# IES UTILITIES INC.

John F. Franz, Jr.
Vice President, Nuclear

December 21, 1994
NG-94-4632

Mr. William T. Russell, Director
Office of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Attn: Document Control Desk
Mail Station P1-37
Washington, DC 20555-0001

Subject: Duane Arnold Energy Center
Docket No: 50-331
Op. License No: DPR-49
Response to NRC RAI on MSIV Leakage Control System Technical Specification Amendment Request (RTS-232)

References:
1) Letter, Franz (IES) to Russell (NRC) NG-94-2629, dated August 15, 1994
2) Summary of Meeting held on October 17, 1994, to discuss the MSIV Leakage Control System Technical Specification Amendment Package, by A. Hsia (NRC) dated October 26, 1994
3) Letter from G. Kelly (NRC) to L. Liu (IES) dated December 1, 1994, Subject: DAEC RAI on MSIV LCS TS Proposed Amendment

File: A-117, N-11

Dear Mr. Russell:

On October 17, 1994, a meeting was held between the NRC and IES Utilities staffs to discuss the IES Utilities request for a Technical Specification amendment to eliminate the Main Steam Isolation Valve (MSIV) Leakage Control System (Reference 1). This meeting was summarized in Reference 2. Reference 2 also contained a request for additional information (RAI). This RAI was modified by Reference 3.

Our responses to these NRC questions are contained in the Attachment.



A001 1/1

Should you have any further questions regarding this information, please contact this office.

Sincerely,

David L Wilson for

John F. Franz
Vice President, Nuclear

JFF/CJR/pjv
N:\Iowa\Licensing\pjv\94-4632

Attachment

cc: C. Rushworth
L. Liu (w/o)
L. Root (w/o)
G. Kelly (NRC-NRR)
J. Martin (Region III)
S. Brown (State of Iowa)
NRC Resident Office
Docu

# IES RESPONSE
# TO NRC
# REQUEST FOR ADDITIONAL INFORMATION

1. **NRC Request**

Provide a description of the soil-structure interaction (SSI) analysis performed by the licensee for the turbine building, including the following:

a. the computer code, the soil model, and structure model used in the analysis;

b. the input ground motion applied to the model and the location of its application;

c. the soil parameters used and the way their uncertainty was addressed; and

d. the way the uncertainty in the structural response was addressed.

**IES Response**

Seismic evaluations for piping, supports, and equipment associated with the main steam isolation valve (MSIV) leakage treatment path were based on new in-structure response spectra generated for the turbine building. This newly-generated response of the turbine building to an earthquake is based on the original seismic building model, a NUREG/CR-0098 ground response spectrum, and a modern soil-structure interaction analysis.

The Duane Arnold Energy Center (DAEC) turbine building (Figures 1-1 and 1-2 on pages 1-4 and 1-5) is a three story rectangular structure, 260 ft long by 140 ft wide by 107 ft high. The basemat is founded on about 15 ft of undisturbed glacial till over bedrock. The sides of the turbine building were backfilled with compacted soil up to grade level (approximately 757 ft). The first floor (basement) consists of a reinforced concrete basemat with reinforced concrete walls. The remainder of the structure consists of braced steel frame walls and roof with reinforced concrete floor slabs. A centrally located reinforced concrete turbine pedestal extends from the basemat to the operating floor at elevation 780 ft.

The original seismic analyses for the turbine building were performed by John A. Blume & Associates, Engineers in the early 1970s. The seismic model (Figure 1-3) consisted of a lumped-mass (stick) model of the structure and accounted for the effects of the single overlaying layer of glacial till on bedrock with soil springs.

Seismic reanalyses of the turbine building and generation of new in-structure response spectra were performed in order to provide a more realistic estimate of seismic response of the structure. The reanalysis employed current state-of-the-art methods which were not available at the time the original seismic analyses were performed.

The methods used in the reanalysis for generation of median centered in-structure response spectra (i.e., seismic demand) were in accordance with the seismic margins assessment (SMA) methodology described in EPRI Report NP-6041-SL (Reference 1) and the Seismic Qualification Utility Group (SQUG) methodology described in the Generic Implementation Procedure (GIP) for Seismic Verification of Nuclear Plant Equipment (Reference 2). The seismic model and the soil properties used in the reanalysis were based on the original seismic analyses. Only the analytic methods used to account for soil-structure interaction were changed.

***Soil-Structure Interaction Methodology***

A soil-structure interaction analysis was performed using an elastic half-space modeling method with the CLASSI (Continuum Linear Analysis for Soil-Structure Interaction) suite of codes. In this method, the structure is assumed to be surface founded and the ground motion is defined at the half-space surface. Radiation damping of the soil is implicitly computed in the calculation. The seismic model and soil properties were based on the original design calculations changing only the method used to account for soil-structure interaction. A shear wave velocity of 860 fps and shear modulus of 2762 ksf for the soil were back calculated from the stiffness values used for the soil springs in the original analyses. Other soil properties used in the reanalysis were Poisson's Ratio of 0.3 and a unit weight of soil of 0.12 ksf. No analyses with variations in the design basis soil properties were performed since the purpose of the analyses was to generate "median centered" (i.e., best estimate) in-structure response spectra; as opposed to "conservative design" in-structure response spectra.

***Seismic Input Motion***

The seismic reanalyses of the turbine building used three (two horizontal and one vertical) free-field acceleration time histories. The calculated response spectra from the acceleration time histories matched the 84th percentile non-exceedance NUREG/CR-0098 ground response spectrum for soil sites at 5 percent damping. See Figures 1-4, 1-5, and 1-6 on pages 1-7, 1-8 and 1-9. The design ground motion spectrum was anchored to the DAEC design basis peak ground accelerations of 0.12g horizontal and 0.10g vertical. The seismic input ground motion was applied at the surface of the soil-structure model.

***Seismic Building Model and Analysis***

A new seismic building model was constructed from the original stick model developed by J. A. Blume for the original seismic analyses of the turbine building. The modal frequencies of the new model with the original soil springs were calculated and found to agree with the frequencies reported in the original analyses, thus verifying the new seismic model. See Table 1-1.

**Table 1-1**
**Comparison of Modal Frequencies**

| Mode | Frequency (Hz) North-South Direction | | Frequency (Hz) East-West Direction | |
|---|---|---|---|---|
| | Original | New | Original | New |
| 1 | 2.27 | 2.26 | 1.43 | 1.42 |
| 2 | 2.60 | 2.61 | 3.46 | 3.57 |
| 3 | 4.17 | 4.15 | 5.03 | -- |
| 4 | 5.81 | 10.2 | 9.17 | 8.79 |
| 5 | 52.6 | 56.0 | 62.5 | 58.5 |

Best estimate in-structure response spectra for the turbine building were calculated based on a structural damping ratio of 7 percent. The resulting spectra (at 5 percent damping) for north-south and east-west directions are provided in Figures 1-7 through 1-16 (on pages 1-10 through 1-19) for the five mass points shown in Figure 1-3 (on page 1-6). Also shown on these figures are the in-structure response spectra from the original seismic analyses by J. A. Blume. These curves clearly show that the original analyses for the turbine building were overly conservative. The lower seismic response from the reanalysis of the turbine building is due to the method used to account for soil-structure interaction in the reanalysis, in particular, the effects of radiation damping in the SSI analysis.

Floor response spectra were not broadened since peak spectral accelerations were used in the seismic evaluations for flexible equipment (e.g., piping) and zero period accelerations (ZPA values) were used for rigid equipment. This approach conservatively accounts for uncertainties in the calculated structural responses.

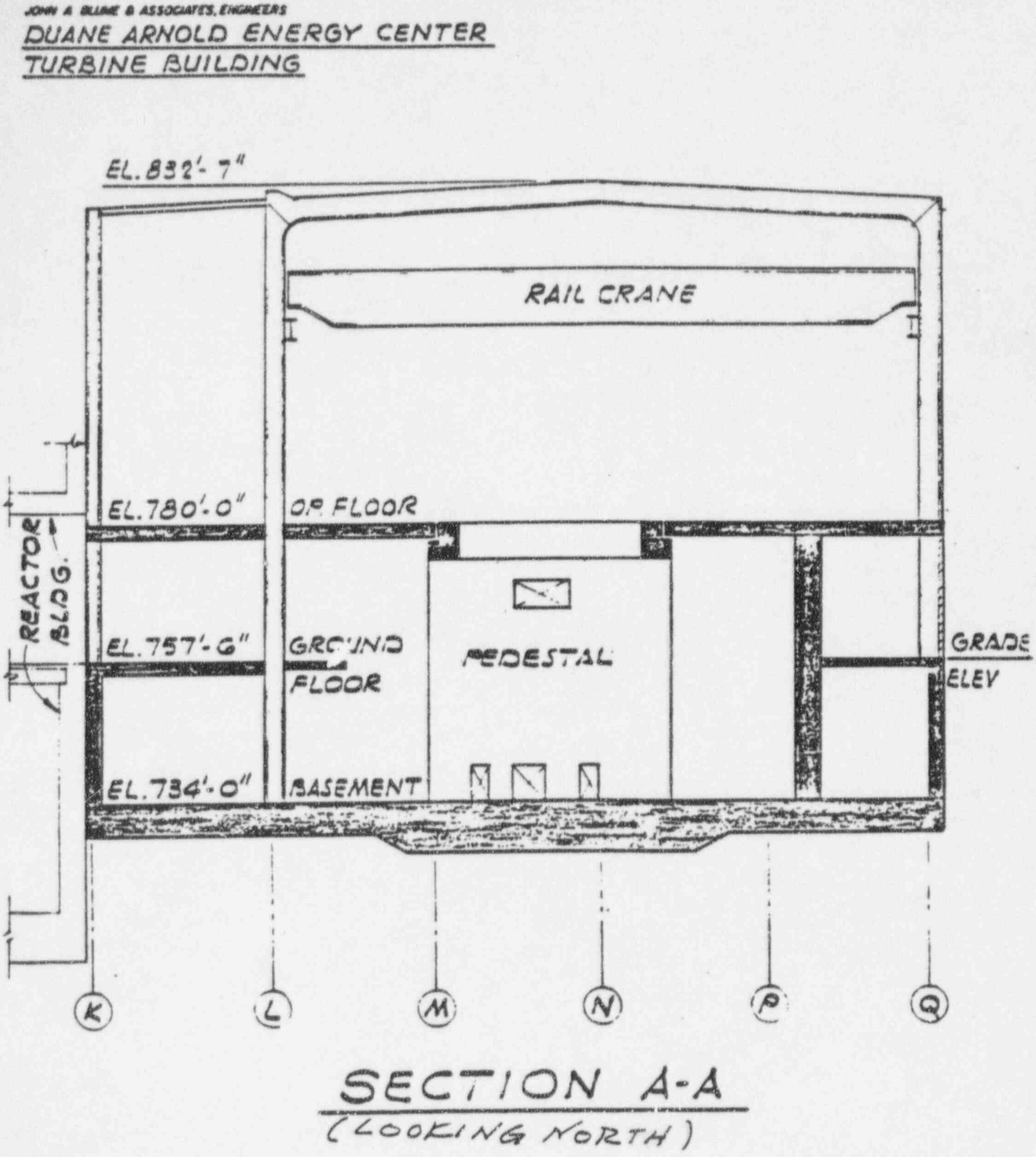



Figure 1-1
DAEC Turbine Building

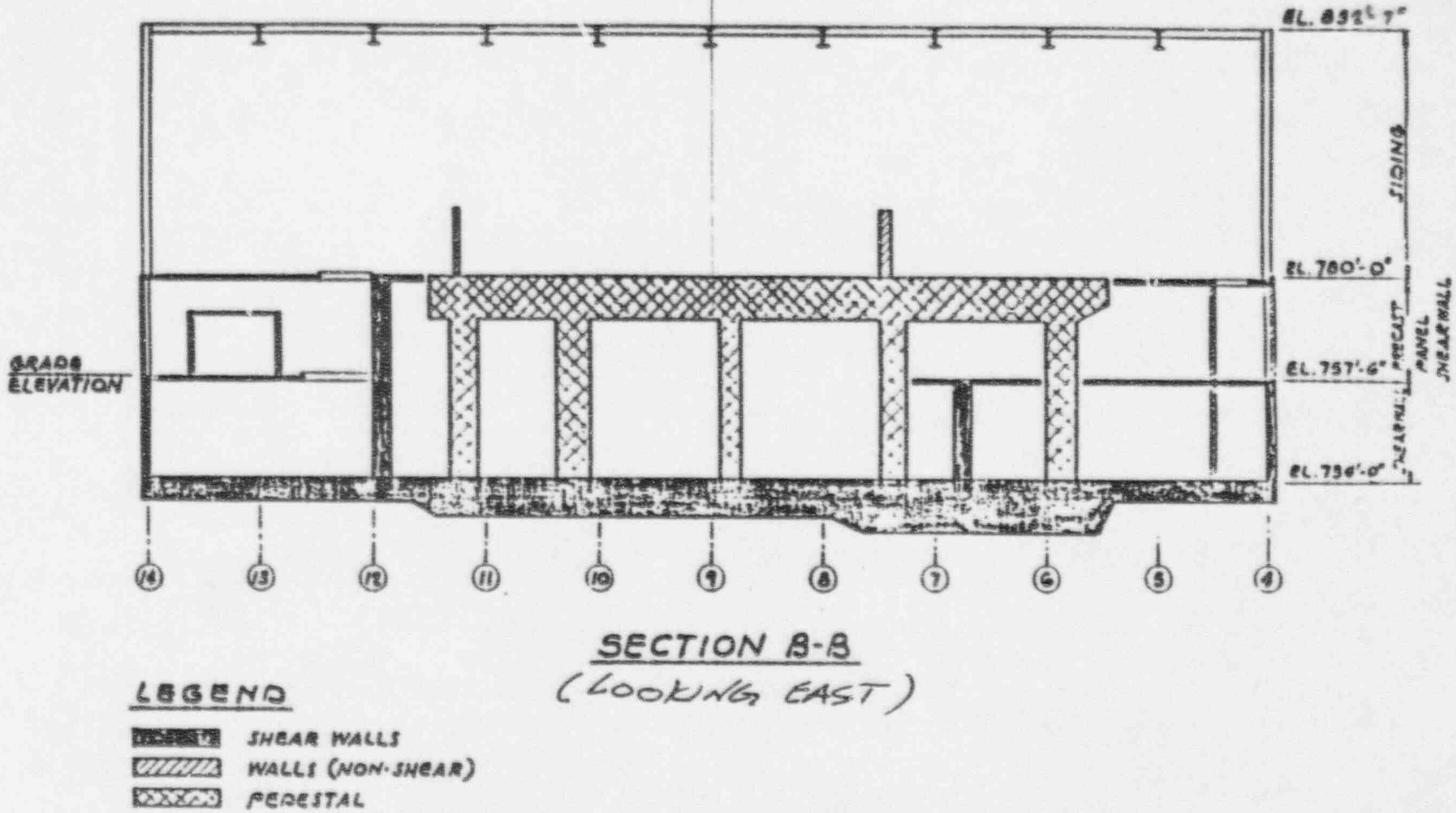



Figure 1-2

DAEC Turbine Building

JOHN A. BLUME & ASSOCIATES, ENGINEERS

DUANE ARNOLD ENERGY CENTER

TURBINE BUILDING

JOHN A. BLUME & ASSOCIATES, ENGINEERS
DUANE ARNOLD ENERGY CENTER
TURBINE BUILDING

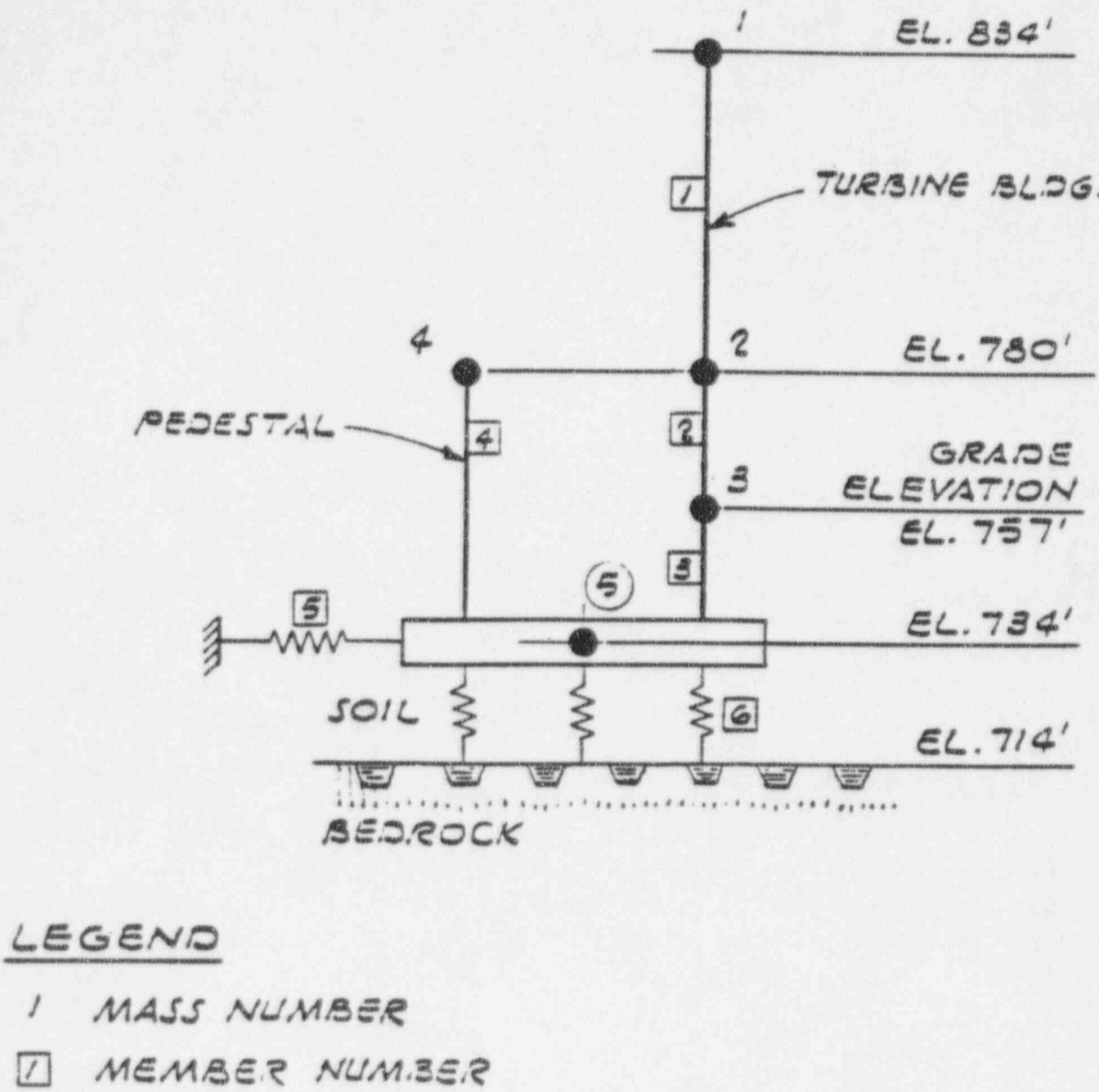
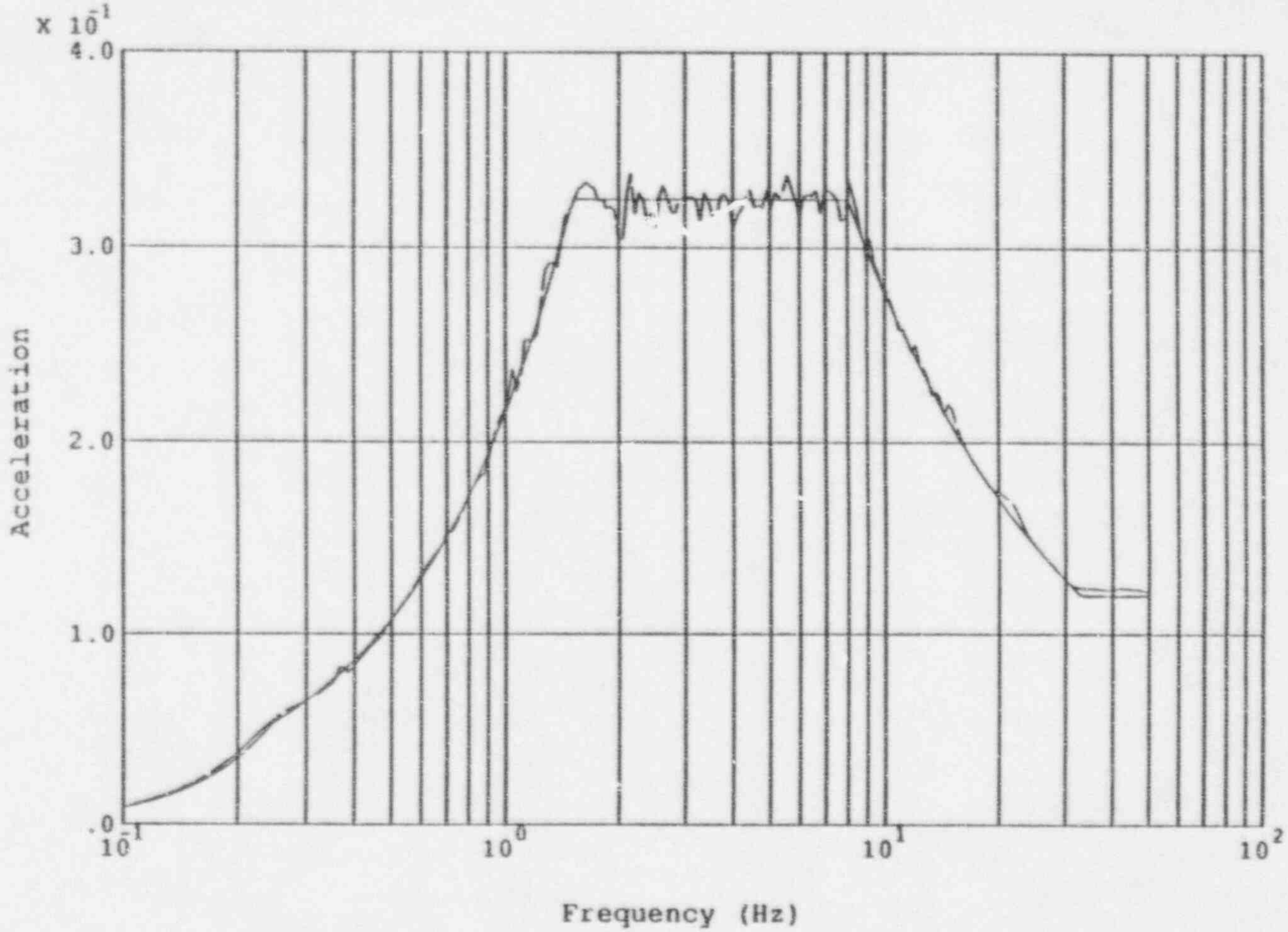



Figure 1-3
Turbine Building Seismic Model

RSPLT INTEL386 VERS 1.2P COMPILED 08/04/93 09:30:31 EXECUTED 05/10/94 17:27:54 pqth.ps




Legend:

Target Spectrum ————————

10 POSTQ iterations ———— ————

Notes:

5% Spectral Damping

Acceleration in g's

**Figure 1-4**

Duane Arnold Energy Center
Component 1 Synthetic Time History

CALC 42116-C-002

RSPLT INTEL386 VERS 1.2P COMPILED 08/04/93 09:30:31 EXECUTED 05/11/94 07:28:33 pqth.ps

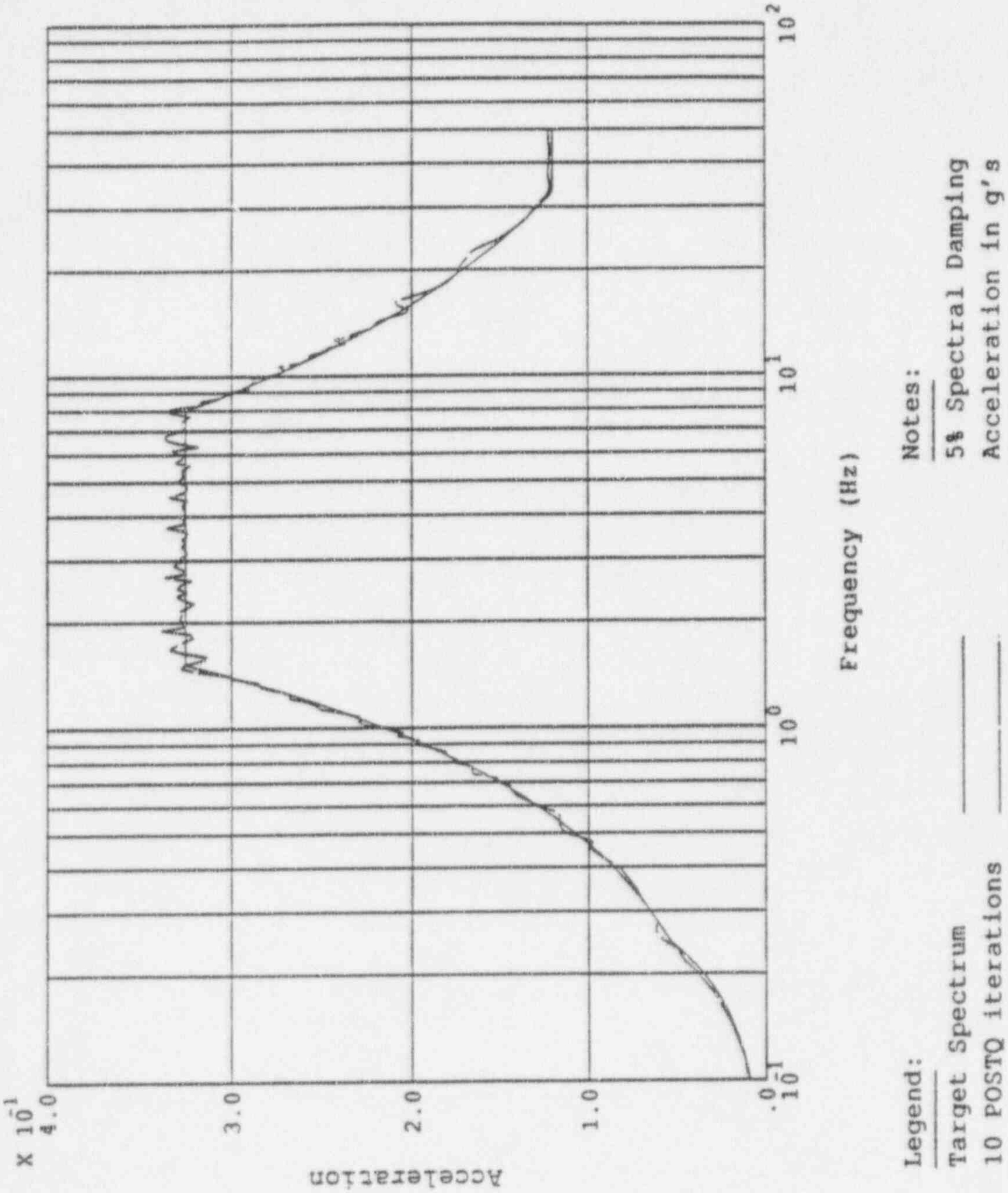
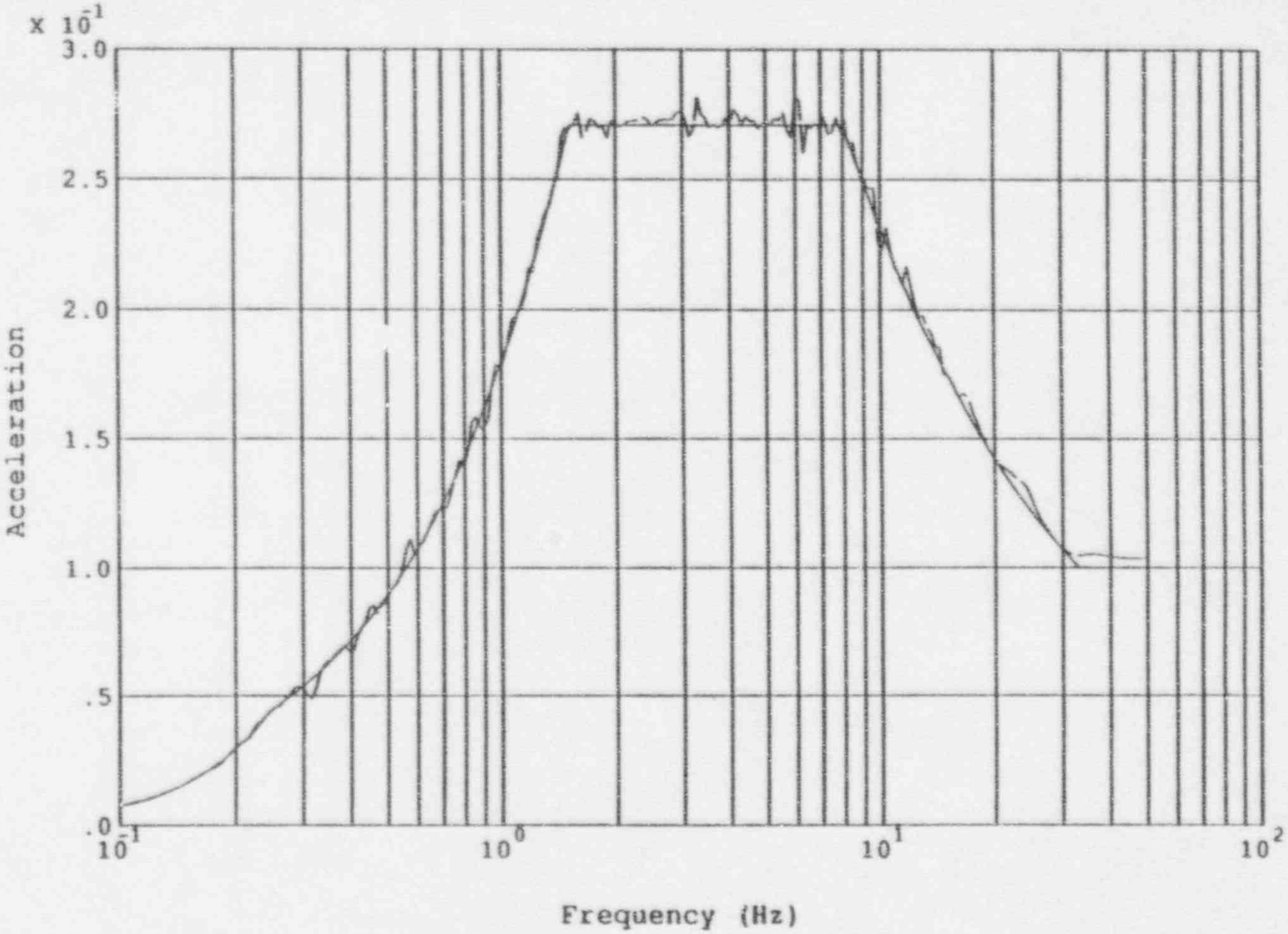



**Figure 1-5**

Duane Arnold Energy Center
Component 2 Synthetic Time History

CAL. 92175-E-002

RSPLT INTEL386 VERS 1.2P COMPILED 08/04/93 09:30:31 EXECUTED 05/11/94 07:49:20 pqth.ps




Legend:

Target Spectrum __________

10 POSTQ iterations ____ ____

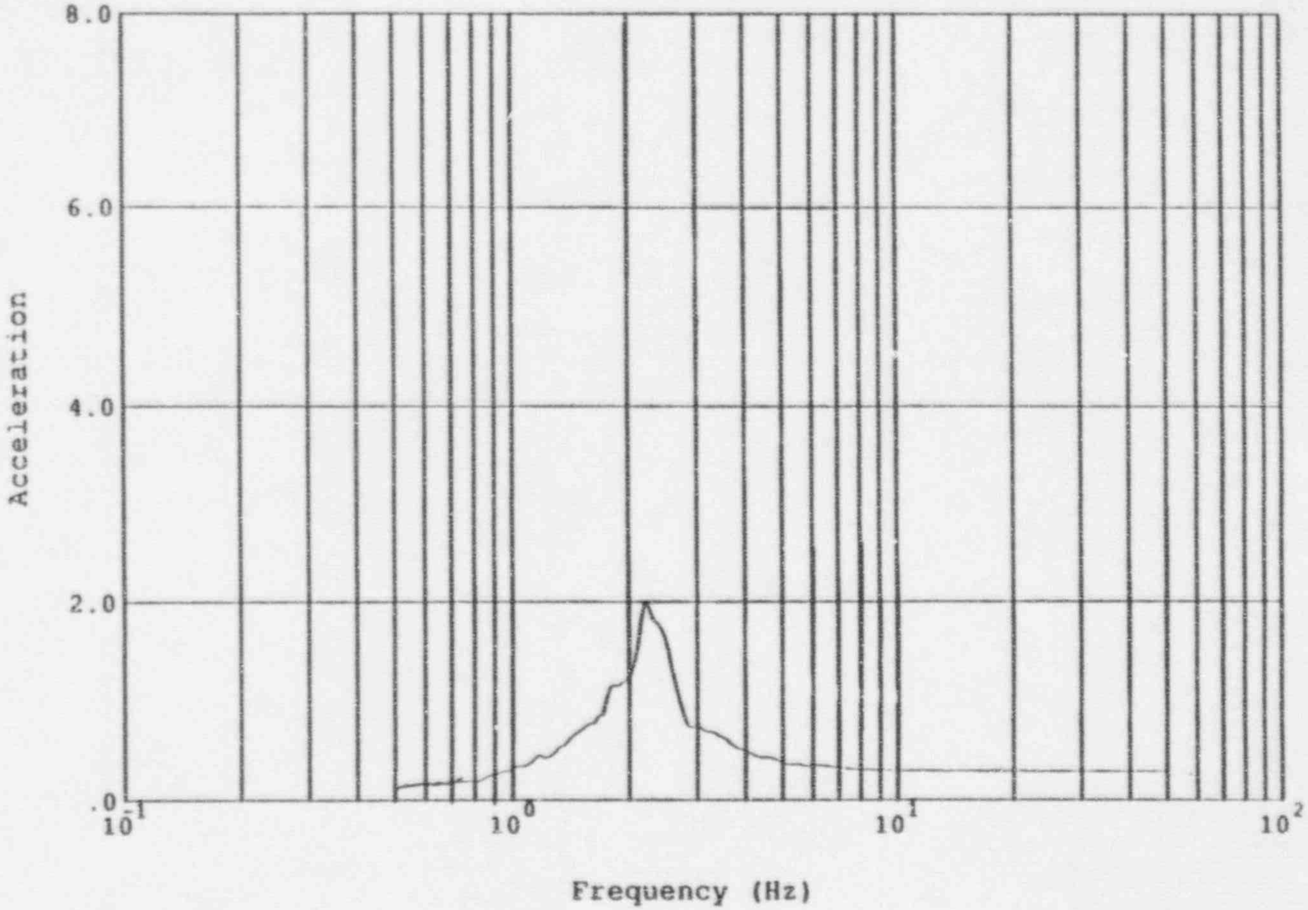
Notes:

5% Spectral Damping

Acceleration in g's

Figure 1-6

Duane Arnold Energy Center
Vertical Synthetic Time History




Legend:

1/2 space w/7% damp ____________

Notes:

Accelerations in g's

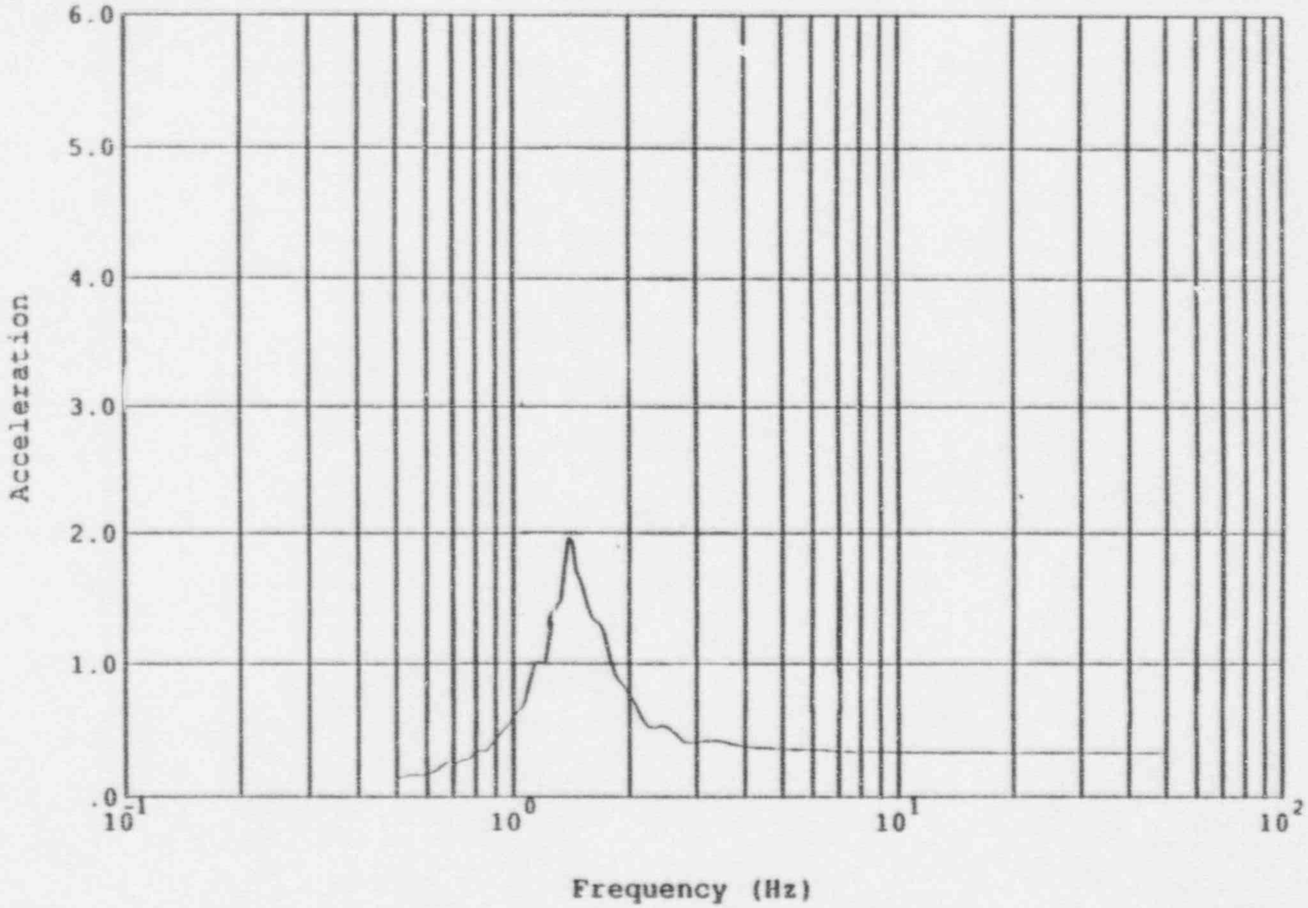
Response spectra for
834' elevation not included
in original analyses.

Figure 1-7

Duane Arnold Turbine Building
Turbine Building, El. 834', NS Response, 5% damping

RSPLT INTEL386 VERS 1.2P COMPILED 08/04/93 09:30:31 EXECUTED 05/16/94 15:18:15 nly.p5b

CALC. 42116-C-002




Legend:

1/2 space w/7% damp ____________

Response spectra for 834' elevation not included in original analyses

Notes:

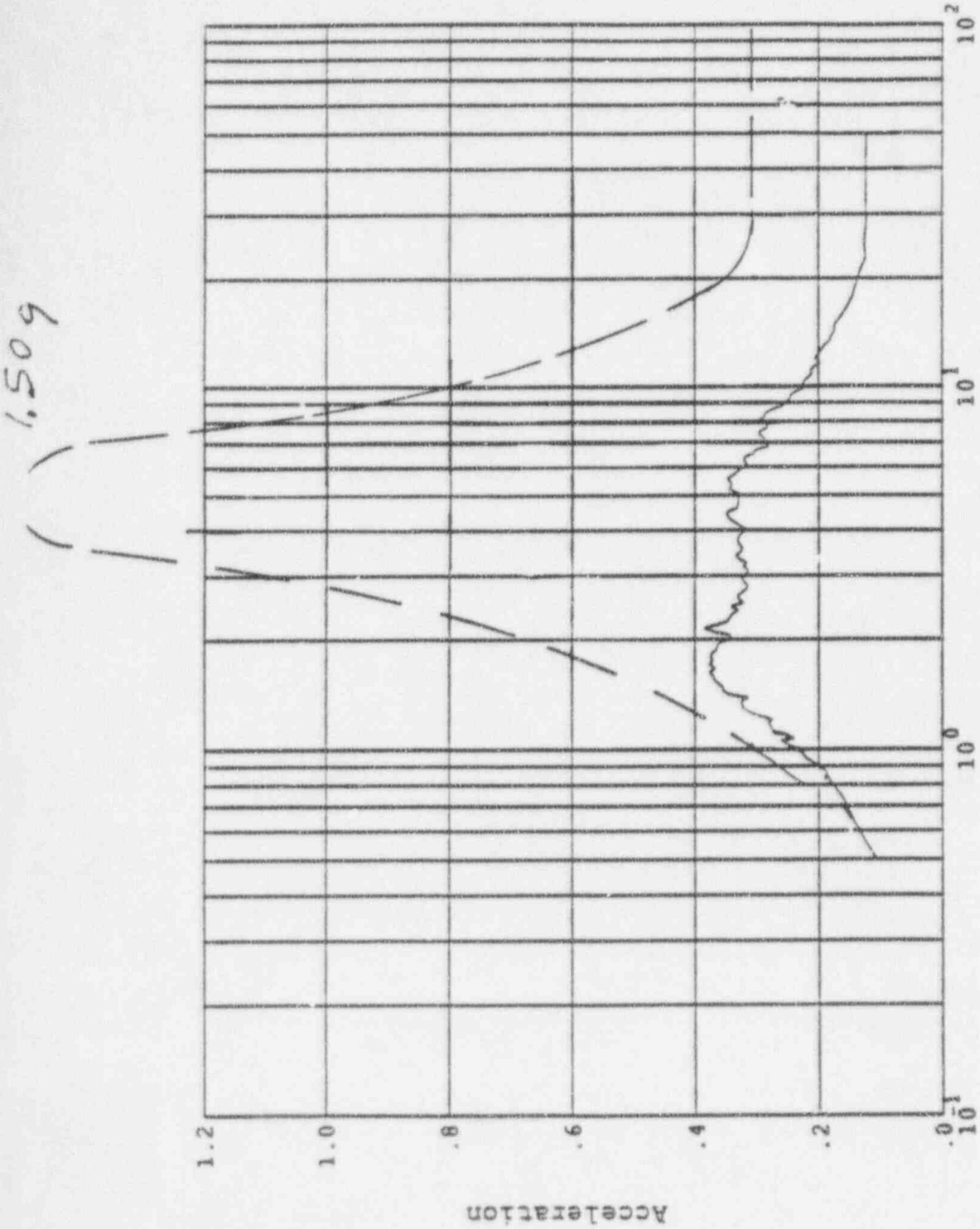
Accelerations in g's

Figure 1-8

Duane Arnold Turbine Building :
Turbine Building, El. 834', EW Response, 5% damping

RSPLT INTEL386 VERS 1.2P COMPILED 08/04/93 09:30:31

CALC. 42116-C-002




Legend:
1/2 space w/7% damp ________
Original Analysis ___ ___

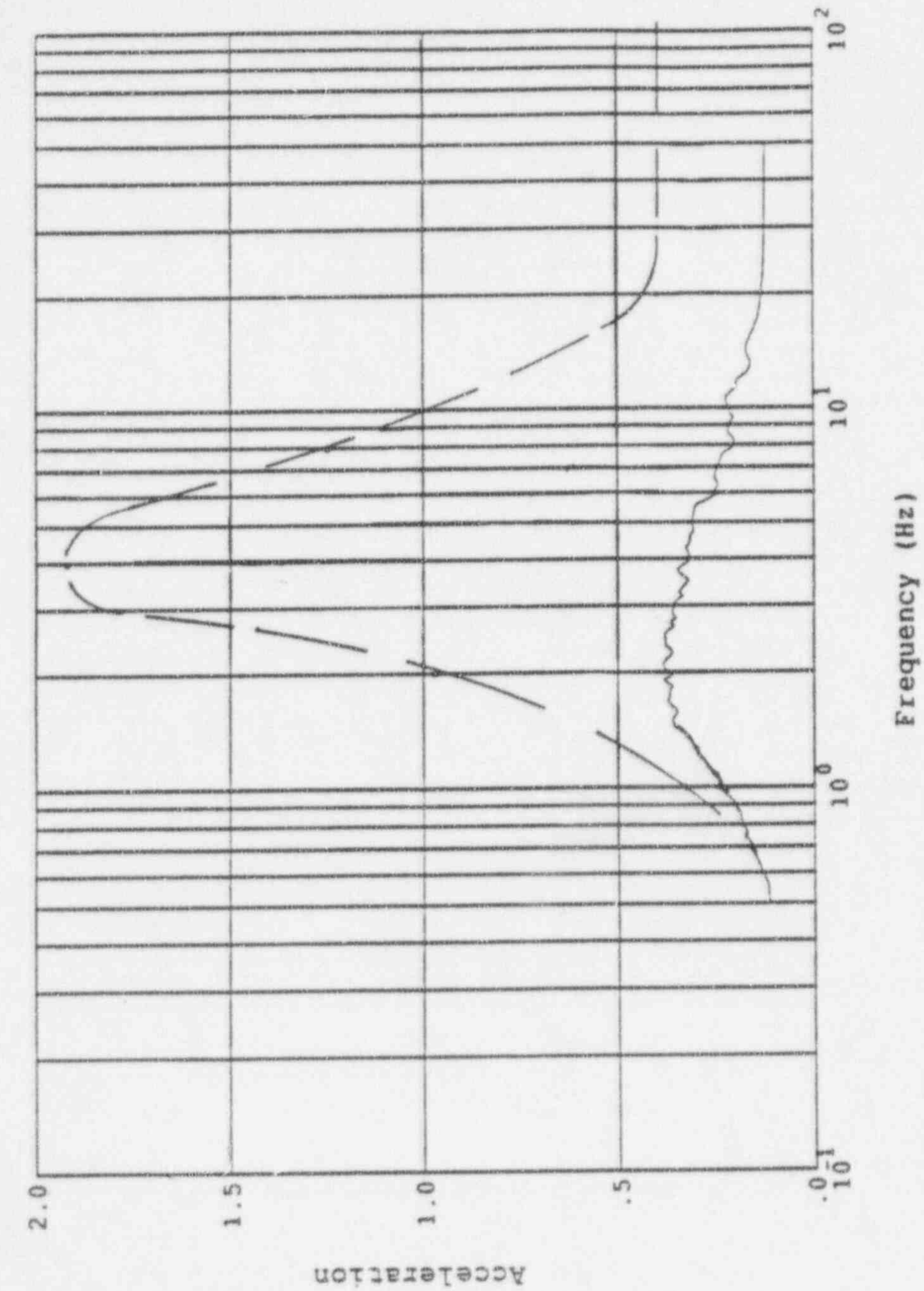
Notes:
Accelerations in g's

Figure 1-9

Duane Arnold Turbine Building :
Turbine Building, El. 780', NS Response, 5% damping

RSPLT INTEL386 VERS 1.2P COMPILED 08/04/93 09:30:31 EXECUTED 05/16/94

CALC. 42116-C-002

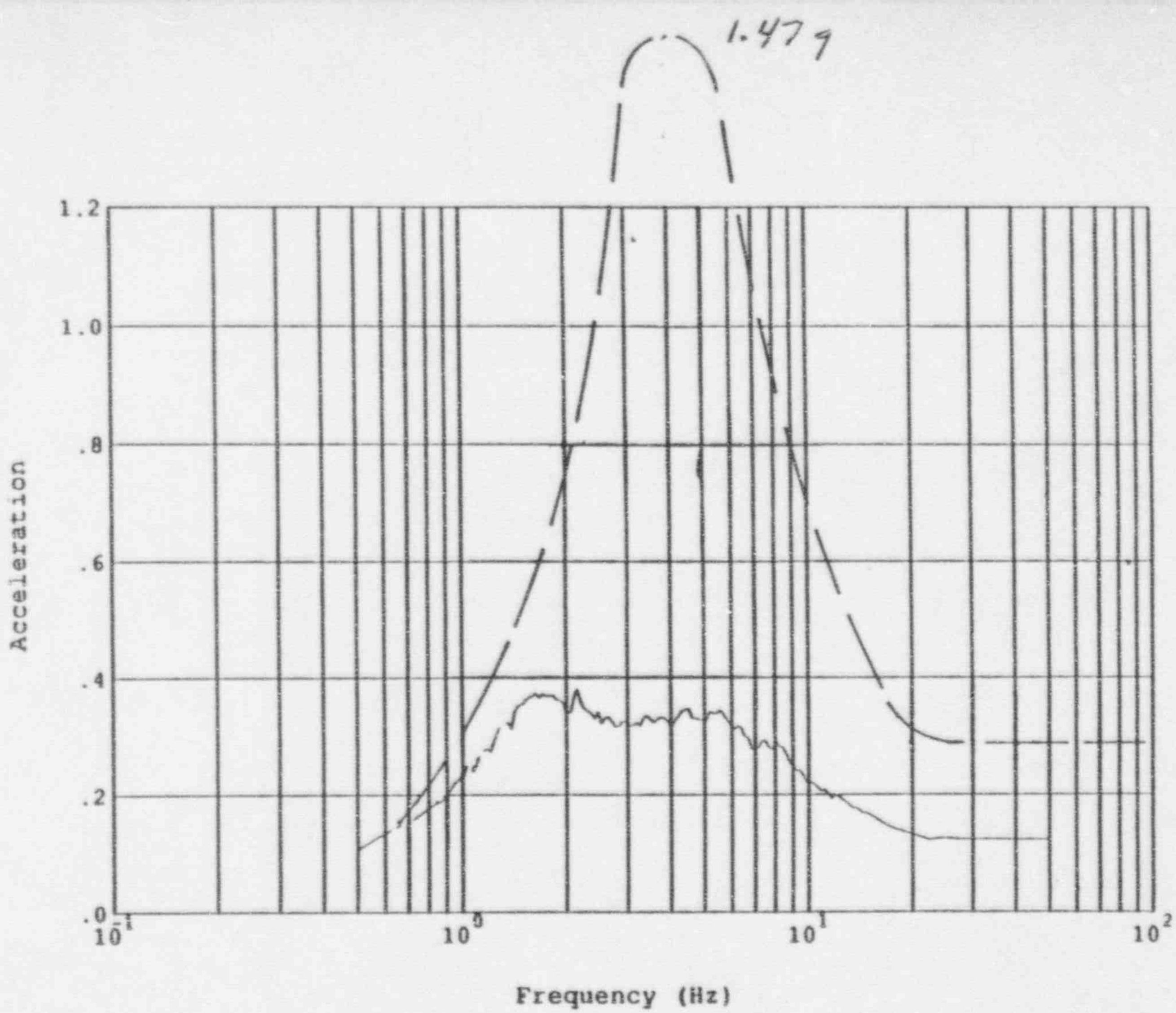



Legend:
1/2 space w/7% damp ______
Original Analysis ______

Notes:
Accelerations in g's

Figure 1-10

Duane Arnold Turbine Building
Turbine Building, El. 780', EW Response, 5% damping




Legend:

1/2 space w/7% damp ————

Original Analysis — — —

Notes:

Accelerations in g's

Figure 1-11

Duane Arnold Turbine Building
Turbine Building, El. 757', NS Response, 5% damping

RSPLT INTEL386 VERS 1.2P COMPILED 08/04/93 09:30:31

CALC. 42116-C-002

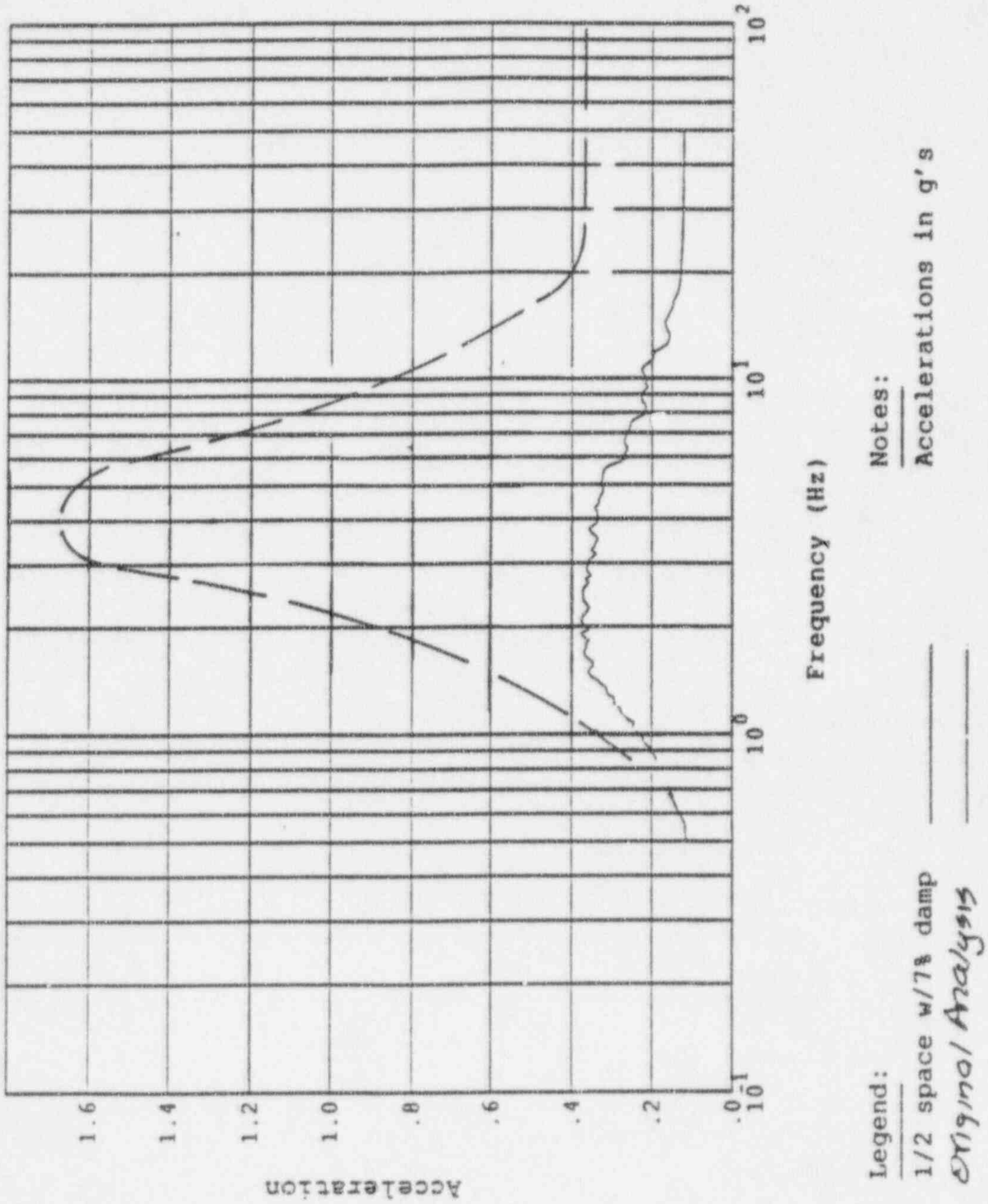
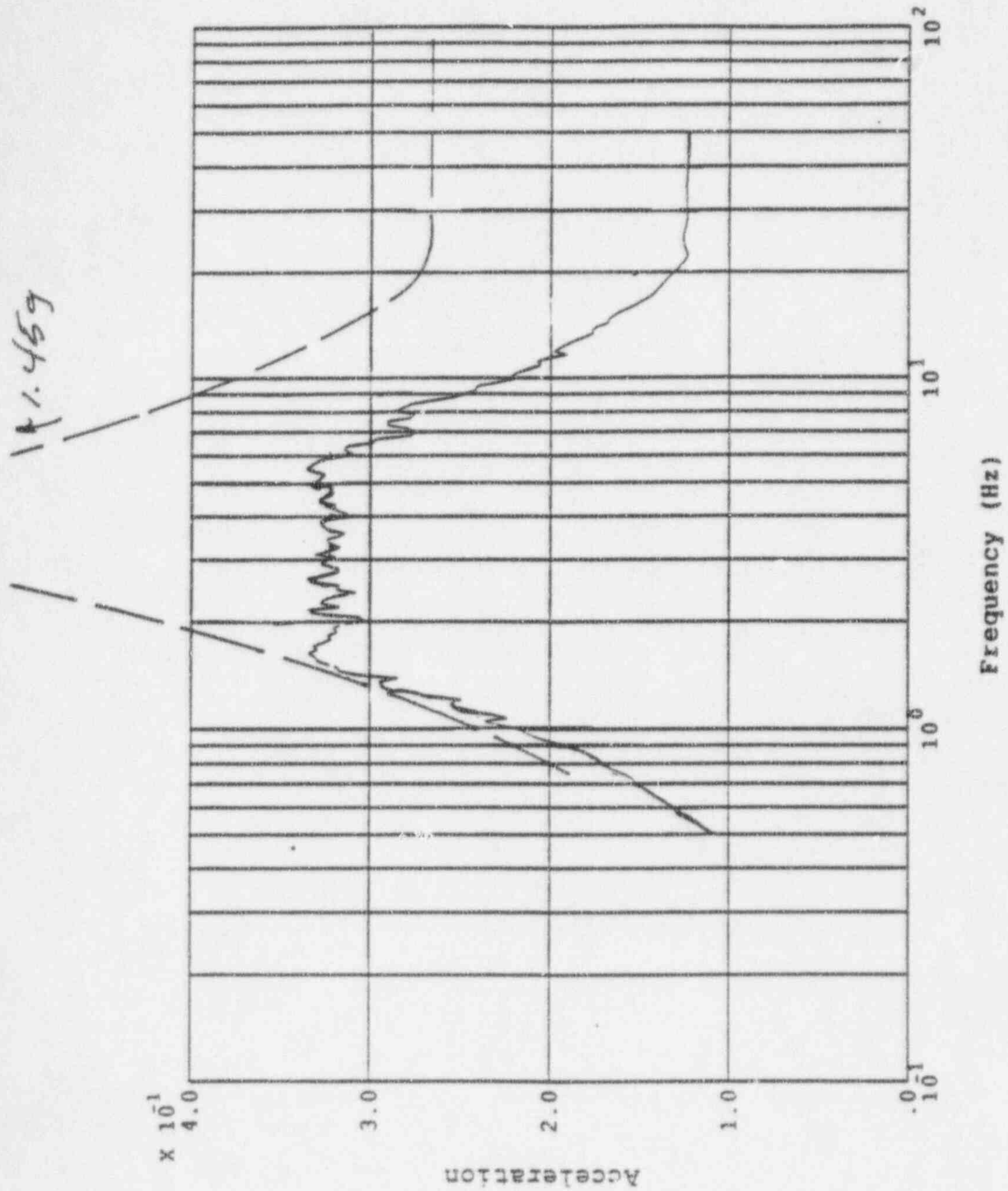



Figure 1-12

Duane Arnold Turbine Building
Turbine Building, El. 757', EW Response, 5% damping

RSPLT INTEL386 VERS 1.2P COMPILED 08/04/93 09:30:31

CALC. 42116-C-002




Legend:
1/2 space w/7% damp ————
original Analysis ————

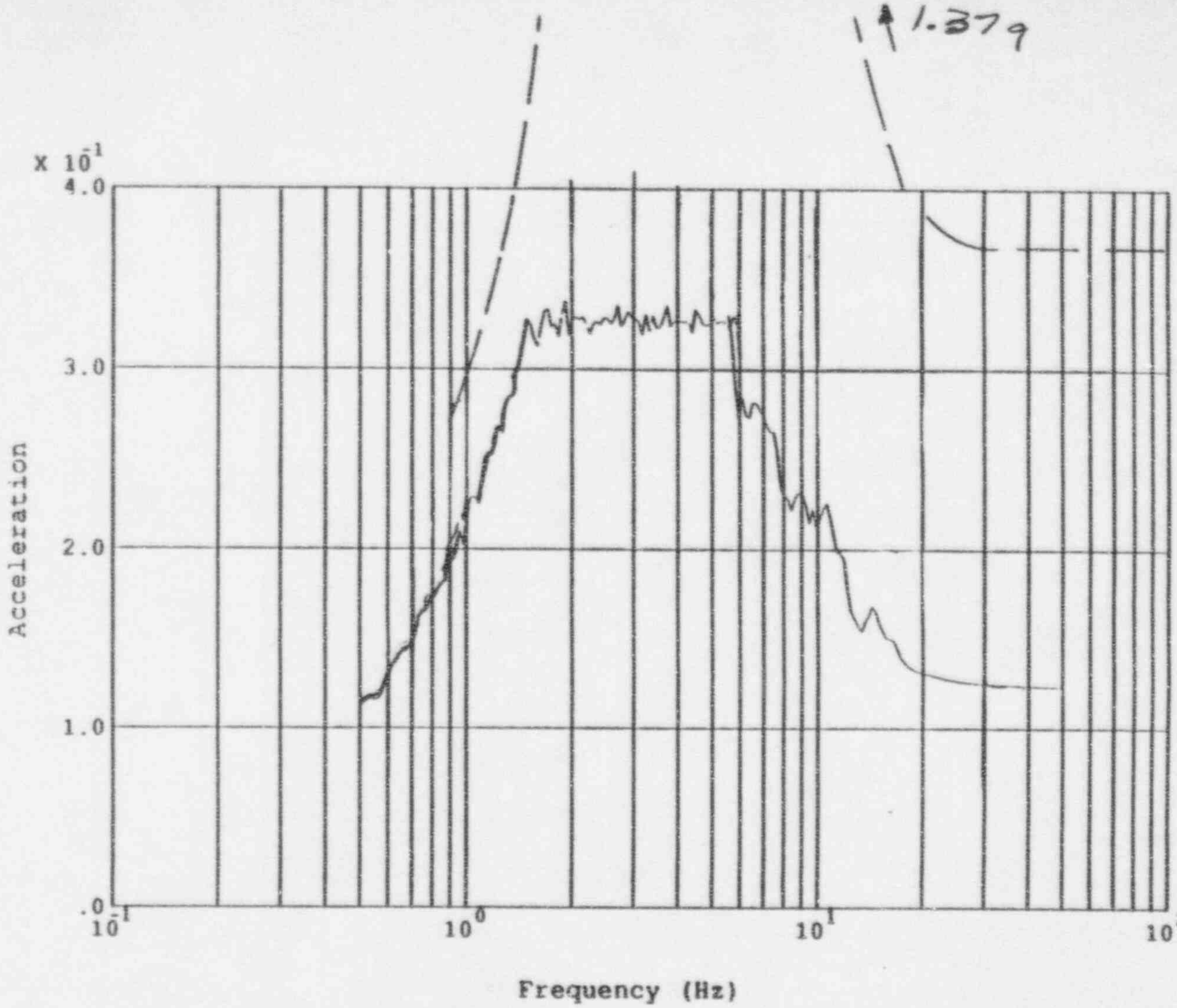
Notes:
Accelerations in g's

Figure 1-13

Duane Arnold Turbine Building
Turbine Building, Foundation, NS Response, 5% damping

RSPLT INTEL386 VERS 1.2P COMPILED 08/04/93 09:30:31 EXECUTED 05/16/94 15:18:15 nfdny.p5b

CALC. 42116-C-002




Legend:

1/2 space w/7% damp ————

original Analysis — — —

Notes:

Accelerations in g's

Figure 1-14

Duane Arnold Turbine Building
Turbine Building, Foundation, EW Response, 5% damping

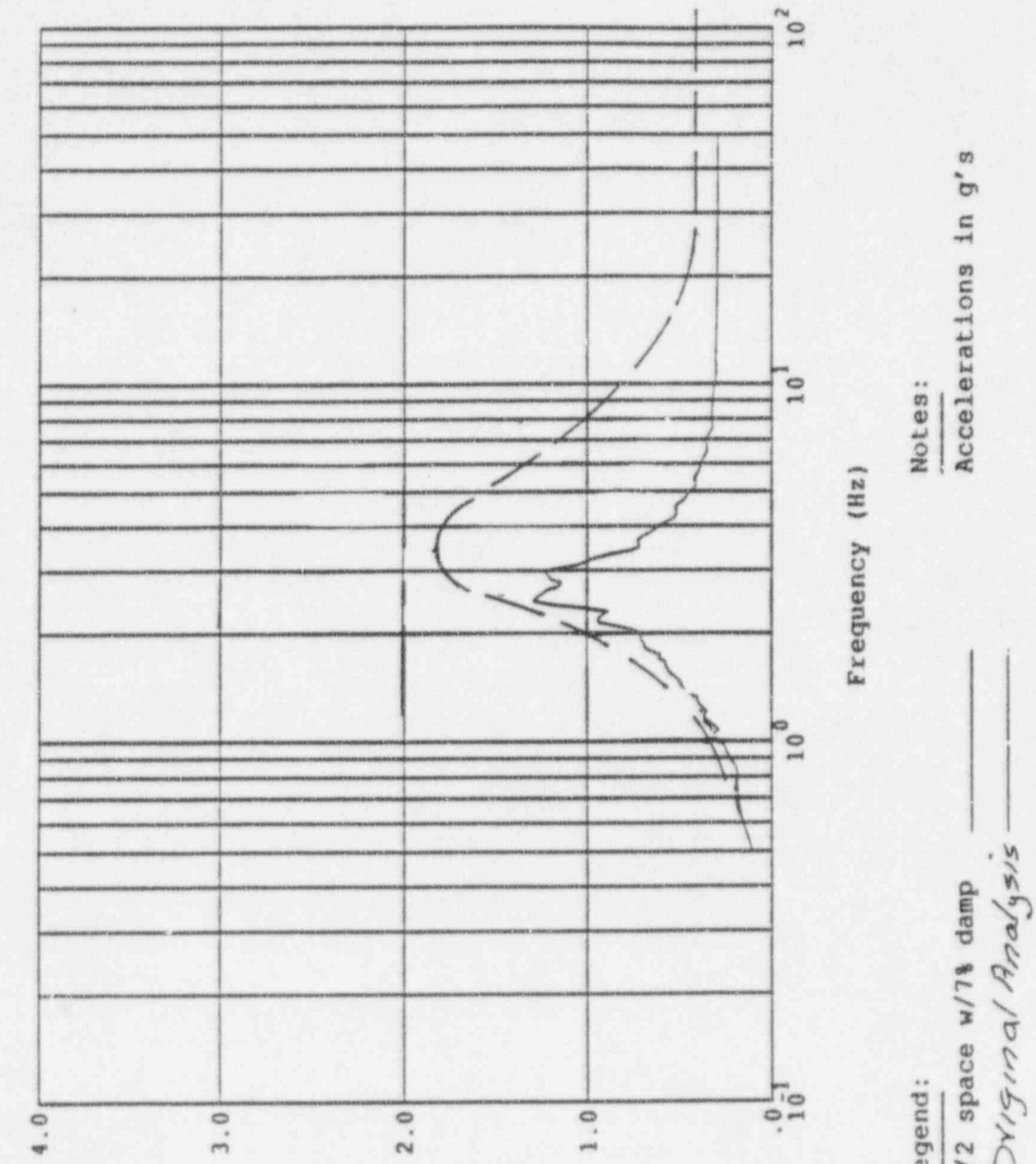
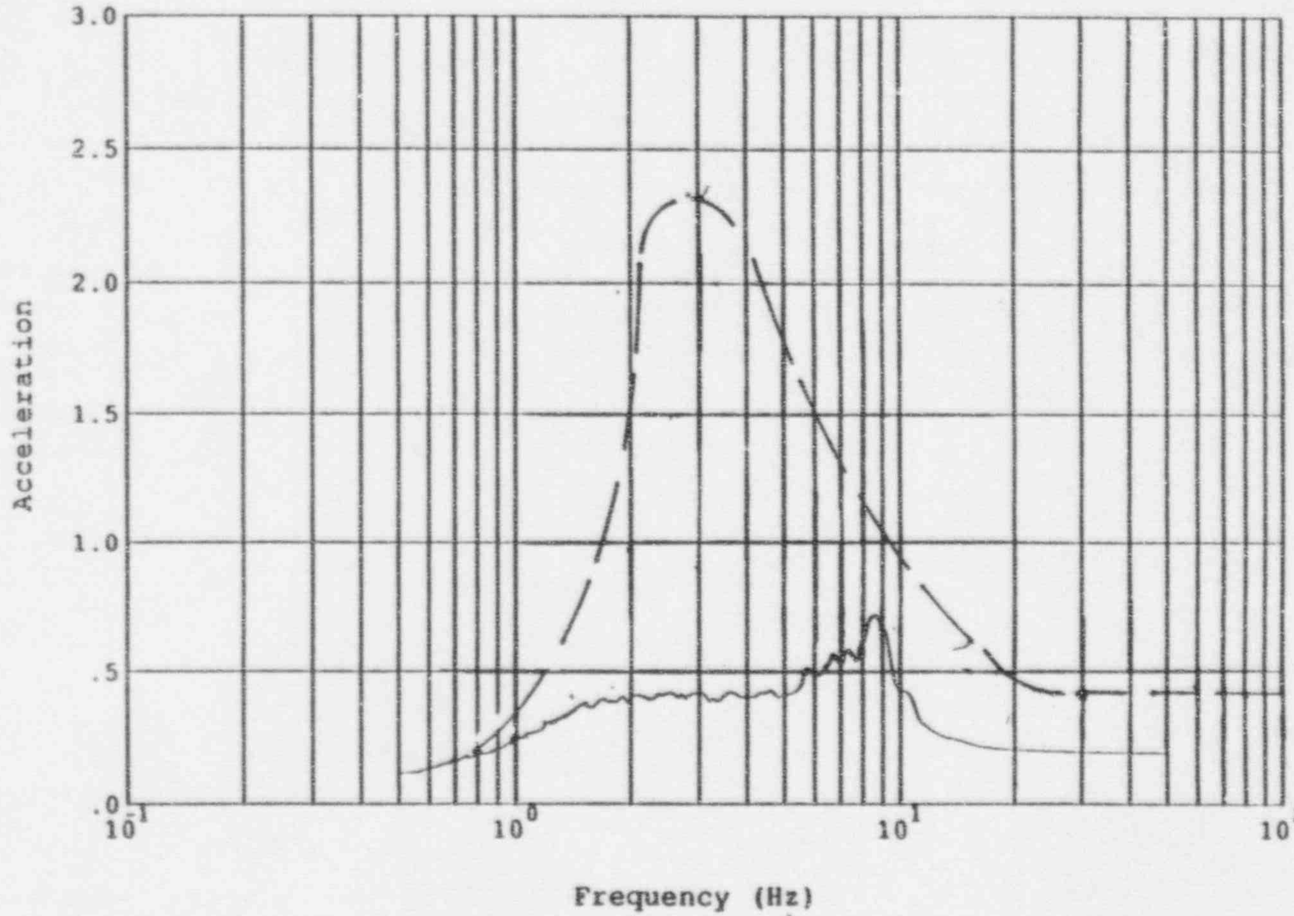



Figure 1-15

Duane Arnold Turbine Building
Turbine Pedestal, El. 780', NS Response, 5% damping

RSPLT INTEL386 VERS 1.2P COMPILED 08/04/93 09:30:31 EXECUTED 05/16/94

CALC. 42116-C-002




Legend:
1/2 space w/7% damp ————
Original Analysis — — —

Notes:
Accelerations in g's

Figure 1-16

Duane Arnold Turbine Building
Turbine Pedestal, El. 780', EW Response, 5% damping

## 2. NRC REQUEST

Provide information on how the ground motions related to the experience database were obtained, including the following:

a. the name, date, time, and magnitude of the earthquakes;

b. the name, location, foundation material, and distance to the earthquake epicenter of each facility being used for the database;

c. the distance to the seismic instruments from the facility on which the ground motion at the facility is based and the foundation material for instruments;

d. the level of ground motion recorded by the instruments;

e. the level of ground motion estimated for the facility; and

f. a description of the method used to estimate the ground motion at the facility.

## IES RESPONSE

The name, year, and magnitude of some of the more important earthquakes in the experience database are included in table 1 of the attachment to Attachment 7 to the IES Request for Technical Specification Change (RTS-232), NG-94-2629. An updated version of this table is included herein as Table 2-1 on pages 2-2 through 2-12. It lists earthquakes for which detailed damage information and some inventory data have been collected. This table also shows the name and description of various facilities that have been investigated as a result of the earthquakes, and the level of ground motion estimated for each facility.

Table 2-2 on page 2-14 provides the location, facility soils data, instrument soils data, distance to the earthquake epicenter, and distance to the nearest seismic instruments for selected database power plant facilities.

Table 2-3 on pages 2-15 and 2-16 provides the date and times of the earthquake records, the level of ground motion recorded by the seismic instruments, and a description of the method used to estimate the ground motions at selected database power plant facilities.

**Table 2-1** (Page 1 of 11)

SUMMARY OF SITES REVIEWED IN COMPILING THE SEISMIC EXPERIENCE DATA BASE

| Earthquake (Magnitude) | Facility | Type of Facility | Estimated Peak Ground Acceleration (g)[1] |
|---|---|---|---|
| San Fernando, CA Earthquake 1971 (M6.5) | Sylmar Converter Station | Large electrical substation | 0.50 |
| | Rinaldi Receiving Station | Large electrical substation | 0.50 |
| | Valley Steam Plant | Four-unit gas-fired power plant | 0.30 |
| | Burbank Power Plant | Six-unit gas-fired power plant | 0.30 |
| | Glendale Power Plant | Five-unit gas-fired power plant | 0.25 |
| | Pasadena Power Plant | Five-unit gas-fired power plant | 0.20 |
| Point Mugu, CA Earthquake 1973 (M5.7) | Ormond Beach Power Plant | Large two-unit oil-fired power plant | 0.20 |
| Ferndale, CA Earthquake 1975 (M5.5) | Humboldt Bay Power Plant | Two gas-fired units, one nuclear unit | 0.30[2] |
| Imperial Valley, CA Earthquake 1979 (M6.6) | El Centro Steam Plant | Four-unit gas-fired power plant | 0.42[2] |
| | Drop IV Hydro. Plant | Two-unit hydroelectric plant | 0.30 |
| Humboldt, CA Earthquake 1980 (M7.0) | Humboldt Bay Power Plant | Two gas-fired units one nuclear unit | 0.25 |

1 Average of two horizontal components of ground motion based on nearest accelerographs
2 Ground acceleration measured by an instrument at the site
3 There were no strong motion records in the heavily damaged region of the earthquake; therefore accurate estimates of PGA cannot be made.

**Table 2-1** (Page 2 of 11)

SUMMARY OF SITES REVIEWED IN COMPILING THE SEISMIC EXPERIENCE DATA BASE

| Earthquake (Magnitude) | Facility | Type of Facility | Estimated Peak Ground Acceleration (g)[1] |
|---|---|---|---|
| Coalinga, CA Earthquake 1983 (M6.7) | Main Oil Pumping Plant | Pumping station feeding oil pipeline from Coalinga area | 0.60 |
| | Union Oil Butane Plant | Petrochemical facility to extract butane and propane from well waste gas | 0.60 |
| | Shell Water Treatment Plant | Petrochemical facility to demineralize water prior to steam injection into oil wells | 0.60 |
| | Coalinga Water Treatment Plant | Water purification facility | 0.60 |
| | Pleasant Valley Pumping Plant | Pumping station from the San Luis Canal to the Coalinga Canal | 0.56[2] |
| | San Luis Canal Pumping Stations | Agricultural pumping stations taking water from the San Luis Canal | 0.20-0.60 |
| | Gates Substation | 500 kV electrical substation | 0.25 |
| | Kettleman Compressor Station | Natural gas pipeline booster station | 0.20 |
| Morgan Hill, CA Earthquake 1984 (M6.2) | IBM/Santa Teresa Facility | Large computer facility for software development | 0.37[2] |
| | San Martin Winery | Wine fermentation facility and tank farm | 0.30 |
| | Metcalf Substation | 500 kV electrical substation | 0.40 |
| | Mirassou Winery | Wine fermentation facility and tank farm | 0.20 |

1 Average of two horizontal components of ground motion based on nearest accelerographs
2 Ground acceleration measured by an instrument at the site
3 There were no strong motion records in the heavily damaged region of the earthquake; therefore accurate estimates of PGA cannot be made.

**Table 2-1** (Page 3 of 11)

SUMMARY OF SITES REVIEWED IN COMPILING THE SEISMIC EXPERIENCE DATA BASE

| Earthquake (Magnitude) | Facility | Type of Facility | Estimated Peak Ground Acceleration (g)[1] |
|---|---|---|---|
| Chile Earthquake 1985 (M7.8) | Bata Shoe Factory | Tannery and shoe manufacturing facility | 0.64 |
| | Llolleo Water Pumping Plant | Water pumping and filtration plant | 0.55 |
| | Rapel Hydroelectric Plant | Five-unit hydroelectric plant | 0.23[2] |
| | Concon Petroleum Refinery | Petrochemical facility producing fuel oil, asphalt, gasoline, and other petroleum products | 0.30 |
| | Oxiquim Chemical Plant | Chemical facility producing various products, including feed stock for paint ingredients | 0.30 |
| | Concon Water Pumping Station | Water pumping station | 0.30 |
| | Renca Power Plant | Two-unit coal-fired power plant | 0.30 |
| | Laguna Verde Power Plant | Two-unit coal-fired peaking plant | 0.25 |
| | Las Ventanas Copper Refinery | Copper refinery/foundry/power plant | 0.25 |
| | Las Ventanas Power Plant | Two-unit gas-fired power plant | 0.25 |

1 Average of two horizontal components of ground motion based on nearest accelerographs
2 Ground acceleration measured by an instrument at the site
3 There were no strong motion records in the heavily damaged region of the earthquake; therefore accurate estimates of PGA cannot be made.

**Table 2-1** (Page 4 of 11)

SUMMARY OF SITES REVIEWED IN COMPILING THE SEISMIC EXPERIENCE DATA BASE

| Earthquake (Magnitude) | Facility | Type of Facility | Estimated Peak Ground Acceleration (g)[1] |
|---|---|---|---|
| Mexico Earthquake 1985 (M8.1) | Infiernillo Dam | Six-unit hydroelectric plant | 0.15 |
| | La Villita Power Plant | Four-unit hydroelectric plant | 0.14 |
| | SICARTSA Steel Mill | Large steel mill | 0.25 |
| | Fertimex Plant | Large fertilizer production plant | 0.25 |
| Adak, Alaska Earthquake 1986 (M7.5) | Adak Naval Base | Diesel-electric power plants, electrical substations, water treatment plant, steam plants | 0.25[2] |
| North Palm Springs, CA Earthquake 1986 (M6.0) | Devers Substation | 500 kV electrical substation | 0.85[2] |
| | Whitewater Hydro. Plant | Small hydroelectric power plant | 0.50 |
| Chalfant Valley, CA Earthquake 1986 (M6.0) | Hi-Head Hydro Plant | Small one-unit hydroelectric plant | 0.25 |
| San Salvador Earthquake 1986 (M5.4) | Soyapango Substation | 115 kV substation | 0.50 |
| | San Antonio Substation | 115 kV substation | 0.30 |

1 Average of two horizontal components of ground motion based on nearest accelerographs
2 Ground acceleration measured by an instrument at the site
3 There were no strong motion records in the heavily damaged region of the earthquake; therefore accurate estimates of PGA cannot be made.

**Table 2-1** (Page 5 of 11)

SUMMARY OF SITES REVIEWED IN COMPILING THE SEISMIC EXPERIENCE DATA BASE

| Earthquake (Magnitude) | Facility | Type of Facility | Estimated Peak Ground Acceleration (g)[1] |
|---|---|---|---|
| Bay of Plenty, New Zealand Earthquake 1987 (M6.25) | Edgecumbe Substation | 230 kV substation | 0.50 |
| | New Zealand Distillery | Liquor distillery | 0.50 |
| | Caxton Paper Mill | Paper and pulp mill | 0.40 |
| | Kawerau Substation | 230 kV substation | 0.40 |
| | Whakatane Board Mill | Paper mill producing cardboard | 0.25 |
| | Matahina Dam | Two-unit hydroelectric plant | 0.26[2] |
| Whittier, CA Earthquake 1987 (M5.9) | Olinda Substation | 230 kV substation | 0.65[2] |
| | SCE Central Dispatch Headquarters | Data Processing Center | 0.56[2] |
| | SCE Headquarters | Large office complex and data processing center | 0.42[2] |
| | California Federal Bank Facility | Data processing facility | 0.40 |
| | Ticor Facility | Data processing facility | 0.40 |
| | Mesa Substation | 230 kV substation | 0.35 |
| | Sanwa Bank Facility | Data processing facility | 0.40 |
| | Alhambra Station | Telephone switching station | 0.40 |

1 Average of two horizontal components of ground motion based on nearest accelerographs
2 Ground acceleration measured by an instrument at the site
3 There were no strong motion records in the heavily damaged region of the earthquake; therefore accurate estimates of PGA cannot be made.

**Table 2-1** (Page 6 of 11)

SUMMARY OF SITES REVIEWED IN COMPILING THE SEISMIC EXPERIENCE DATA BASE

| Earthquake (Magnitude) | Facility | Type of Facility | Estimated Peak Ground Acceleration (g)[1] |
|---|---|---|---|
| Whittier, CA Earthquake 1987 (M5.9) (Cont.) | Rosemead Station | Telephone switching station | 0.40 |
| | Central Station | Telephone switching station | 0.15 |
| | Wells Fargo Bank Facility | Data processing facility | 0.35 |
| | Center Substation | 230 kV Substation | 0.35 |
| | Lighthype Substation | 230 kV Substation | 0.26[2] |
| | Del Amo Substation | 230 kV Substation | 0.20 |
| | Commerce Refuse-to-Energy Plant | Trash-burning power plant | 0.30 |
| | Pasadena Power Plant | Five-unit gas-fired power plant | 0.25 |
| | Glendale Power Plant | Five-unit gas-fired power plant | 0.20 |
| | Puente Hills Landfill Gas & Energy Recovery Plant | Methane burning power plant | 0.20 |

1 Average of two horizontal components of ground motion based on nearest accelerographs
2 Ground acceleration measured by an instrument at the site
3 There were no strong motion records in the heavily damaged region of the earthquake; therefore accurate estimates of PGA cannot be made.

**Table 2-1** (Page 7 of 11)

SUMMARY OF SITES REVIEWED IN COMPILING THE SEISMIC EXPERIENCE DATA BASE

| Earthquake (Magnitude) | Facility | Type of Facility | Estimated Peak Ground Acceleration (g)[1] |
|---|---|---|---|
| Superstition Hills (El Centro), CA 1987 | Mesquite Lake Resource Recovery Plant | Organic waste burning power plant | 0.20 |
| (M6.3) | El Centro Steam Plant | Four-unit gas-fired power plant | 0.26[2] |
| Loma Prieta Earthquake 1989 | Moss Landing Power Plant | Seven-unit gas-fired power plant | 0.34 |
| (M7.1) | Gilroy Energy Cogen Plant | Combined gas turbine and steam plant | 0.32 |
| | Cardinal Cogen Plant | Combined gas turbine and steam plant | 0.25 |
| | University of California at Santa Cruz | Diesel cogeneration plant and HVAC plants | 0.45[2] |
| | Hunter's Point Plant | Three-unit gas-fired power plant | 0.15 |
| | Portrero Plant | Two-unit gas-fired plant | 0.15 |
| | Metcalf Substation | 500 kV substation | 0.30 |
| | San Mateo Substation | 230 kV substation | 0.20 |
| | National Refractory | Large brick & magnesia extraction plant | 0.30 |
| | Green Giant Foods | Food processing and cold storage plant | 0.30 |
| | Watsonville Wastewater Treatment | Sewage treatment plant | 0.40 |

1 Average of two horizontal components of ground motion based on nearest accelerographs
2 Ground acceleration measured by an instrument at the site
3 There were no strong motion records in the heavily damaged region of the earthquake; therefore accurate estimates of PGA cannot be made.

**Table 2-1** (Page 8 of 11)

SUMMARY OF SITES REVIEWED IN COMPILING THE SEISMIC EXPERIENCE DATA BASE

| Earthquake (Magnitude) | Facility | Type of Facility | Estimated Peak Ground Acceleration (g)[1] |
|---|---|---|---|
| Loma Prieta Earthquake 1989 (M7.1) (Cont.) | Santa Cruz Station | Telephone switching station | 0.40 |
| | Watsonville Station | Telephone switching station | 0.33[2] |
| | Seagate Technology Watsonville | Electronic manufacturing facility | 0.40 |
| | Santa Cruz Water Treatment | Water purification facility | 0.40 |
| | Soquel Water District | Pumping stations & storage tanks | 0.50 |
| | Lipton Foods | Food processing and packaging facility | 0.30 |
| | Lone Star Cement | Cement factory | 0.25 |
| | Watkins-Johnson Instruments | Electronic manufacturing plant | 0.35 |
| | Rinconada Water Treatment Plant | Water purification facility | 0.30 |
| | IBM/Santa Teresa Facility | Software development laboratory | 0.20[2] |
| | EPRI Headquarters | Office and data processing complex | 0.25 |

1 Average of two horizontal components of ground motion based on nearest accelerographs
2 Ground acceleration measured by an instrument at the site
3 There were no strong motion records in the heavily damaged region of the earthquake; therefore accurate estimates of PGA cannot be made.

**Table 2-1** (Page 9 of 11)

SUMMARY OF SITES REVIEWED IN COMPILING THE SEISMIC EXPERIENCE DATA BASE

| Earthquake (Magnitude) | Facility | Type of Facility | Estimated Peak Ground Acceleration (g)[1] |
|---|---|---|---|
| Central Luzon, Philippines Earthquake 1990 (M7.7) | Baguio Station | Telephone switching station | 3 |
| | Cabanatuan Substation | 230 kV substation | 3 |
| | La Trinidad Substation | 230 kV substation | 3 |
| | San Manuel Substation | 230 kV substation | 3 |
| | Moog Manufacturing Plant | Electronic manufacturing plant | 3 |
| Valle de Estrella, Costa Rica Earthquake 1991 (M7.4) | Bomba Water Treatment Plant | Water Treatment Plant | 3 |
| | Cachi Dam | Large hydroelectric plant | 0.12[2] |
| | Changuinola Power Plant | Diesel power plant | 3 |
| | Limon Station | Telephone switching station | 3 |
| | Moin Power Plant | Diesel and gas turbine power plant | 3 |
| | RECOPE Refinery | Oil refinery | 3 |
| Sierra Madre, California Earthquake 1991 (M5.8) | Pasadena Power Plant | Five-unit gas-fired power plant | 0.20 |
| | Goodrich Substation | 230 kV substation | 0.30 |

1 Average of two horizontal components of ground motion based on nearest accelerographs
2 Ground acceleration measured by an instrument at the site
3 There were no strong motion records in the heavily damaged region of the earthquake; therefore accurate estimates of PGA cannot be made.

**Table 2-1** (Page 10 of 11)

SUMMARY OF SITES REVIEWED IN COMPILING THE SEISMIC EXPERIENCE DATA BASE

| Earthquake (Magnitude) | Facility | Type of Facility | Estimated Peak Ground Acceleration (g)[1] |
|---|---|---|---|
| Cape Mendocino Earthquakes 1992 (M7.0) | Pacific Mill | Lumber mill & Cogen plant | 0.47 |
| | Centerville Naval Base | HVAC and diesel power plant | 0.40[2] |
| | Humboldt Bay Power Plant | Two gas-fired units One nuclear unit | 0.24[2] |
| Landers & Big Bear Earthquakes 1992 (M7.4) | Cool Water Power Plant | Two gas-fired units Two combined cycle units | 0.35[2] |
| | SEGs 1 & 2 Steam Plants | Solar-powered generating plants | 0.35 |
| | Newberry Compressor Plant | Piston-driven gas compressors | 0.25 |
| | Pfizer Ore Processing | Limestone Production | 0.30 |
| | Mitsubishi Cement | Cement Production | 0.30 |
| Guam Earthquake 1993 (M8.0) | Cabras Power Plant | Two oil-fired units | 0.25[4] |
| | Piti Power Plant | Four oil-fired units | 0.25[4] |
| | Tanguisan Power Plant | Two oil-fired units | 0.25[4] |
| | Yigo Gas Turbine | Packaged gas turbine-generator | 0.25[4] |

1 Average of two horizontal components of ground motion based on nearest accelerographs.
2 Ground acceleration measured by an instrument at the site.
3 There were no strong motion records in the heavily damaged region of the earthquake; therefore accurate estimates of PGA cannot be made.
4 Although there were no strong motion records on the island of Guam, USGS estimated 0.25g as the average peak ground acceleration for the island based on effects.

**Table 2-1** (Page 11 of 11)

SUMMARY OF SITES REVIEWED IN COMPILING THE SEISMIC EXPERIENCE DATA BASE

| Earthquake (Magnitude) | Facility | Type of Facility | Estimated Peak Ground Acceleration (g)[1] |
|---|---|---|---|
| Guam Earthquake 1993 (M8.0) | Dededo Gas Turbine | Turbine-generator and diesels | 0.25[4] |
| (Cont.) | GPA Diesel Plants | Four units with two diesels each | 0.25[4] |
| | Uguma Water Treatment Plant | Water treatment facility | 0.25[4] |
| Northridge Earthquake 1994 (M6.7) | Sylmar Converter Station | Large electrical substation | 0.85 |
| | Olive View Cogen | Two-unit gas turbine plant | 0.72 |
| | Placerita Cogen | Two-unit gas turbine plant | 0.50 |
| | Great Western Data Center | Data processing facility emergency diesel & UPS plant | 0.50 |
| | Castaic Pump-Turbine Plant | Seven-unit hydro plant | 0.35 |

1 Average of two horizontal components of ground motion based on nearest accelerographs.
2 Ground acceleration measured by an instrument at the site.
3 There were no strong motion records in the heavily damaged region of the earthquake; therefore accurate estimates of PGA cannot be made.
4 Although there were no strong motion records on the island of Guam, USGS estimated 0.25g as the average peak ground acceleration for the island based on effects.

**Table 2-2**
**Earthquake Distances and Soils Data**
**Selected Database Power Plant Facilities**

| Facility Name (Earthquake) | Facility Location | Approx. Distance to Epicenter (KM) | Approx. Distance to Seismic Instrument (KM) | Facility Site Soils | Instrument Site Soils |
|---|---|---|---|---|---|
| Valley Steam Plant (1971 San Fernando E.Q.) | East San Fernando Valley, CA | 15 | 8 | Deep alluvium | Deep alluvium |
| Burbank Power Plant (1971 San Fernando E.Q.) | Burbank, CA | 20 | 8 | Compact alluvium | Compact alluvium |
| Ormond Beach Power Plant (1973 Point Mugu E.Q.) | 4 km North of Point Mugu, CA | 3 | 5 | Soft sedimentary material | (Not available) |
| Humbolt Bay Power Plant (1975 Ferndale E.Q.) | 5 km South of Eureka, CA | 10 | 0 | Deep soft soil, strata of dense compact fine to medium grained sand mixed with gravel and claystone to about 200m | Deep soft soil, strata of dense compact fine to medium grained sand mixed with gravel and claystone to about 200m |
| Fukushima Nuclear Power Plant (1978 Miyagi-ken-Oki, Japan E.Q.) | South of Namie and 140 SE of Fukushima, Japan | 140 | 0 | Competent soft mudstone formation with a thickness in excess of 300m | Competent soft mudstone formation with a thickness in excess of 300m |
| Humbolt Bay Power Plant (1980 Humbolt County E.Q.) | 5 km South of Eureka, CA | 50 | 0 | Deep soft soil, strata of dense compact fine to medium grained sand mixed with gravel and claystone to about 200m | Deep soft soil, strata of dense compact fine to medium grained sand mixed with gravel and claystone to about 200m |

**Table 2-2**
**Earthquake Distances and Soils Data**
**Selected Database Power Plant Facilities**

| Facility Name (Earthquake) | Facility Location | Approx. Distance to Epicenter (KM) | Approx. Distance to Seismic Instrument (KM) | Facility Site Soils | Instrument Site Soils |
|---|---|---|---|---|---|
| Humbolt Bay Power Plant (1992 Cape Mendocino E.Q.) | 5 km South of Eureka, CA | 40 | 0 | Deep soft soil, strata of dense compact fine to medium grained sand mixed with gravel and claystone to about 200m | Deep soft soil, strata of dense compact fine to medium grained sand mixed with gravel and claystone to about 200m |
| El Centro Steam Plant (1979 Imperial Valley E.Q.) | El Centro, CA | 25 | 1 | Deep alluvial deposits composed primarily of stiff to hard clay interbain with laminations of silty clay loam and sandy loam | (Similar to Facility Foundation Material) |
| Commerce Refuse to Energy Plant (1987 Whittier E.Q.) | Commerce, CA | 10 | 1 | (Judged similar to soil at instrument site) | Interface of soft and compact alluvium |
| Moss Landing Power Plant (1989 Loma Prieta E.Q.) | Monterey Bay, CA | 20 | 13 | Ancient beach deposits and Santa Cruz coastal terrace deposits | (Somewhat softer conditions than facility) |
| Cool Water Power Plant (1992 Landers/Big Bear E.Q.) | Dagget, CA | 60 | 0 | (Not available) | (On-site instruments, same soil as facility) |
| PALCO Cogeneration Plant (1992 Cape Mendocino E.Q.) | Scotia, CA | 20 | 2 | Soft recent alluvial deposits | Soft recent alluvial deposits |

**Table 2-3**
**Earthquake Record Data**
**Selected Database Power Plant Facilities**

| Facility Name | Earthquake, Date and Time | Recorded Ground Motions | Method Used to Estimate Ground Motions |
|---|---|---|---|
| Valley Steam Plant | Feb. 9, 1971<br>San Fernando E.Q.,<br>6:01 AM | Holiday Inn<br>Van Nuys, CA<br>record:<br>N-S 0.27g<br>VERT 0.17g<br>E-W 0.14g | Records slightly scaled up to a peak of 0.30g based on the site's distance to the causative fault (5km) |
| Burbank Power Plant | Feb. 9, 1971<br>San Fernando E.Q.,<br>6:01 AM | Glendale, CA City Hall<br>record:<br>N-S 0.23g<br>VERT 0.14g<br>E-W 0.28g | Records from Glendale City Hall best represent soil conditions at facility site. Record slightly scaled up to 0.30g because plant is significantly closer to causative fault than the Glendale City Hall Record |
| Ormond Beach Power Plant | Feb. 21, 1973<br>Point Mugu E.Q.,<br>6:46 AM | PGA of 0.13g was recorded at Port Hueneme, about 2km further from epicenter | PGA of 0.20g was estimated based on typical California attenuation relationships, and independently based on observation and measurement of pipe displacements |
| Humbolt Bay Power Plant | June 7, 1975<br>Ferndale E.Q.<br>1:46 AM | Storage Building Slab<br>on site record:<br>N-S 0.26g<br>VERT 0.07g<br>E-W 0.35g | Recorded on site |
| Fukushima Nuclear Power Plant | June 12, 1978<br>Miyagi-ken-Oki E.Q.,<br>17h 14m Japanese Standard Time | On site instrumentation<br>record:<br>PEAK 0.125g<br>N-S 0.10g<br>VERT 0.05g | Recorded on site |
| Humbolt Bay Power Plant | November 8, 1980<br>Humbolt County E.Q.<br>2:27 AM | ZPA recorded by triaxial recorder on operating floor of Unit 3 Refuel Bldg.:<br>N-S 0.25g<br>VERT 0.09g<br>E-W 0.27g | Recorded on site |

**Table 2-3**
**Earthquake Record Data**
**Selected Database Power Plant Facilities**

| Facility Name | Earthquake, Date and Time | Recorded Ground Motions | Method Used to Estimate Ground Motions |
|---|---|---|---|
| Humbolt Bay Power Plant | April 25, 1992 (M7.0, M6.0)<br>April 26, 1992 (M6.5)<br>Cape Mendocino E.Q.<br>11:06 AM (M7.0)<br>12:41 AM (M6.0)<br>4:18 AM (M6.5) | Storage Building Slab on site record for M6.0:<br>N-S 0.23g<br>VERT 0.05g<br>E-W 0.25g | Recorded on site |
| El Centro Steam Plant | Oct. 15, 1979<br>Imperial Valley E.Q.<br>4:16 PM | USGS El Centro Differential Instru ment Array record:<br>N-S 0.51g<br>VERT 0.93g<br>E-W 0.37g | Motion at USGS instrument location was considered to represent the effective free-field motion for the power plant. |
| Commerce Refuse to Energy Plant | Oct. 1, 1987<br>Whittier E.Q.<br>7:42 AM | Record from USGS instruments at L.A. Bulk Mail Center:<br>N-S 0.34g<br>VERT 0.52g<br>E-W 0.46g | Bulk Mail Center instrument was considered applicable because of proximity to Commerce Plant and similar soil conditions. PGA estimate reduced to 0.30g due to observed lack of damage. |
| Moss Landing Power Plant | Oct. 17, 1989<br>Loma Prieta E.Q.<br>5:04 PM | Watsonville, CA record:<br>N-S 0.28g<br>VERT 0.66g<br>E-W 0.39g | Estimated PGA of 0.34g based on studies of available recordings and local soil conditions by PG&E. |
| Cool Water Power Plant | June 28, 1992<br>Landers/Big Bear E.Q.<br>4:58 AM (M7.4)<br>8:04 AM (M6.5) | Maximum record from free-field instrument located on site:<br>E-W 0.43g<br>N-S 0.28g | Recorded on site |
| PALCO Cogeneration Plant | April 25, 1992 (M7.0, M6.0)<br>April 26, 1992 (M6.5)<br>Cape Mendocino E.Q.<br>11:06 AM (M7.0)<br>12:41 AM (M6.0)<br>4:18 AM (M6.5) | Record from CSMIP accelograph array in Rio Dell for M7.0:<br>N-S 0.55g<br>VERT 0.20g<br>E-W 0.39g | Facility motion judged to be the same as accelograph location because of the similarity of the facility and recording sites. |

3. **NRC Request**

Provide examples of supporting documents to confirm that all the equipment associated with the proposed alternate leakage treatment path (including the alternate drain path) is seismically qualified.

**IES Response**

Table 3-1 lists the equipment in the proposed MSIV leakage treatment path (and interconnected systems) that was evaluated for seismic adequacy. The method of evaluation was by a seismic verification walkdown by teams which included personnel experienced in post-earthquake evaluation of piping and equipment. The walkdowns were supplemented with deterministic seismic evaluations of piping, pipe supports, and equipment in the seismic verification boundary. The seismic evaluations were in accordance with Section 6.7 of GE Topical Report NEDC-31858P (Reference 3). The scope of equipment evaluated included all valves (i.e., fluid-operated and motor-operated valves) that may be required to change position during or following the earthquake, instrument racks containing instruments and gages which are in the seismic verification boundary, and the main condenser.

Examples of supporting documents (e.g., walkdown data sheets, equipment data sheets, outlier data sheets) are available at DAEC for review by the staff.

**Table 3-1**
**Equipment Evaluated for Seismic Adequacy**

| Path | Equipment ID | Description |
|---|---|---|
| Primary Path | MO-1043 | 3" motor-operated globe valve (FP) |
| | MO-1044 | 3" motor-operated globe valve (FP) |
| | 1E-007A | Main condenser (Low Pressure) |
| | 1E-007B | Main condenser (High Pressure) |
| Alternate Path | CV-1064 | 2" fluid-operated gate valve (FP) |
| Main steam and main steam bypass to stop valves and bypass to 2nd stage moisture separator & reheater | MO-1054 | 6" motor-operated gate valve (BV) |
| | MO-1055 | 6" motor-operated gate valve (BV) |
| Interconnected systems | | |
| a. Main steam sampling | 1C-213B | Instrument rack for sample lines (PB) |
| b. Main steam bypass to turbine steam seals | MO-1169 | 3" motor-operated gate valve (BV) |
| | MO-1170 | 3" motor-operated globe valve (BV) |
| | MO-1042 | 1" motor-operated globe valve (BV) |
| c. Main steam to air ejectors | V03-0004 | 3" manual gate valve (BV) |
| | V03-0005 | 3" manual gate valve (BV) (Both valves to be converted to motor-operated valves with essential power.) |
| d. HPCI steam line drain | CV-2211 | 1" fluid-operated globe valve (BV) |
| | CV-2212 | 1" fluid-operated globe valve (BV) |
| e. RCIC steam line drain | CV-2410 | 1" fluid-operated globe valve (BV) |
| | CV-2411 | 1" fluid-operated globe valve (BV) |
| f. Drywell steam drains | MO-4424 | 3" motor-operated gate valve (BV) |
| g. Main steam instrumentation lines | 1C-210A | Instrument rack (PB) |
| | 1C-210B | Instrument rack (PB) |
| h. Main steam stop valve drain lines | MO-1038 | 1" motor-operated globe valve (BV) |
| | MO-1039 | 1" motor-operated globe valve (BV) |
| | MO-1040 | 1" motor-operated globe valve (BV) |
| | MO-1041 | 1" motor-operated globe valve (BV) |

BV = Boundary valve     PB = Pressure boundary     FP = Flow path valve

4. **NRC Request**

Provide examples of supporting documents to confirm that all the supports associated with the alternate leakage treatment path piping (including the alternate drain path) are analyzed for their seismic capability.

**IES Response**

Seismic evaluations were performed for all pipe supports in both the primary and alternate MSIV leakage treatment paths, and a representative sample of supports from interconnected piping systems. The method of evaluation was to determine the deadweight and seismic loads per unit length of pipe. This unit loading was multiplied by a conservative tributary length of pipe and combined with the thermal load (if applicable) to arrive at the total load on the support. Support capacities were in accordance with recommendations in EPRI NP-6041-SL (Reference 1) as follows:

| | | |
|---|---|---|
| Steel | 1.7 S | where S = allowable stress for normal loads |
| Welds | 1.7 S | |
| Standard Components | 0.7x5 times normal (catalog) allowable = 0.7xUltimate | |

Seismic loads were conservatively estimated by multiplying the unit weight of the pipe, including contained fluid and insulation, by the peak spectral acceleration from the applicable in-structure response spectrum curve. An additional 1.25 factor of conservatism was applied consistent with Section 4.4.3 of the SQUG Generic Implementation Procedure (GIP).

A total of 22 supports on the primary and alternate MSIV leakage treatment paths and 15 additional supports from two typical interconnected piping systems were evaluated. The evaluation covered the following types of pipe supports.

Rod Hangers
Stanchions
Spring Hangers (rod hung, floor mounted, and trapeze)
Snubbers
Pipe Frames
WF Beam Frames
Stanchion Frames
Frames with U-Bolts
"PS" Series Supports

Results of pipe support evaluations are summarized in Table 4-1. In this table, the support number, type, and ratio of the calculated seismic demand to capacity are tabulated for each support evaluated. As shown in Table 4-1, the capacity of all supports exceeds the seismic demand, i.e., all ratios are less than 1.0. The highest ratio is 0.48 which indicates a minimum margin of at least 2.0 on seismic demand for all supports.

**Table 4-1**
**Summary of Support Evaluations**

| Support (1) | Type | Ratio | Support (1) | Type | Ratio |
|---|---|---|---|---|---|
| EBD-3-H-41* | Rod Hanger | 0.33 | EBD-3-H-40* | Spring Hanger | (Note 2) |
| EBD-3-H-43* | Rod Hanger | 0.33 | EBD-3-H-42* | Spring Hanger | (Note 2) |
| EBD-3-H-59 | Rod Hanger | 0.33 | EBD-3-H-45* | Spring Hanger | (Note 2) |
| EBD-3-H-61 | Rod Hanger | 0.33 | EBD-3-H-46* | Spring Hanger | (Note 2) |
| EBD-3-H-64 | Rod Hanger | 0.33 | EBD-3-H-55 | Spring Hanger | (Note 2) |
| EBD-3-H-65 | Rod Hanger | 0.33 | EBD-3-H-57* | Spring Hanger | (Note 2) |
| EBD-3-H-67 | Rod Hanger | 0.33 | EBD-3-H-58 | Spring Hanger | (Note 2) |
| EBD-3-H-48* | Pipe Frame | 0.43 | EBD-3-H-62 | Spring Hanger | (Note 2) |
| EBD-3-H-51* | Pipe Frame | 0.43 | EBD-3-H-47* | Stanchion | 0.13 |
| EBD-3-H-53 | Pipe Frame | 0.43 | EBD-3-H-49* | Stanchion | 0.13 |
| EBD-3-H-54 | Pipe Frame | 0.43 | EBD-3-H-50* | Stanchion | 0.13 |
| EBD-3-H-44* | W4 Frame | 0.15 | EBD-3-H-52* | Stanchion | 0.13 |
| EBD-3-H-66 | Stanchion Fr. | 0.48 | EBD-3-H-56* | Stanchion | 0.13 |
| EBD-3-H-68 | Stanchion Fr. | 0.48 | EBD-3-SS-137 | Snubber | 0.29 |
| EBD-3-H-60 | U-Bolt Frame | 0.20 | | PS Series*(3) | 0.24 |
| EBD-3-H-63 | U-Bolt Frame | 0.20 | | (7 Supports) | |

Notes:

1. Pipe supports on the primary or alternate MSIV leakage treatment path are indicated by an asterisk (*). All other supports are on interconnected piping systems.

2. Spring hangers are considered adequate for seismic loads since loads on other supports were conservatively calculated assuming that spring hangers carry no load for seismic loading conditions.

3. Details on these supports are contained in DAEC Engineering Design Guide DGC M-100.

Examples of supporting documents (e.g., pipe support calculations) are available at DAEC for review by the staff.

5. **NRC Request**

Confirm that the entire alternate leakage treatment path, including the two motor operated valves (MOVs V03-0004 and V03-0005) which are replacing existing valves, is covered under the ASME Section XI inspection program.

**IES Response**

All valves within the seismic verification boundary required to reposition to establish the boundary or treatment path, including V03-0004 and V03-0005, will be included in the ASME Section XI inservice testing (IST) program. In addition, the primary and alternate MSIV leakage treatment paths from the main steam line to the condenser, including interconnected systems up to the boundary valves, will also be included in the ASME Section XI inservice inspection (ISI) program. Note that existing manual valves V03-0004 and V03-0005 are not being replaced; rather, motor operators are being added to them. The new designations for these valves will be MO1362A and B, respectively.

6. **NRC Request**

Provide examples of detailed analyses and calculations of representative pipe supports. Such analyses should be performed in accordance with the FSAR methodologies, criteria, as well as seismic input motions and support loads, which are acceptable to the staff.

**IES Response**

As discussed in the answer to Item 4, detailed calculations for pipe supports are available at DAEC for review by the staff.

The methodologies for seismic evaluation of pipe supports, as well as other components and equipment associated with the MISV leakage treatment path, were in accordance with Section 6.7 of the GE topical report (Reference 3). Key elements of the seismic evaluations for the main steam and drain line piping and pipe supports are summarized below.

a. The main steam and drain line piping at DAEC were reviewed to verify that the pertinent piping parameters (i.e., design codes, pipe diameter, wall thickness, spans, etc.) were bounded by the piping in the earthquake experience database. For additional information in this regard, see answers to Items 7, 8, 9, and 10.

b. All piping within the seismic verification boundary was walked down 100 percent by seismic review teams which included personnel experienced in post-earthquake evaluation of piping and equipment. The purpose of these walkdowns was to verify that DAEC piping and components have characteristics similar to those in the earthquake experience database, and to identify seismic vulnerabilities or configurations with uncertain seismic capacity. Seismic vulnerabilities and uncertainties were documented as outliers to be evaluated in more detail or modified as required. The walkdowns were performed in accordance with a written procedure and all team members received training in the procedure prior to taking part in the walkdowns.

c. The seismic verification walkdowns were supplemented with deterministic seismic evaluations of limiting or bounding configurations. In the case of the primary and alternate MSIV leakage treatment paths, all pipe supports were evaluated for seismic adequacy, not just bounding configurations.

d. The seismic demand for pipe supports, as well as other components and equipment within the seismic verification boundary, was based on new median-centered in-structure response spectra for the turbine building. The seismic response analysis of the turbine building is described in the answer to Item 1. Capacities for pipe support components were determined in accordance with EPRI NP-6041-SL (Reference 1) as discussed in the answer to Item 4.

In summary, seismic evaluations of non-seismic components and equipment associated with the MSIV leakage treatment path were based on 1) a conservative design ground motion, 2)

median centered (best estimate) response, and 3) conservative allowables or capacities. This approach results in a high confidence of low probability of failure. The intent of the seismic evaluations was to demonstrate "seismic ruggedness" of piping, supports, and equipment associated with the MSIV leakage treatment path; not to perform "licensing basis" seismic analyses. It is the judgment of IES that earthquake experience data and the methodologies provided in the GE topical report (Reference 3) provide an acceptable and preferable method for verifying the seismic adequacy of piping systems and supports that were not originally designed for seismic loads. Accordingly, FSAR methodologies and seismic input motions were not used for these evaluations.

7. **NRC REQUEST**

Provide a detailed comparison between the Duane Arnold piping in the alternate leakage treatment path and the pertinent database piping. The comparison should be specific for each of the pipe diameters at Duane Arnold, its associated pipe thickness, and associated pipe diameter-to-thickness ratio.

**IES RESPONSE**

Table 7-1 shows the pipe diameters, wall thicknesses and pipe diameter-to-thickness (D/t) ratios for the DAEC alternate leakage treatment path piping.

Table 7-2 shows the pipe diameters, wall thickness and pipe diameter-to-thickness (D/t) ratios for piping at selected database power plant facilities. Additional data on piping in the seismic experience database has been submitted to the NRC in the following documents:

- NEDC-31858P, Rev. 2: "BWROG Report for Increasing MSIV Leakage Rate Limits and Elimination of Leakage Control Systems".
- Attachment 7 to IES Request for Technical Specification Change (RTS-232), NG-94-2629, August 15, 1994: "Supplemental Piping Earthquake Performance Data," December 1993.

The information in Table 7-2 is a sampling of main steam piping and process piping at selected power plants in the seismic experience database. This represents a small portion of the facilities with power and petrochemical piping which have been studied for the effects of strong motion earthquakes. The range in piping parameters from Tables 7-1 and 7-2 is summarized in Table 7-3 and Figure 7-1. Table 7-3 and Figure 7-1 demonstrate that the DAEC alternate treatment path piping is well represented within database piping.

**Table 7-1**
**Duane Arnold Piping Data**
**Alternate Leakage Treatment Path**

| System | Pipe Size (NPS) | Pipe O.D. (inch) | Schedule | Wall Thickness (inch) | D/t |
|---|---|---|---|---|---|
| Main Steam and* Turbine Bypass | 20* | 20.0 | 80 | 1.031 | 19 |
| | 12* | 12.75 | 80 | 0.687 | 19 |
| | 10* | 10.75 | 80 | 0.593 | 18 |
| | 6 | 6.625 | 80 | 0.432 | 15 |
| | 4 | 4.5 | 80 | 0.337 | 13 |
| | 3 | 3.5 | 160 | 0.437 | 8 |
| Main Steam Drain to Condenser | 6 | 6.625 | 80 | 0.432 | 15 |
| | 3 | 3.5 | 160 | 0.437 | 8 |
| | 2 | 2.375 | 160 | 0.343 | 7 |
| | 1 | 1.315 | 160 | 0.250 | 5 |
| Main Steam Sample Line | 1 | 1.315 | 160 | 0.250 | 5 |
| Main Steam Instruments | ¾ | 1.05 | 160 | 0.218 | 5 |
| Main Steam to 2nd Stage Reheater Drain | ¾ | 1.05 | 160 | 0.218 | 5 |
| Main Steam to Off Gas Recombiner | 3 | 3.5 | 160 | 0.437 | 8 |
| | 2 | 2.375 | 160 | 0.343 | 7 |
| Steam Bypass to Turbine Steam-Seal | 4 | 4.5 | 80 | 0.337 | 13 |
| | 3 | 3.5 | 160 | 0.437 | 8 |
| | 1 | 1.315 | 160 | 0.250 | 5 |
| Main Steam to Air Ejector | 4 | 4.5 | 80 | 0.337 | 13 |
| | 3 | 3.5 | 160 | 0.437 | 8 |
| Miscellaneous Main Steam Drains, Vents & Branches | 2 | 2.375 | 160 | 0.343 | 7 |
| | 1½ | 1.900 | 160 | 0.281 | 7 |
| | 1 | 1.315 | 160 | 0.250 | 5 |
| | ¾ | 1.050 | 160 | 0.218 | 5 |

* Seismically qualified by the plant design using response spectrum analysis techniques.

**Table 7-2**
**Seismic Experience Database**
**Piping Data**

| Facility | Pipe Size (NPS) | Pipe O.D. (inch) | Schedule | Wall Thickness (inch) | D/t |
|---|---|---|---|---|---|
| | 24 | 24.0 | 20 | 0.375 | 64 |
| | 20 | 20.0 | 20 | 0.375 | 53 |
| | 18 | 18.0 | 30 | 0.437 | 41 |
| | 16 | 16.0 | 30 | 0.375 | 43 |
| | 14 | 14.0 | 30 | 0.375 | 37 |
| | 12 | 12.75 | 40 | 0.406 | 31 |
| | 12 | 12.75 | 30 | 0.330 | 39 |
| | 10 | 10.75 | 160 | 1.125 | 10 |
| | 8 | 8.625 | 160 | 0.906 | 10 |
| | 6 | 6.625 | 40 | 0.280 | 24 |
| Valley Steam Plant | 4 | 4.5 | 160 | 0.531 | 8 |
| Units 1 & 2 | 4 | 4.5 | 40 | 0.237 | 19 |
| | 3 | 3.5 | 160 | 0.437 | 8 |
| | 3 | 3.5 | 80 | 0.300 | 12 |
| | 3 | 3.5 | 40 | 0.216 | 16 |
| | 2 | 2.375 | 160 | 0.343 | 7 |
| | 2 | 2.375 | 40 | 0.154 | 15 |
| | 1½ | 1.9 | 160 | 0.281 | 7 |
| | 1½ | 1.9 | 40 | 0.145 | 13 |
| | 1 | 1.315 | 40 | 0.133 | 10 |
| | ¾ | 1.05 | 160 | 0.218 | 5 |
| | ¾ | 1.05 | 40 | 0.113 | 9 |

**Table 7-2**
**Seismic Experience Database**
**Piping Data**

| Facility | Pipe Size (NPS) | Pipe O.D. (inch) | Schedule | Wall Thickness (inch) | D/t |
|---|---|---|---|---|---|
| | 20 | 20.0 | STD | 0.375 | 53 |
| | 18 | 18.0 | 160 | 1.781 | 10 |
| | 18 | 18.0 | XS | 0.500 | 36 |
| | 18 | 18.0 | STD | 0.375 | 48 |
| | 14 | 14.0 | 40 | 0.437 | 32 |
| | 14 | 14.0 | STD | 0.375 | 37 |
| | 12 | 12.75 | 160 | 1.312 | 10 |
| | 12 | 12.75 | STD | 0.375 | 34 |
| | 10 | 10.75 | 40 | 0.365 | 29 |
| El Centro Steam Plant | 8 | 8.625 | 160 | 0.906 | 10 |
| | 8 | 8.625 | 120 | 0.718 | 12 |
| | 8 | 8.625 | 40 | 0.322 | 27 |
| | 6 | 6.625 | 120 | 0.562 | 12 |
| | 6 | 6.625 | 40 | 0.280 | 24 |
| | 4 | 4.5 | 80 | 0.337 | 13 |
| | 4 | 4.5 | 40 | 0.237 | 19 |
| | 3 | 3.5 | 160 | 0.437 | 8 |
| | 3 | 3.5 | 80 | 0.300 | 12 |
| | 3 | 3.5 | 40 | 0.216 | 16 |
| | 2 | 2.375 | 160 | 0.343 | 7 |
| | 2 | 2.375 | 80 | 0.218 | 11 |
| | 2 | 2.375 | 40 | 0.154 | 15 |
| | 1½ | 1.9 | 160 | 0.281 | 7 |
| | 1½ | 1.9 | 80 | 0.200 | 10 |
| | 1½ | 1.9 | 40 | 0.145 | 13 |
| | 1 | 1.315 | 80 | 0.179 | 7 |
| | 1 | 1.315 | 40 | 0.133 | 10 |
| | ¾ | 1.05 | 80 | 0.154 | 7 |
| | ¾ | 1.05 | 40 | 0.113 | 9 |

**Table 7-2**
**Seismic Experience Database**
**Piping Data**

| Facility | Pipe Size (NPS) | Pipe O.D. (inch) | Schedule | Wall Thickness (inch) | D/t |
|---|---|---|---|---|---|
| Moss Landing Units 1, 2, & 3 | 16 | 16.0 | - | 1.394 | 11 |
| | 12 | 12.75 | - | 1.148 | 11 |
| Moss Landing Units 4 & 5 | 24 | 24.0 | 40 | 0.687 | 35 |
| | 24 | 24.0 | - | 1.066 | 23 |
| | - | 18.3 | - | 2.287 | 8 |
| | 16 | 16.0 | 40 | 0.5 | 32 |
| | 16 | 16.0 | - | 0.902 | 18 |
| | - | 13.2 | - | 1.668 | 8 |
| Moss Landing Units 6 & 7 | 30 | 30.0 | - | 0.632 | 47 |
| | 26 | 26.0 | - | 1.128 | 23 |
| | 18 | 18.0 | - | 3.444 | 5 |
| | 12 | 12.75 | - | 2.444 | 5 |
| | 12 | 12.75 | - | 0.601 | 21 |
| Ormond Beach Units 1 & 2 | 30 | 30.0 | - | 1.298 | 23 |
| | 30 | 30.0 | - | 0.719 | 42 |
| | 21 | 21.0 | - | 3.793 | 6 |
| Humbolt Unit 3 | 12 | 12.75 | 80 | 0.687 | 19 |
| | 10 | 10.75 | 80 | 0.593 | 18 |
| | 6 | 6.625 | 80 | 0.432 | 15 |

**Table 7-3**
**Range of Piping Data**
**Duane Arnold vs. Database Sites**

| Parameter | Duane Arnold | Database Sites |
|---|---|---|
| Diameter (inch) | 1.05 - 20.0 | 1.05 - 30.0 |
| Wall thickness (inch) | 0.218 - 1.031 | 0.113 - 3.793 |
| Diameter-to-Thickness Ratio | 5 - 19 | 5 - 64 |

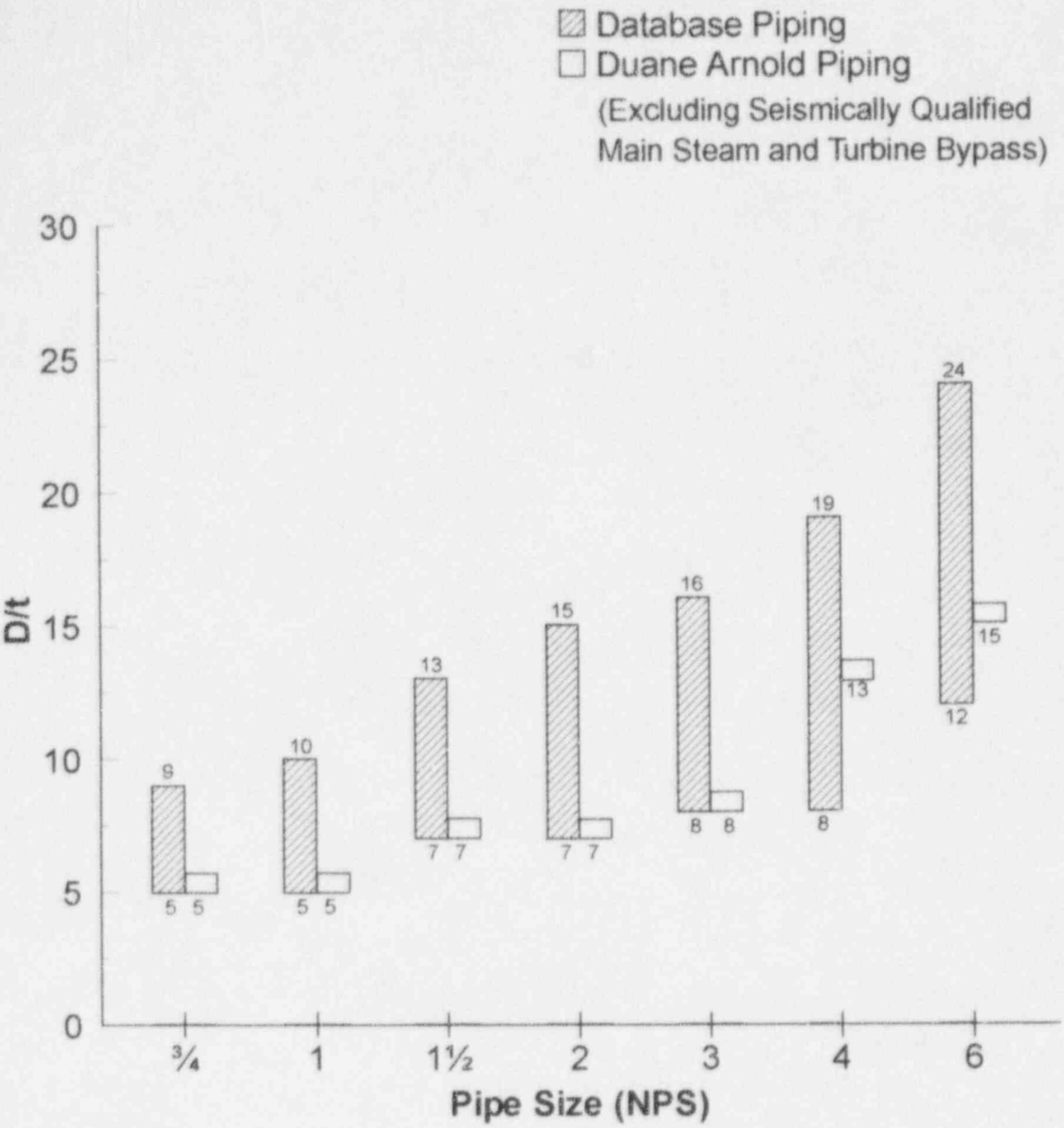



Figure 7-1: D/t Ratios for Duane Arnold Alternate Drain Path Piping and Selected Database Piping

8. **NRC REQUEST**

Explain the basis for concluding that the Duane Arnold piping is bounded by the experience database and that the experience base contains an adequate number of pipe samples.

**IES RESPONSE**

The database currently includes about 60 earthquakes, dating back to the 1933 Long Beach, California earthquake. The response to Item 2 lists selected, more important earthquakes for which detailed data have been collected. Damage and inventory data have been collected for about 30 earthquakes. That includes about 200 industrial sites, and several hundred commercial structures that house piping. These facilities contain many millions of linear feet of pipe, over one million pipe supports and retainers (for lateral loads), many tens of thousands of piping components such as nozzles and elbows and thousands of valves.

These database earthquakes and sites have been studied extensively as part of the GE BWR Owners Group study for increasing MSIV Leakage and other studies documented in EPRI Report NP-5617 (Reference 4). These earthquakes and sites may be considered full scale seismic tests of piping and piping components. These studies have focused on the seismic performance of piping, the identification of commercial design codes and standards, and the identification of design attributes which have resulted in damage to piping, pipe supports or components.

The piping systems in the database are considered to represent the full range of design configurations and supporting details which could be encountered in commercial power piping design practice. The thousands of housed piping systems include a wide variety of support conditions, geometrical configurations, size distributions and all other piping system variables. The conclusion of these studies is that power piping designed to commercial codes and standards has exhibited good seismic performance except when limited and identifiable critical design characteristics are present.

The DAEC piping was found to be representative of the seismic experience database piping based on the following:

1. Review and comparison of design attributes and installation codes with database systems, (e.g., designs to ANSI B31.1 codes, recommended support spans, pipe diameters, catalog support components).

2. Field screening walkdowns performed by qualified seismic engineers with training and knowledge of the database. Walkdowns were performed to physically verify attributes similar to the database (e.g., piping flexibility, support types, and support configurations). Critical design characteristics identified from earthquake experience database piping seismic performance were noted as outliers and evaluated separately.

These design attributes may represent vulnerabilities to the good seismic performance exhibited by database piping systems.

It is concluded that the large inventory of piping and piping components in the database provide a sufficiently large sample of earthquake motions and piping system design configurations to have adequately identified seismic failure modes for power piping systems. The field review of the piping in the MSIV leakage treatment path has insured that the DAEC systems are designed to similar codes and standards as database piping and that they are free from unevaluated design characteristics which have resulted in damage to piping systems in past earthquakes. These reviews provide adequate assurance that the alternate MSIV leakage treatment path piping will exhibit good seismic performance when subject to the plant SSE.

Additional information concerning database representation is also contained in the response to Items 7 and 9.

## 9. NRC REQUEST

Explain the basis of concluding that the Duane Arnold pipe spans are bounded (in terms of physical dimensions and/or dynamic characteristics), by the experience database and address why the number of span samples for each of the layout configurations is adequate.

## IES RESPONSE

Earthquake experience piping data from the El Centro Steam Plant, the Valley Steam Plant, PALCO Co-generation Plant, Cool Water Plant, and various facilities affected by the 1987 Whittier Earthquake are presented for comparison of various piping design parameters and attributes. The El Centro Steam and Valley Steam Plants affected by earlier earthquakes, and the PALCO and Cool Water Plants, affected by the more recent earthquakes, were selected for parametric studies because substantial documentation on the earthquake input and piping configuration is available. The attachment to Attachment 7 of our August 15, 1994 submittal (NG-94-2629), contains summaries of the results of these studies. This information includes a review of piping spans.

Support spans for large and small bore piping systems were compiled from field investigations and/or design documents at the above database facilities. These spans represent the distance between horizontal or vertical supports for piping runs or the distance to the first horizontal and vertical support from nozzles or tees. These spans represent a diversity of pipe runs which have performed successfully during earthquakes.

Spacing between supports and number of samples for the surveyed database piping are presented in Figures 30 through 33 of the attachment to Attachment 7 of our August 15, 1994 submittal (NG-94-2629). These figures are reproduced herein.

A DAEC plant specific seismic verification walkdown of all piping associated with the alternate leakage treatment path was performed by qualified seismic engineers. The seismic engineers were experienced and trained in the seismic experience database for piping. The purpose of the walkdown was to physically verify that the piping and components in the alternate leakage treatment path have attributes similar to those in the database that have good seismic performance and to identify potential seismic vulnerabilities. As a result of the walkdown and subsequent evaluations it was determined that the DAEC piping is bounded by the earthquake experience database.

The walkdown criteria included screening the piping to insure that its installation follows industry standard practice for industrial and power facilities. Piping was screened for span length against the nominal suggested spans recommended in ANSI B31.1, as shown in Table 9-1. The DAEC piping was found to conform with the ANSI B31.1 pipe spans within a reasonable tolerance range. Piping which significantly exceeded the B31.1 spans were identified as outliers and evaluated separately.

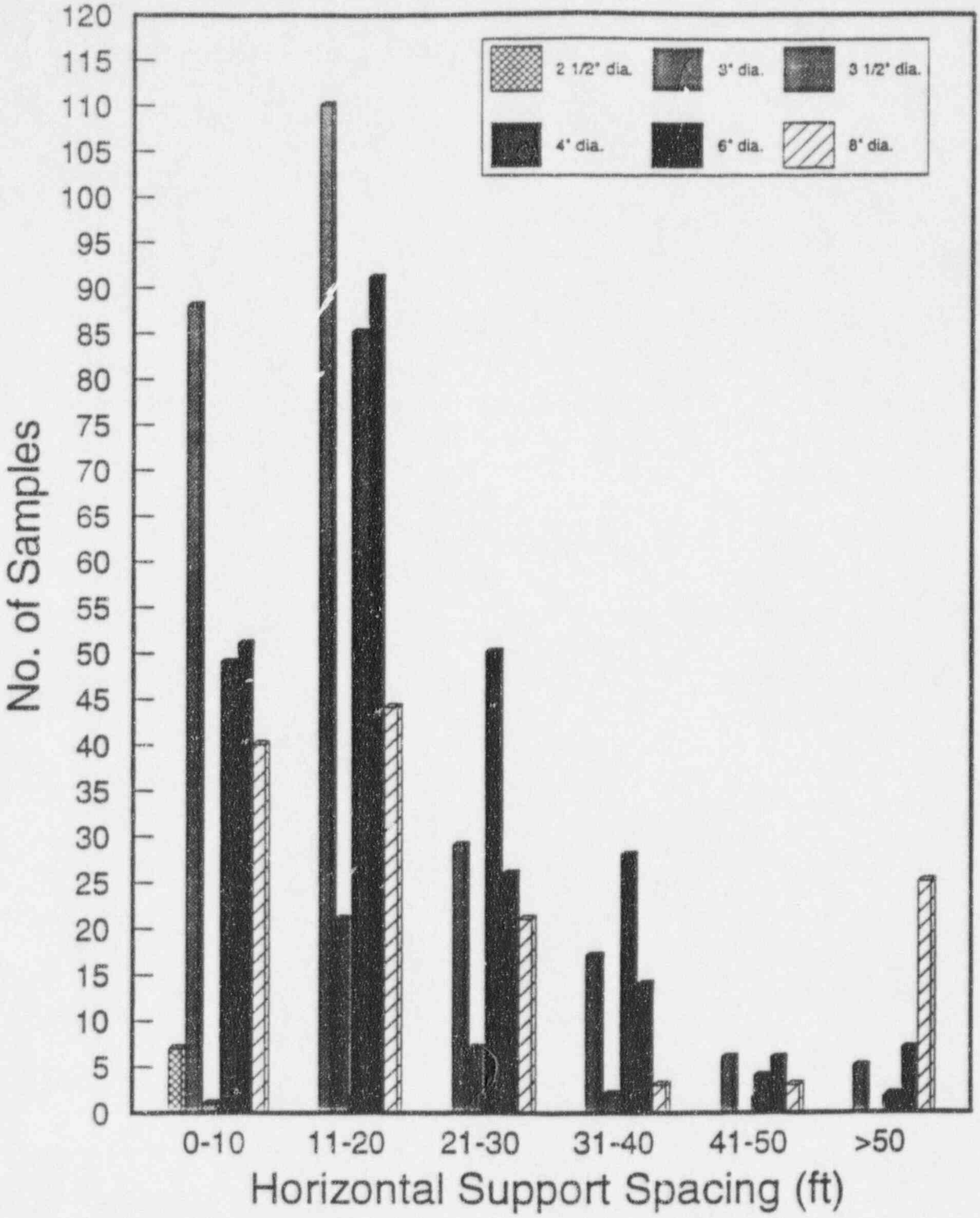
The data presented in Figures 30 through 33 illustrate that the database piping is also supported at spans which are typical of ANSI B31.1 spans. It is concluded from this data that the DAEC piping is bounded by the earthquake experience database.

A discussion of the adequacy of the number of samples in the database is contained in the response to Item 8.

**TABLE 9-1**
**Nominal Suggested Spans per ANSI B31.1**

| Duane Arnold Piping Nominal Pipe Size (in) | Outside Pipe Diameter (in) | Nominal Suggested Maximum Span (ft) | |
|---|---|---|---|
| | | Water Service | Steam, Gas or Air Service |
| ¾ | 1.050 | 6* | 8* |
| 1 | 1.315 | 7 | 9 |
| 1½ | 1.900 | 9* | 11* |
| 2 | 2.375 | 10 | 13 |
| 3 | 3.500 | 12 | 15 |
| 4 | 4.500 | 14 | 17 |
| 6 | 6.625 | 17 | 21 |
| 10 | 10.75 | 21 | 26 |
| 12 | 12.75 | 23 | 30 |
| 20 | 20.00 | 30 | 39 |

* Approximate values -- not included in ANSI B31.1




LARGEHOR.DRW 16000-35 12/20/93

Figure 30: Spacing between horizontal supports and number of samples for data base large bore piping.

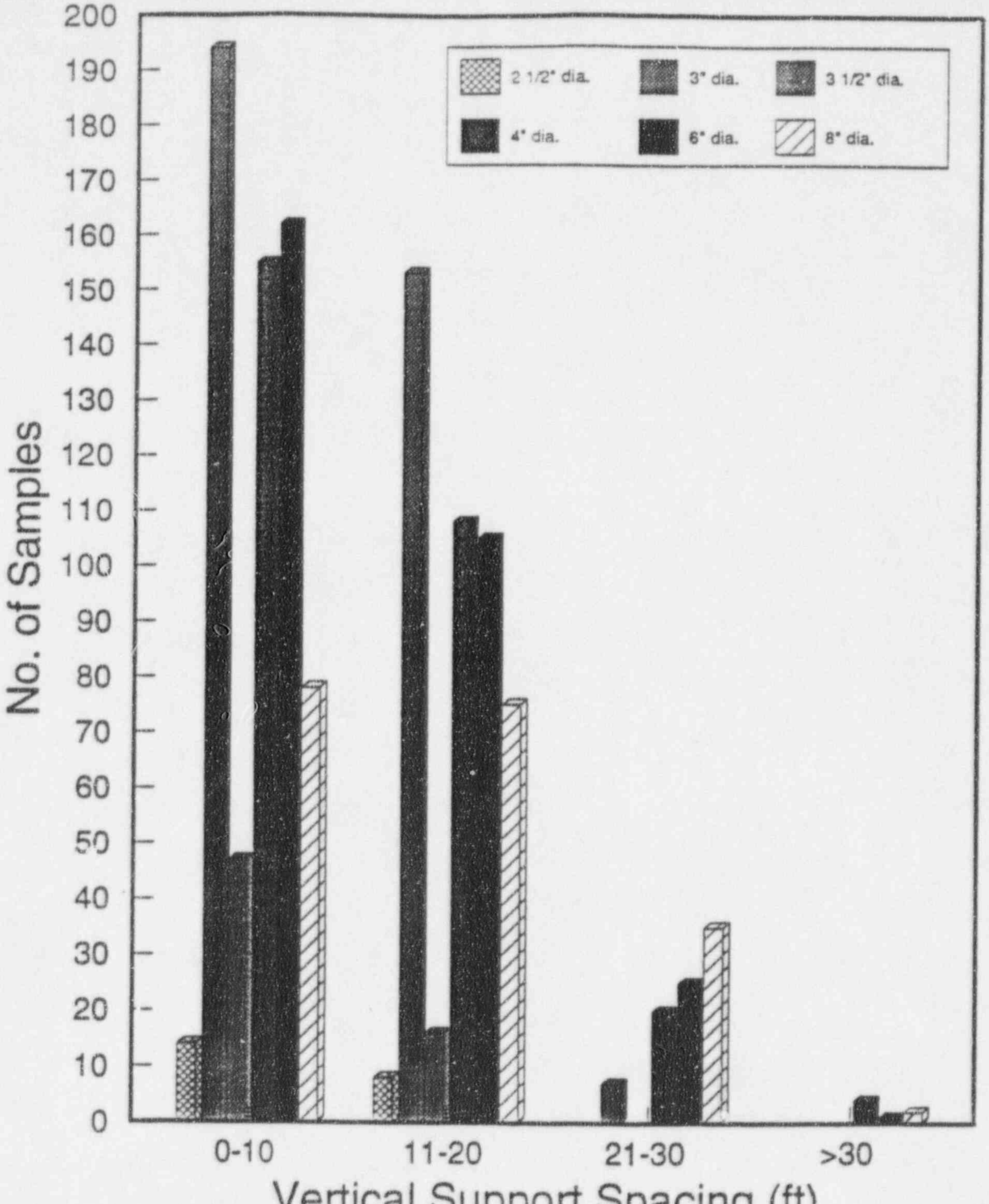
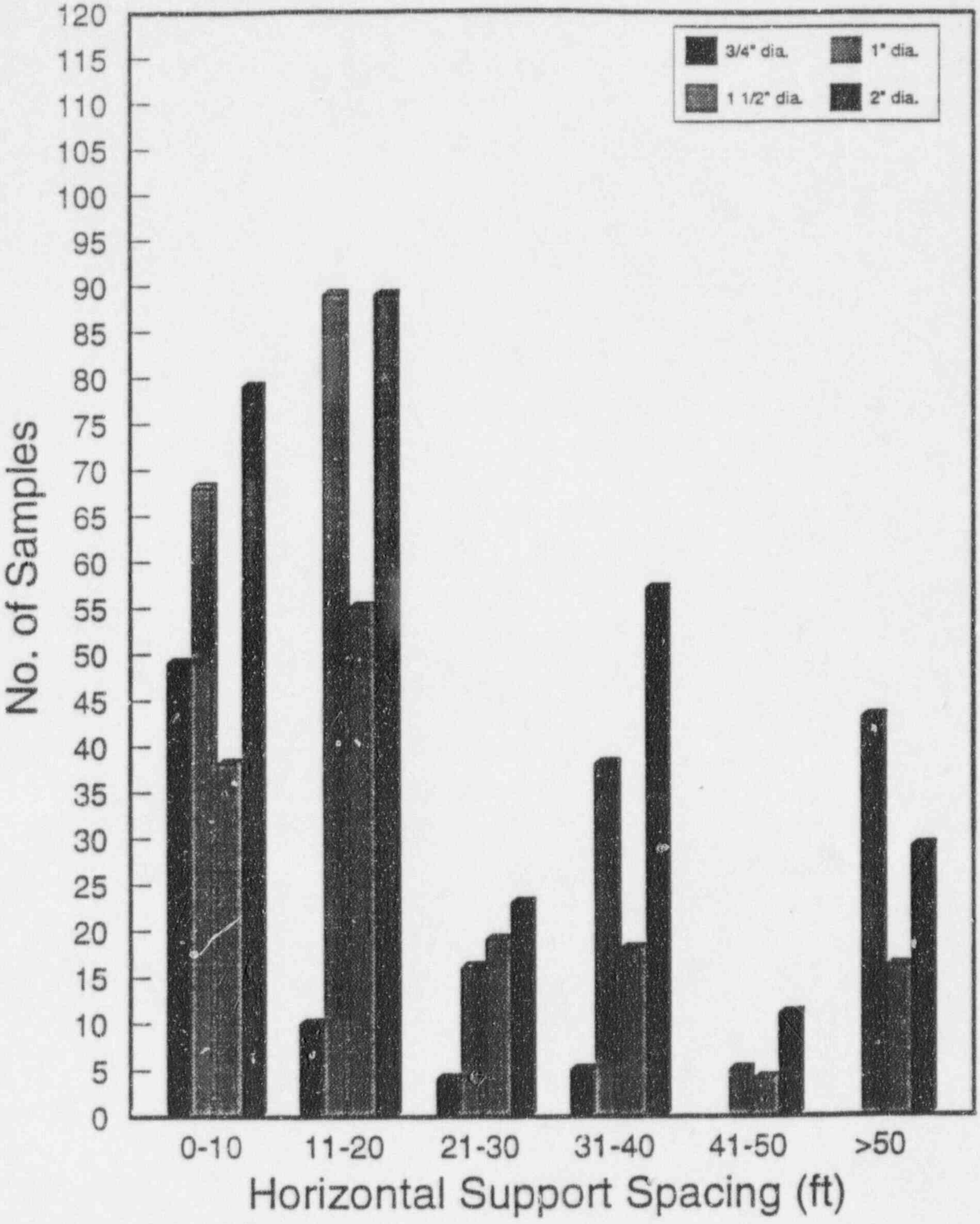



Figure 31: Spacing between vertical supports and number of samples for data base large bore piping.




SMALLHOR.DRW 16000-35 12/20/93

Figure 32: Spacing between horizontal supports and number of samples for data base small bore piping.

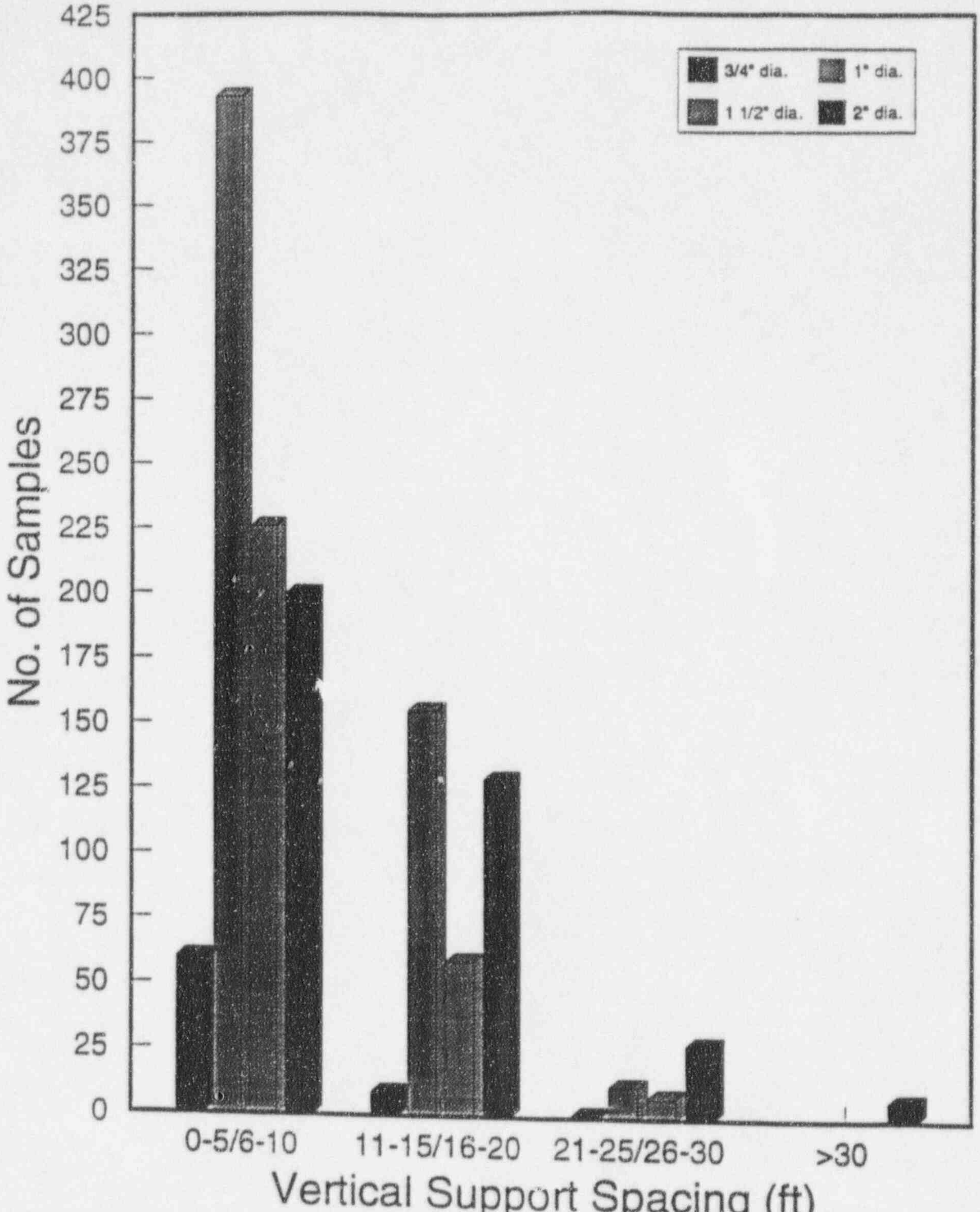



Figure 33: Spacing between vertical supports and number of samples for data base small bore piping.

10. **NRC REQUEST**

Provide a detailed comparison between pipe spans in Duane Arnold and those in the database plants, considering both typical pipe runs as well as those with more unique layout configurations. The comparison should be made for each of the pipe diameters at Duane Arnold.

**IES RESPONSE**

Unique layout configurations which have resulted in piping system damage are associated with provision of adequate piping flexibility required to accommodate seismic induced differential motions. These conditions may be imposed from either building differential movements or from large run to small branch support configurations.

Refer to the response to Item 9. The DAEC piping was walked down and screened for several design attributes including span length against the nominal suggested spans recommended in ANSI B31.1. As noted in the response to Item 9, all piping runs and support spans have been screened and conform to ANSI B31.1 recommendations or they have been subject to further engineering evaluation.

The field review also included screening guidelines for unique layout configurations such as those which could induce differential seismic anchor motions in the piping systems. All such conditions were identified as outliers for further engineering evaluation.

**11. NRC REQUEST**

Justify that the earthquake floor motions which excite the Duane Arnold piping are bounded (in terms of acceleration and frequency content), by those experienced by the corresponding database piping.

**IES RESPONSE**

The DAEC design basis ground response spectrum was compared with the ground motion spectra at several database power plant sites in Figures 3-4, 4-1 and 4-2 from Attachment 7 to our August 15, 1994 submittal (NG-94-2629). These figures are reproduced on pages 11-3 through 11-5.

In addition, a comparison of the DAEC ground response spectrum to the SQUG Generic Bounding Spectrum (from Reference 2) is provided in Figure 11-1 on page 11-6. The SQUG Bounding Spectrum represents database sites reviewed in the USI A-46 Program with piping and valves subject to strong ground motions. The database spectra and the SQUG Generic Bounding Spectrum significantly envelop the DAEC design ground spectrum over the entire frequency range of interest.

Comparison of ground spectra as the basis for representing seismic capacity vs. demand for piping components is consistent with the methods established in the SQUG program for resolution of USI A-46. Based on review of database facilities and records, the Senior Seismic Review and Advisory Panel (SSRAP) concluded the following (Reference 5):

1. Comparison of database free-field spectra with free-field ground spectra for nuclear plants is desirable because floor spectra are generally not available in database plants and realistic floor spectra are often not available in nuclear plants.

2. SSRAP developed a Reference Spectrum from database records which provides a reasonable description of the ground motion level to which the earthquake experience data demonstrate seismic ruggedness.

3. SSRAP also developed the Generic Bounding Spectrum by dividing the Reference Spectrum by 1.5. This factor was to account for the possibility that floor spectra within about 40 feet above grade in a nuclear plant might be amplified over the ground spectra more than occurred in the database plants. The Generic Bounding Spectrum is therefore directly applicable for comparison with ground spectra, and includes a conservative factor to account for differences in building amplification effects which may have occurred.

Amplifed floor response of ground input at other database sites is expected to be similar to those reviewed by the SSRAP in the SQUG Program. Direct comparisons of all the ground response spectra in Figures 3-4, 4-1 and 4-2 are believed to provide adequate consideration for in-structure floor amplification of input ground motion.

All piping in the MSIV leakage treatment path is supported at or below grade (elevation 757'-0"). Therefore, comparison of the DAEC design basis ground spectrum with the Generic Bounding Spectrum provides conservative justification that the floor motions that excite the DAEC piping are bounded by the floor motions experienced by the database piping.

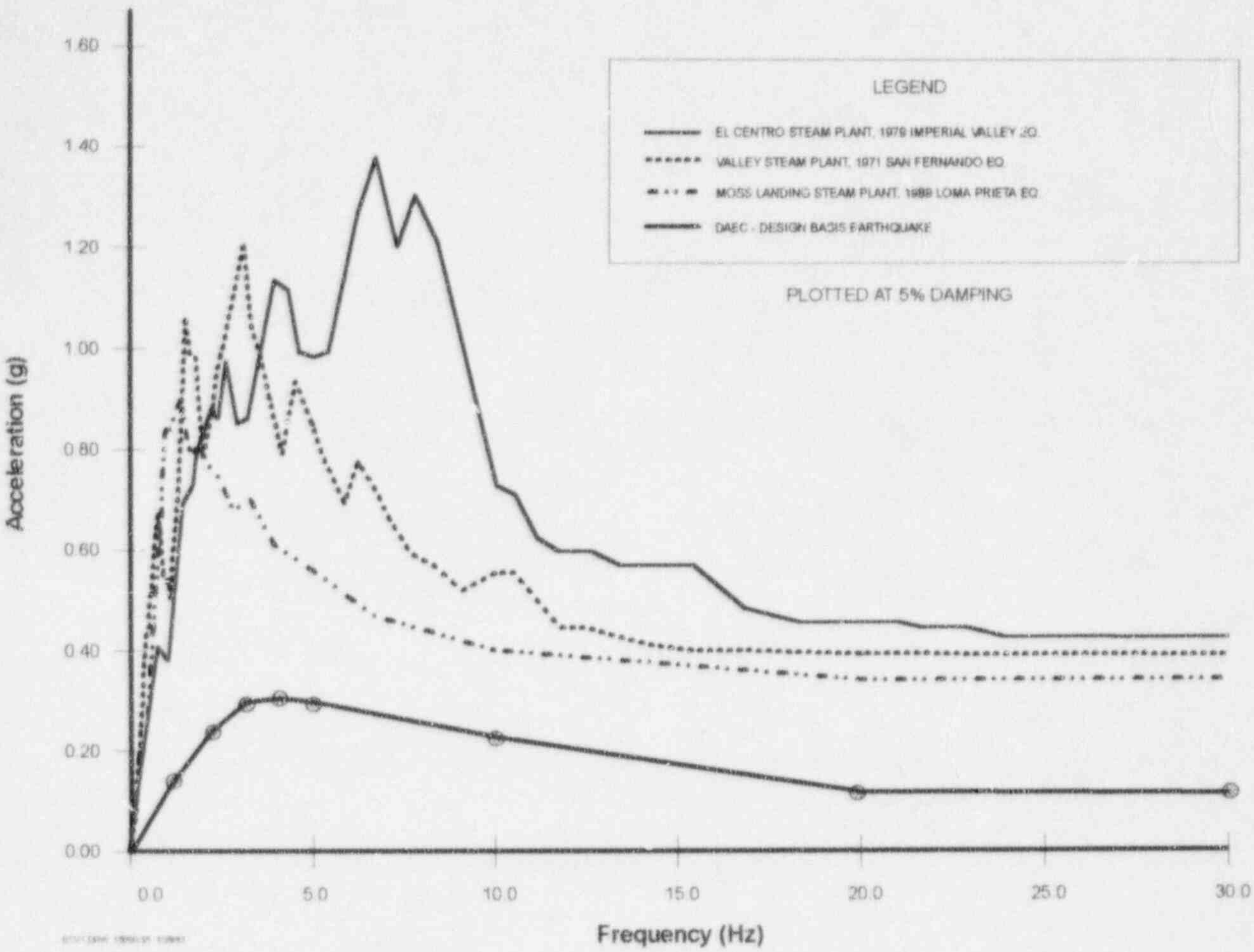



Figure 3-4: Comparison of DAEC Ground Response Spectrum to Data Base Spectra

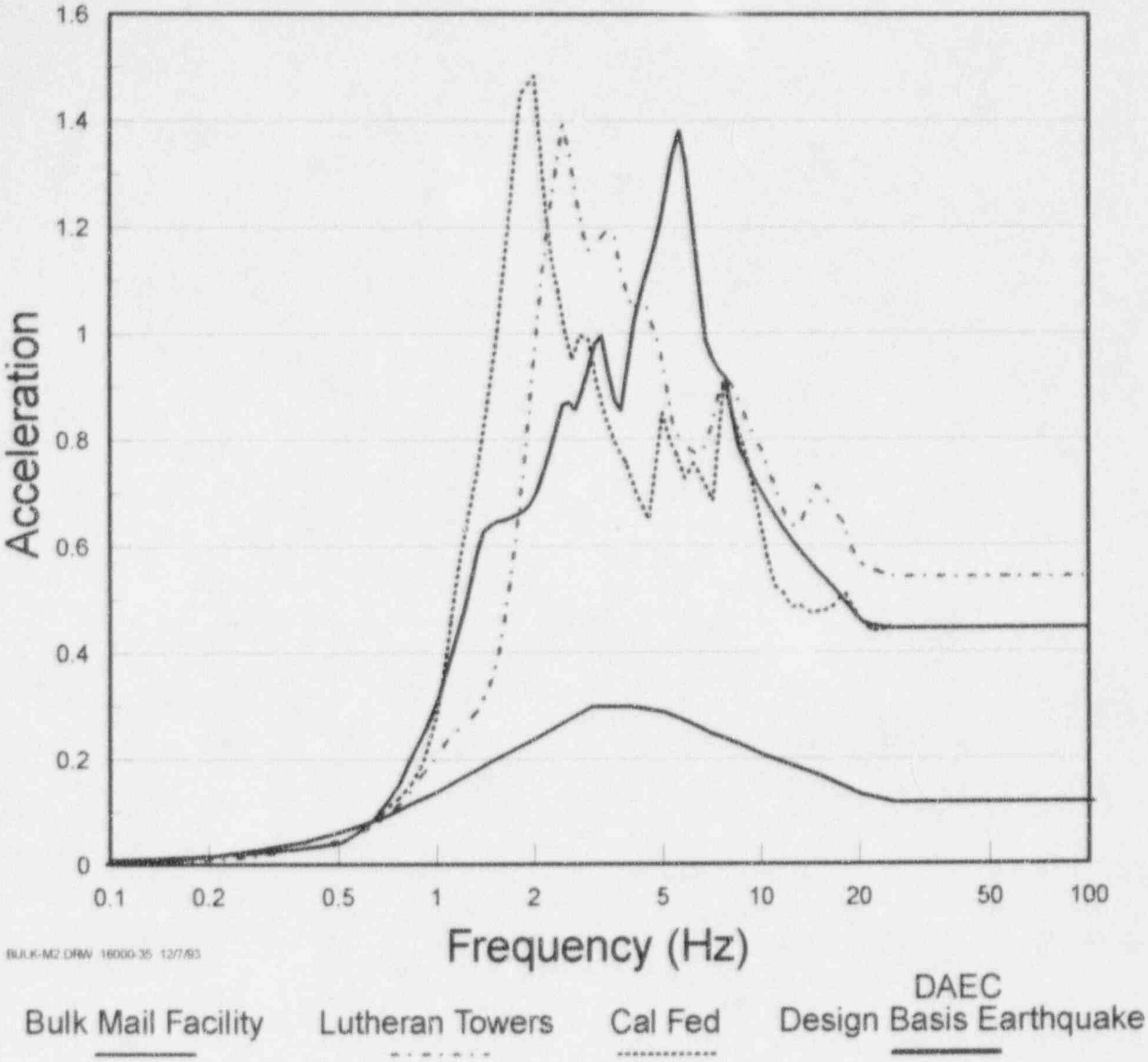



Figure 4-1: Comparison of Whittier database sites and DAEC design spectra (from Attachment 1, Figure 27, and DAEC FSAR Figure 2.5-8, Sheet 4)

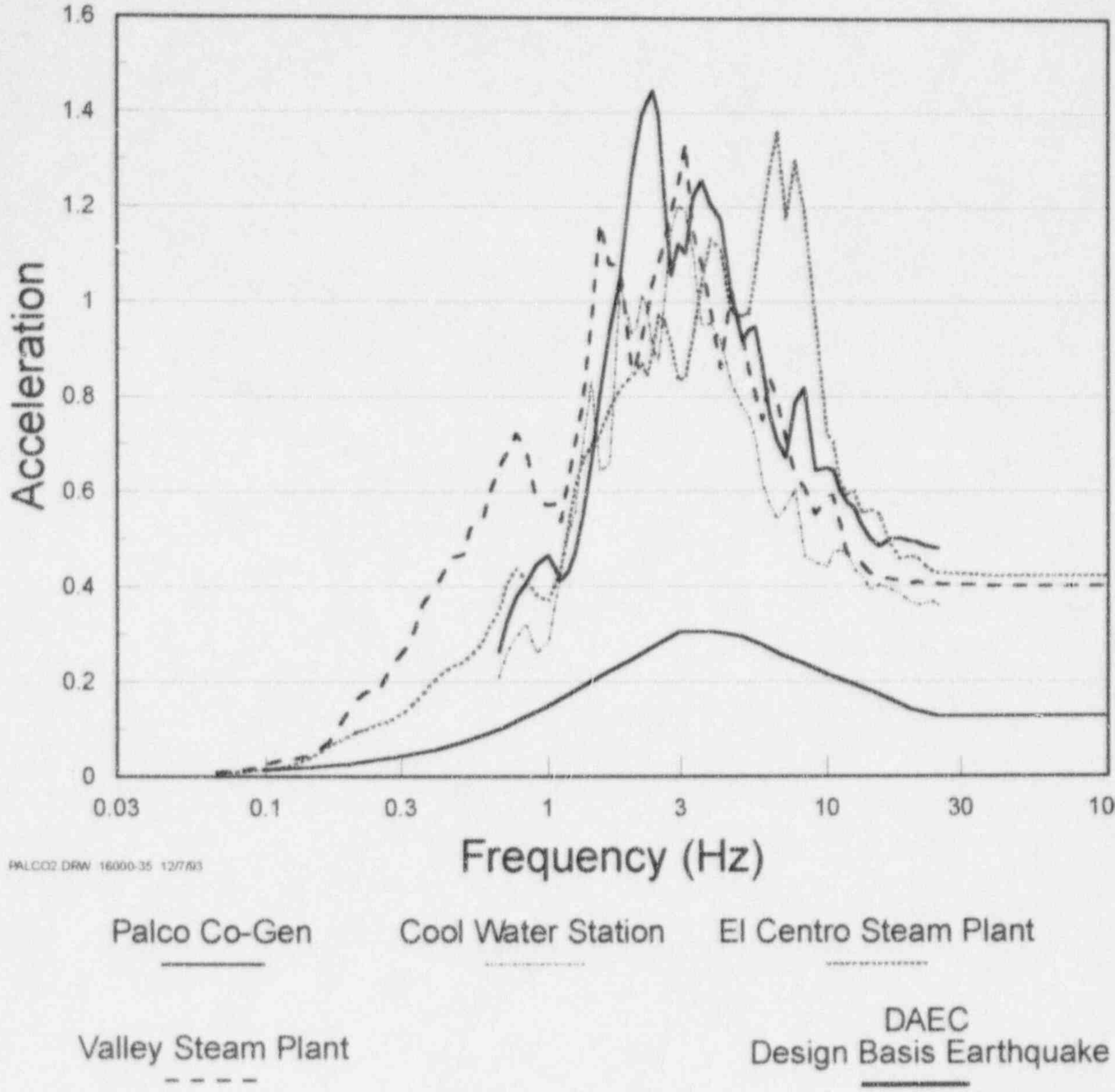



Figure 4-2: Comparison of database power plant sites and DAEC design spectra (from Attachment I, Figure 28, and DAEC FSAR Figure 2.5-8, Sheet 4)

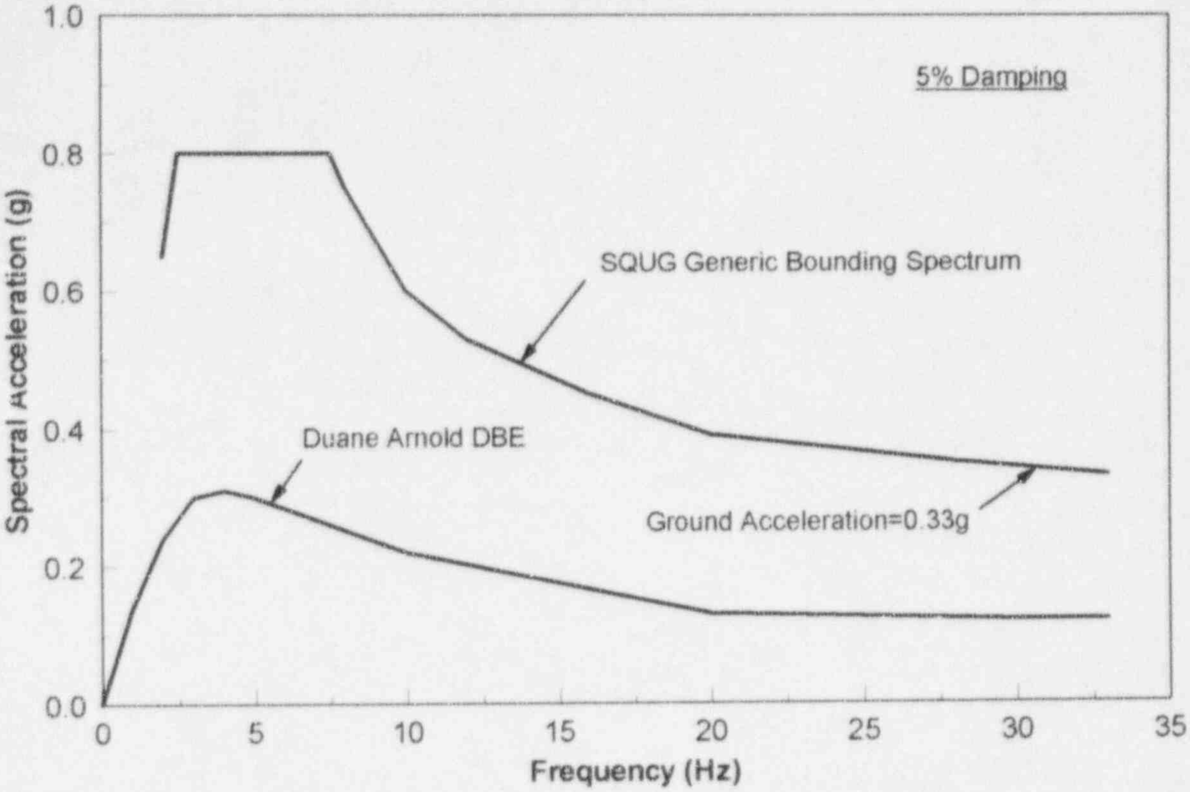



Figure 11-1: Comparison of DAEC Ground Response Spectrum to the SQUG Generic Bounding Spectrum

12. **NRC Request**

Provide examples of evaluations and resolutions performed for the "outliers" which were identified during the plant seismic verification walkdowns. Provide the bases of acceptability for any analytical evaluations that were not performed in accordance with the FSAR methodologies, criteria, and seismic input motions, which have previously been found acceptable by the staff.

**IES Response**

Outliers identified during the seismic verification walkdowns are listed in Table 4-2 of Attachment 7 to our August 15, 1994 submittal (NG-94-2629). This table is reproduced on pages 12-3 through 12-7. The resolution of each outlier is also provided in the table.

Outliers were resolved by various methods. Outlier data sheets and calculations to resolve outliers are available at DAEC for review by the staff. Following is a summary of the general methods used.

a. Valve Outliers. Valve outliers consisted of motor operators with height or weight which exceeded the screening criteria. These outliers were resolved in accordance with the method given in Chapter 20 of Reference 5. In this method the operator height or weight can be increased by the ratio of the peak acceleration of the SQUG bounding spectrum to the peak acceleration of the DAEC design basis spectrum. For DAEC this ratio is 2.58. On this basis, all motor operator heights and weights were found to be acceptable.

b. Piping Outliers. Piping outliers consisted of pipe spans between supports which exceeded ANSI B31.1 recommendations, or piping configurations with questionable flexibility based on the judgment of the walkdown teams. These outliers were resolved by static or, in some cases, dynamic (i.e., response spectrum) analyses which showed that the pipe stresses were acceptable. Seismic input for these analyses was based on the new in-structure response spectra generated for the turbine building. (Additional information on the new seismic response analysis for the turbine building is contained in the response to Item 1.) Acceptance criteria for piping were in accordance with the recommendations in EPRI NP-6041-SL (Reference 1). Additional pipe supports will be added where the calculated pipe stresses exceeded allowables. Where modifications are to be made (e.g., installation of a new pipe support), the modifications were designed and analyzed in accordance with FSAR methodologies and criteria.

c. Masonry Walls. Masonry wall outliers consisted of masonry (block) walls whose failure could cause damage to piping or equipment associated with the MSIV leakage treatment path. These outliers were resolved by static analysis. Seismic input was based on the peak spectral accelerations from the new in-structure response spectra generated for the turbine building. All masonry walls were found to be acceptable.

d. Other Outliers. Other outliers consisted of loose, missing, or broken parts, usually in connection with pipe supports. These outliers will be resolved by restoring the component to its original condition.

## Table 4-2: Outlier Identification and Resolution (Page 1 of 5)

| SYSTEM DESCRIPTION | OUTLIER NUMBER AND DESCRIPTION | OUTLIER TYPE (POTENTIAL FAILURE MODE) | | | | | RESOLUTION STATUS | REQUIRED ACTION |
|---|---|---|---|---|---|---|---|---|
| | | A | F | P | D | V | | |
| MAIN STEAM DRAINS (IN STEAM TUNNEL) | #1: PIPING SPAN EXCEEDS SCREENING CRITERIA | | X | | | | ACCEPTABLE AS-IS BY ANALYSIS | N/A |
| | #23: VALVE MOTOR OPERATOR HEIGHT AND WEIGHT EXCEED SCREENING CRITERIA | | | | | X | ACCEPTABLE AS-IS BY ANALYSIS | N/A |
| STEAM LINE DRAINS (IN TURBINE BLDG) | #5:PIPING SPAN EXCEEDS SCREENING CRITERIA | | X | | | | ACCEPTABLE AS-IS BY ANALYSIS | N/A |
| | #6: DISENGAGED PIPE SUPPORT EDB 3-H-44 | X | | | | | NOT ACCEPTABLE AS-IS | MODIFY AND REINSTALL SUPPORT |
| | #18: VALVE MOTOR OPERATOR HEIGHT EXCEEDS SCREENING CRITERIA | | | | | X | ACCEPTABLE AS-IS BY ANALYSIS | N/A |
| MAIN STEAM LINE BRANCHES | #7: QUESTIONABLE SUPPORT FUNCTION MAY NOT ACCOMMODATE DIFFERENTIAL BUILDING MOVEMENT | | | | X | | NOT ACCEPTABLE AS-IS | FIELD VERIFICATION AND MODIFICATION OF AS-INSTALLED SUPPORT CLEARANCES (IF FOUND INSUFFICIENT) |
| MAIN STEAM LINE BRANCHES | #8: MASONRY WALL IS A POTIENTIAL INTERACTION HAZARD TO ADJACENT PIPING | | X | | | | ACCEPTABLE AS-IS BY ANALYSIS | N/A |

**KEY TO OUTLIER TYPES**

A ANCHORAGE OR SUPPORT CAPACITY
F FAILURE AND FALLING
P PROXIMITY AND INPACT
D DIFFERENTIAL AND DISPLACEMENT
V VALVE OPERATOR SCREENING

Table 4-2: Outlier Identification and Resolution (Page 2 of 5)

| SYSTEM DESCRIPTION | OUTLIER NUMBER AND DESCRIPTION | OUTLIER TYPE (POTENTIAL FAILURE MODE) | | | | | RESOLUTION STATUS | REQUIRED ACTION |
|---|---|---|---|---|---|---|---|---|
| | | A | F | P | D | V | | |
| MAIN STEAM TO STEAM JET AIR EJECTOR (SJAE) | #9: PIPING BRANCH LINE MAY NOT HAVE ADEQUATE FLEXABILITY TO ACCOMMODATE SEISMIC MOVEMENT | | | | X | | ACCEPTABLE AS-IS BY ANALYSIS | N/A |
| | #11: MASONRY WALL IS A POTENTIAL INTERACTION HAZARD TO ADJACENT PIPING | | X | | | | ACCEPTABLE AS-IS BY ANALYSIS | N/A |
| MAIN STEAM SAMPLE LINE | #4: MASONRY WALL IS A POTENTIAL INTERACTION HAZARD TO BRANCH LINES | | X | | | | ACCEPTABLE AS-IS BY ANALYSIS | N/A |
| | #22: POTENTIAL EXCESSIVE CABINET DEFLECTIONS DUE TO BASE DETAIL COULD AFFECT ATTACHED LINES | | | | X | | ACCEPTABLE AS-IS BY ANALYSIS | |
| | #24: TUBING SPAN EXCEEDS SCREENING CRITERIA | | X | | | | ACCEPTABLE AS-IS BY ANALYSIS | N/A |

**KEY TO OUTLIER TYPES**

A ANCHORAGE OR SUPPORT CAPACITY
F FAILURE AND FALLING
P PROXIMITY AND INPACT
D DIFFERENTIAL AND DISPLACEMENT
V VALVE OPERATOR SCREENING

Table 4-2: Outlier Identification and Resolution (Page 3 of 5)

| SYSTEM DESCRIPTION | OUTLIER NUMBER AND DESCRIPTION | OUTLIER TYPE (POTENTIAL FAILURE MODE) | | | | | RESOLUTION STATUS | REQUIRED ACTION |
|---|---|---|---|---|---|---|---|---|
| | | A | F | P | D | V | | |
| MAIN STEAM TO 2ND STAGE REHEATER | #2: PIPING SPAN EXCEEDS SCREENING CRITERIA, PIPE IS SAGGING | | X | | | | NOT ACCEPTABLE AS-IS | ADD SUPPORTS |
| | #3: LOOSE ANCHOR BOLTS ON PIPE SUPPORT | X | | | | | NOT ACCEPTABLE AS-IS | REPAIR BY TIGHTENING ANCHOR BOLTS OR RE-LOCATING SUPPORT AND REPLACING BOLTS |
| MAIN STEAM BYPASS TO TURBINE STEAM SEAL | #12: PIPING SPAN EXCEEDS SCREENING CRITERIA AND SPRING SUPPORT OVERLOADED | | X | | | | SPRING SUPPORT NOT ACCEPTABLE AS-IS. PIPING SPAN ACCEPTABLE AS-IS BY ANALYSIS | RESET SPRING SUPPORT |
| | #13: BROKEN PIPE SUPPORT (U-BOLT) | X | | | | | NOT ACCEPTABLE AS-IS | REMOVE DAMAGED PIPE SUPPORT |
| | #14: VICTAULIC COUPLINGS ON FIRE PROTECTION PIPING SUSPENDED FROM RODS ATTACHED WITH FRICTION CLAMPS | | X | | | | NOT ACCEPTABLE AS-IS | MODIFY PIPING BY ADDING NEW SUPPORTS |

KEY TO OUTLIER TYPES
A ANCHORAGE OR SUPPORT CAPACITY
F FAILURE AND FALLING
P PROXIMITY AND INPACT
D DIFFERENTIAL AND DISPLACEMENT
V VALVE OPERATOR SCREENING

Table 4-2: Outlier Identification and Resolution (Page 4 of 5)

| SYSTEM DESCRIPTION | OUTLIER NUMBER AND DESCRIPTION | OUTLIER TYPE (POTENTIAL FAILURE MODE) | | | | | RESOLUTION STATUS | REQUIRED ACTION |
|---|---|---|---|---|---|---|---|---|
| | | A | F | P | D | V | | |
| SJAE CONDENSERS TO MAIN CONDENSER | #15: MASONRY WALLS ADJACENT TO AIR EJECTOR CONDENSATE TANK ARE POTENTIAL INTERACTION HAZARDS | | X | | | | ACCEPTABLE AS-IS BY ANALYSIS | N/A |
| | REVIEW ANCHORAGE OF SJAE CONDENSATE RETURN TANK (IT-136) | X | | | | | ACCEPTABLE AS-IS BY ANALYSIS | N/A |
| CONDENSER TO SJAES | #17: MASONRY WALLS ADJACENT TO PIPING AND VALVE ARE POTENTIAL INTERACTION HAZARDS | | X | | | | ACCEPTABLE AS-IS BY ANALYSIS | N/A |
| | #20: VALVE AIR OPERATOR HEIGHT EXCEEDS SCREENING CRITERIA | | | | | X | ACCEPTABLE AS-IS BY ANALYSIS | N/A |
| | #21: VALVE AIR OPERATOR HEIGHT AND WEIGHT UNKNOWN | | | | | X | ACCEPTABLE AS-IS BY ANALYSIS | N/A |
| MAIN STEAM TO STEAM SEAL | #19: VALVE MOTOR OPERATOR HEIGHT EXCEEDS SCREENING CRITERIA AND WEIGHT IS UNKNOWN | | | | | X | ACCEPTABLE AS-IS BY ANALYSIS | N/A |

KEY TO OUTLIER TYPES
A ANCHORAGE OR SUPPORT CAPACITY
F FAILURE AND FALLING
P PROXIMITY AND INPACT
D DIFFERENTIAL AND DISPLACEMENT
V VALVE OPERATOR SCREENING

| SYSTEM DESCRIPTION | OUTLIER NUMBER AND DESCRIPTION | OUTLIER TYPE (POTENTIAL FAILURE MODE) | | | | | RESOLUTION STATUS | REQUIRED ACTION |
|---|---|---|---|---|---|---|---|---|
| | | A | F | P | D | V | | |
| MAIN STEAM INSTRUMENTATION LINES | #27: TUBING SPAN EXCEEDS SCREENING CRITERIA | | X | | | | ACCEPTABLE AS-IS BY ANALYSIS | N/A |
| | #28: MISSING U-BOLT FOR PIPE SUPPORT ON ADJACENT AIR LINE | | | X | | | NOT ACCEPTABLE AS-IS | INSTALL U-BOLT |
| MAIN STEAM INSTRUMENTATION LINES | #25: MASONRY WALL IS A POTENTIAL INTERACTION HAZARD TO ADJACENT TUBING AND INSTRUMENT RACKS IC-210A AND IC-210B | | X | | | | ACCEPTABLE AS-IS BY ANALYSIS | N/A |
| | #26: MASONRY WALL IS A POTENTIAL INTERACTION HAZARD TO INSTRUMENT RACKS FOR PS1014, 1015, 1016, 1017 | | X | | | | ACCEPTABLE AS-IS BY ANALYSIS | N/A |
| | REVIEW ANCHORAGE FOR INSTRUMENT RACKS IC-210A,IC-210B,IC-212A | X | | | | | ACCEPTABLE AS-IS BY ANALYSIS | N/A |
| CONDENSER | REVIEW FOR ANCHORAGE AND EXPERIENCE BOUNDING | X | | | | | ANCHORAGE IS ADEQUATE AND CONDENSER IS WELL REPRESENTED IN THE DATABASE | N/A |

**KEY TO OUTLIER TYPES**

A ANCHORAGE OR SUPPORT CAPACITY
F FAILURE AND FALLING
P PROXIMITY AND INPACT
D DIFFERENTIAL AND DISPLACEMENT
V VALVE OPERATOR SCREENING

13. **NRC Request**

Provide calculations that demonstrate the seismic adequacy of the condenser, by using an acceptable analytical methodology, considering the integrity of pertinent structural members, the seismic demand, and the seismic capability of the condenser support members.

**IES Response**

Deterministic seismic calculations were performed only for the condenser anchorage. Results of these calculations are provided in the response to Item 15. The detailed calculations are available at DAEC for review by the staff.

The seismic adequacy of the condenser shell and pertinent internal structural members was based on the earthquake experience database, as documented in the GE topical report (Reference 3). As discussed in our August 15, 1994 submittal (NG-94-2629), the DAEC condensers (one high pressure and one low pressure condenser) are bounded in size, weight, and condensing area by several large surface condensers in the earthquake experience database, in particular Moss Landing and Ormond Beach. (See Figures 3-1, 3-2, and 3-3 of Attachment 7 to the August 15, 1994 submittal, reproduced on pages 13-2 through 13-4.) In addition, the DAEC design basis ground response spectrum is enveloped by the ground motions for the database sites as shown in Figure 3-4 of that submittal, reproduced on page 13-5.

It is the judgment of IES that earthquake experience data and the methodologies provided in the GE topical report provide an acceptable and preferable method for verifying the seismic adequacy of the DAEC condensers which were not originally designed for seismic loads. Accordingly, deterministic calculations were not performed for the condenser shell and pertinent internal support members.

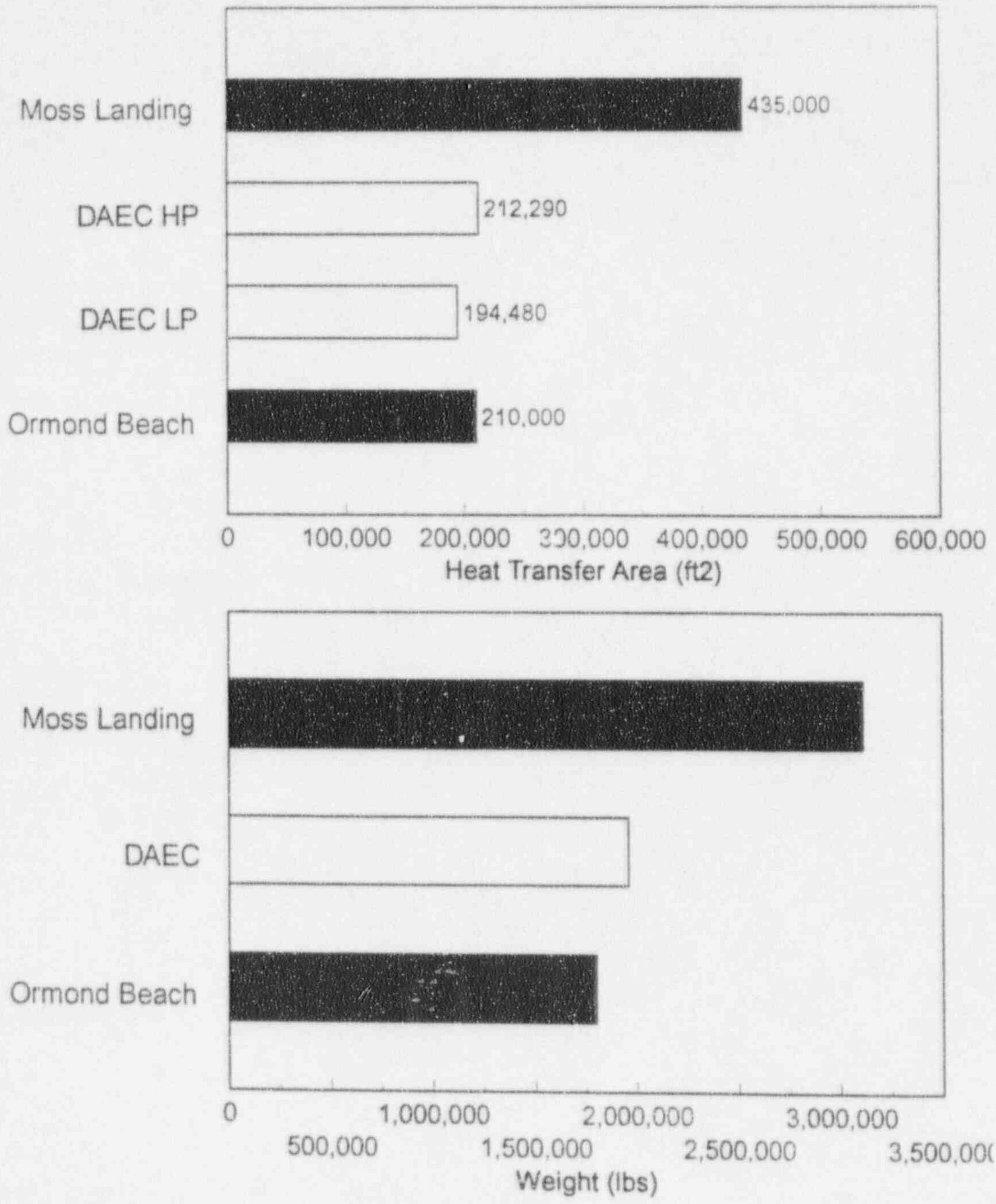



Figure 3-1: Size Comparison of the DAEC Condenser with Representative Condensers from the Earthquake Experience Database

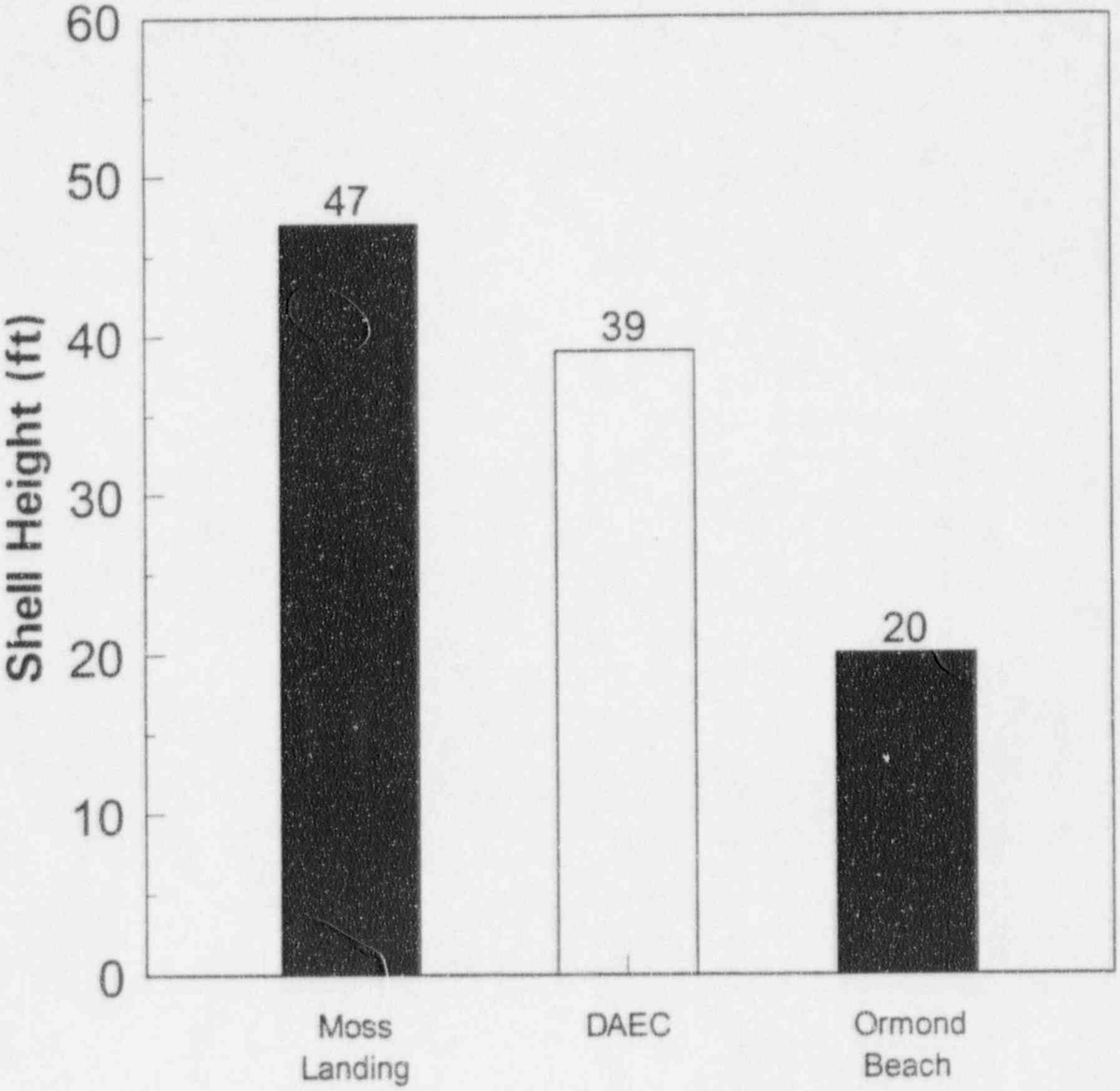
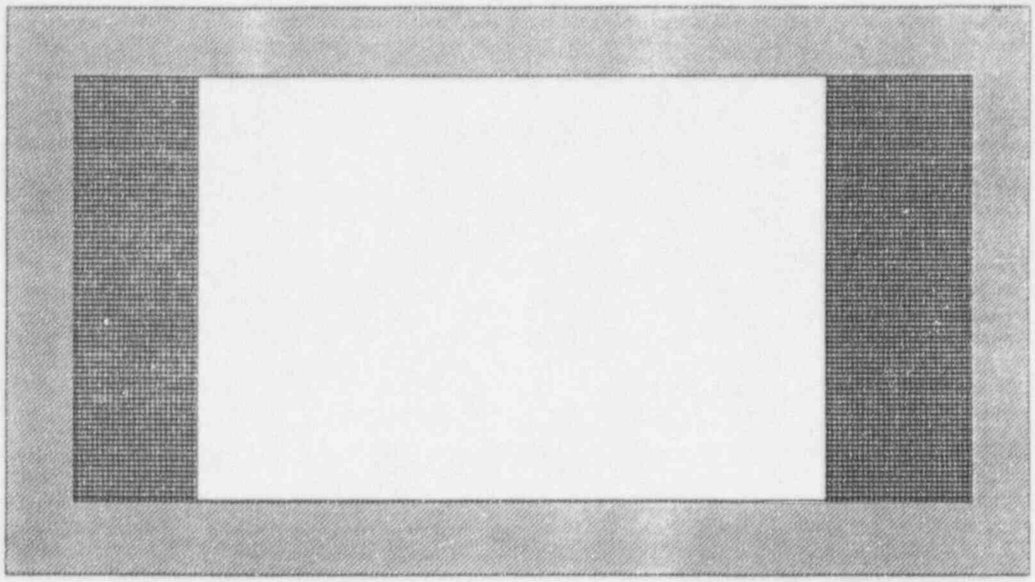



Figure 3-2: Size Comparison of the DAEC Condenser with Representative Condensers from the Earthquake Experience Database



| | | |
|---|---|---|
| (shaded, light) | Moss Landing 6 & 7 | ( 65' x 36' ) |
| (shaded, dark) | Ormond Beach 1 & 2 | ( 52' x 27' ) |
| (unshaded) | DAEC LP & HP | ( Approx. 39' x 29' ) |

Figure 3-3 Condenser Shell Footprint Comparison

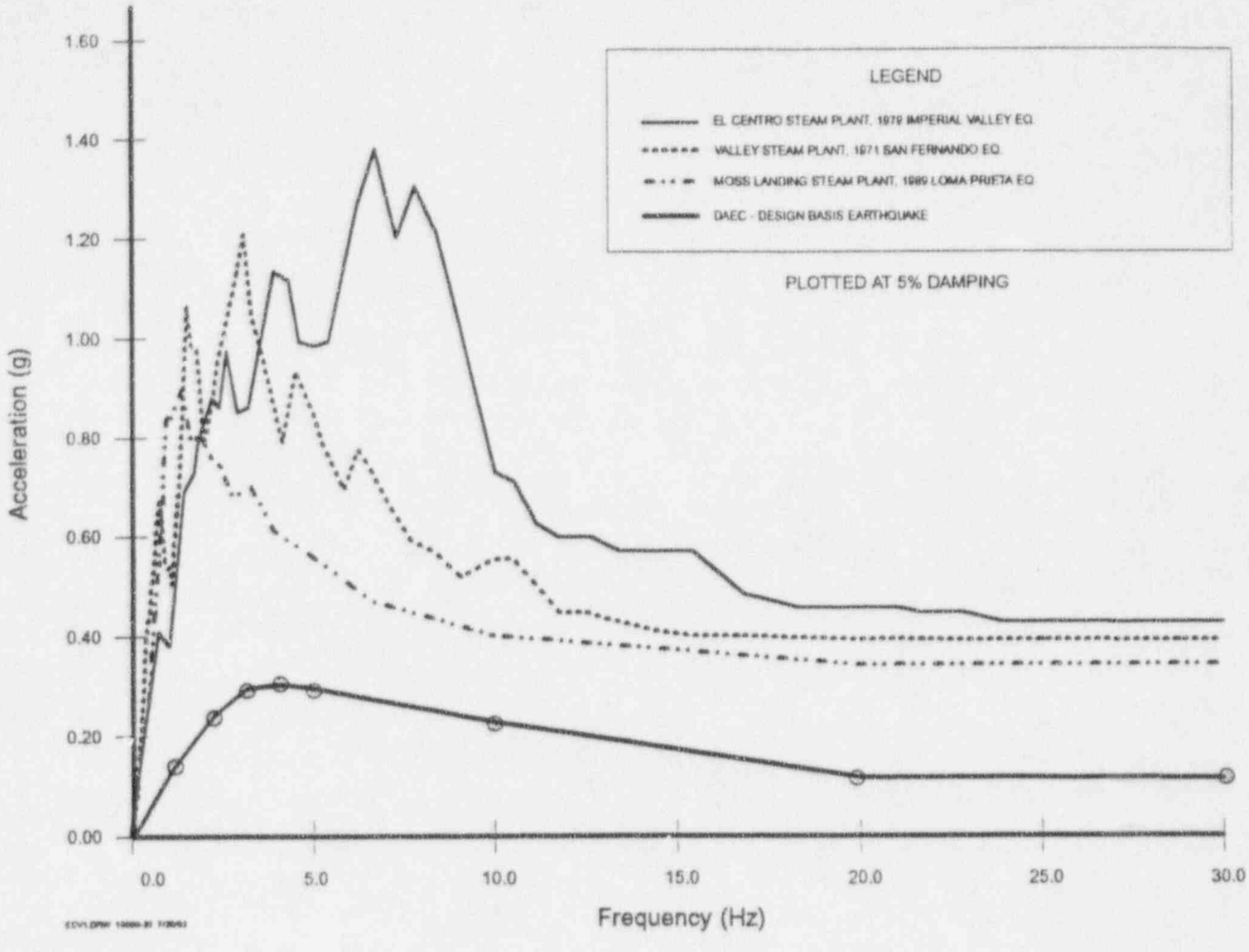



Figure 3-4: Comparison of DAEC Ground Response Spectrum to Data Base Spectra

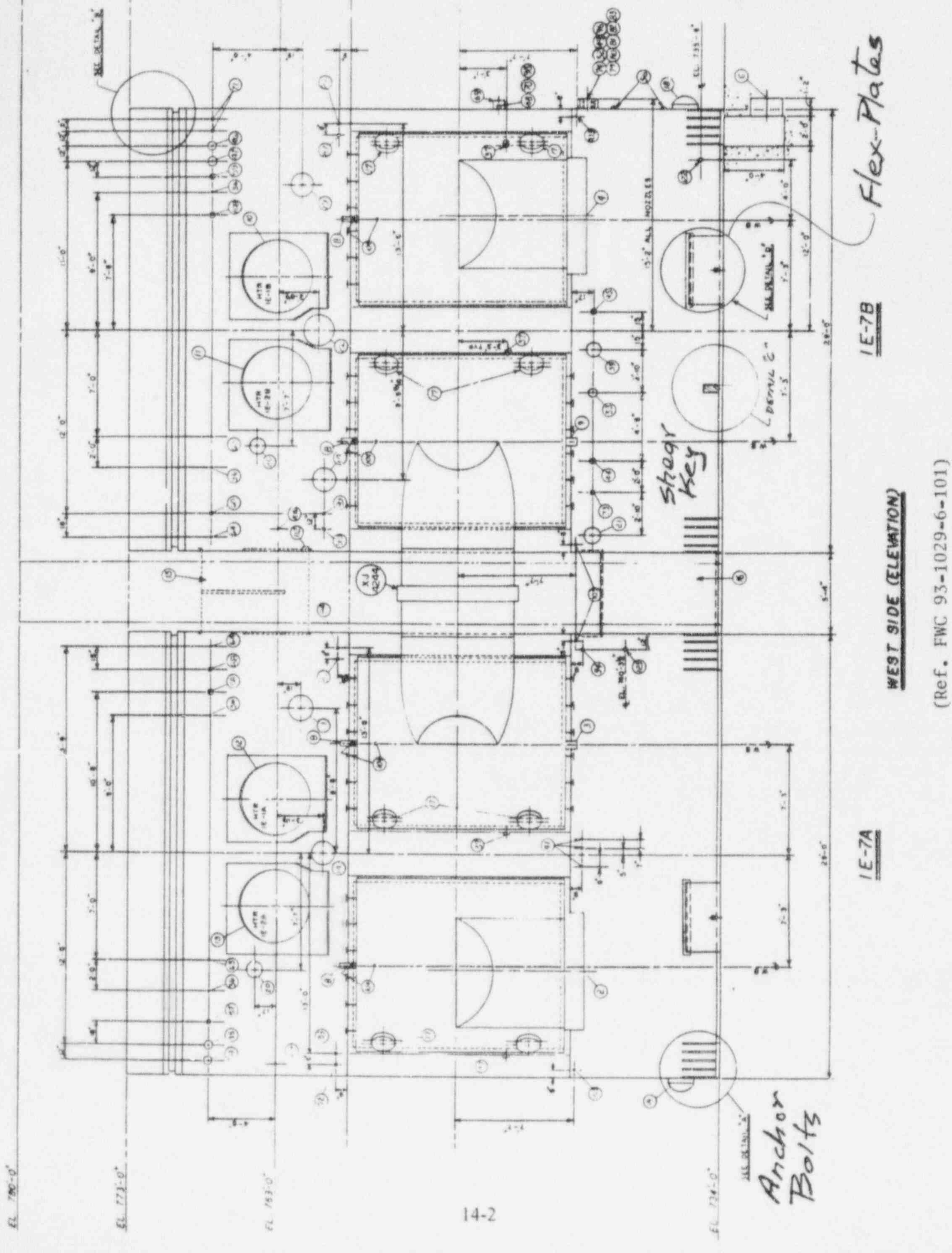
14. **NRC Request**

Provide detailed drawings of the shear key and anchor bolts, as well as their anchoring mechanism into concrete of the condenser anchorage system.

**IES Response**

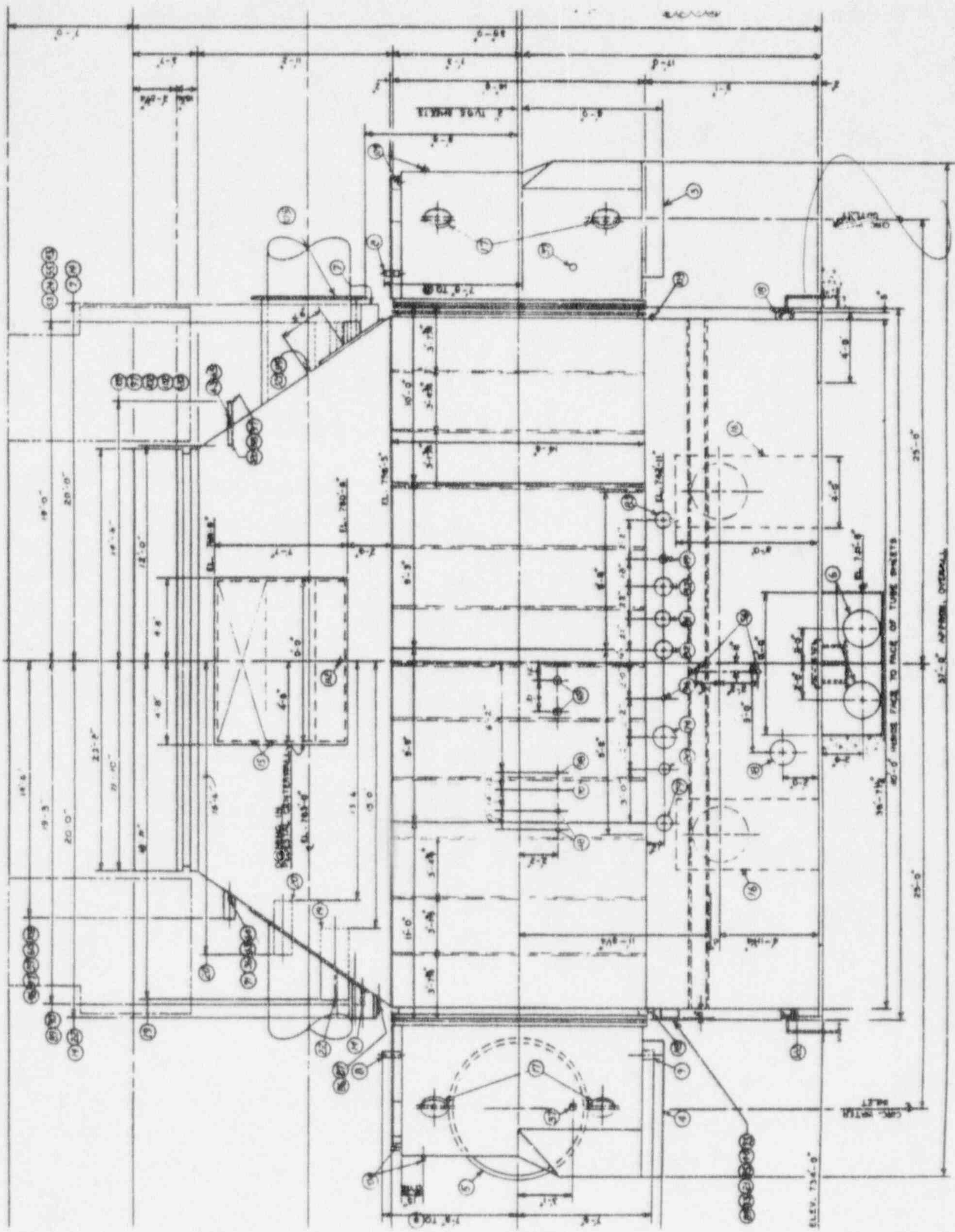
Anchorage details for the main condenser are shown on the following drawings. These details are provided on pages 14-2 through 14-6.

| Anchorage Detail | Foster Wheeler Dwg. 93-1029-6-101 | Bechtel Dwg. 7884-C-204 |
|---|---|---|
| Anchor bolts | Detail A | Detail 3 |
| Shear key | Detail C | Detail 4 |
| Flex plates | Detail D | Detail 5 |



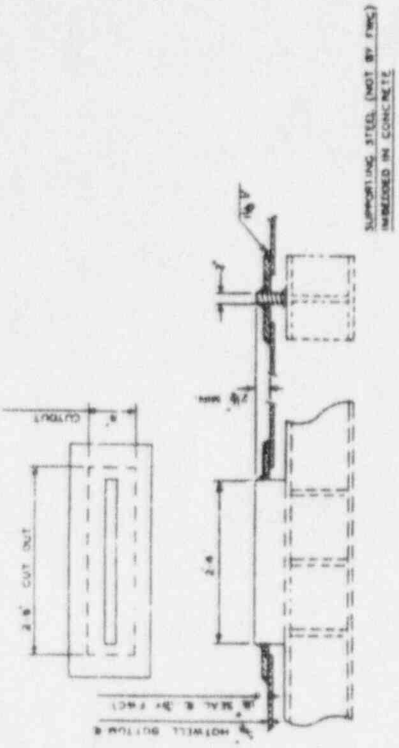

WEST SIDE (ELEVATION)

(Ref. FWC 93-1029-6-101)

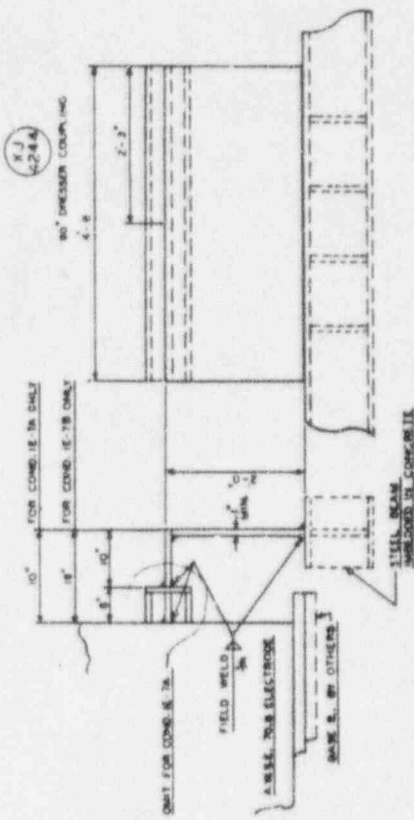



1E-7B
SOUTH END (ELEVATION)

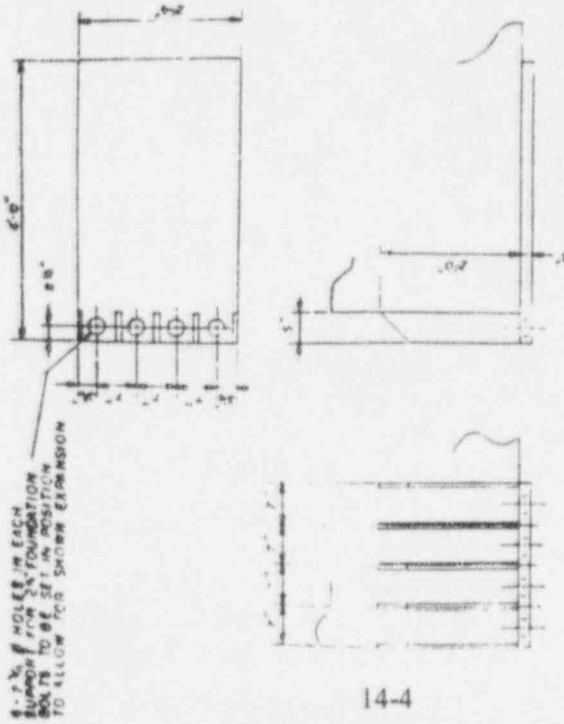
(Ref. FWC 93-1029-6-101)




DETAIL 'C'
ANCHOR

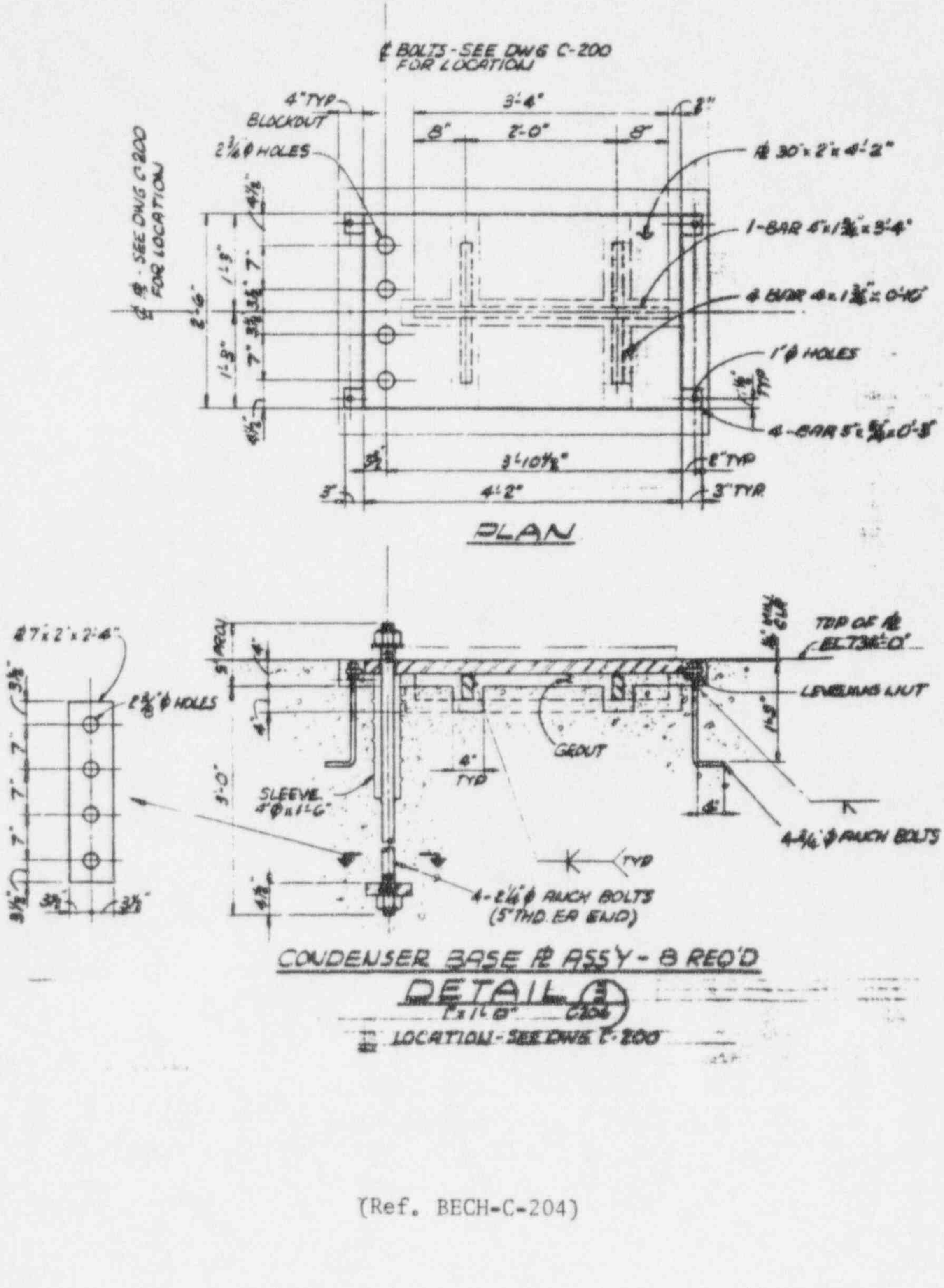



DETAIL 'D'
FLEX PL

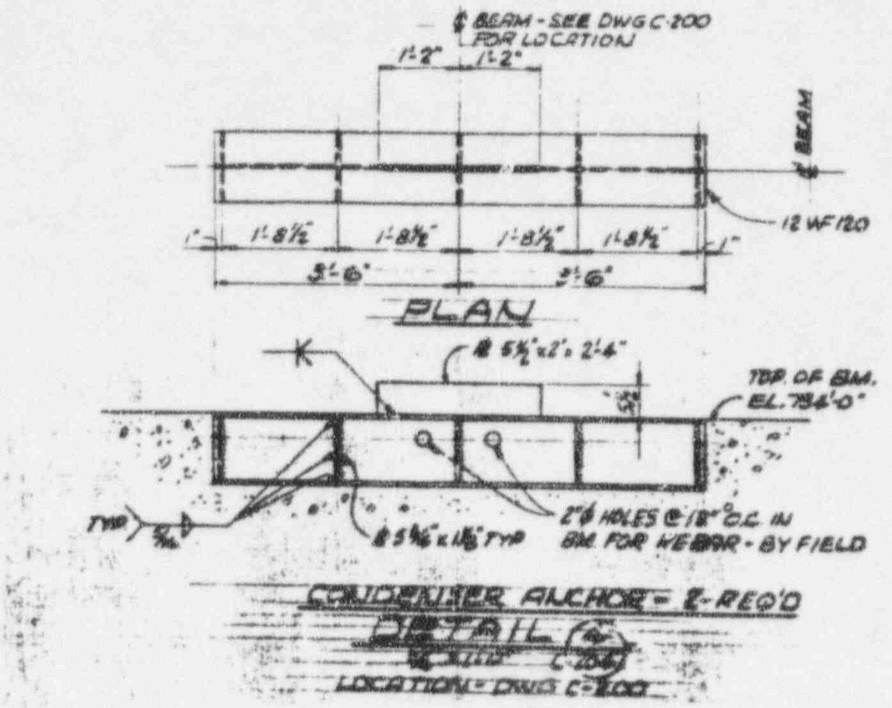



DETAIL 'A'
LEG

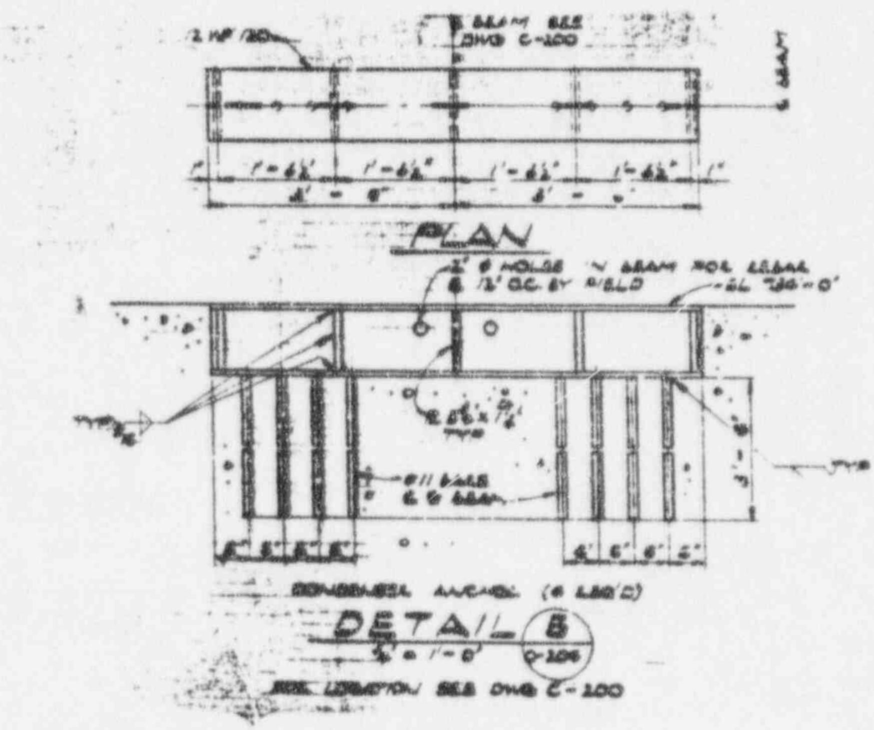
(Ref. FWC 93-1029-6-101)




(Ref. BECH-C-204)




(Ref. BECH-C-204)




(Ref. BECH-C-204)

15 **NRC Request**

Provide calculations that demonstrate the seismic adequacy of anchorages for piping and condenser.

**IES Response**

Horizontal loads in the north-south direction (direction parallel to turbine shaft) are restrained by two flex plates; one each on the east and west sides of the condenser. The flex plates allow for thermal growth of the condenser in the east-west direction but are rigid in the north-south direction. The total shear area of the two flex plates is 108 $in^2$.

Horizontal loads in the east-west direction (direction perpendicular to turbine shaft) are restrained by a single shear key at the center of the condenser. Thermal growth of the condenser is outward from the shear key. The shear area of the shear key is 54 $in^2$.

Vertical restraint of the condenser for condenser uplift loads is provided by sixteen 2.25 inch diameter anchor bolts. There are four anchor bolts at each corner of the condenser. The total area of the anchor bolts is 64 $in^2$.

Calculations were performed to determine the seismic loads in the condenser anchorage. The seismic demand was taken as the peak spectral acceleration from the applicable in-structure response spectrum curve times the weight of the condenser. These calculations were in addition to the earthquake experience based calculations described in our August 15, 1994 submittal (NG-94-2629). Results of these deterministic evaluations are presented in Table 15-1, below.

**Table 15-1**
**Results of Deterministic Seismic Evaluations for Condenser Anchorage**

| Support | Loads (kip) | | | |
|---|---|---|---|---|
| | Normal | Seismic | Total | Capacity |
| Flex-Plates (2) | 689 | 833 | 1522 | 2722 |
| Shear Key (1) | 197 | 833 | 1030 | 1411 |
| Anchor Bolts (4) | 328 | 207 | 535 | 541 |

As shown in Table 15-1, the total loads on the condenser anchorage are less than their capacities, and a significant portion of the total loads are normal operating loads. The seismic loads range from 31 percent of capacity for the flex-plates to 60 percent of capacity for the shear key. The seismic load in the anchor bolts is 38 percent of capacity. Capacities of the condenser anchorage were in accordance with the recommendations in the SQUG Generic Implementation Procedure (GIP) as follows.

| | | |
|---|---|---|
| Steel (Shear) | 0.42 Su | where Su = ultimate strength |
| Anchor Bolts | 1.7 S | where S = allowable stress for normal loads |

Anchorage calculations for the main condenser, as well as pipe supports, are available at DAEC for review by the staff.

16. **NRC Request**

Explain what is meant by "typical support anchorage" and "boundary support anchorage" as discussed on page 9 of Attachment 5 to NG-94-2629.

**IES Response**

On page 9 of Attachment 5 to NG-94-2629, the last sentence of the third paragraph should read "for typical or bounding support anchorages." As discussed in the response to Item 4, all pipe supports on the primary and alternate MSIV leakage treatment paths (22 in all) were evaluated, as well as 15 additional pipe supports on interconnected systems. These supports were selected to include typical support types and limiting or bounding configurations.

17. **NRC Request**

NOTE: This request was contained in the "Summary of Meeting Held on October 17, 1994, to Discuss the MSIV Leakage Control System Technical Specification Amendment Package" by A. Hsia (NRC) dated October 26, 1994.

The licensee presented some preliminary graphs (see enclosure 2) at the meeting. The staff would like to have the final graphs for review, when they become available. Specifically, the staff would like the following final graphs:

a. Integrated Release to the MSIVs from Containment.

b. Integrated Release from Piping to the Condenser (2 separate graphs; one for the first day, and one for the first 30 days).

c. Integrated Release to the Environment (2 separate graphs; one for the first day, and one for the first 30 days).

**IES Response**

The graphs are provided on pages 17-3 through 17-11. A description of these graphs follows.

Graph #1: I-131 Activity in Containment

This graph depicts the Iodine inventory in containment within the first 24 hours.

Graph #2: I-131 Activity in Containment

This graph depicts the Iodine inventory in containment within the first 30 days.

Graph #3: Integrated I-131 Inventory Released from Containment via MSIVs

This graph displays the total integrated release of Iodine as measured just past the MSIVs within the first 24 hours.

Graph #4: Integrated I-131 Inventory Released from Containment via MSIVs

This graph displays the total integrated release of Iodine as measured just past the MSIVs within the first 30 days. This graph along with graph #3 is provided in response to request 7.a of the "Summary of Meeting Held on October 17, 1994, to Discuss the MSIV Leakage Control System Technical Specification Amendment Package" by A. Hsia (NRC) dated October 26, 1994.

Graph #5: Integrated Release of I-131 into Condenser

This graph displays the total integrated release of Iodine as measured at the inlet to the condenser within the first 24 hours.

Graph #6: Integrated Release of I-131 into Condenser

This graph displays the total integrated release of Iodine as measured at the inlet to the condenser within the first 30 days. This graph, along with graph #5, is provided in response to request 7.b of the "Summary of Meeting Held on October 17, 1994, to Discuss the MSIV Leakage Control System Technical Specification Amendment Package" by A. Hsia (NRC) dated October 26, 1994.

Graph #7: I-131 Release to Environment from Condenser

This graph displays the total integrated release of Iodine from the condenser to the environment within the first 24 hours.

Graph #8: I-131 Release to Environment from Condenser

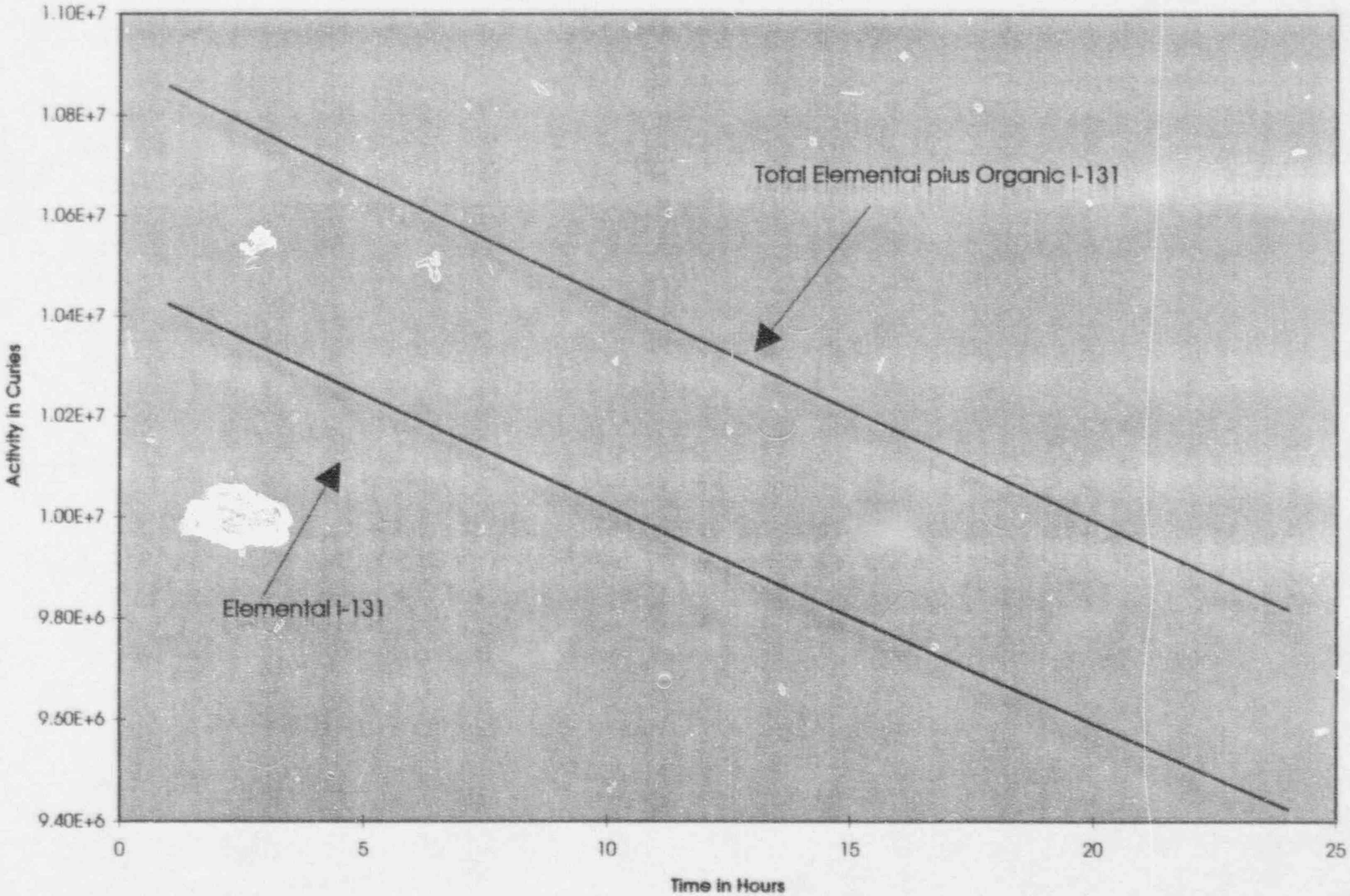
This graph displays the total integrated release of Iodine from the condenser to the environment within the first 30 days.

Graph #9: I-131 Release to Environment from Condenser

This graph displays the total integrated release of Iodine from the condenser to the environment within the first 30 days. It is differentiated from graph #8 by the vertical axis being plotted on a logarithmic scale to show the Elemental Iodine. Graphs 7, 8 and 9 are provided in response to request 7.c of the "Summary of Meeting Held on October 17, 1994, to Discuss the MSIV Leakage Control System Technical Specification Amendment Package".

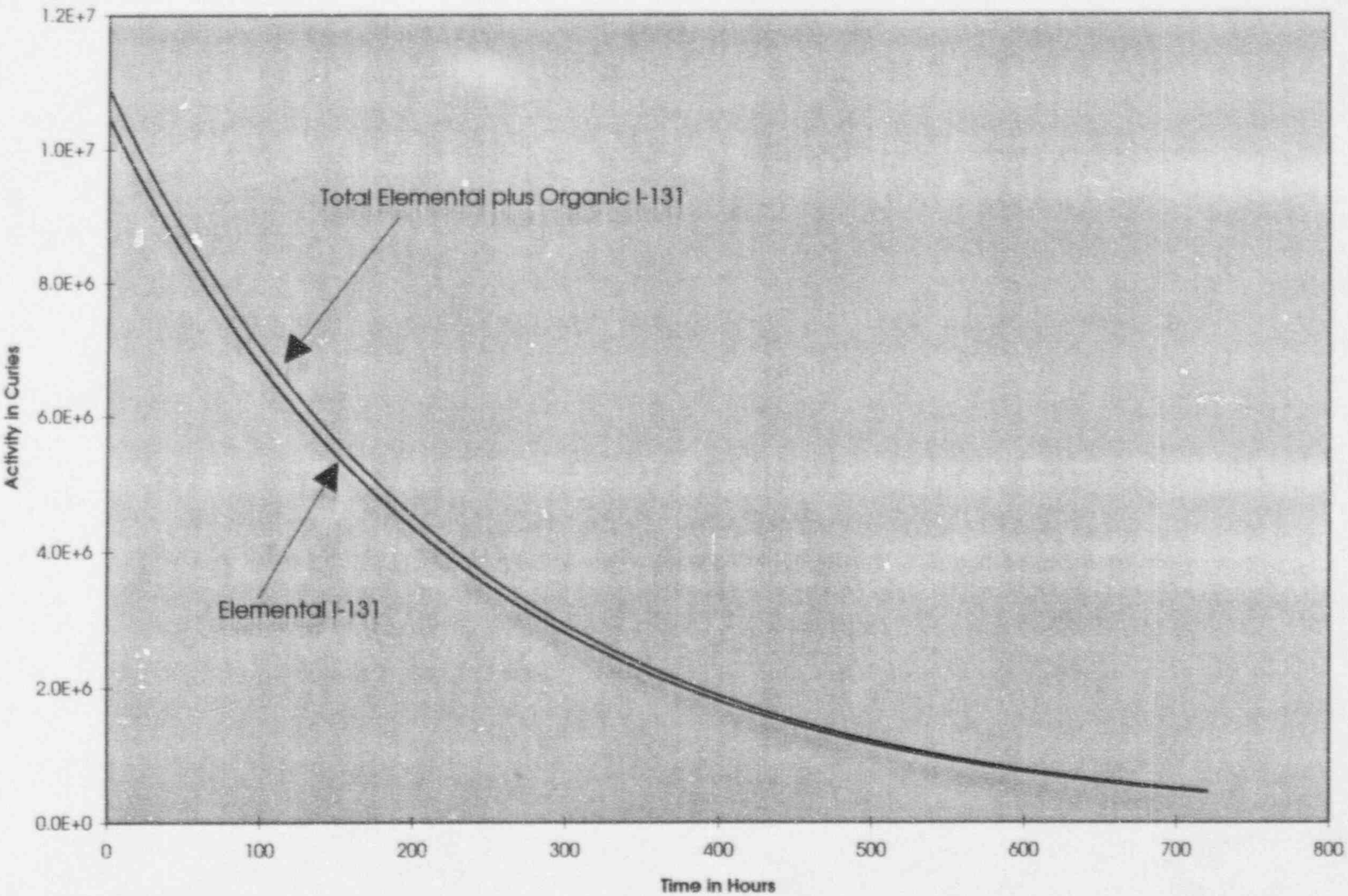
Graph #1

**I-131 Activity In Containment**



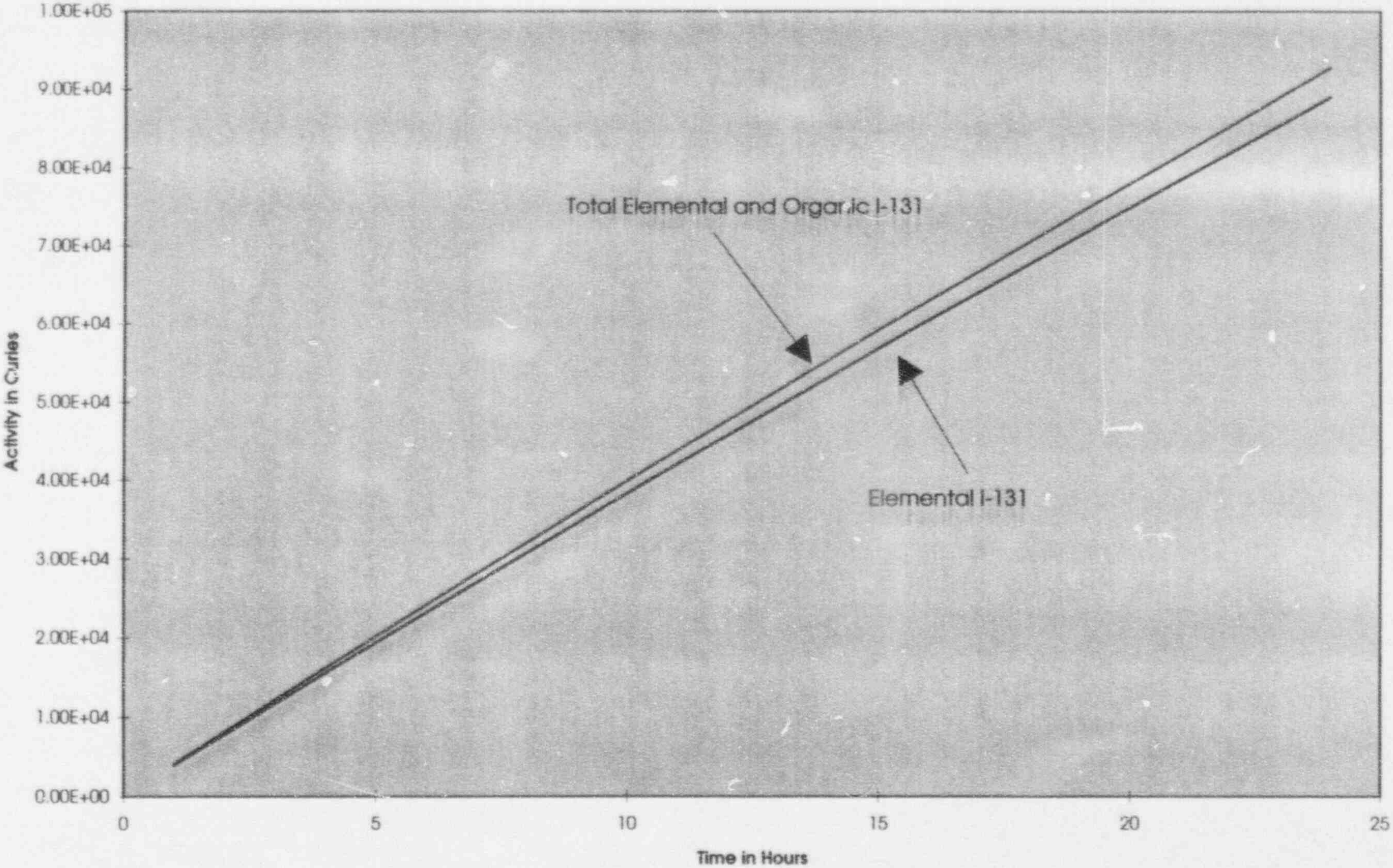
Graph #2

I-131 Activity In Containment



Graph #3

**Integrated I-131 Inventory Released from Containment via MSIVs**

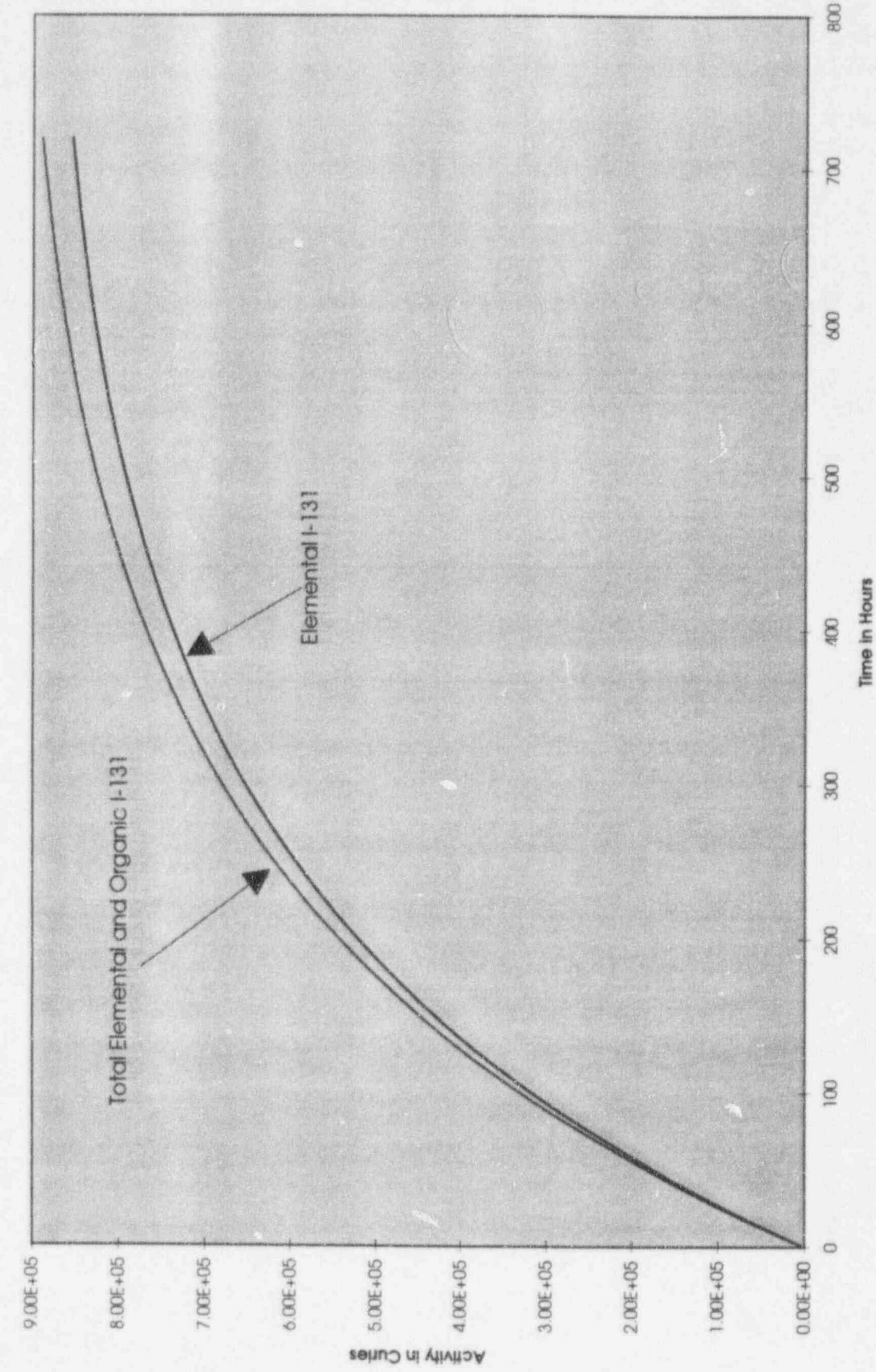



17-5

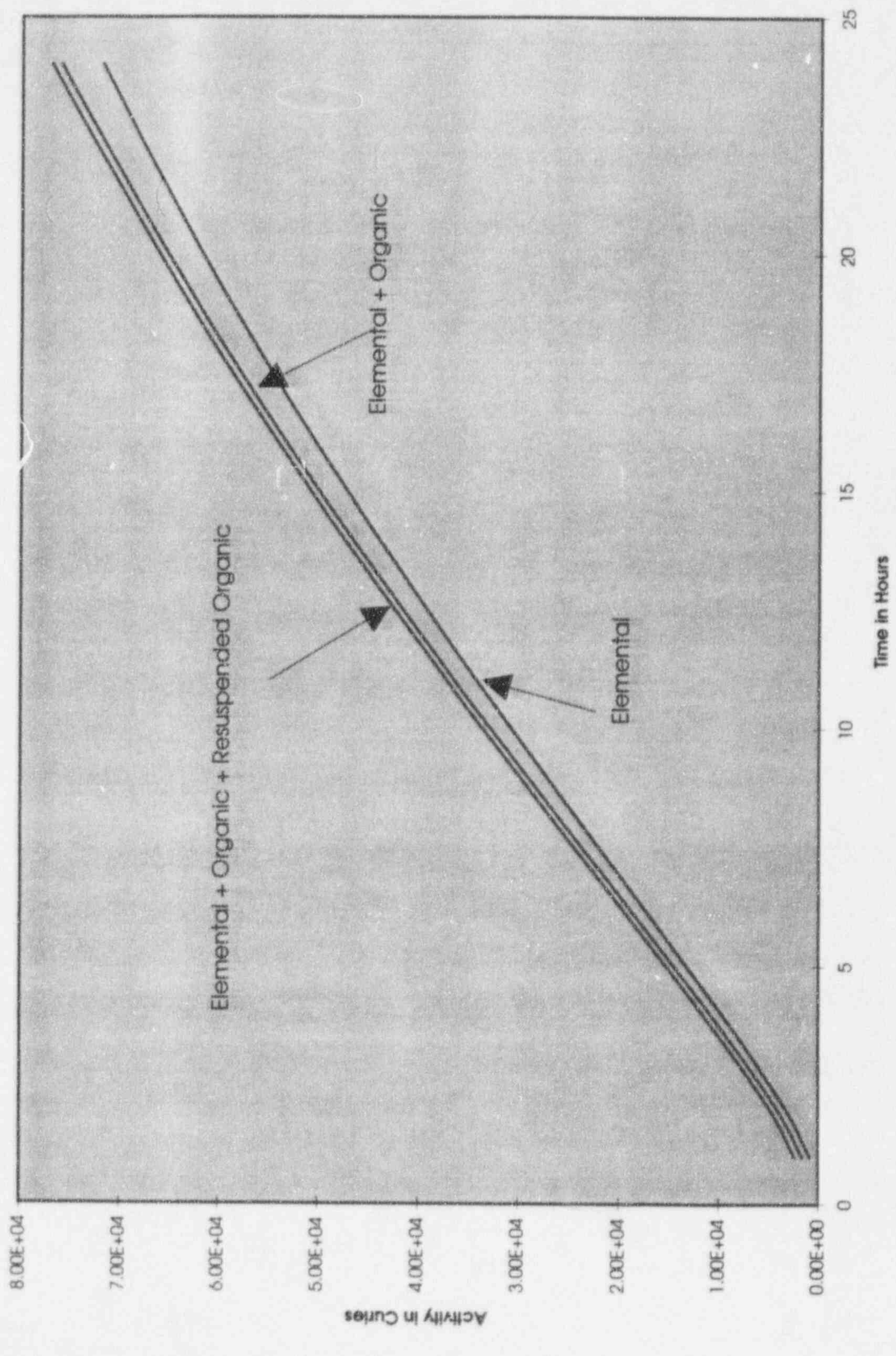
Attachment to NG-94-4632

Graph #4

**Integrated I-131 Inventory Released from Containment via MSIVs**

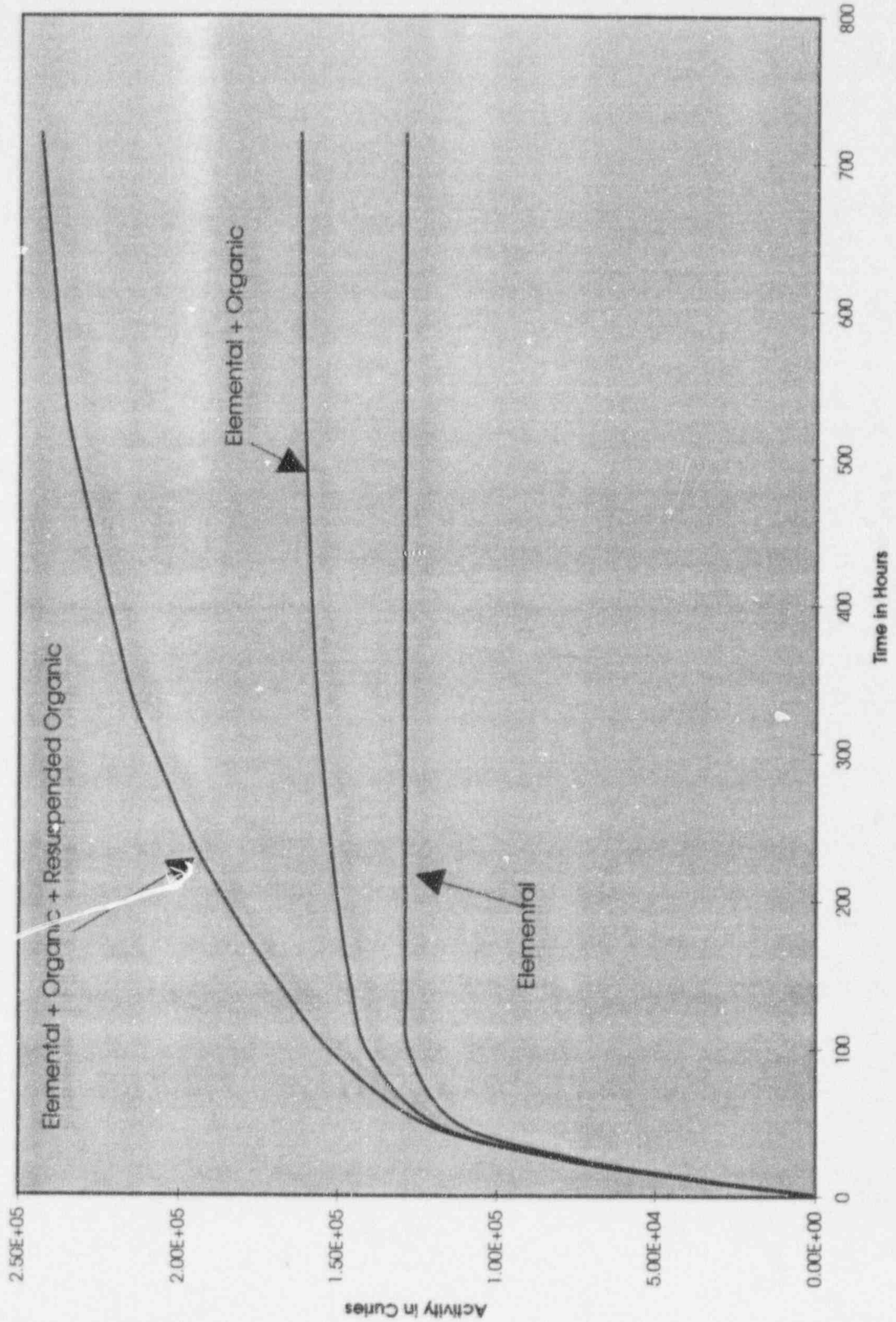


Graph #5
**Integrated Release of I-131 into Condenser**

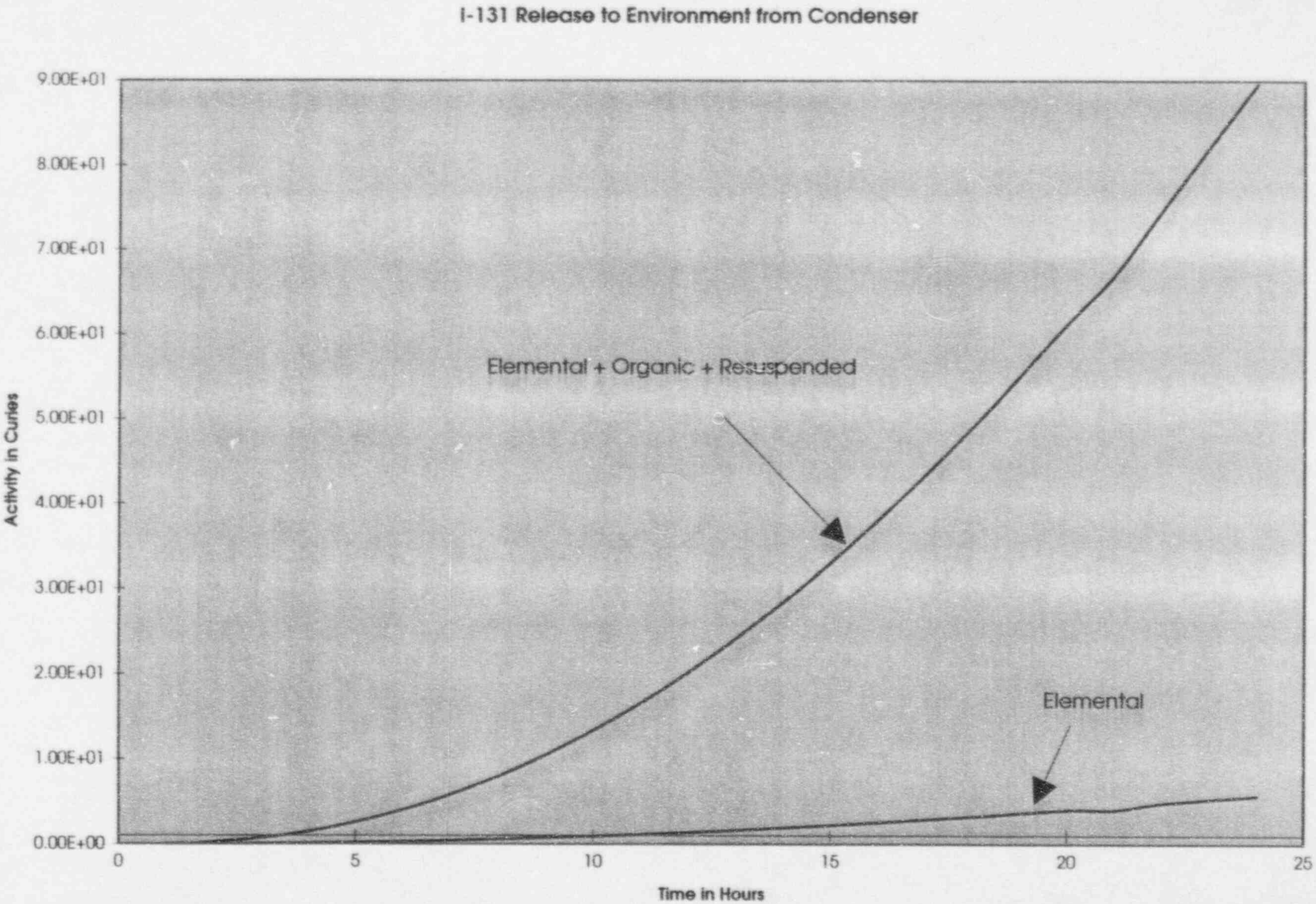


Graph #6

**Integrated Release of I-131 Into Condenser**

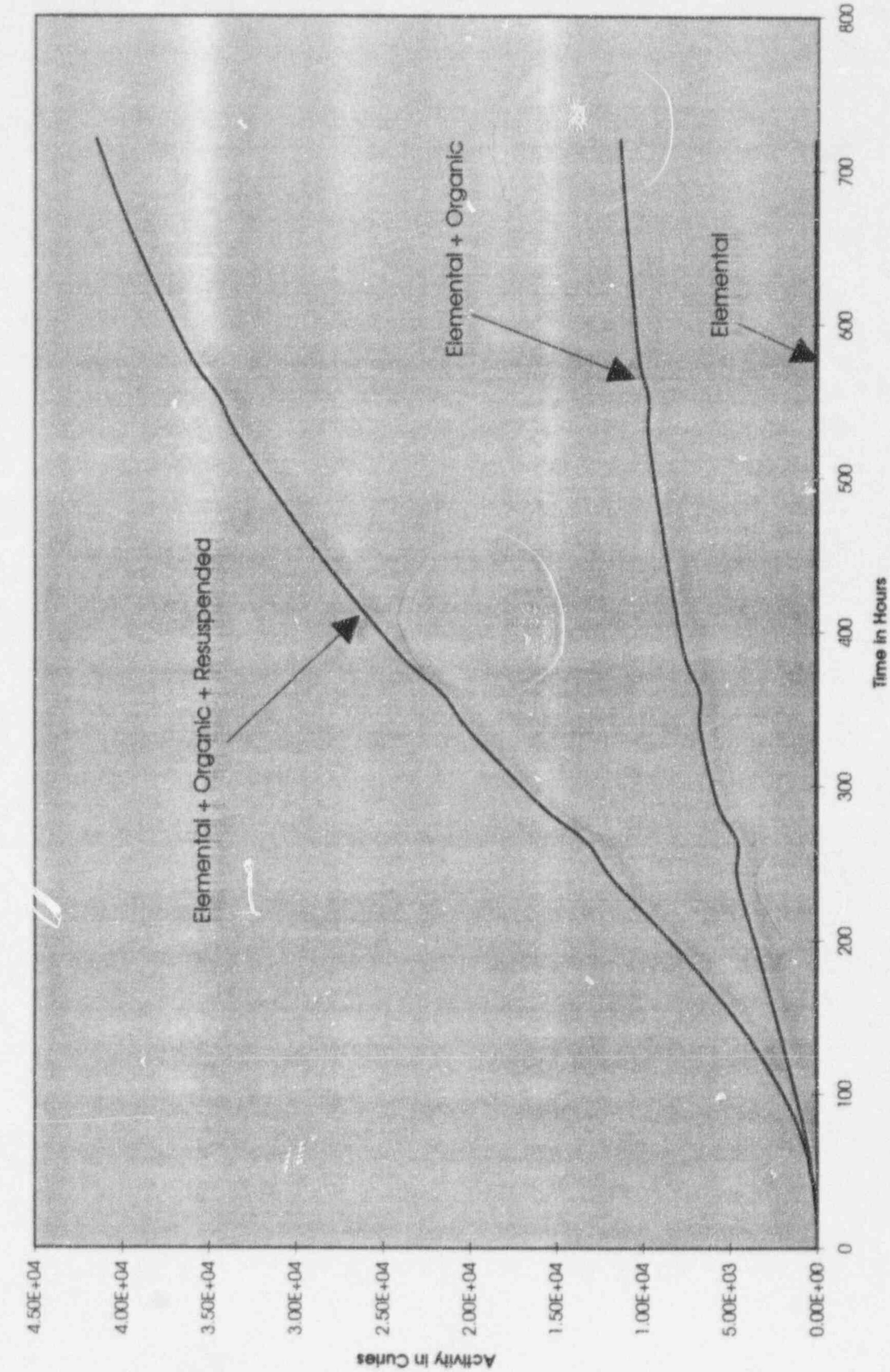


Graph #7




17-9

Attachment to NG-94-4632

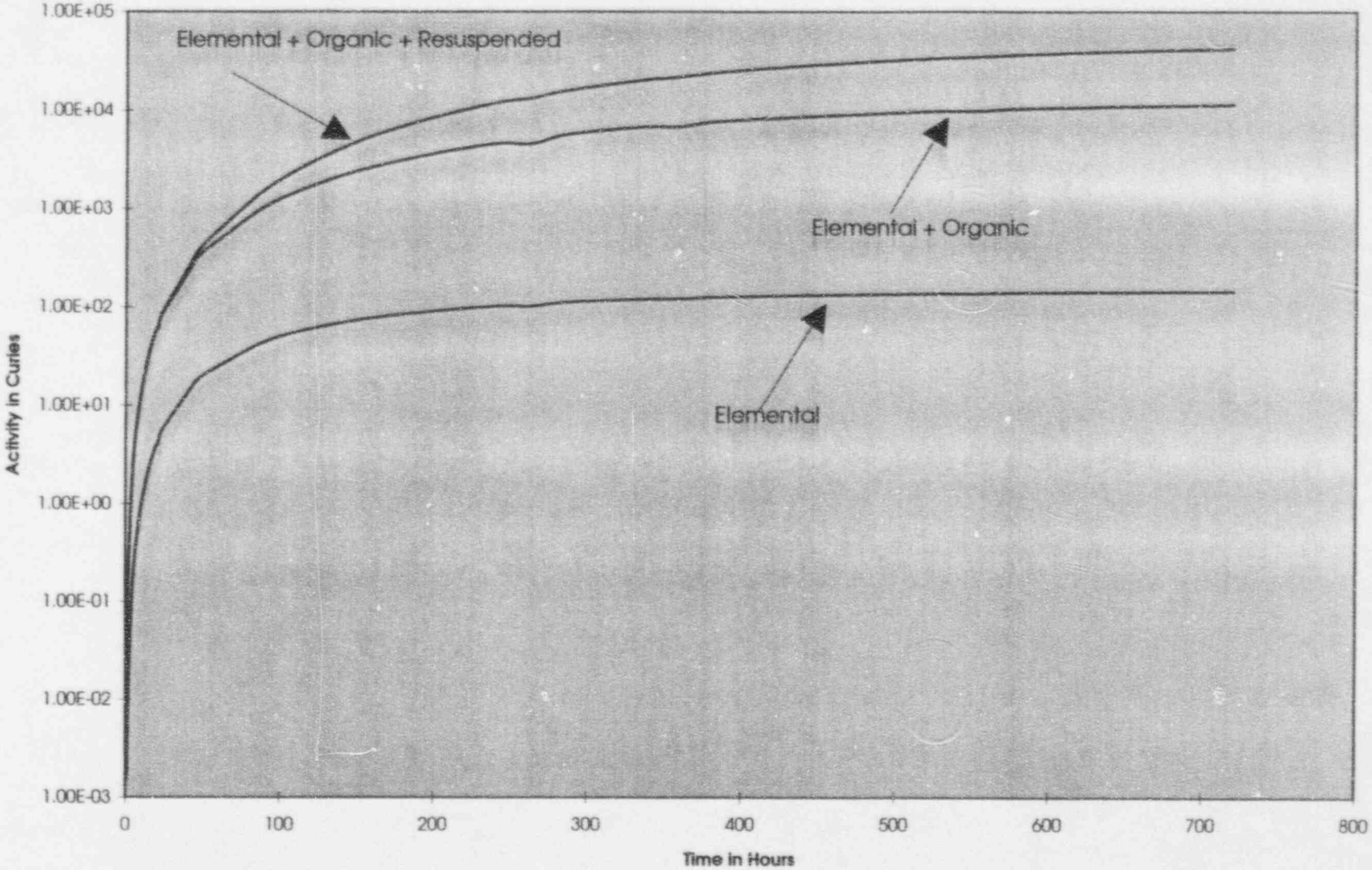



Graph #8

I-131 Release to Environment from Condenser

Graph #9

I-131 Release to Environment from Condenser






Attachment to NG-94-4632

## *References*

1. A Methodology for Assessment of Nuclear Power Plant Seismic Margin, EPRI Report NP-6041-SL, Rev. 1, Electric Power Research Institute, August 1991.

2. Generic Implementation Procedure (GIP) for Seismic Verification of Nuclear Plant Equipment, Rev. 2 Corrected 2/14/92, Seismic Qualification Utility Group, February 1992.

3. BWROG Report for Increasing MSIV Leakage Rate Limits and Elimination of Leakage Control Systems, NEDC-31858P, Rev. 2, General Electric, September 1993.

4. Piping Seismic Adequacy Criteria Recommendations Based on Performance During and After Earthquakes, EPRI Report NP-5617, Electric Power Research Institute, January 1988, prepared by EQE Engineering.

5. Use of Seismic Experience Data to Show Ruggedness of Equipment in Nuclear Power Plants, Senior Seismic Review and Advisory Panel, Rev. 4.0, February 28, 1991.