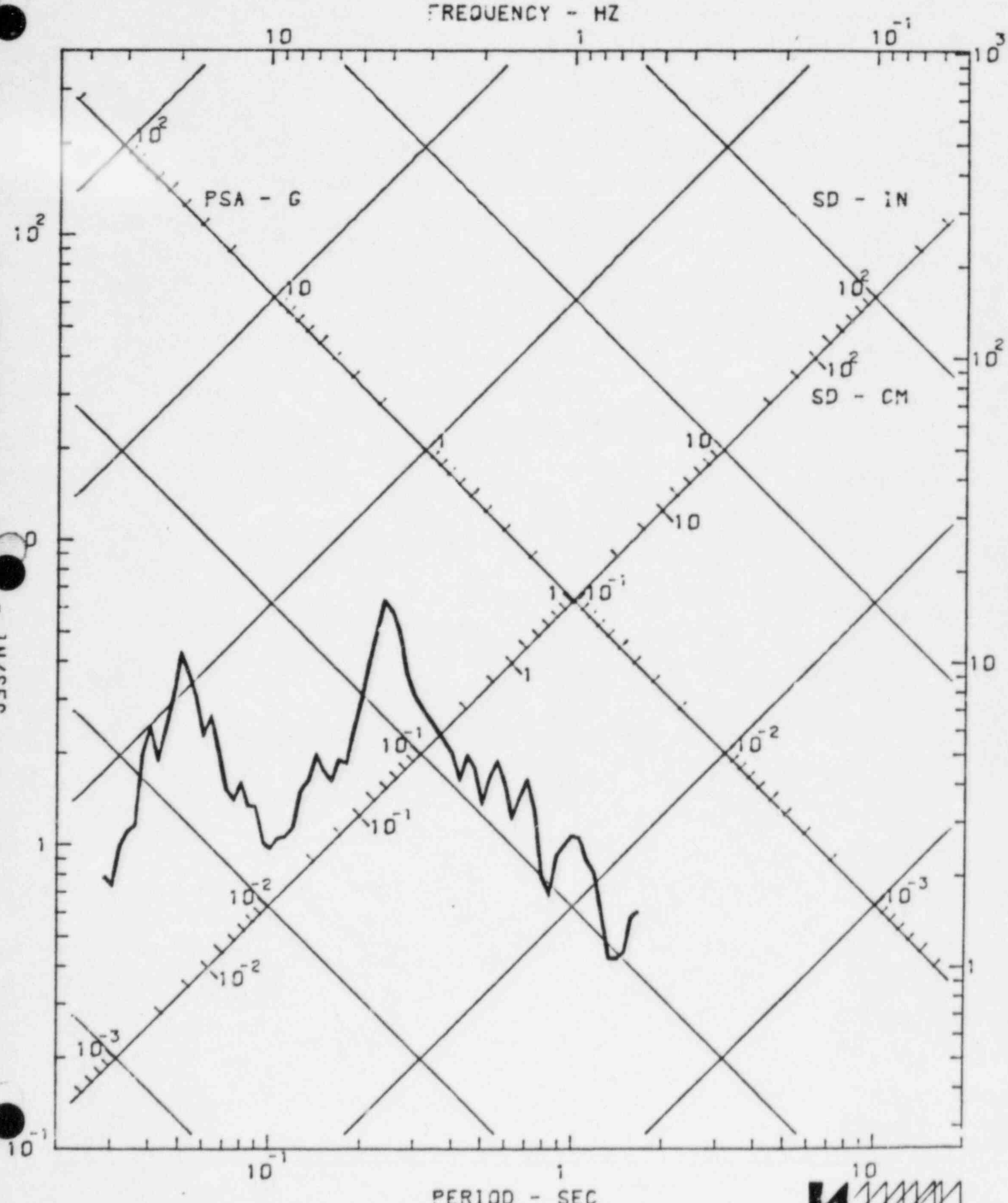
DAMPING VALUES ARE 2 PERCENT OF CRITICAL



ML 5.0 EARTHQUAKE JANUARY 31, 1986

11A8002 PERRY NUCLEAR POWER PLANT COMP WEST SMA3S/N 165-2T

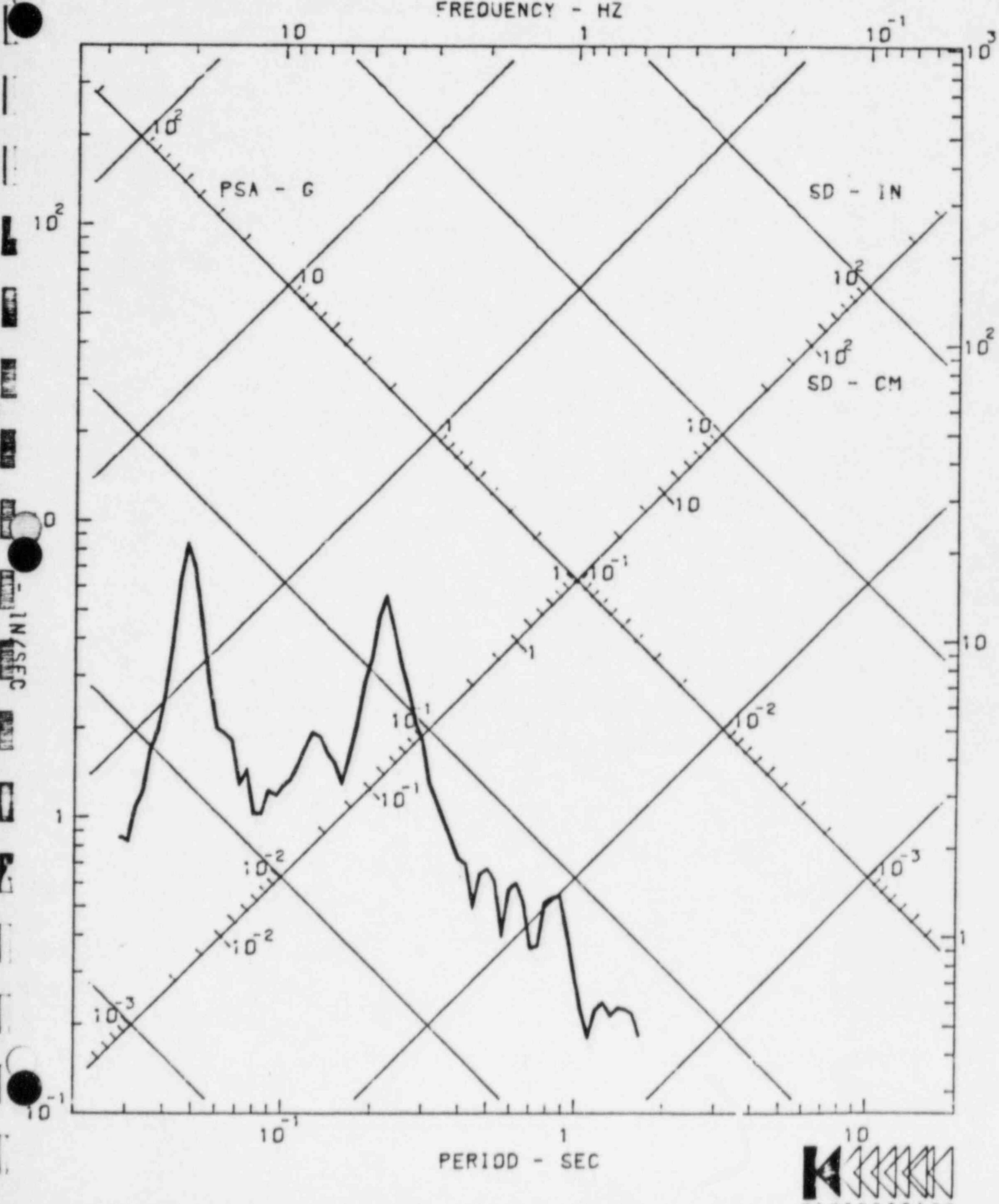
DAMPING VALUES ARE 2 PERCENT OF CRITICAL



ML 5.0 EARTHQUAKE JANUARY 31, 1986

11A8002 PERRY NUCLEAR POWER PLANT COMP UP SMA3S/N 165-2V

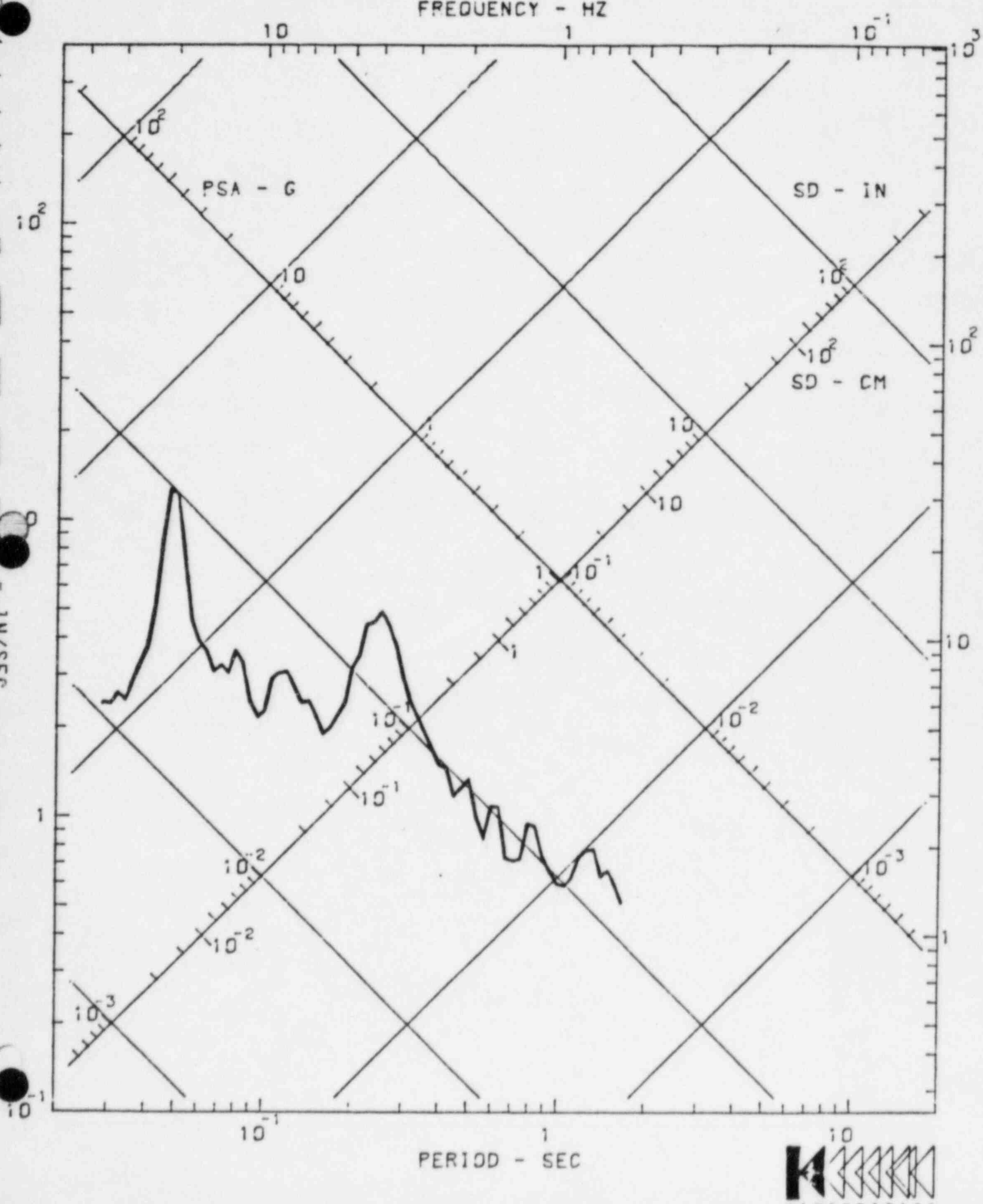
DAMPING VALUES ARE 2 PERCENT OF CRITICAL



ML 5.0 EARTHQUAKE JANUARY 31, 1986

IIA8002 PERRY NUCLEAR POWER PLANT COMP SOUTH SMA3S/N 165-2L

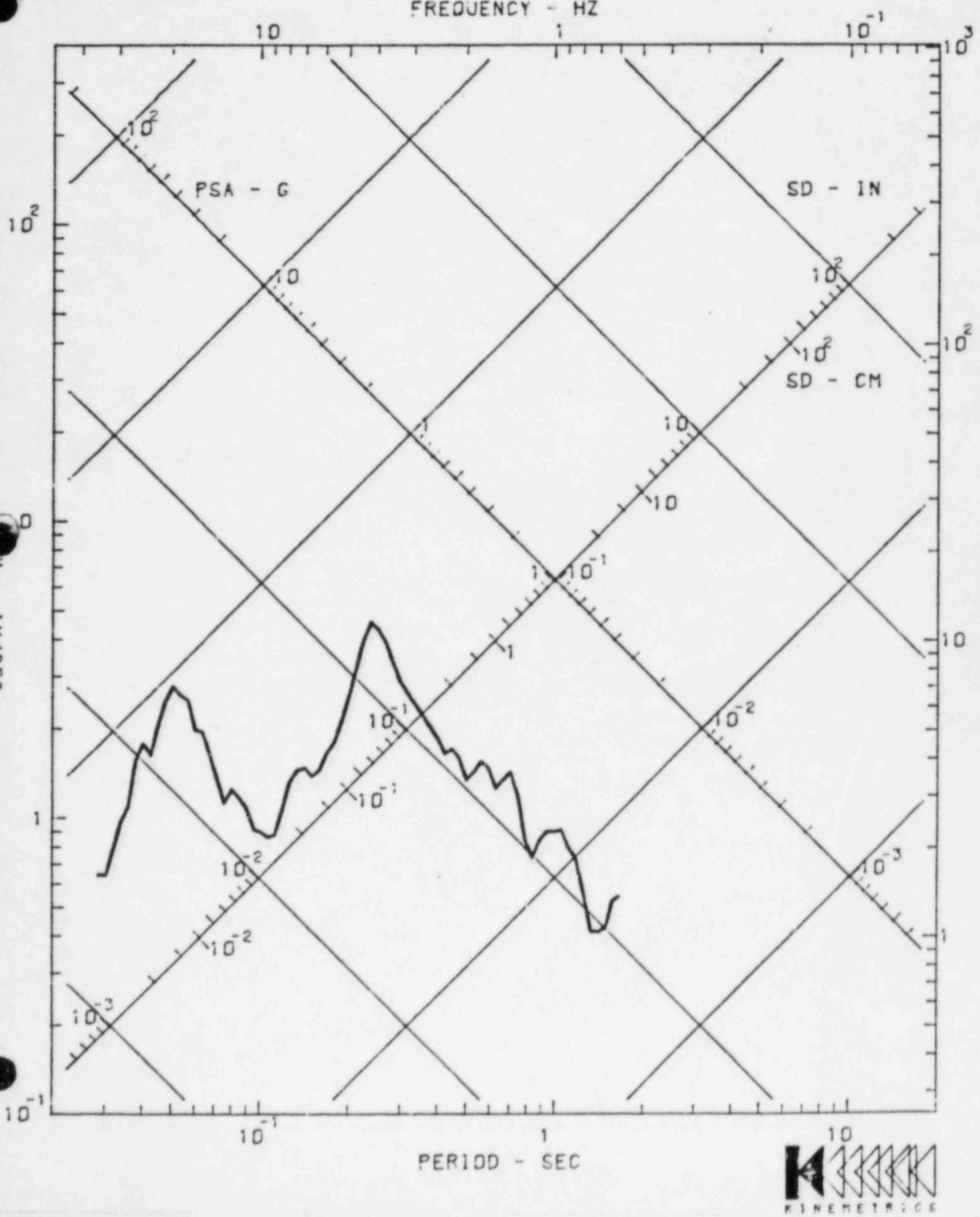
DAMPING VALUES ARE 4 PERCENT OF CRITICAL



ML 5.0 EARTHQUAKE JANUARY 31, 1986

IIA8002 PERRY NUCLEAR POWER PLANT COMP WEST SMA3S/N 165-2T

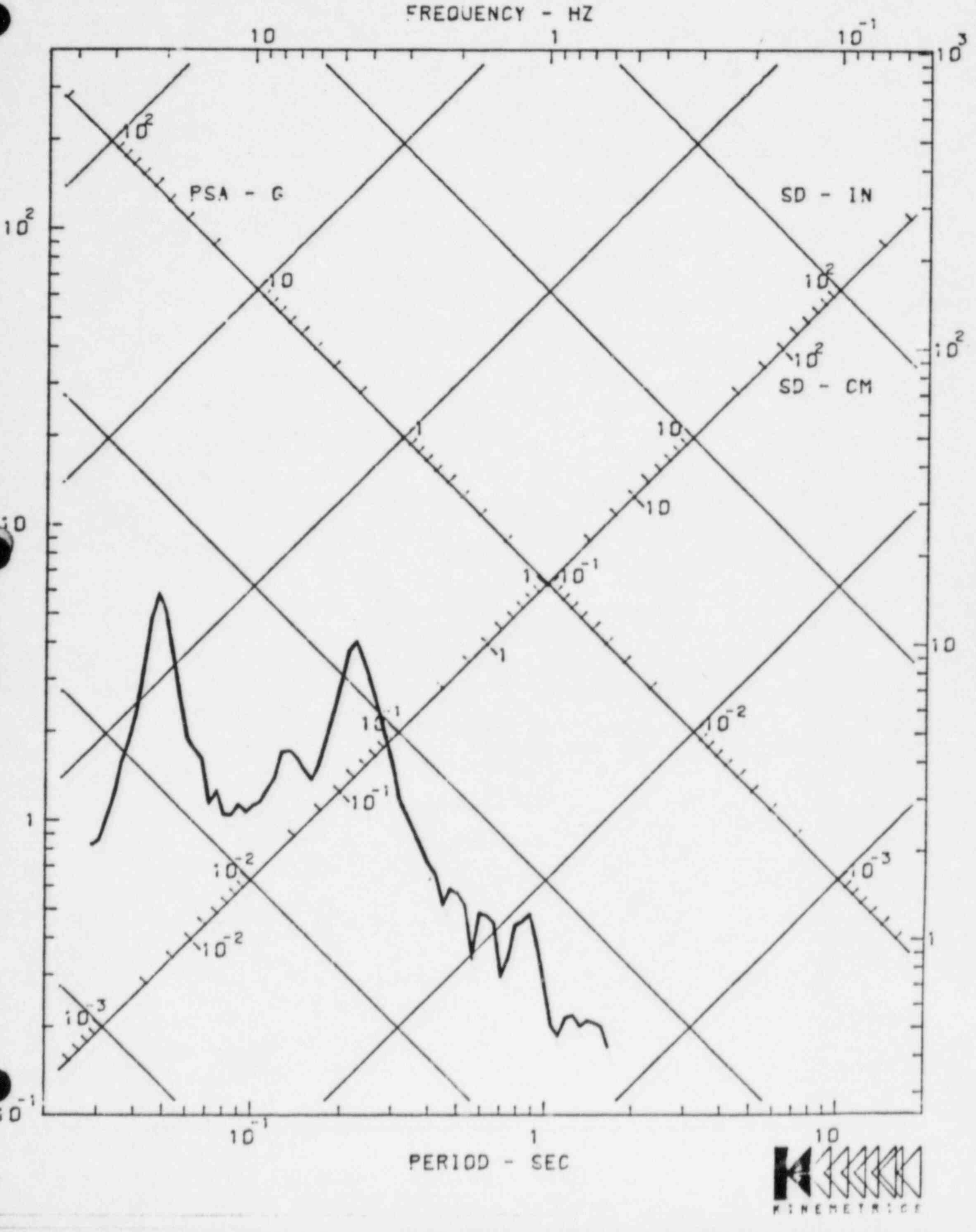
DAMPING VALUES ARE 4 PERCENT OF CRITICAL



ML 5.0 EARTHQUAKE JANUARY 31, 1986

11A8002 PERRY NUCLEAR POWER PLANT COMP UP SMA3S/N 165-2V

DAMPING VALUES ARE 4 PERCENT OF CRITICAL



APPLICATION NOTE

Conditioning and Correction of Strong Motion Data on Analog Magnetic Tapes

No. 7

Kinemetrics has developed programs for routine computer processing of data recorded on the analog magnetic tape accelerographs, Models SMA-2 and SMA-3. The software from published research for film recording accelerographs (Trifunac & Lee, 1973) has been adapted to the analog magnetic tape recording instruments.

Magnetic tape is used where rapid playback and analysis of data are required. These accelerographs are normally located at large engineered facilities, such as nuclear power plants. Figure 1, "Kinemetrics Earthquake Data Reduction System Flow Diagram," illustrates the specialized services needed to prepare data immediately after an earthquake.

The purpose of this Note is to describe the standard data conditioning and correction used to prepare accelerograms for subsequent response spectrum or time-series analysis. On Figure 1 are references to the following paragraphs: 1.0--Data Playback, 2.0--Analog-to-Digital Conversion, 3.0--Data Conditioning, and 4.0--Data Correction.

There are two "tape speed" errors in all FM analog recording/playback systems. One "error" is a change in apparent amplitude due to unwanted tape speed changes. Correction of this error is called "amplitude compensation". This is shown in Figure 2 and described in Sections 1.0 and 3.0. The second "error" is a change in apparent length of the earthquake due to different tape speeds during recording and playback. Correction of this error is called "time base compensation". This is shown in Figure 3 and described in Section 2.0.

1.0 Data Playback

1.1 The playback system is a Model SMP-1 (Figure 4). If the SMP-1 is used to play out the SMA-2 or SMA-3 tapes, the signals

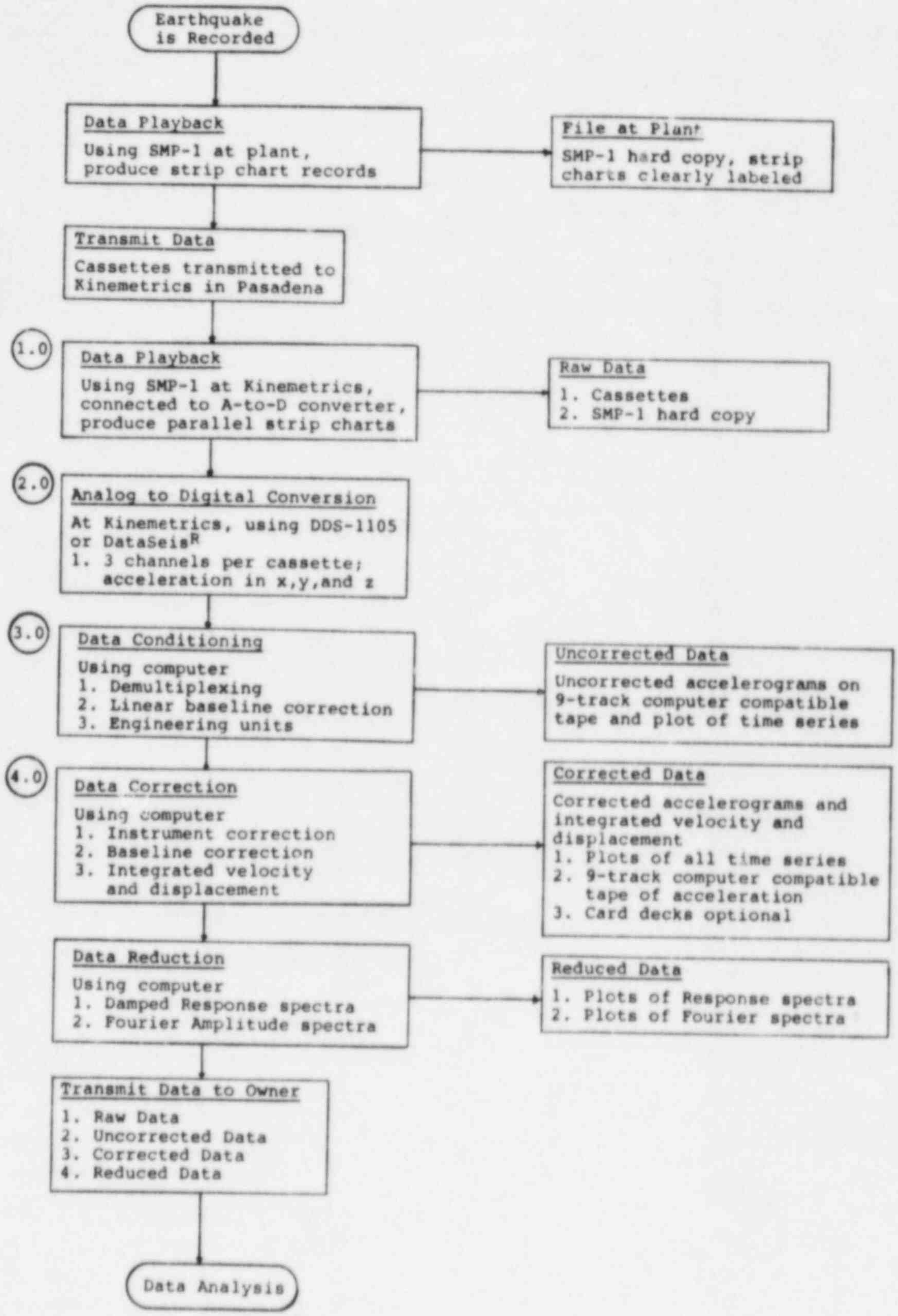


FIGURE 1 Flow Diagram for Kinemetrics E.D.R.S. (Earthquake Data Reduction Sequence)

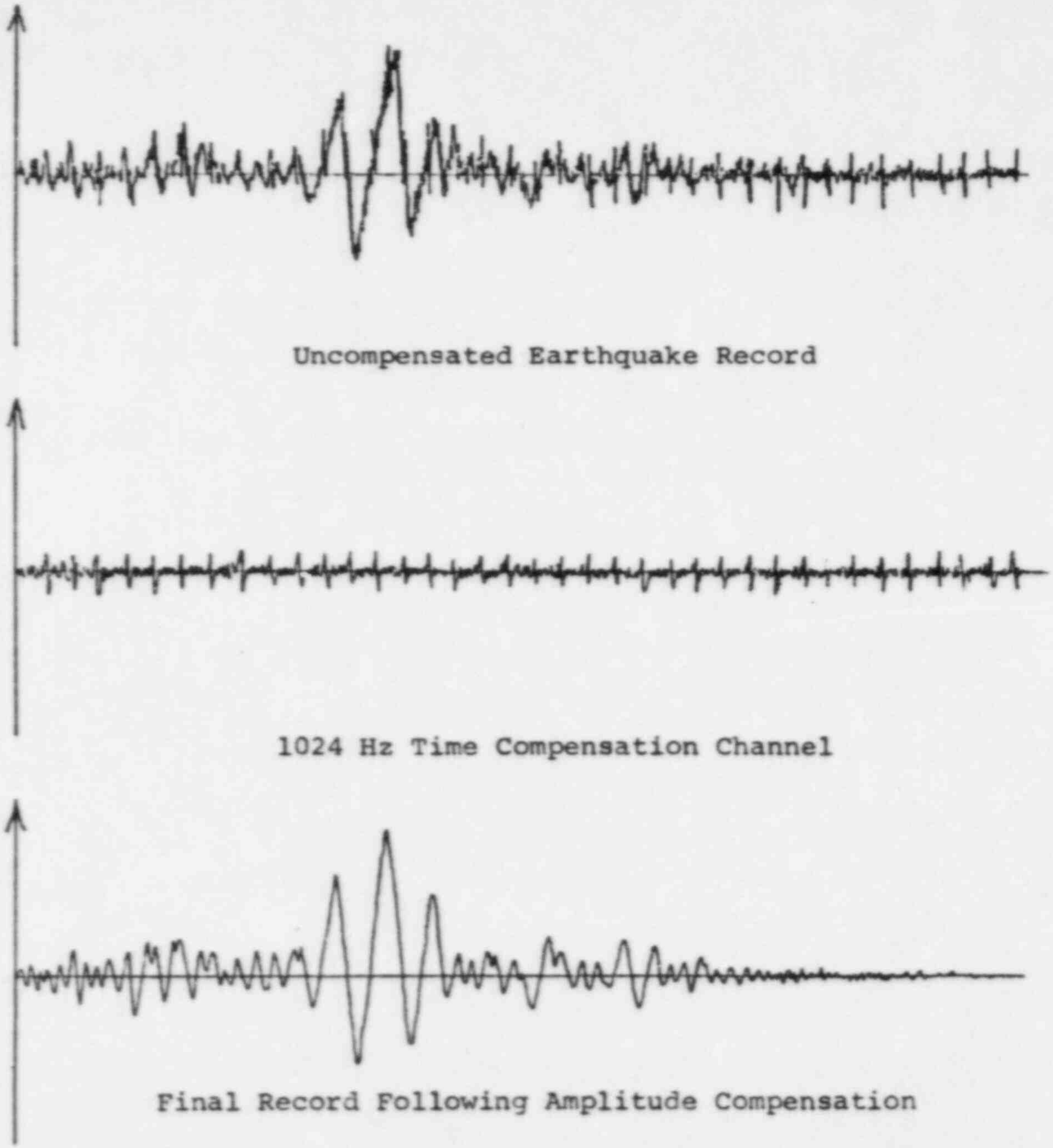


FIGURE 2 Amplitude Compensation

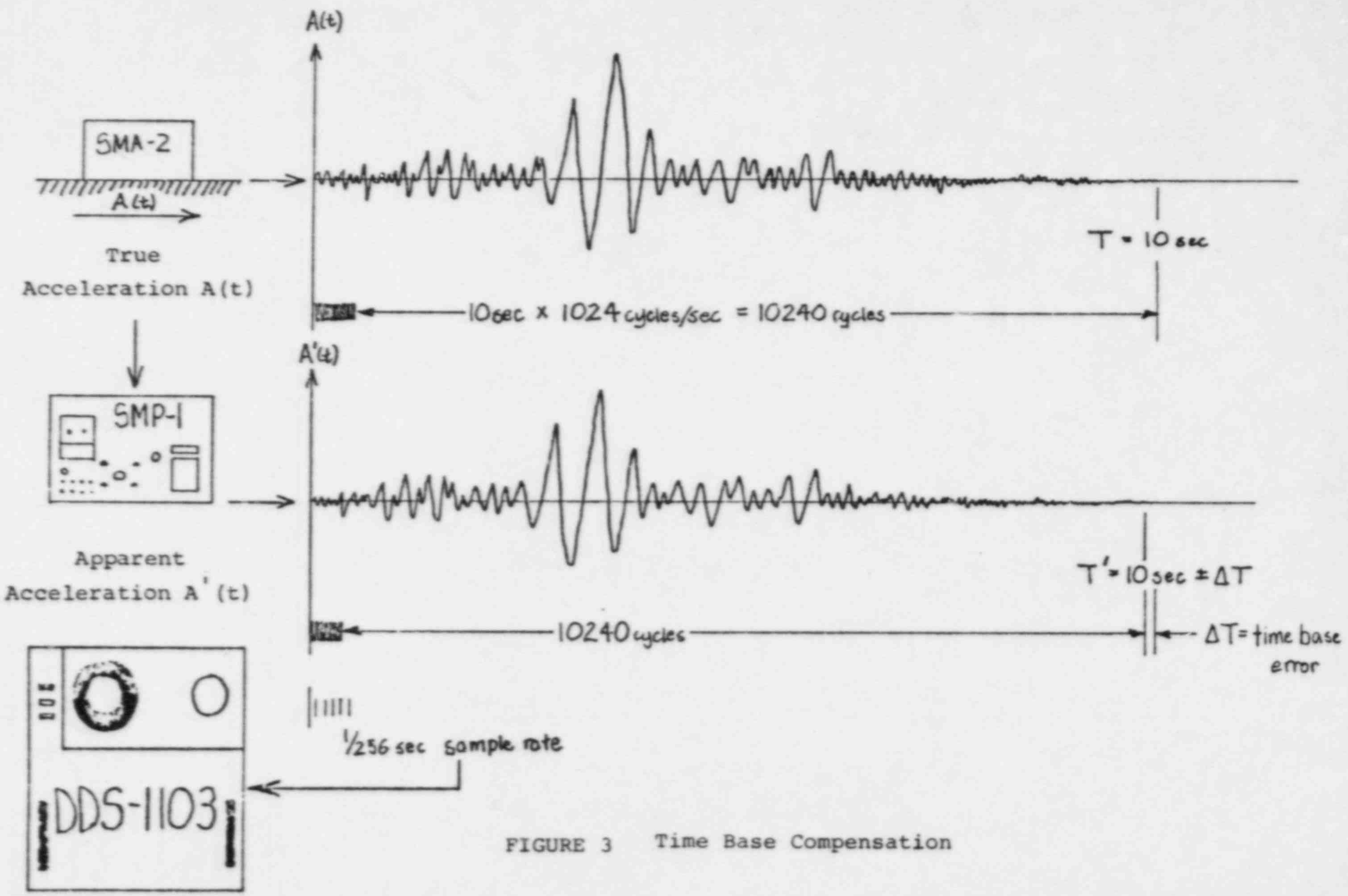
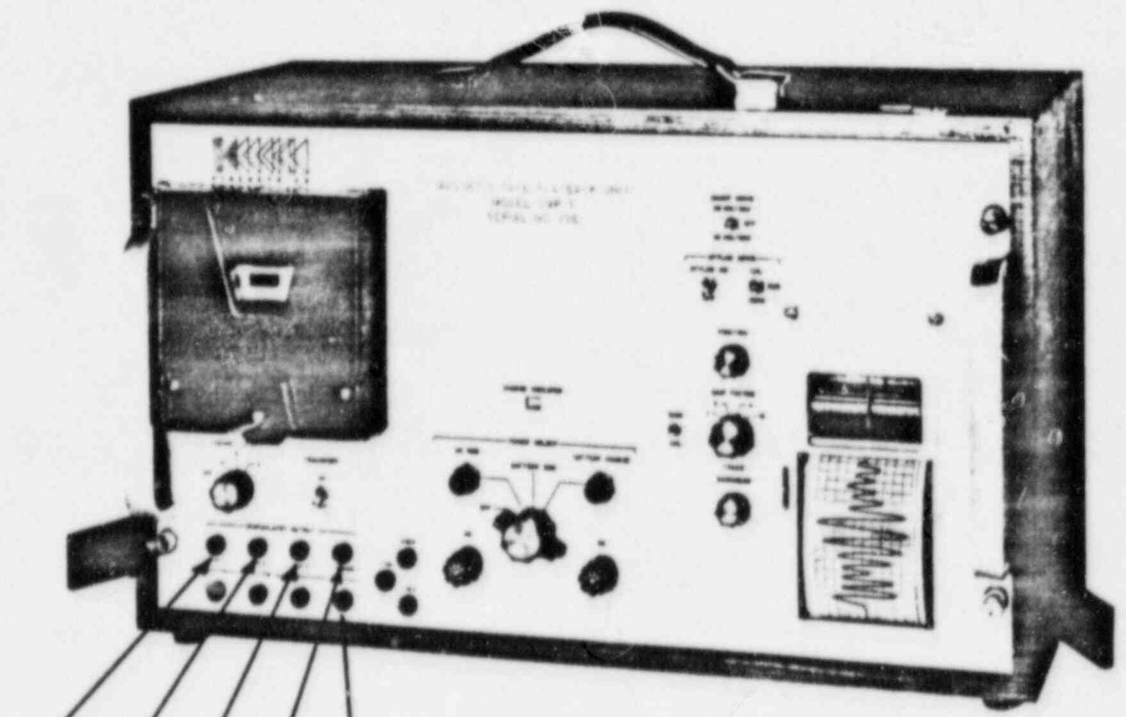


FIGURE 3 Time Base Compensation

SMP-1

Magnetic Tape Playback System

FIGURE 4



(1) (2) (3) (4) (5)

The SMP-1 is a versatile magnetic tape playback system designed for use with the Kinemetrics SMA-2 and SMA-3 Magnetic Tape Acceleration Systems. The combination of the SMA-2 or SMA-3 Acceleration Systems with the SMP-1 Magnetic Tape Playback System meets the applicable requirements of US NRC Regulatory Guide 1.12, and provides immediate visual playback capability of recorded acceleration data.

The SMP-1 is portable and may be operated either from 110 Vac or internal rechargeable batteries. Optionally the unit may be mounted in a standard 19-inch cabinet. An internal battery charger is included with the unit.

which appear on the chart recorder are amplitude compensated.

1.2 The electrical outputs taken from the DEMODULATED OUTPUT jacks (Channels 1, 2, or 3 of Figure 4) are not amplitude compensated. However, Kinemetrics has an electronic Data Compensator which plugs into an SMP-1.

If this Data Compensator is used, the electrical signals are amplitude compensated by electronic subtraction of Channel 4 from Channels 1, 2, and 3. The Data Compensator should be used if the signals are to be recorded on a three-channel strip-chart recorder for display. The signals are not time base compensated.

1.3 If the signals are to be processed on a computer, there are two options:

1.3.1 Use the Data Compensator for amplitude compensation.

1.3.2 Without a Data Compensator, have software perform amplitude compensation.

2.0 Analog-to-Digital Conversion

The following steps are taken at Kinemetrics using the SMP-1 connected to the Analog-to-Digital Converter, Model DDS-1105 or DataSeis[R].

2.1 Three (3) analog outputs of the SMP-1 with Data Compensator are digitized simultaneously: longitudinal, transverse, and vertical (Channels 1, 2, 3 of Figure 4). A 12-bit analog-to-digital converter is used with normal full scale of ±5 volts.

2.2 The FM Time reference output (Channel 5 of Figure 4) is 1,024 Hz plus or minus tape speed error. This signal is divided down by four (256 Hz ± deviation) and used as the timing signal for the digital conversion time interval. Thus, the accelerogram time base is corrected for tape speed error and the voltage values are equally spaced at 1/256 second. This is "time base compensation" and can be done on analog-to-digital converters other than DDS-1105 or DataSeis[R].

2.3 The final uncorrected accelerograms are written on 9-track computer-compatible tape. The three channels are multiplexed (i.e., 1, 2, 3, 1, 2, 3, 1, 2,...), and are in a 16-bit, offset binary format.

3.0 Data Conditioning

Figure 5 illustrates the flow of the "Data Conditioning" software. Tape speed variations during recording and during playback of FM analog tape change the apparent time base and affect the analog amplitude. The time base has been compensated in the previous section by using the FM time reference output (Channel 5 of Figure 4) as the timing signal for the analog-to-digital converter. The amplitude has been compensated using the Data Compensator module.

The output accelerograms are uncorrected in the sense that no modifications have been introduced which involve any hypothesis of the ground motion character or of the instrument involved.

4.0 Data Correction

Figure 6 illustrates the flow of the "Data Correction" software. The purpose is to present corrected acceleration data and integrated ground velocity and displacement curves in as accurate a form and over as wide a frequency range as is compatible with the original data. The modified data is believed to be the most accurate form of input data feasible to produce from the original record for structural response calculations and for response spectrum determinations.

Instrument correction is introduced to compensate for the accelerometers' frequency response. The Caltech publication EERL 71-05 discusses the approach used. The baseline correction uses an Ormsby high-pass filter. The technique is explained in Caltech publication EERL 70-07.

Figure 7 contains a sample output plot of corrected data for one component of the Santa Barbara earthquake of 13 August 1978, recorded on a SMA-2 accelerograph.

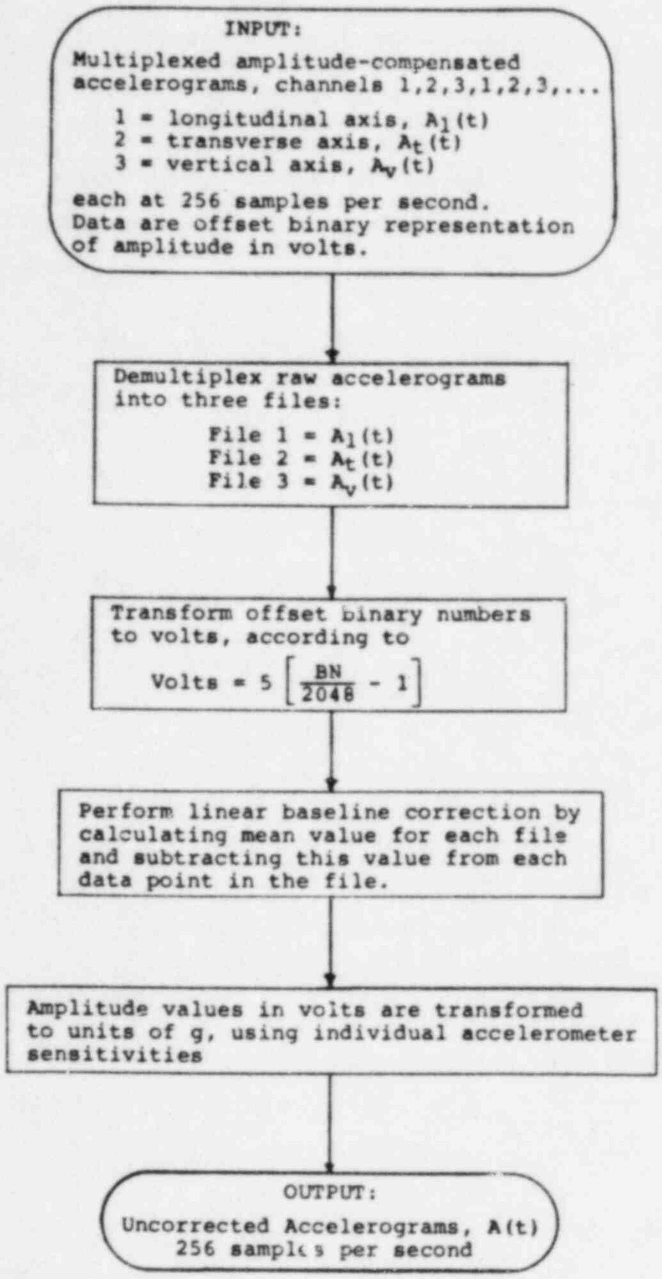


FIGURE 5

Data Conditioning, E.D.R.S.

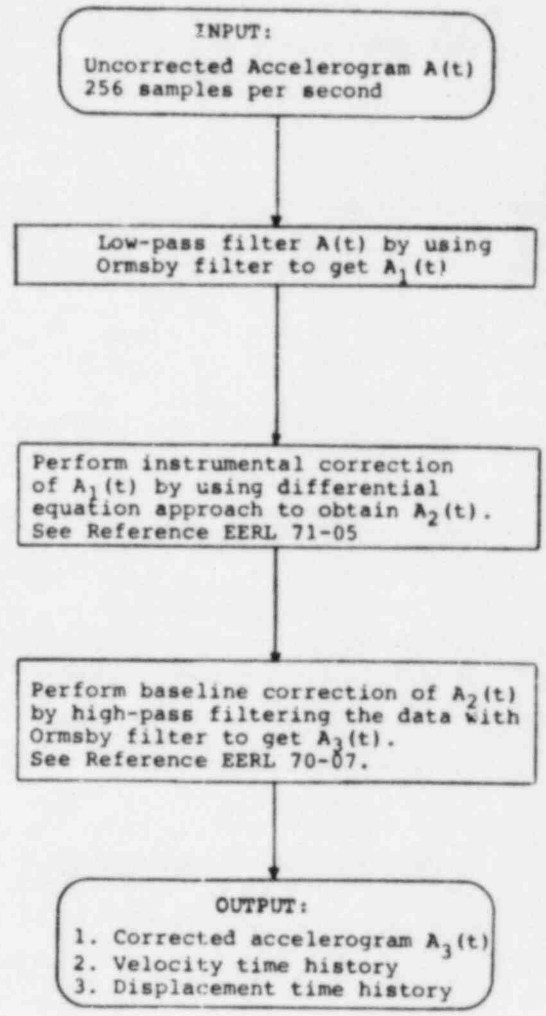
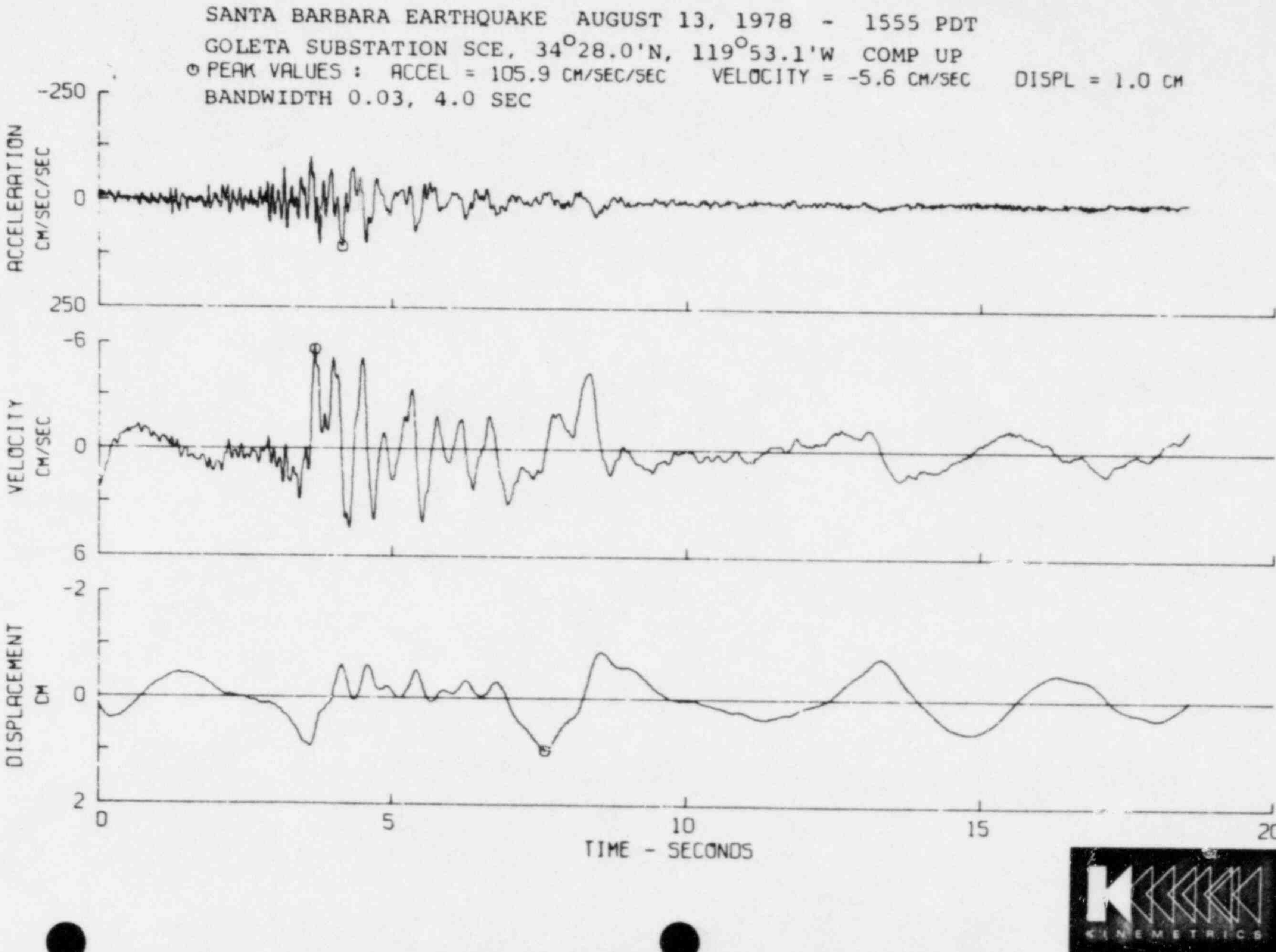


FIGURE 6

Data Correction, E.D.R.S.

FIGURE 7


SANTA BARBARA EARTHQUAKE AUGUST 13, 1978 - 1555 PDT
GOLETA SUBSTATION SCE, 34°28.0'N, 119°53.1'W COMP UP
PEAK VALUES : ACCEL = 105.9 CM/SEC/SEC VELOCITY = -5.6 CM/SEC DISPL = 1.0 CM
BANDWIDTH 0.03, 4.0 SEC
ACCELERATION CM/SEC/SEC
-250
0
250
VELOCITY CM/SEC
-6
0
6
DISPLACEMENT CM
-2
0
2
0
5
10
15
20
TIME - SECONDS
KINEMETRICS

REFERENCES

Trifunac, M. D. (1970). Low Frequency Digitization Errors and a New Method for Zero Baseline Correction of Strong-Motion Accelerograms, Earthquake Engineering Research Laboratory, EERL 70-07, pgs. 32-52, California Institute of Technology, Pasadena

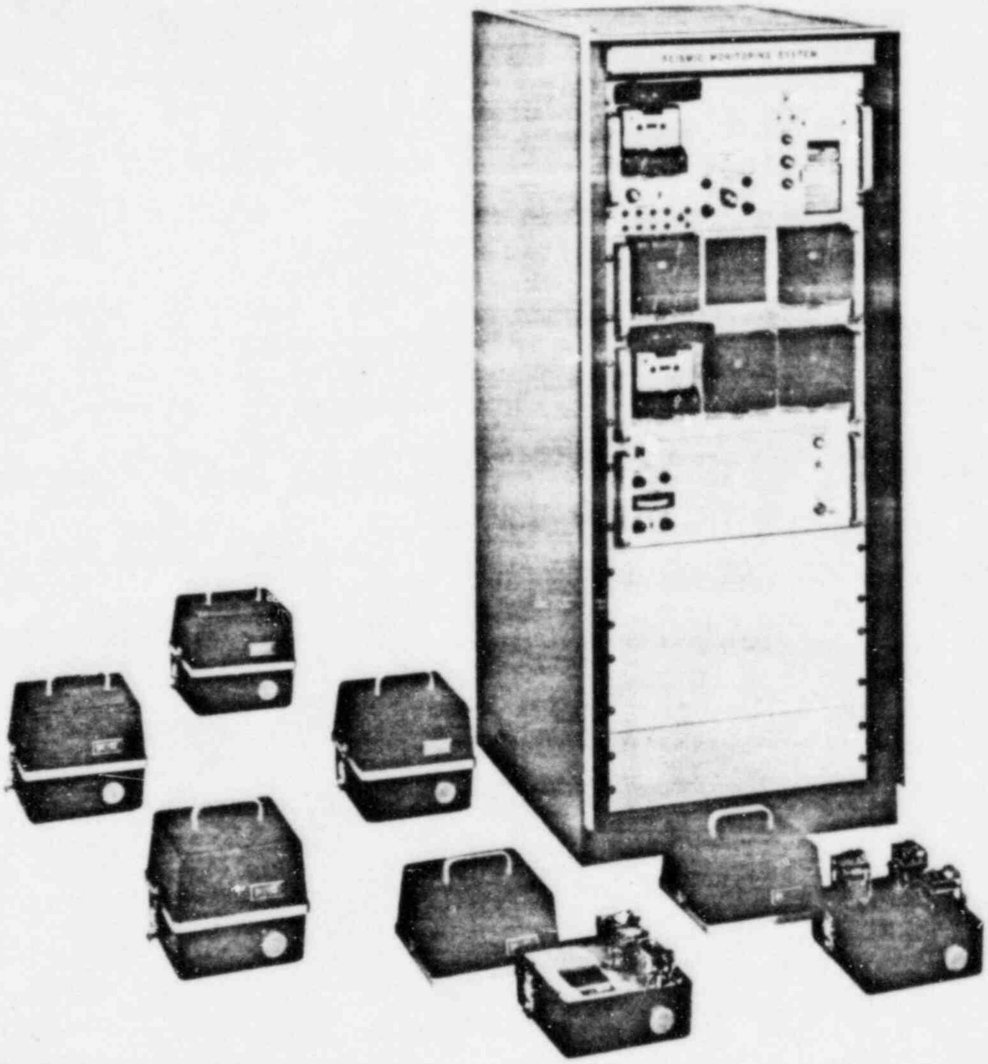
Trifunac, M. D., F. E. Udwadia and A. G. Brady (1971). High Frequency Errors and Instrument Corrections of Strong-Motion Accelerograms, Earthquake Engineering Research Laboratory, EERL 71-05, pgs. 33-47, California Institute of Technology, Pasadena

Trifunac, M. D. and V. Lee (1973). Routine Computer Processing of Strong-Motion Accelerograms, Earthquake Engineering Research Laboratory, EERL 73-03, California Institute of Technology, Pasadena

KINEMETRICS SYSTEMS

SMA-3

Strong Motion Acceleration System



The SMA-3 is a multi-channel, centralized recording, magnetic tape accelerograph system designed to detect and record strong local earthquakes. Typical structural applications include nuclear power plants, tall buildings, dams, offshore platforms and bridges. The SMA-3, used with the companion SMP-1 Playback System, meets the requirements of U.S. NRC Regulatory Guide 1.12 and is being used at over 90 nuclear power plants around the world.

An SMA-3 can accommodate up to 27 channels of acceleration data, usually from triaxial force balance accelerometers, Model FBA-3. Downhole triaxial sensors (FBA-13DH) can be installed, and uniaxial and biaxial accelerometers may also be used. The sensors may be located up to 1500 feet from the central recorder. The TS-3 triaxial seismic trigger is standard with any SMA-3 system. The SMA-3 comes supplied with two cassettes per recording section, and all mounting hardware and mating connectors for the specified number of triggers and accelerometers.

KINEMETRICS / SYSTEMS, 222 VISTA AVENUE; PASADENA, CA 91107 (818) 795-2220; TELEX 67-5402 KMETRICS PSD

GENERAL DESCRIPTION

The SMA-3 is a versatile multi-channel acceleration recording system. It is self-actuating when a local earthquake exceeds a predetermined level of ground acceleration. When acceleration falls below the preset value, the SMA-3 automatically returns to the standby condition.

The standard FBA-3 triaxial accelerometer package is approximately a 20 centimeter cube. It contains three force-balance acceleration sensors. The accelerometer package accepts calibration commands for damping and natural frequency.

Each accelerometer signal is buffered, frequency modulated, and recorded on an assigned track of a four-track magnetic tape cassette. Three tracks are used for acceleration data and the fourth for a timing signal, which is common for all recording tape transports in the system.

TECHNICAL SPECIFICATIONS

SEISMIC TRIGGERS (Model TS-3)

Type: Triaxial acceleration trigger
Housing: Cast aluminum, waterproof
Set Point: 0.01g standard; field adjustable, 0.005g to 0.05g
Option: Adjustment range of 0.025g to 0.25g
Current Drain: 0.45 mA in standby; 60 mA operating

TRANSDUCERS (Model FBA-3)

Type: Force balance accelerometers
Housing: Cast aluminum, waterproof
Bandwidth: 0 to 50 Hz
Range: ± 1g full scale
Output: ± 2.5 V full scale
Damping: 70% of critical
Natural Frequency: 50 Hz
Calibration: Damping and natural frequency recorded by command
Temperature Range: —20° to 70° C (0° to 160° F)
Temperature Effects: ± 1.5% of full scale over operating range

RECORDING SYSTEM

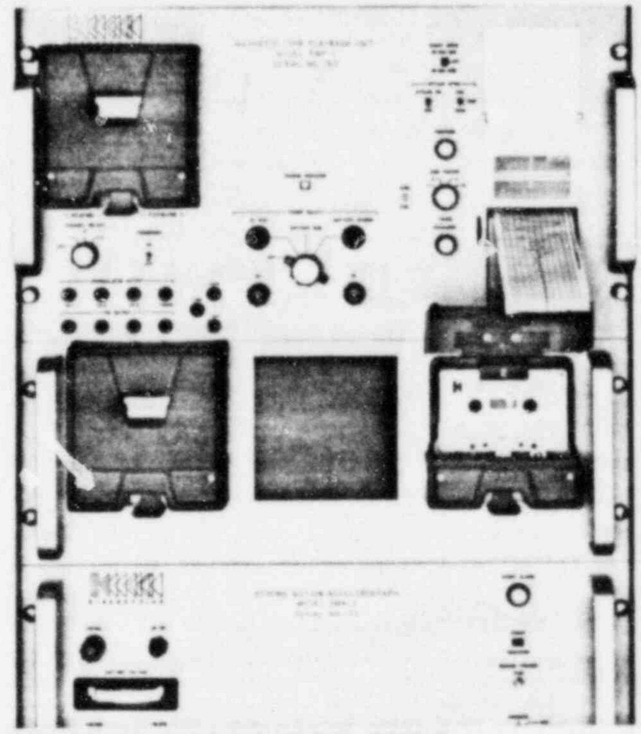
Type: Frequency modulation
Tape: Four track magnetic tape cassette
Tape Speed: 1-7/8" per second
Recording Time: 30 minutes
Bandwidth: 0 to 50 Hz
Dynamic Range: 40 dB from 15° to 35° C (with SMP-1)
Modulation Frequency: 1000 Hz ± 50% modulation.
Timing Frequency: 1024 Hz ± 0.2%
System Accuracy (with SMP-1): ± 5% at full scale, changing linearly to 1.5% of full scale at 0.01g
Start-up Time: Less than 0.1 seconds
Event Alarm: Normally open contacts, rated 1 amp @ 12 Vdc.
Event Indicator: Electromagnetic visual display

POWER SUPPLY

Two 12 V internal, rechargeable batteries. An internal battery charger, operating from 110 Vac, is supplied.

OPERATING ENVIRONMENT

Temperature: 0° to 55° C (30° to 130° F)
Humidity: Remote packages, 100% R.H.
Cabinet mounted panels, 80% R.H. non-condensing



ORDERING INFORMATION, SMA-3

Kinemetrics Part Number: 101100
Strong Motion Acceleration System, including:

One triaxial seismic trigger, Model TS-3
Specify triggering threshold (0.01g standard)
Specify number of additional triggers if desired

Up to nine triaxial acceleration sensors, Model FBA-3; 1.0g full scale
Cost Option—Model FBA-11 uniaxial sensor
Cost Option—Model FBA-13DH downhole triaxial sensor
Option—Range 0.25g, 0.5g, 2.0g full scale
Specify number and type of sensors, up to 27 channels

Up to nine triaxial tape recording modules, with cassettes
Cost Option—Flame resistant wiring
Specify number of channels, up to twenty-seven

Control/Power Panel
Cost Option—Conversion to 220 Vac

Accessories:

Interconnecting Cables for seismic trigger(s)
Cost Option—Flame retardant cable
Specify lengths required, up to 1500' to each trigger

Interconnecting Cables for remote accelerometers
Cost Option—Flame retardant cable
Specify lengths required, up to 1500' to each sensor

19-Inch Rack Mounting Cabinet
Cost Option—Seismically braced cabinet

Tape Playback, Model SMP-1 (see SMP-1 data sheet)

Spares and Supplies:
Magnetic Tape Cassettes, Part #700030
Desiccant Envelopes, Part #700049
12 V Batteries (pair), Part #103413

APPENDIX B

REPORT ON THE PEAK SHOCK RECORDERS AND PEAK ACCELERATION RECORDERS INSTALLED AT THE PERRY NUCLEAR POWER PLANT DURING THE SEISMIC EVENT ON JANUARY 31, 1986 ENGDAHL ENTERPRISES

ENGDAHL ENTERPRISES 2850 Monterey Avenue, Costa Mesa, California 92626, (714) 540-0398

REPORT ON THE PEAK SHOCK RECORDERS AND PEAK ACCELERATION RECORDERS INSTALLED AT THE PERRY NUCLEAR POWER PLANT DURING THE SEISMIC EVENT ON JANUARY 31, 1986

Copy Number 04

Engdahl Enterprises
Costa Mesa, CA 92626

February 7, 1986

CONTENTS

1. INTRODUCTION

On January 31, 1986, the effects of a seismic event were recorded by the Engdahl PSR1200, Peak Shock Recorders and PAR400, Peak Acceleration Recorders at the Perry Nuclear Power Plant located at Perry, Ohio. The record plates were removed from the recorders within hours and new plates were installed by Perry Plant and Engdahl personnel. A preliminary data reduction was completed the same day. A second independent data reduction was made on February 2, 1986. Photographs of all of the scribed records were made on February 2-3, 1986.

This report reviews the status of the instruments at the time of the event, contains the recorded data, and evaluates the data. The report also reviews the present status of the recorders and work to be done in the near future.

2. INSTRUMENT DESCRIPTIONS

2.1 PEAK SHOCK RECORDER (Response Spectrum Recorder and Response Spectrum Switch)

The Model PSR1200-H/V, Peak Shock Recorder, is designed to meet the characteristics of the Response Spectrum Recorder and the Response Spectrum Switch as described in the American Nuclear Society Standard ANSI/ANS-2.2-1978, "Earthquake Instrumentation Criteria for Nuclear Power Plants", and NRC Regulatory Guide 1.12 (Rev. 1), "Instrumentation for Earthquakes". It is a completely passive device covering the range of 2-25 HZ in 1/3 octave increments. Damping of each accelerometer is nominally 2%. It is completely self contained. Three recorders are arranged triaxially.

Twelve reeds of different lengths and weights, one for each frequency, are fabricated from spring steel. A diamond-tipped stylus is attached to the free end of each reed to inscribe a permanent record of its deflection on one of twelve record plates. The record plates are aluminum, plated with successive layers of nickel, tin, and lead-tin.

The Model PSR1200-H/V-12A comprises the standard PSR1200-H/V plus the capability of providing instantaneous warning signals when preset accelerations at selected frequencies have been exceeded. This is achieved by adding dual contacts which are closed by the reed when it is deflected through a predetermined distance.

2.2 PEAK ACCELERATION RECORDER (Peak Accelerograph)

The Model PAR400, Peak Acceleration Recorder, is designed to meet the characteristics of the Peak Accelograph described in ANSI/ANS-2.2-1978 and NRC Regulatory Guide 1.12. It senses and records peak accelerations triaxially. It is a self-contained passive device requiring no external power or control connections and has a minimum band width of 0 to 26 Hertz with a sensitivity as low as .01 g. The recorder is nominally 60% damped. A diamond tipped scriber at the end of an amplifier arm traces a very fine visible permanent record on an aluminum record plate with successive layers of nickel, gold, and burnt gold.

3. DESIGNATIONS, LOCATIONS, AND CALIBRATION STATUS OF INSTRUMENTS

3.1 D51-R160 - REACTOR BUILDING FOUNDATION

Triaxial Response Spectrum Recorder (PSR1200-H/V-12A)
Location - 574' Reactor Building foundation mat, azimuth 210° (see drawing D-811-801 and D-814-663-909)
Active scratch recorder, which alarms on control room panel 1H13-P969, annunciator panel D51-R215
Most recent calibration on 1-14-85. *

3.2 D51-R170 - REACTOR BUILDING I.D W. 630' PLATFORM

Triaxial Response Spectrum Recorder (PSR1200-H/V)
Location - inside Drywell platform - 630', azimuth, 240° (see drawing D-811-605 and D-814-665-910)
Most recent calibration completed on 1-30-86. *

3.3 D51-R180 - HPCS PUMP BASE MAT

Triaxial Response Spectrum Recorder (PSR1200-H/V)
Location - HPCS Pump Room - Auxiliary Building foundation mat 574' (see drawing D-811-701 and D-814-663-911)
Equipment being calibrated on 1-31-86 during earthquake. (North-South and East-West recorders operable).
Previous calibration on 1-14-85. *

* Calibration interval is established at 18 months by ANSI/ANS - 2.2-1978, "Earthquake Instrumentation Criteria for Nuclear Power Plants."

3.4 D51-R190 - RCIC PUMP BASE MAT

Triaxial Response Spectrum Recorder (PSR1200-H/V)
Location - RCIC Pump Room - Auxiliary Building foundation mat 574' (see drawing D-811-702 and D-814-663-912)
Equipment being calibrated on 1-31-86 during earthquake (all recorders operable).
Previous calibration on 1-14-85.*

3.5 D51-R120 - REACTOR RECIRCULATION PUMP

Peak Acceleration Recorder (PAR400)
Location - inside Drywell - 574' elevation. (see drawing D-811-602 and D-814-663-906). Located on recirculation pump B33-C001A.
Most recent calibration 12-4-85.*

3.6 D51-R140 - HPCS PUMP BASE MAT

Peak Acceleration Recorder (PAR400)
Location - Auxiliary Building - 574'
HPCS Pump Room - Auxiliary Building foundation mat 574' (see drawing D-814-633-908 and D-811-701)
Most recent calibration on 1-30-86. *

4. DATA REDUCTION

The following tabulations on Pages 8 through 13, show the initial data reduction made on January 31, 1986 by Perry Plant personnel and a field representative of Engdahl Enterprises. An independent data reduction made by Engdahl Enterprises on February 2, 1986 is listed alongside the initial reduction.

A total of 129 data point readings were tabulated. A comparison of the two independent data reductions indicates a very close correspondence. Most indicate no significant differences. For those cases where differences exist, the greatest differences (with one exception) are on the order of 0.03g. The largest acceleration difference between the two data reductions was 9% (MPL Number D51-R170, reed number 12, vertical). Even in this case, the difference is within tolerances allowed by industry standards.

5. DATA EVALUATION

The record plates from three of the four triaxial PSR1200 recorders had many scratches and some had multiple zero lines which made them difficult to read. This condition was due to construction work in progress since the recorders had been calibrated and installed in January 1985. Although initial review of these plates indicated that data reduction might be questionable, further review (including comparison with data from the Kinemetrics Time-History recorders**) has established the validity of the data reduction.

**Kinemetrics/Systems, "Strong-Motion Data Report for the M_L 5.0 Earthquake of 1147 EST, January 31, 1986" (February 4, 1986)

5.1 D51-R120, Reactor Recirculation Pump and
D51-R140, HPCS Pump Base Mat

The records from these PAR400 recorders were good. D51-R120 had the best records. D51-R140 had poorer zero lines but the results were nonetheless in close agreement with Reactor Building foundation mat data from Kinemetrics Time-History recorder data.

5.2 D51-R160, Reactor Building Foundation

A reading was made for each reed in the horizontal directions. The North/South accelerations were in very close agreement with the response spectrum generated from the Time-History recorder (D51-N101). The East/West did not agree as well but was similar. Only six of twelve vertical data points were readable. All of these values were quite low indicating a low vertical component of acceleration.

5.3 D51-R170, Reactor Building I.D.W. 630' Platform

The most readable of the PSR1200 records were on the Reactor Building I.D.W. 630' Platform. The North/South was especially good with very good zero lines. The East/West and the vertical recorders each had two of twelve records that were difficult to read.

5.4 D51-R180, HPCS Pump Base Mat and
D51-R190, RCIC Pump Base Mat

These two installations are both on the Auxiliary Building foundation mat but separated by approximately 80 feet. The resulting North/South response spectra are almost identical. The East/West response spectra were similar. The vertical D51-R180 recorder was not in service due to recalibration activities, so no comparison can be made. The vertical D51-190 recorder is questionable since the zero lines were offset by large amounts in most cases.

5.5 Dual records were noted on some of the record plates. The clearest of these are on D51-R160, East/West. A separate tabulation is made of the six best records (see page 14). A dual record is normally made when the record plate moves a very slight amount (.001 to .002 inches) after one record is made and then a second record is made. It is possible that all six plates moved at low levels and that the second record is just a continuation of the same event. It is also possible that the low level event was recorded and then the plates moved before the second event.

6. CURRENT STATUS

6.1 At present, the instruments are in operation with new record plates except the vertical recorder, D51-R180, which has been removed for recalibration.

6.2 Plans have been made to start the recalibration of all of the instruments on February 10, 1986. This recalibration is in preparation of fuel loading, and not as a result of the seismic event.

7. CONCLUSIONS

Although the records were not always easy to read because of activity at the plant during the construction phase, the records were clear enough in most cases to give very good overall results. Recalibration of the instruments was not required by the seismic event. Recalibration will be performed starting February 10, 1985 in preparation for fuel loading.

Paul D. Engdahl

cjw

MPL NUMBER: D51-R120
LOCATION: REACTOR RECIRCULATION PUMP

SENSOR LOCATION	ACCELERATION (g)	
	1-31-86	2-2-86
NORTH/SOUTH (L)	.32	.318
EAST/WEST (T)	.10	.106 *
VERTICAL	.07	.048 *

* Zero lines not clear, best estimate

MPL NUMBER: D51-R140
LOCATION: HPCS PUMP BASE MAT - 574'

SENSOR LOCATION	ACCELERATION (g)	
	1-31-86	2-2-86
NORTH/SOUTH (L)	.15	.167
EAST/WEST (T)	.06	.058
VERTICAL	.04	.029

MPL NUMBER: D51-R160
LOCATION: REACTOR BUILDING FOUNDATION - 574'

REED NUMBER	NOMINAL FREQUENCY (HERTZ)	ACCELERATION (g)					
		North/South		East/West		Vertical	
		1-31-86	2-2-86	1-31-86	2-2-86	1-31-86	2-2-86
1	2.00	.027	.027	.029	.030	.007	**
2	2.52	.038	.038	.046	.046	.013	.011
3	3.17	.062	.060	.039	.040	**	**
4	4.00	.032	.035	.022	.026	**	**
5	5.04	.067	.069	.056	.054	**	.018
6	6.35	.065	.075	.054	.054	**	.016
7	8.00	.143	.133	.056	.051	.010	**
8	10.1	.136	.091	.176	.160	.061*	.053*
9	12.7	.196	.227	.236	.230	.032	.038
10	16.0	.286	.305	.284	.284	.101	.111
11	20.2	1.04	1.02	.605	.586	.224	**
12	25.4	.7657	.766	.540	.513	.329	**

* "C" surface
** Unreadable

MPL NUMBER: D51-R170
LOCATION: REACTOR BUILDING I.D.W. 630' PLATFORM - DW 630', 240°

REED NUMBER	NOMINAL FREQUENCY (HERTZ)	ACCELERATION (g)					
		North/South		East/West		Vertical	
		1-31-86	2-2-86	1-31-86	2-2-86	1-31-86	2-2-86
1	2.00	.047	.048	.049	.051	.007	.007
2	2.52	.082	.082	.086	.084	*	.013
3	3.17	.184	.184	.144	.140	.015	.014
4	4.00	.226	.223	.128	.127	.023	.023
5	5.04	.132	.134	.158	.158	.035	.033
6	6.35	.131	.134	.058	.055	.033	.030
7	8.00	.104	.104	.109	.090	*	.019 (2)
8	10.1	.093	.093	*	.052 (1)	.093	.085 (2)
9	12.7	.188	.182	.166	.080 (2)	.198	.199
10	16.0	.194	.204/ .167	.348	.312	.490	.500
11	20.2	.152	.152	.191	.175	.973	.973
12	25.4	.114	.091	.155	.158	1.7	1.54

* Unreadable
(1) Unusual appearance
(2) Very difficult to read - best estimate

MPL NUMBER: D51-R180
LOCATION: HPCS PUMP BASE MAT - 574'

REED NUMBER	NOMINAL FREQUENCY (HERTZ)	ACCELERATION (g)					
		North/South		East/West		Vertical*	
		1-31-86	2-2-86	1-31-86	2-2-86	1-31-86	2-2-86
1	2.00	.0198	.020	.022	.021	-	-
2	2.52	.0358	.036	.033	.031	-	-
3	3.17	.0677	.068	.045	.048	-	-
4	4.00	.0474	.047	.022	.020	-	-
5	5.04	.0637	.064	.033	.029	-	-
6	6.35	.0735	.068	.054	.050	-	-
7	8.00	.0473	.052	.046	.046	-	-
8	10.1	.0744	.074	.566	**	-	-
9	12.7	.125	.149	.182	.176	-	-
10	16.0	.4582	.449	.253	.214	-	-
11	20.2	.9130	.896/ .432	.413	.429	-	-
12	25.4	.6100	.610/ .293	.191	**	-	-

* Not in service
** Unreadable

MPL NUMBER: D51-R190
LOCATION: RCIC PUMP BASE MAT - 574'

REED NUMBER	NOMINAL FREQUENCY (HERTZ)	ACCELERATION (g)					
		North/South		East/West		Vertical	
		1-31-86	2-2-86	1-31-86	2-2-86	1-31-86	2-2-86
1	2.00	.021	.018	.026	.022	**	**
2	2.52	.039 (1)	.030	.031	.021	**	.013
3	3.17	*	*	.024	.017	**	**
4	4.00	.0367	.031	.028	.023	.029	**
5	5.04	.0305	.045	.037	.038	**	**
6	6.35	.0896	.065	.057	.048	**	**
7	8.00	.0750	.040	.068	.034	.019	.014
8	10.1	*	*	.097	.044	**	**
9	12.7	.130	.124	.142	.136	.053	.024
10	16.0	.409	.400	.162	.162	.082	.055
11	20.2	.810	.794	.237	**	**	.099
12	25.4	.556	.557	**	.156	.256	.256

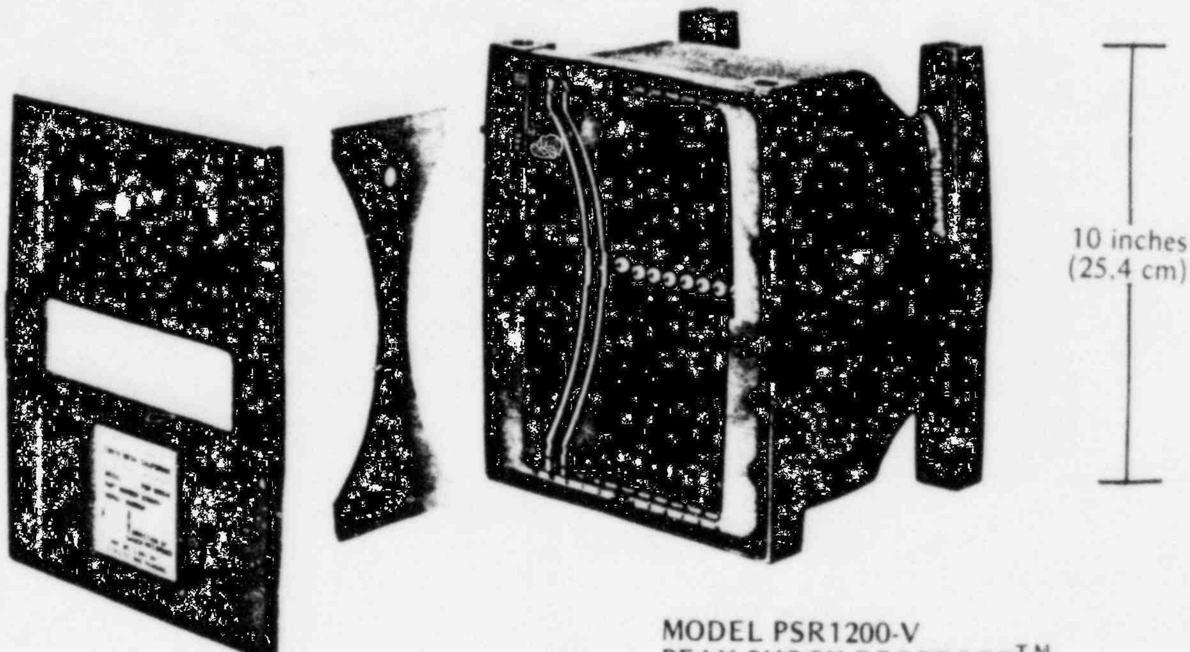
(1) Mathematical error corrected. Originally reported acceleration 0.198.
* Unable to read due to corrosion
** Unreadable

MPL NUMBER: D51-R160
LOCATION: REACTOR BUILDING FOUNDATION - 574'
DUAL RECORDS

REED NUMBER	NOMINAL FREQUENCY (HERTZ)	ACCELERATION (g)					
		North/South		East/West		Vertical	
		1-31-86	2-2-86	1-31-86	2-2-86	1-31-86	2-2-86
1	2.00	-	-	-	.006	-	-
2	2.52	-	-	-	.009	-	-
3	3.17	-	-	-	.010	-	-
4	4.00	-	-	-	.026	-	-
5	5.04	-	-	-	.054	-	-
6	6.35	-	-	-	.035	-	
7	8.00	-	-	-	-	-	-
8	10.1	-	-	-	-	-	-
9	12.7	-	-	-	-	-	
10	16.0	-	-	-	-	-	
11	20.2	-	-	-	-		-
12	25.4	-	-	-	-	-	-

APPENDICES

MODEL PSR1200-H/V-4A and PSR1200-H/V-12A



MODEL PSR1200-V
PEAK SHOCK RECORDER™

SENSES AND PERMANENTLY RECORDS THE SPECTRAL ACCELERATION AT SPECIFIED FREQUENCIES

PROVIDES SIGNALS FOR IMMEDIATE REMOTE INDICATION THAT SPECIFIED PRESET SPECTRAL ACCELERATIONS HAVE BEEN EXCEEDED

- EARTHQUAKES
- STORMS
- EXPLOSIONS

RELIABLE and ECONOMICAL

ENGDAHL ENTERPRISES

2850 Monterey Avenue • Costa Mesa, California 92626 • (714) 540-0398

Introduction

Traditionally, measurement of acceleration has implied measurement with the aid of a device whose resonant frequency was far removed from the frequency range of interest. A typical accelerometer for aerospace applications might have a mass of 10 grams and a resonant frequency of 10 kHz or higher. Such devices were designed primarily for attachment to a structural member to measure its response to shock or vibration. Their low mass was necessary to avoid modifying the characteristics of the device under test, while the resonant frequency had to be at least five times that of the highest frequency of interest. At the other end of the spectrum, earthquakes and other low frequency phenomena are conventionally detected and recorded using instruments whose resonant frequencies are much lower than the frequency range of interest.

A structure such as a large office building, a missile silo or an electrical generating station has many members and subassemblies with a wide range of resonant frequencies, and many of these are lightly damped, i.e., a shock will cause them to "ring" for a relatively long time. To measure the effects of an earthquake or other shock on such a structure in the traditional way, would require a very large number of transducers and a complex data acquisition system followed by computer analysis to digest the raw data and decide whether or not structural damage had been sustained.

To simplify the design of shock resistant structures, dynamicists frequently define shocks and earthquakes in terms of response shock spectra. Basically, a response shock spectrum is a plot of acceleration vs. frequency in which each point represents the peak acceleration experienced by an accelerometer tuned to that specific frequency. The range of frequencies covered by the peak shock accelerometers corresponds to those found in most structures, systems, and components. Since all structural elements possess some low inherent damping, the Peak Shock Recorder™ has been designed with 2% of critical damping. The output obtained is thus directly applicable to structural design and analysis.

A response spectrum may be derived from the conventional acceleration vs. time record of a suitable recording accelerometer, but this involves either digitizing the records followed by computer manipulation of the data or the use of a large amount of auxiliary equipment. The first method is time consuming, while the second is expensive. The Model PSR1200-H/V is an inexpensive instrument requiring no source of power, and virtually no maintenance. It provides a permanent record of data from which the response spectrum may be plotted by a very simple reduction process.

Description

The Model PSR1200-H/V, Peak Shock Recorder™, is a completely passive device covering the range of 2-25 Hz in 1/3 octave increments. Damping of each accelerometer is nominally 2%. It is completely self contained.

Twelve reeds of different lengths and weights, one for each frequency, are fabricated from spring steel. A diamond-tipped stylus is attached to the free end of each reed to inscribe a permanent record of its deflection on one of twelve record plates. A calibration sheet for each recorder lists the resonant frequency and g-sensitivity of each reed.

–V designates a recorder designed for vertical shock recording (compensated for earth's gravitational force). –H designates a recorder designed for horizontal shock recording.

The Model PSR1200-H/V-4A/12A comprises the standard PSR1200-H/V plus the capability of providing instantaneous warning signals when preset accelerations at selected frequencies have been exceeded. This is achieved by adding dual contacts which are closed by the reed when it is deflected through a predetermined distance. Model –4A monitors four selected reeds, while –12A monitors all of the reeds.

Uses

The PSR1200, Peak Shock Recorder™, is useful whenever acceleration measurements are desired at low frequencies. These accelerations may be due to earthquakes, storms, or explosions. The plot of the recorder's twelve individual measurements is the response spectrum of the acceleration to which the recorder was subjected.

The response spectrum switch (–A) version of the PSR1200 is useful whenever remote indications are desired that acceleration limits have been exceeded. The remote indication that four or twelve dual acceleration limits have or have not been exceeded provides immediate information on which to act.

The Peak Shock Recorder™ can be used in connection with:

1. Nuclear power plants
2. Steel mills
3. Refineries
4. Bridges and dams
5. High-rise structures
6. Oil explorations
7. Mines
8. Ships
9. Earth studies
10. Towers

Features

Dzus, quarter-turn fasteners, are used to secure the cover, making it easily removable. The cover is clamped tight enough against the gasket bonded to the watertight housing to provide protection of the unit to 50 PSI (3.6 kg/Cm^2) of water pressure.

The record plates are serialized so only one set of twelve have the same number. In addition, the plates have two types of slots to allow keying. The narrow key slot allows the plate to slide into only one slot in the housing to its full depth. That is, the plates all have to be in their correct locations in the housing to attach the cover.

The record plates can be inserted four different ways into the housing, allowing four records to be made before using a second set of plates. To prevent mixing the records, all plates must be inserted for the record to appear at A, B, C, or D or, again, the cover cannot be attached. A viewing window is provided, and the appropriate letter A through D will show so the cover need not be removed to know how the plates are inserted. During shipping, a red dot is seen. This means that the plates have been removed and the reed support structure is in place.

Additional keying is provided between the covers and housings in the form of dowel pins. These pins prevent the cover from being put on upside down. They also prevent a cover from a horizontal recorder (–H) being put on a vertical recorder (–V) or a –V on a –H.

Since a lower atmospheric pressure could be created inside the recorder than outside during shipment by air, a jackscrew is provided in the cover to lift a corner of the cover and break the partial vacuum. It will also be of assistance when the unit has been closed for a long period of time as the neoprene gasket may adhere slightly to the cover.

The recorder is reliable because of its simplicity. It does not contain any of the more complex and less reliable components, i.e., batteries, connectors, motors, and bearings. Its rugged structure is fabricated from aluminum alloy. Only a few parts are used. The recorder is self-contained, and requires no start-up time.

The recorder is economical in that no external connections or power are required. The record plates are reusable by replating after four records have been obtained. Maintenance is very low since the unit can be unattended for long periods of time. Data reduction is very simple, requiring only one measurement and one multiplication for each record plate to plot its point on the response spectrum.

The response spectrum switch (—A) version of the recorder has all of the features of the PSR1200.

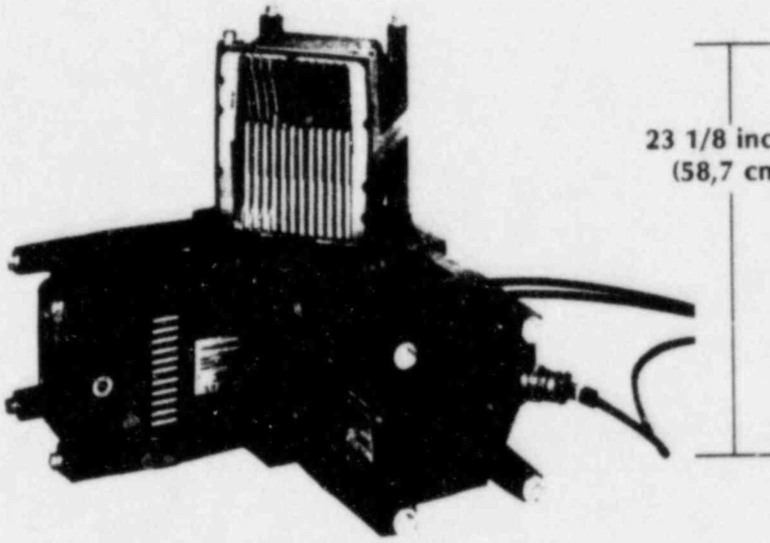
To retain the basic reliability of the PSR1200, no batteries, motors, or bearings have been added. Electrical power is provided from the Peak Shock Annunciator™.

Every effort has been made to achieve the utmost reliability in the switching circuitry so as to match the reliability of the basic Peak Shock Recorder™. Closure of a switch contact sets an electronic latching switch which energizes the appropriate circuit in the annunciator and holds it energized until reset by the key-switch.

High impedance circuitry permits normal operation even if switch contact resistance exceeds several hundred thousand ohms. Ceramic encapsulated integrated circuits offer maximum resistance to the effects of temperature and humidity.

Finally, the heavy cast aluminum housing of the recorder offers protection against radiated interference or spurious mechanical operation caused by striking the recorder.

The recorder can be used singly, biaxially, or triaxially.



TRIAXIAL INSTALLATION OF THREE MODEL PSR 1200-H/V-12A PEAK SHOCK RECORDERS™ ON TRIAXIAL MOUNT

Switch Settings (—A version only)

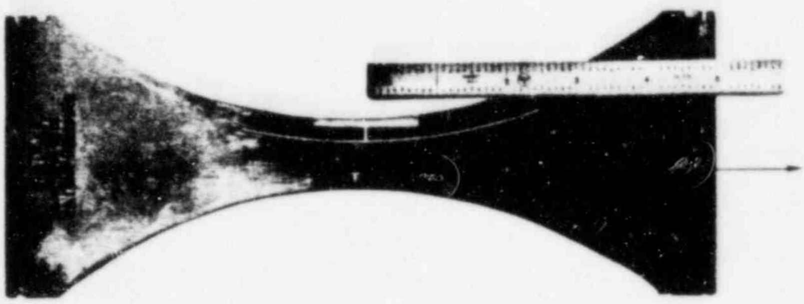
The switch settings are permanently set to positions required by the customer's application. The —4A allows four dual settings, that is, the customer selects four frequencies to be monitored between 2 and 25 Hertz. Two acceleration levels can be selected for switch contacts for each reed frequency, e.g., .47 g and .70 g at 3.2 Hertz. The —12A has twelve dual settings between 2 and 25 Hertz. See the tabulation of "Frequency and Switch Setting Limits" for selection available.

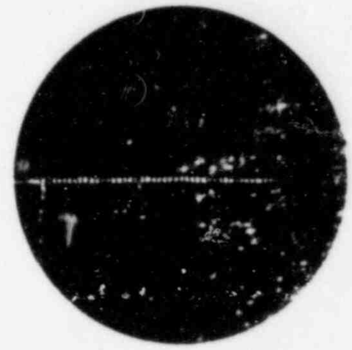
Data Reduction

Data reduction is done by measuring the maximum distance of the scratched record from the zero line. Normally just the maximum is recorded regardless of the direction. List this distance under "Displacement" on the calibration sheet.

Multiply the "Displacement" times the "Acceleration sensitivity" and record in the "Equivalent static acceleration" column. Plot the response spectrum graph.

Large displacement measurements can be made with a six-inch (152 mm) scale with graduations in hundreths (.01) of an inch (.25 mm). Small displacements can be made using a microscope with a reticle having graduations in thousandths (.001) of an inch (.025 mm).



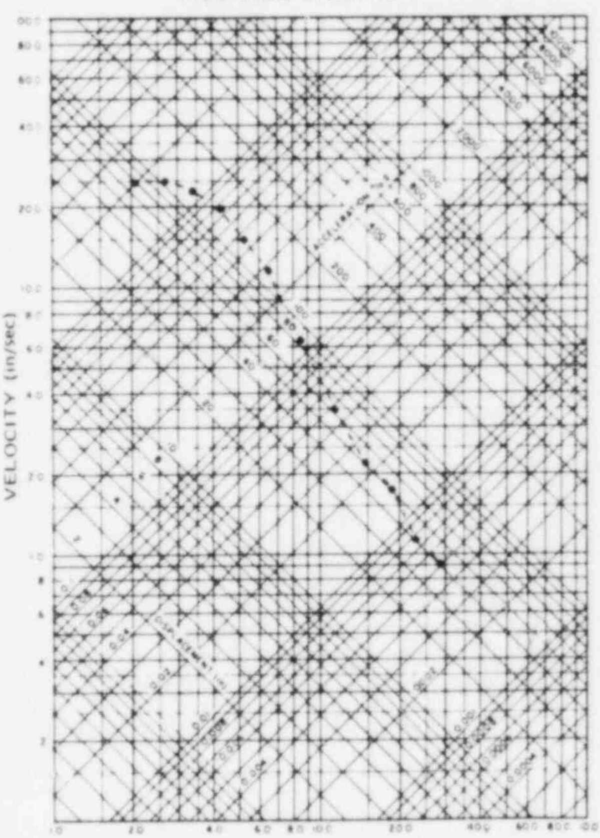


CALIBRATION SHEET AND TEST DATA

Reed Number	Frequency (Hertz)	Acceleration Sensitivity (g/inch)	Displacement (inches)	Equivalent Static Acceleration (g)
1	2.02	.359	2.51	.90
2	2.54	.55	2.00	1.1
3	3.20	.85	1.41	1.2
4	4.02	1.32	.98	1.3
5	4.92	2.34	.55	1.3
6	6.02	3.62	.33	1.2
7	8.08	5.5	.15	.83
8	10.2	7.6	.079	.6
9	12.7	6.6	.078	.5
10	16.2	10.5	.046	.5
11	20.6	17.5	.022	.4
12	26.1	26.8	.015	.4

CALIBRATION — Frequency, Acceleration Sensitivity; DATA REDUCTION — Displacement, Equivalent Static Acceleration

RESPONSE SPECTRUM



PEAK SHOCK RECORDER™

MODELS PSR1200-H/V-4A and PSR1200-H/V-12A

QUALIFIED TO: GUIDE FOR SEISMIC QUALIFICATION OF CLASS I ELECTRICAL EQUIPMENT FOR NUCLEAR POWER GENERATING STATIONS — IEEE GUIDE 344

Designed to meet the characteristics of the Response Spectrum Recorder and the Response Spectrum Switch described in the American Nuclear Society's Standard, ANSI/ANS-2.2-1978, Earthquake Instrumentation Criteria for Nuclear Power Plants and the U.S. Nuclear Regulatory Commission's Regulatory Guide 1.12, Nuclear Power Plant Instrumentation for Earthquakes, Revision 1. NOTE: Frequency range from 2.00 to 25.4, instead of 1.00 to 30.0.

PHYSICAL

Length	12-27/32 inches (32,6 cm)
Width	11-1/2 inches (29,2 cm)
Thickness	10 inches (25,4 cm)
Weight	34 pounds (15,4 kg) 36 pounds (−A) (16,3 kg)

ENVIRONMENTAL

Temperature	−40°C to +85+C
Altitude	To 50,000 feet (15,240 meters)
Humidity	To 100% RH
RFI	No adverse radiated or conducted RFI
Water-Tight	To 50 PSI (3,6 kg/cm²) To 10 PSI (−A) (,7 kg/cm²)
Nuclear Radiation	No effect on performance of permanent recorder. Switch electronics are not radiation hardened, unless requested at extra cost.

SENSORS

Number of Sensing Elements	12
Damping	2% (Q of 25)
Arrangement of Sensing Elements	Coplanar
Number of Switch Contacts	
−4A	4 Dual Contacts
−12A	12 Dual Contacts

ACCURACY

Frequency	±1%
Acceleration	±3% at 1g
Dynamic Range	See Table
Switch Settings	±3% at 1g

MOUNTING

4 through holes for 1/2 inch bolts

FREQUENCY, RANGE, and SWITCH SETTING LIMITS OF SENSING ELEMENTS

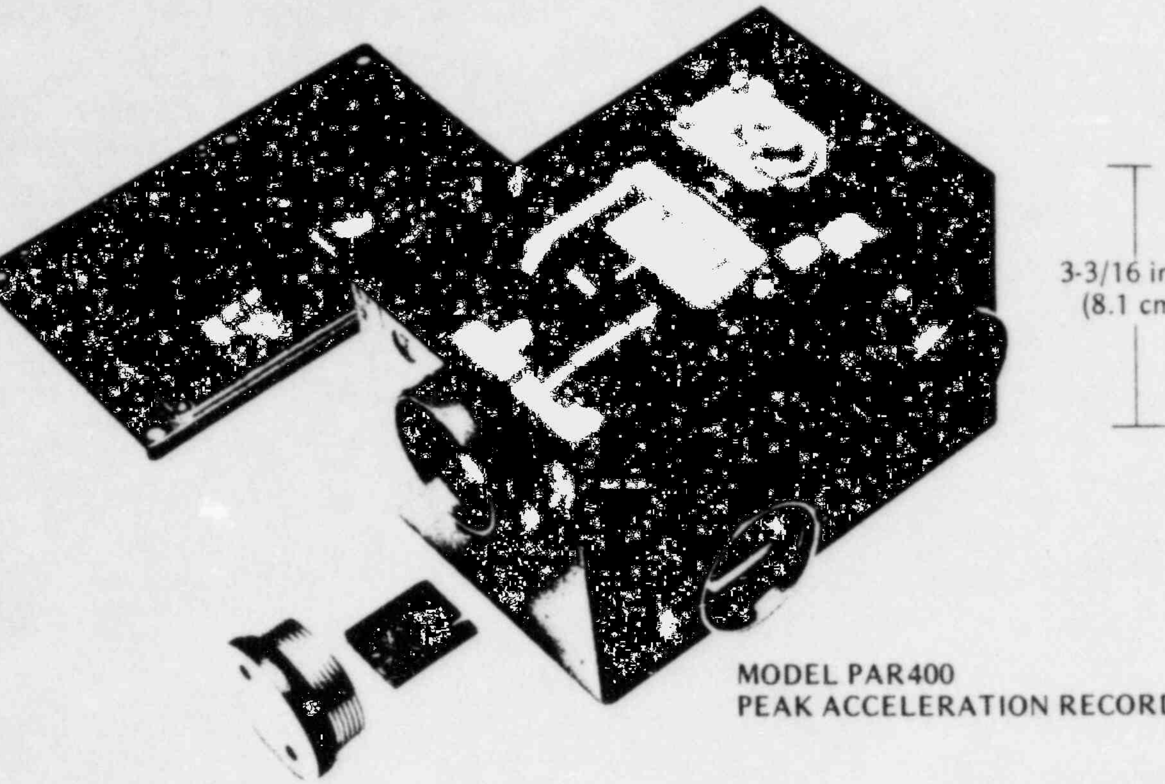
Reed Number	Nominal* Resonant Frequency (Hertz)	Full Scale Acceleration (g)	Dynamic Range		Switch Setting Limits** (g)	
			(db)	Ratio	Minimum*** (Accuracy ±100%)	Maximum (Physical Stops)
1	2.00	1.6	54.5	530:1	.003	1.6
2	2.52	2.5	55.8	620:1	.004	2.5
3	3.17	4	58.1	800:1	.005	4
4	4.00	6	58.7	860:1	.007	6
5	5.04	10	60.9	1110:1	.009	10
6	6.35	16	61.8	1230:1	.013	16
7	8.00	24	63.0	1410:1	.017	24
8	10.1	34	64.6	1700:1	.020	34
9	12.7	8	54.5	530:1	.015	8
10	16.0	12	55.6	600:1	.020	12
11	20.2	4	46.0	200:1	.020	4
12	25.4	6	49.5	300:1	.020	6

* — 4A Allows choice of 4 frequencies to be monitored from 2 to 25 Hertz
— 12A Allows all 12 frequencies to be monitored from 2 to 25 Hertz
** — Two switch settings for each frequency to be monitored.
*** — Do not use PSR1200-H/V-A for settings under 0.10g. For lower settings use RSR1600-H/V-A.

REPRESENTED BY:

1-85-1M 120700B

MODEL PAR400



MODEL PAR400
PEAK ACCELERATION RECORDER™

SENSES AND PERMANENTLY RECORDS PEAK ACCELERATIONS

- EARTHQUAKES
- STORMS
- EXPLOSIONS

RELIABLE and ECONOMICAL

ENGDAHL ENTERPRISES 2850 Monterey Avenue · Costa Mesa, California 92626 · (714) 540-0398

Introduction

Seismic events are random events, and may occur in remote and inaccessible locations or in built-up areas. Scientists and engineers frequently need to know the acceleration levels associated with these events, and for this reason, have developed instruments requiring no source of power, which can provide permanent records of peak acceleration.

Instruments of this type have been used for many years, but with the advent of the nuclear power plant, higher sensitivity and increased bandwidth are required to measure the accelerations induced in piping and other equipment. Since the older types of peak accelerometers had been pushed to their design limits, an entirely new instrument was required.

This requirement has been met with the Model PAR400, Peak Acceleration Recorder™. It is an inexpensive triaxial unit which requires no power supply, and is virtually maintenance free. Peak accelerations as low as .01 g can be recorded, and the minimum bandwidth extends from 0 to 26 Hertz. Permanent records are scribed by diamond stylii on replaceable metal plates. The peak acceleration is computed by multiplying the maximum excursion of the trace by the acceleration sensitivity of the recorder.

Description

The Model PAR400, Peak Acceleration Recorder™, senses and records peak accelerations triaxially. It is a self-contained passive device requiring no external power or control connections and has a minimum band width of 0 to 26 Hertz with a sensitivity as low as .01 g.

Each sensor of the PAR400 incorporates a new method of mechanical amplification which makes it more than five times as sensitive as previous devices. With the aid of optical magnification, its permanent record can be read to .001 of an inch (.025 mm) or less. With a full scale deflection of .200 inches (5 mm), the −1 version (2 g full scale) has a dynamic range of 200:1 (46 db).

Air damping is used since it is very efficient for its size and weight. Minor adjustments of damping can be made in the field, if required.

Sensors are available in three natural frequencies: 32, 51 and 64 Hertz. The assemblies are mechanically identical and completely interchangeable, so any combination may be included in a triaxial recorder.

The record is scratched permanently on a metal plate which is both serialized and keyed to the recorder to assure that the records are not confused among the three axes. Since the record is scratched, it can be measured without further processing. The record plates are inserted through side holes in the casting without taking off the cover. This minimizes the possibility of damaging the recorder or inadvertently recording on the record plate during insertion or removal by touching the mechanism.

Applications

The PAR400 is useful whenever low frequency peak acceleration measurements are needed. These accelerations may be due to earthquake, storms, or explosions. The three records give the acceleration levels along three mutually perpendicular axes.

The Peak Acceleration Recorder™ can be used in connection with:

1. Nuclear power plants
2. Steel mills
3. Refineries
4. Bridges and dams
5. High-rise structures
6. Mines
7. Ships
8. Off-shore oil rigs
9. Transportation shock

Features

The PAR400 is a very sensitive, wide band, low frequency acceleration recording instrument. The high sensitivity is obtained by using a heavy mass to detect the acceleration, and then mechanically amplifying its motion. A diamond tip scriber at the end of the amplifier arm traces a very fine visible permanent record of the arm's excursions. The scribe line widths are on the order of .0004 inches (.01 mm).

Three plates, stamped L, T, and V, respectively, are used to record the excursions in the three axes. Slotted keyways on the plates match up with pins in the housing so that only the correctly stamped plate can be inserted full depth into the corresponding sensor. Each set of three plates also carries a unique serial number. This permanent identification system eliminates the possibility of confusing the records.

The rugged cast aluminum housing has three pads to contact the mating surface when mounted. A single screw is used for attachment. Shims can be slid under the appropriate pad to level the unit. The screw is then tightened. A clearance hole is provided in the cover for the screw head so the cover need not be removed during mounting of the recorder.

To install the record plates, three plugs are removed from the side walls of the casting and the plates are slipped into the appropriate holders. The plugs are of such a size as to preclude damage to the mechanism during insertion or removal of the record plates. Since the cover does not have to be removed to replace record plates, the mechanism is not exposed to inadvertent damage.

When a record plate is inserted, a spring-loaded pin forces the plate to one side of the track to eliminate any side play which would introduce an error in the recorded acceleration. The insertion produces a zero line on the plate. On removal, a zero line is also scratched. These zero lines should coincide if there is no mechanical shifting between insertion and removal. If there is a shift, the user is made aware that a problem exists.

To obtain wide band response, the instrument is damped to 60% of critical. A preadjusted air damper is used for damping to keep the size and weight of the total package as small as possible.

The recorder is reliable because of its simplicity. It does not contain any of the more complex and less reliable components, i.e., batteries, connectors, motors, and bearings. The recorder is self-contained, and requires no start-up time.

The recorder is economical in that no external connections or power are required. The record plates are reusable by replating. Maintenance is very low since the unit can be unattended for long periods of time.

Materials have been selected for long life even when exposed to nuclear radiation. The cast housing, along with the cover and three plugs, is chemically filmed (alodine) and painted with epoxy paint. The gaskets are made of EPDM to increase resistance to radiation. All hardware is stainless steel. An indicating silica gel desiccant is also provided to decrease the humidity inside the recorder.

Data reduction is very simple requiring only one measurement and one multiplication for each of the three record plates to obtain its maximum acceleration.

Data Reduction

Data reduction is accomplished by measuring the maximum displacement of the scratched record from the zero line. Normally just the maximum is recorded regardless of the direction. List this distance under "Displacement" on the calibration sheet.

Multiply the "Displacement" times the "Acceleration Sensitivity" and record in the "Acceleration" column.

Small displacement measurements can be made using a microscope with a reticle having graduations in thousandths (.001) of an inch. A magnifier with a recticle graduated in tenths (.1) of a mm can be used for medium displacements. Consult Engdahl Enterprises for microscopes.

MAGNIFIED RECORD
USING A RETICLE

SAMPLE OF A
CALIBRATION AND TEST DATA SHEET

Sensor	Natural Frequency (Hertz)	Acceleration Sensitivity (g/inch) [g/mm]	Displacement (inches) [mm]	Acceleration (g)
L	32.3	14.0 (.551)	.023 (.58)	.32
T	30.9	13.5 (.532)	.010 (.26)	.14
V	33.3	14.2 (.559)	.005 (.13)	.07

CALIBRATION DATA REDUCTION

PEAK ACCELERATION RECORDER™

MODEL PAR400

QUALIFIED TO IEEE RECOMMENDED PRACTICES FOR SEISMIC QUALIFICATION OF CLASS 1E EQUIPMENT FOR NUCLEAR POWER GENERATING STATIONS, STD. 344-1975

Designed to meet the characteristics of the Peak Accelerograph described in the American National Standard ANSI/ANS-2.2-1978, Earthquake Instrumentation Criteria for Nuclear Power Plants and the U.S. Nuclear Regulatory Commission's Regulatory Guide 1.12, Nuclear Power Plant Instrumentation for Earthquakes, Revision 1.

SENSORS

Number of Sensing Elements		3
Arrangement of Elements		Triaxial
Full Scale Acceleration	–1	2 g
	–2	5 g
	–3	10 g
Dynamic Range	–1	200:1 (46 db)
	–2	385:1 (52 db)
	–3	500:1 (54 db)
Natural Frequency (± 5%)	–1	32 Hz
	–2	51 Hz
	–3	64 Hz
Damping		55 to 70% of Critical[1]
Bandwidth	–1	0 to 26 Hz
	–2	0 to 41 Hz
	–3	0 to 52 Hz
Overall Accuracy		Within ± 5% at full scale, changing linearly to ± 1.5% of full scale at 0.01 g
Detail Acceleration Accuracy	–1	.01 to .50 g ± .01 g
		.50 to 1¼ g ± 2%
		1¼ to 2 g ± 3%
	–2	.013 to .65 g ± .013 g
		.65 to 2 g ± 2%
		2 to 5 g ± 3%
	–3	.02 to 1 g ± .02 g
		1 to 3 g ± 2%
		3 to 10 g ± 3%

Spurious Resonances: None ithin frequency range c interest

Cross Axis Sensitivity: Less than .03 g/g

PHYSICAL DIMENSIONS

Length	5-1/4 inches (13.34 cm)
Width	3-5/8 inches (9.21 cm)
Height	3-11/32 inches (8.49 cm)
Weight	2-3/4 pounds (1.3 kg)

[1]Damping adjusted at nominal atmospheric pressure expected at time of operation.

MOUNTING

One (1) #10-24 Screw.

Level Recorder to ± 1° (1/16 inch in 3½ inches) (1.6 mm in 90 mm) by adding shims under the appropriate mounting pad. "V" will measure the vertical accelerations. Align long side of recorder within 3° (¼ inch in 5-1/8 inches) (6.4 mm in 130 mm) of designated North/South line. "L" (longitudinal) will measure N/S accelerations. "T" (transverse) will measure E/W.

ENVIRONMENTAL

Temperature	–40°C to + 85°C
Humidity	To 100% RH
RFI	Does not radiate or conduct RFI. Not affected by external RFI.
Water	Water-Tight to 70 PSI (5 kg/cm2)

Nuclear Radiation

The following materials are used in the construction of the PAR400.

1. Metals: Aluminum, Brass, Stainless Steel, Beryllium Copper, Gold, Nickel
2. Non-Metallic Materials

Description	Material	Stress Level	Approx. Stability[2] (RAD)
Paint	Epoxy	Low	1×10^8
Adhesive	Epoxy	Low	1×10^8
Adhesive	Anaerobic	Low	2×10^8
Adhesive	Cyanocrylate	Low	2 x 108
Gaskets	EPDM	Low	1×10^8
Piston	Graphite	Low	2×10^8
Cylinder	Pyrex	Low	2×10^8
Scriber	Diamond	Low	2×10^8

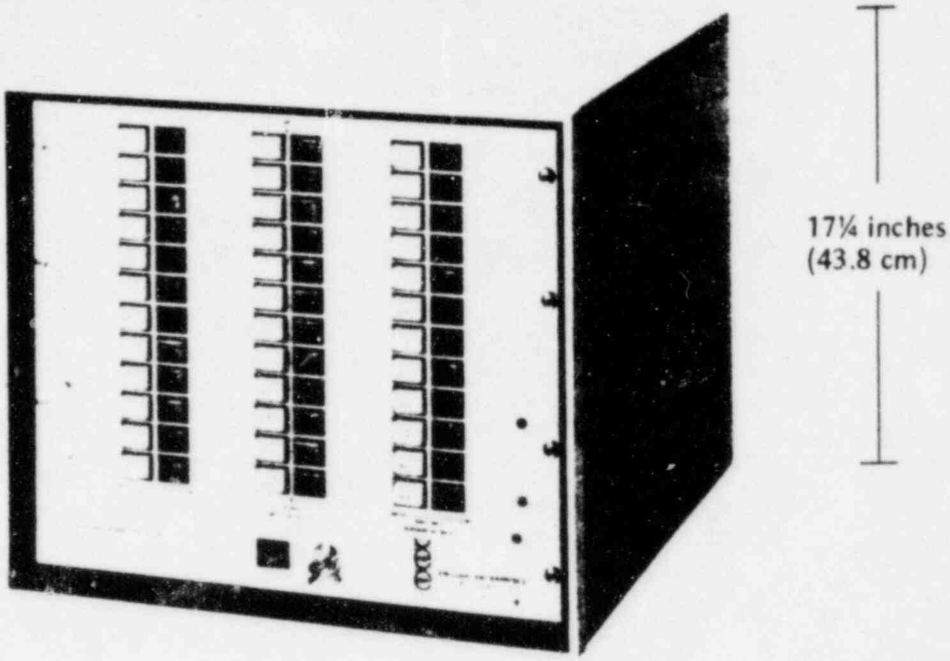
POWER REQUIREMENTS – None

[2]Source: Dow Corning Corporation, Loctite Corporation, Corning Glass Work, E.I. Du Pont De Nemours & Company, Parker Seal Company, Raychem Corporation, General Electric

REPRESENTED BY:

1-85-1M 4007008

MODEL PSA875 and PSA1575



MODEL PSA1575
PEAK SHOCK ANNUNCIATOR™

INDICATES THAT SPECIFIED PRESET SPECTRAL ACCELERATIONS HAVE BEEN EXCEEDED

PROVIDES CONTACT CLOSURES FOR REMOTE INDICATORS OR ALARMS

- EARTHQUAKES
- STORMS
- EXPLOSIONS

RELIABLE and ECONOMICAL

ENGDAHL ENTERPRISES 2850 Monterey Avenue • Costa Mesa, California 92626 • (714) 540-0398

Description

The Models PSA875 and PSA1575, Peak Shock Annunciators™, give visual warning that predetermined acceleration limits, making up a response spectrum, have been exceeded at certain frequencies. They are designed to operate in conjunction with tuned Peak Shock Recorders™, PSR1200-H/V-4A/12A. Both models have three banks of indicator lamps, one bank for each of three mutually perpendicular axes. Amber lights indicate accelerations approaching design limits (normally 70%) while red lights indicate that design limits have been exceeded. Model PSA875 monitors four frequencies per axis while Model 1575 monitors twelve. Both models may be equipped with relays to operate remote indicators or alarms. (See "Options and Accessories".)

Applications

The annunciators may be used whenever it is desired to indicate instantaneously the reaction of a structure to a complex shock such as an earthquake or an explosion. The information provided permits an immediate decision as to whether or not the operation can continue or must be shut down.

The Peak Shock Annunciator™ can be used in connection with:

1. Nuclear power plants
2. Steel mills
3. Refineries
4. Bridges and dams
5. High-rise structures
6. Mines
7. Ships
8. Off-shore oil rigs
9. Transportation shock

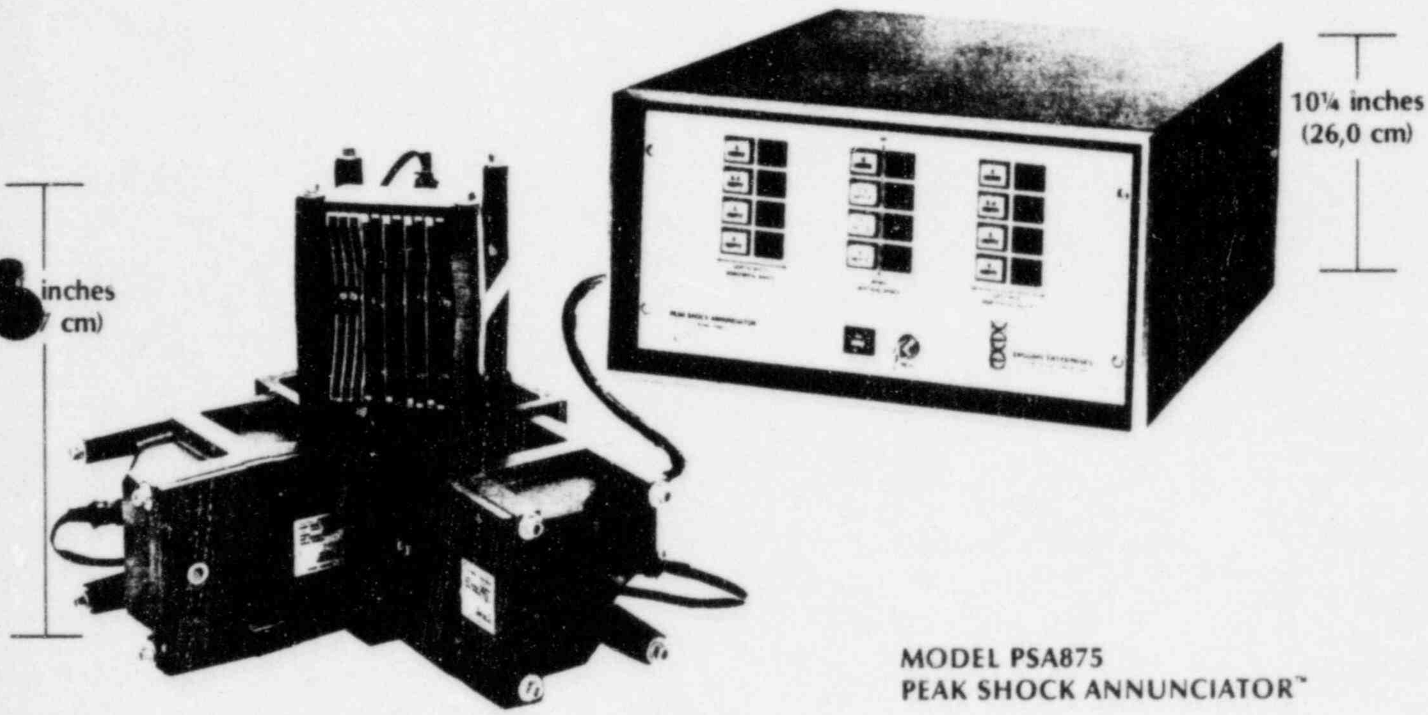
Features

The "AC Power" indicator lamp is fed from the DC power on the printed circuit boards and shows that the incoming power line and the regulated DC supply are both operating normally.

A key-operated test/reset switch is provided. It controls two functions. In the "test" position, all of the indicator lamps should be illuminated and all relays (if provided) should be energized. This permits an immediate check that the annunciator is functioning correctly. When the key is returned to the "reset" position and removed from the switch, all indicators will be de-energized, the latches will be reset, and the annunciator is ready to receive signals from the Response Spectrum Recorder™. Once a signal has been received, the appropriate lamp and relay, if any, will remain energized until the annunciator is reset with the key.

Where relays are provided for remote indicators or alarms, separate electronic driving circuitry is provided. Dual redundancy is thereby achieved for additional reliability.

Uninterruptible power supplies incorporating batteries for emergency operation can also be provided. If power failure is anticipated, battery operation is strongly recommended since power failure will reset any annunciated signal at the time of failure. Two additional indicators are mounted on the panel. One monitors the AC power at the transformer of the battery charger. The second monitors the charging circuit.



MODEL PSA875
PEAK SHOCK ANNUNCIATOR™

TRIAXIAL INSTALLATION OF THREE
MODEL PSR-1200-H/V-4A,
PEAK SHOCK RECORDERS™
ON TRIAXIAL MOUNT

PEAK SHOCK ANNUNCIATOR™
Models PSA875 and PSA1575

QUALIFED TO: GUIDE FOR SEISMIC QUALIFICATION OF CLASS I ELECTRICAL EQUIPMENT FOR NUCLEAR POWER GENERATING STATIONS – IEEE GUIDE 344

Designed to meet the characteristics of the Control Room Indicator for Response Spectrum Switch described in the American Nuclear Society's Standard ANSI/ANS-2.2-1978, Earthquake Instrumentation Criteria for Nuclear Power Plants and the U.S. Nuclear Regulatory Commission's Regulatory Guide 1.12, Nuclear Power Plant Instrumentation for Earthquakes, Revision 1.

PHYSICAL

	PSA875	PSA1575
Length	19 inches (48,3 cm)	19 inches (48,3 cm)
Width	20⅝ inches (52,4 cm)	20⅝ inches (52,4 cm)
Thickness	10¼ inches (26,0 cm)	17¼ inches (43,8 cm)
Weight	33 pounds (15 kg)	45 pounds (20,5 kg)

INDICATORS

Number of Axes Monitored	3	3
Number of Frequencies Monitored	12	36
Number of Indicators	24	72

ENVIRONMENTAL

Temperature	0 to +70°C
Humidity	To 100% RH
RFI	No adverse radiated or conducted RFI

POWER REQUIREMENTS

Voltage	115 VAC
Current	2½ amperes maximum

MOUNTING

Bench or
Standard 19" (48,3 cm) Relay Rack
8¾" (22,2 cm) high or
15¾" (40,0 cm) high
27 lbs. (12,3 kg)

Options and Accessories (available at extra cost)

1. Relay closures for remote indication and alarm. One relay with Form C contacts can be provided for each output indicator. A connector on the back of the chassis facilitates system implementation. The connector is wired for normally open or normally closed operation.

To date, most customers have selected a two-relay system. One relay indicates that the lower level (amber) has been exceeded. The second relay indicates the upper level (red) has been exceeded at least once.

Relays are rated at: 1/10 Hp, 3 amps @ 120 VAC or 3 amps @ 28 VDC resistive.

2. Uninterruptible power supplies incorporating batteries for emergency operation can be furnished within the confines of the annunciator. If power failure is anticipated, battery operation is strongly recommended since power failure will reset any annunciated signals at the time of the failure.

REPRESENTED BY:

1-85-1M 875700B

APPENDIX C

A PRELIMINARY EVALUATION OF THE SIGNIFICANCE OF THE SEISMIC EVENT ON JANUARY 31, 1986 AT THE PERRY NUCLEAR POWER PLANT

STEVENSON

STEVENSON & ASSOCIATES

a structural-mechanical consulting engineering firm

9217 Midwest Avenue • Cleveland, Ohio 44125 • (216) 587-3805 • Telex: 980101

Document Number 861401-1
Revision 0 -- 2/10/86

A PRELIMINARY EVALUATION OF THE SIGNIFICANCE OF THE SEISMIC EVENT ON JANUARY 31, 1986 ON THE PERRY NUCLEAR POWER PLANT

February 10, 1986

Perry Nuclear Power Plant
Cleveland Electric Illuminating Co.
10 Center Road
Perry, Ohio 44080

PREPARED BY:

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1.0 INTRODUCTION

On January 31, 1986, at 11:47 a.m. EST, a brief (approximately 0.75 second strong motion duration) and shallow (10 km focal depth) earthquake with a 4.9 m_b magnitude occurred. Its epicenter was south of Lake Erie, at a distance of approximately eleven (11) miles from the Perry Nuclear Power Plant site at Perry, Ohio.

Stevenson and Associates was retained to analyze the data provided by seismic recorders installed at various locations in the Perry plant, and determine: (1) how the earthquake parameters, as recorded by the instrumentation at the site, compare to those for the Safe Shutdown Earthquake (SSE) and Operating Basis Earthquake (OBE) postulated in the design of the Perry plant's buildings, systems and components; (2) the structural significance of the readings by the seismic recorders at the Perry site during the January 31, 1986 earthquake; and (3) the anticipated impact of the earthquake on the plant's buildings, systems and components.

This report contains Stevenson and Associates' preliminary evaluation of the above-described matters. It is based on a physical walkdown of the site, analysis of data recorded by the seismic instrumentation, and discussions with plant technical and operating personnel. Since some of the evaluations of the earthquake are still underway, this report may be supplemented and/or revised at a later date if new information developed during these ongoing activities so warrants.

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A resume of the qualifications and experience of Stevenson and Associates is included as Attachment 1 to this report.

2.0 SEISMIC INSTRUMENTATION AT THE PERRY PLANT

The earthquake motion at the Perry site was recorded by three different types of instrumentation. One type of recorder is the Kinemetrics Model SMA-3 strong motion time history recording accelerograph; this system detects and records the three orthogonal components of acceleration signals over the duration of an earthquake. Another type of instrumentation is the Engdahl PSR 1200-H/V response spectrum recorder, which provides the response at selected frequencies in three orthogonal directions. The third type of instrumentation is the Engdahl PAR 400 peak accelerograph, which records the three orthogonal components of peak local accelerations produced by the earthquake. The locations and readings taken by these systems will be discussed separately below.

2.1 Locations and Readings by the Kinemetrics SMA-3 Accelerographs

Two Kinemetrics SMA-3 strong motion time history recording accelerographs installed at the Perry plant provided time history data on the earthquake. One system is located on the Unit 1 reactor containment concrete wall at the basemat at Elevation 575', as shown in Figure 1. The second system is attached to the steel containment vessel wall at Elevation 686', 111 feet above the first system and offset by less than one degree in Azimuth. The longitudinal axes of both instruments are in the N-S direction.

The time history motions recorded by these two systems are shown in Figures 2 through 8. A detailed interpretation of the readings from these recorders is contained in Reference 1.[1/]

The lower instrument (Elevation 575') gave a peak acceleration of 0.18g in the N-S direction, 0.10g in the E-W direction, and 0.11g in the vertical direction. The upper instrument (Elevation 686') gave a peak acceleration of 0.55g in the N-S direction, 0.18g in the E-W direction, and 0.30g in the vertical direction. It should be noted that both instruments are installed on cantilever brackets off the wall. While the brackets are quite heavy and relatively rigid, they are attached by four 3/8" diameter bolts, approximately 5 inches on center vertically and 8 inches horizontally. This arrangement may result in amplified bracket motion.

2.2 Locations and Readings of the Engdahl Response Spectra Recorders

There are four Engdahl PSR 1200-H/V triaxial response spectra recorders at the Perry plant. This type of recorder includes twelve reeds of different lengths and weights, one for each

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1/ References are listed at the end of this report.

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frequency, fabricated from spring steel. A diamond-tipped stylus is attached to the free end of each reed to inscribe a permanent record of its deflection on one of twelve record plates. The record plates are aluminum, plated with successive layers of nickel, tin, and lead-tin.

The four PSR 1200-H/V recorders at the Perry plant are located as follows (all locations are for Unit 1):

1. Reactor Building Foundation: Elevation 574', Reactor Building foundation mat, Azimuth 210°. This recorder was most recently calibrated on January 14, 1985.

2. Reactor Building Drywell Platform: Inside the drywell platform at Elevation 630', Azimuth 240°, mounted as shown in Figure 9. This recorder was most recently calibrated on January 30, 1986.

3. HPCS Pump Base Mat: In the HPCS Pump Room, in the Auxiliary Building foundation mat, Elevation 574'. The equipment was being calibrated at the time of the earthquake. Previous calibration occurred on January 14, 1985.

4. RCIC Pump Base Mat: In the RCIC Pump Room in the Auxiliary Building foundation mat at Elevation 574'. The equipment was being calibrated at the time of the earthquake. Previous calibration was on January 14, 1985.

The readings taken by these four instruments are discussed in detail in Reference 2. Briefly stated, three of the four instruments provided response spectra which were consistent with each other and which were reasonable in light of the time history readings of the Kinemetrics instruments. The fourth spectra recorder, mounted inside the drywell on the Elevation 630' platform (see Figure 9), indicated vertical acceleration response components of .973g and 1.54g at frequencies of 20.2 and 25.4 Hz, respectively. These readings were 8 to 10 times higher than the corresponding horizontal accelerations at the same frequencies measured by the instrument. See Table 1.[2/]

2.3 Location and Readings of the Engdahl Peak Acceleration Recorders

The Engdahl Model PAR 400 peak acceleration recorder senses and records peak accelerations triaxially. A diamond tipped scriber at the end of an amplifier arm traces a very fine visible permanent record on an aluminum record plate with successive layers of nickel, gold, and burnt gold.

2/ Figure 9 shows the mounting of the Engdahl PSR 1200-H/V instrument on the Elevation 630' platform. The instrument is located approximately 6 feet from the face of the reactor vessel shield wall on an outer beam which provides supports for the platform, recirculation and safety injection piping, and a monorail. Given the highly complex nature of the steel platform and support structure on which the instrument is mounted, it is quite possible the instrument may have measured the acceleration caused by a secondary impact resulting from the earthquake.

The two peak acceleration recorders are located as follows:

1. Reactor Recirculation Pump: Inside the drywell at Elevation 574', on recirculation pump B33-C001A. This instrument was most recently calibrated on December 4, 1985.

2. HPCS Pump Base Mat: In the HPCS Pump Room, in the Auxiliary Building foundation mat at Elevation 574', mounted as shown in Figure 10. This instrument was most recently calibrated on January 30, 1986.

The readings by the Engdahl PAR 400 recorders are discussed in detail in Reference 2.

3.0 COMPARISON AND EVALUATION OF RECORDED ACCELERATIONS AGAINST THOSE ASSUMED FOR THE PERRY SSE AND OBE

Table 2 shows a comparison of the zero period acelerations ("ZPAs"), as recorded by the various instruments, with the corresponding SSE and OBE design accelerations. According to the recorded accelerations, the design basis values of ZPA for the OBE, and in a few instances the SSE, were exceeded during the January 31, 1986 earthquake. As will be discussed below, given the short duration and low energy of the earthquake, the exceedences were not significant from an engineering point of view. This is supported by the apparent lack of damage to plant structures and mechanical and electrical components detected as a result of the earthquake. Moreover, inspection of engineered facilities located near the epicenter and not designed to withstand any earthquake force did not reveal any damage from the earthquake (Reference 3). In order to correlate the short duration, high frequency acceleration that was recorded with the lack of impact on structures and equipment, it is necessary to understand how measured ground acceleration can and should be correlated with design basis accelerations.

In postulating the limiting earthquake conditions for designing nuclear power plant facilities, a key parameter has been the zero period acceleration or Instrumental Peak Acceleration (A_{IP}), which represents the peak acceleration recorded during the entire earthquake motion. As concluded in many studies (References 4 through 11), A_{IP} is a poor indicator of the damage potential of earthquake ground motions. It has been observed that structures performed much better than would have been predicted based on the measured A_{IP} to which the structures were subjected; this phenomenon has been particularly noticeable in connection with short duration, high energy ground motions due to low to moderate magnitude earthquakes, such as the January 31, 1986 earthquake near Perry.[3/] The differences

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3/ Examples of this behavior may be found in the records of the 1966 Parkfield earthquake, the 1971 Pacoima Dam earthquake, the 1972 Ancona earthquake, and the 1972 Melendy Ranch Barn earthquake. These earthquakes showed recorded instrumental peak ground accelerations of between 0.5g and 1.2g, yet only minor damage occurred in the vicinity of the recording sites.

between measured ground motion, assumed design levels, and observed physical behavior is so significant that it cannot be attributed to the safety factors which are utilized in the design and in elastic seismic analyses.

Kennedy (Reference 12), based on the work of others (References 13 through 16) has suggested that it is not appropriate to use just measured A_{IP} to define the characteristics of the SSE and OBE. It is necessary to take also into account, in addition to A_{IP}, the dominant frequency of the strong motion excitation and the duration of the strong motion.[4/] He has proposed the following relationship to develop an equivalent design acceleration for the anchoring elastic spectra:

$$A_D = (K_p)\ (rms),$$

where A_D is the equivalent design acceleration and the other parameters are defined as follows:

$$K_p = \sqrt{2 \ln (2T_D/To)} \geq 2.0$$

T_D = Duration of strong motion (sec.)

4/ Thus, for a high dominant frequency and/or short duration earthquake, the equivalent peak acceleration would be significantly less than that predicted on the basis of A_{IP} measurements alone.

T_o = Predominant period of motion (sec.)

rms = $\sqrt{P}$

P = $E(T)/T_D$ = earthquake power (average rate of energy input)

$E_T = \int_{t_o}^{t_o + T_D} a^2(t)dt$ = total energy fed into the structure between times to and to + T_D, and

$a(t)$ = instrument acceleration at time t.

Efforts are underway to compute A_D for the January 31, 1986 earthquake. In the meantime and by way of comparison, four earthquakes similar in magnitude and duration to the Perry earthquake have been selected from Tables 1 and 2 of Reference 12. The characteristics of those earthquakes, and those of the one at Perry, are summarized in Table 3. For the four earthquakes listed, an average ZPA of 0.434g is required to cause the same level of response for elastic structures as that postulated by the NRC Reg. Guide 1.60 (Reference 17) spectra for a .20g ground acceleration. This result suggests that a correction factor of 0.20/0.434 = 0.46 should be applied to the accelerations measured during low to moderate magnitude earthquakes (such as the one near Perry) to obtain elastic responses that can be compared to those from the limiting Reg. Guide 1.60 earthquake.

If, in fact, a 0.46 correction factor is applied to the accelerations recorded at Perry and shown in Table 2, accelerations well below the SSE and OBE levels are obtained for all locations except for the readings at the Reactor Building Containment Vessel (Elevation 686'), where the corrected N-S and vertical ZPA are approximately equal to the OBE design value. This is shown in Table 4, where the recorded values of Table 2 have been adjusted by a .46 factor.

4. STRUCTURAL SIGNIFICANCE OF THE PERRY EARTHQUAKE AND ANTICIPATED IMPACT OF EVENT ON THE ADEQUACY OF THE PLANT STRUCTURES, SYSTEMS AND COMPONENTS

Table 4 indicates that if the recorded accelerations from the Perry earthquake are corrected to take into account the short duration and low energy of the event, the average elastic response ZPAs are in all but one instance equal to or less than one-third of the OBE design values, and are approximately equal to the OBE values in the remaining case. In light of these results and the design limits placed on the strength of materials for safety applications (i.e., not to exceed a 0.6 to 0.8 factor of yield during an OBE), all safety-related plant structures, systems and equipment should have remained essentially elastic during an earthquake such as the one experienced on

January 31, 1986, and thus should have emerged undamaged from it. This expectation has been corroborated by physical observation of plant conditions following the earthquake.

Some auxiliary or secondary structural systems, such as suspended ceilings and plaster ceilings and walls, might be expected to sustain some displacement or cracking. One might also expect actuation of instrumentation measuring or sensing changes in liquid levels or the presence of vibration. In addition, one might expect some activation of inertia-sensing relays or switches (fluid or spring loaded), if such controls or instrumentation have not been qualified for seismic operability. If any of these circumstances are determined to have taken place at Perry, their occurrence would only be indicative of the anticipated response of non-seismically qualified structures to moderate earthquake conditions.

TABLE 1 (From Reference 2)

READINGS FROM RESPONSE SPECTRA RECORDER
MPL NUMBER: D51-R170
LOCATION: REACTOR RECIRCULATION
PIPING SUPPORT - DW 630', 240°

REED NUMBER	NOMINAL FREQUENCY (HERTZ)	ACCELERATION(g) North/South		East/West		Vertical	
		1-31-86	2-2-86	1-31-86	2-2-86	1-31-86	2-2-86
1	2.00	.047	.048	.049	.051	.007	.007
2	2.52	.082	.082	.086	.084	(*)	.013
3	3.17	.184	.184	.144	.140	.015	.014
4	4.00	.226	.223	.128	.127	.023	.023
5	5.04	.132	.134	.158	.158	.035	.033
6	6.35	.131	.134	.058	.055	.033	.030
7	8.00	.104	.104	.109	.090	(*)	.019
8	10.1	.093	.093	(*)	.052	.093	.085
9	12.7	.188	.182	.166	.080	.198	.199
10	16.0	.194	.204/.167	.348	.312	.490	.500
11	20.2	.152	.152	.191	.175	.973	.973
12	25.4	.114	.091	.155	.158	1.7	1.54

(*) Unreadable

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TABLE 2

COMPARISON OF DESIGN ZPAs (1)
VS RECORDED ZPAs
(Expressed in g values)

		Auxiliary Building Foundation Mat Elevation 568' PAR 400 (Engdahl) D51-R140	Reactor Building Foundation Mat Elevation 574'-10" SMA -3 (Kinemetrics) D51-N101	Reactor Building Recirculation Pump Elevation 605' PAR 400 (Engdahl) D51-R120	Reactor Building Containment Vessel Elevation 686' SMA-3 (Kinemetrics) D51-N111	Reactor Building Platform Elevation 630'-1" Inside Drywell PSR 1200 (Engdahl) D51-R170
NS	Recorded	.17	.18	.32	.55	.09
	SSE	.17	.18	1.06	.40	.48
	OBE	.10	.10	.86	.24	.40
EW	Recorded	.06	.10	.11	.18	.16
	SSE	.20	.18	1.06	.40	.48
	OBE	.10	.10	.86	.24	.40
VERT	Recorded	.03	.11	.05	.30	Note 2
	SSE	.20	.18	.47	.24	.28
	OBE	.10	.10	.38	.15	.16
SRSS(3)	Recorded	.18	.23	.34	.65	Note 2
	SSE	.33	.31	1.57	.62	.73
	OBE	.17	.17	1.27	.37	.59

(1) Zero period acceleration
(2) ZPA indeterminable from available data
(3) Square-root-of-the-sum of the squares

TABLE 3

CHARACTERISTICS AND GROUND ACCELERATION LEVELS
REQUIRED TO ACHIEVE EQUAL STRUCTURAL ELASTIC
RESPONSE BETWEEN R.G. 1.60 AND SELECTED EARTHQUAKES

Earthquake	Magnitude M_V	Recording Station Epicentral Distance(km)	Peak Inst. Ground Acceleration, g	Strong Motion Duration, sec.	Equiv. ZPGA to the 0.20g R.G. 1.60 Spectra
Parkfield - 1966	5.6	1	0.49	1.4	.3275
Hollister - 1974	5.2	13	0.138	1.1	.4825
Santa Barbara - 1978	5.1	4	0.347	3.0	.2825
Bear Valley-1972	4.7	6	0.520	0.8	.6450
					.434(Average)
Ohio - 1986	4.9	17	(*)	0.75	--

(*) 0.18g in N-S direction, 0.10g in E-W direction, measured at the foundations.

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TABLE 4

COMPARISON OF DESIGN ZPAs (1)
VS CORRECTED RECORDED ZPAs
(Expressed in g values)

		Auxiliary Building Foundation Mat Elevation 568' PAR 400 (Engdahl) D51-R140	Reactor Building Foundation Mat Elevation 574'-10" SMA -3 (Kinemetrics) D51-N101	Reactor Building Recirculation Pump Elevation 605' PAR 400 (Engdahl) D51-R120	Reactor Building Containment Vessel Elevation 686' SMA-3 (Kinemetrics) D51-N111	Reactor Building Platform Elevation 630'-1" Inside Drywell PSR 1200 (Engdahl) D51-R170
	Recorded	.08	.08	.15	.25	.04
NS	SSE	.17	.18	1.06	.40	.48
	OBE	.10	.10	.86	.24	.40
	Recorded	.03	.05	.06	.08	.07
EW	SSE	.20	.18	1.06	.40	.48
	OBE	.10	.10	.86	.24	.40
	Recorded	.02	.06	.02	.14	Note 2
VERT	SSE	.20	.18	.47	.24	.28
	OBE	.10	.10	.38	.15	.16
	Recorded	.08	.11	.16	.30	Note 2
SRSS(3)	SSE	.33	.31	1.57	.62	.73
	OBE	.17	.17	1.27	.37	.59

(1) Zero period acceleration
(2) ZPA indeterminable from available data
(3) Square-root-of-the-sum of the squares

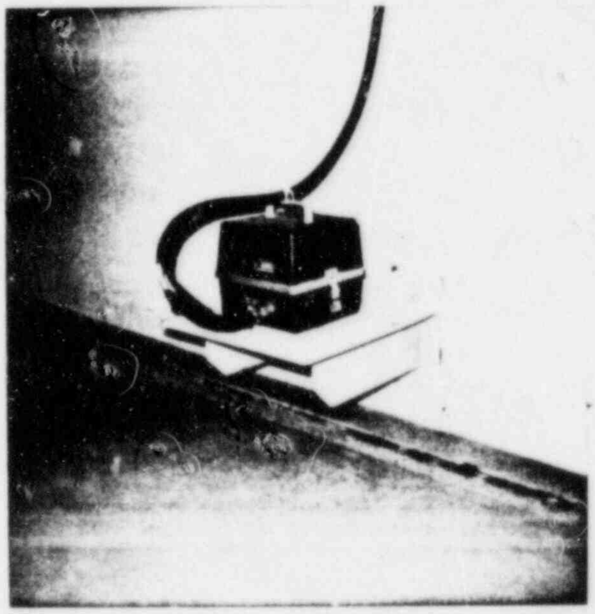

FIGURE 1 - KINEMETRICS SMA-3
ACCELERATION TIME HISTORY RECORDER
SERIAL NO. 165-1, TAG NO. D51-N101
LOCATED AT BASE OF CONTAINMENT WALL
ELEVATION 575.

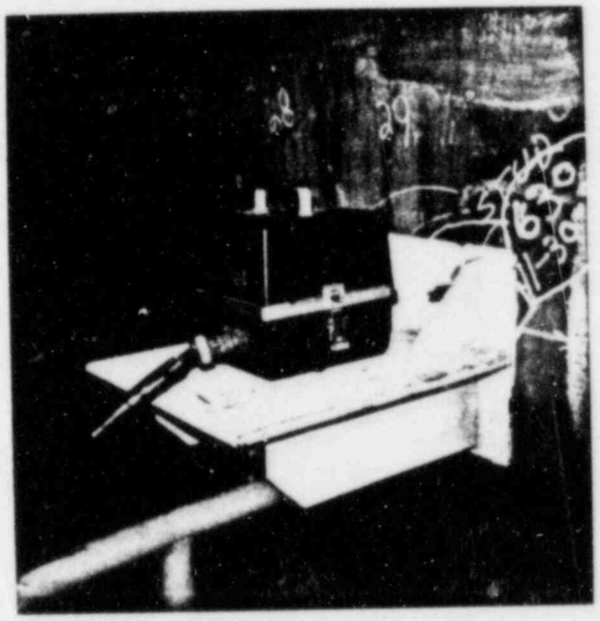

FIGURE 2 - KINEMETRICS SMA-3 ACCELERATION TIME HISTORY RECORDER SERIAL NO. 165-2, TAG NO. D51-[illegible] LOCATED ON THE STEEL CONTAINMENT SHELL AT EL. 682.

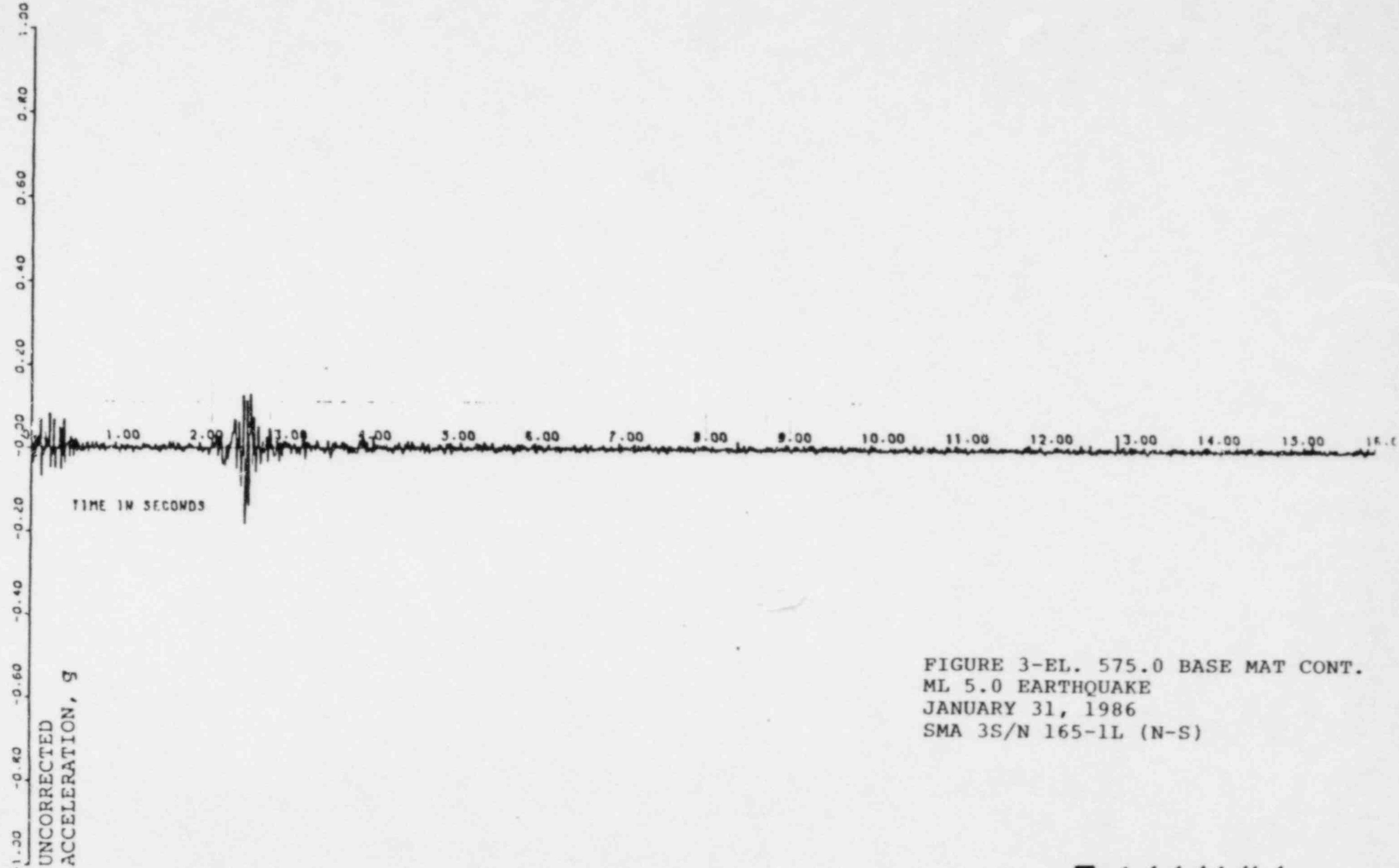

FIGURE 3-EL. 575.0 BASE MAT CONT.
ML 5.0 EARTHQUAKE
JANUARY 31, 1986
SMA 3S/N 165-1L (N-S)

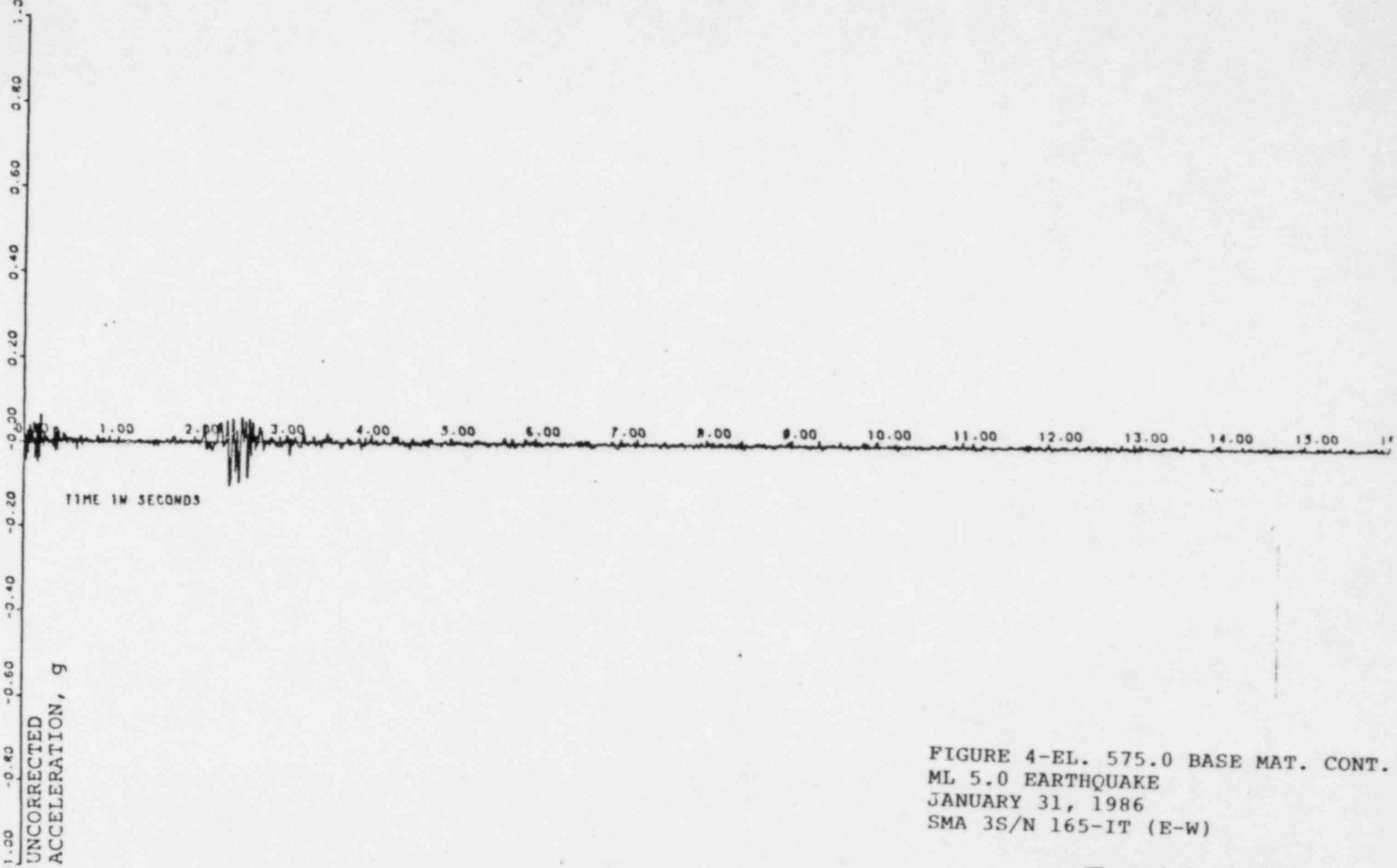

FIGURE 4-EL. 575.0 BASE MAT. CONT.
ML 5.0 EARTHQUAKE
JANUARY 31, 1986
SMA 3S/N 165-IT (E-W)

KINEMETRICS

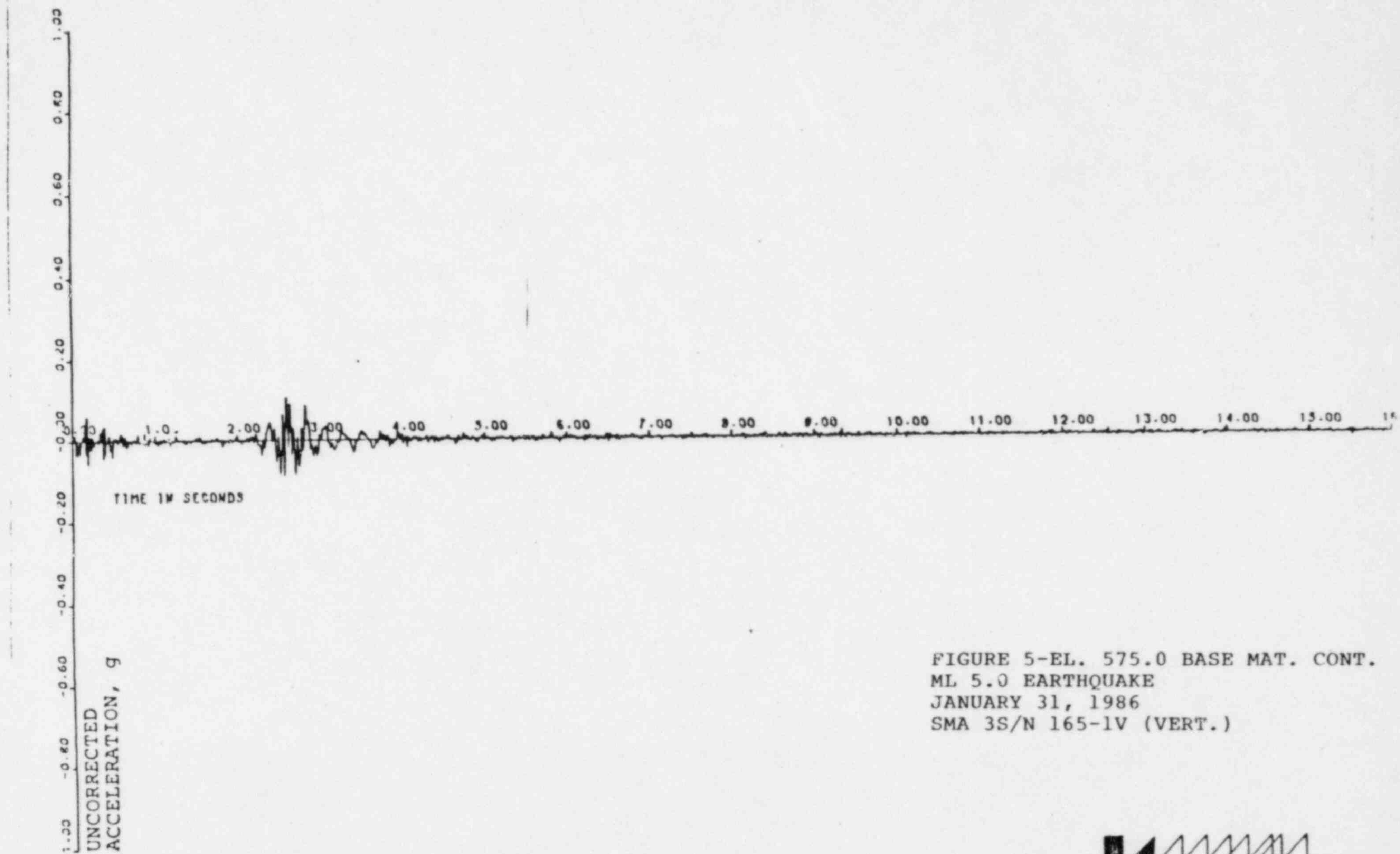

FIGURE 5-EL. 575.0 BASE MAT. CONT.
ML 5.0 EARTHQUAKE
JANUARY 31, 1986
SMA 3S/N 165-1V (VERT.)

KINEMETRICS

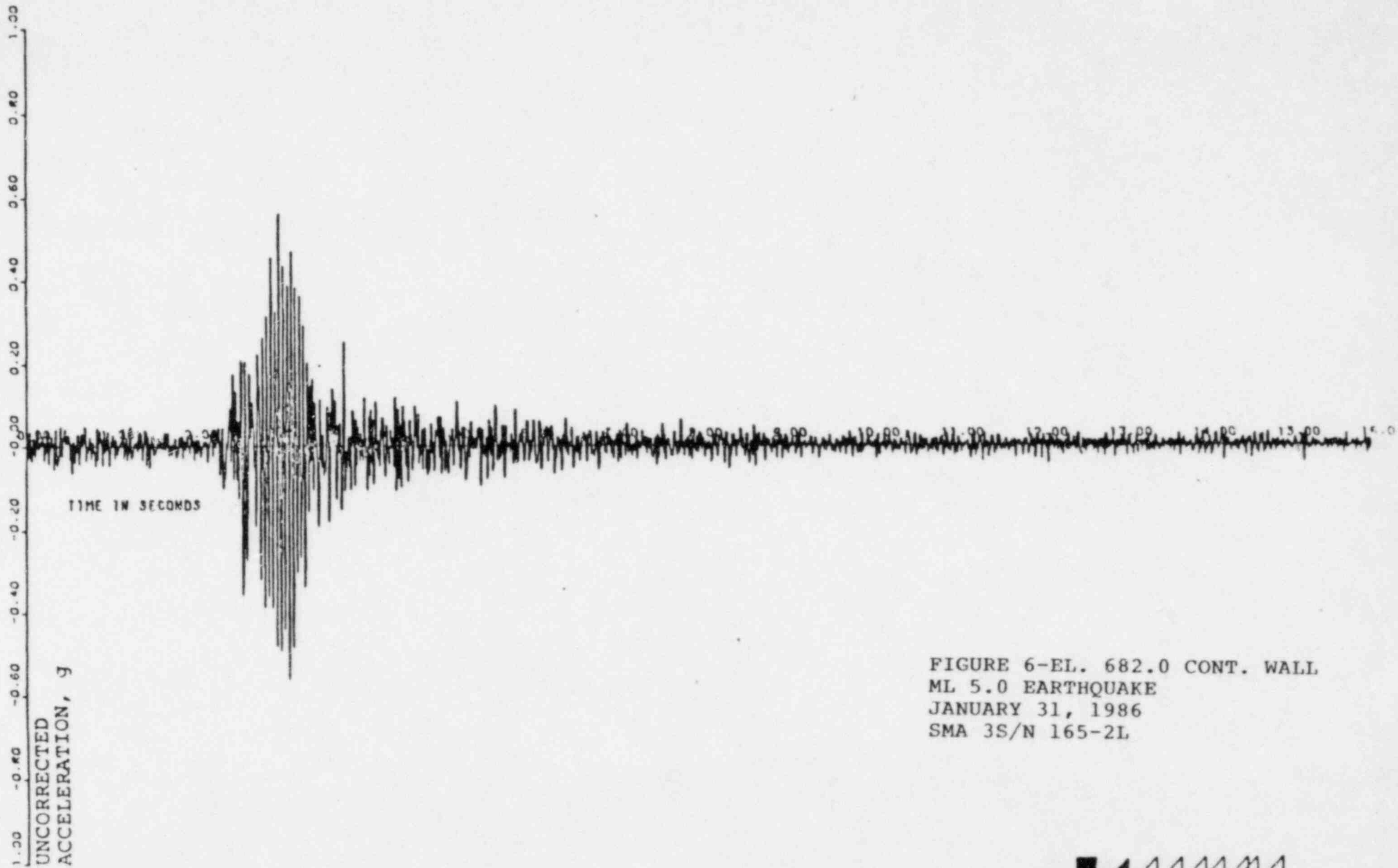

FIGURE 6-EL. 682.0 CONT. WALL
ML 5.0 EARTHQUAKE
JANUARY 31, 1986
SMA 3S/N 165-2L

KINEMETRICS

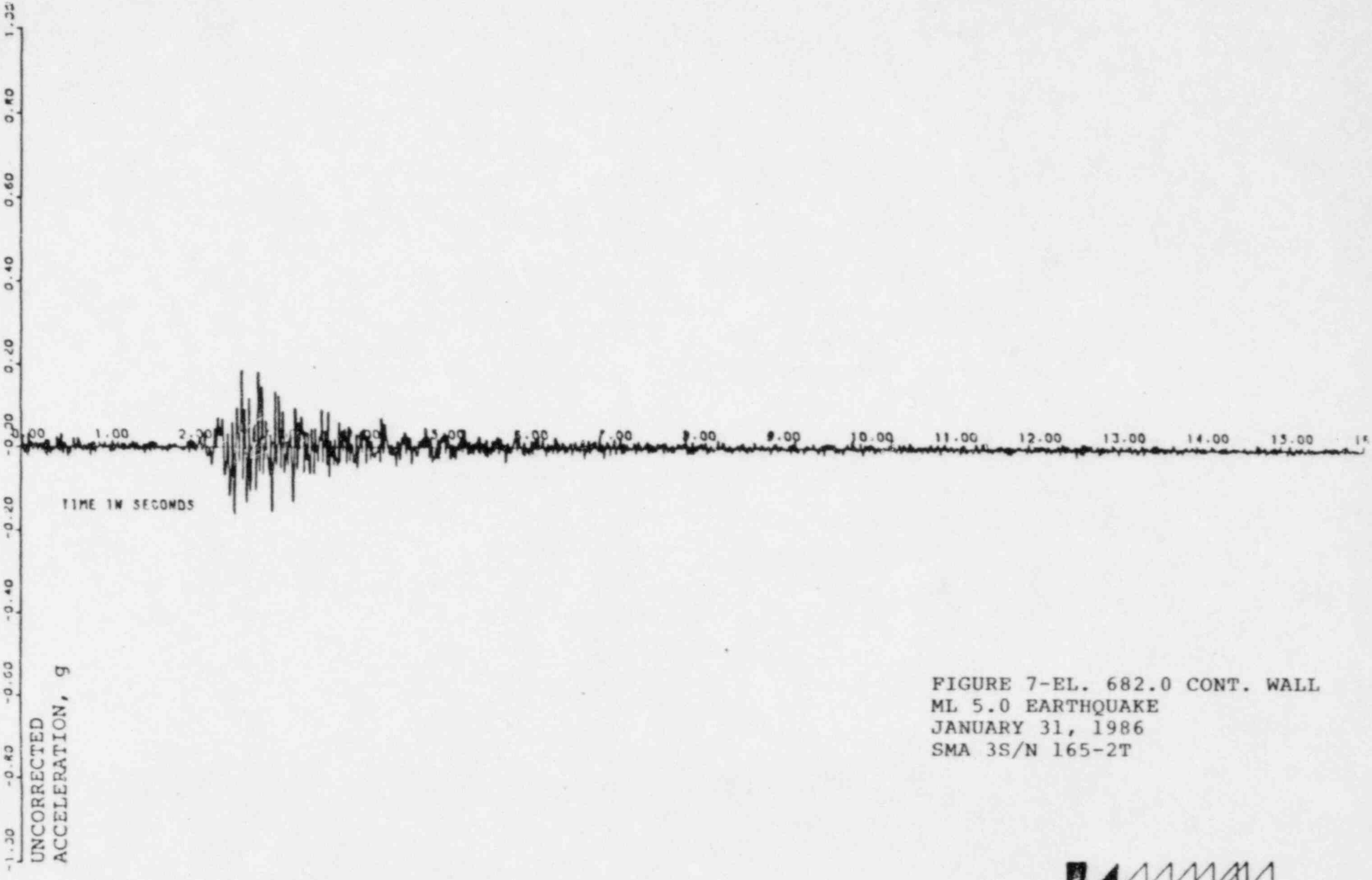

FIGURE 7-EL. 682.0 CONT. WALL
ML 5.0 EARTHQUAKE
JANUARY 31, 1986
SMA 3S/N 165-2T

KINEMETRICS

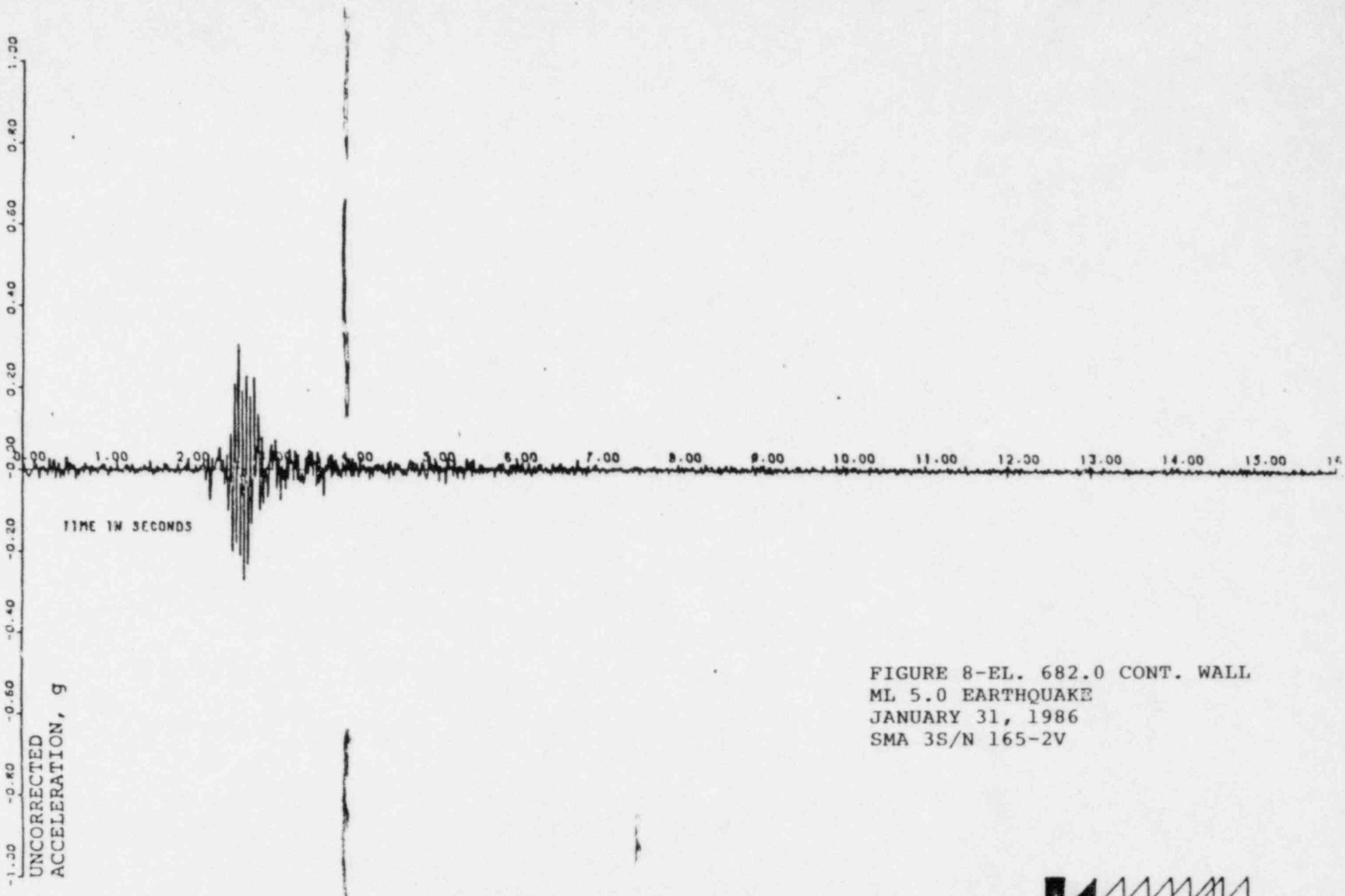

FIGURE 8-EL. 682.0 CONT. WALL
ML 5.0 EARTHQUAKE
JANUARY 31, 1986
SMA 3S/N 165-2V

KINEMETRICS

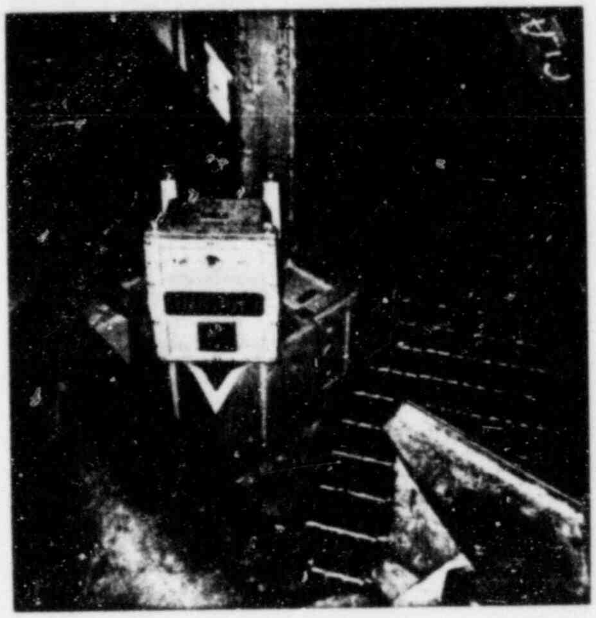

FIGURE 9 - MOUNTING OF ENGDAHL PSR 1200-H/V RECORDER ON THE EL. 630 DRYWELL PLATFORM.

FIGURE 10 - MOUNTING OF ENGDAHL TYPE PAP 400 RECORDER ON AUXILIARY BUILDING FOUNDATION MAT EL. 563.

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(12) Kennedy, R.P., "Peak Acceleration as a Measure of Damage", Presented at 4th International Seminar on Extreme-Load Design of Nuclear Power Plants", Paris, France, August 1981.

(13) Arias, A., "A Measure of Earthquake Intensity", Seismic Design for Nuclear Power Plants, MIT Press, Cambridge, Mass. (1970).

(14) Housner, G.W., "Measures of Severity of Earthquake Ground Shaking", Proceedings of the U.S. National Conference on Earthquake Engineering, EERI, Ann Arbor, Michigan, June 1975, pp. 25-33.

(15) Mortgat, C.P., "A Probabilistic Definition of Effective Acceleration", Proceedings of the 2nd U.S. National Conference on Earthquake Engineering, Stanford University, August 22-24, 1979, pp. 743-752.

(16) McCann, M.W., Jr. and Shah, H.C., "RMS Acceleration for Seismic Risk Analysis: An Overview", Proceedings of the 2nd U.S. National Conference on Earthquake Engineering, Stanford University, August 22-24, 1979, pp. 883-897.

(17) U.S. Nuclear Regulatory Commission, Regulatory Guide 1.60, "Design Response Spectra for Seismic Design of Nuclear Power Plants" (Rev. 1, December 1973).

JOHN D. STEVENSON

EXPERIENCE:

PRESIDENT - MANAGING PARTNER	Since November 1981, Dr. Stevenson has managed and has served as President and Senior Consultant to Stevenson & Associates. The firm specializes in high technology consulting and forensic engineering associated with failure analysis of structural and mechanical systems; extreme loads; and nonlinear, dynamic, and probabilistic high temperature analyses.
VICE-PRESIDENT - GENERAL MANAGER 1976 - 1981	As Vice-President, Dr. Stevenson managed and served as Senior Engineering Consultant to the Cleveland Offices of Woodward-Clyde Consultants and Structural Mechanics Associates specializing in areas of high technology applicable to the structural-mechanical design and analysis of systems and components. Prior to this time, the consulting group he headed provided similar services as a Division of Davy-McKee Co. Dr. Stevenson also served as Corporate Manager of Engineering Quality Assurance for Davy-McKee Co.
ASSOCIATE PROFESSOR AND PRINCIPAL MANAGER OF EASTERN OPERATIONS 1974 - 1976	Case Western Reserve University, CWRU, and EDAC, Inc., Cleveland, Ohio. As an Associate Professor at CWRU, Dr. Stevenson served as Director of a program in Design for the Extreme Load Environment and held a joint appointment in the Departments of Civil Engineering and Mechanical Design. He also conducted a number of seminars on Seismic Quality Assurance Scheduling and Manpower Requirements and Mechanical and Electrical Equipment Pipe and Duct Design of Industrial Facilities. Dr. Stevenson was a Principal and managed one of three consulting offices for Engineering Decision Analysis Corp., Palo Alto, California. He was active in marketing and providing consulting services in the area of extreme load, seismic, tornado, high energy systems rupture, and component failure analysis.
CONSULTANT 1973 - 1974	Westinghouse Nuclear Energy Systems, Pittsburgh, Pennsylvania. As a Consulting Engineer for Westinghouse Nuclear Energy Systems, Dr. Stevenson acted as an advisor to the Technical Director on the Executive Vice-President for Nuclear Power Staff. He performed evaluations of balance of plant requirements associated with nuclear power plant design and constructed and represented Westinghouse on a number of Industry Committees associated with nuclear power.

CONSULTANT 1972 - 1973	Westinghouse Water Reactor Divisions, Pittsburgh, Pennsylvania. As an Advisory Engineer for the Westinghouse Standard Plant Project, Dr. Stevenson acted as a consultant to the Manager of the Westinghouse Standard Plant Project. In this capacity he had responsibility for determining interface requirements with site-related design parameters and set envelope requirements for the standard plant design. He was responsible for nuclear island PSAR text developments and AEC licensing requirements associated with the standard plant layout development.
ADJUNCT PROFESSOR AND PRESIDENT 1970 - 1972	University of Pittsburgh and NSSA Inc., Pittsburgh, Pennsylvania. As a member of the Civil Engineering Facility of the University of Pittsburgh, Dr. Stevenson was particularly active in the areas of structural dynamic response to earthquake, tornado, missile and fluid jet effects as well as reliability and risk analysis and optimum design of structural systems. Dr. Stevenson was responsible for the development of a graduate study program for the study of structural design and analysis for the extreme load environment. Dr. Stevenson founded and served as President and Managing Director of Nuclear Structural Systems Associates, Inc. During this period, the firm served as consultants to the nuclear power industry, particularly in the areas of structural and mechanical design and licensing of nuclear plant facilities. Dr. Stevenson was active in developing Standard Plant design concepts and also conducted engineering design seminars for the nuclear industry throughout the U.S., Europe and Japan for over 500 representatives of over 150 companies.
MANAGER STRUCTURAL SYSTEM ENGINEERING 1968 - 1970	Westinghouse PWR Systems Division, Pittsburgh, Pennsylvania. Dr. Stevenson had overall responsibility within Westinghouse for the development and approval of structural design criteria and layout used in the design of the six nuclear power stations for which Westinghouse had prime design and construction responsibility for product line management of design and development of support structures for major nuclear components.

LEAD ENGINEER
1966 - 1968

Westinghouse PWR Systems Division, Pittsburgh, Pennsylvania.

As Lead Engineer, Dr. Stevenson was responsible for liaison with the various architect-engineer-constructor firms which performed the detailed structural design and construction of turnkey plants, and as such he was responsible for design review and approval. Dr. Stevenson was active in representing Westinghouse structural design policy before the Atomic Energy Commission and Advisory Committee on Reactor Safeguards.

GRADUATE STUDENT
1963 - 1966

Case Institute of Technology, Cleveland, Ohio.

Work toward a Ph.D. in Structures with emphasis on computer applications and risk analysis applied to structural design.

RESEARCH ENGINEER
1962 - 1963

I.I.T. Research Institute, Chicago, Illinois.

Responsibilities included integrated radiation, structural and operational analysis and minimum cost design of nuclear blast resistant underground structures.

ASSISTANT PROFESSOR
1957 - 1962

Virginia Military Institute, Lexington, Virginia.

Courses in structural design of concrete and steel structures were taught to Civil Engineering undergraduates.

John Hopkins University, Baltimore, Maryland (Part-Time) Research Assistant.

Responsibilities included report editing and research in the location, type quantity and packaging of low level solid atomic wastes.

FIELD ENGINEER
1956 - 1957

McDowell Construction Co., Cleveland, Ohio

Field Engineer responsible for Technical Supervision and engineering field modifications to construction of a Sintering Plant for U.S. Steel Corp. Youngstown Works.

Dr. Stevenson has been particularly active in the review and evaluation of design adequacy of structures and equipment in nuclear power plants and other industrial facilities. Particular projects where he personally performed such evaluations include the following:

Nuclear Power Plants:

Indian Point Units 2 & 3
H.B. Robinson
R.E. Ginna
Point Beach
Dresden 2
Monticello
D. C. Cook
Palisades
Oyster Creek
Millstone
South Texas Project
Fessenheim - France
Cordoba - Argentina
Mihama - Japan
Conn Yankee
Maine Yankee
Midland

Other Industrial Facilities:

Tokamac Fusion Test Facility
Purex Facility Hanford
Rocky Flats Processing Facility
Centrifuge Plant
Granger Soda Ash Plant
LMFBR
Hercules Polypropalene Plant
Shuichang Steel Complex
Touss Oil Fired Power Station
Hanford Coal Fired Power Station
Addy Ferro Silicate Plant
Killen Coal Fired Power Station
LNG Storage Facilities - U.S.

EDUCATION:

B.S. - Civil Engineering -
Virginia Military Institute, 1954

AEC Institute on Nuclear Engineering -
Purdue University, Summer 1960

M.S. - Civil Engineering -
Case Institute of Technology, 1962

Ph.D. - Civil Engineering -
Case Institute of Technology, 1968

PROFESSIONAL:

1. Member: American Society of Civil Engineers
   Chairman: Executive Committee Technical Council Codes And Standards
   Chairman: Nuclear Standards Committee
   Member: Structural Division Committee on Nuclear Safety
   Member: Structural Division Committee on Nuclear Structures and Materials

2. Member: American Concrete Institute
   Member: Joint ACI-ASME Subgroup on Design of Concrete Components in Nuclear Service, ASME BPVC-Section III-Div. 2, Corresponding Consultant ACI 349 Safety Class Concrete Structures

3. Member: American Society of Mechanical Engineers
   Member: Subgroup on Design of ASME BPVC-Section III-Div. 1 Nuclear Components
   Member: Subcommittee on Qualification of Mechanical Components in Nuclear Service

4. Member: Nuclear Standards Management Board of ANSI representing ASCE

5. Member: U.S. Respresentative International Standards Committee SC 85/3/7 on Seismic Criteria for Nuclear Plants

6. Member: U.S. Representative International Atomic Energy Agency Working Group on the Development of Seismic Design Standards

7. Vice Chairman: ANS-2, American Nuclear Society Committee on Site Evaluation
   Member: NUPPSCO, American Nuclear Society Committee on Nuclear Power Plant Codes and Standards

8. Member: AISC, American Institute of Steel Construction Committee on Specifications for Structural Steel in Safety Class Nuclear Structures

9. Member: Earthquake Engineering Research Institute

10. Register Professional Engineer: Virginia, Pennsylvania, and Ohio

11. Winner: Moiseiff Award - ASCE, 1971

PUBLICATIONS:

1. Stevenson, J.D., and Haga, P.G., "Pressurized Water Reactor Containment Structures Design Experience," Journal of the Power Division, ASCE, Vol. 96, No. PO 1, Proc. Paper 7037, January 1970.

2. Moses, F., and Stevenson, J.D. "Reliability Based Structural Design," Journal of the Structural Division, ASCE, Vol. 96, No. ST 2, Proc. Paper 7072, February 1970.

3. Stevenson, J.D., and Moses, F. "Reliability Analysis of Frame Structures," Journal of the Structural Division, ASCE, Vol. 96, No. ST 11, Proc. Paper 7692, November 1970.

4. Stevenson, J.D., "Criteria and Design of Pressurized Water Reactor Coolant System Support Structures - State-of-the-Art," First International Conference on Structural Mechanics in Reactor Technology, Berlin, Germany, September 1971.

5. Stevenson, J.D., and Abrams, J.I., (Editors) "Proceedings of Symposium on Structural Design of Nuclear Power Plant Facilities," University of Pittsburgh, 1972.

6. Stevenson, J.D., "Seismic Design of Small Diameter Pipe and Tubing for Nuclear Power Plants," Proc. 5th World Conference on Earthquake Engineering, Rome, June 1973.

7. Stevenson, J.D., "Containment Structures for Pressurized Water Reactor Systems: Past, Present, and Future State-of-the Art," Proc. 2nd International Conference on Structural Mechanics in Reactor Technology, North Holland Publishing Company, 1973.

8. Stevenson, J.D. (Editor), "Proceedings of Symposium on Structural Design of Nuclear Power Plant Facilities," ASCE Speciality Conference, Chicago, December 1973.

9. Stevenson, J.D. and LaPay, W.S. "Amplification Factors to be Used in Simplified Seismic Dynamic Analysis of Piping Systems," Proc. Pressure Vessel and Piping Conference, ASME, June 1974.

10. Stevenson, J.D. (Editor), "Proceedings of Second ASCE Speciality Conference on Structural Design of Nuclear Power Plant Facilities," New Orleans, December 1975.

11. Stevenson, J.D., "Rational Determination of Operational Basis Earthquake and its Impact on Overall Safety and Cost of Nuclear Facilities," Nuclear Engineering and Design, Vol. 135, North Holland Publishing Company, 1975.

12. Stevenson, J.D. "Survey of Extreme Load Design Regulatory Agency Licensing Requirements for Nuclear Power Plants," Nuclear Engineering and Design, Vol. 36, North Holland Publishing Company, 1976.

13. Stevenson, J.D., "External Hazards in Reliability and Risk Assessment of Nuclear Power Plants," Proceeding 2nd International Conference on Structural Safety and Reliability, Munich, Sept. 1977.

14. Stevenson, J.D., "Preliminary Design of a Containment to Withstand Core Melt for a 1300 MWe LWR System," Nuclear Engineering and Design, Vol. 48, North Holland Publishing Company, June 1978.

15. Stevenson, J.D., "The Economic Effect of Increased Seismic Load on Nuclear Power Plant Design and Construction Costs," Nuclear Engineering and Design, Vol. 48, North Holland Publishing Company, June 1978.

16. Stevenson, J.D., "Research Needs Associated with Seismic Load on Nuclear Power Plants," Nuclear Engineering and Design, Vol. 50, North Holland Publishing Co., October 1978.

17. Stevenson, J.D. (Editor), "International Seminar on Probabilistic and Extreme Load Design of Nuclear Plant Facilities," Presented August 22-24, 1977 by SMIRT 4 and ASCE, March 1979.

18. Stevenson, J.D., "Standards - Status and Development in the Nuclear Industry," Proceedings of ASCE Speciality Conference on Design of Nuclear Plant Facilities, Boston, April 1979.

19. Stevenson, J.D., "Probabilistic Analysis of Nuclear Containment Structures to Resist Seismic Loads," Proceedings of ASCE Speciality Conference on Design of Nuclear Plant Facilities, Boston, April 1979.

20. Bergman, L.A. and Stevenson, J.D., "The Effects of Support Stiffness Upon the Response of Piping Systems," Presented at ASME National Congress on Pressure Vessels and Piping, June 1979.

21. Gorman, M. and Stevenson, J.D., "Probability of Failure of Piping Designed to Seismically Induced Emergency and Faulted Condition Limits," to be Presented 5th SMIRT Conference, Berlin, Germany, August 1979.

22. Stevenson, J.D. Chairman, Editing Board, Structural Analysis and Design of Nuclear Plant Facilities, ASCE Manuals and Reports on Engineering Practice - No. 58, American Society of Civil Engineers, August 1980.

23. Stevenson, J.D., "Structural Damping Values as a Function of Dynamic Response Stress and Deformation Levels," Nuclear Engineering and Design, Vol. 60 No. 2, September 1980.

24. Stevenson, J.D. "Nuclear Standards Applicable to the Civil-Structural Design of Nuclear Power Plants," Proceedings of Speciality Conference on Experience with the Implementation of Construction Practices, Codes Standards, and Regulations in Construction of Power Generating Facilities, Pennsylvania State University, September 1981.

25. Stevenson, J.D. and Thomas, F.A., "Selected Review of Foreign Licensing Practices for Nuclear Power Plants," NUREG/CR-2664, U.S. Nuclear Regulatory Commission, April 1982.

26. Stevenson, J.D. and Thomas, F.A., "Selected Review of Regulatory Standards and Licensing Issues for Nuclear Power Plants," NUREG/CR-3020, U.S. Nuclear Regulatory Commission, November 1982.

27. Stevenson, J.D. and Thomas, F.A., "Selected Review of Foreign Safety Research for Nuclear Power Plants," NUREG/CR-3040, U.S. Nuclear Regulatory Commission, November 1982.

28. Stevenson, J.D., "Use of the Delphi Approach in Seismic Qualification of Existing Electrical and Mechanical Equipment and Distribution Systems in Industrial Facilities," Proceedings of the 6th Japan Earthquake Engineering Symposium - 1982, Tokyo, Japan, December 1982.

29. Stevenson, J.D. and Thomas, F.A., "Selected Review and Evaluation of U.S. Safety Research Vis-a-Vis Foreign Safety Research for Nuclear Power Plants," NUREG/CR-3212, U.S. Nuclear Regulatory Commission, March 1983.

30. Stevenson, J.D., "Seismic Design of Nuclear Plant Facilities at Low Seismicity Sites," Lawrence Livermore Laboratories Sponsored Conference on Seismic Design of Industrial Facilities, San Francisco, May 1983.

31. Hall, W.J., Kennedy, R.P. and Stevenson, J.D., "Nuclear Power Plant Seismic Design - A Review of Selected Topics," Paper K 14/1 Presented at the 7th International Conference on Structural Mechanics in Reactor Technology, Chicago, Ill., August 1983. (Submitted for Publication in Nuclear Engineering and Design)

32. Stevenson, J.D., "Designing for Extreme Loads - The Impact on Cost and Schedule", Nuclear Engineering International, July 1984

33. Stevenson, J.D., "A Review of Procedures Available to Seismically Requalify Operating Nuclear Plant Structures, Equipment and Distribution Systems", Paper K 936 To be Presented at 8th SMIRT, August 1985

34 Stevenson, J.D. "A Summary of Snubber Failure Experience in Nuclear Power Plant Facilities", Paper F1 935, To be Presented at 8th SMIRT, August, 1985

35. Stevenson, J.D., "Rational Seismic Design of Nuclear Power Plant Piping at Low and Moderate Seismicity Sites", Paper K937, To Be Presented at 8th SMIRT, August 1985

APPENDIX D

PERRY SPECIFIC
RESPONSE SPECTRA PLOTS

FLOOR RESPONSE SPECTRA DESIGN VERSUS RECORDED

TABLE OF CONTENTS

Instrument Number	Location	Direction	OBE/SSE	Damping Percentage	Figure
D51-R170	Inside Drywell Reactor Building Platform–630′	N-S	SSE	2	D-7
D51-R170	Inside Drywell Reactor Building Platform–630′	E-W	SSE	2	D-8
D51-R170	Inside Drywell Reactor Building Platform–630′	VERT	SSE	2	D-9
D51-N111	Reactor Building Containment Vessel–686′	N-S	SSE	2	D-10
D51-N111	Reactor Building Containment Vessel–686′	E-W	SSE	2	D-11
D51-N111	Reactor Building Containment Vessel–686′	VERT	SSE	2	D-12

PNPP UNIT NO.1
AUXILIARY BUILDING
RESPONSE SPECTRA (SSE)
N/S DIRECTION
ELEVATION 568'-4"

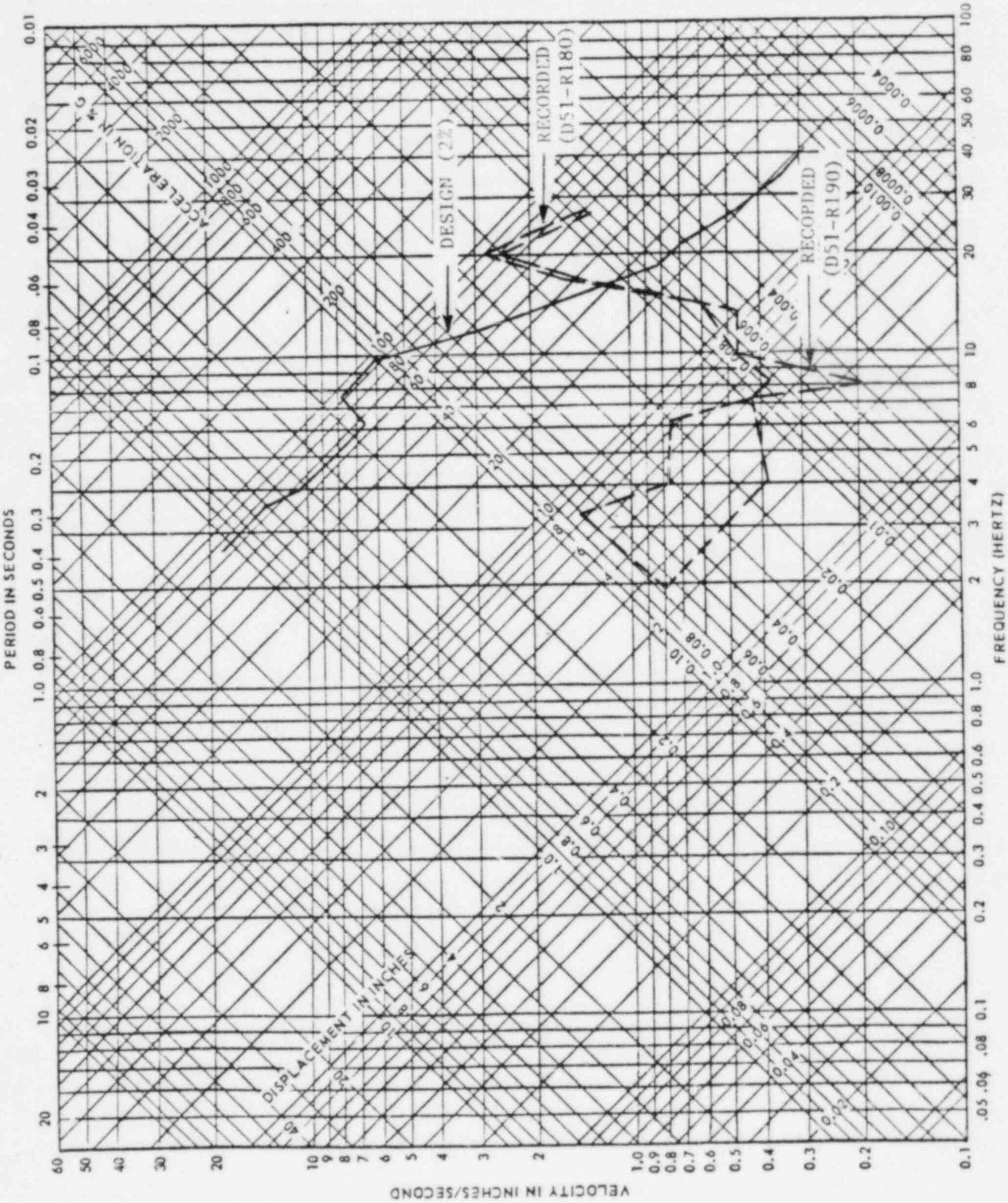


FIGURE D-1

PNPP UNIT NO.1
AUXILIARY BUILDING
RESPONSE SPECTRA (SSE)
E/W DIRECTION
ELEVATION 568'-4"

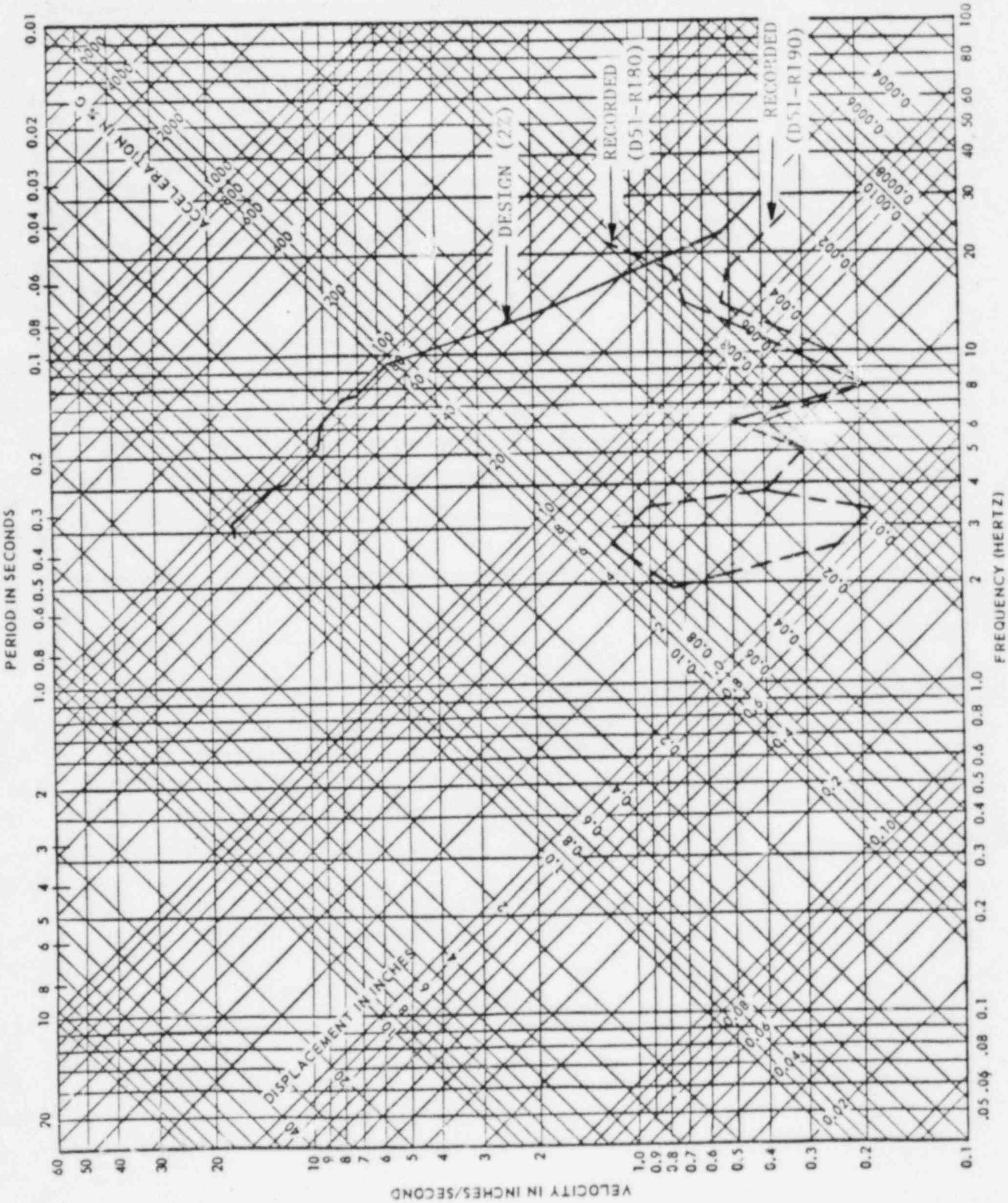
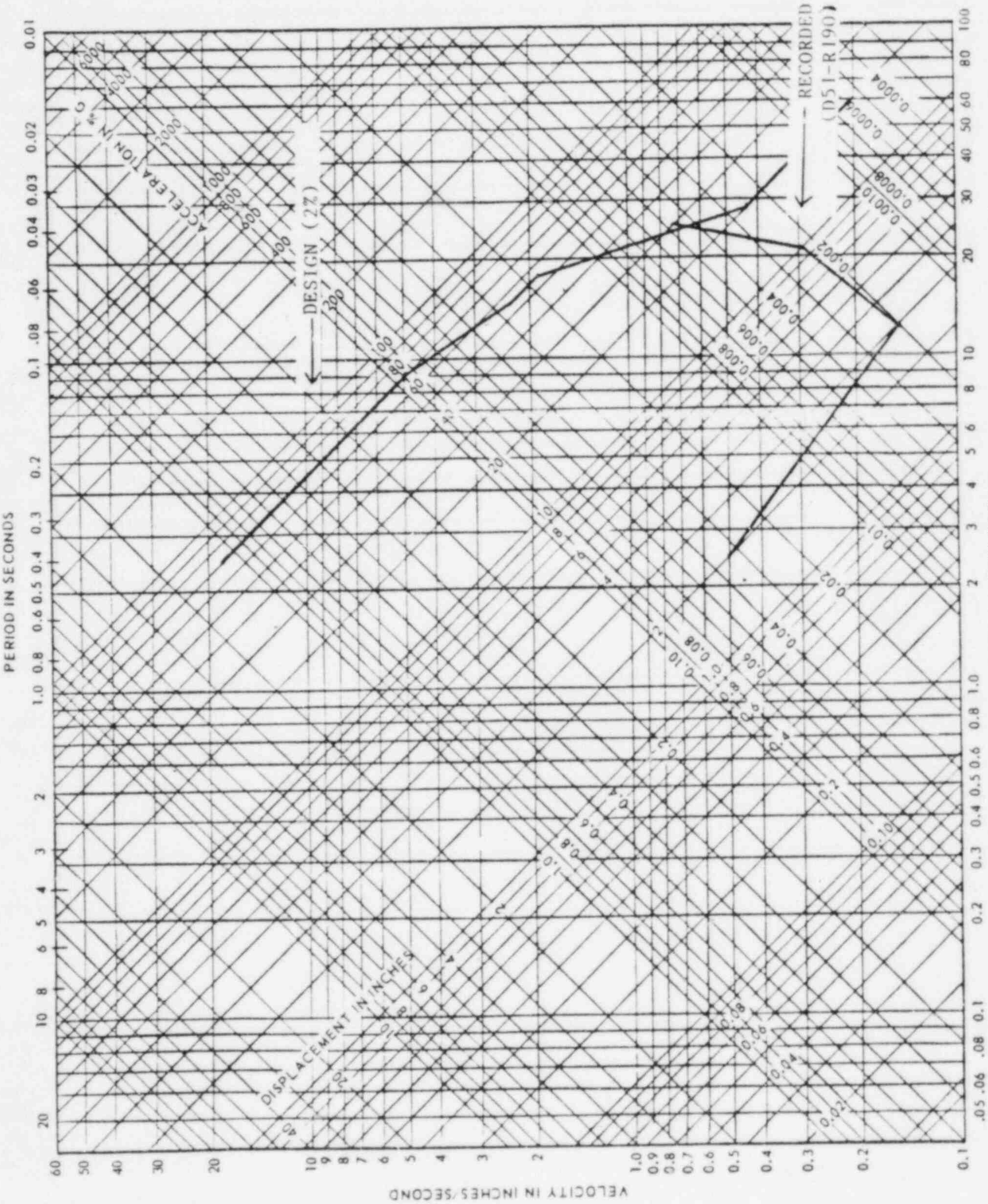


FIGURE D-2

PNPP UNIT NO. 1
AUXILIARY BUILDING
RESPONSE SPECTRA (SSE)
VERTICAL
ELEVATION 568'-4"



NOTE: D51-R180 (Vertical) Out of Service Due to Recalibration

FIGURE D-3

11A8001 PERRY NUCLEAR POWER PLANT COMP SOUTH SMA3S/N 165-1L

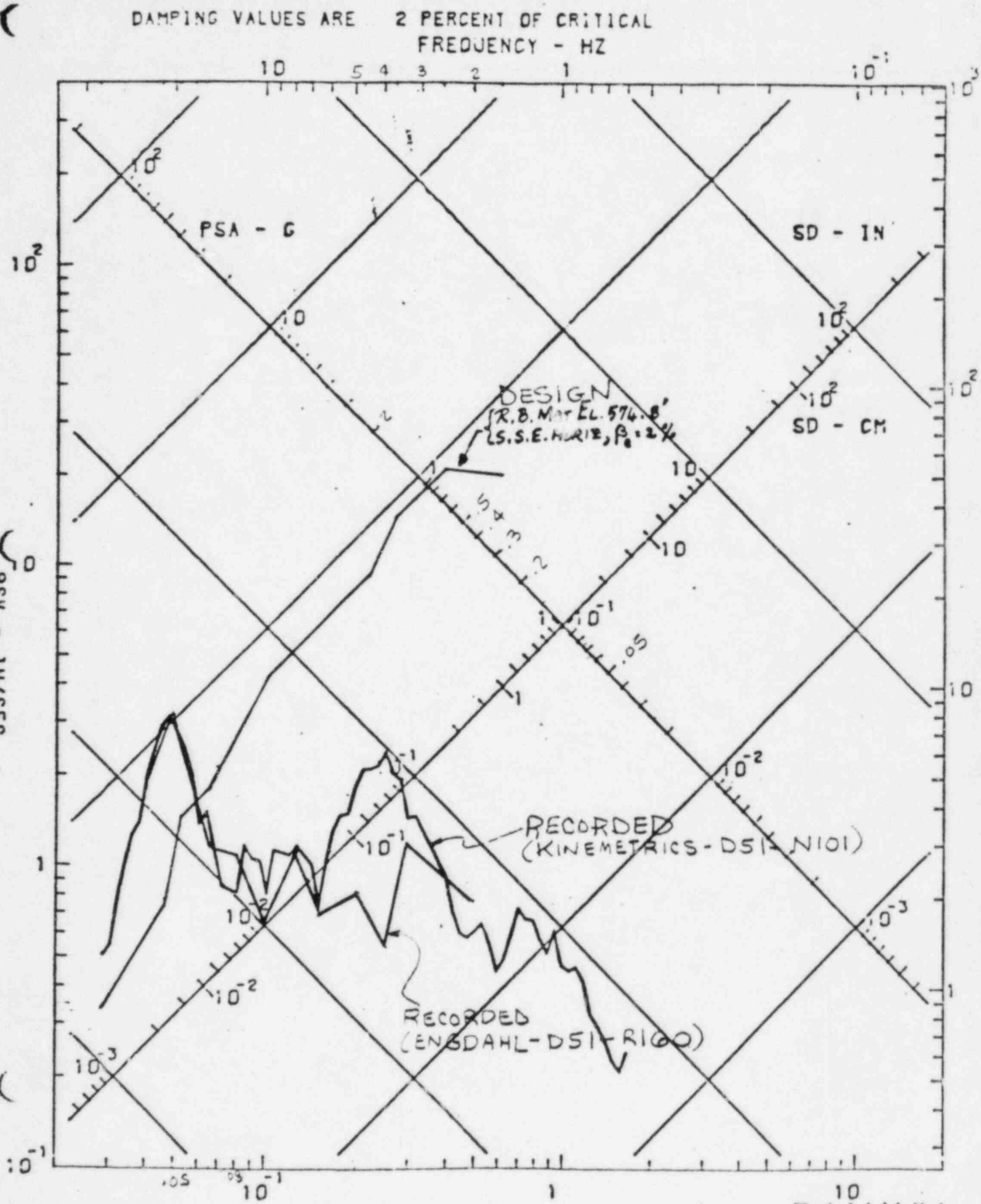


FIGURE D-4

ML 5.0 EARTHQUAKE JANUARY 31, 1986

11AB001 PERRY NUCLEAR POWER PLANT COMP WEST SMA3S/N 165-11

DAMPING VALUES ARE 2 PERCENT OF CRITICAL

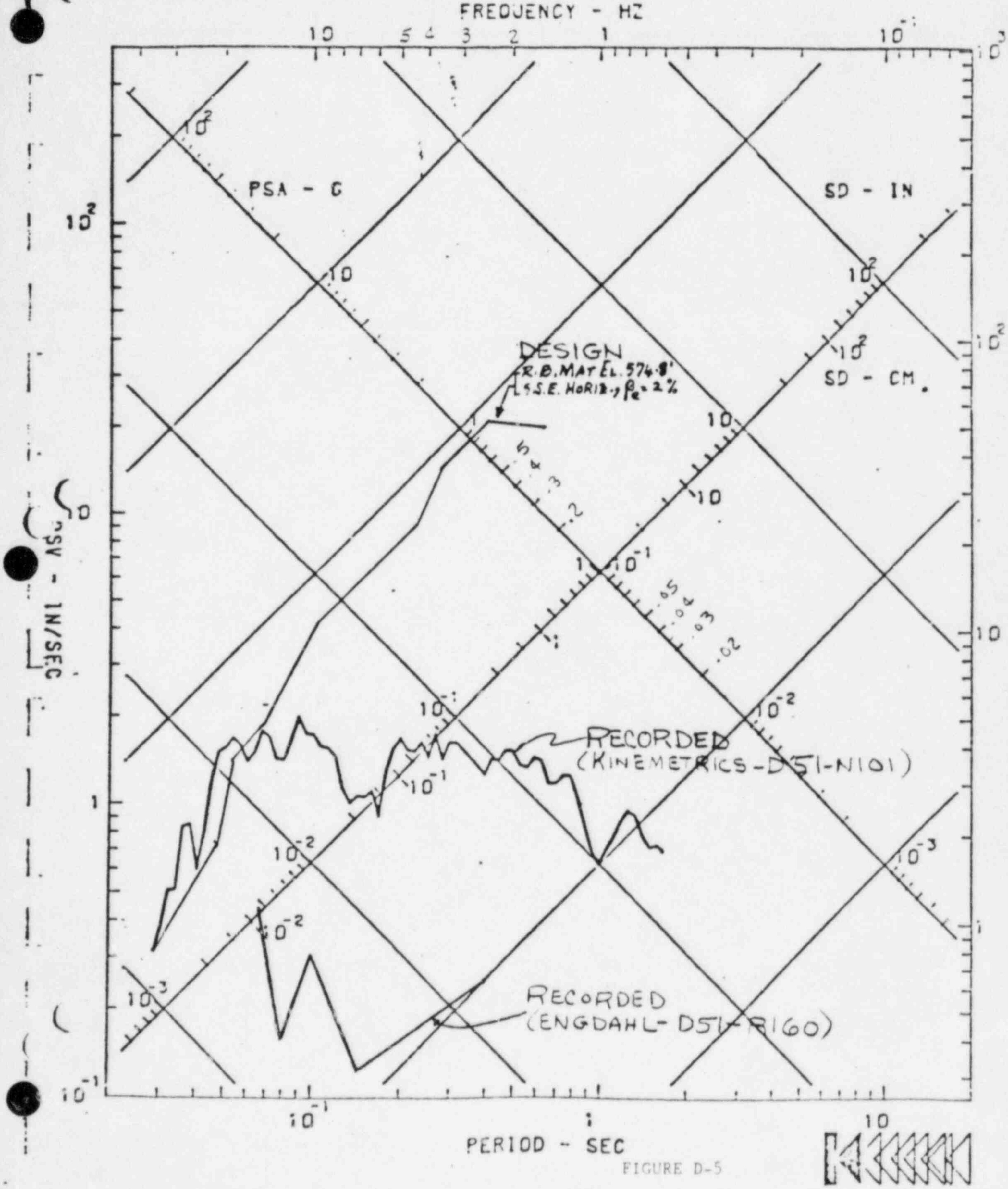


FIGURE D-5

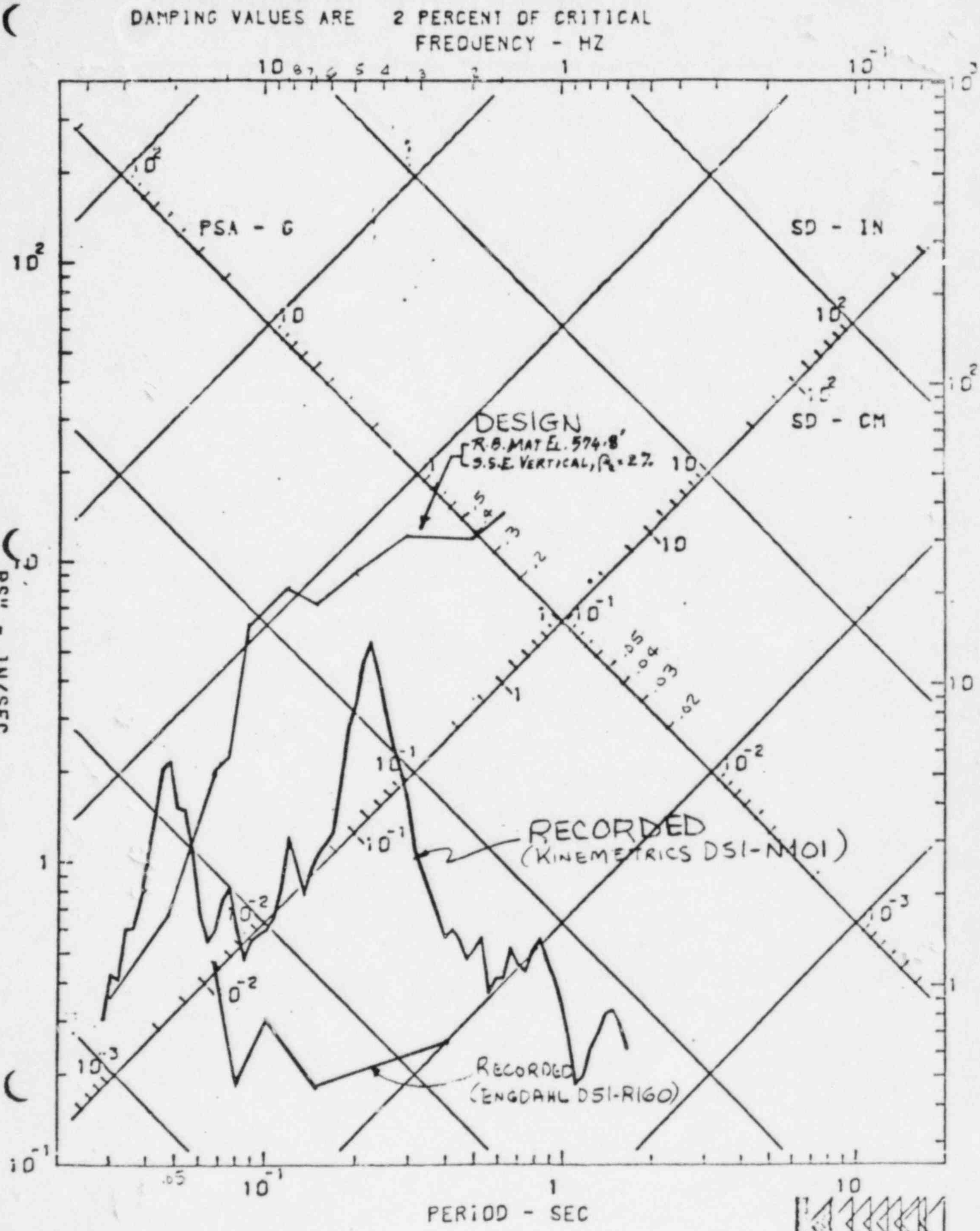

DAMPING VALUES ARE 2 PERCENT OF CRITICAL
FREQUENCY - HZ
PSA - G
SD - IN
SD - CM
PSV - IN/SEC
PERIOD - SEC
DESIGN
R.B. MAT EL. 574.8'
S.S.E. VERTICAL, β = 2%
RECORDED
(KINEMETRICS DS1-N101)
RECORDED
(ENGDAHL DS1-R160)

FIGURE D-6

PNPP UNIT NO. 1
REACTOR BUILDING
RESPONSE SPECTRA (SSE)
NORTH-SOUTH
EL 631' PLATFORM

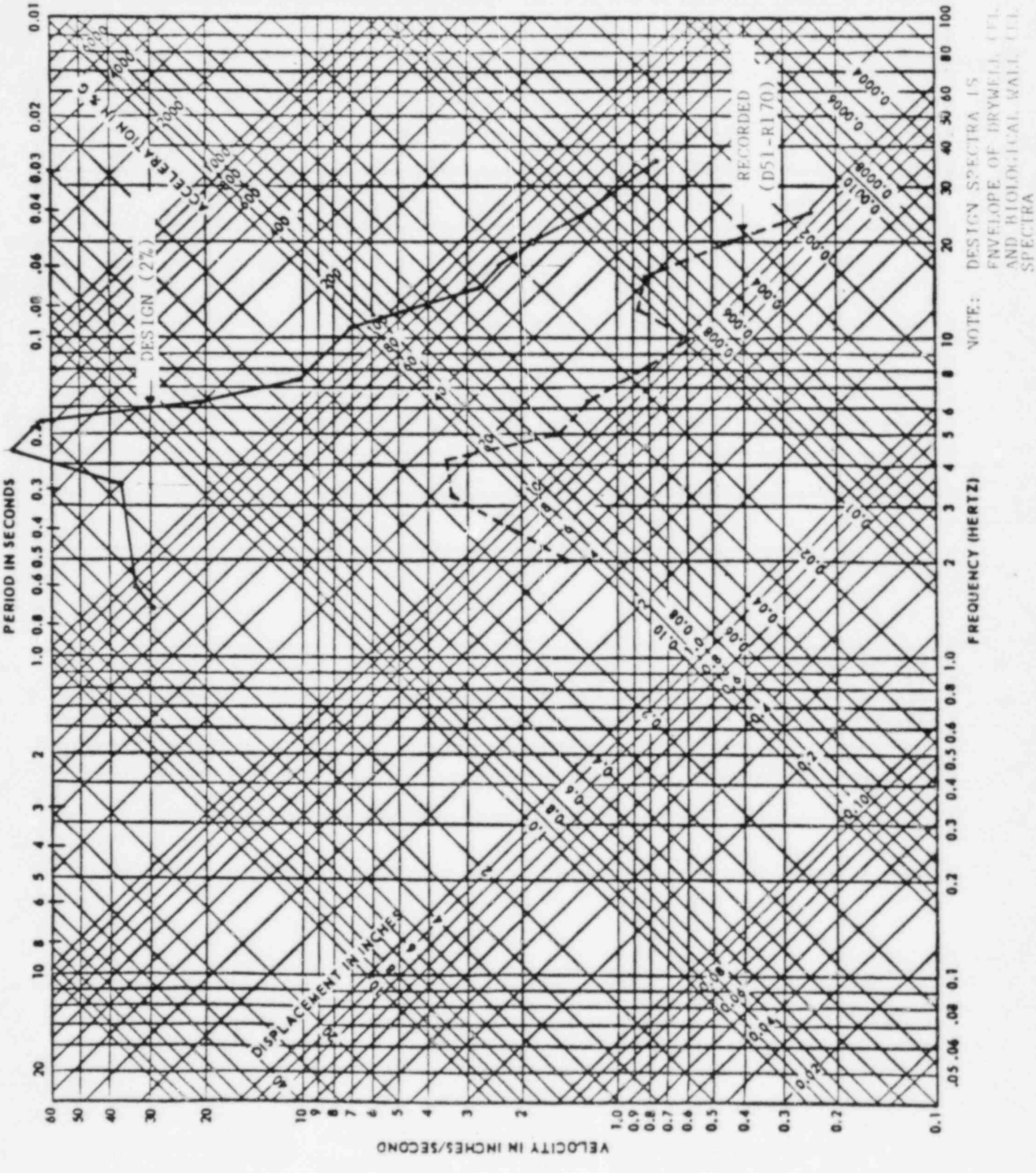


FIGURE D-7

PNPP UNIT NO. 1
REACTOR BUILDING
RESPONSE SPECTRA (SSE)
EAST-WEST
EL 631' PLATFORM

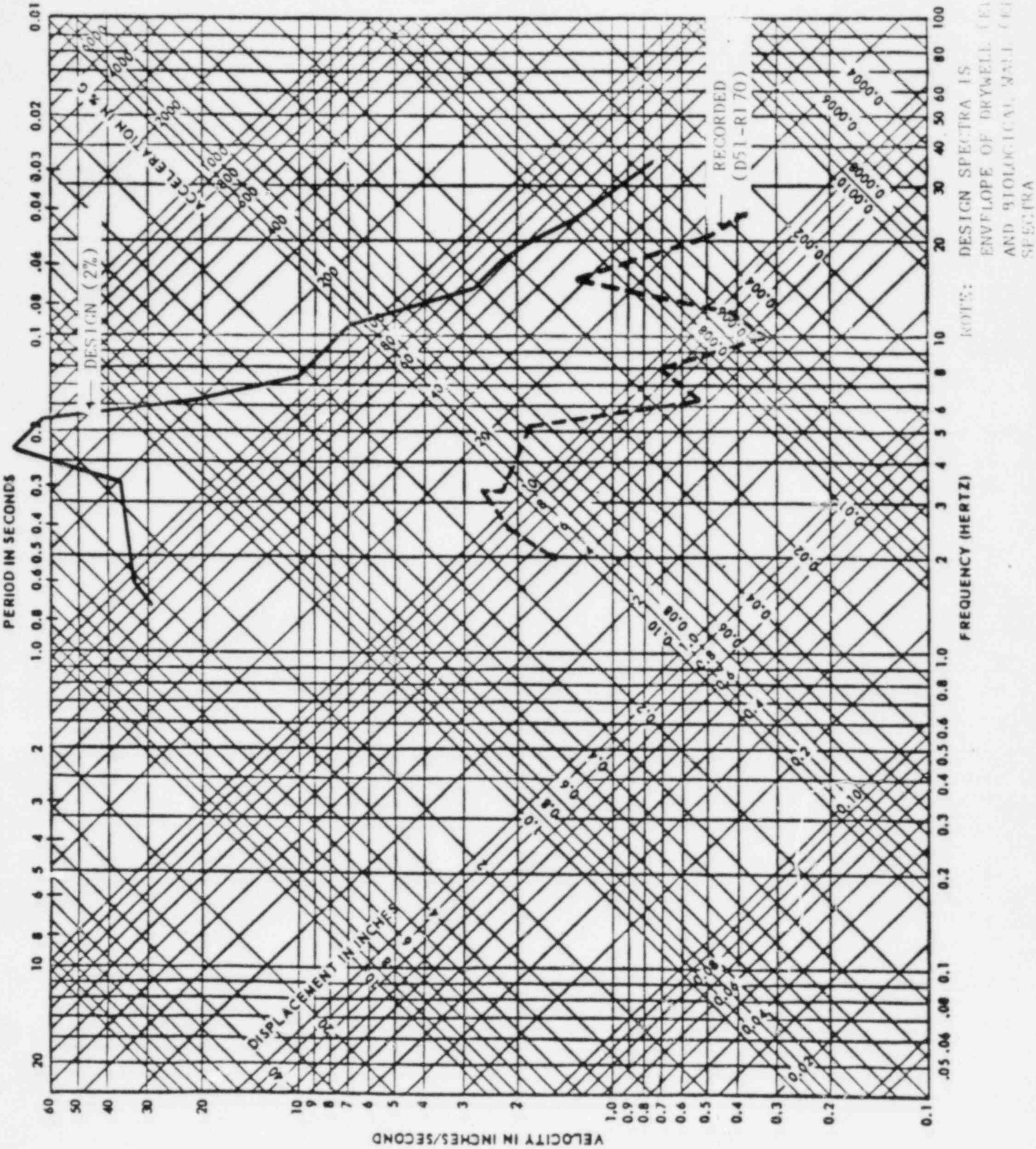


FIGURE D-8

PNPP UNIT NO. 1
REACTOR BUILDING
RESPONSE SPECTRA (SSE)
VERTICAL
EL 631' PLATFORM

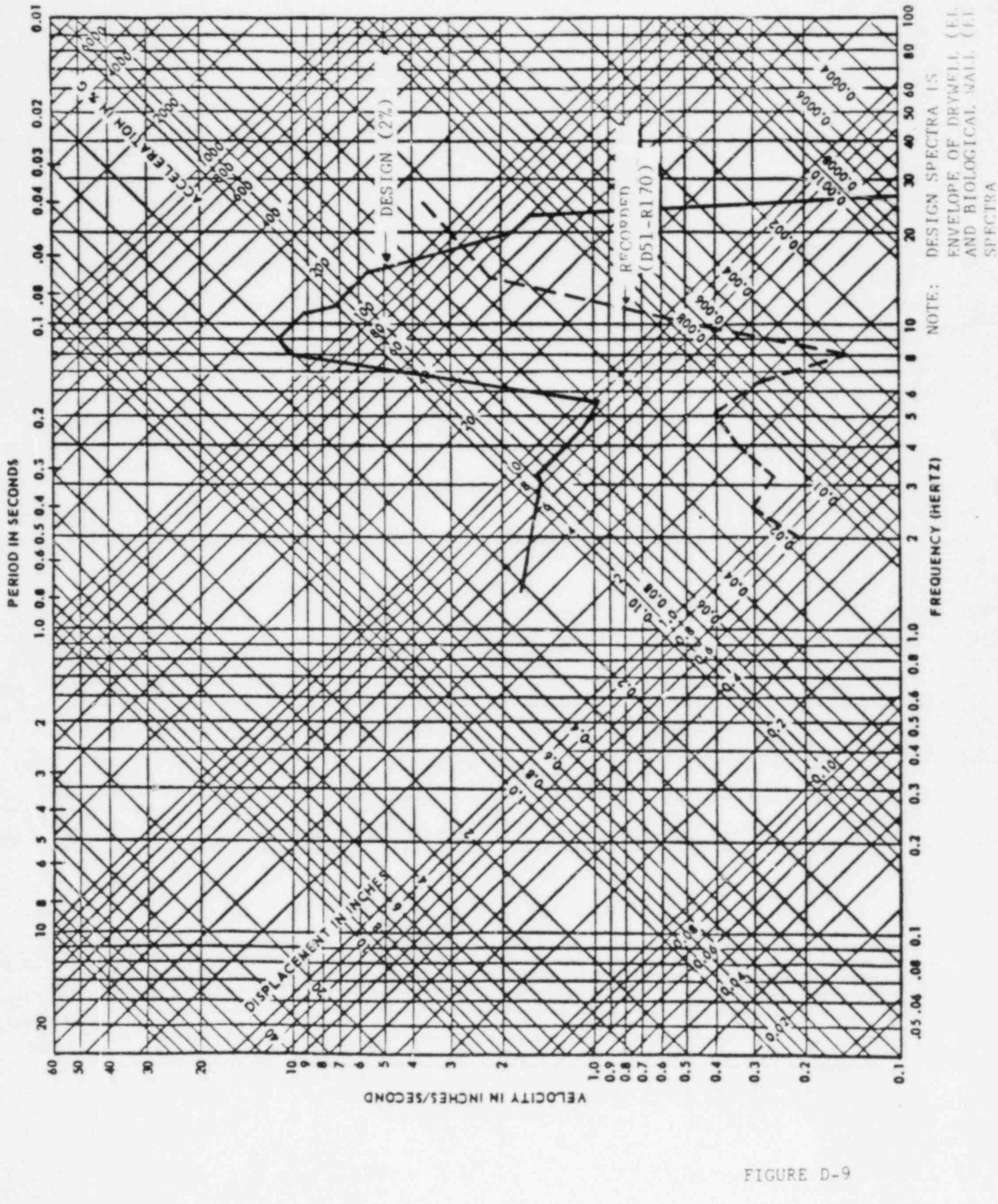


FIGURE D-9

ML 5.0 EARTHQUAKE JANUARY 31, 1986

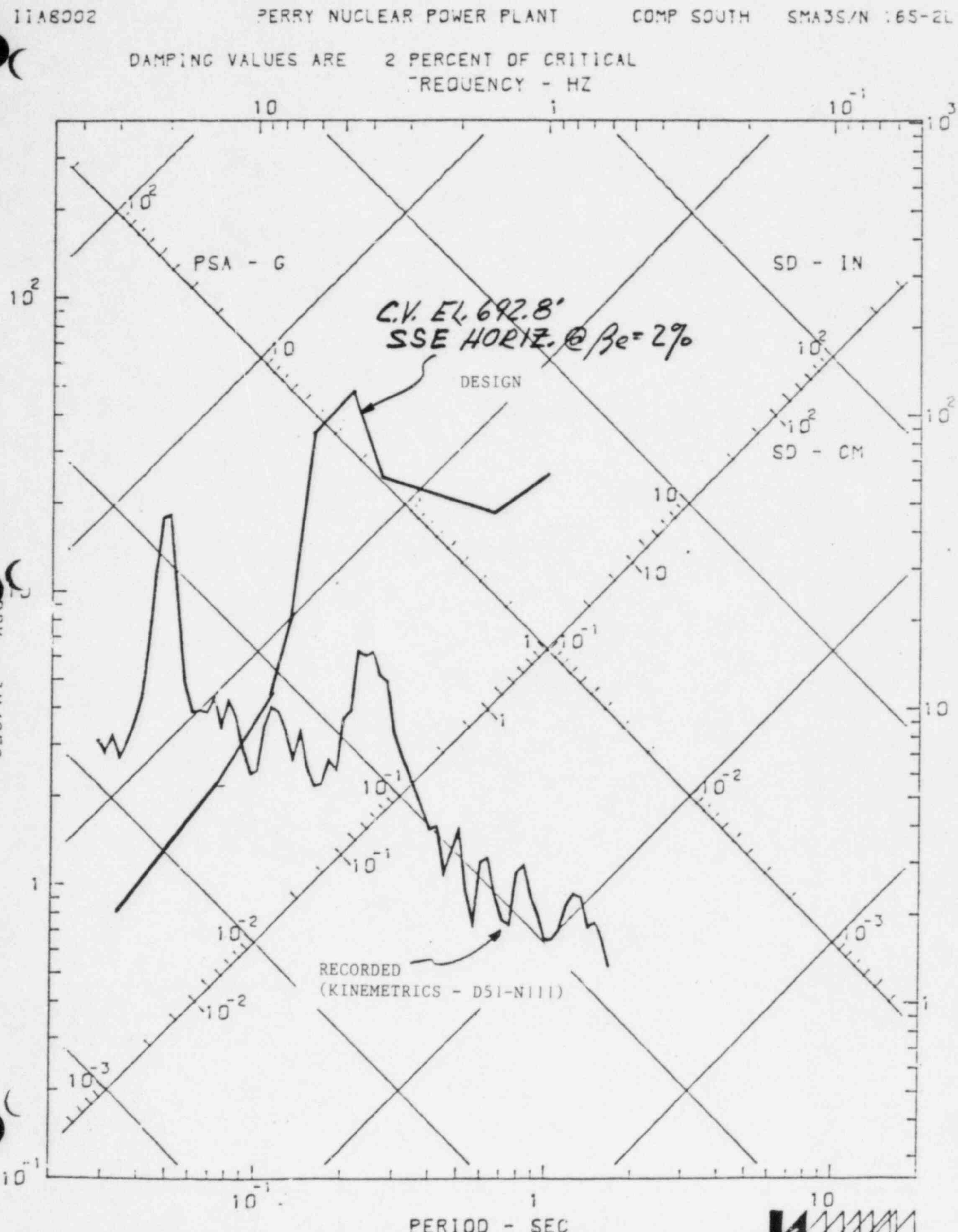


FIGURE D-10

ML 5.0 EARTHQUAKE JANUARY 31, 1986

IIA8002 PERRY NUCLEAR POWER PLANT COMP WEST SMA3S/N 165-21

DAMPING VALUES ARE 2 PERCENT OF CRITICAL

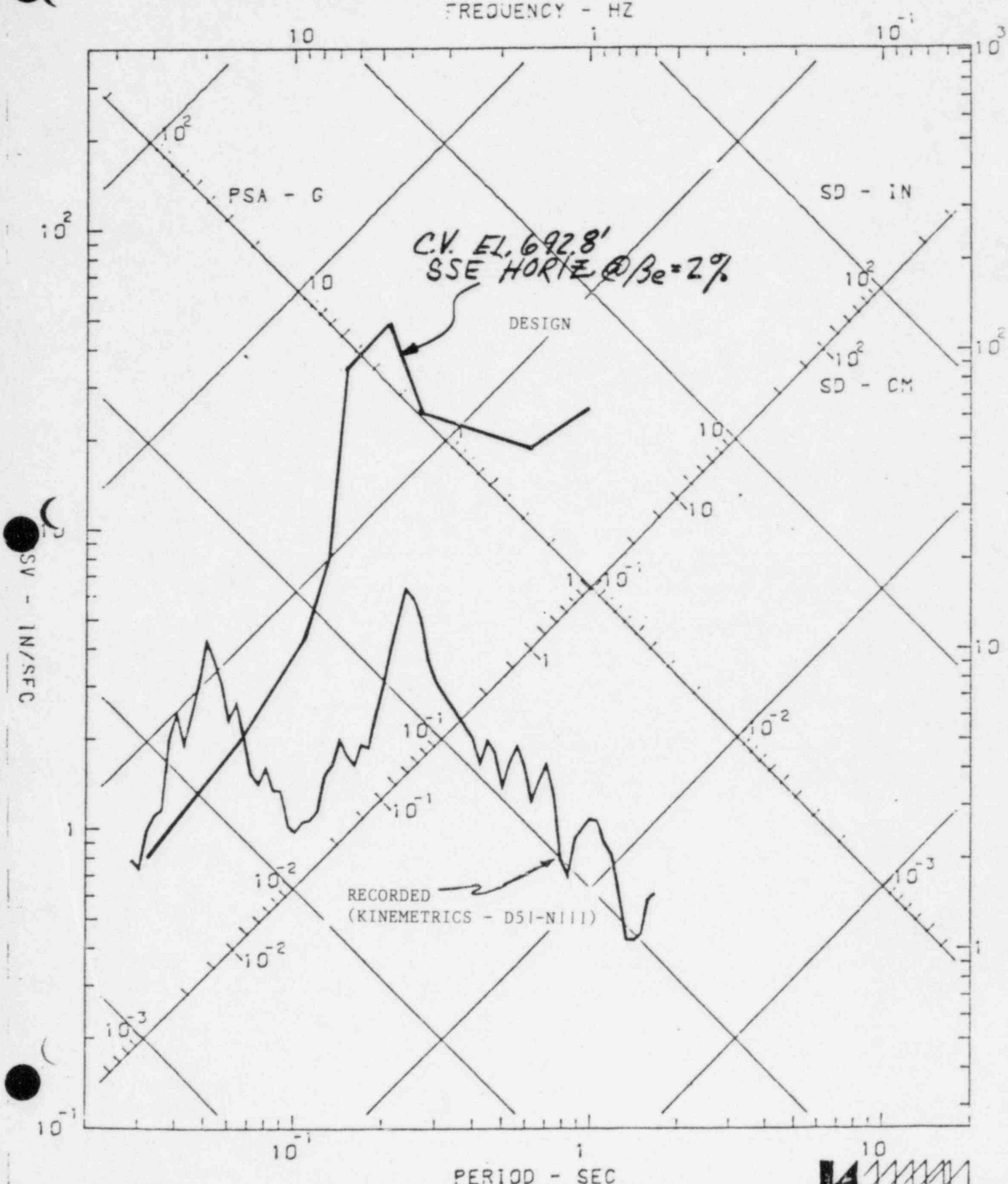


FIGURE D-11

ML 5.0 EARTHQUAKE JANUARY 31, 1986

IIA8002 PERRY NUCLEAR POWER PLANT COMP UP SMA3S/N 165-2V

DAMPING VALUES ARE 2 PERCENT OF CRITICAL

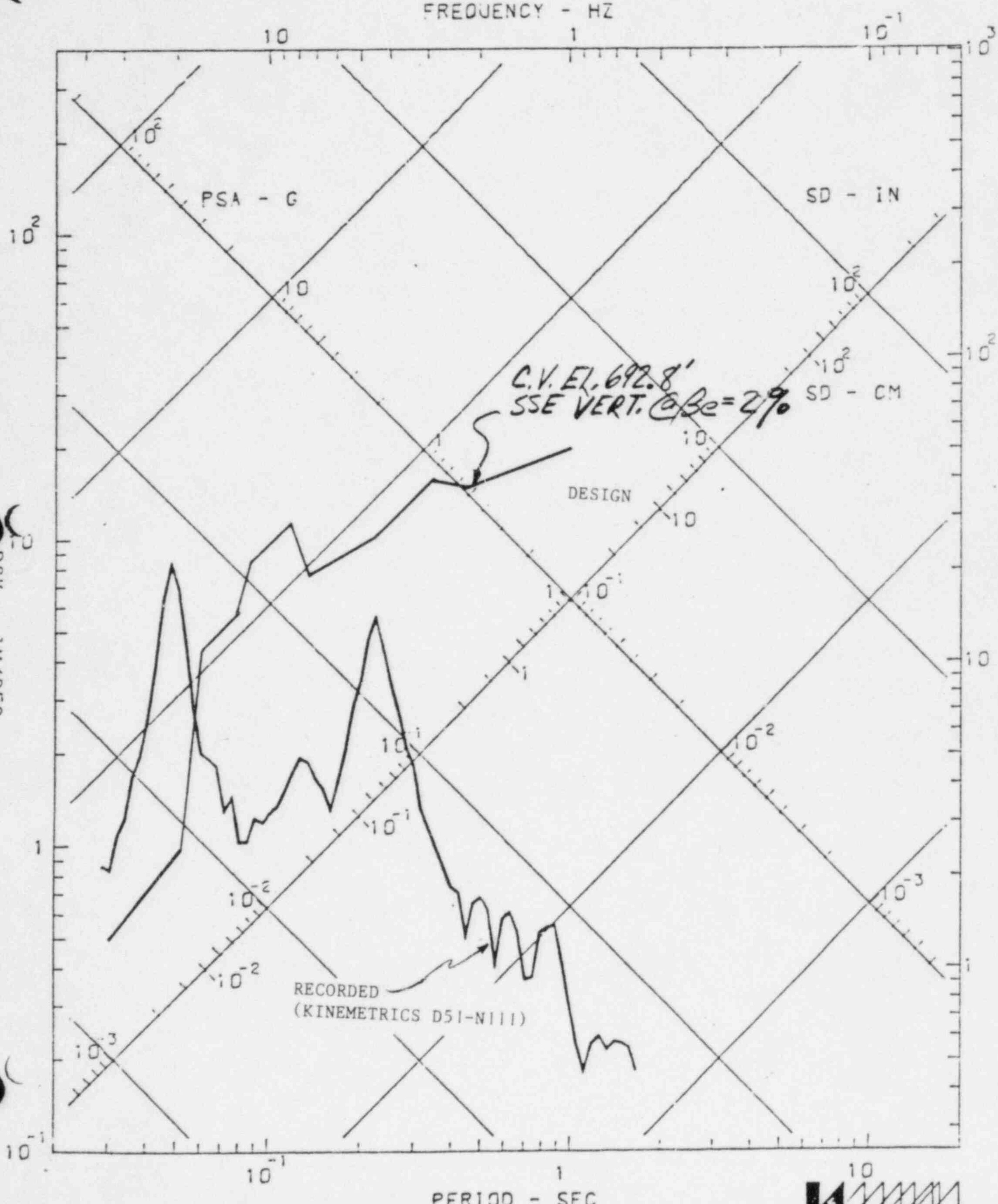


FIGURE D-12

APPENDIX E

RESULTS OF SPECIFIC INSPECTIONS

EVALUATION OF WALKDOWN ITEMS
PLANT SETTLEMENT READINGS
SEISMIC CLEARANCE WALKDOWN
COOLING TOWER WALKDOWN
REVIEW OF ENERGIZED CIRCUITS

THE CLEVELAND ELECTRIC ILLUMINATING COMPANY

G-2
REV. 1-82

MEMORANDUM

☐ I no longer wish to receive this material.

TO F. R. Stead ROOM E270 FROM K. R. Pech PHONE 5246 ROOM W220 DATE 11-Feb-86

SUBJECT Evaluation of Walkdown Items

As a result of the plant walkdowns conducted the evening of 1/31/86, Perry Plant Technical Department prepared a list of the observations of the inspection teams. These observations were given the title Earthquake Inspection Team Items or EITI's. The list of EITI's was then forwarded to Engineering for determination of whether the item was a result of the earthquake and whether or not the item needed to be repaired. The assessment of the need for repair and the documentation of that decision whether on a Non-Conformance Report or a Work Request was done in accordance with POP-1501.

The evaluation of all 473 items was completed this afternoon, and the final summary of determinations is presented in the attached table. Each item was placed in one of three categories with respect to its relationship to the earthquake.

1. Caused by the earthquake

2. Indeterminate

3. Not caused by the earthquake

As shown in the summary, 375 items were determined not to be caused by the earthquake, 96 to be indeterminate, and 2 to be caused by the earthquake. With respect to the latter two items, one was the trip of the main transformer, noted in the walkdown of electrical bus L10. The second was a non-safety heater exchanger drain valve that was found dripping water during the walkdown and was reported to be closed and not dripping prior to the earthquake.

In addition each item was categorized as to its final disposition using the procedures contained in POP-1501. Through this process, 330 items were determined to require no repair, 119 to be repaired via a Work Request and 24 items were determined to require dispositioning via a Non-Conformance Report. Of the 24 NR's, 20 are anticipated to be use-as-is and the remainder constitute cosmetic repairs to concrete and drywall walls.

By copy of this memo, the Engineering evaluation of the EITI's is being issued to the Perry Plant Technical Department for preparation of approiate documentation and inclusion in their Condition Report.

KRP:jg

EITI LIST EVALUATION SUMMARY

13:15 2/11/86

DISCIPLINE	TOTAL	C	I	N	NR	WR	NA
ELECTRICAL	35	1	22	12	0	25	10
I & C	18	0	10	8	0	15	3
MECHANICAL	83	1	29	53	2	53	28
PIPING	23	0	18	5	2	10	11
STRUCTURAL	314	0	17	297	20	16	278
TOTAL	473	2	96	375	24	119	330

C = Caused by Earthquake
I = Indeterminate
N = Not Caused by Earthquake
N/A = No Action Required

THE CLEVELAND ELECTRIC ILLUMINATING COMPANY

G-2
REV. 1-82

MEMORANDUM

☐ I no longer wish to receive this material.

TO K. Pech ROOM W210 FROM M.R. Kritzer DATE 2-6-86
PHONE 6460 ROOM TQ6
SUBJECT PLANT SETTLEMENT READINGS

Per our discussion, plant settlement readings were taken on February 5, 1986 (Attached). No significant difference in the building elevation before and after the seismic event was observed. The maximum change occurred in the Reactor Building #1. This change was only a minus (-)0.006 of a foot or 1/16 of an inch. The maximum growth was +0.003 of a foot or 1/32 of an inch, which occurred in the Radwaste Building.

A review of settlement readings taken last February 15, 1985, revealed that the Reactor Building #1 was at the same elevation as it is today.

The minute changes in plant elevation can be expected due to structural growth as a result of weather.

cc: E. Riley
J. Eppich
C. Angstadt
T. Keaveney
S. Dodeja
302.MRK

.RRETT & ASSOC. REG. ENGINEERS & SURVEYORS — PERRY NUCLEAR POWER PLANT, PERRY, OHIO

SKETCH OF: PLANT SETTLEMENTS

DATE: (M) | SCALE: | FIELD BOOK:

DISC # \ DATE	1/16/86	2/5/86				
1-F	625.406	625.402				
2-D	624.339	624.333				
3-D	624.363	624.359				
4-F	626.391	626.386				
5-D	624.540	624.538				
6-D	622.105	622.108				
7-C	621.300	621.298				
SP-8	624.458	624.459				
SP-9	624.924	624.921				
SP-10	624.450	624.453				
SP-11	624.491	624.487				
Initial						

DISC # \ DATE						
1-F						
2-D						
3-D						
4-F						
5-D						
6-D						
7-C						
SP-8						
SP-9						
SP-10						
SP-11						

GARRETT & ASSOC. REG. ENGINEERS & SURVEYORS — PERRY NUCLEAR POWER PLANT, PERRY, OHIO

SKETCH OF: PLANT SETTLEMENTS

DATE: (M)

SCALE:

FIELD BOOK:

PT \ DATE	AUG 20, 1985	SEPT. 25. 1985	OCT. 18, 1985	NOV. 14, 1985	DEC. 17, 1985	JAN. 16, 86	
1·F	625.402	625.410	625.411	625.413	625.404	625.406	
2·D	624.341	624.342	624.340	624.345	624.338	624.339	
3·D	624.358	624.361	624.365	624.366	624.362	624.363	
4·F	626.388	626.390	626.390	626.387	626.388	626.391	
5·D	624.538	624.544	624.544	624.548	624.540	624.540	
6·D	622.106	622.106	622.104	622.103	622.106	622.105	
7·C	621.303	621.301	621.304	621.300	621.292	621.300	

PT \ DATE							
1·F							
2·D							
3·D							
4·F							
5·D							
6·D							
7·C							

PT \ DATE							
1·F							
2·D							
3·D							
4·F							
5·D							
6·D							
7·C							

GARRETT & ASSOC. REG. ENGINEERS & SURVEYORS — PERRY NUCLEAR POWER PLANT, PERRY, OHIO. (8)

SKETCH OF: PLANT SETTLEMENTS

DATE: (M)

SCALE:

FIELD BOOK:

PT.	SEPT 27,83	OCT 27, 1983	NOV. 22,83	DEC 21 83	JAN. 5, 1984	FEB 10, 84	MAR. 24, 84	
1-F	625.396	625.395	625.402	625.407	625.405	625.406	625.401	
2-D	624.332	624.329	624.335	624.338	624.334	BLOCKED	624.331	
3-D	624.372	624.365	624.365	624.363	624.361	624.362	624.361	
4-F	626.389	626.384	626.388	626.388	626.385	626.391	626.381	
5-D	624.543	624.517	624.547	624.549	624.550	624.546	624.542	
6-D	622.101	622.098	622.096	622.101	622.093	622.101	622.099	
7-C	621.295	621.295	621.294	621.303	621.295	621.290	621.281	

PT.	APRIL 28,84	MAY 24, 84	JUNE 20, 1984	JULY 10, 84	AUG. 21, 84	SEPT 14, 84	OCT 10, 84	NOV. 23, 84
1-F	625.397	625.401	625.400	625.402	625.405	625.403	625.406	625.402
2-D	624.335	624.334	624.337	624.336	624.338	624.341	624.339	624.333
3-D	624.365	624.365	624.369	624.368	624.369	624.370	624.366	624.363
4-F	626.385	626.383	626.394	626.390	626.389	626.393	626.391	626.391
5-D	624.537	624.544	624.545	624.546	624.552	624.553	624.550	624.535
6-D	622.102	622.102	622.105	622.108	622.106	622.106	622.103	622.094
7-C	621.287	621.291	621.300	621.298	621.298	621.301	621.300	621.297

PT.	[illegible]	1/10/85	2/15/85	3/22/85	4/12/85	5/15/85	6/25/85	7/9/85
1-F	[illegible].405	625.403	625.406	625.401	625.403	625.396	625.398	625.398
2-D	624.335	624.334	624.333	624.341	624.343	624.336	624.333	624.330
3-D	624.36[illegible]	624.358	624.361	624.359	624.360	624.360	624.357	624.364
4-F	626.3[illegible]9	626.384	626.389	626.380	626.382	626.384	626.381	626.384
5-D	[illegible]46	624.542	624.544	624.547	624.543	624.542	624.546	624.543
6-D	622.096	622.094	622.105	622.103	622.106	622.100	622.101	622.108
7-C	[illegible]	621.296	621.292	621.297	621.297	621.297	621.306	621.299

PERRY POWER PLANT
FOUNDATION SETTLEMENT CHART

MARK NO	DEC 18, 78	JAN 2?	FEB 13 79	MARCH 20	MAY 6, 1979	MAY 21 79	JULY 10 79	SEPT 10, 79	OCT 5, 79	OC[redacted]
1-E	625.286	625.274	625.270	625.270	625.270	—	—			
1-F	NEW DISC →			625.393	625.397	625.395	625.406	625.399	625.420	625.41[redacted]
2-D	624.351	624.336	624.331	624.332	624.336	624.337	624.343	624.342	624.352	624.346
3-D	624.423	624.403	624.388	624.394	624.401	624.397	624.398	624.395	624.403	624.396
4-C	596.003	COVERED		596.007	COVERED	COVERED	COVERED			
4-D	REVISED READING →	604.626	604.626	604.626	604.620	COVERED	"			
4-B	COVERED —			596.947	COVERED	COVERED	"			
5-C	603.615	603.607	COVERED	603.605	TEMPORARILY COVERED	COVERED	"			
5-D				NEW DISC →	624.561	624.551	624.548	624.548	624.551	624.554
6-C	619.025	COVERED								
6-D	NEW DISC. →			622.086	622.088	622.096	622.085	622.091	NEW MARK 622.112	622.109
7-A	COVERED	→			COVERED	COVERED —				
7-B	NEW MARK		→	616.733	616.735	616.732	616.737	616.729	616.725	(?)621.300
4-E	NEW →				620.464	620.465	620.462			
4-F							626.412	626.409	NEW 626.407	626.405

MARK NO	OCT 31, 1979	NOV 19, 1979	JAN 21, 1980	MAR 27 1980	APR ? 1980	JUNE 23, 80	AUG 12, 1980	SEPT. 18, 1980	OCT. 22, 1980	DEC 15, 1980	JAN 21, 1981
1-F	625.418	625.413	625.402	625.414	625.415	625.419	625.407	625.392	625.390	625.400	625.385
2-D	624.346	624.349	624.337	624.353	624.350	624.354	624.344	624.336	624.333	624.336	624.326
3-D	624.396	624.391	624.382	624.386	624.388	624.400	624.385	624.372	Blocked	624.370	624.362
4-F	626.405	626.409	626.370	626.403	626.407	626.409	626.397	626.387	626.390	626.414	626.379
5-D	624.554	624.551	624.540	624.547	624.549	624.549	624.546	624.554	624.552	624.548	624.541
6-D	622.104	622.104	622.099	622.098	622.100	622.101	622.099	622.108	622.095	622.104	622.091
7-C	621.300	621.300	621.303	621.288 (621.276) RECHECKED	621.308	621.311	621.310 WALL	621.314 WALL	621.309 WALL	621.303	621.301 0-1 mm

GARRETT & ASSOC. REG. ENGINEERS SURVEYORS

PERRY NUCLEAR POWER PLANT PERRY, OHIO.

SKETCH OF

DATE

SCALE

FIELD BOOK

GARRETT & ASSOC. REG. ENGINEERS SURVEYORS — PERRY NUCLEAR POWER PLANT, PERRY, OHIO.

SKETCH OF PLANT SETTLEMENTS

DATE | SCALE | FIELD BOOK

POINT \ DATE	FEB 9, 1981	MARCH 31, 1981	APRIL 15 1981	MAY 22 1981	July 1, 1981	July 26 1981	AUG 11, 1981	SEPT 2 1981	OCT. 21, 1981	NOV 27, 8[illegible]	
1-F	625.395	625.395	625.394	625.395	625.392	625.395	625.387	625.396	625.396	625.391	
2-D	624.332	624.325	624.325	624.327	624.332	624.333	624.335	624.337	624.330	624.335	
3-D	BLOCKED	624.366	624.365	624.366	624.370	624.371	624.369	624.375	624.367	624.369	
4-F	626.390	626.390	626.384	626.388	626.390	626.387	626.391	626.389	626.387	626.383	
5-D	624.547	624.521	624.543	624.541	624.538	624.538	624.540	624.540	624.547	624.546	
6-D	622.096	622.096	622.100	622.099	622.096	622.099	622.095	622.103	622.094	622.093	
7-C	621.306	621.312	621.310	621.311	621.314	621.314	621.315	621.318	621.289*	621.290	
	WALL	WALL	WALL	[illegible]	WALL	[illegible]	WALL	WALL	MON.		

POINT \ DATE	JAN 5 1982	JAN 15 1982	FEB 19, 82	MAR. 21, 1982	APRIL 26, 82	MAY 17 1982	JUNE 22 1982	July 28, 1982	8-25-82	9-82	10-21-82
1-F	625.393	625.390	625.390	625.394	625.392	625.394	625.391	625.390	625.394	625.398	625.398
2-D	624.329	624.325	624.322	Blocked	624.328	624.333	624.324	624.331	624.330	624.335	624.335
3-D	624.365	624.362	624.352	624.361	624.366	624.365	624.358	Blocked	BLOCKED	Blocked	BLOCKED
4-F	626.385	626.381	626.368	626.384	626.384	626.383	626.374	626.381	626.383	626.385	626.385
5-D	624.545	624.543	624.540	624.539	624.541	624.538	624.541	624.541	624.544	624.538	624.538
6-D	622.092	622.095	622.096	622.096	622.095	622.096	622.098	622.099	622.098	622.097	622.097
7-C	621.281	621.276	621.276	621.269	621.284	621.289	621.282	621.249	621.290	621.290	621.294

POINT \ DATE	NOV. 30. 82	DEC. 8, 1982	JAN 25, 1983	FEB 16, 83	MAR 28, 1983	APR. 20, 83	MAY 18, 83	MAY 24. 83	JUNE 23, 83	July 26, 1983	AUG. 24 83
1-F	625.395	625.392	625.392	625.399	625.400	625.401	~~625.407~~	625.393	625.399	625.403	625.399
2-D	624.334	624.328	624.331	624.328	624.333	624.330	~~624.327~~	624.321	624.333	624.339	624.332
3-D	Blocked	Blocked	BLOCKED	624.367	624.367	624.361	~~624.368~~	624.356	624.363	624.374	624.367
4-F	626.387	626.374	626.379	626.382	626.385	626.380	~~626.394~~	626.380	626.383	626.394	626.388
5-D	624.539	624.5[illegible]	624.537	624.539	624.543	624.536	624.535		624.543	624.541	624.542
6-D	622.097	622.101	622.097	622.097	622.101	622.096	622.098		622.100	622.104	622.101
7-C	621.288	621.296	621.288	621.294	621.291	621.286	621.288		621.295	621.289	621.295

PERRY NUCLEAR POWER PLANT
FOUNDATION SETTLEMENT CHART CONTINUED BY GARRETT [illegible]
SHEET NO. 5-C

MARK NO.	FEB. 16, 78	MARCH 13, 78	APRIL 7, 1978	MAY 9, 1978	MAY 25, 78	JUNE 15 78	JULY 20 78	JULY 31, 78	AUG. 17, 78	AUG 28. 78	SEPT 27, 78	[illegible]
1-B	COVERED	COVERED	WILL BE CLEAR NEXT MONTH	NOT CLEAR	595.625	COVERED	NOT CLEAR	COVERED	COVERED			
2-D PER	624.362	NOT ABLE TO READ	624.360	624.355	624.360	624.360	624.348	624.358	624.357		624.360	624.35[illegible]
3-B	599.046	599.041	599.040	599.044	599.052	RAISED 5' TO 604.046	604.047	604.033	604.041			
4-B	596.940	596.938	596.939	596.940	COVERED	COVERED	COVERED	COVERED	COVERED			
5	COVERED	COVERED	COVERED	COVERED	COVERED	COVERED	COVERED	"	"			
6-B	602.188	602.170	602.191	602.195	602.188	602.118	602.200	602.197	602.210			
7	NOT ABLE TO READ	NOT ABLE TO READ	NOT ABLE TO READ	NOT ABLE TO READ	COVERED UNDER [illegible]	COVERED	COVERED	COVERED	COVERED			
5-A		NEW POINT SET ON WALL →	APRIL 12 78 591.524	COVERED	COVERED	COVERED	COVERED	"	"			
2-C		600.144			600.146	COVERED	COVERED	"	"			
1-C			NEW	593.517	593.514	593.517	COVERED	"	"			
[illegible]-B				598.805	598.794	COVERED	COVERED	"	"			
1-D					NEW 614.287	COVERED	COVERED	"	"		614.291	614.295
3-C					623.514	623.507	623.506	"	"			
4-C					596.018	COVERED	COVERED	595.997	595.999			596.007
7-A	MARK ON WALL 15' W. OF SE COR.				NEW 563.143	563.122	563.113	COVERED				563.180
3-D					PERMANENT DISC SET. REACTOR No2 (270°) →					INITIAL 624.425	624.422	624.411
4-D											NEW →	604.625
1-E											NEW →	625.292
6-C											NEW →	619.028
5-C											NEW →	605.600 (SEE NOTE A)

[illegible] BLOCKED OR CANNOT READ

NOTE [illegible]: REVISED DUE TO ERROR IN NOV.

PERRY NUCLEAR POWER PLANT

FOUNDATION SETTLEMENT CHART CONTINUED BY GARRETT & ASSOCIATES INCORPORATED

SHEET № 2

№	JULY 8, 77	July 15, 77	JULY 21 77	July 29	8/5/77	AUG. 12 77	AUG 19, 77	Aug 29, 77	SEPT. 14, 77	SEPT 26, 77	OCT 12 77	[illegible]
1A	582.090	582.093	582.092	582.095	582.095	582.087	582.092	582.091	COVERED	—	—	
1B	595.619	595.619	595.622	595.625	595.627	595.615	595.624	595.620	595.620	595.619	595.622	595.6[illegible]
2	572.984	572.983	COVERED			572.979	572.984	COVERED	—	—	—	—
2A	578.334	578.333	578.335	COVERED		—	COVERED	COVERED	—	—	—	—
2B	589.980	COVERED	589.981	589.981	589.984	589.978		589.982	589.981	COVERED	—	—
3	572.983	572.982	572.984	572.987	COVERED	572.986	572.990	572.989	572.987	COVERED	—	—
[illegible]	585.491	585.493	585.494	585.493	585.493	585.493	585.493	585.493	585.495	585.494	585.496	585.498
[illegible]	572.906	572.904	572.906	572.905	572.904	572.904	572.906	572.899	572.903	572.898	572.891	572.891
A	587.475	587.476	587.478	587.481	587.496	587.467	587.478	587.475	587.474	587.477	587.474	587.469
3A	—					590.267	590.267	590.265	590.266	590.262	590.270	590.265
2-C	NEW MARK —								600.146	600.144	600.144	—
2-D = BRASS DISC	—							SEPT 12 77 624.359	624.361	624.360	624.365	624.358

	NOV. 17, 77	DEC 2, 77	DEC 19, 77	DEC 29, 77	JAN 23, 78	Feb 16, 78
• 1-B	COVERED BY FILL	COVERED	COVERED BY FORM	COVERED	COVERED	—
• 2-D	624.358	624.358	624.361	624.362	624.358	624.362
3-A	COVERED	—		—	—	—
• 4-A	COVERED BY BACKFILL	—		—	—	—
• 5	COVERED	COVERED	COVERED	COVERED	COVERED	—
• 6-A	587.470		587.450	587.460	587.416	587.446
• 4-B	596.943	596.942	596.938	596.940	596.940	596.940
• 2-C	600.142	—	600.143	600.155	600.155	
• 6-B	602.183	602.180	602.200	602.194	VOID ~~602.160~~	602.188
3-B	599.045	599.048	599.042	599.044	599.049	599.046

CONTINUED ON SHEET "5-C"

Perry Nuclear Power Plant

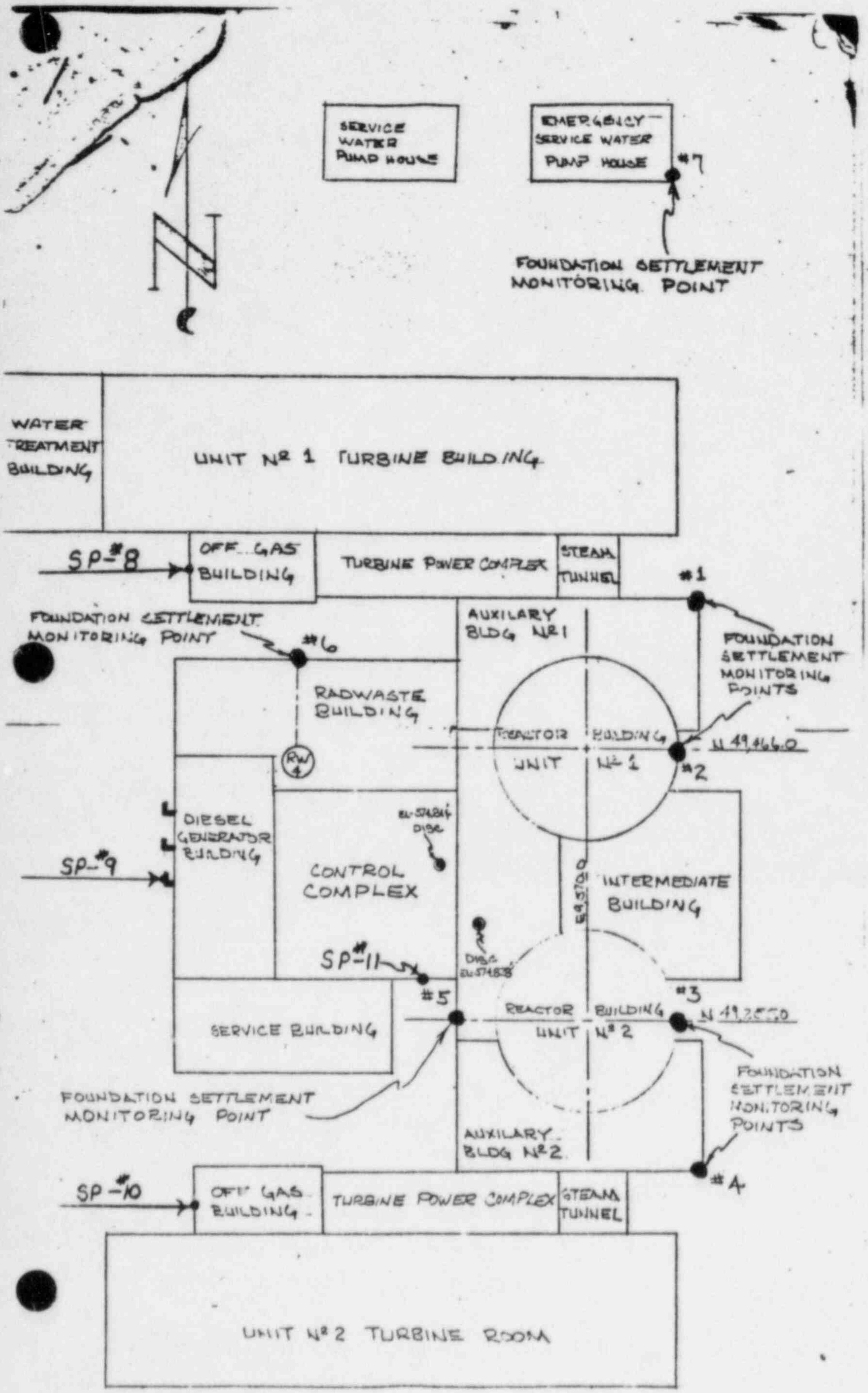
Foundation Settlement Chart By Garrett + Assoc. Incorporated

Started Jan. 18, 77

Notes. 1) Use in conjunction with Gilbert Print RDB 121416.
2) Elevations are in feet and decimals.
3) Ref. - Garrett Book Nº 28
Sheet Nº 1

Mark Nº	Jan. 18, 77	Jan 24, 77	Feb. 1, 77	Feb 7 77	Feb. 15, 77	Feb 21, 77	Feb. 28, 77	March 8, 77	March 17, 77	March 25 77	March 30 77	April 6, 77
1	568.334	568.346	568.339	568.333	568.334	568.334	568.333	568.333	568.333	568.318	568.333	568.333
2	572.992	572.993	572.990	572.991	572.990	572.988	572.987	572.988	572.988	572.987	572.986	572.982
3	572.998	572.996	572.996	572.996	572.995	572.994	572.992	572.993	572.989	572.986	572.984	572.987
4								Set March 10, 77	568.295	568.291	568.287	568.287
5												
6					Set Feb. 18, 77	573.934	573.931	573.936	573.938	573.931	573.930	573.937

Mark Nº	April 14, 77	April 29, 77	April 22 77	May 6, 77	May 12, 77	May 19, 77	May 27, 77	June 3, 1977	June 10, 77	June 15, 77	June 22 77	July 1 77
1	568.333	568.330	568.331	568.330	568.334	1-B = 582.0[illegible] 568.335	1-A: 582.097	582.094	582.095	1A 582.0[illegible] 1B 575.618	[illegible] 575.619	1-A [illegible] 1-B 576.624
2	572.986	572.986	572.986	572.986	2-A: 578.316 572.986	2-A: 578.3[illegible] 572.984	2-A: 578.335	578.337	578.330	[illegible] 2A 578.3[illegible] 2B 587.983	2A 578.337 2B 587.983	2-A 578.336 2-B 587.982
3	572.987	572.984	572.987	572.988	572.990	572.986	572.985	572.989	572.986	572.990	692.987	572.984
4	568.287	568.284	568.285	568.287	568.288	568.287	568.291	568.290	568.286	4A 586.493	585.493	4-A: 586.493
5		Set April 27. 77	572.905	592.905	592.906	572.905	572.904	572.899	572.896	592.905	592.895	572.904
6	573.938	573.936	573.939	587.462 573.935	573.935	573.932	587.499 573.932	6-A: 587.4[illegible] 6 - covered	587.478	587.475	587.493	587.469


SERVICE WATER PUMP HOUSE
EMERGENCY SERVICE WATER PUMP HOUSE
#7
FOUNDATION SETTLEMENT MONITORING POINT
N
WATER TREATMENT BUILDING
UNIT Nº 1 TURBINE BUILDING
SP-#8
OFF GAS BUILDING
TURBINE POWER COMPLEX
STEAM TUNNEL
#1
FOUNDATION SETTLEMENT MONITORING POINT
#6
AUXILARY BLDG Nº1
FOUNDATION SETTLEMENT MONITORING POINTS
RADWASTE BUILDING
REACTOR BUILDING UNIT Nº 1
N 49,466.0
#2
RW 4
DIESEL GENERATOR BUILDING
SP-#9
CONTROL COMPLEX
INTERMEDIATE BUILDING
SP-#11
DISC
#5
SERVICE BUILDING
REACTOR BUILDING UNIT Nº 2
#3
FOUNDATION SETTLEMENT MONITORING POINT
FOUNDATION SETTLEMENT MONITORING POINTS
AUXILARY BLDG Nº2
#4
SP-#10
OFF GAS BUILDING
TURBINE POWER COMPLEX
STEAM TUNNEL
UNIT Nº 2 TURBINE ROOM

THE CLEVELAND ELECTRIC ILLUMINATING COMPANY

G-2
REV. 1-82

MEMORANDUM

☐ I no longer wish to receive this material.

TO K. Pech ROOM W210 FROM M. Kritzer/J. Messenger DATE 2-5-86
PHONE 6460 ROOM TQ6
SUBJECT SCV WALKDOWN AFTER SEISMIC EVENT
Ref. documents NIR's C-23642,
C-23661 thru and including C-23666
also C-23677

Due to the seismic event which occurred on 1/31/86, the Seismic Clearance Group has conducted a walkdown of all open "Repair" dispositioned Seismic Clearance Violations.

The scope of the walkdown was to evaluate if any dimensional changes from the original SCV, and to note any structural or system damage in these particular areas that could have been attributed to the earthquake.

The results of the evaluation, as shown on the above referenced inspection reports, indicates that there were no dimensional changes from the document SCV's. There was also no plant damage associated with the unrepaired SCV's.

It should be noted that 7 of the ~~28~~ 29 SCV's have at minimum, partial work complete.

Any questions, please feel free to contact us.

attachments: 8

cc: E. Riley
S. Dodeja
302.MRK
302. JWM
J. Eppich
C. Angstadt

PNPP No. 5978

N/A	N/A	C-23642
CONTRACTOR	SPEC. NO.	INSPECTION REPORT NUMBER
SCV INSPECTION WALKDOWN AFTER SEISMIC EVENT		~~See Below~~ N/A
SYSTEM/COMPONENT/ACTIVITY		M.P.L. NUMBER
AX-1 599 EL	21	2-3-86
LOCATION	INSP. TYPE	DATE

DUE TO THE SEISMIC EVENT WHICH OCCURED ON 1-31-86 THE FOLLOWING OPEN SCVs HAVE BEEN FIELD VERIFIED TO DETERMINE IF ANY DIMENSIONAL CHANGES HAVE OCCURED.

SCV 6215
SCV 6292
SCV 6550

CORRECTIVE ACTION DOCUMENTATION - (D.R.'s): N/A

MEASURING/INSPECTION TOOLS I.D.: MISC INSPECTION TOOLS

REMARKS NO DIMENSIONAL CHANGES DIRECTLY ATTRIBUTED TO THE SEISMIC EVENT WERE FOUND AND NO DAMAGE ENCOUNTERED.

cc: S. DODEJA - E180

[signature] 2-3-86
INSPECTOR DATE

[signature: John W Messenger] 2-4-86
REVIEWED - LEAD INSPECTOR DATE

441/T/1/ba

PNPP No. 5978

N/A CONTRACTOR	N/A SPEC. NO.	C-23661 INSPECTION REPORT NUMBER
Walkdown of open S.C.U.s after the seismic event of 1-31-86 SYSTEM/COMPONENT/ACTIVITY		N/A M.P.L. NUMBER
Control Complex, 679'-6" Floor elev. LOCATION	21 INSP. TYPE	2-3-86 DATE

Due to the seismic event which occured on 1-31-86, the following open S.C.U.s have been field verified to determine if any dimensional changes had occured: SCU # 5978

S.C.U. # 6060 rev. △1

S.C.U. # 6061 rev. △1

NO dimensional changes or damage, directly attributed to the seismic event, were found.

CORRECTIVE ACTION DOCUMENTATION - (D.R.'s): N/A.

MEASURING/INSPECTION TOOLS I.D.: Miscellaneous inspection Tools.

REMARKS N/A

cc: S. Dodeja E-180

FCMann [signature] — INSPECTOR — DATE 2-4-86

John W Masenga [signature] — REVIEWED - LEAD INSPECTOR — DATE 2-4-86

441/T/1/ba

N/A	N/A	C-23662
CONTRACTOR	SPEC. NO.	INSPECTION REPORT NUMBER
Walkdown of open S.C.U.s after the seismic event of 1-31-86		N/A
SYSTEM/COMPONENT/ACTIVITY		M.P.L. NUMBER
Intermediate Bldg., All elevations	21	2-3-86
LOCATION	INSP. TYPE	DATE

Due to the seismic event which occured on 1-31-86, the following open S.C.U.s have been field verified to determine if any dimensional changes had occured:

S.C.U. # 6500, S.C.U. # 6536 – 620'-6" Floor elev.

S.C.U. # 6639, S.C.U. # 6688 – 599' Floor elev.

S.C.U. # 5968 - 574'-~~6"~~ 10" Floor elev. (2-4-86)

NO dimensional changes or damage, directly attributed to the seismic event, were found.

CORRECTIVE ACTION DOCUMENTATION - (D.R.'s): N/A.

MEASURING/INSPECTION TOOLS I.D.: Miscellaneous inspection Tools.

REMARKS S.C.U. # 5968 has 3 of the 4 repair supports added.

cc: S. Dodeja E-180

H. Manno (signature) — INSPECTOR — DATE 2-4-86

(signature) — REVIEWED - LEAD INSPECTOR — DATE 2-4-86

441/T/1/ba

N/A CONTRACTOR	N/A SPEC. NO.	C-23663 INSPECTION REPORT NUMBER
Walkdown of open S.C.O.s after the seismic event of 1-31-86 SYSTEM/COMPONENT/ACTIVITY		N/A M.P.L. NUMBER
Auxiliary Bldg # 1, All elevations LOCATION	21 INSP. TYPE	2-3-86 DATE

Due to the seismic event which occured on 1-31-86, the following open S.C.U.s have been field verified to determine if any dimensional changes had occured: S.C.U.# 6563 - 620'-6" Floor elev.

S.C.U.# 6136 } 599' Floor elev.
S.C.U.# 6262 }

NO dimensional changes or damage, directly attributed to the seismic event, were found.

CORRECTIVE ACTION DOCUMENTATION - (D.R.'s): N/A.

MEASURING/INSPECTION TOOLS I.D.: Miscellaneous inspection Tools.

REMARKS S.C.U.# 6262 has repair work in-progress.

cc: S. Dodeja E-180

[signature] 2-4-86
INSPECTOR DATE

[signature: J. Messenger] 2-4-86
REVIEWED - LEAD INSPECTOR DATE

441/T/1/ba

PNPP No. 5978

N/A	N/A	C-23664
CONTRACTOR	SPEC. NO.	INSPECTION REPORT NUMBER
WALKDOWN OF OPEN SCV'S AFTER SEISMIC EVENT OF 1/31/86		N/A
SYSTEM/COMPONENT/ACTIVITY		M.P.L. NUMBER
IB @ FLOOR EL. 599' & 682'	21	2-3-86
LOCATION	INSP. TYPE	DATE

DUE TO THE SEISMIC EVENT WHICH OCCURED ON 1-31-86 THE FOLLOWING OPEN SCV'S HAVE BEEN FIELD VERIFIED TO DETERMINE IF ANY DIMENSIONAL CHANGES HAD OCCURED: SCV# 596 *, 597 *, 5518 *, 6633 — EL. 599'; 4727 *, 4729 * — EL. 682'

NO DIMENSIONAL CHANGES OR DAMAGE, DIRECTLY ATTRIBUTED TO THE SEISMIC EVENT, WERE FOUND.

CORRECTIVE ACTION DOCUMENTATION - (D.R.'s): N/A

MEASURING/INSPECTION TOOLS I.D.: MISC. INSPECTION TOOLS

REMARKS * ALL REPAIR WORK WAS COMPLETE AT TIME OF WALKDOWN.

cc: S. DODEJA : E-180

G.P. Shaner, Jr. 2/4/86
INSPECTOR DATE

John W Messenger 2-4-86
REVIEWED - LEAD INSPECTOR DATE

441/T/1/ba

PNPP No. 5978

N/A	N/A	C-23665
CONTRACTOR	SPEC. NO.	INSPECTION REPORT NUMBER
WALKDOWN OF OPEN SCV'S AFTER SEISMIC EVENT OF 1/31/86		N/A
SYSTEM/COMPONENT/ACTIVITY		M.P.L. NUMBER
AX-1 @ FLOOR EL. 599'	21	2-3-86
LOCATION	INSP. TYPE	DATE

DUE TO THE SEISMIC EVENT WHICH OCCURED ON 1-31-86 THE FOLLOWING OPEN SCV'S HAVE BEEN FIELD VERIFIED TO DETERMINE IF ANY DIMENSIONAL CHANGES HAD OCCURED: SCV # 6833 (NR # CQCN-0126)

NO DIMENSIONAL CHANGES OR DAMAGE, DIRECTLY ATTRIBUTED TO THE SEISMIC EVENT, WERE FOUND.

CORRECTIVE ACTION DOCUMENTATION - (D.R.'s): N/A

MEASURING/INSPECTION TOOLS I.D.: MISC. INSPECTION TOOLS

REMARKS N/A

cc: S DODEJA : E-180

G.P. Shaner, Jr. 2/4/86
INSPECTOR DATE

John W Messenger 2-4-86
REVIEWED - LEAD INSPECTOR DATE

441/T/1/ba

PNPP No.: 5978

N/A	N/A	C-23666
CONTRACTOR	SPEC. NO.	INSPECTION REPORT NUMBER
WALKDOWN OF OPEN SCV'S AFTER SEISMIC EVENT OF 1/31/86		N/A
SYSTEM/COMPONENT/ACTIVITY		M.P.L. NUMBER
CC @ FLOOR EL. 679'	21	2-4-86
LOCATION	INSP. TYPE	DATE

DUE TO THE SEISMIC EVENT WHICH OCCURED ON 1-31-86 THE FOLLOWING OPEN SCV'S HAVE BEEN FIELD VERIFIED TO DETERMINE IF ANY DIMENSIONAL CHANGES HAD OCCURED: SCV # 6014

NO DIMENSIONAL CHANGES OR DAMAGE, DIRECTLY ATTRIBUTED TO THE SEISMIC EVENT, WERE FOUND.

CORRECTIVE ACTION DOCUMENTATION - (D.R.'s): N/A

MEASURING/INSPECTION TOOLS I.D.: MISC. INSPECTION TOOLS

REMARKS N/A

cc: S. DODEJA : E-180

G.P. Shaner, Jr. 2/4/86
INSPECTOR DATE

John W. Messenger 2-4-86
REVIEWED - LEAD INSPECTOR DATE

441/T/1/ba

Construction Quality Section
Nonsafety Inspection Report (NIR)

PNPP No. 5978

N/A	N/A	C-23677
CONTRACTOR	SPEC. NO.	INSPECTION REPORT NUMBER
WALKDOWN OF OPEN SCV'S AFTER SEISMIC EVENT OF 1/31/86		N/A
SYSTEM/COMPONENT/ACTIVITY		M.P.L. NUMBER
CC & IB @ VARIOUS ELEVS.	21	2-5-86
LOCATION	INSP. TYPE	DATE

THE ATTACHED MEMO DATED 2-5-86 CONCERNING THE WALKDOWN PERFORMED BY ENGINEERING TO EVALUATE CERTAIN OPEN REPAIR DISPOSITIONED SCV'S (EIR'S) FOR POTENTIAL DIMENSIONAL CHANGES CAUSED BY THE EARTHQUAKE OCCURING ON 1-31-86.

RESULTS INDICATED - NO NOTICABLE CHANGES.

CORRECTIVE ACTION DOCUMENTATION - (D.R.'s): N/A

MEASURING/INSPECTION TOOLS I.D.: N/A

REMARKS N/A

cc: S. DODEJA - E180

G.P. Shaner, Jr. 2/5/86
INSPECTOR DATE

John W Messenger 2/5/86
REVIEWED - LEAD INSPECTOR DATE

441/T/1/ba

memorandum Gilbert/Commonwealth

February 5, 1986

to J. W. Messenger/M. R. Kritzer

from H. Dharia/S. C. Dodeja

subject Walkdown of Open EIR's for Potential Earthquake Effect

The following EIR's were walked down to see if the previously reported condition had changed due to the earthquake event.

EIR #	SCV #
CC-620-3	6712
CC-679-7	6720
IB-654-4	6797
CC-574-1	6708
CC-679-17	6730
CC-679-13	6726
Cc-679-1	6714

The conclusion of the walkdown was that there had been no noticeable change due to the earthquake.

H. Dharia

H. Dharia

S. C. Dodeja

S. C. Dodeja

CC: C. R. Angstadt
K. R. Pech

G-2
REV. 1-82

THE CLEVELAND ELECTRIC ILLUMINATING COMPANY

MEMORANDUM "E"SO/-2712

☐ I no longer wish to receive this material.

TO E. M. Mead ROOM E280 FROM I. B. Babiak DATE February 3, 1986
T. M. Jameson E260 PHONE 6699 ROOM E260
T. P. Keaveney E230 SUBJECT N71, Circulating Water System Walkdown to Assess the Intensity of the January 31, 1986 Earthquake

On February 1, 1986, a system walkdown was performed on the N71 Circulating Water System and the following was observed:

No yard flooding was observed above the buried 12' diameter FRP on both supply to the condensers, and return line to cooling tower. No water was present in the Oil Storage Tank Dyke or beneath the temporary (trailers) lunch room building or in the Sodium Hypochlorite Storage Tank Dyke.

A walkdown was also performed inside the Turbine Building basement to assess if any damage was present to the system, and none was observed.

A walkdown of the cooling tower basin wall was performed and two vertical (minor) leaks were observed. One located on the south cooling tower forebay flume wall and other near the cooling tower raiser manifold (entry into the basin).

The severity of the vertical seam leak in the forebay flume wall exhibits approximately 1 to 2 gpm flow rate out into the yard and with approximately (less than) 1 gpm flow rate through the second vertical seam leak.

The Civil/Structural element is to advise on the severity of the leak with a repair solution.

clm

cc: R. A. Newkirk - E280
E. B. Ortalan - E260
N71 System File - E280
PO/DC - R290

THE CLEVELAND ELECTRIC ILLUMINATING COMPANY

MEMORANDUM

"C"SO-2773

☐ I no longer wish to receive this material.

TO K. R. Pech ROOM W220 FROM E. C. Christiansen ECC DATE February 7, 1986
PHONE 5467 ROOM W245
SUBJECT Review of Energized Circuits During 1/31/85 Seismic Event

Per your request, NCES - Electrical has reviewed the circuits that were energized during the January 31, 1986 seismic event. The intent of the review was to determine the number of active electrical components in the energized circuits. Active components were categorized in seven subgroups for this study. The groups were motors, power sources, switches, instruments, relays, transformers, and miscellaneous. The later category included lamps, fuses, resistors, diodes, etc. Attachment I lists major suppliers of equipment in each subgroup. Passive devices such as cables, lugs, terminal boards, conduits, and trays wre not considered in this study.

A listing of systems that were operating during the seismic event was obtained from Perry Plant Operating Department. This list is included as Attachment II of this memorandum. Upon an engineering review of this list it was determined that it was incomplete. Power sources, communication, security, and computer systems were added by Engineering. Attachment II also reflects these additions.

The total number of active components in the energized circuits was 47,460 . Attachment III contains Electrical Device Lists used by each engineer in their review of each energized system. A breakdown of the total active components by subgroup follows:

Motors	775
Power Sources	6493
Switches	6962
Instruments	4721
Relays	6968
Transformers	1885
Miscellaneous	19656
Total Devices	47,460

ECC/mcw

Attachment I

Vendors

Motors

General Electric

Siemens-Allis

Westinghouse

Reliance

U.S. Electrical

Transformers

Westinghouse

General Electric

Brown Boveri

Relays

General Electric

Westinghouse

Brown Boveri

Cutler-Hammer

Agastat

Potter Braumfield

Switchgear Breakers

Brown Boveri

General Electric

Cutler-Hammer

Switches

Allen Bradley

General Electric

States

Electroswitch

Batteries

C & D

Exide

Contractors

Cutler-Hammer

Allen Bradley

General Electric

Attachment I

MOV Operators

Limitorque

Rotorque

EIM

ITT

Chargers/Inverters

C & D

Power Conversion

Topaz

CYBREX

Fuse Disconnects

Cutler-Hammer

General Electric

Cutler-Hammer

Limit Switches

Limitorque

Instrument Switches

Magnetrol

Rosemount

ITT Barton

Mercoid

Meriam

MSW Instruments

Meters

General Electric

Brown Boveri

Westinghouse

Weksler

Instruments (T/C, RTD's)

Weed

Recorders

Leeds & Northrup

Transmitters

Rosemount

Gould

Foxboro

Magnetrol

Weed

Molded Case Breakers

General Electric

Westinghouse

Cutler-Hammer

Gould (Brown Boveri)

Attachment II

Systems Energized During Seismic
Event of January 31, 1986

System Supplied of PPOD

System	Description
C11	Control Rod Drive
C41	Standby Liquid Control
C71	Reactor Protection System
D17	Plant Radiation Monitors
E12	Residual Heat Removal
E21	Low Pressure Core Spray
E22	High Pressure Core Spay
F42	Fuel Transfer Equipment
G33	Reactor Water Cleanup
G41	Fuel Pool Cooling and Cleanup
M11	Containment Vessel Cooling
M13	Drywell Cooling
M15	Annulus Exhaust Gas Treatment
M21	Controlled Access HVAC
M23	MCC, Switchgear, & Misc. Area HVAC
M24	Battery Room Exhaust
M25	Control Room HVAC
M26	Control Room Emergency Recirculation
M27	Computer Room HVAC
M32	ESW Pumphouse Ventilation
M35	Turbine Building Cooling & Ventilation
M36	Off-Gas Building Exhaust
M40	Fuel Handling Building Ventilation
M41	Heater Bay Ventilation
M43	Diesel Building Ventilation
M45	Circulating Water Pump House Ventilation
N21	Condensate
N23	Condensate Filtration
N24	Condensate Demineralizers
N32	Turbine Control (EHC)
N71	Circulating Water
P11	Condensate Transfer and Storage
P20	Water Treatment
P21	Two Bed Demineralizer
P22	Mixed Bed Demineralizer
P41	Service Water
P42	Emergency Closed Cooling
P43	Nuclear Closed Cooling
P44	Turbine Building Closed Cooling
P45	Emergency Service Water
P47	Control Complex Chill Water
P49	ESW Screen Wash
P52	Instrument Air
P54	Fire Protection
P55	Building Heating
P61	Auxiliary Steam
P62	Auxiliary Boiler Fuel Oil
P72	Plant Underdrain

Attachment II

Systems Added by Engineering

System	Description
C91	Process Computer
C95	Emergency Response Information System
P51	Service Air
P56	Security
R11	Station Transformers
R14	110 VAC Vital Inverters
R15	Technical Support Center UPS
R22	Metalclad Switchgear
R23	480 V Load Centers
R25	Distribution Panels - 120, 208 & 480 volts
R36	Heat Tracing & Anti Freeze Protection
R41	Instrumentation
R42	D.C. System
R43	Standby Diesel Generator (SDG)
R44	SDG Starting Air
R45	SDG Fuel Oil
R46	SDG Jacket Water Coolant
R47	SDG Lube Oil
R51	Intra Plant Communications
R52	Maintenance & Calibration
R53	Exclusion Area Paging System
R57	Radio & In-Plant Antenna System
R61	Main Control Room Annunciator
R71	Lighting
S11	Power Transformers