INSTRUCTIONS FOR FILING AMENDMENT NO. 21

A tab is also included for Appendix 15E.

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<tr><td colspan="2">Summary Table of Contents</td></tr>
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1.9-4.17-1/1.9-4.17-2</td><td>1.9-3/1.9-4,1.9-4.1-19, and
1.9-4.17-1/1.9-4.17-2</td></tr>
<tr><td>----</td><td>1.9-14a,1.9-14b, and 1.9-14c</td></tr>
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15B.9-1/15B.9-2</td><td>15B.3-5/15B.3-6 and
15B.9-1/15B.9-2</td></tr>
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	Appendix 15D	
15D.1-1 and 15D.1-3/15D.1-4		15D.1-1 and 15D.1-3/15D.1-4
	Appendix 15E	
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SUMMARY TABLE OF CONTENTS (Continued)

1.9.1.3 Nuclear Island-BOP Design Interfaces (Continued)

allowables are specified as acceptable. Interface control documentation is provided which will indicate the exceptions.

1.9.1.4 PRA Interfaces

The key PRA interfaces and interface requirements are provided in Table 1.9-24. The Applicant will demonstrate that the BOP design is consistent with these interface requirements before applying the PRA results of Section 15D.3 to his FSAR. If not consistent, the Applicant must demonstrate that there is a negligible impact on the overall public risk.

1.9.2 Exceptions

Applicant will supply.

1.9.3 References

1. Letter, J. F. Quirk to D. G. Eisenhut, "GESSAR II Seismic Event Analysis," September 21, 1983.

2. Letter, J. F. Quirk to D. G. Eisenhut, "Information in Response to Request for Additional Information Regarding GESSAR II Severe Accidents," January 31, 1984.

Table 1.9-1

CHAPTER 1
GESSAR II/FSAR INTERFACES (CONTINUED)

ITEM NO.	SUBJECT	DESCRIPTION	PAGE	SUBSECTION	INTERFACE CATEGORY
1.127	Hydrogen Control System Evaluation	Provide design descriptions of equipment, function and layout of ignition Hydrogen Control System based on the results of the BWR HCOG sponsored tests and analyses.	1G.12-1	1G.12	3
1.128	Long-Term Training Upgrade	Establish a training program which addresses the concerns related to Item I.A.4.2 of NUREG 0718.	1G.13-1	1G.13	3
1.129	Long-Term Program of Upgrading of Procedures	Establish a program for integrating and expanding current efforts to improve plant procedures.	1G.14-1	1G.14	3
1.130	Hydrogen Control System	Provide an igniter Hydrogen Control System capable of handling hydrogen generated as required by the proposed Interim Requirements Related to Hydrogen Control (December 23, 1981, 46 F.R. 62281).	1G.21-2	1G.21	3
1.131	Purging	Provide performance information of purge valves.	1G.27.1	1G.27	3

Table 1.9-1

CHAPTER 1
GESSAR II/FSAR INTERFACES (CONTINUED)

ITEM NO.	SUBJECT	DESCRIPTION	PAGE	SUBSECTION	INTERFACE CATEGORY
1.132	Upgrade License Emergency Support Facility	Provide Technical Support Center, an Onsite Operational Support Center and a near site Emergency Operations Facility.	1G.37-1	1G.37	3
1.133	In-Plant Radiation Monitoring	Provide monitoring of in-plant radiation and airborne radioactivity for routine and accident conditions.	1G.39-1	1G.39	3
1.134	Feedback of Operating, Design and Construction Experience	Provide administrative procedure for evaluating operating, design and construction experience and ensure applicable important industry experience is provided to other plants.	1G.41-1	1G.41	3
1.135	Expansion of QA List	Ensure that the Quality Assurance list required by Criterion II, App. B. 10CFR50, includes all structures, systems, and components important to safety.	1G.42-1	1G.42	3
1.136	Containment Penetration	Provide details of containment penetration arrangement.	1G.44-1	1G.44	5
1.137	Containment Integrity	Provide containment vessel design capability of 45 psig for Service Level C.	1G.45-3	1G.45	3

Table 1.9-17

CHAPTER 17
GESSAR II/FSAR INTERFACES

ITEM NO.	SUBJECT	DESCRIPTION	PAGE	SUBSECTION	RELATED QUESTION	INTERFACE CATEGORY
17.1	Q-List	Identify safety-related structures, and components (Q-List) to be controlled by the quality assurance program. Performance specifications and monitoring procedures to include the applicable interface requirements of Tables 1.9-1 through 1.9-24 and Figures 1.9-1 through 1.9-5 in performance specifications and monitoring procedures.	17.1-1	17.1.2		3
17.2	QA During the Operating Phase	Describe the QA program that will assure the quality of all safety-related items and activities during the operations phase per R.G. 1.70 Section 17.2. Performance specifications and monitoring procedures to include the applicable interface requirements of Tables 1.9-1 through 1.9-24 and Figures 1.9-1 through 1.9-5 in performance specifications and monitoring procedures.	17.2-1	17.2		3

Table 1.9-24

PRA INTERFACES

Item No.	Subject	GESSAR II/FSAR Interface			PRA Interface Requirement
		Table No.	Item No.	Subsection	
1.	Grid Reliability Analysis	1.9-8	8.6	8.2.2	Initiation Frequency <0.05 events/year and loss of feeder probability $<10^{-2}$ (Table D2-14 of Appendix D to Section 15D.3)
2.	ESW Reliability Analysis	1.9-9	9.6	9.2.1	Sufficient as to not degrade the conclusions in Appendix D of Section 15D.3 tables: D2-2 RCIC D2-11 ESW to RHR/LPCS D2-14 EDG Service Water
3.	Seismic Hazard Curve, Geology and Seismology	1.9-2	2.28	2.5.1	Site hazard curve response within Figure 2-1 of Reference 1. Geology and seismology same as GESSAR II/FSAR interface.
4.	Meteorology	1.9-2	2.10 and 2.11	2.3.4 and 2.3.5	Total risk within Figure 7.1-2 of Section 15D.3 bounds. Site unique data to be applied to confirm applicability of risk conclusions.
5.	Population Distribution	1.9-2	2.3	2.1.3	
6.	Emergency Planning	1.9-1	1.39	1.8.101	

Table 1.9-24

PRA INTERFACES (Continued)

Item No.	Subject	GESSAR II/FSAR Interface Table No.	 Item No.	 Subsection	PRA Interface Requirement
7.	Containment Design	1.9-3	3.24	Table 3.8-3	Failure location and capability consistent with Appendix G of Section 15D.3.
8.	Emergency Procedures	1.9-1	1.68	1A.8	Plant emergency procedures consistent with EPGs.
9.	Maintenance Procedures	1.9-1	1.27	1.8.33	Consistent with Reference 2: a. References 3 and 4 of Tables D.2.1-1 and D.2.4-1 b. Footnote 1 of Table 2.2.3-1
10.	Flood and Groundwater	1.9-2	2.16 and 2.26	2.4.3 and 2.4.13	Same as GESSAR II/FSAR interface.
11.	Ultimate Heat Sink	1.9-9	9.10	9.2.5	Same as GESSAR II/FSAR interface.
12.	Site-Dependent Blasts	1.9-2	2.6	2.2.3.1	Same as GESSAR II/FSAR interface.
13.	Collapse of Non-Seismic Category I Components	1.9-3	3.5	3.3.2.3	Consistent with Reference 1, Table 3-18.

Table 1.9-24

PRA INTERFACES (Continued)

Item No.	Subject	GESSAR II/FSAR Interface			PRA Interface Requirement
		Table No.	Item No.	Subsection	
14.	Missiles Generated by Natural Phenomena	---	---	---	Same as Subsection 3.5.1.4 requirement.
15.	Turbine Missiles	1.9-3	3.9	3.5.1.3.4	Same as GESSAR II/FSAR interface requirement.
16.	Aircraft Hazards	---	---	---	Same as Subsection 2.2.2.5 requirement.

1G.12 EVALUATION OF ALTERNATIVE HYDROGEN CONTROL SYSTEMS [Item (l) (xii)]

NRC Position

Perform an evaluation of alternative hydrogen control systems that would satisfy the requirements of paragraph (f) (2) (ix) of 10CFR50.34(f). As a minimum include consideration of a hydrogen ignition and post-accident inerting system. The evaluation shall include:

(A) A comparison of costs and benefits of the alternative systems considered.

(B) For the selected system, analyses and test data to verify compliance with the requirements of (f) (2) (ix) of 10CFR50.34.

(C) For the selected system, preliminary design descriptions of equipment, function, and layout.

Response

(A) GE has conducted evaluations of the various hydrogen control concepts for the GESSAR II design. These concepts included distributed ignition, catalytic burners and post-accident inerting with carbon-dioxide or halon. Of the concepts considered, only distributed ignition (igniters) and carbon-dioxide post-accident inerting appear to be viable alternatives. The costs and benefits of these two alternatives are summarized in Table 1G.12-1.

Neither igniters nor post-accident inerting exhibit overriding benefits. However, from a cost standpoint, igniters should be an order of magnitude less expensive that post-accident inerting, provided the first GESSAR II Applicant is not required to incur the cost

1G.12 EVALUATION OF ALTERNATIVE HYDROGEN CONTROL SYSTEMS [Item (1) (xii)] (Continued)

of an equipment qualification program. Assuming that the first Applicant referencing GESSAR II can fully utilize the results of the BWR Hydrogen Control Owners Group (HCOG) sponsored tests, igniters are clearly more cost-effective than post-accident inerting. Hence, the Applicant shall commit to an igniter Hydrogen Control System.

(B) The results of the BWR HCOG tests and analyses will be used to satisfy the requirements of 10CFR50.34(f)(2)(ix).

(C) The Applicant will provide the design descriptions of equipment, function, and layout based on the results of the BWR HCOG sponsored tests and analyses.

Table 1G.12-1

COMPARISON OF HYDROGEN CONTROL ALTERNATIVES

Item	Igniters	Post-Accident Inerting
Description	Distributed ignition systems controlled burn at low H_2 concentration	Liquid CO_2 discharged into containment airspace (prevents combustion)
Cost (Order of Magnitude)	$1 Million*	$10 Million*
R&D Concerns	Flammability, mixing, pressure response	Possible partial inerting flammability characteristics. Mixing, effects on electronic equipment
R&D Programs	Underway EPRI/NRC/BWR HCOG**	None planned
Pros	• Minor impact of inadvertent operation • Low cost • Minimum design impact • Lower containment pressures	• No heat loads • No dependence on H_2 generation rate • Minor impact on existing equipment • AC power not required for inerting
Cons	• Potential for large equipment qualification program • Assurance of combustion at low concentrations • Sensitize to hydrogen generation rate and containment entry point • Requires active heat removal	• Inadvertent actuation has potential adverse impact on plant operation • High containment pressure • High cost • Some redesign of containment piping to accommodate • Potential adverse effects from low temperatures during injection

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*These costs do not include the cost of corresponding equipment qualification programs. Inclusion of equipment qualification costs could result in nearly equal total costs for the first Applicant referencing GESSAR II.

**Igniter Hydrogen Control System testing by the BWR Hydrogen Control Owners Group (HCOG).

1G.21 HYDROGEN CONTROL SYSTEM PRELIMINARY DESIGN [Item (2) (ix)]

NRC Position

Provide a system for hydrogen control that can safely accommodate hydrogen generated by the equivalent of a 100% fuel-clad metal water reaction. Preliminary design information on the tentatively preferred system option of those being evaluated in paragraph (1) (xii) of 10CFR50.34(f) is sufficient at the construction permit stage. The hydrogen control system and associated systems shall provide, with reasonable assurance, that: (II.B.8)

(A) Uniformly distributed hydrogen concentrations in the containment do not exceed 10% during and following an accident that releases an equivalent amount of hydrogen as would be generated from a 100% fuel clad metal-water reaction, or that the post-accident atmosphere will not support hydrogen combustion.

(B) Combustible concentrations of hydrogen will not collect in areas where unintended combustion or detonation could cause loss of containment integrity or loss of appropriate mitigating features.

(C) Equipment necessary for achieving and maintaining safe shutdown of the plant and maintaining containment integrity will perform its safety function during and after being exposed to the environmental conditions attendant with the release of hydrogen generated by the equivalent of a 100% fuel-clad metal water reaction including the environmental conditions created by activation of the hydrogen control system.

1G.21 HYDROGEN CONTROL SYSTEM PRELIMINARY DESIGN [Item (2) (ix)] (Continued)

(D) If the method chosen for hydrogen control is a post-accident inerting system, inadvertent actuation of the system can be safely accommodated during plant operation.

Response

The Applicant will provide an igniter Hydrogen Control System capable of handling hydrogen generated as required by the proposed Interim Requirements Related to Hydrogen Control (December 23, 1981, 46 F.R. 62281). This Hydrogen Control System will be based on NRC approved results of the BWR Hydrogen Control Owners Group (HCOG) tests and analyses. Although the hydrogen generation required by Item (2)(ix) is higher than required by the proposed Interim Requirements Related to Hydrogen Control, utilization of the HCOG results are acceptable because the GESSAR II design, utilizing the Ultimate Plant Protection System (UPPS), reduces the overall risk of core damage an order of magnitude.

The Applicant shall demonstrate that the BWR HCOG results are applicable to his igniter Hydrogen Control System. This will constitute reasonable assurance that:

(1) Uniformly distributed hydrogen concentrations in the containment do not exceed 10% during and following an accident that releases hydrogen as required by the proposed Interim Requirements Related to Hydrogen Control.

1G.21 HYDROGEN CONTROL SYSTEM PRELIMINARY DESIGN [Item (2) (ix)] (Continued)

Response (Continued)

(2) Combustible concentrations of hydrogen will not collect in areas where unintended combustion or detonation could cause loss of containment integrity or loss of appropriate mitigating features.

(3) Equipment necessary for achieving and maintaining safe shutdown of the plant and maintaining containment integrity will perform its safety function during and after being exposed to the environmental conditions attendant with the release of hydrogen generated as required by the proposed Interim Requirements Related to Hydrogen Control.

1G.21 HYDROGEN CONTROL SYSTEM PRELIMINARY DESIGN [Item (2) (ix)] (Continued)

, including the environmental conditions created by activation of the hydrogen control system.

The following criteria will be used to design the Hydrogen Control System:

(1) The system will be single active failure proof.

(2) Operation of the Hydrogen Control System will not adversely affect the safe shutdown of the plant.

(3) The system will be protected from tornado and external missile hazards.

(4) The system will not compromise the containment design.

5.3.3.1.4.1 Vessel Support (Continued)

for a description of the connection and a summary of stresses. Loading conditions are as follows:

A & B = Power Range + OBE
C = Power Range + OBE + Scram
D = Power Range + SSE + Pipe Break

5.3.3.1.4.2 Control Rod Drive Housings

The control rod drive housings are inserted through the reactor vessel bottom head and are welded inside the bottom head. Each housing transmits loads to the bottom head of the reactor vessel. These loads include the weights of a control rod, a control rod drive, a control rod guide tube, a four-lobed fuel-support piece, and the four fuel assemblies that rest on the fuel-support piece. The housing are fabricated of Alloy 600 and are welded using Alloy 82 weld metal.

5.3.3.1.4.3 In-Core Neutron Flux Monitor Housings

Each in-core neutron flux monitor housing is inserted through the in-core penetrations in the bottom head and welded to the inner surface of the bottom head.

An in-core flux monitor guide tube is welded to the top of each housing and either a source-range-monitor/intermediate-range monitor (SRM/IRM) drive unit or a local power-range monitor (LPRM) is bolted to the seal/ring flange at the bottom of the housing (Section 7.6).

5.3.3.1.4.4 Reactor Vessel Insulation

The reactor pressure vessel insulation is reflective metal type, constructed entirely of series 300 stainless steel and designed

5.3.3.1.4.4 Reactor Vessel Insulation (Continued)

for a 40-year life. The insulation is made of prefabricated units engineered to fit together and maintain insulating efficiency during temperature changes. The insulation is designed to remain in place and resist damage during a safe shutdown earthquake. Each unit is designed to permit free drainage of any moisture that may accumulate in the unit and prevent internal pressure buildup due to trapped gases.

The insulation for the reactor pressure vessel is supported from the biological shield wall surrounding the vessel and not from the vessel shell. Insulation for the upper head and flange is supported by a steel frame independent of the vessel and piping. During refueling the support frame along with the top head insulation is removed. The support frame is designed as a Seismic Category I structure. Insulation access panels and insulation around penetrations is designed in sections with quick release latches which provide for ease of installation and removal for vessel inservice inspection and maintenance operation. Each insulation unit has lifting fittings attached to facilitate removal. Insulation units attached to the shield wall are not required to be readily removable except around penetrations.

At operating conditions, the insulation on the shield wall and around the refueling bellows has an average maximum heat transfer rate of 65 Btu per hour per square foot of outside insulation surface. The maximum heat transfer rate for insulation on the top head is 60 Btu per hour per square foot. Operating conditions are 550°F for the outside temperature of the reactor vessel and 135°F for the drywell air. The maximum air temperature is 150°F, except for the head area above the bulkhead and refueling seal which has a maximum allowable temperature of 200°F.

6.3.3.2 Acceptance Criteria for ECCS Performance (Continued)

Criterion 3: Maximum Hydrogen Generation

"The calculated total amount of hydrogen generated from the chemical reaction of the cladding with water or steam shall not exceed 0.01 times the hypothetical amount that would be generated if all the metal in the cladding cylinder surrounding the fuel, excluding the cladding surrounding the plenum volume, were to react." Conformance to Criterion 3 is shown in Table 6.3-5.

Criterion 4: Coolable Geometry

"Calculated changes in core geometry shall be such that the core remains amenable to cooling." As described in Reference 2, Section III.A, conformance to Criterion 4 is demonstrated by conformance to Criterion 1 and 2.

Criterion 5: Long-Term Cooling

"After any calculated successful initial operation of the ECCS, the calculated core temperature shall be maintained at an acceptably low value and decay heat shall be removed for the extended period of time required by the long-lived radioactivity remaining in the core." Conformance to Criterion 5 is demonstrated generically for General Electric BWRs in Reference 2, Section III.A. Briefly summarized, the core remains covered to at least the jet pump suction elevation and the uncovered region is cooled by spray cooling.

6.3.3.3 Single-Failure Considerations

The functional consequences of potential operator errors and single failures (including those which might cause any manually

6.3.3.3 Single-Failure Considerations (Continued)

controlled electrically operated valve in the ECCS to move to a position which could adversely affect the ECCS) and the potential for submergence of valve motors in the ECCS are discussed in Subsection 6.3.2. There it was shown that all potential single failures are no more severe than one of the single failures identified in Table 6.3-3.

It is therefore only necessary to consider each of these single failures in the ECCS performance analyses. For large breaks, failure of one of the diesel generators is, in general, the most severe failure. For small breaks, the HPCS is the most severe failure.

A single failure in the ADS (one ADS valve) has no effect in large breaks. Therefore, as a matter of calculational convenience, it is assumed in all calculations that one ADS valve fails to operate in addition to the identified single failure. This assumption reduces the number of calculations required in the performance analysis and bounds the effects of one ADS valve failure and HPCS failure by themselves. The only effect of the assumed ADS valve failure by the calculations is a small increase (on the order of 100°F) in the calculated temperatures following small breaks.

6.3.3.4 System Performance During the Accident

In general, the system response to an accident can be described as:

(1) receiving an initiation signal;

(2) a small lag time (to open all valves and have the pumps up to rated speed); and

(3) finally, the ECCS flow entering the vessel.

7.2.2.2.A.7 Conformance to Regulatory Codes, Guides, and Standards (Continued)

Manual initiation of reactor scram, once initiated, goes to completion as required by IEEE 279-1971, Section 4.16.

8. Regulatory Guide 1.68, Initial Test Programs for Water-Cooled Reactor Power Plants

Applicant will supply.

9. Regulatory Guide 1.75, Physical Independence of Electric Systems

The Reactor Protection System complies with the criteria set forth in IEEE 279-1971, Paragraph 4.6., and Regulatory Guide 1.75. Class 1E circuits and Class 1E-associated circuits are identified and separated from redundant and non-Class 1E circuits. Isolation devices are provided in the design where an interface exists between redundant Class 1E divisions and between non-Class 1E and Class 1E or Class 1E-associated circuits. Independence and separation of safety-related systems is discussed in Section 7.1.2.8.

Physical and electrical independence of the instrumentation devices of the system is provided by channel independence for sensors exposed to each process variable. Separate and independent raceways are routed from each device to the respective control room panel. Each channel has a separate and independent control room panel. Trip logic outputs are separate in the same manner as the channels are. Signals between redundant RPS divisions are electrically and physically isolated by Class 1E isolators.

The optical isolators used in the GESSAR II design fully comply with the requirements of Regulatory Guide 1.75. Each divisional chamber contains only wiring and equipment associated with that specific division. Each chamber is enclosed by metal barriers also in accordance with the guide. Therefore, any individual failure of card or component can at most affect only equipment within the same chamber, which is the same division. The single-failure criterion is thus preserved regardless of the optical isolators capability to withstand line-to-line or line-to-ground faults. Such capability is of interest for reliability and system availability evaluations, but is not pertinent for safety evaluations because of the isolation and redundancy provided in the design.

GE has designed the cards for high reliability, which includes tolerance of abnormally high voltages on the input gates. This is accomplished by high impedance resistors which limit input currents to non-destructive levels. The 12-volt logic input pins of sample cards were subjected to the following overrange voltages for the time durations shown:

DC Volts	Temperature	Time
150	Ambient	2 minutes
400	Ambient	1 millisecond (pulse)

After applying a 150-volt DC signal to the inputs for two minutes, the card was determined to be functioning properly. The 400-volt, 1 millisecond pulse was then applied at the inputs and verified on the oscilloscope. Following the application of the pulse, the card was still functioning normally.

7.2.2.2.A.10 Conformance to Regulatory Codes, Guides, and Standards (Continued)

10. Regulatory Guide 1.89, Qualification of Class 1E Equipment for Nuclear Power Plants

Written procedures and responsibilities are developed for the design and qualification of all RPS equipment. This includes preparation of specifications, qualification procedures, and documentation for RPS equipment. Standards manuals are maintained containing specifications, practices, and procedures for implementing qualification requirements and an auditable file of qualification documents is available for review.

11. Regulatory Guide 1.97: Refer to Section 1.8 for assessment of Regulatory Guide 1.97.

12. Regulatory Guide 1.100: Refer to Section 1.8 for assessment of Regulatory Guide 1.100.

13. Regulatory Guide 1.105: Refer to Section 1.8 for assessment of Regulatory Guide 1.105.

14. Regulatory Guide 1.118: Refer to Section 1.8 for assessment of Regulatory Guide 1.118.

Regulatory Position C.5 for APRM:

With respect to conformance to position C.5, the inherent time response of the in-core sensors used for APRM (fission detectors operating in the ionization chamber mode) is many orders of magnitude faster than the APRM channel response time requirements and the signal conditioning electronics. The sensors cannot be tested without disconnecting and reconnecting to special equipment.

15B.3.5 Applicability of the Generic Analysis (Continued)

Applicability of the generic analysis is discussed in Reference 6. The generic analysis is applicable to all initial core fuel loading patterns developed and analyzed in accordance with Reference 6. As new design features are implemented, compliance checks will be performed and documented to demonstrate the applicability of the generic analysis.

15B.9 REFERENCES

1. W. R. Morgan, "In-Core Neutron Monitoring System for General Electric Boiling Water Reactors", April 1969 (APED-5706).
2. C. J. Paone, "Banked Position Withdrawal Sequence," General Electric Company, January 1977 (NEDO-21231).
3. J. A. Woolley, "Three-Dimensional BWR Core Simulator", General Electric Company, May 1976 (NEDO-20953).
4. W. B. Nelson, et al, "STATPAC - A General-Purpose Program for Data Analysis and for Fitting Statistical Models to Data", General Electric Company, May 1972 (75GEN012).
5. "General Electric BWR Thermal Analysis Basis (GETAB): Data, Correlation and Design Application", January 1977 (NEDO-10958-A).
6. "General Electric Standard Application for Reactor Fuel," (NEDE-24011-P-A), latest approved revision.

15D.1 INTRODUCTION

This section provides background information and defines the objective, scope and content of Appendix 15D to the GESSAR II 238 Nuclear Island submittal. Additional information on severe accidents is contained in Appendix 15.E and References 5 and 6.

15D.1.1 Severe Accident Rulemaking Background

Following the accident at Three Mile Island, the NRC, in a number of NUREG documents (References 1-3) indicated the intent to conduct rulemaking activities to consider potential future requirements for plant modifications and licensing changes to address accidents beyond the current design basis. In October, 1980, an Advanced Notice of Proposed Rulemaking (ANR) was published in the Federal Register indicating areas of NRC concern regarding severe accident issues.

Since the ANR was published, a number of activities and program directions have been pursued by the NRC relating to severe accident issues. Most recently (January, 1982) the NRC Staff presented its approach regarding severe accident issues to the NRC Commissioners. The documentation of the NRC's proposed direction (Reference 4) specifies that a viable approach to implement severe accident rulemaking on future plants is to address severe accident issues on Standard Plant dockets.

In response to the approach outlined in Reference 4, General Electric is providing Appendix 15D to GESSAR II to address severe accidents for the GE BWR/6 Mark III 238 Nuclear Island design.

15D.1.2 Objective, Scope and Content of Appendix 15D

The objective of Appendix 15D to GESSAR II is to provide a summary of the key features, and a quantification of their capabilities, of the 238 Nuclear Island which prevent or minimize the effects of severe accidents. The quantification of these capabilities is presented by means of a Probabilistic Risk Assessment (PRA) which provides an analysis of the probability and consequences of postulated severe accidents.

The technical content of Section 15D is presented in two Sections -- 15D.2 and 15D.3. In 15D.2 the features of the 238 Nuclear Island design which prevent severe accidents from leading to core damage or which mitigate the effects of severe accidents should core damage occur, are presented. Plant improvements which are significant in reducing the calculated plant risk are also identified. Section 15D.3 presents the comprehensive probabilistic risk assessment of the 238 Nuclear Island Design. A summary and conclusion to Appendix 15D is provided in Section 15D.4.

The quantification of the accident prevention and mitigation features of the 238 Nuclear Island design is provided in the probabilistic risk assessment. From this analysis, it has been concluded that no additional design changes beyond those discussed in Subsection 15D.2.1 and Appendix 1A are required. Furthermore, it is concluded that Appendix 15D provides a basis to resolve severe accident issues for the 238 Nuclear Island design.

15D.1.3 References

1. U. S. Nuclear Regulatory Commission, "TMI-2 Lessons Learned Task Force Status Report and Short-Term Recommendations," USNRC Report NUREG-0578, July 1979.

2. U. S. Nuclear Regulatory Commission, "TMI-2 Lessons Learned Task Force Final Report," USNRC Report NUREG-0585, October 1979.

3. U. S. Nuclear Regulatory Commission, "NRC Action Plan Developed as a Result of the TMI-2 Accident," USNRC Report NUREG-0660, Volumes 1 and 2, May 1980.

4. Executive Director for Operations, Nuclear Regulatory Commission Policy Issue for the Commissioners, Subject: Severe Accident Rulemaking and Related Matters, SECY-82-1, January 4, 1982.

5. J. N. Fox, et al, "Resolution of Applicable Unresolved Safety Issues and Generic Safety Issues for GESSAR II," General Electric Company, June 1984 (NEDO-30670).

6. K. W. Holtzclaw and P. D. Knecht, "Evaluation of Proposed Modifications to the GESSAR II Design," General Electric Company, June 1984 (NEDE-30640) (Proprietary).

APPENDIX 15E

ADDITIONAL SEVERE ACCIDENT INFORMATION

APPENDIX 15.E

CONTENTS

APPENDIX 15.E

CONTENTS (Continued)

15.E.0 INTRODUCTION

This section defines the objective, scope, and content of Appendix 15.E to the GESSAR II 238 Nuclear Island submittal.

15.E.0.1 Objective, Scope and Content of Appendix 15.E

Appendix 15.E to GESSAR II provides additional information to support the severe accident analyses presented in Appendix 15D, and responds to requirements of the severe accident policy statement proposed by the Nuclear Regulatory Commission to provide information that goes beyond the analyses of Appendix 15D.

Appendix 15.E consists of seventeen parts arranged cronologically in order of submittal. Sections 15.E.1, 15.E.4, 15.E.6, 15.E.12, and 15.E.13 contain responses to NRC requests for additional information regarding the severe accident portion of GESSAR II. Section 15.E.2 contains information submitted to support resolution of the postaccident monitoring instrumentation issue. Section 15.E.3 provides the GESSAR II responses to the action plan for resolving the containment design issues identified by John Humphrey.

Section 15.E.5 contains the two volume report "Confirmatory Soil-Structure Interaction Analysis for GESSAR-II" in response to Confirmatory Issue No. 3 of the GESSAR II Safety Evaluation Report. Section 15.E.17 provides responses to requests for additional information resulting from the NRC review of this report. The "GESSAR II Seismic Event Analysis" is provided in Section 15.E.7 in response to the NRC draft policy statement on Severe Accidents, which requires the consideration of seismic and other external events. The Seismic Event uncertainty analysis is presented in Section 15.E.11. Section 15.E.8 contains the report "GESSAR II Fire and Flood External Event Analysis," and Section 15.E.15 provides a qualitative evaluation of external event risk.

Section 15.E.9 contains the GESSAR II internal event PRA uncertainty analysis. This analysis provides the variability in total internally-initiated core damage frequency by propagation of uncertainties through the fault and event trees in order to estimate the frequency of radionuclide release.

The GESSAR II station blackout capability is documented in Section 15.E.10. The assessed capability of more than ten hours is based on plant design without the addition of the Ultimate Plant Protection System (UPPS) and assumes credit for operator actions that are straightforward and where means exist to enable the operator to execute the action.

Section 15.E.14 contains a source term sensitivity study which was performed to provide information on the impact of variations of source term parameters from the base case values used in the GESSAR II Probabilistic Risk Assessment.

Finally, Section 15.E.16 describes how the Nuclear Island (NI)/Balance of Plant (BOP) interfaces are controlled in the GESSAR II design.

APPENDIX 15.E.1

RESPONSES TO REQUEST FOR ADDITIONAL INFORMATION

GE PROPRIETARY - provided under separate cover

APPENDIX 15.E.2

JUSTIFICATION OF R.G. 1.97 DEVIATIONS IN GESSAR II

15.E.2 Justification of R.G. 1.97 Deviations in GESSAR II, Section 1D

The following information is provided for each Deviation:

1. GESSAR Reference

2. Problem Statement - Key concerns with variable regarding specifications in the guide

3. Deviation statement - GE position

4. Justification - key points supporting position

5. Supporting figures - GESSAR figures marked to show subject instrumentation or pertinent material. (figure numbers shown in brackets [ ])

GESSAR II
Regulatory Guide 1.97 Assessment
Deviation Justification

Post Accident Monitoring
RG 1.97 (Rev. 2)

OPEN ITEMS

- Comply with RG 1.97, Rev. 2
- Justify each deviation

GESSAR II STATUS

- Submitted Nov 1982
- 43 BWR variables assessed
  - 10 - Applicant to address
  - 15 - Justified with deviations
  - 18 - Full compliance
- 3 design changes under review

GESSAR II
Regulatory Guide 1.97 Assessment
Deviation Justification

Post Accident Monitoring
Summary of
Justification of Deviations From Guide

Deviations	Variables	Basis
• Alternate Variable (6 variables)	MSIV LCS press. RHR HX temperature SLC flow Vent flow LPCI flow Cont. spray flow	Meets intent of guide
• Alternate Range (5 variables)	RPV level Cont. pressure SP water level DW air temp.	EPGs and human factors task analysis
• Not Provided (3 variables)	Incore temperature Coolant radiation Sump samples	Intent met by other RG 1.97 variables
• Alternate Category (2 variables)	DW sump level SLC tank level	Back up variables

GESSAR II
Regulatory Guide 1.97 Assessment
Deviation Justification

Variable: NEUTRON FLUX GESSAR Sections: 1D.2.3.1

PROBLEM See Next Page

DEVIATION New System Added

GESSAR II
Regulatory Guide 1.97 Assessment
Deviation Justification

Design Changes Being Made
Wide Range Neutron Monitor
(WRNM)

PROBLEM

- IRM/SRM drives & cabling not qualifiable
- Needed for post accident reactivity monitoring
- Field maintenance

SOLUTION

- 8 fixed incore detectors
- New electronics/cabling (qualified)
- Existing displays (qualified)

STATUS

- Prototype test starting
- Available 1984

GESSAR II
Regulatory Guide 1.97 Assessment
Deviation Justification

Variable: MSIV LCS Pressure relief 6.7-1a,b

GESSAR Section: 1D.2.3.21

PROBLEM

- Table 1 (R.G. 1.57) specifies LCS Pressure (0-15" H_2O or 0-5 psid)
- GESSAR is positive Leakage Control
- Pressure is ambiguous because of unpredictable leak rate

DEVIATION

- MSIV LCS FLOW considered as alternate variable (FRS R607, FRS R627)

JUSTIFICATION

- Indication of high Flow (MSIV excess leakage) or zero flow indicates system malfunction

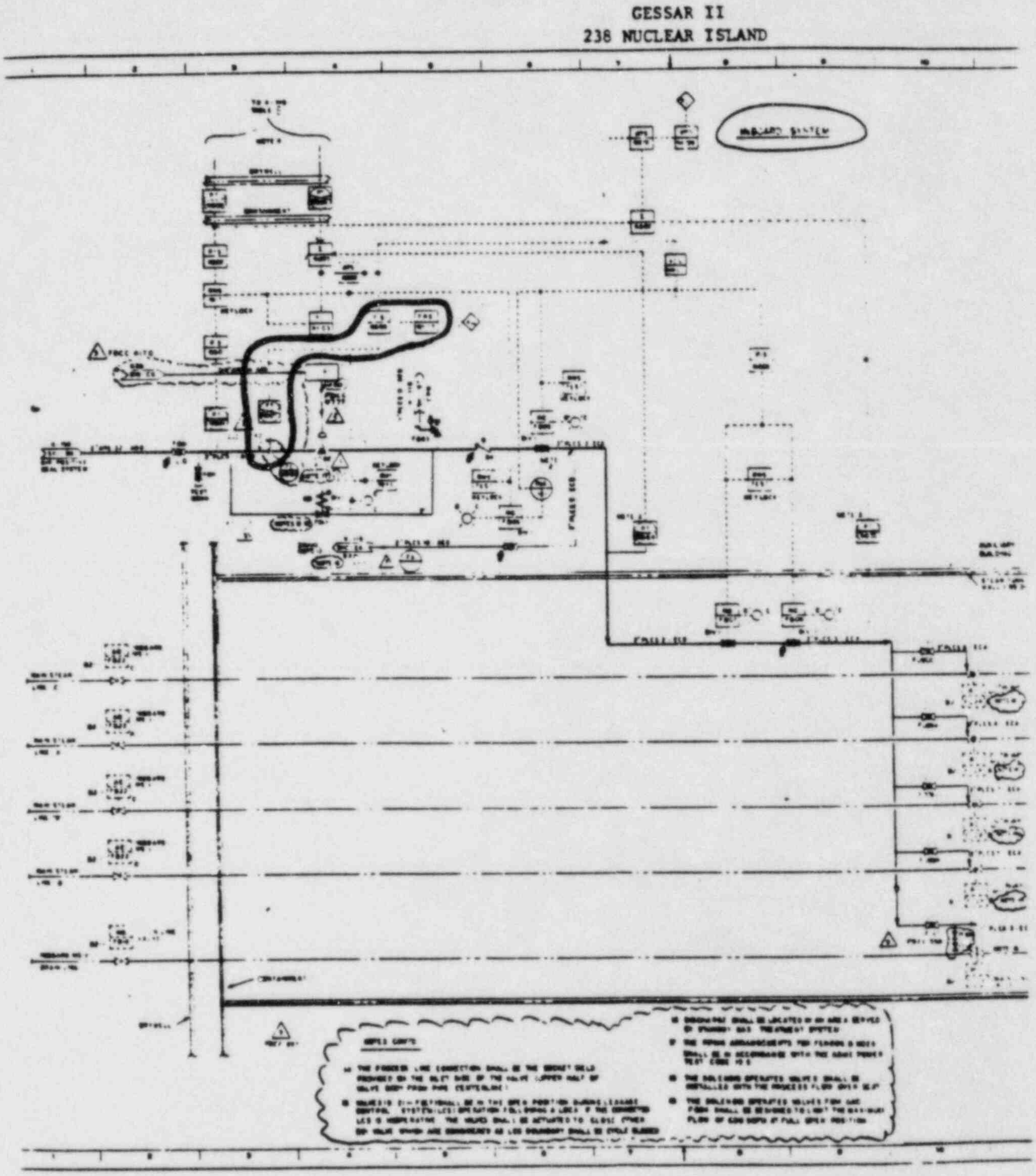


Figure 6.7-1a

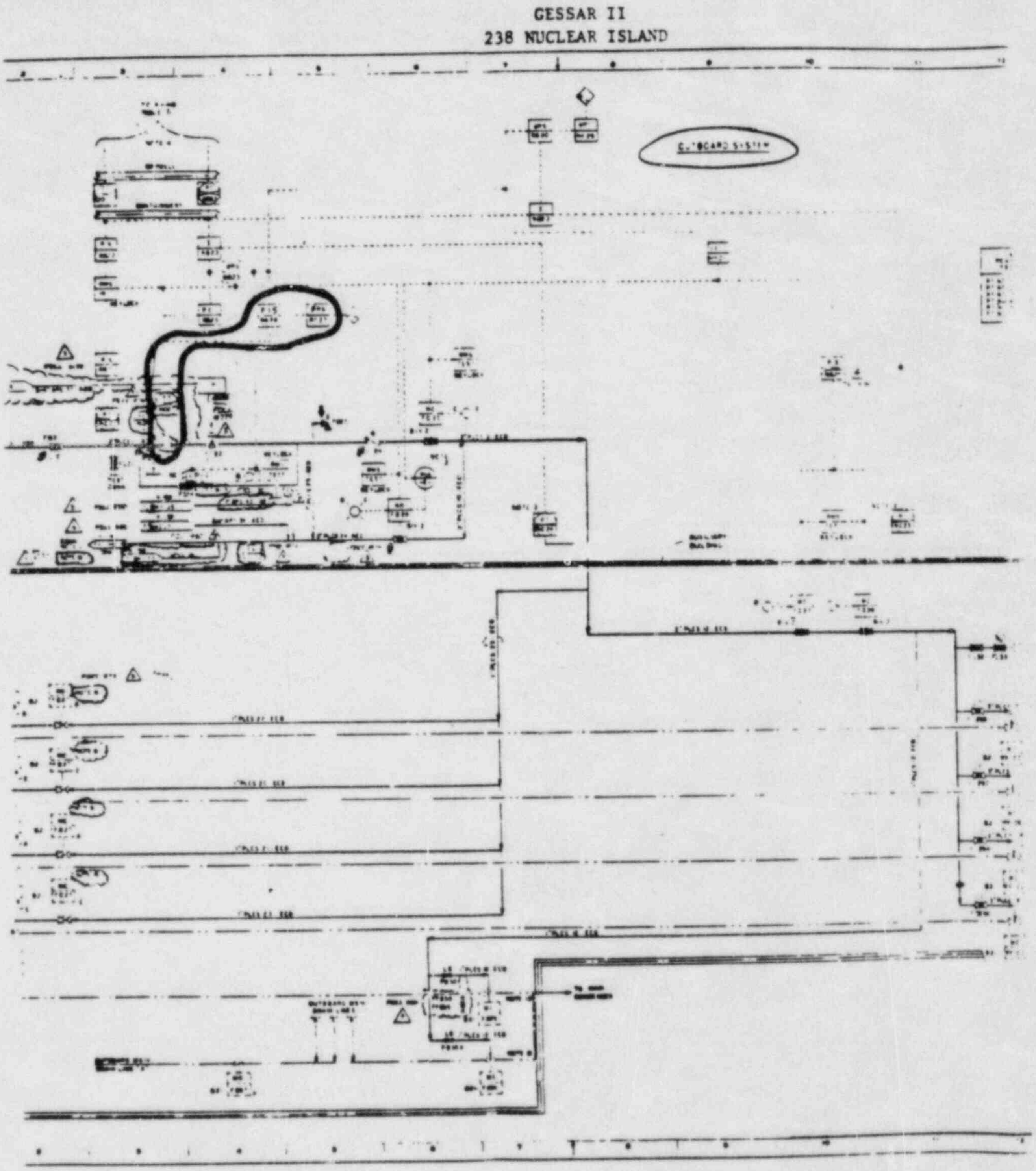


Figure 6.7-1b

GESSAR II
Regulatory Guide 1.97 Assessment
Deviation Justification

Variable:
- RHR Heat Exchanger temperature
  ref Figures 5.4-12a,b,c

GESSAR Section: 1D.2.3.23

PROBLEM
- RHR temperature recorder (TRS R601) [Figure 5.4-12a] not qualified (environmental or seismic)
- Non-Essential Power used

DEVIATION
- RHR service water flow (F1 R602A,B) [Figure 9.2-1a] considered an alternate variable

JUSTIFICATION
- Meets all category 2 requirements
- Positive indication of heat removal capability

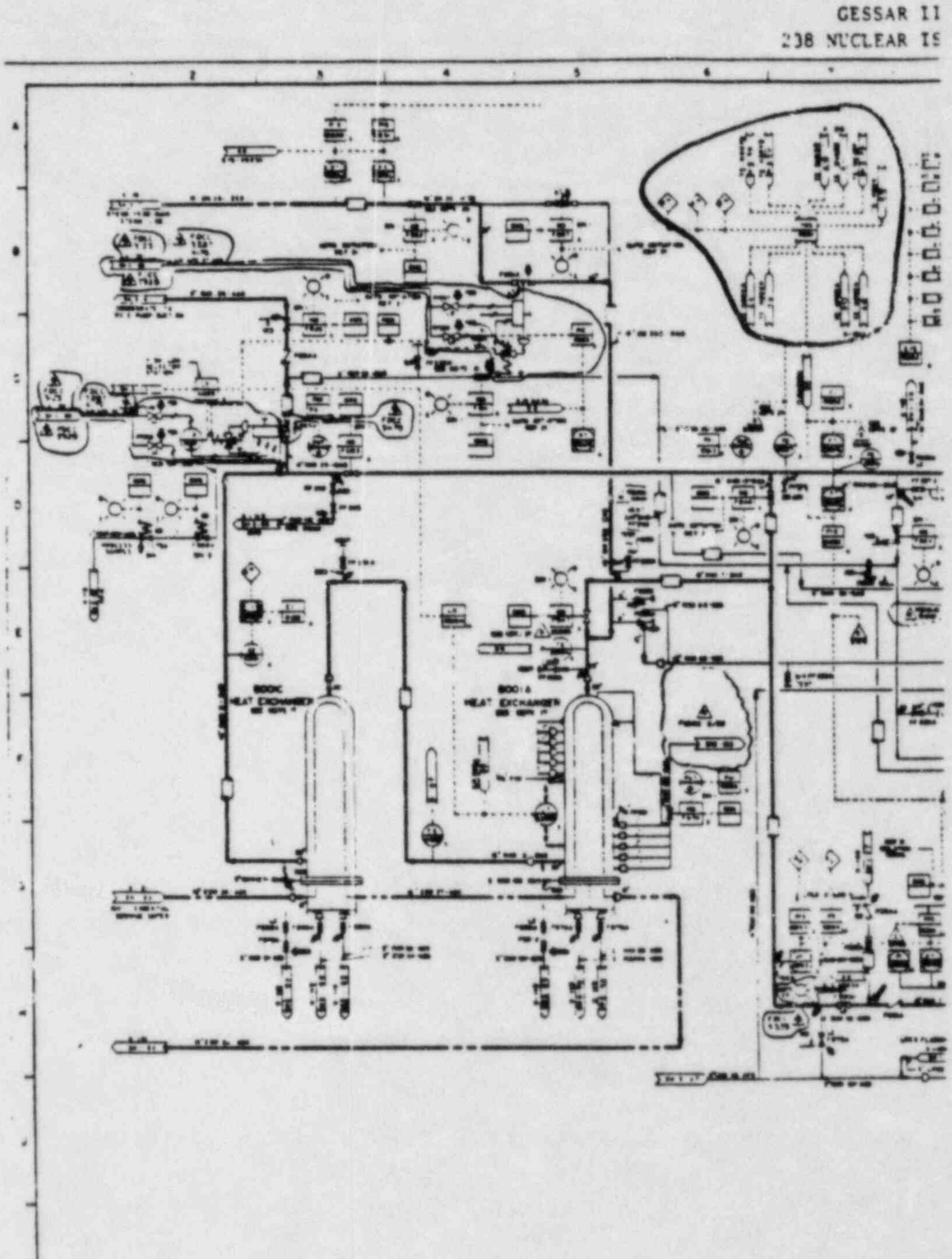


Figure 5.4-12a

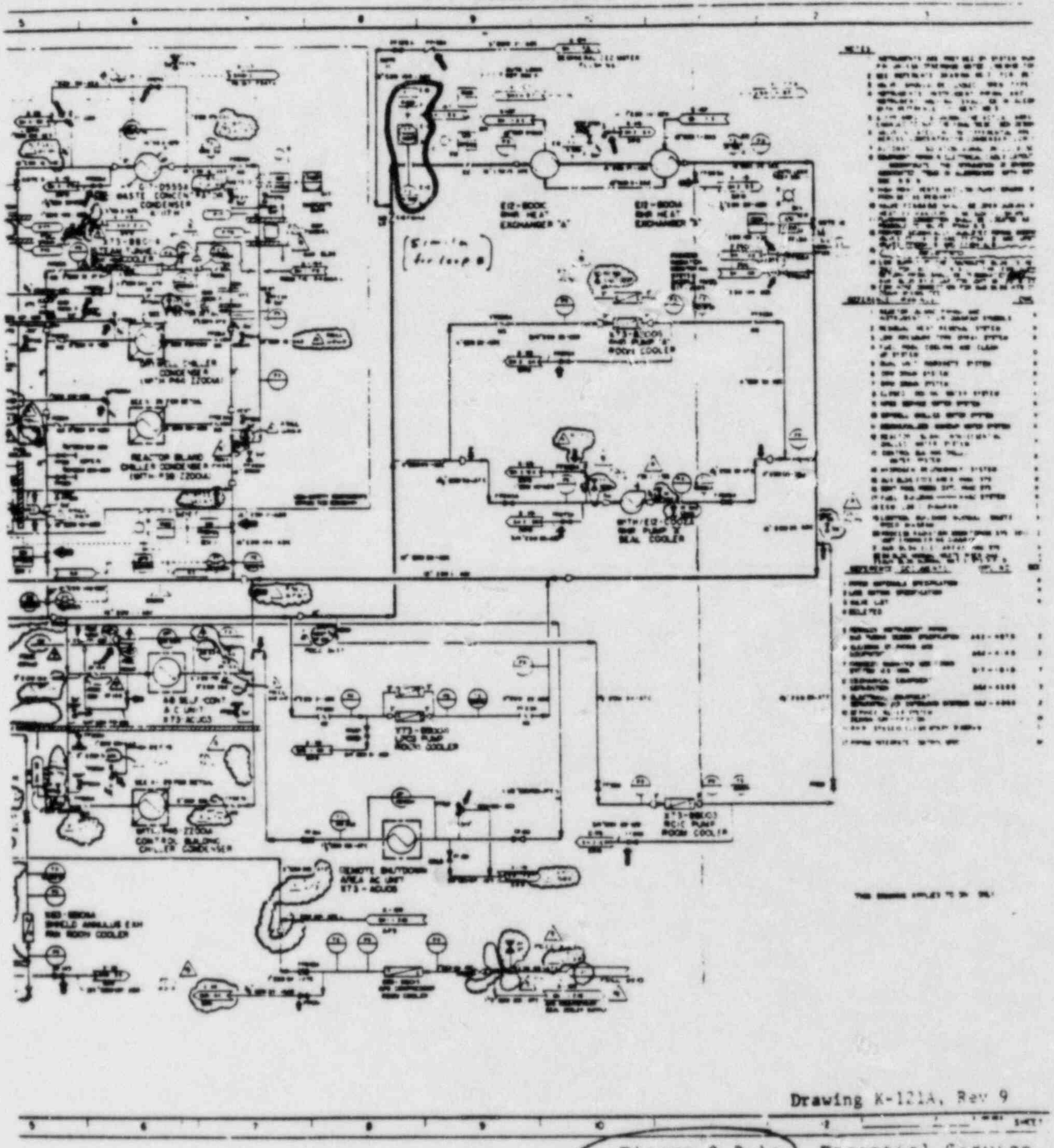


Figure 9.2-1a. Essential Service
System (Div. 1) P&
Diagram

GESSAR II
Regulatory Guide 1.97 Assessment
Deviation Justification

Variable: SLC Flow Ref: Figure 9.3-5 GESSAR Section: 1.D.2.3.25

PROBLEM

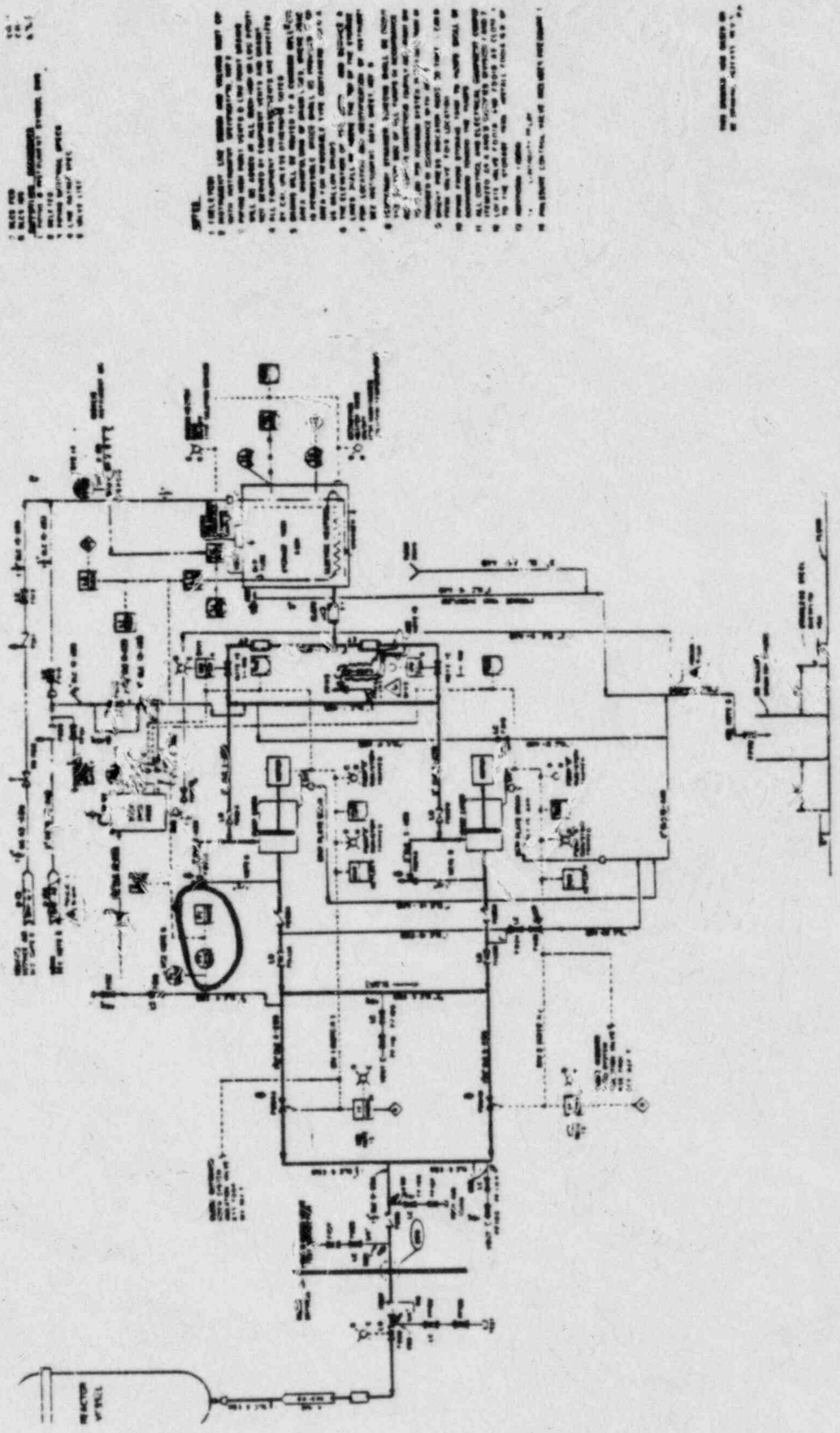
- No flow indication provided
- Flow meter could cause flow blockage

DEVIATION

- SLC Pressure considered an alternate variable (PI R600) [Figure 9.3-5]

JUSTIFICATION

- Indicates proper system function
  - high pressure indicates flow blockage
  - erratic or low pressure indicates line break
- Back up information available
  - Squib valve position
  - Neutron Flux
  - SLC tank level
- Qualification of indicator required (change to essential MPL classification)



Drawing K-105, Rev f

Figure 9.3-5. Standby Liquid Cont
P&I Diagram

GESSAR II
Regulatory Guide 1.97 Assessment
Deviation Justification

Variable: Vent Flow Rate
(SGTS Common Vent)
Ref. Figure 6.5-1

GESSAR Section: 1D.2.3.34

<u>PROBLEM</u>

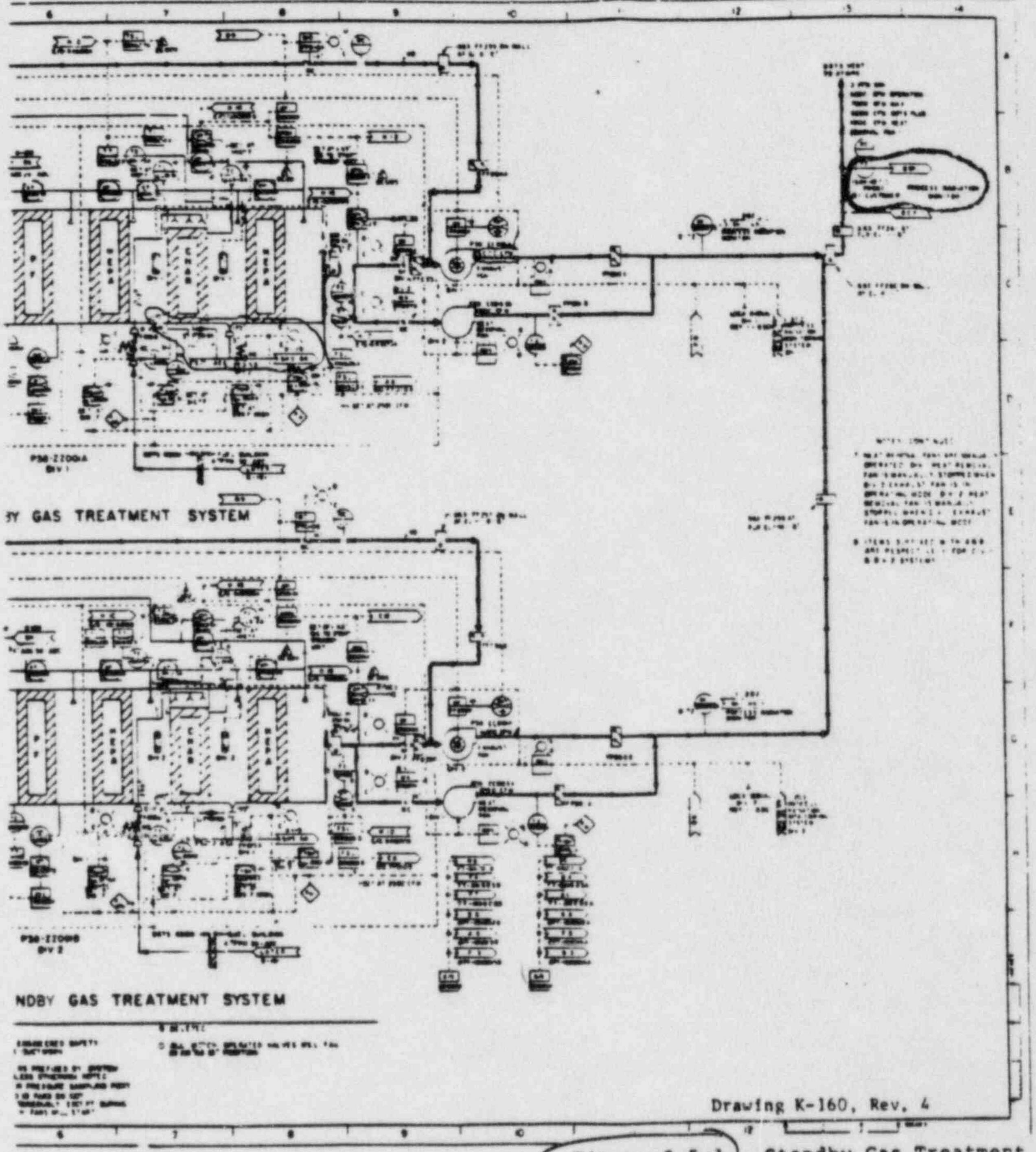
- No SGTS Flow monitor in design (Isokinetic Probe provided by applicant) [Figure 6.5-1]

<u>DEVIATION</u>

- Damper position is an alternate variable [Figure 6.5-1]

JUSTIFICATION

- Indication in control room [Figure 7A.3-9a]
- Design flow rate may be used for release assessment if isokinetic flows are unavailable.



Drawing K-160, Rev. 4

Figure 6.5-1. Standby Gas Treatment System - PSI Flow Diagram

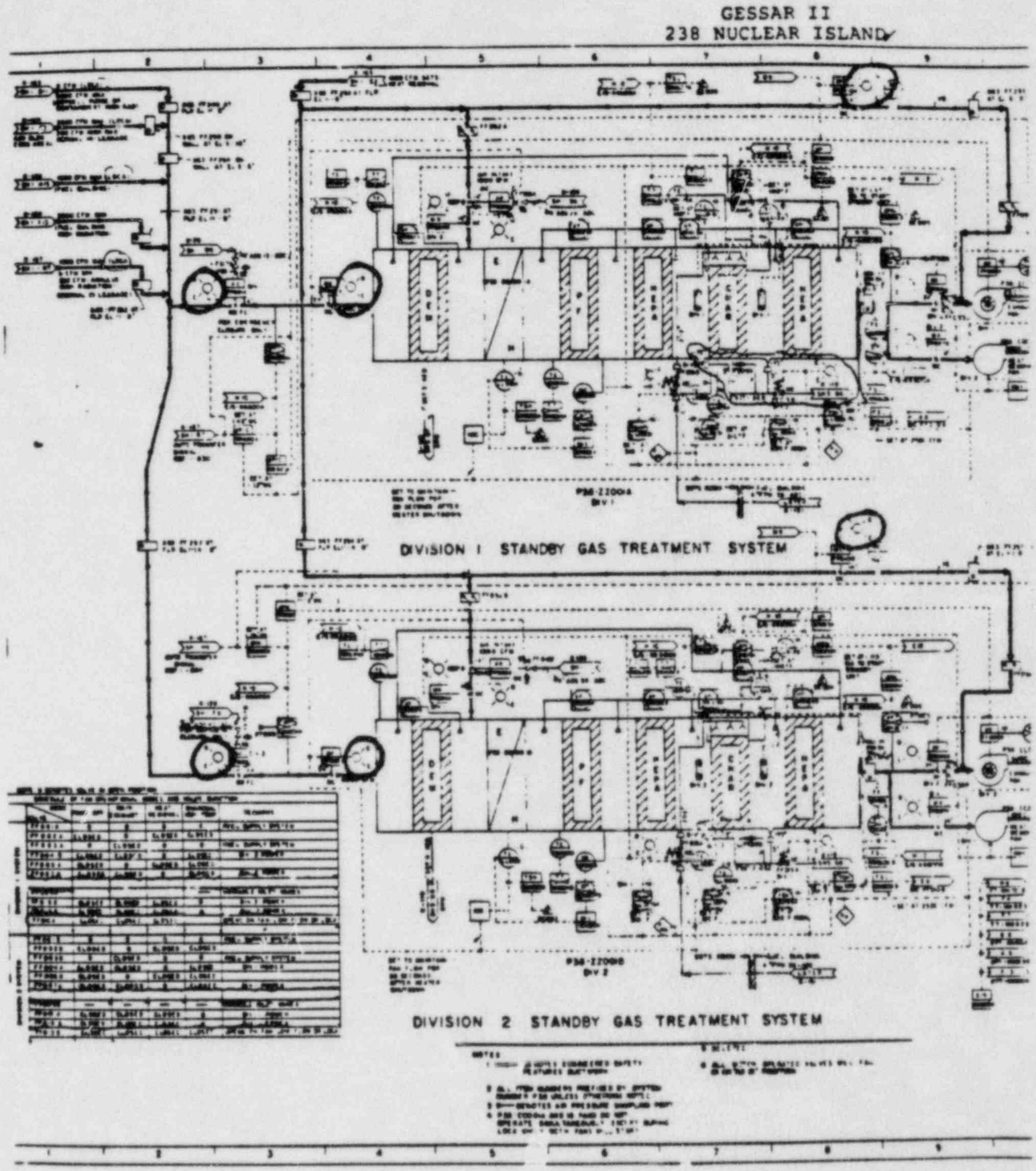

GESSAR II
238 NUCLEAR ISLAND
DIVISION 1 STANDBY GAS TREATMENT SYSTEM
DIVISION 2 STANDBY GAS TREATMENT SYSTEM
DIV 1
DIV 2
NOTES

Figure 6.5-1

GESSAR II
Regulatory Guide 1.97 Assessment
Deviation Justification

Variable: LPCI Flow
Ref. Figure 5.4-12
GESSAR Section: 1D.2.3.22

PROBLEM

- No Flow monitoring of LPCI Leg only (Loop A,B only; Loop C is LPCI dedicated)
- RHR system flow provided [Figure 5.4-12a,c] for all three loops

DEVIATION

- For Loop A&B LPCI injection valve position & RHR flow is alternate variable [Figure 5.4-12b]

JUSTIFICATION

- Valve position sensors are qualified; indication in control room
- RPV water level is a backup variable

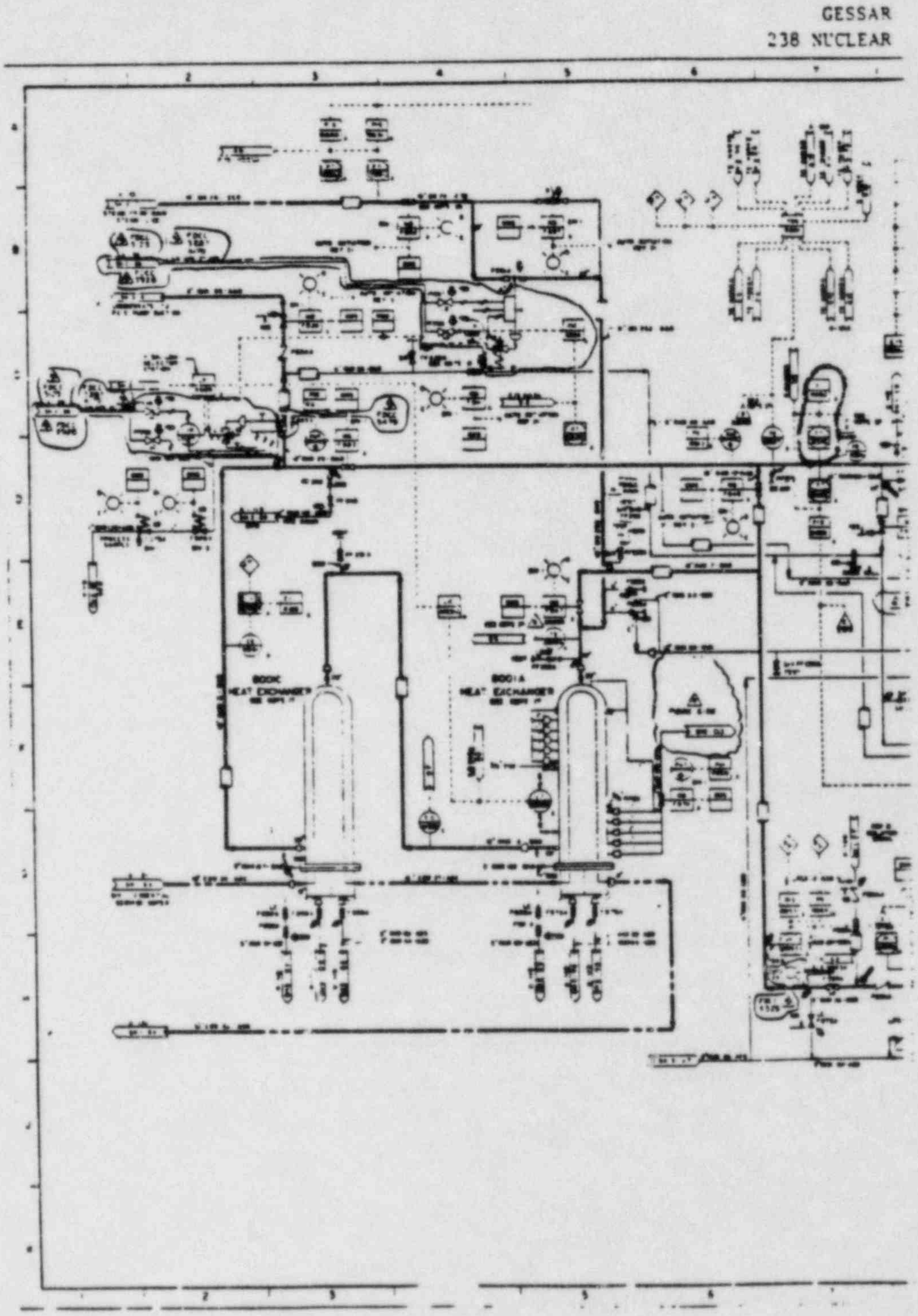


Figure 5.4-12a

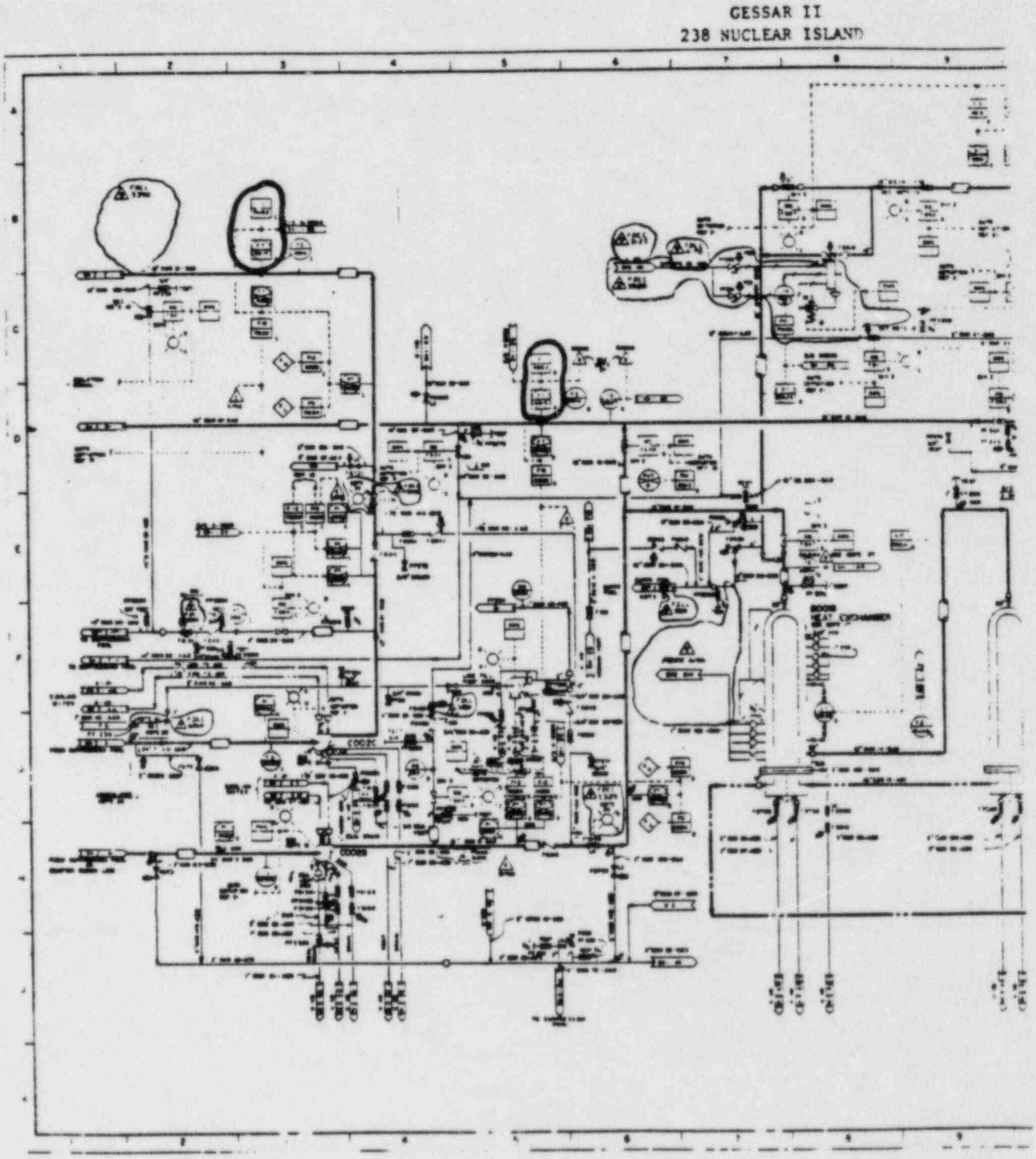


Figure 5.4-12c

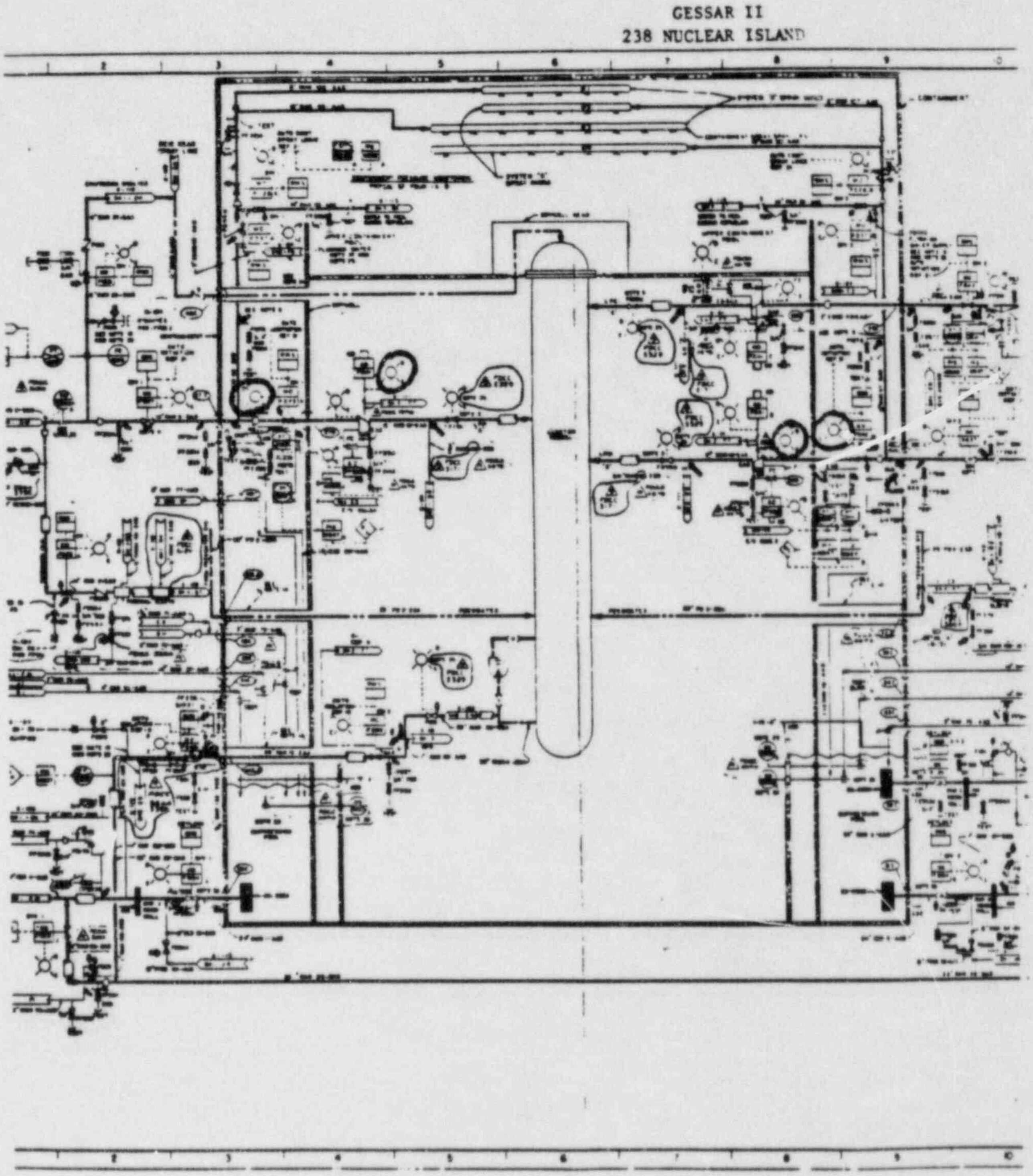


Figure 5.4-12b

GESSAR II
Regulatory Guide 1.97 Assessment
Deviation Justification

Variable: Containment Spray Flow
Ref: Figure 5.4-12
GESSAR Section: 1D.2.3.22

PROBLEM

- No flow monitor of Containment Spray only
- RHR System (Loop A and B) flows monitored [Figure 5.4-12a]

DEVIATION

- Containment Spray valve position & RHR flow is alternate variable [Figure 5.4-12b]

JUSTIFICATION

- Valve position sensors are qualified indications in control room
- Containment Pressure indication is back up variable

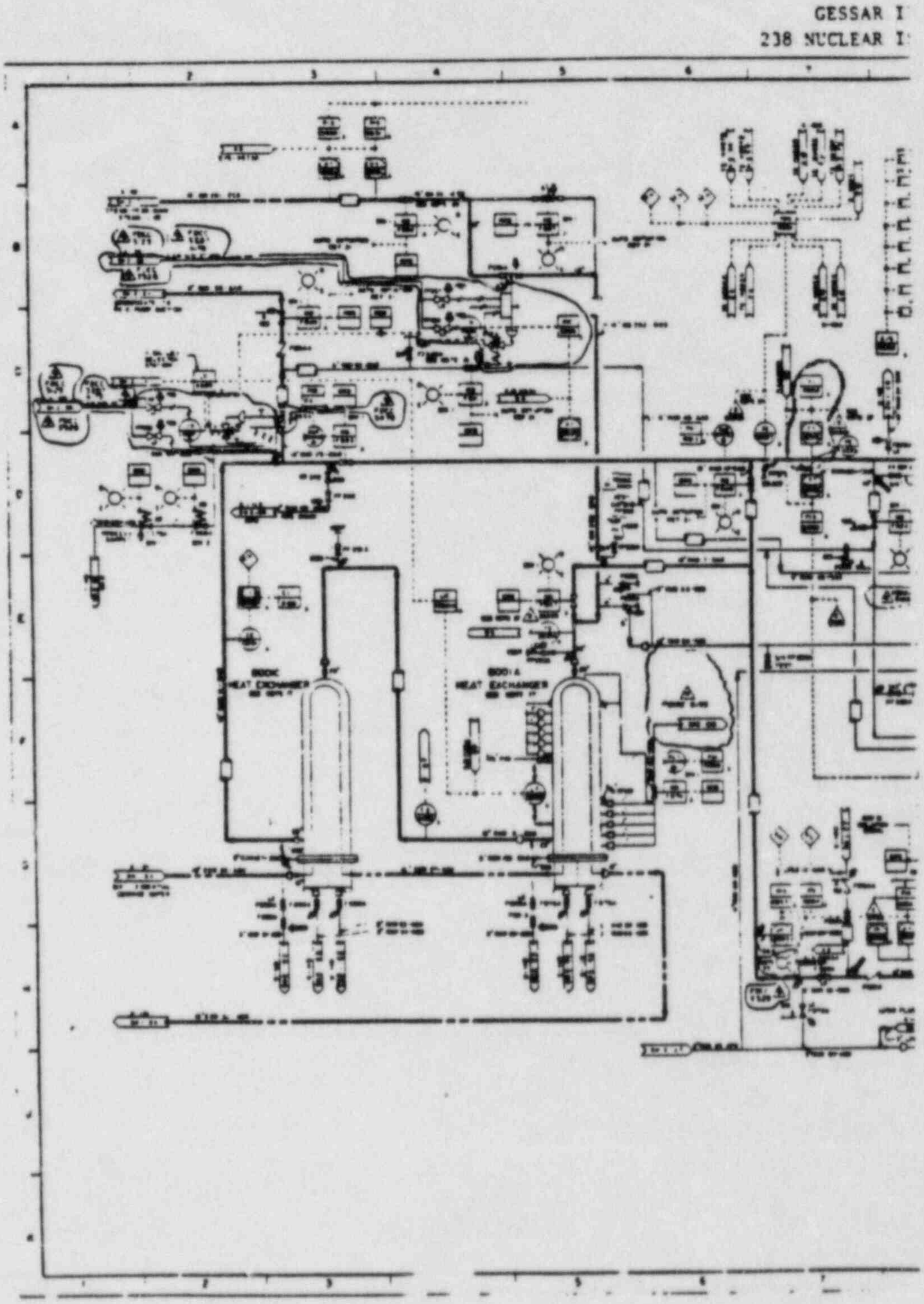


Figure 5.4-12a

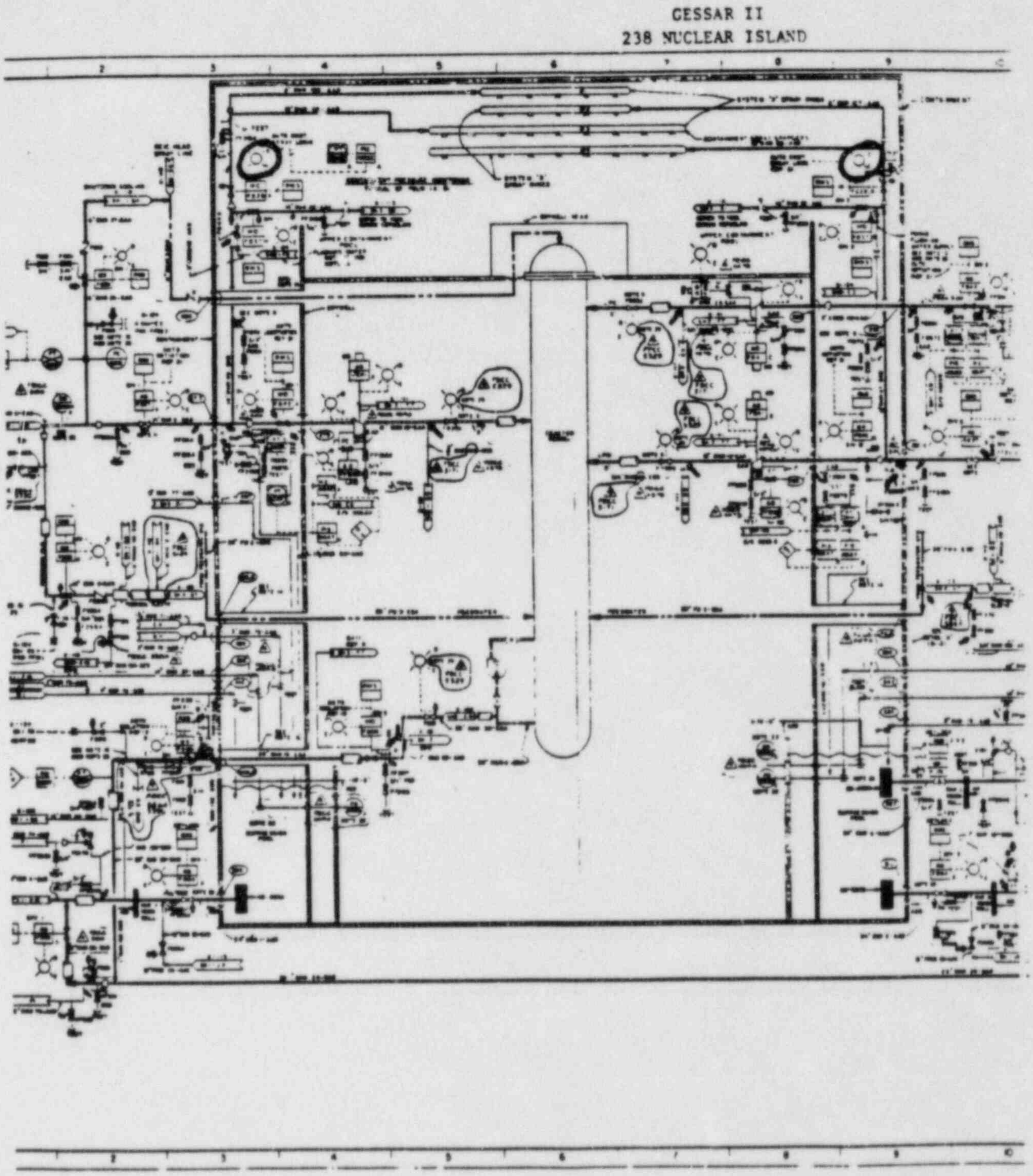


Figure 5.4-12b

GESSAR II
Regulation Guide 1.97 Assessment
Deviation Justification

Variable: RPV Level GESSAR Section: 1D.2.3.4
Ref: Figure 5.1-3

PROBLEM

- Mechanical Separation above wide range not possible (single dome reference pot) [Figure 5.1-3c]
- High water indication not a safety concern (with good LB trips on High Pressure Systems) (only needed for EPG contingency 5)
- Table 1 (R.G. 1.97) specifies range to centerline of steam line

DEVIATION

- Alternate range for Category 1 indication is to top of wide range zone

JUSTIFICATION

- Existing shutdown range is adequate to main steam lines (meets category 3)

NOTE: Deviation assumes Enhanced Level Instrument (ELI) to meet the intent of R.G. 1.97.

GESSAR II
Regulatory Guide 1.97 Assessment
Deviation Justification

Variable: Incore Temprature GESSAR Section: 1D.2.3.4

PROBLEM

- No incore temperature measurement
- Table 1 (R.G. 1.97, Rev. 2) specifies incore thermocouples
- Table 1 (R.G. 1.97 Draft 1, Rev. 3) specifies incore temperature (considered pending further development)
- No diverse indication of core cooling
- Indication of inadequate core cooling required (NUREG 0737 II.F.2) (approach to, onset, recovery from)

DEVIATION

- RPV water level measurement satisfies requiements for core cooling indication

JUSTIFICATION

- Enhanced water level (ELI) provides unambiguous indication of approach to and existance of ICC
- EPG's provide operator actions to prevent ICC
- ELI Third division eliminates need for diversity
- ECCS Flow indication provides indication of recovery from ICC. (NEDO 24708A Analysis Supports)

GESSAR II
Regulatory Guide 1.97 Assessment
Deviation Justification

Design Changes Being Made
ENHANCED LEVEL INSTRUMENT (ELI)

PROBLEM

- Fuel zone non-safety
- Ambiguous indication with conflicting channels
- Poor accuracy under off-calibration conditions
- No diverse indication (inadequate core cooling monitor) (Per NUREG 0737 II.F.2)

SOLUTION

- 3 Class 1E mechanical divisions
- Bottom core plate to above normal range
- Compensation for:
  - RPV pressure
  - Drywell temperature
- Alarms to prompt operator
  - Boiling/flashing
  - Channel mismatch
  - Leaking equalizer or line break

STATUS

- Design defined
- Commercially available
- Other level system features
  - Limited sensing line drop
  - Orifices near drywell wall
  - Non-safety high water level monitors

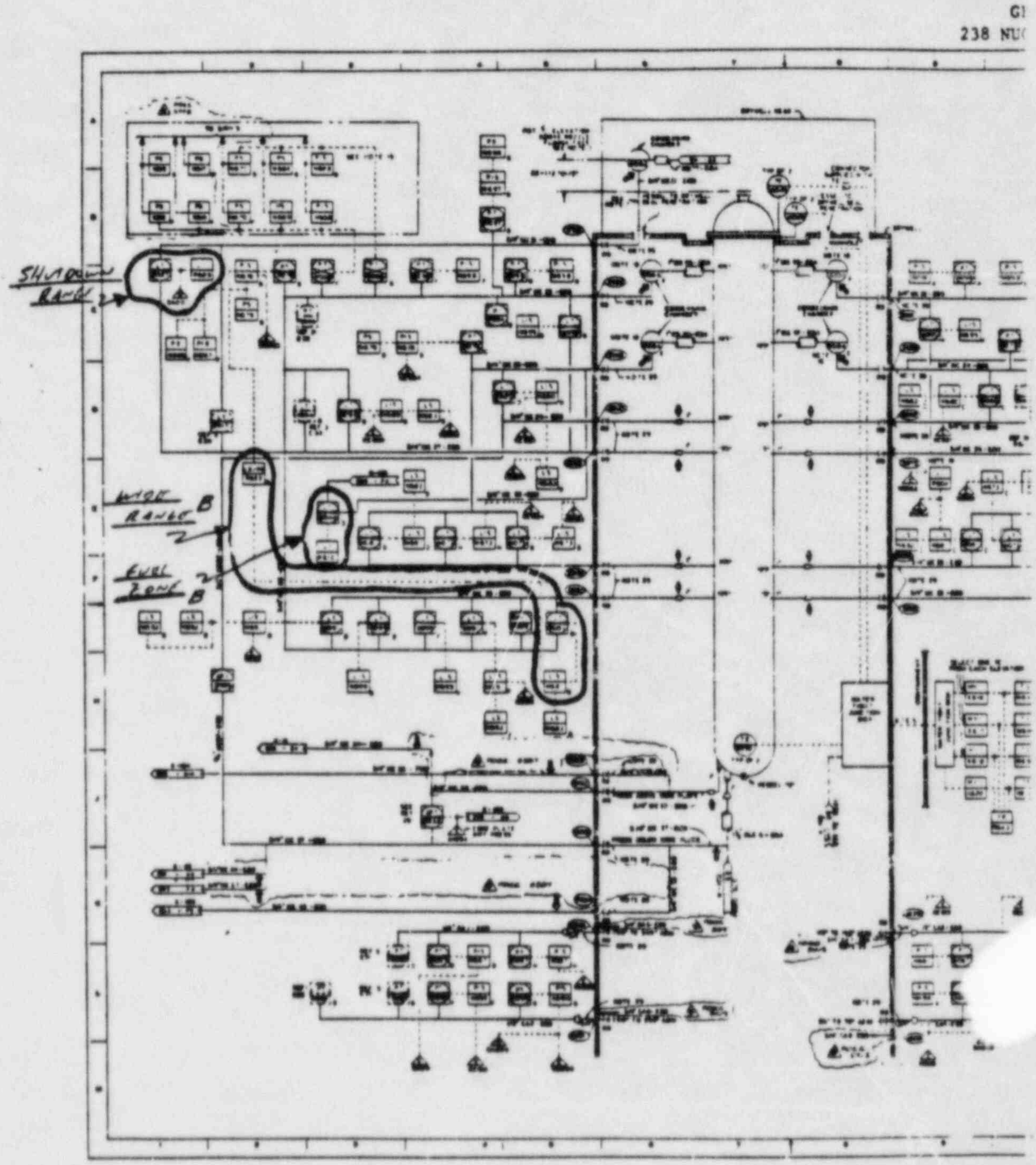


Figure 5.1-3c

GESSAR II
238 NUCLEAR ISLAND

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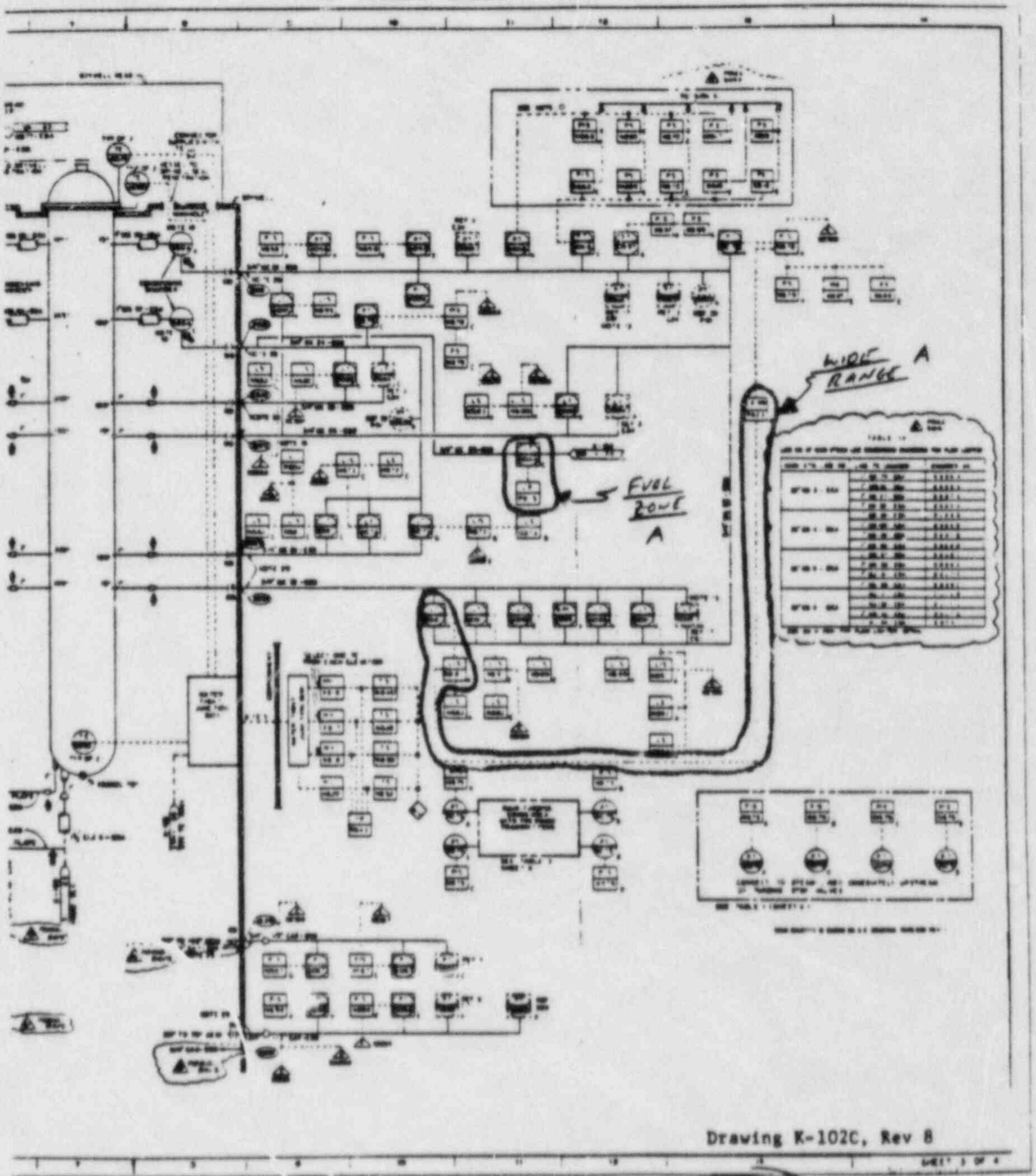
Rev. 0



Drawing K-102C, Rev 8

Figure 5.1-3c. Nuclear Boiler Sys P&I Flow Diagram

5.1-11

GESSAR II
Regulatory Guide 1.97 Assessment
Deviation Justification

Variable: Containment Pressure GESSAR Section: 1D.2.3.12
Ref: Figure 9.4-6

PROBLEM

- Table 1 (R.G. 1.97) specifies 4 x Design Pressure Range (= 60 psig)
- Existing Range is 2 x Design Pressure (= 30 psig)
- Ultimate Containment Pressure is 58 psig per BWR/6 PRA.
- No indication of Containment Failure
- No recording of indication

DEVIATION

- Existing range and method of indication is adequate

JUSTIFICATION

- 35 hrs available before reaching top of indicating range - time available to open MSIV's or reestablish containment cooling. [Table 18.2-3a]
- Trend information is useful, but not essential to follow EPG's

POTENTIAL ALTERNATE

- Change Design to 0-60 psig range

  Change pressure indicators to recorders (R.G. 1.97 Rev. 3 requires all category 1 channels to be recorded)

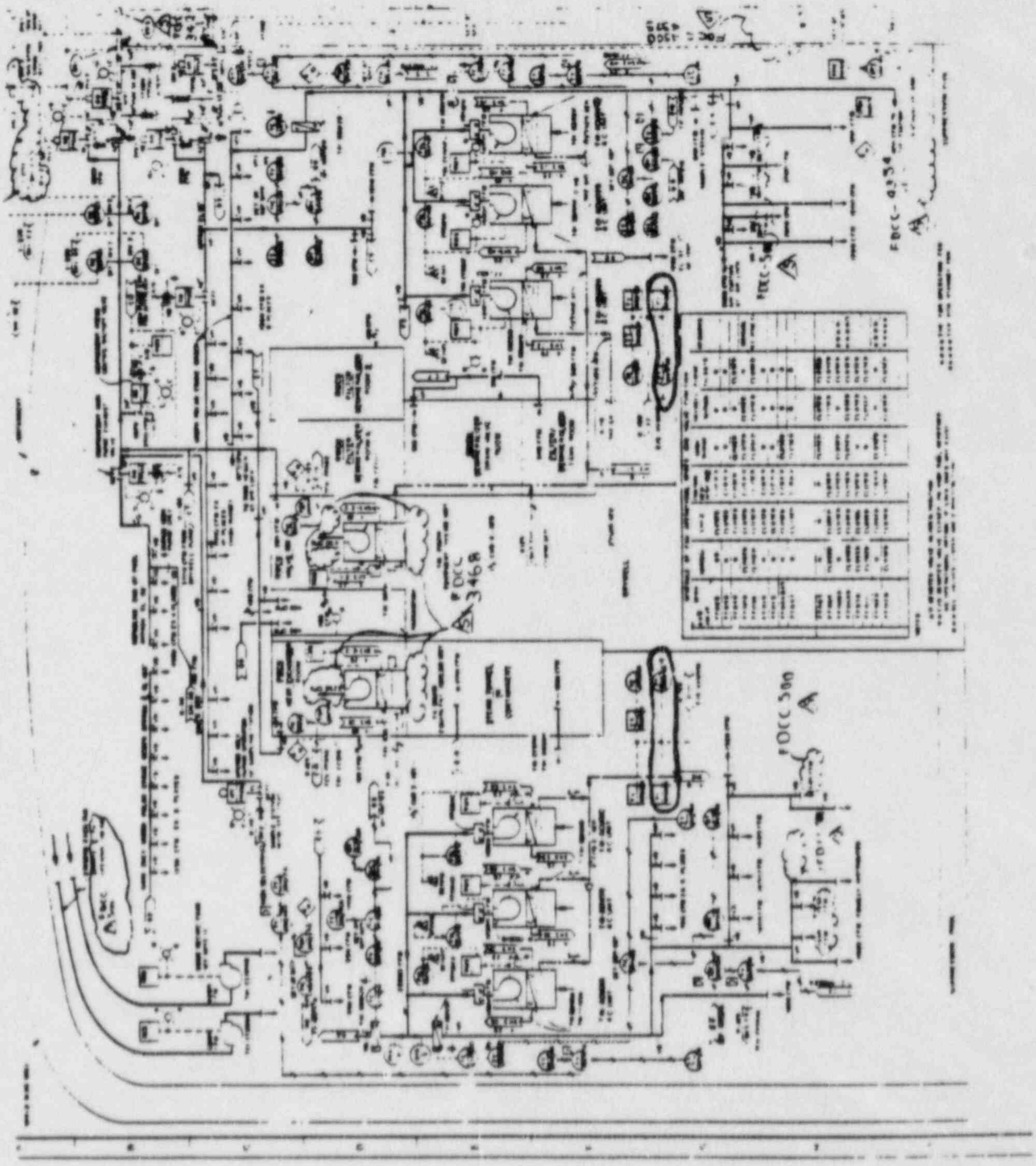


Figure 9.4-6

GE PROPRIETARY - provided under separate cover

GESSAR II
Regulatory Guide 1.97 Assessment
Deviation Justification

Variable: Suppression Pool Water Level — GESSAR Section: 1D.2.3.9

PROBLEM

- Table 1 (R.G. 1.97) specifies bottom of ECCS Suction to 5 feet above normal for type c [Figure 5.1-4a markup]
- Table 1 (R.G. 1.97) specifies top of vent to top of wier wall for type d.
- GESSAR Design covers 12 foot range to 6 ft 8" above normal water level

DEVIATION

The existing range is adequate for expected situations

JUSTIFICATION

Re: Low End of Scale

- Upper Pool Dump initiates at 18'5" (raises water level)
- High suppression pool level causes auto transfer to pumps external to containment to pool (20'5")
- Lower tap risks fouling following SRV action or vent clearing.

Re: High End of Scale

- Dry well sump level indicates wier overflow
- ADS causes ≈5' pool rise (within scale of indication)

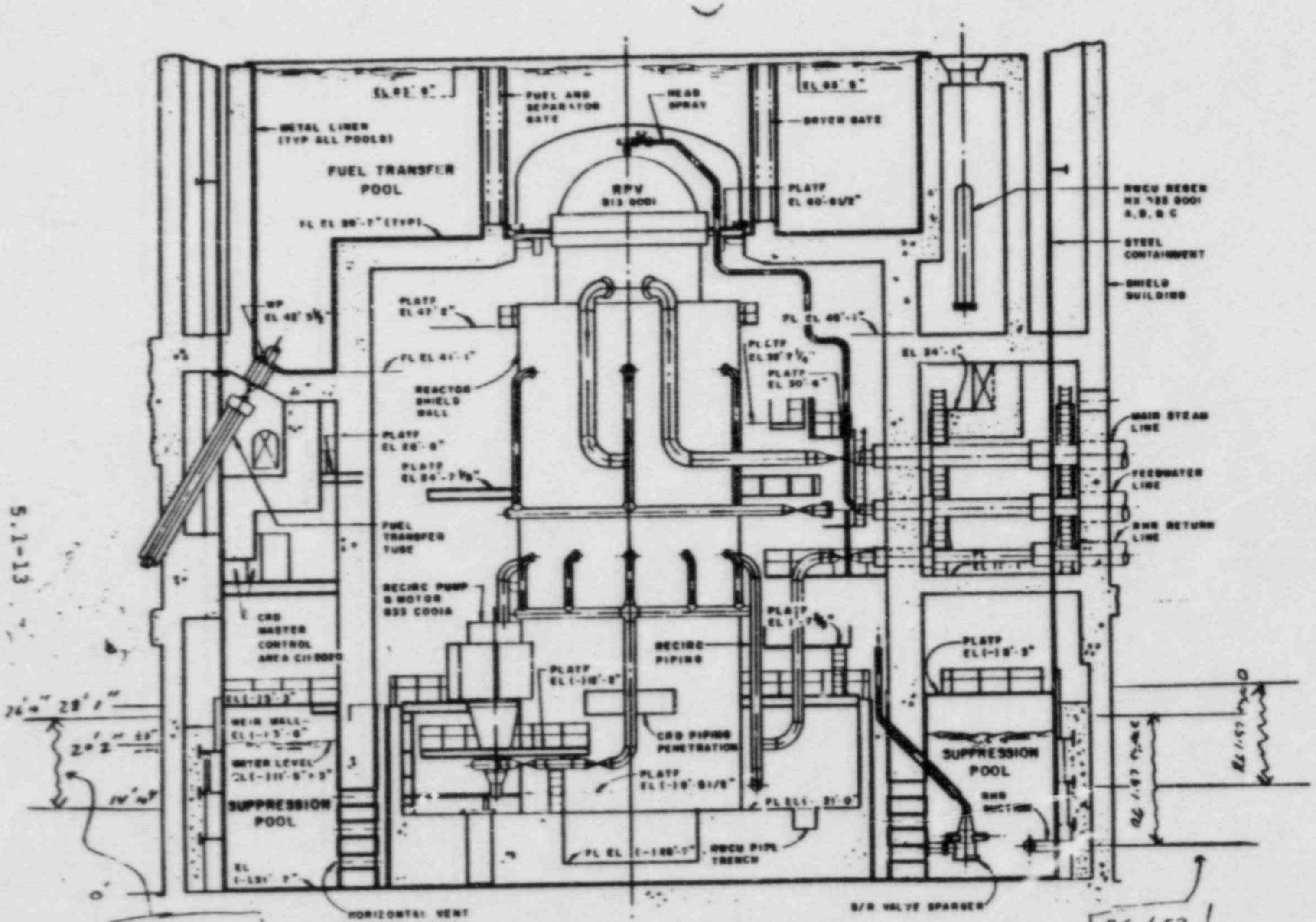


Figure 5.1-4a. Containment Elevation Piping Drawing (Section A-A)

GESSAR
Design

RG 1.57
Requirement

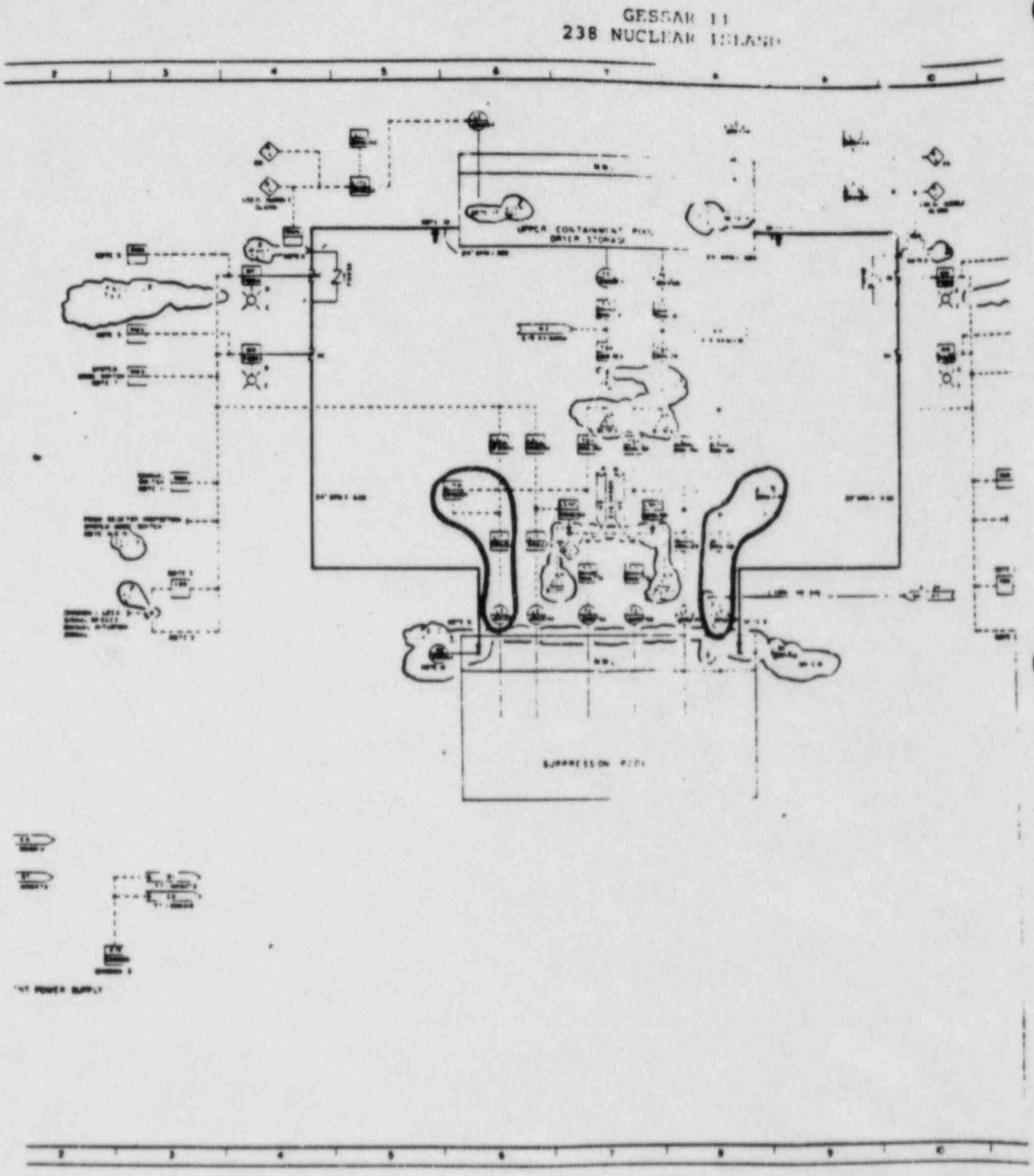

GESSAR II
238 NUCLEAR ISLAND
UPPER CONTAINMENT POOL
DRYER STORAGE
SUPPRESSION POOL
NT POWER SUPPLY

Figure 6.2-65

GESSAR II
Regulatory Guide 1.97 Assessment
Deviatin Justification

Variable: Drywell Air temperature
Ref: Figure 9.4-5

GESSAR Section: 1D.2.3.18

PROBLEM

- Table 1 (R.G. 1.97) specifies 440°F upper range
- GESSAR Design is to 400°F [Figure 9.4-5]

<u>DEVIATION</u> The lower range is acceptable

<u>JUSTIFICATION</u>

- Highest post LOCA Drywell temperature is ≈ 340° for a Main Steam Line Break [Figure 6.2-12]

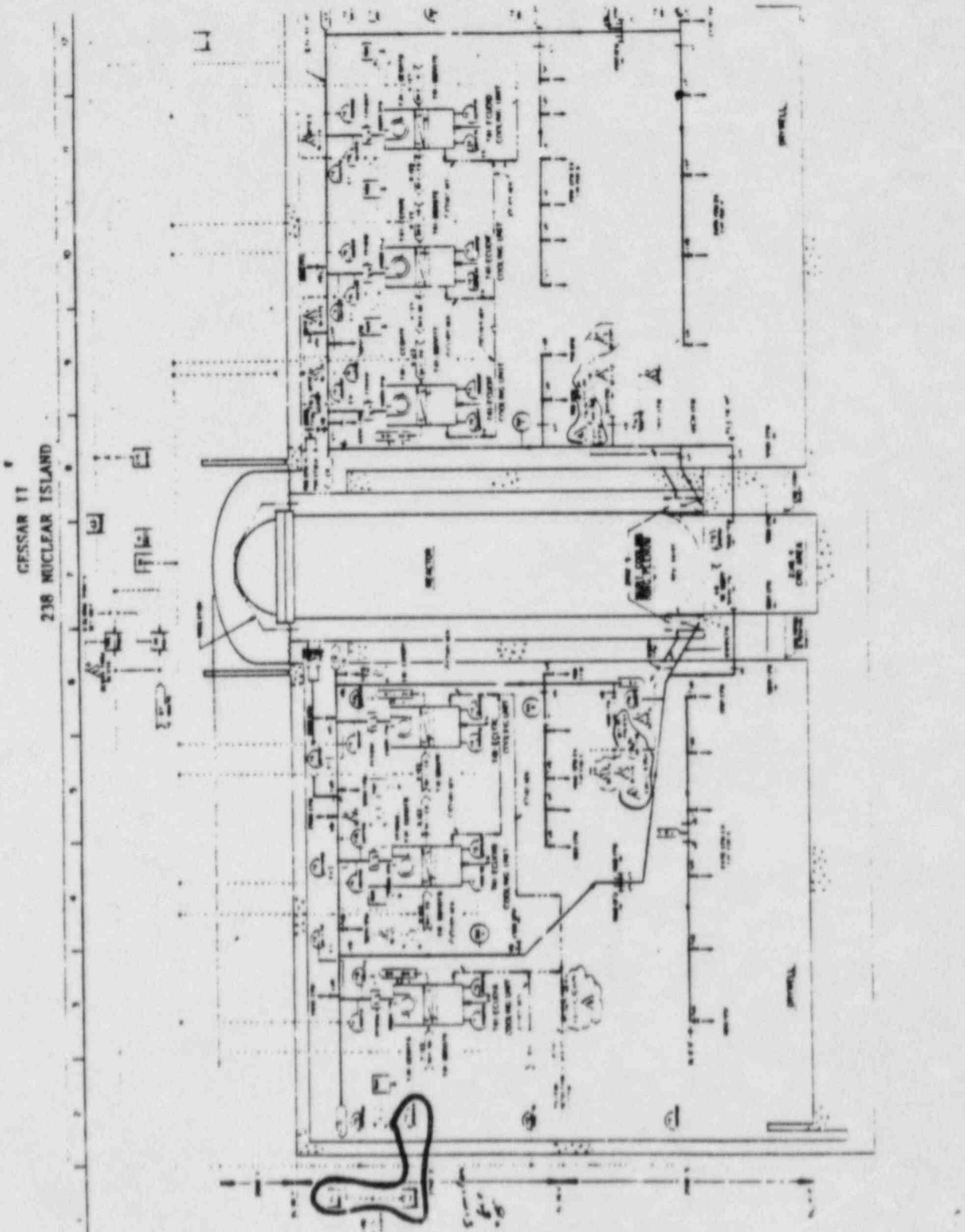


Figure 9.4-5

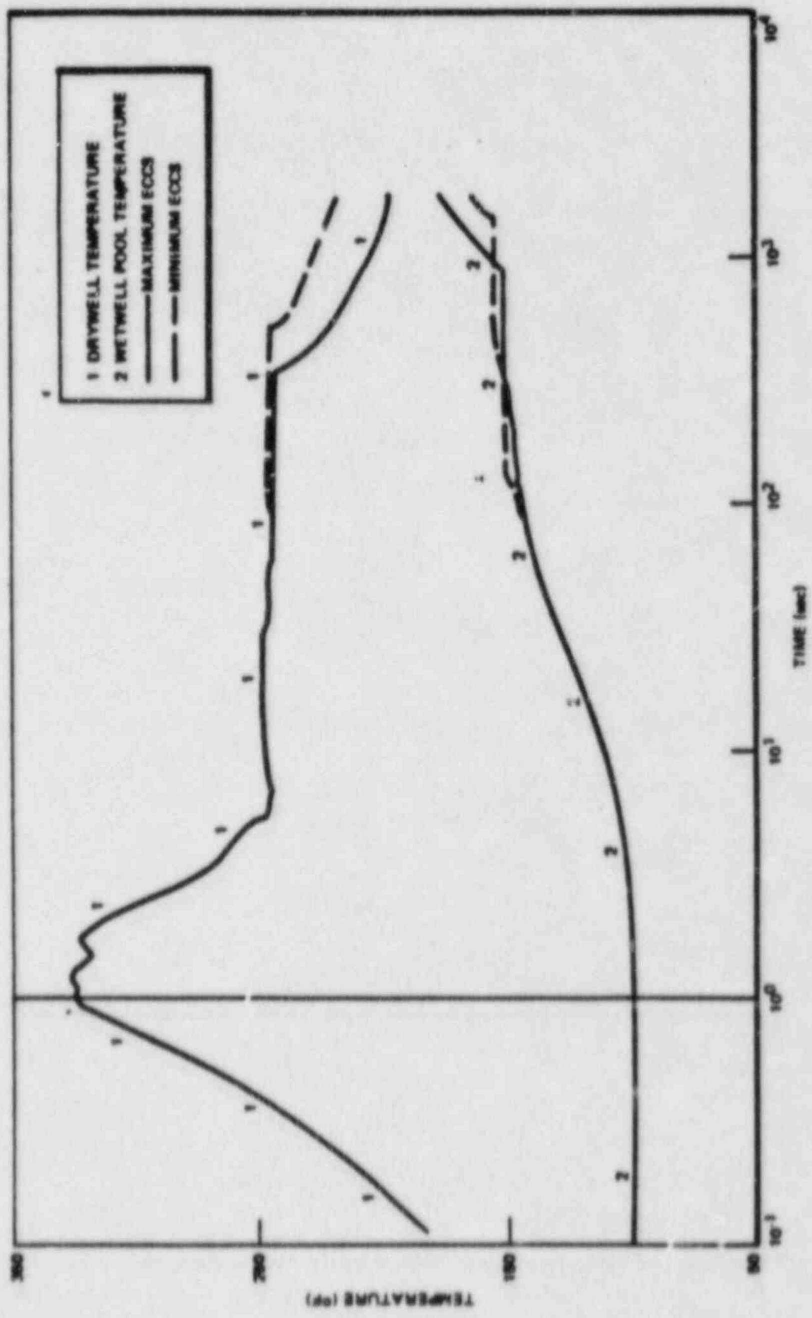


Figure 6.2-12. Short-Term Temperature Response Following a Main Steamline Break

GESSAR II
Regulatory Guide 1.97 Assessment
Deviation Justification

Variable: Coolant Radiation GESSAR Section: 1D.2.3.19

PROBLEM

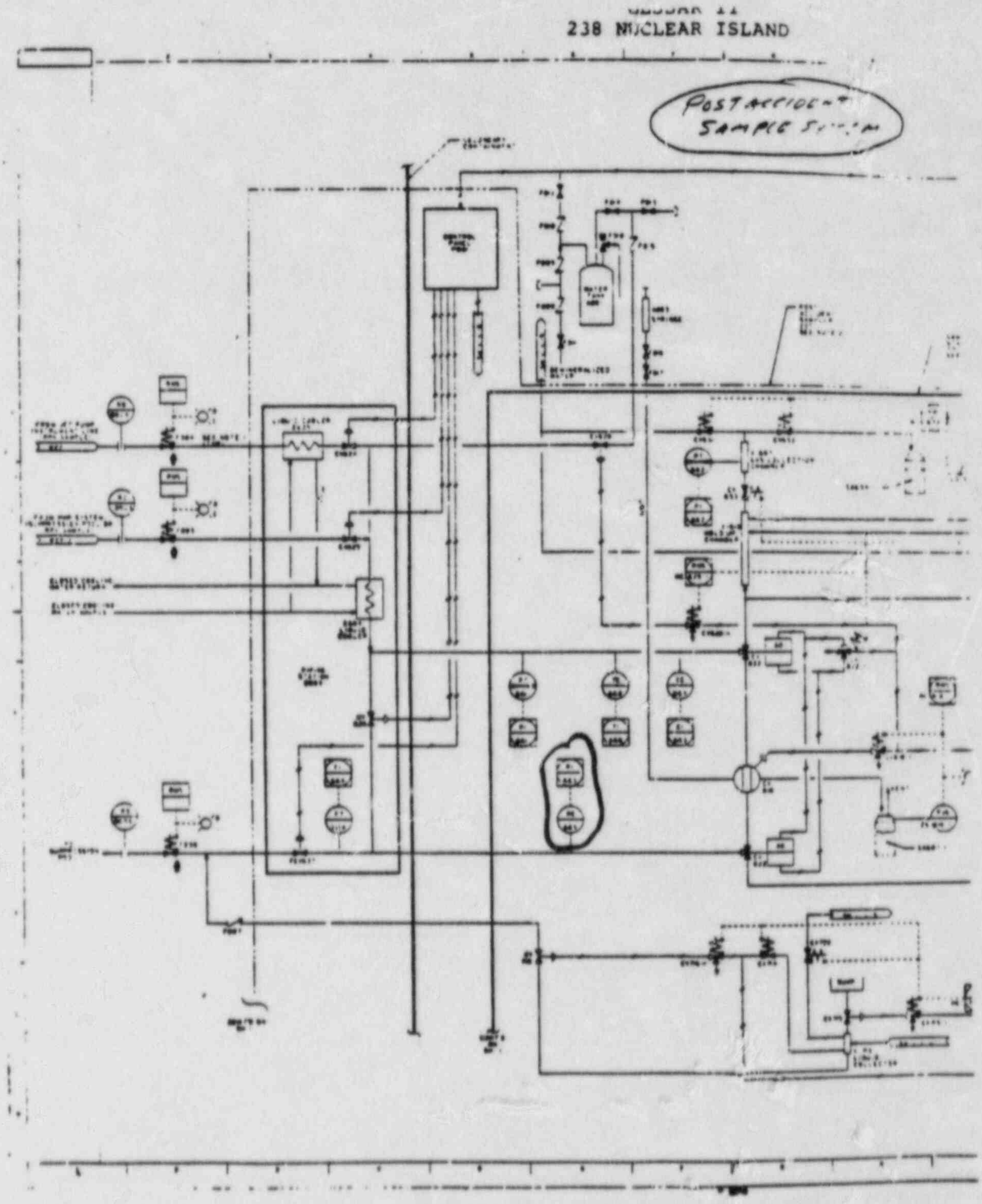
- No Instrumentation Provided
- Table 1 (R.G. 1.97) specifies radioactivity monitor of "Circulating Primary Coolant" to detect fuel cladding breach
- Table 1 (R.G. 1.97) range specified is ½ tech spec limit (TSL) to 100 x TSL

DEVIATION

- Post accident sample system provides adequate information

JUSTIFICATION

- Interference by N-16 and Co-60 may make monitoring of TSL impractical or ambiguous
- Significant fuel release would exceed 100 TSL (100 TSL is not a public health risk)
- Post accident sample station identified gross [Figure 1AB.1-1a]
  Gamma indication - indicates radiation of circulating sample prior to sample.



POST ACCIDENT
SAMPLE SYSTEM

Figure 1AB.1-1a

GESSAR II
Regulation Guide 1.97 Assessment
Deviation Justification

Variable: Post Accident Samples

GESSAR Section: 1D.2.3.38

PROBLEM

- No sampling capability for Containment or Auxiliary Building Sumps
- Table 1, Note 17 (R.G. 1.97) specifies that capability should be provided for Release Assessment, Verification or analysis.

DEVIATION

- Sump samples are not needed

JUSTIFICATION

- Sumps are isolated (not a source of release)
- RPV or suppression pool liquid samples provide indication of extent of core damage
- Process radiation monitors are used for release assessment
- Analysis of sumps would be ambiguous

GESSAR II
Regulatory Guide 1.97 Assessment
Deviation Justification

Variable: Drywell Sump Level GESSAR Section: 1D.2.3.6
Ref: Figure 7.6-12c,d

PROBLEM

- Single Channel Sump Monitoring Provided in design
- Table 1 (R.G. 1.97) specifies category 1 requirements (Redundant, qualified, station standby power)

DEVIATION

- Category 3 (commercial, single channel) requirements are acceptable

JUSTIFICATION

- Sumps isolated by accident
- Backup indication to Drywell pressure and radiation level
- Early indication only

NOTE: Equipment Drain Sump modification is being made

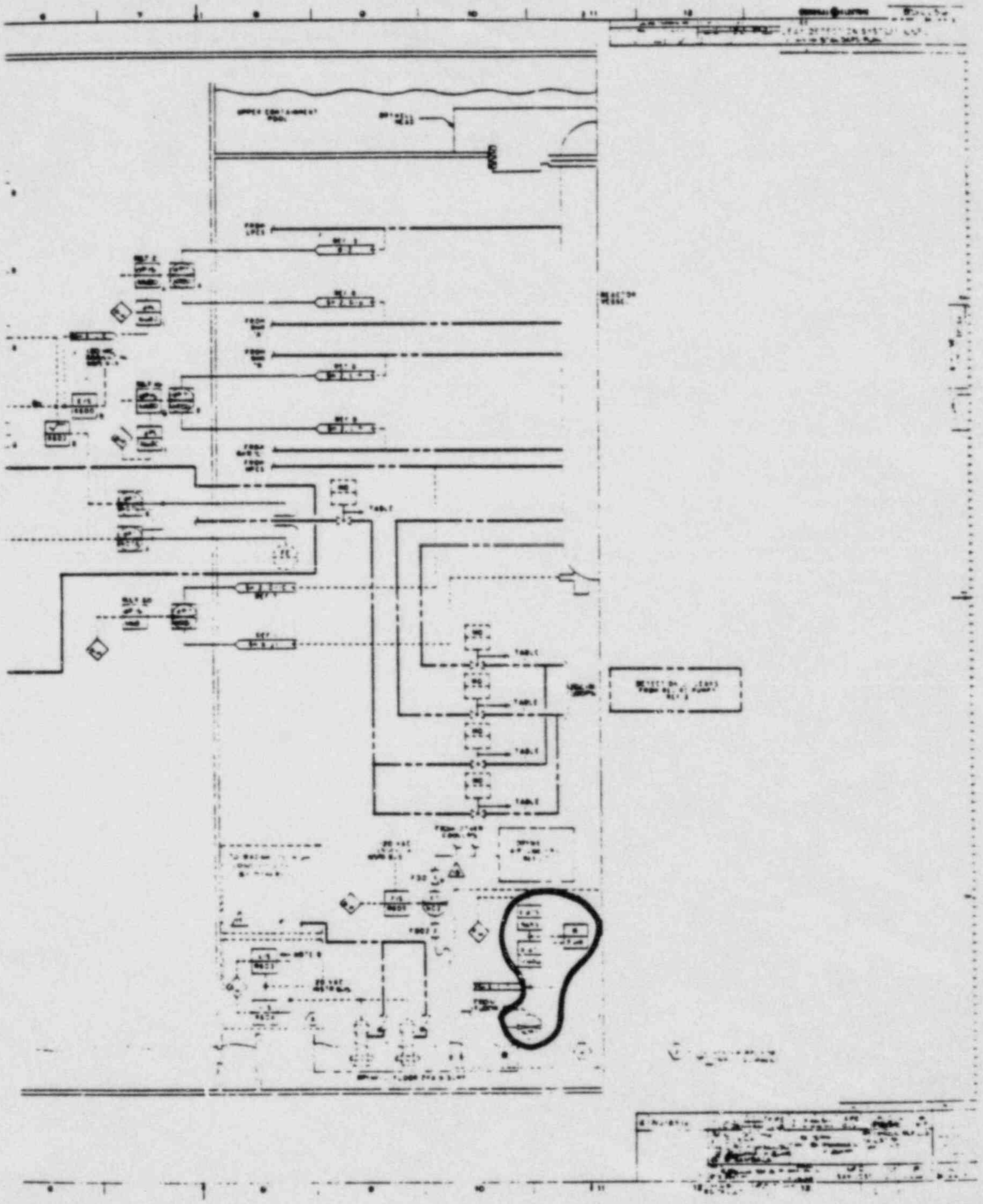


Figure 7.6-12c. Leak Detection System IED

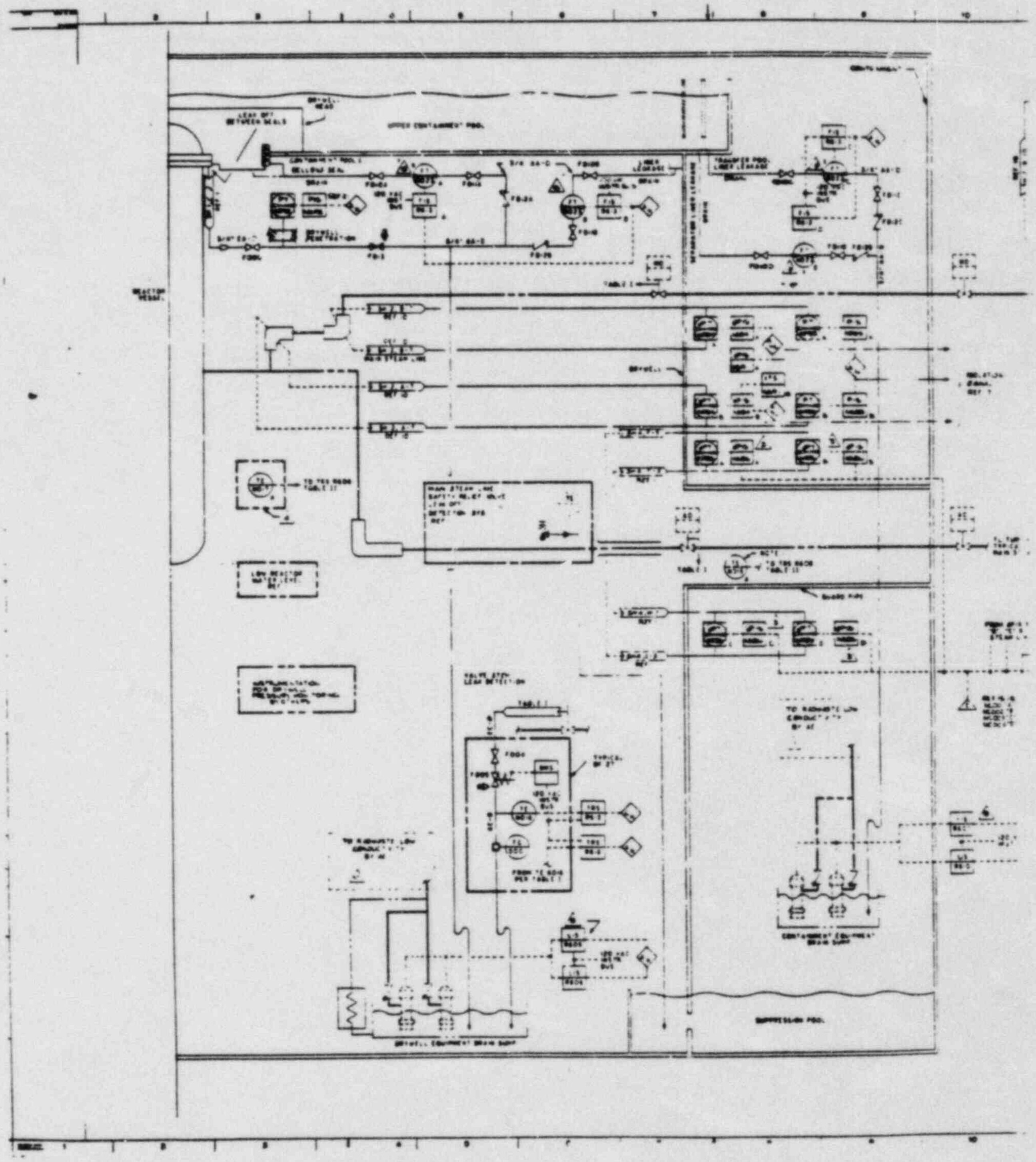


Figure 7.6-12d

GESSAR II
Regulatory Guide 1.97 Assessment
Deviation Justification

Design Changes Being Made
DRYWELL SUMP MONITORS

PROBLEM

- No indication of drywell equipment drain sump level
- Indication of floor drain sump is non-safety, single channel

SOLUTION

- Justify single channel non-safety design criteria (Cat. 3)
- Add level monitor to equipment drain sump (level and rate of change)

STATUS

- Design complete

GESSAR II
Regulatory Guide 1.97 Assessment
Deviation Justification

Variable: SLC tank level GESSAR Section: 1D.2.3.26
Ref: Figure 9.3-5

PROBLEM

- Single channel, commercial indication in design
- Table 1 specifies category 2 requirements (qualified, reliable power)
- Improved ATWS 3A design is narrow range only
- Air supply reliability not assured with containment isolation

DEVIATION

- Present design is adequate

JUSTIFICATION

- Back up variable to SLC pressure
- Air supply reliability is assured until isolated air supply bleeds off [Figure 9.3-5] [Figure 9.3-2b]

POTENTIAL ALTERNATE

Add category 3 differential pressure wide range instrumentation

GESSAR II
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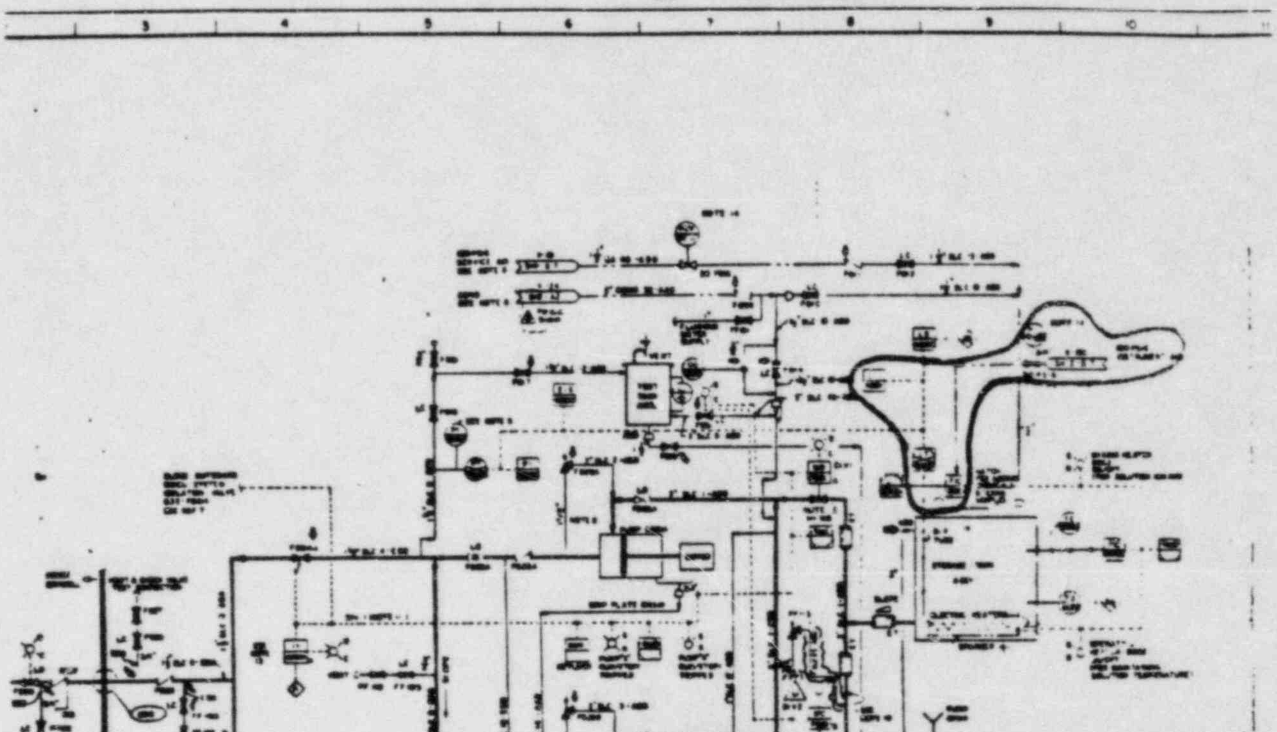

Figure 9.3-5

GESSAR II
238 NUCLEAR ISLAND

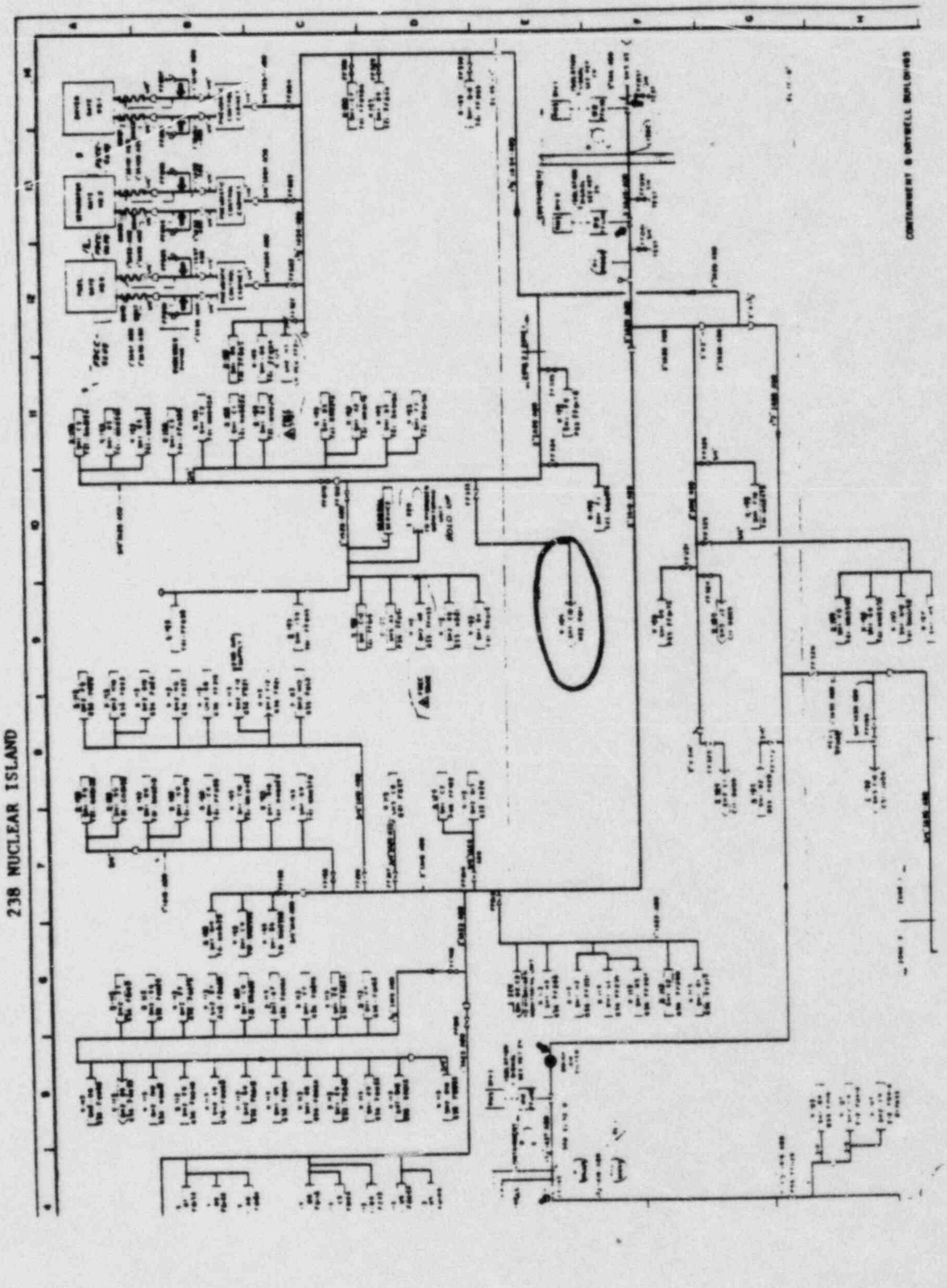

Figure 9.3-2b

APPENDIX 15.E.3

ACTION PLAN FOR RESOLUTION OF CONTAINMENT DESIGN ISSUES IDENTIFIED BY JOHN HUMPHREY

GENERAL ELECTRIC -- GESSAR II -- ACTION PLAN

Action Plan 1

I. Issues Addressed

1.1 Presence of local encroachments such as the TIP platform, the drywell personnel airlock and the equipment and floor drain sumps may increase the pool swell velocity by as much as 20 percent.

1.2 Local encroachments in the pool may cause the bubble breakthrough height to be higher than expected

1.4 Piping impact loads may be revised as a result of the higher pool swell velocity.

II. Program for Resolution

1.+ Provide details of the one-dimensional analysis which was completed and showed a 20% increase in pool velocity.

2.+ The two-dimensional model will be refined by addition of a bubble pressure model and used to show the pool swell velocity decreases near local encroachments. The code is a version of SOLA.

3.+ The inherent conservatisms in the code and modeling assumptions will be listed.

4.+ The modified code will be benchmarked against existing clean pool PSTF data.

5.+ A recognized authority on hydrodynamic phenomena will be retained to provide guidance on conduct of the analyses.

6. A discussion of the local encroachment effects on pool swell will be provided.

III. Schedule

Item 6 will be completed at the time of first application.

\+ These results are generic in that they deal with analytical methods, data, or a combination of the two. The GGNS Action Plan response is applicable, and this element is considered to be closed.

GENERAL ELECTRIC - GESSAR II - ACTION PLAN

Action Plan 2

I. Issues Addressed

1.3 Additional submerged structure loads may be applied to submerged structures near local encroachments.

II. Program For Resolution

1. The results obtained from the two-dimensional analyses completed as part of the activities for Action Plan 1 have been used to define changes in fluid velocities in the suppression pool which are created by local encroachments. Supporting arguments to verify that the results from two-dimensional analyses are bounding with respect to velocity changes in the suppression pool are given in the attached response.

2. The velocity fields generated in Action Plan Element 2.1 have been reviewed. See the attached summary.

3. See the attached summary of design basis hydrodynamic loads.

Action Plan 2 -- GENERAL ELECTRIC RESPONSE

1. Fluid Velocities

Additional loads may be applied to both submerged structures and the pool boundary due to the effect of local encroachments. These two areas will be addressed separately:

A) Submerged Structure Loads

The results of the SOLA code analysis completed for Action Plan Element 1.6 are used in this study. The velocity and pressure fields throughout the pool are direct outputs of the modified SOLAV01. These changes in these fields may then be used to calculate the changes in loading determined in Action Plan Element 2.2

B) Pool Swell Boundary Loads

The present load definition specifies the pool swell boundary load on the drywell wall to be the peak drywell presure. There is a concern that the encroachment will increase the bubble pressure and cause the bubble to be translated closer to the containment wall, which will increase the pool boundary loading on the containment wall. Pressure on the containment wall is a direct output of the SOLAV code. The pool boundary load definition on the containment wall is based on PSTF full scale test data that has been correlated with SOLAV output. The PSTF design value is 10 psid. The maximum containment wall pressure is 97% of the PSTF design value. Thus, the encroachments do not cause the boundary design loads for GESSAR II to be exceeded. Consequently, General Electric considers this issue closed.

2. Velocity Fields

The SOLA fluid velocity fields in the vicinity of known submerged structures in the GESSAR II suppression pool have been analyzed for the unencroached and encroached cases. The maximum standard acceleration drag forces were calculated from the SOLAV velocity fields near the SRV quencher and ECCS piping. The sum of these two maximum drag loads was found to be less than the standard drag load calculated using a velocity of 32 ft/sec*. If the plant design included submerged structures at or above the top vent and within 12 feet of the drywell wall, additional analysis would be required, since the loads would be expected to exceed this envelope. GESSAR II does not have submerged structures in this area.

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*Based on current information, the minimum design criterion for submerged structures is a 32 ft/sec standard drag load.

Action Plan 2 -- GENERAL ELECTRIC RESPONSE

3. Hydrodynamic Loads

The hydrodynamic loading on the submerged equipment in the suppression pool due to structural encroachments has been found to be less than the load corresponding to the 32 ft/sec standard drag velocity per Action Plan Element 2.2. This value (32 ft/sec) has been used as the basis for comparison with the design loads on the existing submerged equipment.

The submerged equipment has been designed to the following standard drag velocities:

Wetwell Equipment

	SRV Quencher	ECCS Suction	RCIC Suction
a) Water jet loads	50 ft/sec	50 ft/sec	50 ft/sec
b) Air bubble loads	32 ft/sec	50 ft/sec	50 ft/sec
c) Pool swell loads	45 ft/sec	50 ft/sec	50 ft/sec
d) Pool fallback loads	35 ft/sec	50 ft/sec	50 ft/sec

As it can be seen from the table above, SRV quenchers, ECCS and RCIC suctions have been designed to a standard drag velocity no less than 32 ft/sec. It can be concluded that they are adequately designed to withstand the hydrodynamic loading due to structural encroachments.

As for SRV, ECCS and RCIC discharge pipes and instrumentation, the Applicant shall design this submerged equipment to withstand the hydrodynamic loading resulting from structure encroachment.

GENERAL ELECTRIC -- GESSAR II -- ACTION PLAN

Action Plan 3

I. Issues Addressed

1.5 Impact loads on the HCU floor may be imparted and the HCU modules may fail which could prevent successful scram if the bubble breakthrough height is raised appreciably by local encroachments.

II. Program For Resolution

1. The commitment of Action Plan 1 is expected to demonstrate by a conservative analysis that the maximum impact on the HCU floor due to encroachments is less than the existing design basis. This issue will be resolved prior to the first applicant reference to GESSAR II.

GENERAL ELECTRIC -- GESSAR II -- ACTION PLAN

Action Plan 4

I. Issues Addressed

1.6 Local encroachments or the steam tunnel may cause the pool swell froth to move horizontally and apply lateral loads to the gratings around the HCU floor.

II. Program For Resolution

1. A bounding analysis for determining the horizontal liquid and air flows created by the presence of the steam tunnel and HCU floor has been performed. The forces imposed on the HCU floor supports and grating were also calculated from this information. See the attached summary.

2. For a statement on the HCU floor lateral load capability, see the attached response.

GE PROPRIETARY - provided under separate cover

GENERAL ELECTRIC -- GESSAR II -- ACTION PLAN

Action Plan 5

I. Issues Addressed

2.1 The annular regions between the safety/relief valve discharge lines and the drywell wall penetration sleeves may produce condensation oscillation (CO) frequencies near the drywell and containment wall structural resonance frequencies.

2.2 The potential condensation oscillation and chugging loads produced through the annular area between the SRVDL and sleeve may apply unaccounted for loads to the SRVDL. Since the SRVDL is unsupported from the quencher to the inside of the drywell wall, this may result in failure of the line.

2.3 The potential condensation oscillation and chugging loads produced through the annular area between the SRVDL and sleeve may apply unaccounted for loads to the penetration sleeve. The loads may also be at or near the natural frequency of the sleeve.

II. Program for Resolution

1.+ The existing condensation data will be reviewed to verify that no significant frequency shifts occurred. The data will also be reviewed to confirm that the amplitudes were not closely related to acoustic effects.

2.+ GE intends to produce a generic SRVDL sleeve CO load definition. The driving conditions for condensation oscillation at the SRVDL exit will be calculated. Based on these calculations, existing test data will be used to estimate the frequency and bounding pressure amplitude of condensation oscillation at the SRVDL annulus exit. The new load case, taken in combination with existing main vent CO loads (CLR-basis), will then be compared, on an amplified response spectrum (ARS) basis, to other existing loads to show that existing load cases are bounding.

\+ These results are generic in that they deal with analytical methods, data, or a combination of the two. The GGNS Action Plan response is applicable, and this element is considered to be closed.

GENERAL ELECTRIC -- GESSAR II -- ACTION PLAN

3. Deleted

4. A detailed description of all hydrodynamic and thermal loads that are imposed on the SRVDL and the SRVDL sleeve during LOCA blowdowns is attached.

5&6. GESSAR II Appendix 3B will be modified by adding the following paragraphs to Section 3BA.10.2:

   (7) Applicant to provide SRVDL sleeve design which accommodates loads created by steam flow through the annulus region.

   (8) Applicant to provide definition of the external pressure loads which the SRVDL enclosed by the sleeve can withstand.

7. The maximum lateral loads which could be applied to the sleeve by phenomena analogous to the Mark I and Mark II downcomer lateral loads will be defined.

III. Schedule

Item 7 will be completed at the time of first application.

Action Plan 5 -- GENERAL ELECTRIC RESPONSE

4. SRVDL Loads

The hydrodynamic and thermal loads that are imposed on the SRVDL and the SRVDL sleeve during LOCA blowdowns are listed below:

SRVDL Piping

a. Hydrodynamic Loads

1) Dynamic response due to SRV (one, all, ADS) actuation
2) Horizontal Vent Chugging/Condensation Oscillation
3) Drag Loads due to Quencher Air Clearing
4) Vent Air Clearing Drag Loads

b. Thermal Loads

Thermal loads on piping are based on 470°F maximum steam temperature in the entire line.

SRVDL Sleeve

a. Hydrodynamic Loads

1) Horizontal Vent Chugging/Condensation Oscillation
2) Drag Loads due to Quencher Air Clearing
3) Vent Air Clearing Drag Loads

b. Thermal Loads

Thermal loads are based on 350°F steam temperature inside the sleeve.

GENERAL ELECTRIC -- GESSAR II -- ACTION PLAN

Action Plan 6

I. Issues Addressed

3.1 The design of the STRIDE plant did not consider vent clearing, condensation oscillation and chugging loads which might be produced by the actuation of the RHR heat exchanger relief valves.

3.7 The concerns related to the RHR heat exchanger relief valve discharge lines should also be addressed for all other relief lines that exhaust into the pool.

II. Program for Resolution

1. The appropriate section(s) of GESSAR II will be revised to specify the applicant to define all applicable dynamic loads and to demonstrate that all relief valve lines will be designed not to produce unacceptable loads on the containment boundary, the relief valve line containment penetration, submerged structures or safety related equipment. See attachment.

2. The appropriate section(s) of GESSAR II will be revised to specify the applicant to provide design/configuration of relief valve lines which exhaust into the suppression pool. See attachment.

Action Plan 6 -- GENERAL ELECTRIC RESPONSE

General Electric will revise GESSAR II by adding the following paragraphs to the appropriate section identified:

Section 5.4.7.2.3

The design and configuration of all safety related valve lines which exhaust into the suppression pool shall be provided by the applicant. The RHR System safety relief valves are to be designed to assure that physical damage to the RHR System and containment/structure will not result from dynamic loading associated with relief valve actuation. Specifically, all RHR System relief valves, except RHR relief valves E12-F055, that discharge to the suppression pool, discharge water. Normal actuation of these relief valves is caused by small quantities of water that either leak back from the reactor and/or result from thermal expansion of water in the systems' lines. Since these actuation conditions are characterized by pressure slowly approaching the relief valve setpoint on discharge of small quantities of water, significant water hammer and dynamic loads do not occur. The dynamic loading associated with abnormal actuation of these relief valves caused by spurious failure of the valves in the open position shall be provided by the applicant.

RHR relief valve E12-F055 is provided to prevent overpressurization of the RHR heat exchanger during the steam condensing mode (SCM). Actuation of this relief valve would occur if it spuriously failed open or if the steam pressure reducing valve E12-F051 failed open during the SCM and steam would be discharged to the suppression pool. The dynamic loading associated with actuation of valve E12-F055 during the SCM shall be provided by the applicant.

Section 6.3.1.1.3

The design and configuration of all ECCS safety relief valve lines which exhaust into the suppression pool shall be provided by the applicant. All ECCS safety relief valves are to be designed to assure that physical damage to these systems and containment/structure will not result from dynamic loading associated with relief valve actuation. Specifically, all ECCS relief valves, except RHR relief valve E12-F055 discussed in Section 5.4.7.2.3, that discharge to the suppression pool, discharge water. Normal actuation of these relief valves is caused by small quantities of water that either leak back from the reactor and/or result from thermal expansion of water in the systems' lines. Since these actuation conditions are characterized by pressure slowly approaching the relief valve setpoint and discharge of small quantities of water, significant water hammer and dynamic loads do not occur. The dynamic loading associated with abnormal actuation of these relief valves caused by spurious failure of the valves in the open position shall be provided by the applicant.

GENERAL ELECTRIC -- GESSAR II -- ACTION PLAN

Action Plan 7

I. Issues Addressed

3.2 The STRIDE design provided only nine inches of submergence above the RHR heat exchanger relief valve discharge lines at low suppression pool levels.

II. Program for Resolution

The Program for Resolution of Action Plan Element 6.1 and 6.2 apply to this item; accordingly, this issue is closed.

GENERAL ELECTRIC -- GESSAR II -- ACTION PLAN

Action Plan 8

I. Issues Addressed

3.4 The RHR heat exchanger relief valve discharge lines are provided with vacuum breakers to prevent negative pressure in the lines when discharging steam is condensed in the pool. If the valves experience repeated actuation, the vacuum breaker sizing may not be adequate to prevent drawing slugs of water back through the discharge piping. These slugs of water may apply impact loads to the relief valve or be discharged back into the pool at the next relief valve actuation and apply impact loads to submerged structures.

3.5 The RHR relief valves must be capable of correctly functioning following an upper pool dump which may increase the suppression pool level as much as five feet creating higher back pressures on the relief valves.

II. Program for Resolution

The Program for Resolution of Action Plan Element 6.1 and 6.2 apply to this item; accordingly, this issue is closed.

GENERAL ELECTRIC -- GESSAR II -- ACTION PLAN

Action Plan 9

I. Issues Addressed

3.6 If the RHR heat exchanger relief valves discharge steam to the upper levels of the suppression pool following a design basis accident, they will significantly aggravate suppression pool temperature stratification.

II. Program for Resolution

The Program for Resolution of Action Plan Element 6.1 and 6.2 apply to this item; accordingly, this issue is closed.

GENERAL ELECTRIC -- GESSAR II -- ACTION PLAN

Action Plan 10

I. Issues Addressed

4.1 The present containment response analyses for drywell break accidents assume that the ECCS systems transfer a significant quantity of water from the suppression pool to the lower regions of the drywell through the break. This results in a pool in the drywell which is essentially isolated from the suppression pool at a temperature of approximately 135°F. The containment response analysis assumes that the drywell pool is thoroughly mixed with the suppression pool. If the inventory in the drywell is assumed to be isolated and the remainder of the heat is discharged to the suppression pool, an increase in bulk pool temperature of 10° may occur.

II. Program for Resolution

1.+ Complete analysis to quantify maximum bulk suppression pool temperature increase produced as a result of an isolated drywell pool.

\+ These results are generic in that they deal with analytical methods, data or a combination of the two. The GGNS Action Plan response is applicable, and this element is considered to be closed.

GENERAL ELECTRIC -- GESSAR II -- ACTION PLAN

Action Plan 11

I. Issues Addressed

4.2 The existence of the drywell pool is predicated upon continuous operation of the ECCS. The current Emergency Procedure Guidelines require the operators to throttle ECCS operation to maintain vessel level below level 8. Consequently, the drywell pool may never be formed.

9.1 The current FSAR analysis is based upon continuous injection of relatively cool ECCS water into the drywell through a broken pipe following a design basis accident. The EPG's direct the operator to throttle ECCS operation to maintain reactor vessel level at about level 8. Thus, instead of releasing relatively cool ECCS water, the break will be releasing saturated steam which might produce higher containment pressurizations than currently anticipated. Therefore, the drywell air which would have been drawn back into the drywell will remain in the containment and higher pressures will result in both the containment and drywell.

II. Program for Resolution

1.+ Calculations will be submitted to demonstrate that failure to form the drywell pool will not cause adverse consequences. The calculations will quantify the variation of suppression pool level without formation of the drywell pool and with upper pool dump.

2.+ Interactions between ESF system operation and suppression pool level will be reviewed to assure that higher suppression pool level will not degrade performance.

3.+ A realistic analysis of the effects of failure to recover the drywell air mass will be performed. This analysis will include the effects of containment heat sinks and the mitigating effects of containment spray.

\+ These results are generic in that they deal with analytical methods, data, or a combination of the two. The GGNS Action Plan response is applicable, and this element is considered to be closed.

GENERAL ELECTRIC -- GESSAR II -- ACTION PLAN

Action Plan 12

I. Issues Addressed

4.3 All Mark III analyses presently assume a perfectly mixed uniform suppression pool. These analyses assume that the temperature of the suction to the RHR heat exchangers is the same as the bulk pool temperature. In actuality, the temperature in the lower part of the pool where the suction is located will be as much as 7½° cooler than the bulk pool temperature. Thus, the heat transfer through the RHR heat exchanger will be less than expected.

II. Program for Resolution

1.+ A study will be completed to identify and quantify the major conservatisms which have been used in the analyses of RHR suppression pool cooling performance.

2.+ An assessment will be provided of the maximum difference which could exist between the bulk suppression pool temperature and the RHR heat exchanger inlet temperature. Based on existing test data this assessment should show that the difference will be below 7½°F. An analysis will be performed to assess the effect of this temperature difference on peak pool temperature.

3.+ Applicable heat exchanger test data and other test data will be reviewed to provide assurance that the correct heat exchanger capacity has been used.

\+ These results are generic in that they dea th analytical methods, data, or a combination of the tw he GGNS Action Plan response is applicable, and this element nsidered to be closed.

GENERAL ELECTRIC -- GESSAR II -- ACTION PLAN

Action Plan 13

I. Issues Addressed

4.4 The long term analysis of containment pressure/temperature response assumes that the wetwell airspace is in thermal equilibrium with the suppression pool water at all times. The calculated bulk pool temperature is used to determine the airspace temperature. If pool thermal stratification were considered, the surface temperature, which is in direct contact with the airspace, would be higher. Therefore, the airspace temperature (and pressure) would be higher.

7.1 The containment is assumed to be in thermal equilibrium with a perfectly mixed, uniform temperature suppression pool. As noted under issue 4, the surface temperature of the pool will be higher than the bulk pool temperature. This may produce higher than expected containment temperature and pressures.

II. Program for Resolution

1.+ The maximum increase in bulk suppression pool temperature which could occur as a result of temperature stratification will be determined from Action Plan 12. The maximum suppression pool surface temperature will be estimated based on the current understanding of thermal stratification as contained in GESSAR II. The effects of this higher surface temperature on containment airspace pressure and thermal will be calculated.

2.+ The conservatism inherent in assuming thermal equilibrium between the containment atmosphere and suppression pool surface will be quantified. This conservatism results from neglecting the effects of drywell and containment heat sinks and conduction of heat through the containment structure into the secondary containment.

\+ These results are generic in that they deal with analytical methods, data, or a combination of the two. The GGNS Action Plan response is applicable, and this element is considered to be closed.

GENERAL ELECTRIC -- GESSAR II -- ACTION PLAN

Action Plan 14

I. Issues Addressed

4.5 A number of factors may aggravate suppression pool thermal stratification. The chugging produced through the first row of horizontal vents will not produce any mixing from the suppression pool layers below the vent row. An upper pool dump may contribute to additional suppression pool temperature stratification. The large volume of water from the upper pool further submerges RHR heat exchanger effluent discharge which will decrease mixing of the hotter, upper regions of the pool. Finally, operation of the containment spray eliminates the heat exchanger effluent discharge jet which contributes to mixing.

II. Program for Resolution

1.+ Testing information will be submitted to demonstrate the effectiveness of chugging as a mixing mechanism in the suppression pool.

Chugging will be present under all accident conditions when the containment temperature or pressure requires activation of the containment sprays. Therefore, effective mixing will still be maintained during spray operation.

\+ These results are generic in that they deal with analytical methods, data, or a combination of the two. The GGNS Action Plan response is applicable, and this element is considered to be closed.

GENERAL ELECTRIC -- GESSAR II -- ACTION PLAN

Action Plan 15

I. Issues Addressed

4.6 The initial suppression pool temperature is assumed to be 95°F while the maximum expected service water temperature is 90°F for all GGNS accident analyses as noted in FSAR Table 6.2-50. If the service water temperature is consistently higher than expected, as occurred at Kuo Sheng, the RHR system may be required to operate nearly continuously in order to maintain suppression pool temperature at or below the maximum permissible value.

II. Program for Resolution

Under normal plant operating conditions, the required operational frequency (duty cycles) of the RHR system pool cooling mode will depend to a large extent on the actual temperature of the essential service water provided. GESSAR II contains conservative assumptions used in performing containment accident response analysis, and for sizing associated systems. It is assumed that the actual plant service water temperature will always be below the design basis. Consequently, General Electric believes this item is not applicable to GESSAR II and is considered closed.

GENERAL ELECTRIC -- GESSAR II -- ACTION PLAN

ACTION PLAN 16

I. Issues Addressed

4.7 All analyses completed for the Mark III are generic in nature and do not consider plant specific interactions of the RHR suppression pool suction and discharge.

4.10 Justify that the current arrangement of the discharge and suction points of the pool cooling system maximizes pool mixing. (pp. 150-155 of 5/27/82 transcript).

II. Program For Resolution

1. A discussion of analyses and test results is provided to demonstrate that the RHR system design achieves satisfactory pool mixing. See attachment.

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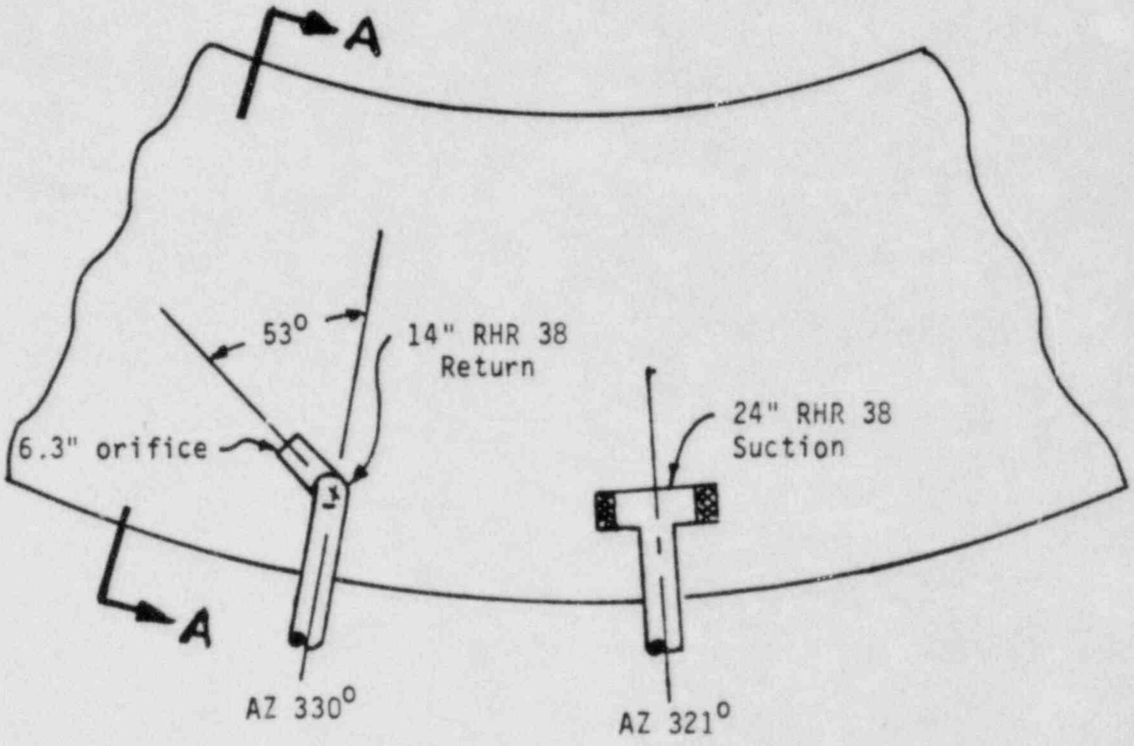
TABLE 16.1

COMPARISON OF KUO SHENG AND GESSAR II QUENCHER AND RHR SUCTION AND DISCHARGE LOCATIONS

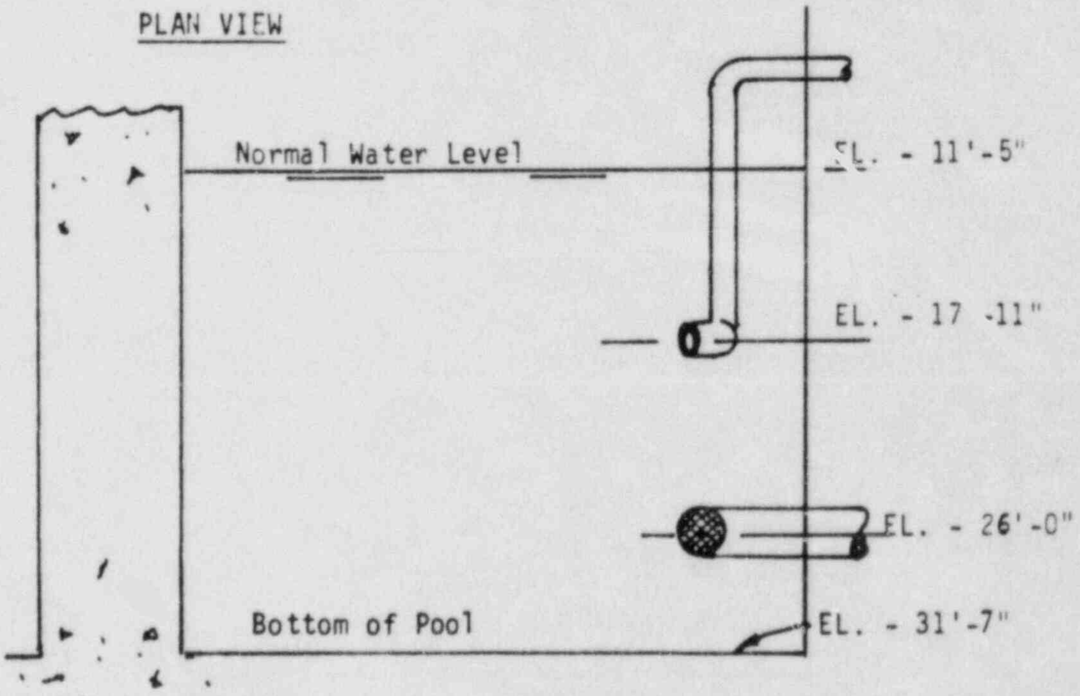
Parameter		Kuo Sheng	GESSAR II
Suppression pool depth, ft. (NWL)		19.2	20.2
Height of Quencher arm centerline above basemat, ft.		5.3	6.5
Height of RHR suction above basemat, ft.		4.0	5.6
Height of RHR discharge above basemat, ft.	RHR A	12.0	13.7
	RHR B	12.0	13.7
Elevation difference between suction and discharge, ft.		8.0	8.1

FIGURE 16.1

STRIDE RHR SUCTION AND RETURN LINE CONFIGURATION



PLAN VIEW



SECTION A-A

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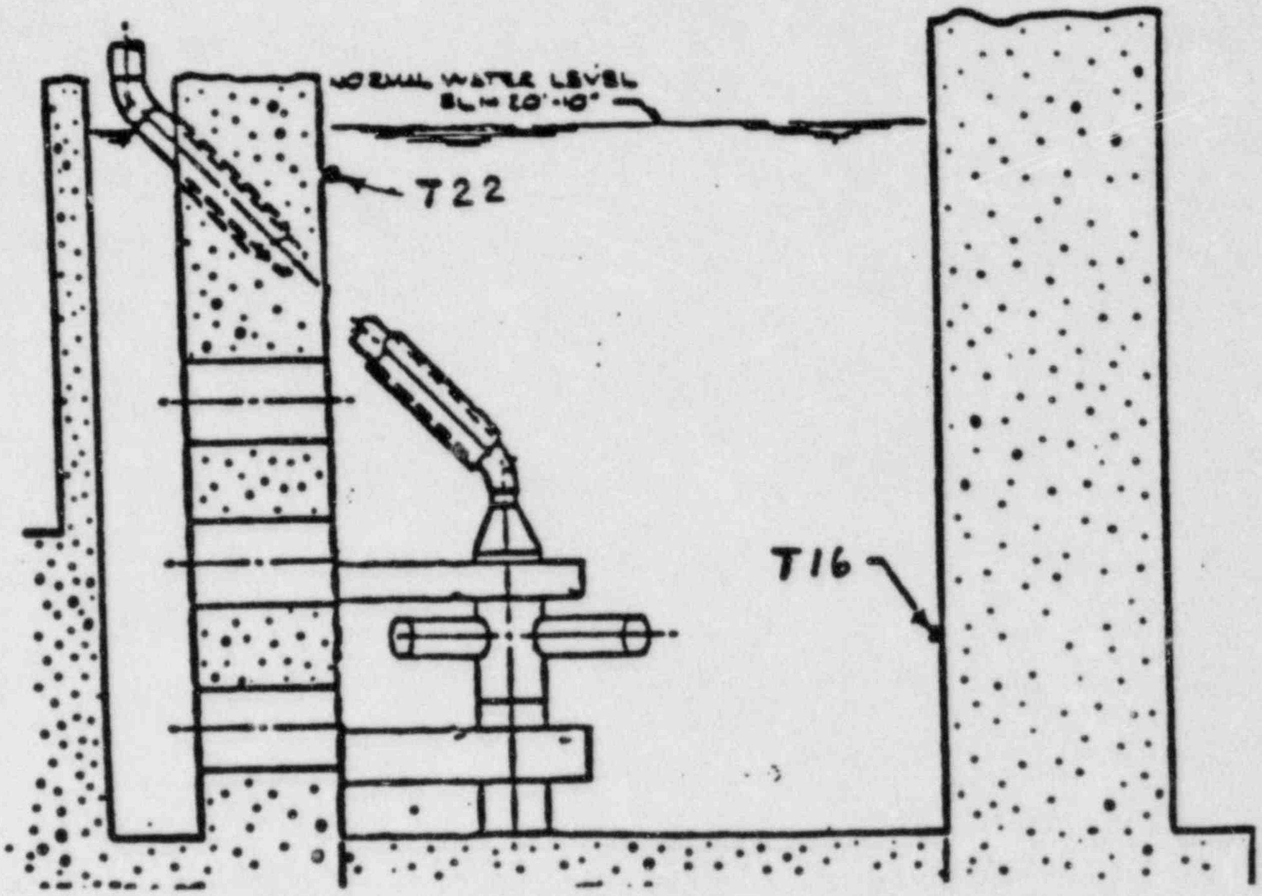

NOTE: Temperature sensors T16 & T22 located 52^{o} Azimuth from SRV Discharged in Test.

FIGURE 16.3

Kuo Sheng Suppression Pool Temperature Sensor Locations

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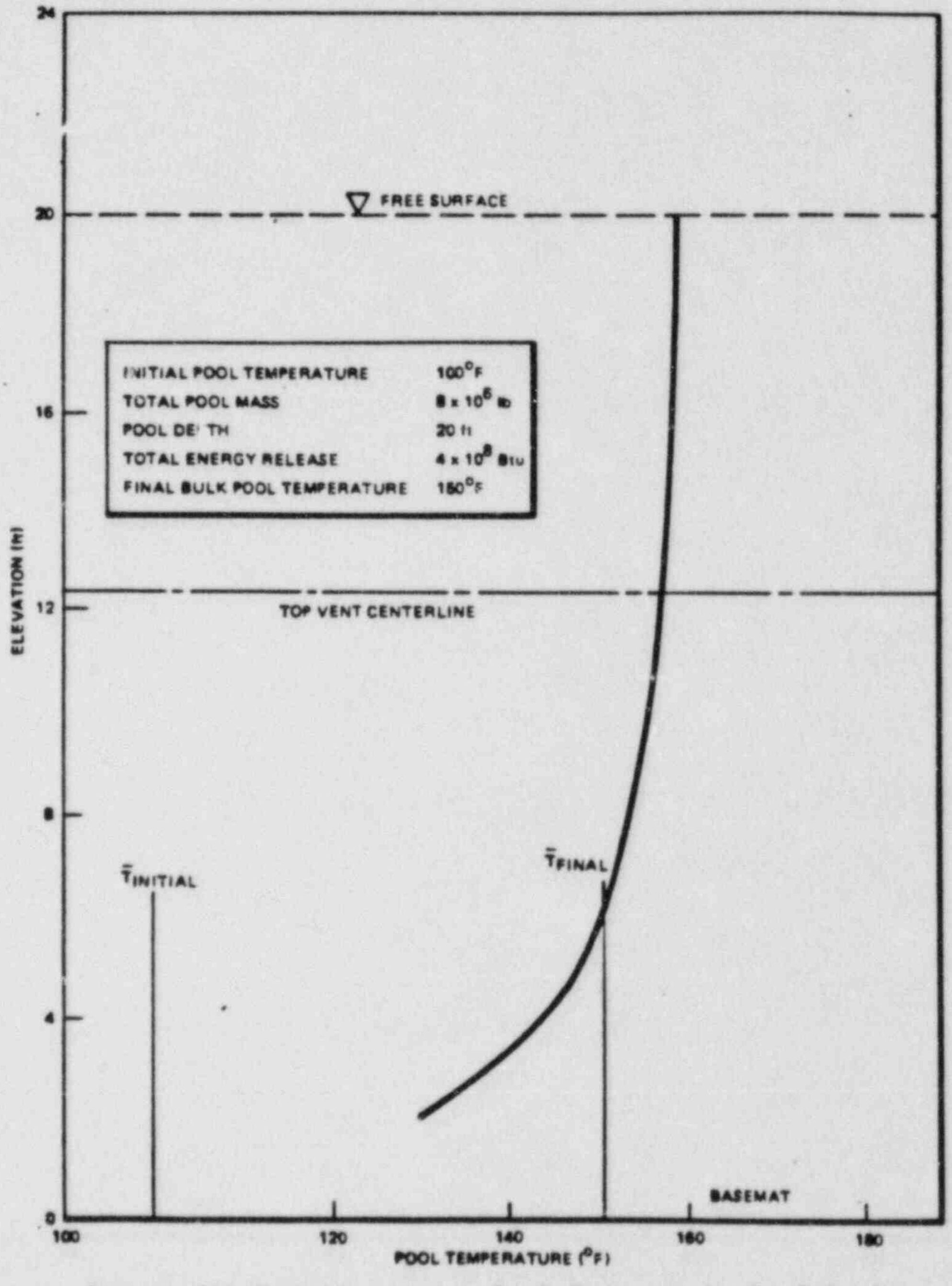

Figure 3BI-3. Suppression Pool Temperature Profile for Large Breaks
(16.5)

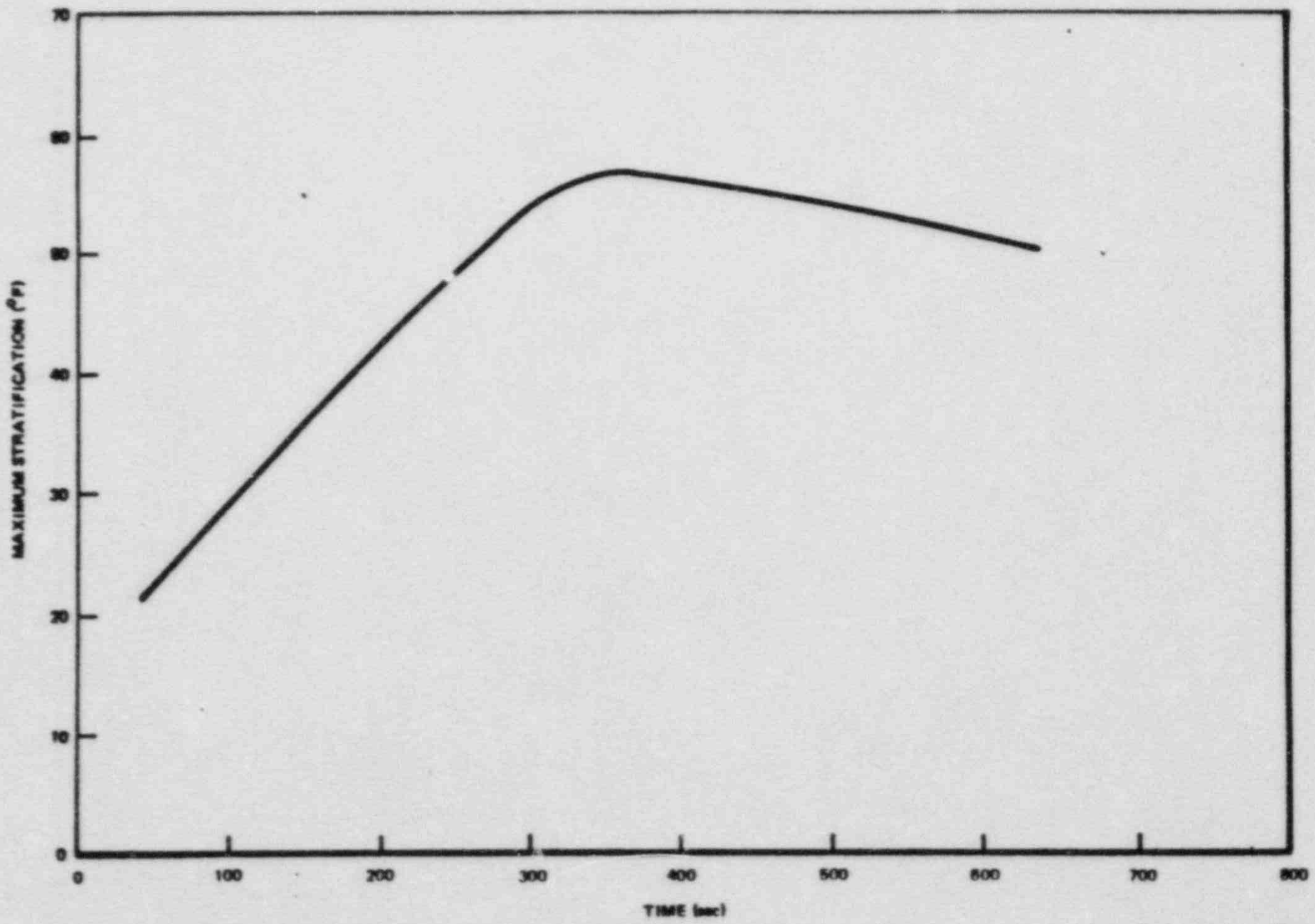

Figure 3B.28-6. Post Pool Swell Stratification Time History Seen in RELAP Simulation of Mark III IBA
(16.6)

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GENERAL ELECTRIC -- GESSAR II -- ACTION PLAN

ACTION PLAN 17

I Issues Addressed

4.8 Operation of the RHR system in the containment spray mode will decrease the heat transfer coefficient through the RHR heat exchangers due to decreased system flow. The FSAR analysis assumes a constant heat transfer rate from the suppression pool even with operation of the containment spray.

II. Program For Resolution

1.+ Additional analyses will be completed which incorporate lower RHR heat exchanger heat transfer coefficients during the period when the RHR system is in the containment spray mode. The analyses will be performed both with and without the presence of the bypass leakage capability.

2.+ The analyses performed in Item 1 will be repeated so that the effects of containment heat sinks can be included and quantified. The containment spray will be assumed to be operational only when it is necessary to assure pressure control.

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* These results are generic in that they deal with analytical methods, data or a combination of the two. The GGNS Action Plan response is applicable, and this element is considered to be closed.

GENERAL ELECTRIC -- GESSAR II -- ACTION PLAN

ACTION PLAN 18

I. Issues Addressed

4.9 The effect on the long term containment response and the operability of the spray system due to cycling the containment sprays on and off to maximize pool cooling needs to be addressed. Also provide and justify the criteria used by the operator for switching from the containment spray mode to pool cooling mode, and back again.

5.3 Leakage from the drywell to containment will increase the temperature and pressure in the containment. The operators will have to use the containment spray in order to maintain containment temperature and pressure control. Given the decreased effectiveness of the RHR system in accomplishing this objective in the containment spray mode, the bypass leakage may increase the cyclical duty of the containment sprays.

II. Program for Response

1. Analyses completed for Grand Gulf Action Plan 18 demonstrated that containment spray cycling is not an issue. These results are also applicable to GESSAR II. This item is considered closed.

GENERAL ELECTRIC -- GESSAR II -- ACTION PLAN

ACTION PLAN 19

I. Issues Addressed

5.1 The worst case of drywell to containment bypass leakage has been established as a small break accident. An intermediate break accident will actually produce the most significant drywell to containment leakage prior to initiation of containment sprays.

5.6 The test pressure of 3 psig specified for the periodic operational drywell leakage rate tests does not reflect additional pressurization in the drywell which will result from upper pool dump. This pressure also does not reflect additional drywell pressurization resulting from throttling of the ECCS to maintain vessel level which is required by the current EPG.

9.2 The continuous steaming produced by throttling the ECCS flow will cause increased direct leakage from the drywell to the containment. This could result in increased containment pressures.

II. Program For Resolution

1.+ A complete spectrum of analyses for varying break sizes will be completed neglecting depressurization of the drywell prior to initiation of containment sprays, but including the effects of containment heat sinks.

2. Not applicable.

3.+ An evaluation of the need for reducing the GE internal draft Technical Specification recommendations, intended for publication in GGNS Chapter 16, covering a proposed allowable technical specification for drywell leakage, will be provided. Any revised limit would be based upon a pressure of 6 psig in the drywell which would reflect the additional pressure produced by upper pool dump. In the evaluation, credit will be taken for drywell and containment heat sinks.

NOTE: Refer to the GESSAR II SER Section 6.2.1.7

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* These results are generic in that they deal with analytical methods, data, or a combination of the two. The GGNS Action Plan response is applicable, and this element is considered to be closed.

GENERAL ELECTRIC -- GESSAR II -- ACTION PLAN

ACTION PLAN 20

I. Issues Addressed

5.4 Direct leakage from the drywell to the containment may dissipate hydrogen outside the region where the hydrogen recombiners take suction. The anticipated leakage exceeds the capacity of the drywell purge compressors. This could lead to pocketing of hydrogen which exceeds the concentration limit of 4% by volume.

II. Program For Resolution

1. A discussion of hydrogen mixing and potential pocketing follows.

GENERAL ELECTRIC RESPONSE

Pocketing can be defined as a volume which does not participate fully in the post-LOCA global circulation patterns in the containment and drywell. Pocketing can lead to flammability only if a source of hydrogen exists within a pocketed volume. No large source of hydrogen, sufficient to cause flammability, exists in any enclosed volume (mostly RWCU rooms) in the containment. Since the bulk hydrogen concentration in the surrounding atmosphere will always be maintained at less than 4 volume percent, the concentration in any potential pocket also will not exceed 4 percent. More specifically, because the drywell hydrogen concentration will always be less than 4 percent, any leakage from the drywell will not form a flammable pocket in the containment. This is because hydrogen, like all gases, will not settle, rise, or selectively diffuse to form a mixture more enriched than its source.

If the mixing path in the containment is completely short-circuited, it may be possible for a buildup in drywell hydrogen concentration to occur. This buildup could occur only if both the recombiners and the bulk containment were bypassed. Conceivably, the complete short-circuiting could only occur if drywell leakage equivalent to the technical specification limit or more was located at a point very close to the operating mixer inlet (conservatively assume the other mixer, located away from this concentrated leakage point, is inoperative). In this manner, the mixer would be recycling all the leakage directly back into the drywell.

Three factors prevent this direct recycling from occurring. The first is that, although the mixers are located in the containment on the drywell ceiling slab, they take suction from an elevation near the operating floor, approximately 20 feet above the drywell. This arrangement minimizes the development of any short, direct path from the drywell or the suppression

Action Plan 20 -- GENERAL ELECTRIC RESPONSE

unrecombined hydrogen through the mixers is further reduced. Secondly, the design of the hydrogen mixing system provides for the mixers to take suction from the containment and discharge into the drywell, depressing the water in the weir annulus, and allowing the drywell atmosphere to flow through the horizontal vents into the suppression pool. A portion of the mixer flow will always be diverted through drywell leakage. Only when the drywell leakage approaches or exceeds the technical specification will most or all of the mixer flow go through leakage paths, and perhaps be recycled directly back to the drywell.

Thirdly, there is no valid technical argument to support the contention that drywell leakage will be concentrated in one area. The lower portion of the drywell and the removable drywell head are steel structures, precluding leakage through either of these regions. The portions of the drywell covered by the fuel storage, fuel transfer, and refueling pools are also not viable leakage paths. Available evidence leads to the conclusion that the leakage from the drywell into the containment under nominal, vent-clearing pressures (~2 to 3 psi) will be primarily at the structural-mechanical interfaces such as electrical and pipe penetrations and seals. All these concrete-penetration interfaces constitute potential leakage paths, and are distributed randomly around the drywell, well below the mixer and recombiner elevations. Strong, free convective currents exist in the lower containment which circulate mixer flow from the suppression pool to the bulk containment atmosphere. This has been established in analyses presented in Section 6.2.5 of GESSAR II. At the random leakage around the drywell, similar passive mixing mechanisms exist. Therefore, hydrogen leakage from the drywell will mix with the bulk containment atmosphere along with hydrogen and air from the pool.

In light of the multiple Combustible Gas Control System design features which prevent the accumulation of flammable amounts of hydrogen in either the drywell or the containment, regardless of drywell leakage, General Electric considers this issue closed.

GENERAL ELECTRIC -- GESSAR II -- ACTION PLAN

ACTION PLAN 21

I. Issues Addressed

5.5 Equipment may be exposed to local conditions which exceed the environmental qualification envelope as a result of direct drywell to containment bypass leakage.

II. Program For Resolution

1. A discussion of essential equipment located near the drywell wall is provided.

GENERAL ELECTRIC RESPONSE

Section 3.11.1, Equipment Identification and Environmental Conditions, in GESSAR II addresses safety-related mechanical and electrical equipment located within various environmental zones of the Nuclear Island Buildings and the Turbine Building. The environmental conditions such equipment is exposed to within a given building (including potential local hot spots resulting from direct drywell to containment bypass leakage and/or hydrogen recombiner operation) depend on where in the building the equipment is located and other factors (i.e., enclosures, cooling systems, heat sinks, etc.). Since the equipment location and environmental control measures provided are the responsibility of the BWR/6 - Mark III purchasing utility and its design representative, the GESSAR II Table 3.11-2, Environmental Conditions for Reactor Building Equipment, and Table 3.11-9, Safety Related Equipment Identification and Environmental Qualification Summary, specify "Applicant to Supply." Consequently, General Electric considers this issue closed.

GENERAL ELECTRIC -- GESSAR II -- ACTION PLAN

ACTION PLAN 22

I. Issues Addressed

5.8 The possibility of high temperatures in the drywell without reaching the 2 psig high pressure scram level because of bypass leakage through the drywell wall should be addressed.

II. Program For Resolution

1.+ A new analysis will be performed using the capability bypass leakage. This analysis will show that a temperature of 330°F is not reached in the drywell until after ten minutes. In this interval, the operator will have received sufficient information to manually scram the reactor.

2. A detailed list of alarms and parameter displays which inform the operator of conditions in the drywell is attached.

+ These results are generic in that they deal with analytical methods, data, or a combination of the two. The GGNS Action Plan response is applicable, and this element is considered to be closed.

Action Plan 22 -- GENERAL ELECTRIC RESPONSE

2. Drywell Instrumentation

Considerable instrumentation is provided to inform the operator of high drywell temperature and cooling system conditions. This instrumentation enables the operator to make a timely determination of whether drywell high temperature is caused by a HVAC failure or a small reactor cooling leak and also allows the operator to avoid operation outside of specified bands of drywell pressure and temperature. There are a total of 44 temperature sensors in various locations and elevations in the drywell (including 21 spares). These sensors provide signals to control room monitoring by indicators, recorders and computer printouts as shown in Table 22.1. Ten of the temperature monitors also actuate high temperature alarms in the control room. Included among the various temperature monitoring channels are two which are Class 1E and are located at an intermediate height for monitoring average drywell temperature. Because of these redundant and diverse temperature indications, it is unlikely that a high temperature condition would go unnoticed by the operator.

In addition to high temperature, there are other indications available which would alert the operator to a small reactor coolant leak in the drywell. Drywell floor drain sump level and level fill-up rate are recorded in the control room. An alarm is actuated when the sump fill rate exceeds setpoints (5 gpm for floor drain and 25 gpm for equipment drain). Drywell floor and equipment drain sump pumps are equipped with timers which actuate alarms when the time required to fill the sump between pumping cycles is short enough to be indicative of a leak or the time required to pump out the sump is long enough to be indicative of a leak. Condensate flow from the drywell coolers, which is indicative of steam condensing from a leak, is indicated in the control room and actuates an alarm when flow exceeds 5 gal/min. The drywell atmosphere is continuously monitored for particulate, and noble gas activity. These variables are recorded in the control room and initiate alarms when they increase significantly above background levels. An increase in drywell cooler differential temperature, as monitored by the drywell cooler inlet and outlet temperature indicator may indicate an increase heat load due to condensing steam from a leak. In addition, a narrow range drywell pressure channel is recorded in control room, and small pressure increases, in conjunction with temperature change may indicate reactor coolant leakage.

In addition to drywell high temperature, other means are provided to alert the operator to a failure in the drywell cooling system. The run-stop status of drywell cooling fans and open-closed status of drywell cooling dampers are displayed in the control room by indicating lights. Chiller water flow rates to drywell coolers, as well as both air and differential temperatures are available through the plant computer.

Action Plan 22 -- GENERAL ELECTRIC RESPONSE

The indications available to the operator provide a straightforward means for determining whether a drywell temperature increase is caused by a reactor coolant leak or drywell cooler failure. A reactor coolant leak will cause an increase in drywell particulate radioactivity, an increase in cooler condensate drain flow, and an increase in sump level fill-up rate and sump pump use, whereas a drywell cooler failure will not. A leak will cause an increase in drywell cooler load as indicated by greater differential temperatures, whereas a drywell cooler fan failure will produce smaller differential temperature. It is possible that a tube leak in a drywell cooler would produce an increase in cooler drain flow along with increased flows to the floor drain sump. A defective cooler would also affect the drywell chiller performance as indicated by its temperature and/or flow indication recording and alarms.

It can therefore be concluded that adequate instrumentation has been provided to alert the operator of a high drywell temperature condition and to allow him to determine the cause of the high drywell temperature. Therefore, General Electric considers this issue closed.

TABLE 22.1

DRYWELL TEMPERATURE MONITORING PROVISIONS

No. of Points	Sensor Locations	Indicator	Control Room Readouts Recorder	 Computer	 Alarm
1	~90° Azimuth, D.W. Upper Elevation	-	MP*	Print Out	Annun
1	~90° Azimuth, D.W. Mid Elevation	-	MP	Print Out	Annun
1	~90° Azimuth, D.W. Lower Elevation	-	MP	Print Out	Annun
1	~180° Azimuth, D.W. Upper Elevation	-	MP	Print Out	Annun
1	~180° Azimuth, D.W. Mid Elevation	-	MP		
1	~180° Azimuth, D.W. Lower Elevation	-	MP		
6	D. W. Cooler Outlet (each)	Selected Indication	-	-	-
6	D. W. Cooler Inlets (each)	Selected Indication	-	-	-
1	~190°/~50' Azimuth/ Elevation	Class 1E Meter	-	-	-
1	~0°/~50' Azimuth/ Elevation	Class 1E Meter	-	-	-
1	Under vessel		MP	-	-
1	Air Duct "A" to Skirt Region			Print out	Annun
1	Air Duct "B" to Skirt Region			Print out	Annun

*MP = Multipoint

GENERAL ELECTRIC -- GESSAR II -- ACTION PLAN

ACTION PLAN 23

I. Issues Addressed

6.3 The recombiners may produce "hot spots" near the recombiner exhausts which might exceed the environmental qualification envelope or the containment design temperature.

6.5 Discuss the possibility of local temperatures due to recombiner operation being higher than the temperature qualification profiles for equipment in the region around and above the recombiners. State what instructions, if any, are available to the operator to actuate containment sprays to keep this temperature below design values.

II. Program For Resolution

1. Arrangement of equipment in the region above the recombiner exhausts is discussed.

2. A discussion of the criteria used for actuating the containment sprays on high temperature is attached.

Action Plant 23 -- GENERAL ELECTRIC RESPONSE

Locating essential equipment, and providing and meeting environmental qualification envelopes is the responsibility of the purchasing utility and its design representative. Tables 3.11-12 and 3.11-9 of GESSAR II address environmental qualification of safety-related equipment and specify that the applicant is to supply information to complete the tables. Accordingly, it is the responsibility of the purchasing utility and its architect-engineer to assure that the qualification envelope for each containment zone includes any contribution to pressure, temperature and relative humidity from the recombiners.

More generally, it should be noted that General Electric's design requirements and the test results for the recombiner used in the GESSAR II design indicate a recombiner exhaust temperature no higher than 50°F above the recombiner inlet. This is achieved by mixing the cooler ambient containment atmosphere with the hot recombiner process stream in an exhaust plenum within the recombiner. Since the recombiners are actuated late in the design basis event, the containment temperature has decayed sufficiently so that locally high temperatures around the recombiners should not be a concern. Because the recombiners are located to participate in global circulation patterns in the containment, it is reasonable to expect the heat from the recombiners to be distributed throughout a major portion of the containment volume. Comparing the magnitude of the extensive, low temperature, heat sinks available (assuming free convection heat transfer) and the maximum heat input from the recombiners, General Electric also expects heating of the bulk containment atmosphere not to be a concern.

Should containment spray be required to control temperature, the generic BWR EPGs (Rev. 3) instruct the plant operator to initiate containment sprays before the general containment temperature reaches 185°F, based on multiple temperature sensors located throughout the primary containment. Given the high rate of heat transfer available late in the event and the availability of spray per the EPG's, General Electric considers this issue closed.

GENERAL ELECTRIC -- GESSAR II -- ACTION PLAN

ACTION PLAN 24

I. Issues Addressed

7.2 The computer code used by General Electric to calculate environmental qualification parameters considers heat transfer from the suppression pool surface to the containment atmosphere. This is not in accordance with the existing licensing basis for Mark III environmental qualification. Additionally, the bulk suppression pool temperature was used in the analysis instead of the suppression pool surface temperature.

II. Program For Resolution

1. A description of the calculation methods for environmental qualification parameters follows.

GENERAL ELECTRIC RESPONSE

General Electric usesthe methodology of NEDO-20533, "The General Electric Mark III Pressure Suppression Containment System Analytical Model," for calculating Mark III environmental qualification parameters. This methodology is the licensing basis, and has been approved by the NRC. Therefore, General Electric considers this issue closed.

GENERAL ELECTRIC -- GESSAR II -- ACTION PLAN

ACTION PLAN 25

I. Issues Addressed

8.1 This issue is based on consideration that some technical specifications allow operation at parameter values that differ from the values used in assumptions for FSAR transient analyses. Normally analyses are done assuming a nominal containment pressure equal to ambient (0 psig) a temperature near maximum operating (90°F) and do not limit the drywell pressure equal to the containment pressure. The technical specifications permit operation under conditions such as a positive containment pressure (1.5 psig), temperatures less than maximum (60 or 70°F) and drywell pressure can be negative with respect to the containment (-0.5 psid). All of these differences would result in transient response different than the FSAR descriptions.

II. Program For Resolution

GESSAR II does not contain technical specifications which define these parameters. The applicant will provide technical specifications which are compatible with the assumptions used in the transient analyses.

GENERAL ELECTRIC -- GESSAR II -- ACTION PLAN

ACTION PLAN 26

I. Issues Addressed

8.2 The draft GGNS technical specifications permit operation of the plant with containment pressure ranging between 0 and -2 psig. Initiation of containment spray at a pressure of -2 psig may reduce the containment pressure by an additional 2 psig which could lead to buckling and failures in the containment liner plate.

8.3 If the containment is maintained at -2 psig, the top row of vents could admit blowdown to the suppression pool during an SBA without a LOCA signal being developed.

II. Program For Resolution

GESSAR II does not contain technical specifications which define these parameters. The applicant will provide technical specifications which are compatible with the containment design bases.

GENERAL ELECTRIC -- GESSAR II -- ACTION PLAN

ACTION PLAN 27

I. Issues Addressed

8.4 Describe all of the possible methods both before and after an accident of creating a condition of low air mass inside the containment. Discuss the effects on the containment design external pressure of actuating the containment sprays.

II. Program For Resolution

1. A complete list of scenarios which might result in reduced containment air mass follows.
2. The list of scenarios developed in Item 1 was reviewed and a worst case, bounding scenario was selected.
3. An analysis was completed to establish the containment response under the bounding scenario.

NOTE: Refer to the GESSAR II SER Section 6.2.1.5

GENERAL ELECTRIC RESPONSE

1. Scenarios leading to reduction of containment air mass

a. Initiation Event: Small line break in the containment airspace (RWCU or steam) while the containment is not isolated.

Sequence of Events:

- containment air space temperature rises due to energy input from the break.
- containment air is purged through the open ventilation system due to thermal expansion and steam addition (direct or flashing of hot water) to the airspace.
- containment isolated on high radiation level or operator action.

b. Initiating Event: loss of containment HVAC

Sequence of events:

- containment airspace temperature rises
- containment air is being lost through the open ventilation system due to thermal expansion.
- Containment isolated by operator action.

Action Plan 27 -- GENERAL ELECTRIC RESPONSE

c. Initiating event: LOCA in drywell

Sequence of Events:

- containment isolated on LOCA signal (2 psig in drywell).
- upper pool dump (UPD) occurs at 30 minutes post-LOCA.
- hydrogen mixing compressors are put in operation by the operator.
- air is being transferred from containment to drywell until the top row of vents is uncovered. That requires assuming previous UPD approximately 6 psid between drywell and wetwell.

2. Selection of Bounding Scenario

The first scenario (SBA in containment airspace) results in the minimum containment air mass and hence the minimum containment pressure after spray activation. The second scenario (loss of containment HVAC) caused the steepest pressure drop during the short time when the containment spray is cooling by evaporation, but the containment has a higher final pressure. The third scenario (LOCA in drywell) has little impact on the containment negative pressure since any drop in containment pressure resulting from the spray actuation results in the flow of air from the drywell to the wetwell through the drywell horizontal vents.

3. Analysis of Bounding Scenario

The containment heat-up rate resulting from a SBA in the containment is sufficiently slow enough for the operator to react to prevent significant air loss. It is estimated that a 201°F rise in the containment air temperature would take 2 hours following a small steam line break.

Following containment isolation, the operator must follow the Emergency Procedure Guidelines (EPG's). Step PC/P-2 was designed to insure that the negative pressure design limit will not be exceeded even if the operator erred in not preventing excessive containment air loss. Step PC/P-2 instructs the operator not to initiate the containment spray unless the containment pressure is above 1.7 psig. This pressure limit was obtained from an analysis varying the initial containment conditions of temperature and relative humidity. Automatic spray actuation is at a containment pressure of 9 psig, well above the 1.7 psig limit; therefore, no adverse effect will be caused by automatic spray actuation. Consequently, General Electric considers this issue closed.

GENERAL ELECTRIC -- GESSAR II -- ACTION PLAN

ACTION PLAN 28

I. Issues Addressed

9.3 It appears that some confusion exists as to whether SBA's and stuck open SRV accidents are treated as transients or design basis accidents. Clarify how they are treated and indicate whether the initial conditions were set at nominal or licensing values.

II. Program for Resolution

1. A response is provided confirming that the small break accident and stuck open relief valve transient were treated as design basis accidents. The analyses for these transients are completed using licensing basis values for the initial conditions.

GENERAL ELECTRIC RESPONSE

The list of assumptions, used by GE in evaluating SBA and SORV is attached (Table 28.1). Both events are conservatively treated as accidents with one exception: in case of SORV, credit is taken for non-safety grade systems, RHR shutdown cooling mode and main condenser. This is consistent with the requirements of NUREG-0783 (see the response to GESSAR II question 480.05 for the NUREG-0783 evaluation). All other assumptions and initial conditions are those applied to FSAR design basis accident analysis. General Electric considers this issue closed.

TABLE 28.1

SUMMARY OF INITIAL CONDITIONS, EVENT SEQUENCES, AND ASSUMPTIONS
(FOR EXCLUSIVE USE IN THE SUPPRESSION POOL TEMPERATURE TRANSIENTS GIVEN IN THIS TABLE)

	PARAMETERS	STUCK-OPEN SRV		DEPRESSURIZATION FROM ISOLATION		SMALL BREAK ACCIDENT	
		EVENT 1(a) During Power	EVENT 1(b) During Hot Standby	EVENT 2(a) 1 RHR (>100°F/hr)	EVENT 2(b) 2 RHR ($\leq$100°F/hr)	EVENT 3(a) Accident Mode	EVENT 3(b) Normal Mode
1.	INITIAL CONDITIONS						
1.01	Reactor Power (% Rated)	←		102%			→
1.02	Service Water Temp. (°F)	←		Max. Plant Data			→
1.03	Initial Pool Temp. T_i (°F)	←		Max. Tech. Spec.			→
1.04	Initial Pool Volume (cu. ft)	←		Min. Tech. Spec.			→
1.05	Drywell Pressure and Temp. (psig, °F)	←	135°F and normal operating pressure				→
1.06	Wetwell Air Pressure (psig)	←	Normal operating pressure				→
2.	EVENT SEQUENCE						
2.01	Reactor Scram, Manual @ Pool	T_p = 110°F	N/A	N/A	N/A	N/A	N/A
2.02	Reactor Scram, Automatic	N/A	t=o	t=o	t=o	High Drywell Pressure	
2.03	Isolation Time, t_i (sec.)	Note (1)	3.5	3.5	3.5	3.5	3.5
2.04	Feedwater Stops, Motor Driven Pumps	←		Note (2)			→
2.05	Feedwater Stops, Turbine Driven Pumps	←		Note (2)			→
2.06	Add'l SRV's Opened	← Note (3)	→	← Note (3)	→	Note (4)	Note (3)
2.07	Time to Turn RHR on in Pool Cooling Mode (See Note 12)	10 Min	10 Min	10 Min	10 Min	10 Min	10 Min
2.08	Bypass Valves to Main Condenser Opened (See Note 5)	20 Min	No	No	No	No	No
2.09	Shutdown Cooling Initiated	Note (7,8)	No	Note (7,8)	No	No	Yes
2.10	Maximum Pool Temperature						
2.11	Time Max. Pool Temp. Reached						

TABLE 28.1 (Continued)

PARAMETERS	STUCK-OPEN SRV		DEPRESSURIZATION FROM ISOLATION		SMALL BREAK ACCIDENT	
	EVENT 1(a)	EVENT 1(b)	EVENT 2(a)	EVENT 2(b)	EVENT 3(a)	EVENT 3(b)
3.0 ASSUMPTIONS						
3.01 Auxiliary Power Available	Yes	Yes	Yes	Yes	No	Yes
3.02 Condensate Storage Tank Water Temp. (°F)			Max. Plant Data (Note 9)			
3.03 HPCI (HPCS) Available	Yes	Yes	Yes	Yes	Note (10)	Yes
3.04 RCIC Available	Yes	Yes	Yes	Yes	Note (11)	Yes
3.05 Condensate Storage Tank Avail	Yes	Yes	Yes	Yes	No	Yes
3.06 Drywell Fan Coolers Available		See Note (13)			No	No
3.07 RHR Heat Exchanger Duty		Based on Maximum Observed Equilibrium Crud Buildup				
3.08 Number of RHR Loops Avail.	1	2	1	2	1	2
3.09 SRV Capacities (% of ASME Rated)	←		122.5%			→
3.10 Decay Heat Curve	←	Decay Heat Curves for Containment Analysis				→

NOTES;

N/A = Not Applicable

1. In Event 1(a), the turbine control valves (TCV) will close on low turbine throttle pressure approx. 20 sec (plant specific) after the SORV occurs, effectively isolating the reactor from the main condenser. The MSIV's will not close because the low steamline pressure trip is bypassed when the operator scrams the plant by changing the mode switch from the RUN to the SHUTDOWN position. In the other events, 3.5 seconds is the isolation time (one-half second closure signal delay time plus MSIV closure time).
2. It is assumed that the containment accepts the "hot" portion of the feedwater in the feedwater system. The available mass energy data will be prorated according to flow rates on the NSSS heat balance sheets to provide estimates for plants without feedwater mass-energy data.
3. When the pool temperature reaches 120°F as required by the Technical Specifications.
4. All ADS SRV's are manually opened at 10 minutes after scram and isolation for Mark III plants.

TABLE 28.1 (Continued)

NOTES: (Continued)

5. In Event 1(a), the main condenser is assumed to be made available as a heat sink for reactor steam 20 minutes after the TCVs initially closed (see Note 1). The main condenser is assumed to be available until the reactor pressure is less than approx. 150 psia (plant specific).
6. In Event 3(b), it is not necessary that the main condenser be made available as a heat sink to avoid exceeding the pool temperature limit, but the main condenser could be made available after 20 minutes.
7. When reactor pressure $\leq$ interlock pressure (plant specific). If possible, it should be assumed that shutdown cooling is not used if the main condenser is made available as a heat sink (see 2.08). However, if the main condenser is not assumed to be available, then the use of shutdown cooling should be assumed.
8. The 16 minute switchover time assumes no flushing of the RHR loops to maintain water chemistry standards. With flushing, the total switchover time is 66 minutes. For plants which can avoid the pool temperature limit with flushing of the loops, flushing should be assumed.
9. If no Condensate Storage Tank data are available, the CST water temperature is assumed to be 10°F less than the initial pool temperature (T).
10. HPCS available except if the small line break is the HPCS line.
11. RCIC is only available (safety grade) on Mark III plants.
12. The RHR is assumed to be in operation in the pool cooling mode 10 minutes after the maximum pool temperature allowed by Tech Specs during normal operation is exceeded.
13. It is assumed that the drywell fan coolers keep the drywell pressure below the high drywell pressure trip setpoint (approx. 2 psig, but plant specific) in all events except 3(a) and 3(b). If this trip setpoint is reached, the RHR will automatically switch out of the pool cooling mode and line up in the LPCI mode. The operator would have to manually switch the RHR back into the pool cooling mode. This would require 10 minutes. No pool cooling would occur during this time. The time at which the high drywell pressure trip occurs, and the 10 minute loss of pool cooling will be considered for Mark III plants.

GENERAL ELECTRIC -- GESSAR II -- ACTION PLAN

ACTION PLAN 29

I. Issues Addressed

10.1 The suppression pool may overflow from the weir wall when the upper pool is dumped into the suppression pool. Alternately, negative pressure between the drywell and the containment which occurs as a result of normal operation or sudden containment pressurization could produce similar overflow. Any cold water spilling into the drywell and striking hot equipment may produce thermal failures.

II. Program for Resolution

1. An evaluation has been performed to identify possible weir wall overflow scenarios based on the GESSAR II containment and auxiliary system design.

GENERAL ELECTRIC RESPONSE

An assessment of the GESSAR II containment design indicates that a potential weir wall overflow during normal or upset plant conditions could only occur if an inadvertent or intentional upper pool dump is assumed coincident with other abnormal plant conditions (i.e., a negative drywell-to-containment differential pressure). Per GESSAR II Tables 6.2-1 and 6.2-30, the top of the weir wall is located 5 ft.-8 in. (freeboard) above the suppression pool normal high water level (HWL). Under normal plant operating conditions, the GESSAR II drywell vacuum breakers are designed to remain closed until a 2 psid (equivalent to approximately 4 ft.-7 in. of water) containment-to-drywell differential pressure exists. However, even this drywell negative differential pressure would not raise the water level in the weir annulus above the normal minimum freeboard of 5 ft - 8 in. required to flood the drywell.

The remaining text addresses the probability and potential consequences of an inadvertent or intentional upper pool dump flooding the drywell during normal or upset operating conditions.

The design of the control logic for opening the suppression pool makeup system (SPMS) dump valves assures with high probability that no inadvertent dump will occur. The suppression pool level signal (LLWL) to open the valves is in series with a permissive which only allows the open signal to pass through when a LOCA signal exists on that division. A manual system start of either Division 1 or 2 ECCS also supplies the LOCA permissive signal to the appropriate division of the SPMS.

Action Plan 29 -- GENERAL ELECTRIC RESPONSE

The suppression pool makeup system dump valves can be tested manually one at a time during plant power operations. An interlock prevents manual testing of one valve unless the other valve in series on the same line is closed. A single failure in this interlock during testing would have to occur to result in an inadvertent upper pool dump through this line. To intentionally perform a manual dump through one line without a LOCA permissive signal present, the following conditions and operator actions would be required:

(1) The SPMS mode selector switch would have to be in the 'AUTO' position, and

(2) The operator would have to turn the keylock test switch to the 'TEST' mode position, and

(3) The operator would have to actuate the remote manual switches of both valves on that line.

The valve initiation logic is designed with interlocks such that neither automatic nor manual action can open the suppression pool makeup valves while the plant is in the refueling mode.

Although an inadvertent dump is very remote, the GESSAR II weir wall elevation was designed (per Reference 1 G.E. SPMS Requirements Specification) to provide sufficient freeboard volume to accept a dump of the upper pool without resulting in overflow flooding into the drywell. This design is based on the assumptions that prior to the dump, the water in the suppression pool and weir annulus are at the same level, and the containment upper pool water was at its nominal level (elevation 83 ft. - 7 in. maintained by continuous overflow of level control weirs). If the drywell pressure were negative ($\geq$0.2 psid) relative to that in the containment and the suppression pool were at HWL when the inadvertent upper pool dump occurred, overflow of the weir wall becomes possible.

If either an inadvertent or intentional manual upper pool dump occurred, the control room operators would be quickly alerted to the event by alarms from both the suppression pool high water and the upper pool low water level alarms. In addition, an alarm is sounded in the control room whenever the SPMS has been manually bypassed when required to be functional (i.e., system mode switches in 'OFF' and reactor mode switch not in 'REFUEL') or the system is enabled during refueling operation when it is required to be deactivated (i.e., system mode switches in 'AUTO' and reactor mode switch in 'REFUEL'). Once alerted, the generic BWR EPGs (Rev. 3) direct the control room operator to 'maintain suppression pool water level between 23 ft - 9 in. (or 2 ft. - 4 in. below the top of the GESSAR II weir wall) and 19 ft. - 11 in. (minimum suppression pool water level)'. Based on the calculated flow rate through one of the dump lines, it would take over 8 minutes for the entire upper pool water volume to be delivered to the suppression pool. This should be adequate time for an operator to terminate the pool dump by manually actuating the appropriate valve closure switch (either one of the two in series on each line) in the control room. The operator could extend the time to dump the entire upper pool water volume by actuating the RHR system loop which returns suppression pool water back to the upper pool.

In the event that suppression pool water did spill into the drywell during reactor operation, assessment of the consequences indicate that it would represent a plant availability concern, but not a safety issue. The thermal stresses on equipment most likely impacted (recirculation piping and pumps) by such an event are in a category (secondary and peak) that does not require evaluation except for normal and upset plant conditions. The peak stresses produced by the thermal shock are important only for fatigue, and fatigue usage for such a rare event is not required by the ASME codes or by NRC rules. If it were necessary to consider the fatigue usage due to such a thermal shock, calculations show based on worst case conditions (insulation removed and a 450°F temperature difference between the outside and inside of the recirculation piping) that excessive fatigue usage would not result unless there were several hundred such cycles. Under a worst case condition, the potential damage to the piping could be slight distortion at the weld joints.

In summary, based on (1) the remote probability of an inadvertent or otherwise unwarranted manual initiated upper pool dump occurring when two or more abnormal or out-of-tech. spec. plant conditions exist, (2) the alarm annunications provided to the operator, (3) operator EPG instructions and means to quickly terminate or mitigate the event, and (4) the non-safety consequences of suppression pool water spilling into the drywell; General Electric believes the applicable containment and SPMS designs in GESSAR II are acceptable and this issue is considered closed. However, the appropriate part of Section 6.2.7 of GESSAR II will be revised to include the assumptions used in establishing the minimum weir wall freeboard before and after an upper pool dump.

References:

1. GE Requirements Specification, A62-4300 (22A7411), 'Suppression Pool Makeup System'.

GENERAL ELECTRIC -- GESSAR II -- ACTION PLAN

ACTION PLAN 30

I. Issues Addressed

10.2 Describe the interface requirement that specifies that no flooding of the drywell shall occur. Describe your intended methods to follow this interface or justify ignoring this requirement.

II. Program for Resolution

1. The wording of the requirement, and the interpretation of this requirement which were used to assure that the requirement was met are as follows.

GENERAL ELECTRIC RESPONSE

This response is given with the understanding that the issue addressed in this Action Plan refers to the requirements imposed upon the Suppression Pool Makeup System (SPMS) design through the GE requirements specification for this system. The SPMS requirements specification (see Reference 1) does not specify, per se, that drywell flooding shall not occur. The design intent is that, with consideration that other containment design parameters are within plant operations specifications, sufficient suppression pool volume will be available to contain the SPMS dump. The applicable specific requirement of the Reference 1 document is as follows:

"4.2.5 The suppression pool weir wall height shall provide sufficient freeboard volume to accept a dump of the upper pool without resulting in overflow flooding into the drywell. The freeboard height shall be measured between the top of the weir wall and HWL which is 7'-6" above the top vent center line."

To assure that this requirement is met, it is GE's intent to monitor that the system design as developed by the BOP A/E is in accordance with these requirements and that proper consideration is given to other containment design variables (e.g., the maximum upper pool water level for plant operation, the worst case design basis drywell/containment pressure differential, etc.).

Reference

1. BWR Requirements Specification, 22A7411, "Suppression Pool Makeup System".

GENERAL ELECTRIC -- GESSAR II -- ACTION PLAN

ACTION PLAN 31

I. Issues Addressed

11.0 Mark III load definitions are based upon the levels in the suppression pool and the drywell weir annulus being the same. The GGNS technical specifications permit elevation of differences between these pools. This may effect load defintion for vent clearing.

II. Program for Resolution

The Mark III containment load definitions in GESSAR II are reported on a generic basis assuming equal water levels in the suppression pool and drywell weir annulus. During normal plant operation, elevation differences between these pool waters will be controlled by the applicable Technical Specifications which define such influential parameters as drywell/containment temperature, humidity and pressure. It is the responsibility of the Mark III Owner/AE who follows the GESSAR II containment design to develop Technical Specifications which are consistent with their FSAR defined loads.

GESSAR II does not include these Technical Specifications; consequently, General Electric believes this issue is not applicable and is considered closed.

GENERAL ELECTRIC -- GESSAR II -- ACTION PLAN

ACTION PLAN 32

I. Issues Addressed

14.0 A failure on the check valve in the LPCI line to the reactor vessel could result in direct leakage from the pressure vessel to the containment atmosphere. This leakage might occur as the LPCI motor operated isolation valve is closing and the motor operated isolation valve in the containment spray line is opening. This could produce unanticipated increases in the containment spray.

II. Program for Resolution

1.+ The potential effect of maximum backflow which can occur will be estimated. This will include calculating the maximum backflow which can occur, evaluating thermal interaction with the relatively cool RHR spray flow and estimates of the limitations on flashing created by flow through the spray nozzles.

2.+ An evaluation of the possibility of adding interlocks to prevent simultaneous actuation of these valves will also be performed.

\+ These results are generic in that they deal with analytical methods, data, or a combination of the two. The GGNS Action Plan response is applicable, and this element is considered to be closed.

GENERAL ELECTRIC -- GESSAR II -- ACTION PLAN

ACTION PLAN 33

I. Issues Addressed:

16.0 Some of the suppression pool temperature sensors are located (by GE recommendation) 3" to 12" below the pool surface to provide early warning of high pool temperature. However, if the suppression pool is drawn down below the level of the temperature sensors, the operator could be misled by erroneous readings and required safety action could be delayed.

II. Program for Resolution

1. The GESSAR suppression pool temperature monitoring system and the Emergency Procedure Guidelines were reviewed to ensure that proper sensor installation locations have been defined, and that the appropriate operator instructions exist for determining bulk suppression pool temperature.

GENERAL ELECTRIC RESPONSE

The GESSAR II suppression pool temperature monitoring system (SPTMS), described in Figure 7.6-16, specifies 32 temperature sensors to be located 3" to 12" below normal low water level, and 8 (post-LOCA) temperature sensors to be located between minimum post-LOCA and 12" below minimum post-LOCA water level. Section 6.2.7.5 in GESSAR II specifies safety grade suppression pool level monitors to provide control room operator alarm/indication whenever the water level is outside the normal (Technical Specification) high and low water level range.

A general operator caution (Caution #5) in the BWR generic Emergency Procedures Guidelines (EPG, Revision 3) reads; "Suppression pool temperature is determined by procedure for determining bulk suppression pool water temperature". Each BWR owner completes this operator caution by specifying in their Emergency Operating Procedures a specific procedures for determining bulk pool temperature which is based on their plant unique SPTMS design.

With pool temperature sensors at multiple elevations, control room alarm provided whenever the water level falls below the normal operating range, and a basis for establishing procedures for determining bulk suppression pool water temperature; the GESSAR II design should present no delay in safety action by the plant operator in the event some of the pool temperature monitors have uncovered. Consequently, General Electric believes this issue is closed.

GENERAL ELECTRIC -- GESSAR II -- ACTION PLAN

Action Plan 34

I. Issues Addressed

19.1 The chugging loads were originally defined on the basis of 7.5 feet of submergence over the drywell to suppression pool vents. Following an upper pool dump, the submergence will actually be 12 feet which may effect chugging loads.

II. Program for Resolution

1. The maximum, bounding effect of vent submergence on chugging boundary loads has been quantified. The GGNS results bound the GESSAR II results for loads on the drywell wall and basemat floor. The GESSAR II containment wall chug load is three percent higher than the GGNS containment wall chug load. The exceedance is judged to be negligible due to the degree of conservatism employed in developing the increased chug loading response. The GGNS response to this Action Plan Element is the applicable GESSAR II response. The existing local and global load definitions adequately bound increased submergence effects on chugging pressure loads, therefore, this item is considered to be closed.

GENERAL ELECTRIC -- GESSAR II -- ACTION PLAN

Action Plan 35

I. Issues Addressed

19.2 The effect of local encroachments on chugging loads needs to be addressed.

II. Program for Resolution

1.+ An evaluation of the adequacy of available models to investigate the impact of longer acoustic paths on chugging load definition will be performed.

2.+ The inertial impedance effect of the GESSAR II local encroachments on the chugging source is negligible. The GESSAR II encroachments, like the GGNS encroachments, are greater than two bubble diameters away from the chugging bubble. The GESSAR II encroachments have a negligible contribution to the hydrodynamic mass of the source. The GGNS response to this Action Plan Element is the applicable GESSAR II response.

+ These results are generic in that they deal with analytical methods, data, or a combination of the two. The GGNS Action Plan response is applicable, and this element is considered to be closed.

GENERAL ELECTRIC -- GESSAR II -- ACTION PLAN

Action Plan 36

I. Issues Addressed

20.0 During the latter stages of a LOCA, ECCS overflow from the primary system, can cause drywell depressurization and vent backflow. GESSAR II defines vent backflow vertical impingement and drag loads to be applied to drywell structures, piping and equipment, but no horizontal loading is specified.

II. Program for Resolution

1. No action is required on this item based on MP&L/GE discussions with the NRC staff. This item is closed.

GENERAL ELECTRIC -- GESSAR II -- ACTION PLAN

Action Plan 37

I. Issues Addressed

22.0 The EPGs currently in existence have been prepared with the intent of coping with degraded core accidents. They may contain requirements conflicting with design basis accident conditions. Someone needs to carefully review the EPGs to assure that they do not conflict with the expected course of the design basis accident.

II. Program for Resolution

1. GE believes that the development program through which the Eemergency Procedure Guidelines have passed has adequately addressed this concern. GE has participated in bringing this concern to the attention of the Emergency Procedures Committee of the BWR Owners Group. GE will pursue generic resolution of this issue with the BWR Owners Group. Accordingly, GE believes that for GESSAR II, this issue is closed.

GENERAL ELECTRIC -- GESSAR II -- ACTION PLAN

Action Plan 38

I. Issues Addressed

1.8 Bechtel drawing C-1043A which supposedly represents the as-built condition of the TIP platform does not show the platfrom extending into the suppression pool. This is not in agreement with MP&L's contention that the TIP platform extends into the pool.

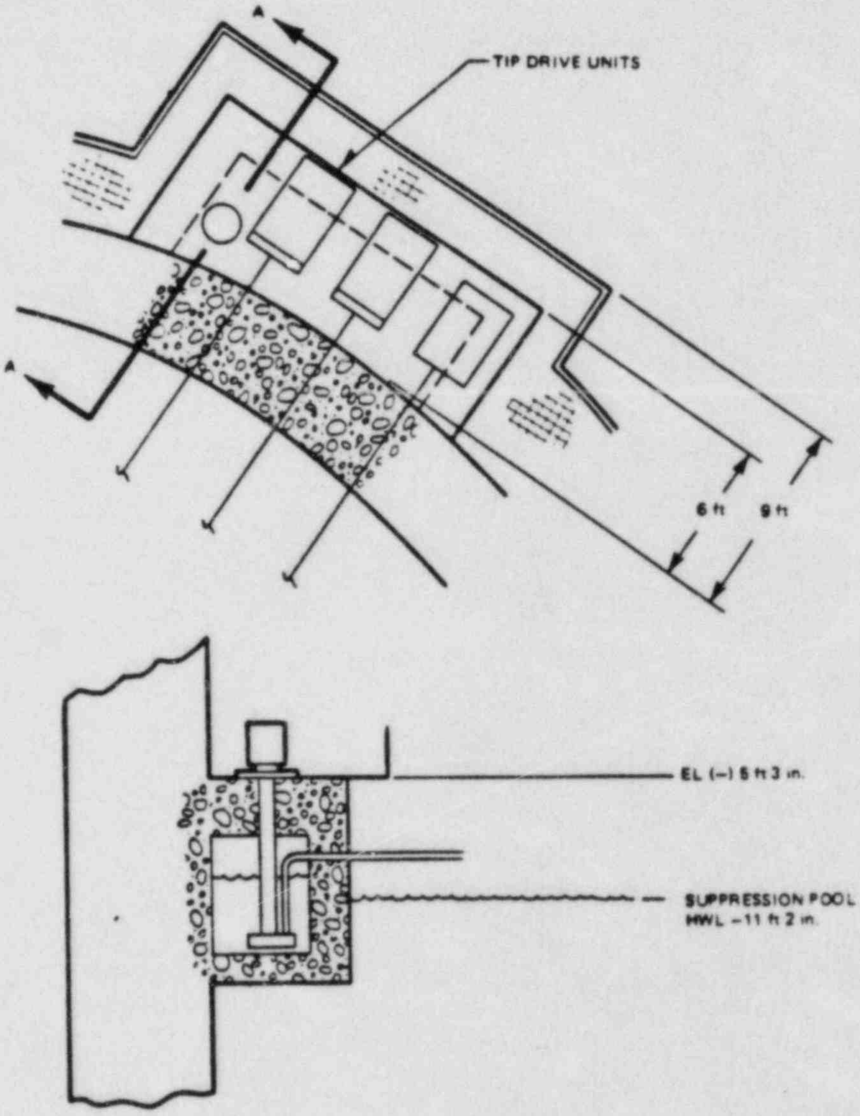
II. Program for Resolution

1. Although the specific issue relates only to GGNS, GE has reviewed the GESSAR II drawings to ensure that the TIP platform base extends into the suppression pool.
2. A sketch is provided to show the general configuration and elevations in relation to the pool normal operating level range.
3. The drawings were also reviewed to ensure all other significant structures, e.g., the personnel hatch, at this near-pool elevation also extend beneath the pool surface.

GENERAL ELECTRIC RESPONSE

General Electric has reviewed the GESSAR II drawings which show the TIP platform design. Section A-A in Figure 38.1, attached, confirms that the base of the TIP platform extends into the suppression pool.

Figures 38.2, 38.3 and 38.4, attached, showing the general containment configuration above the suppression pool, also confirm that all the other significant structures (e.g., sumps, personnel lock, etc.) extend beneath the pool surface. Consequently, General Electric considers this issue closed.



SECTION A–A

Figure 3B-2. Containment Floor Drain Sump - 238 Plant
(38.1)

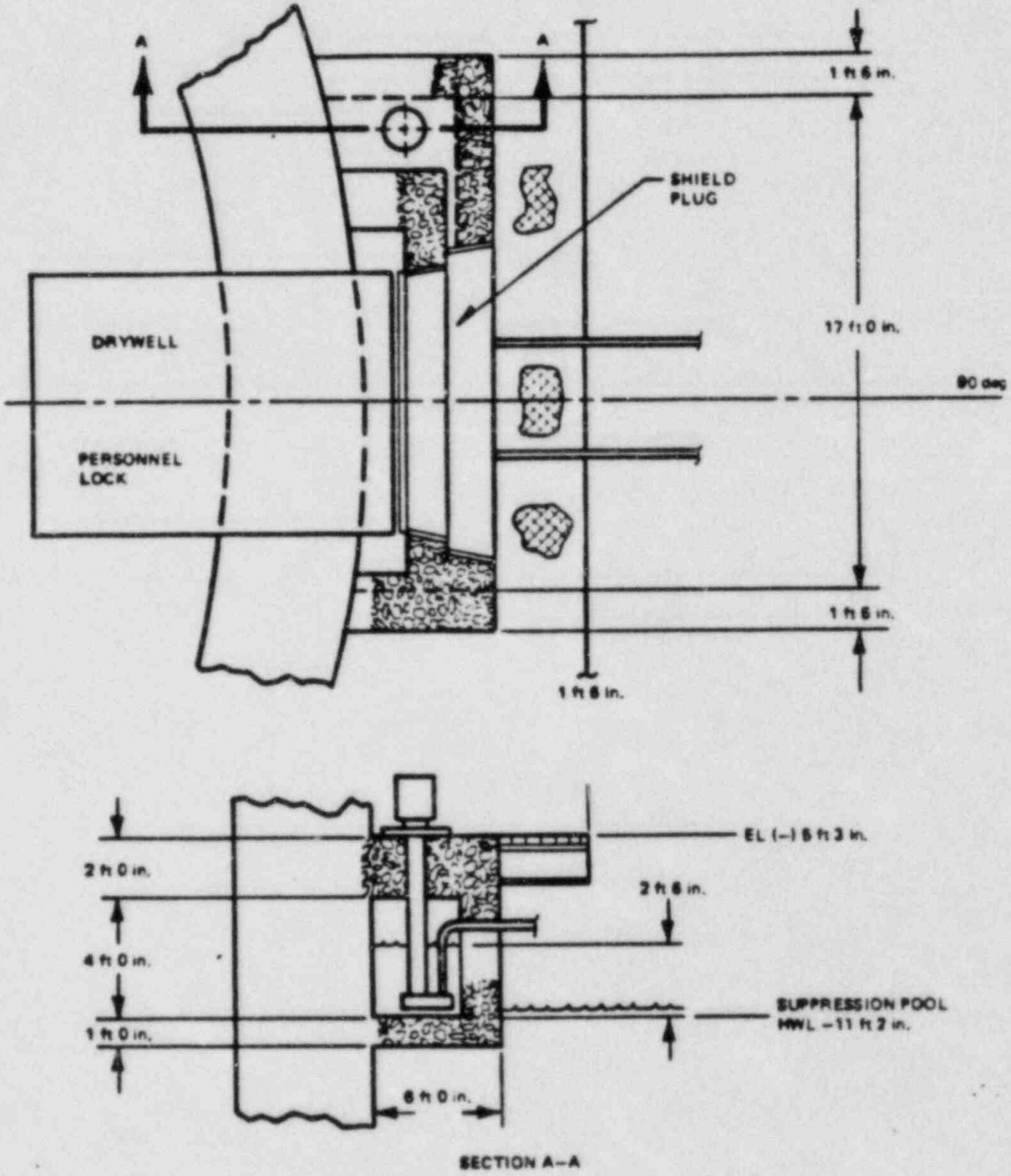


Figure 3B-3. Containment Equipment Drain Sump - 238 Plant
(38.2)

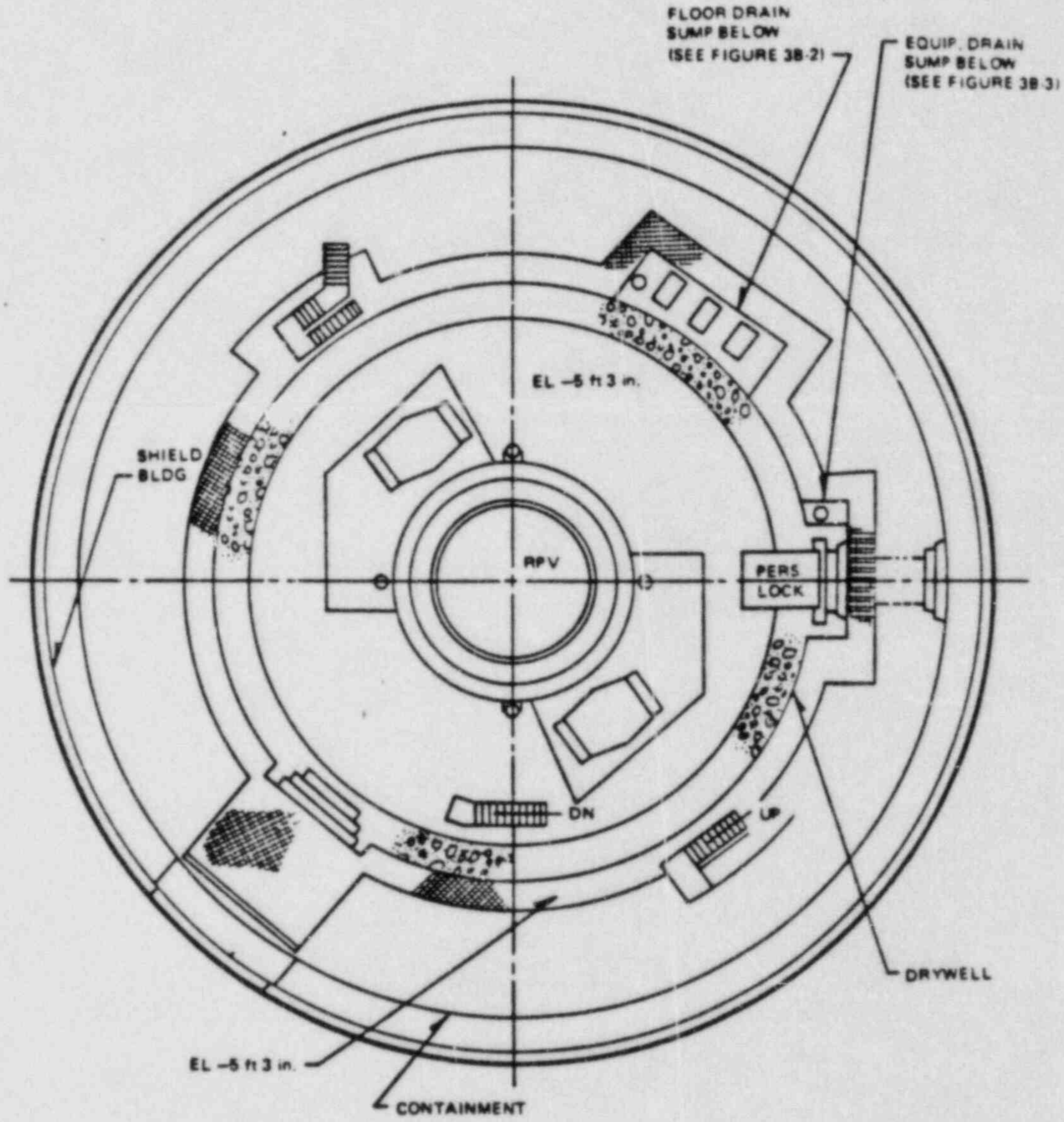


Figure 3B-4. Plan At Elevation (-)5 Feet, 3 Inches
(3B.3)

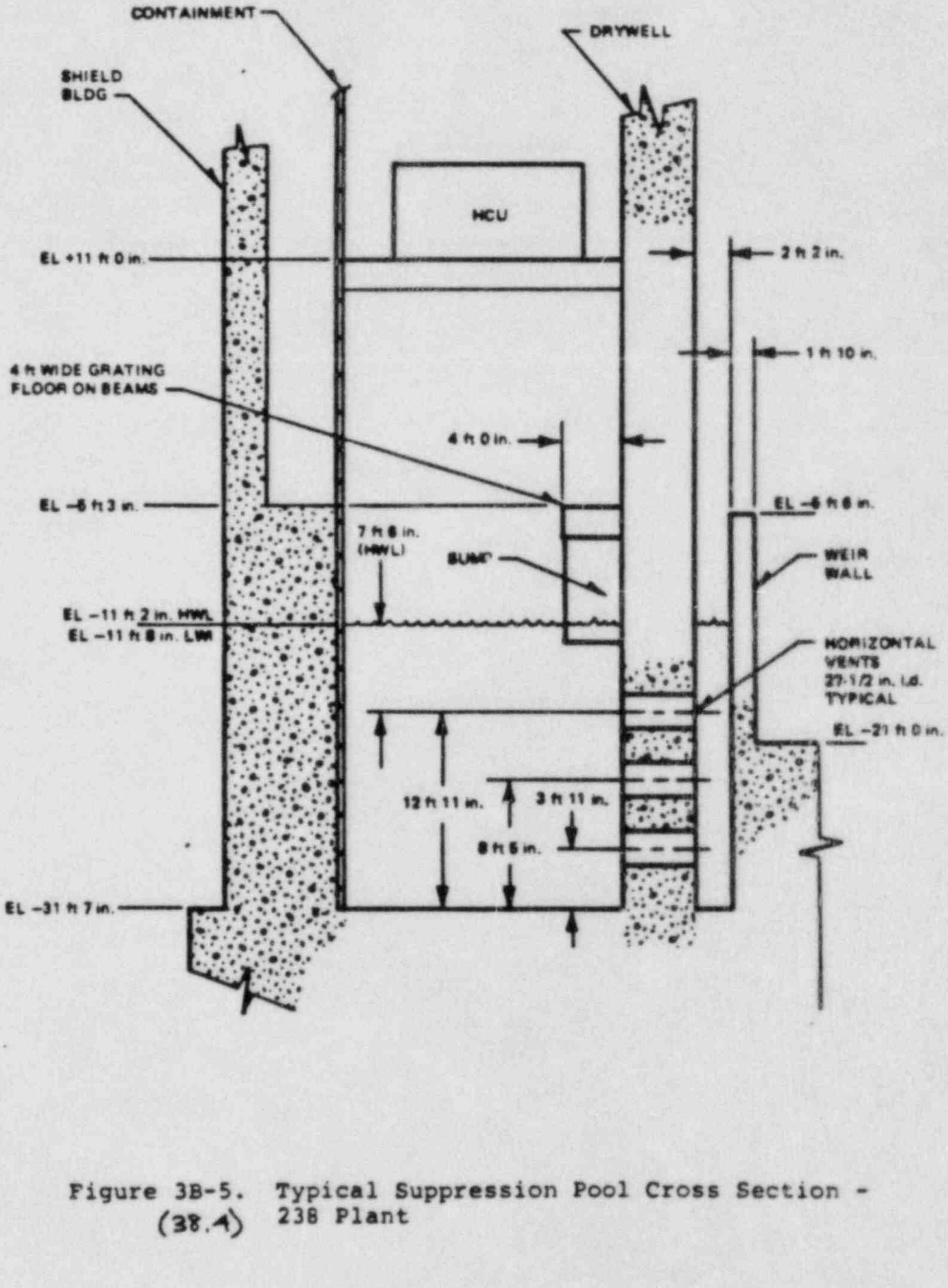


Figure 3B-5. Typical Suppression Pool Cross Section -
(3B.4) 238 Plant

GENERAL ELECTRIC -- GESSAR II -- ACTION PLAN

Action Plan 39

I. Issues Addressed

6.4 For the containment air monitoring system furnished by General Electric, the analyzers are not capable of measuring hydrogen concentration at volumetric steam concentrations above 60%. Effective measurement is precluded by condensation of steam in the equipment.

II. Program for Resolution

1. The containment air monitoring system (CAMS) which was described in GESSAR II has been removed from the GE scope of supply, because it does not meet all post-TMI regulatory requirements. To reflect this change, the CAMS descriptions in GESSAR II have been deleted by GESSAR II Amendment 14 (March 31, 1983), and replaced with the words "Applicant to Provide". Consequently, General Electric considers this issue closed.

GENERAL ELECTRIC -- GESSAR II -- ACTION PLAN

Action Plan 40

I. Issues Addressed

1.7 GE suggests that at least 1500 square feet of open area should be maintained in the HCU floor. In order to avoid excessive pressure differentials, at least 1500 square feet of opening should be maintained at each containment elevation.

II. Program for Resolution

1. References to the applicable portions of GESSAR II which address this issue are provided.
2. The amounts of open area contained in the GESSAR design at the HCU floor, and at key containment elevations about the HCU floor, are also provided.

GENERAL ELECTRIC RESPONSE

The applicable portions of GESSAR II which address the issue of maintaining 1500 square feet of open area at the HCU floor elevation are found in Appendix 3B; Sections 3B.6.1.6 and 3B.11, and Attachment K.

The calculated free-flow open area above the suppression pool at the HCU floor 11'-0" elevation is 1,500 square feet.

The open area at the only other key floor (elevation 37'-1") was calculated to be over 2,000 square feet. Consequently, General Electric considers this issue closed.

GENERAL ELECTRIC -- GESSAR II -- ACTION PLAN

Action Plan 41

I. Issues Addressed

6.2 General Electric has recommended that an interlock be provided to require containment spray prior to starting the recombiners because of the large quantities of heat input to the containment. Incorrect implementation of this interlock could result in inability to actuate the recombiners without containment spray.

II. Program for Resolution

Review of the technical issues involved has indicated the interlock should be removed. This activity is not seen as part of the GE Action Plan to resolve the issues identified by Mr. Humphrey as they relate to the GESSAR docket.

GENERAL ELECTRIC RESPONSE

General Electric has never recommended adding an interlock to require containment spray prior to starting the hydrogen recombiners. The source of this issue is an erroneous permissive on the GE RHR FCD document (Figure 7.3-5f in GESSAR II) which enabled the hydrogen mixing system to be operated only after containment spray has been actuated. This logic permissive signal was carried over from a previous design concept.

GE identified this disconnect in 1982 and has initiated the required design change process to correct it. A poll of the Mark III utilities by GE found that no plant had the subject interlock installed, so no hardware change was required. Consequently, General Electric considers this issue closed.

GENERAL ELECTRIC -- GESSAR II -- ACTION PLAN

Action Plan 42

I. Issues Addressed

12. The upper pool dumps into the suppression pool automatically following a LOCA signal with a thirty-minute delay timer. If the signal which starts the timer disappears on the solid state logic plants, the timer resets to zero preventing upper pool dump.

II. Program for Resolution

1. Review of the technical issues involved has identified the need for documentation changes to insure that a seal-in of the LOCA signal is provided.

   This activity is not seen as part of the GE Action Plan to address Mr. Humphrey's concerns as they relate to the GESSAR II docket.

GENERAL ELECTRIC RESPONSE

GESSAR II requires, in paragraph 7.3.1.1.6.C.2, that the signal to the thirty-minute timer, once initiated, is to be sealed-in unless terminated by operator action.

To provide assurance that this feature will be incorporated into the actual system design, the General Electric document which imposes requirements for design of the SPMS (see Reference 1) has been clarified as follows:

(1) A new paragraph has been added which reads:

"4.5.20 The SPMS initiation logic shall include seal-in circuitry as is necessary to assure compliance with IEEE-279 requirement that protective system actions, once initiated, shall go to completion unless terminated by deliberate operator action."

(2) The Functional Control Diagram (Drawing #794E797) which forms a part of this requirements document as a recommended design has been clarified to display a seal-in for the thirty-minute timer.

Reference

1. BWR Requirements Specification, 22A7411, "Suppression Pool Makeup System".

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GENERAL ELECTRIC -- GESSAR II -- ACTION PLAN

Action Plan 44

I. Issues Addressed

15. Secondary Containment Vacuum Breaker Plenum Response

The STRIDE plants had vacuum breakers between the containment and the secondary containment. With sufficiently high flows through the vacuum breakers to containment, vacuum could be created in the secondary containment.

II. Program for Resolution

1. The response of the STRIDE secondary containment has been evaluated for the most severe depressurization transient in the primary containment.

GENERAL ELECTRIC RESPONSE

The most severe depressurization transient in the primary containment is caused by the actuation of one containment spray loop with the wetwell airspace at high temperature, low pressure, and high relative humidity. Thus, at the time of spray actuation, the wetwell pressure is assumed to be 1.7 psig (minimum wetwell pressure for spray actuation according to EPG) with 100% relative humidity. Operator action to isolate the containment is assumed to occur within 20 minutes of the initiating event and prior to containment spray actuation. Once the containment is isolated and the wetwell airspace reaches the minimum airspace pressure for spray actuation, analysis has shown that for a spray temperature of 80°F, the maximum environment/shield building annulus negative pressure difference does not exceed -1.0 psi, which is below the design negative pressure difference for the shield building and the standby gas treatment system. Thus, for those conditions, the secondary containment integrity is preserved, and General Electric considers this issue closed.

GENERAL ELECTRIC -- GESSAR II -- ACTION PLAN

Action Plan 45

I. Issues Addressed

18.2 Insulation debris may be transported through the vents in the drywell wall into the suppression pool. This debris could then cause blockage of the suction strainers.

II. Program for Resolution

1. The insulation used on TVA STRIDE (GESSAR II) is the stainless steel, "Mirror", heat reflective type of material, consisting of inner and outer layers of heavy gage stainless with 6 layers of thinner metal (SS) sheets in between. An analysis, using conservative assumptions, on the potential of this insulation material plugging ECCS suction strainers following a LOCA was completed by GE and found to be of minor significance. See attachment.

Action Plan 45 -- GENERAL ELECTRIC RESPONSE

As stated in the Program for Resolution, TVA STRIDE (GESSAR II) uses the stainless steel, "Mirror", heat reflective type of insulation on all primary piping within the drywell, and an analysis was completed by GE to determine the potential of this material plugging ECCS suction strainers following a LOCA. The analysis was broken down into three sub-tasks:

1) Determination of the amount of reflective insulation likely to be torn loose in the drywell following a DBA.

2) Determination of the fraction of insulation that would be held up in the drywell.

3) Determination of the amount of insulation entering the suppression pool that would be captured by the suction strainers.

The quantity of piping insulation torn loose following a LOCA was estimated as 3 panels (each 2 ft long) on each side of the break. The amount of insulation depends on the size of the pipe and the location of the break relative to bends. Consequently a main steam line break probably offers the greatest potential for insulation damage. Considering the jet loads from a 26 inch steam line with a 1000 psi stagnation pressure, this evaluation assumed conservatively that the six insulation panels were completely ripped apart. Neglecting the relatively heavy inner and outer sheets, this would generate roughly 620 ft^2 of 30 mil stainless steel mirror insulation.

Both the analyses of drywell holdup and suction strainer capture fraction were based on insulation trajectories defined by the vectorial addition of their terminal velocity and the fluid flow field. Terminal velocities for the mirror type insulation fragments were 29 ft/sec in the drywell and 1.0 ft/sec in the suppression pool, assuming a drag coefficient of 1.0.

Drywell holdup fractions were calculated assuming the insulation fragments were uniformly distributed across the top of the drywell in the second before vent cleraing, followed by the trajectory calculations described above with a drywell volumetric flow rate of 122,000 ft^3/sec. The resulting velocity flow field in the drywell was calculated to exhaust 80% of the steel insulation into the suppression pool. Because of the high flow velocities in the weir annulus and the subsequent clearing of the 2nd and 3rd row of vents, no credit was taken for insulation holdup in the annulus.

Suction strainer capture areas were calculated based on the suction strainer flow field and the insulation terminal velocities. For a uniform insulation distribution across the surface of the pool, this resulted in a capture fraction of 1.6% for the mirror insulation.

Action Plan 45 -- GENERAL ELECTRIC RESPONSE (Continued)

The five ECCS suction strainers for the GESSAR II design have a total surface area of about 95 ft^2, and are designed to accommodate a 50% flow blockage. The results of this conservative analysis indicated a suction strainer blockage fraction of less than 10% for the mirror type insulation. Consequently, it is concluded that the stainless steel mirror type insulation used in the GESSAR II drywell piping design is of minor significance in potential ECCS suction strainer plugging following a LOCA, and this issue is considered to be closed.

GENERAL ELECTRIC -- GESSAR II -- ACTION PLAN

Action Plan 46

I. Issues Addressed

5.7 After upper pool dump, the level of the pool will be 6 feet higher, and drywell-to-containment differential pressure will be greater than 3 psi. The drywell H_2 purge compressor head is nominally 6 psid. The concern is that after an upper pool dump, the purge compressor head may not be sufficient to depress the weir annulus enough to clear the upper vents. In such a case, H_2 mixing would not be achieved.

II. Program for Resolution

1. GE has reviewed the possible suppression pool water levels and containment/drywell differential pressures over the period the compressors will be operated, in order to confirm that compressor purge discharge head will accomplish positive air flow through the drywell horizonal vents.

GENERAL ELECTRIC RESPONSE

The maximum suppression pool water level, as determined in Action Plan 29, could be very close to the top of the weir wall. Assuming the water level is at the top of the weir wall, approximately 5.6 psi is required to clear the vents. The drywell purge compressor is nominally rated at 500 SCFM at 6 psi. At the time of purge compressor initiation, only 40 SCFM is required to control the hydrogen concentration. Therefore, adequate margin exists in the drywell purge compressor sizing. General Electric considers this issue closed.

GENERAL ELECTRIC -- GESSAR II -- ACTION PLAN

Action Plan 47

I. Issues Addressed

Containment Pressure Response

7.3 The analysis assumes that the containment airspace is in thermal equilibrium with the suppression pool. In the short term this is non-conservative for Mark III due to adiabatic compression effects and finite time required for heat and mass to be transferred between the pool and containment volumes.

II. Program for Resolution

1. The written response provided in MP&L's submitted AECM-82/237 letter concerning this issue is also applicable to GESSAR II, and therefore GE believes this issue is closed.

GENERAL ELECTRIC -- GESSAR II -- ACTION PLAN

Action Plan 48

I. Issues Addressed

Effects of Insulation Debris

18.1 Failures of reflective insulation in the drywell may lead to blockage of the gratings above the weir annulus. This may increase the pressure required in the drywell to clear the first row of drywell vents and perturb the existing load definitions.

II. Program for Resolution

1. There are no gratings over the weir annulus in the GESSAR II drywell design; therefore, GE believes this issue is not applicable.

GENERAL ELECTRIC -- GESSAR II -- ACTION PLAN

Action Plan 49

I. Issues Addressed

21. Containment Makeup Air for Backup Purge

Regulatory Guide 1.7 requires a backup purge H_2 removal capability. This backup purge for Mark III is via the drywell purge line which discharges for the shield annulus, which in turn is exhausted through the standby gas treatment system (SGTS). The containment air is blown into the drywell via the drywell purge compressor to provide a positive purge. The compressors draw from the containment, however, without hydrogen-lean air makeup to the containment, no reduction in containment hydrogen concentration occurs. It is necessary to assure that the shield annulus volume contains a hydrogen lean mixture of air to be admitted to the containment via containment vacuum breakers.

II. Program for Resolution

1. The GESSAR II drywell purge hydrogen recombiner backup design has been reviewed to determine if any change is required to assure adequate reduction in containment hydrogen concentration occurs during its operation.

GENERAL ELECTRIC RESPONSE

An assured supply of air or hydrogen-lean air to balance the potentially hydrogen-rich Standby Gas Treatment System flow is required. The expected leakage of outside air to the Shield Building annulus may not be sufficient to provide a reduction in the containment and drywell hydrogen concentrations. A line with normally-closed valves will be ducted into the suction of the shield annulus exhaust and recirculation fans to permit controlled air leakage into the shield building. The valves on this line will be opened in the event the backup purge line is required for hydrogen control. The appropriate portions of sections 6.2.5 and 9.4 of GESSAR II will be revised to include this change, in accordance with General Electric's normal change control process. With this change, General Electric considers this issue closed.

APPENDIX 15.E.4

RESPONSES TO REQUEST FOR ADDITIONAL INFORMATION

GE PROPRIETARY - provided under separate cover

APPENDIX 15.E.5

CONFIRMATORY SOIL-STRUCTURE INTERACTION ANALYSIS FOR GESSAR II

1.0 INTRODUCTION

This report, prepared by Impell Corporation for General Electric Company, describes a series of soil-structure interaction (SSI) analyses performed for the GESSAR II Standard Plant. The objective of this work was to provide an independent assessment of SSI effects as stipulated by the NRC Standard Review Plan, Section 3.7.2. Previous SSI analyses for the GESSAR II design were performed using a general finite element approach (Reference 1). The results from those analyses form the existing seismic design basis for the standard plant. The present study was conducted using a substructure approach based upon continuum mechanics. The two approaches are fundamentally different in both theory and application, and thus satisfy the requirements outlined in the Standard Review Plan for a confirmatory analysis.

A corollary objective of this study was to evaluate the influence of the free-field control elevation on the predicted response of the structures. In the work described in Reference 1, the free-field control motion was defined at the ground surface and then deconvoluted to the bottom boundary of the finite element model. For the present study, the free-field motion is applied directly at the foundation level of the embedded Reactor Building. The results of this study may thus be used to determine the influence of the deconvolution process as applied in the previous work.

The scope of work involved a series of eight analyses which covered a very broad range of site conditions and thus form an adequate basis for a confirmatory analysis. Section 2.0 of this report describes the cases considered and provides the details of the site parameters, structure models, and control motions. Each analysis was designed to be as consistent as possible with the earlier finite element work (Reference 1). Such differences as do exist are the result of inherent limitations of the different analytical methods. Section 3.0 discusses the substructure approach used in this study and describes the steps taken to ensure a basic compatibility with the finite element analyses.

The results of the confirmatory analyses are presented in Section 4.0, and are directly compared with the existing seismic design bases for GESSAR II. Both maximum in-structure accelerations and acceleration response spectra are compared. The peak acceleration values obtained from the substructure approach are uniformly lower than the design values obtained from the previous finite element analyses. The response spectra from the present work are also generally well within the existing design envelopes, particularly for the frequency range of primary interest. Such exceedances as do occur are confined to the lower frequencies (below approximately 3 Hz) and are of secondary importance.

The conclusions of this study are presented in Section 5.0. The results demonstrate that, for the frequency range of interest, the existing envelopes are conservative, and the finite element approach as applied to the GESSAR II Standard Plant is adequate.

2.0 SCOPE OF WORK

The scope of work for this study involved a series of eight SSI analyses of the reactor building structure, using the continuum mechanics approach as implemented in the CLASSI series of computer programs. This section describes the site parameters considered for each analysis case, the structural models, and the control motions used for all the SSI analyses.

2.1 Site Parameters

The previous SSI analyses for GESSAR II were performed for a total of twelve analysis cases which covered a broad range of site conditions. For this study, the scope of work is limited to a total of eight analysis cases. Because this is a confirmatory study, this number of cases is considered sufficient, inasmuch as they cover the same broad range of site conditions used for the previous SSI analyses (Reference 1). For this reason, it is not expected that any additional cases would significantly alter the results observed in this study.

The eight analysis cases that were considered are shown in Table 2.1. Seven of these cases are for analysis in the horizontal direction and one for analysis in the vertical direction. The soil properties (at low strain levels) corresponding to each analysis case are identical to those used in the previous SSI evaluations.

For horizontal excitations, the two main soil parameters influencing soil-structure interaction are the soil shear stiffness (or shear wave velocity) and damping of the soil material. For vertical excitations, the constrained modulus (or P-wave velocity) is the most significant parameter. Consequently, these constitute the main parameters considered in this study.

The nonlinear behavior of soil was taken into account by factoring the properties at low strain by appropriate coefficients obtained by considering the range of strain levels expected at each site. Both the shear modulus and the damping were modified to arrive at strain-compatible soil properties in accordance with Figure 2.1. Other soil properties, such as unit weight and Poisson's ratio were kept constant for all analysis cases. Table 2.2 summarizes the soil properties used in this study for all the cases. The range of shear wave velocities for the horizontal analysis cases varies from 648 ft/sec. to 3422 ft/sec. Thus, soil properties varying from "soft" to "very stiff" were covered. This is essentially the same range considered for the previous SSI analyses (Reference 1).

A single analysis was performed in the vertical direction, corresponding to a site with "average" soil properties. This is considered sufficient for a confirmatory study, since the results of this analysis case are similar to those obtained by the finite element method; and the controlling analysis is the fixed base case.

2.2 Structural Models

Two separate mathematical models of the reactor building were developed, one for the horizontal analyses and one for the vertical analysis. These models were constructed based on the models used by GE for the previous SSI evaluations (Reference 1).

Horizontal Model: The model used for all the analyses in the horizontal direction is shown in Figure 2.2. The detailed portion of the model corresponding to the Reactor Pressure Vessel (RPV) section is shown in Figure 2.3. The reactor building model contains the following different areas:

- Shield Building
- Containment
- Drywell
- Shield Wall
- RPV Pedestal
- RPV and Internals

Each area of the model consists of a series of interconnected vertical beam elements having the appropriate shear and bending properties. Masses resulting from structural and hydrodynamic effects were added and lumped at the nodal points. A lumped-mass formulation was used in the solution of the equations of motion; for this reason, the off-diagonal hydrodynamic mass coupling terms were not incorporated in the model. This is the only significant difference between the model used in this study and the model used by GE to perform the SSI analysis using the finite element method. These off-diagonal mass terms represent only about 1.3 percent of the total mass of the reactor building and internals. Consequently, neglecting these terms should have no significant effect on global SSI response of the reactor building. However, because these off-diagonal masses couple the RPV and its internals, the local response obtained for these areas of the model are not expected to be identical to those of the model used by GE for the previous SSI analyses. For this reason, comparison of structural responses is limited to those areas in which the effects of the coupling masses are not present (Reactor Shield Building, Containment, Drywell). Trends observed for these areas can reasonably be extended to other areas as well.

An eigenvalue analysis was performed on the model in order to determine its dynamic characteristics. The Impell proprietary program EDSGAP was used for this purpose. A total of 20 frequencies and mode shapes were extracted. Material damping for each material type was specified as shown in Table 2.3. The composite modal damping technique was used to determine the appropriate damping for each mode.

Table 2.4 summarizes the results of the eigenvalue analysis. The first 20 frequencies of the model and corresponding modal dampings and mass participation factors are tabulated. A very good match is obtained between these results and those obtained by GE and reported in Reference 2 for modes corresponding to the Shield Building, Containment, and Drywell. As expected, modes corresponding to the Shield Wall, RPV, and Internals show some differences which are directly attributed to the absence of the off-diagonal mass terms.

Vertical Model: The model used for analysis in the vertical direction is shown in Figure 2.4. As with the horizontal case, the model consists of a series of interconnected vertical beam elements with the appropriate axial properties. The translational vertical masses are concentrated at the nodal points. An eigenvalue analysis was performed on this model using the Impell program EDSGAP. Frequency analysis results for the vertical model are shown in Table 2.3. These results are identical to those reported by GE in Reference 2.

2.3 Control Motions

Three statistically independent, synthetic earthquake acceleration time histories were used for the SSI analyses performed in this study. They are identified as H1, H2, and V. H1 and H2 correspond to the two horizontal directions and V corresponds to the vertical direction. They were developed based on the specified NRC Regulatory Guide 1.60 design response spectra. The development of these earthquake acceleration time histories is discussed in Reference 1.

Plots of each component of the acceleration time histories are shown in Figures 2.5 to 2.7 for H1, H2, and V respectively. The horizontal motion H1 and vertical motion V have a duration of 22 seconds. The horizontal motion H2 has a duration of 20 seconds. All motions are discretized at time steps of 0.01 seconds and were scaled to have a peak acceleration value of 0.15g.

The response spectrum at 2 percent damping, generated from each of the time histories, is shown in Figures 2.8 to 2.10 for motions H1, H2, and V respectively. These response spectra provide a reasonable fit to the Regulatory Guide 1.60 response spectrum.

For the SSI analyses in the horizontal directions, the control motions H1 and H2 were assumed to consist of vertically propagating shear waves. For the SSI analysis in the vertical direction, the motion was assumed to consist of vertically propagating compressional waves. Both of the above assumptions are consistent with previous analyses for GESSAR II using finite element techniques.

In the previous finite element study, which forms the existing seismic design basis for GESSAR II, the control motion was applied in the free-field at the ground surface and then deconvoluted to the bottom boundary of the finite element model. For this confirmatory study, the control motion is applied in the free-field at the foundation level of the structure. This is consistent with the current version of NRC Standard Review Plan Section 3.7.2 (Reference 3). Therefore, the results of this confirmatory study can be used to verify the adequacy of the GE approach, which consists of a surface definition of motion, combined with extensive parametric variations of site conditions.

3.0 ANALYSIS METHOD

The soil structure interaction analyses described in this report were performed using an adaptation of the CLASSI series of computer codes. These codes employ a general substructure approach to the SSI problem, and are based upon a linear viscoelastic formulation of a three-dimensional continuum. In the CLASSI approach, the soil foundation system is modeled by a series of frequency-dependent impedance functions. The influence of a seismic wave field on this system is defined in terms of the driving force vector or foundation input motion. The driving force vector and system impedances can be combined with the dynamic properties of the structure to evaluate the SSI behavior and determine the complete response of the structure.

While the theory underlying CLASSI is reasonably well developed, there are certain limitations of practical application of the code. Industry versions of CLASSI can treat a broad range of problems involving surface-founded structures. Research versions of the code can also evaluate selected cases involving embedded structures; e.g., single isolated foundations with regular geometry (hemispherical, cylindrical etc.). At present, however, CLASSI has not been developed to the point where it is capable of treating the general problem of multiple embedded structures. The basic limitation, therefore, is the inability to simultaneously consider both embedment and structure-to-structure interaction.

Of these two effects, embedment is probably the more significant. With the possible exception of well tuned adjacent structures, the primary influence of structure-to-structure interaction is on rigid body response. In terms of peak accelerations and in-structure response spectra, it can reasonably be considered a second-order effect and one which would tend to reduce overall response levels. Embedment, however, is known to affect both the site impedance functions and the driving force vectors. In the case of deeply embedded structures such as those of GESSAR II, both of these effects are significant.

For the present study, therefore, the choice was made to incorporate the influence of embedment rather than structure-to-structure interaction. Such an approach is believed to be more consistent with the previous finite element study than would be an analysis based upon surface-founded structures. For these confirmatory analyses, then, the industry version of CLASSI has been used, but applicable research results have been employed to make the appropriate adjustments to incorporate the effects of embedment in both the impedances and the driving force vectors.

Details of this approach to CLASSI are in the following sections.

3.1 CLASSI Substructuring Approach

The CLASSI substructure approach divides the SSI problem into the following three steps:

a. Determination of the foundation input motions.

b. Determination of the frequency-dependent impedance functions.

c. Analysis of the coupled soil-structure system, using results from steps a and b and the dynamic properties of the structure.

In the first step -- determination of the foundation input motion -- the CLASSI program applies the design earthquake motion at the foundation level of the reactor building in the free field. This free-field motion is then used in conjunction with the complex, frequency-dependent scattering matrix in order to determine the foundation input motion. Details on the development of the foundation input motion based on scattering matrices obtained for embedded rigid foundations are described in Section 3.2.

In the second step, the foundation impedances corresponding to rigid foundations, embedded in a uniform viscoelastic media, are developed. The procedure used for the development of the frequency-dependent impedances is described in Section 3.3.

The third step -- analysis of the coupled soil-structure system -- is carried out by CLASSI in the frequency domain. Time history of responses are obtained by inverse Fourier transform techniques.

3.2 Determination of Foundation Input Motions

In the context of the CLASSI approach, the foundation input motion corresponds to the response of the rigid, massless foundation to the seismic environment described by the free-field in the absence of the superstructure. The response of the rigid massless foundation to the seismic excitation can be described by the six-component vector:

$$\left\{U_o^*\right\} = (\Delta_x^*, \Delta_y^*, \Delta_z^*, \Theta_x^*, \Theta_y^*, \Theta_z^*)^T$$

in which $\Delta_x^*, \Delta_y^*, \Delta_z^*$ represent the translational components of the response, while $\Theta_x^*, \Theta_y^*, \Theta_z^*$ represent the rotational components of the response.

The foundation input motion $\left\{U_o^*\right\}$ is related to the free-field ground motion by means of the complex-valued, frequency-dependent scattering matrix $[S(\omega)]$:

$$\left\{U_o^*\right\} = [S(\omega)] \quad \left\{f(\omega)\right\}$$

where the vector $\{f(\omega)\}$ is the complex Fourier transform of the free-field ground motion. At a given frequency, ω, each complex number in $\{f(\omega)\}$ corresponds to the amplitude and phase of a wave component of the free-field motion. Each column of the scattering matrix $[S(\omega)]$ represents the response of a massless rigid foundation to a given incident wave of unit amplitude. The matrix product $[S(\omega)]\ \{f(\omega)\}$ is therefore the response of the rigid massless foundation to a particular free-field motion. Thus, in general, the foundation input motion depends on the geometry of the foundation, the characteristics of the soil (material properties and configuration), and the type of wave field assumed for the free-field motion.

For a surface-founded rigid foundation subjected to vertically propagating shear or compressional waves, the response of the foundation includes only translational components with amplitudes equal to those of the free-field motion on the ground surface. However, if the foundation is embedded, a horizontal component of the control motion consisting of vertically propagating shear waves produces both a horizontal translation and a rocking motion of the massless foundation. This is primarily due to the scattering of waves from the soil-foundation interface and the kinematic constraints imposed on the soil by the rigid foundation. Thus, for embedded foundations, the combined effect of translation and rocking must be considered in order to obtain accurate structural responses.

In this study, the effects due to embedment of a rigid cylindrical foundation on the foundation input motions have been explicitly accounted for by modifying the scattering matrix obtained by CLASSI for the surface foundation case. Both the translation and rocking components of the foundation input motion were modified throughout the frequency range considered for each analysis case. The basis of these modifications was results reported in References 4 and 5, which considered the effects of embedment depth on the foundation input motion for cylindrical foundations subjected to vertically incident shear waves. Both the real and imaginary terms of the scattering matrices corresponding to horizontal translational and rocking response were developed.

As shown in these references, one resulting effect of embedment on the foundation input motion is that the resulting translational component is modified with respect to the free-field motion. This is in contrast with the case of surface foundations subjected to vertically incident shear waves, in which the translational response of the foundation has the same amplitude as the free-field motion. The other resulting effect of embedment on the foundation input motion is the presence of a rocking component, which is absent in the case of surface foundations. Thus, for this study, the combined effect of both translational and rocking motion of the massless foundation were considered.

For the vertical analysis case, no modification to the scattering matrices obtained for the surface foundation has been made. This is conservative, since embedment leads to a reduction in the vertical motion (as shown in Reference 5), and a corresponding reduction in vertical structural response would be expected.

3.3 Determination of Foundation Impedances

The foundation impedances are complex-valued, frequency-dependent functions which relate the dynamic forces that the foundation exerts on the soil to the resulting soil displacements, i.e.:

$$\left\{F_s(\omega)\right\} = [K(\omega)] \left\{U_s\right\}$$

where $\{F_s(\omega)\}$ represents the generalized forces, $[K(\omega)]$ is the complex impedance matrix, and $\{U_s\}$ represents the generalized displacements. The real part of the complex impedance matrix represents the stiffness of the soil and the imaginary part represents the energy dissipation of the soil, including both radiation and material damping.

For a rigid foundation, the impedances are uniquely defined by a 6 x 6 matrix relating a resulting set of forces and moments to the six rigid-body degrees of freedom. Results reported in the literature (References 6,7,8,9) indicate that the impedances for embedded foundations are generally higher than those of surface foundations. The real part (stiffness terms) is increased because of the additional soil resistance provided by the side walls. The imaginary part (damping terms) -- which tend to be more affected than the real part -- also increase because of additional radiation of energy into the soil adjacent to the side walls of the embedded foundation. This mechanism of energy dissipation is not present in surface foundations.

The difference in impedance values between surface and embedded foundations can be significant depending on the degree of embedment. In this study, correction to the impedances obtained by CLASSI for the surface foundation were deemed necessary in order to obtain accurate structural responses. These corrections were based on detailed results reported in Reference 7. By interpolation of the impedances given in this reference for various embedment depths, to the appropriate embedment depth corresponding to the GESSAR II reactor building, frequency-dependent impedances which account for embedment of the foundation were determined.

Both the horizontal translation and the rocking impedances were obtained. The translation/rocking coupling impedances were not modified to account for embedment. This was determined to be conservative, based on sensitivity analysis specifically performed to evaluate the influence of the coupling impedances in structural response. For the vertical analysis case, no modification to the vertical impedances obtained for the surface foundation was made. This is conservative since it is well known that embedment tends to reduce the amplitude of structural response.

3.4 Analysis of Coupled Soil-Structure System

The final step in the CLASSI substructure approach is to perform the actual soil-structure interaction analysis. The impedances and scattering matrices calculated in the previous steps are used to solve the equations of the coupled soil-structure system. For this step, the dynamic characteristics of the structure (previously calculated and described in Section 2.2) are used to reduce the effects of the superstructure to six dynamic inertial parameters (modal participation factors) for each mode and a 6 x 6 rigid-body mass matrix of the structure about a reference point on the foundation (top of foundation basemat) where the SSI response is determined. Once the motion of the foundation has been obtained, the time history response at any level of the structure is computed using Fourier transform techniques. The method described above permits modeling of the structure to any desired degree of complexity in order to obtain accurate in-structure responses.

4.0 ANALYSIS RESULTS

This section summarizes the results of the confirmatory SSI analyses performed for GESSAR II using the continuum mechanics approach. Also, the results of this study were compared with those generated by GE using the finite element approach. This latter set forms the existing seismic design basis for the GESSAR II standard plant.

Peak accelerations and in-structure response spectra at the top of the basemat and at various locations of the reactor building were generated from the CLASSI analyses. The locations in the horizontal and vertical reactor building models at which the responses were generated are described in Tables 4.1 and 4.2, respectively. Other design parameters such as shear forces and bending moments are directly related to peak acceleration response. Thus, they were not specifically generated. Trends observed for the peak accelerations can be extended to shear forces and bending moments as well.

Peak accelerations at the various locations in the reactor building, corresponding to each horizontal analysis case are presented in Table 4.3. A comparison of the envelopes obtained from the CLASSI and the finite element analyses is shown in Table 4.4. This comparison shows that similar responses are obtained at the top of the basemat level; however, the continuum mechanics approach yields consistently lower in-structural peak accelerations. The decrease with respect to the finite element results is of the order of 13% at the top of the containment area (node 22) to 39% at the top of the drywell (node 42). As the amplitude of the response tends to increase with increasing soil stiffness, the continuum approach values are generally controlled by analysis Case 5 which corresponds to the very stiff soil configuration case.

Peak acceleration values obtained for the vertical analysis case are shown in Table 4.5. Also shown in this table are, for comparison purposes, the values corresponding to the existing seismic design basis for the vertical direction earthquake. It is observed that the continuum mechanics approach results -- for the case considered -- are well below those which form the existing seismic design basis. Additional reduction of responses would have been obtained had the impedances and scattering matrices been modified to incorporate effects of embedment. As explained in Sections 3.2 and 3.3 of this report, the impedances and scattering matrices corresponding to a surface founded structure were conservatively used for the analysis in the vertical direction.

For each analysis case, an acceleration response spectrum corresponding to 2% damping value was developed at all the building locations specified in Tables 4.1 and 4.2. The spectrum was developed for a total of 150 frequency points evenly distributed on a logarithmic scale of 0.5 to 33 Hz.

Enveloped response spectra covering the results of all the horizontal analyses cases were developed at each specified location. These envelopes were then compared with those similarly developed by GE and based on the finite element approach. Response spectra plots showing these comparisons are shown in Figures 4.1 through 4.16.

Comparison of enveloped response spectra shows that the envelopes based on the finite element approach, which form the GESSAR II seismic design basis, generally envelop the response spectra obtained from the continuum approach. This is especially valid for the frequency range of interest for seismic design of GESSAR II (3-33 Hz). In some isolated instances, minor exceedances are observed in the low frequency range but these are of no significance in seismic design.

For the vertical analysis case, the response spectra obtained using the continuum approach are very similar to the design envelopes up to approximately 3 Hz and well below in the frequency range of 3 - 33 Hz. This is because the fixed-base analysis case controls the design envelopes over this frequency range.

5.0 CONCLUSIONS

This report describes the results of a confirmatory set of soil-structure interaction analyses for the GESSAR II Standard Plant. These analyses were performed using a substructure approach based upon contimuum mechanics. This approach is fundamentally different in both theory and application to the finite element method used for the existing seismic design basis. Thus, the substructure approach satisfies the SRP requirements for a confirmatory analysis.

The results demonstrate the conservatism of the seismic design basis envelopes in the frequency range of primary interest for design of GESSAR II. Any exceedances of the design envelopes are confined to the lower frequency range (below 3 Hz) and are of secondary importance. Thus, this study provides an independent assessment of the SSI effects as stipulated by Section 3.7.2 of the SRP to verify the conservatism of the existing seismic design basis.

In addition, the results of this study demonstrate that the design basis methodology, which consists of a surface definition of motion, combined with extensive parametric variations of site conditions, yields a conservative design basis.

In conclusion, the conservatism of the GE SSI approach to generate seismic design envelopes for the GESSAR II reactor building has been demonstrated. As a generic approach, the GE methodology will yield conservative results for any Nuclear Island structure because:

a. As a result of extensive soil variational cases, attentuation effects due to any particular set of soil conditions are eliminated. In addition amplification effects occurring for each specific case are retained.

b. The structure is subjected to the full energy content of the design spectrum through a fixed-base analysis using the R. G. 1.60 control motion as input.

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2. Letter from General Electric Company to Impell Corporation Describing Input for SSI Analysis for GESSAR II, Dated March 21, 1983.

3. Standard Review Plan, Section 3.7.2, "Seismic System Analysis," NUREG-0800, Office of Nuclear Reactor Regulation, U.S. Nuclear Regulatory Commmission.

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5. Day, S. M., "Seismic Response of Embedded Foundations," Presented at the ASCE Convention and Exposition, Chicago, October 1978.

6. Soil-Structure Interaction: The Status of Current Methods and Research, Seismic Safety Margins Research Program (SSMRP), Prepared for the U.S. NRC by Lawrence Livermore National Laboratory, January 1981.

7. Apsel, R. J., "Dynamic Green's Functions for Layered Media and Applications to Boundary-Value Problems," Ph.D. Thesis, Univeristy of California at San Diego, 1979.

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9. Phase I Final Report, Soil Structure Interaction (Project III), Seismic Safety Margins Research Program (SSMRP), Prepared for the U.S. NRC, Lawrence Livermore National Laboratory, June 1982.

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1. Seismic Soil-Structure Interaction Analysis of the Nuclear Island, Appendix 3A, General Electric Report.

2. Letter from General Electric Company to Impell Corporation Describing Input for SSI Analysis for GESSAR II, Dated March 21, 1983.

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8. Uncertainty in Soil-Structure Interaction Analysis Arising From Differences in Analytical Techniques, NUREG/CR-2077, Prepared for the U.S. NRC, Lawrence Livermore National Laboratory, July 1982.

9. Phase I Final Report, Soil Structure Interaction (Project III), Seismic Safety Margins Research Program (SSMRP), Prepared for the U.S. NRC, Lawrence Livermore National Laboratory, June 1982.

Table 2.1

Cases Considered for CLASSI Analyses

Case No.	Description
1	Lower bound soil properties. Horizontal Motion H2.
2	Average soil properties. Horizontal Motion H2.
3	Upper bound soil properties. Horizontal Motion H2.
4	VP3 profile soil properties. Horizontal Motion H2.
5	Uniform rock profile with $V_s = 3422$ fps. Horizontal Motion H2.
6	Upper bound soil properties. Horizontal Motion H1.
7	VP5 profile soil properties. Horizontal Motion H2.
8	Average soil properties. Vertical Motion V.

Table 2.2

Summary of Soil Properties for CLASSI Analyses

Case No.	Shear Modulus $\times 10^6$ (psf)	Shear Wave Velocity (ft/sec)	Unit Weight (pcf)	Poisson's Ratio	Material Damping (%)	Constrained Modulus $\times 10^6$ (psf)	P-Wave Velocity (ft/sec)
1	1.63	648	125	0.35	8.0	N/A	N/A
2	2.70	834	125	0.35	6.6	N/A	N/A
3	6.00	1,243	125	0.35	5.0	N/A	N/A
4	11.50	1,721	125	0.35	5.0	N/A	N/A
5	45.50	3,422	125	0.35	2.0	N/A	N/A
6	6.00	1,243	125	0.35	5.0	N/A	N/A
7	27.20	2,647	125	0.35	5.0	N/A	N/A
8	2.70	834	125	0.35	6.6	11.7	1,736

Note:

N/A - not applicable

Table 2.3

Material Damping Values for Reactor Building Components

Component	Critical Damping
Shield Building	0.04
Containment	0.02
Drywell	0.04
Shield Wall	0.04
Pedestal	0.04
RPV	0.02
Fuel Assembly	0.06
CRD Guide Tubes	0.01
CRD Housing	0.01
Other Internals	0.02

Table 2.4

Reactor Building Horizontal Model
- Frequency Analysis Results

Frequency Number	Modal Frequency (Hz)	Modal Damping Factor	Mass Participation Factor
1	5.18	0.0399	-945.7
2	5.32	0.0310	-900.0
3	5.52	0.0368	-721.4
4	8.05	0.0209	262.0
5	9.01	0.0277	140.2
6	10.86	0.0324	-134.6
7	12.41	0.0525	- 23.1
8	16.70	0.0399	-482.3
9	19.33	0.0247	151.8
10	21.78	0.0400	-417.7
11	21.92	0.0137	- 45.1
12	22.81	0.0169	- 49.4
13	25.62	0.0194	- 91.3
14	26.24	0.0231	-244.0
15	30.40	0.0377	-296.1
16	30.73	0.0534	- 46.5
17	32.89	0.0136	- 31.3
18	35.28	0.0353	92.8
19	36.14	0.0400	229.3
20	40.06	0.0387	-374.5

Table 2.5

Reactor Building Vertical Model - Frequency Analysis Results

Frequency Number	Modal Frequency (Hz)	Modal Damping Factor	Mass Participation Factor
1	14.45	0.0399	-988.5
2	16.09	0.0400	-1076.7
3	20.71	0.0208	-332.5
4	23.66	0.0387	-229.1
5	26.33	0.0388	202.3
6	32.53	0.0422	303.3
7	39.98	0.0490	31.5

Table 4.1

Locations in Horizontal Model For Evaluation of In-Structure Response

Node No.	Location
1	Top of Shield Building
18	Middle of Shield Building
22	Top of Containment
42	Top of Drywell
46	Middle of Drywell
71	Top of Basemat

Table 4.2

Locations in Vertical Model for Evaluation of In-Structure Response

Node No.	Location
1	Top of Shield Building
22	Top of Containment
42	Top of Drywell
46	Middle of Drywell
60	Middle of Shield Wall
64	Top of Pedestal
71	Top of Basemat
72	RPV Internals
74	Bottom of RPV
80	Middle of RPV

Table 4.3

Maximum Acceleration Responses
for Horizontal Analysis Cases 1 to 7

Node Numbers	Maximum Accelerations (ft/sec^2)						
	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7
1	6.13	6.83	10.22	12.76	23.05	12.99	15.26
18	3.69	4.04	4.84	5.76	7.21	5.15	6.63
22	5.50	6.66	8.44	11.90	16.51	10.13	16.08
42	4.43	5.69	7.57	9.25	14.80	7.98	12.34
46	3.24	4.10	5.05	5.76	9.06	5.20	7.99
71	3.13	3.35	3.69	4.13	4.95	4.15	4.71

Table 4.4

Comparison of Envelopes of Maximum Accelerations for Horizontal Analyses

Node Numbers	Envelope of Maximum Accelerations (ft/sec^2) Continuum Mechanics Approach	 Finite Element Approach
1	23.05	32.5
18	7.21	10.0
22	16.51	19.1
42	14.80	24.3
46	9.06	14.6
71	4.95	4.8

Table 4.5

Maximum Acceleration Responses for Vertical Analysis

	Maximum Accelerations (ft/sec^2)	
Node Number	Continuum Mechanics Approach (Case 8)	GE Seismic Design Envelopes
1	4.86	12.0
22	4.83	9.7
42	5.05	10.2
46	4.95	8.0
60	4.73	5.6
64	4.69	5.2
71	4.66	4.8
72	4.80	9.7
74	4.73	5.8
80	4.70	5.3

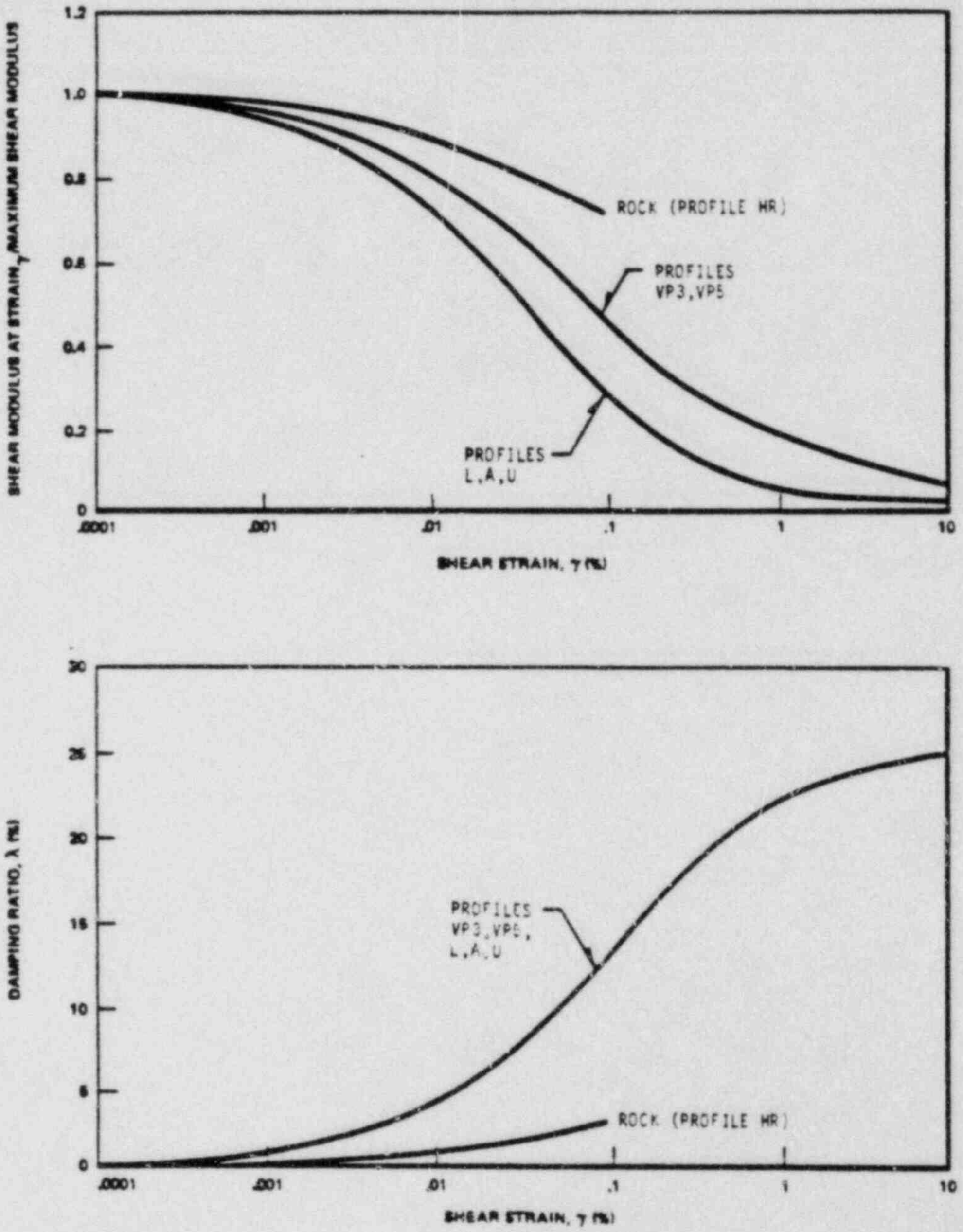


Figure 2.1 Variation of Shear Modulus and Damping Ratio with Shear Strain

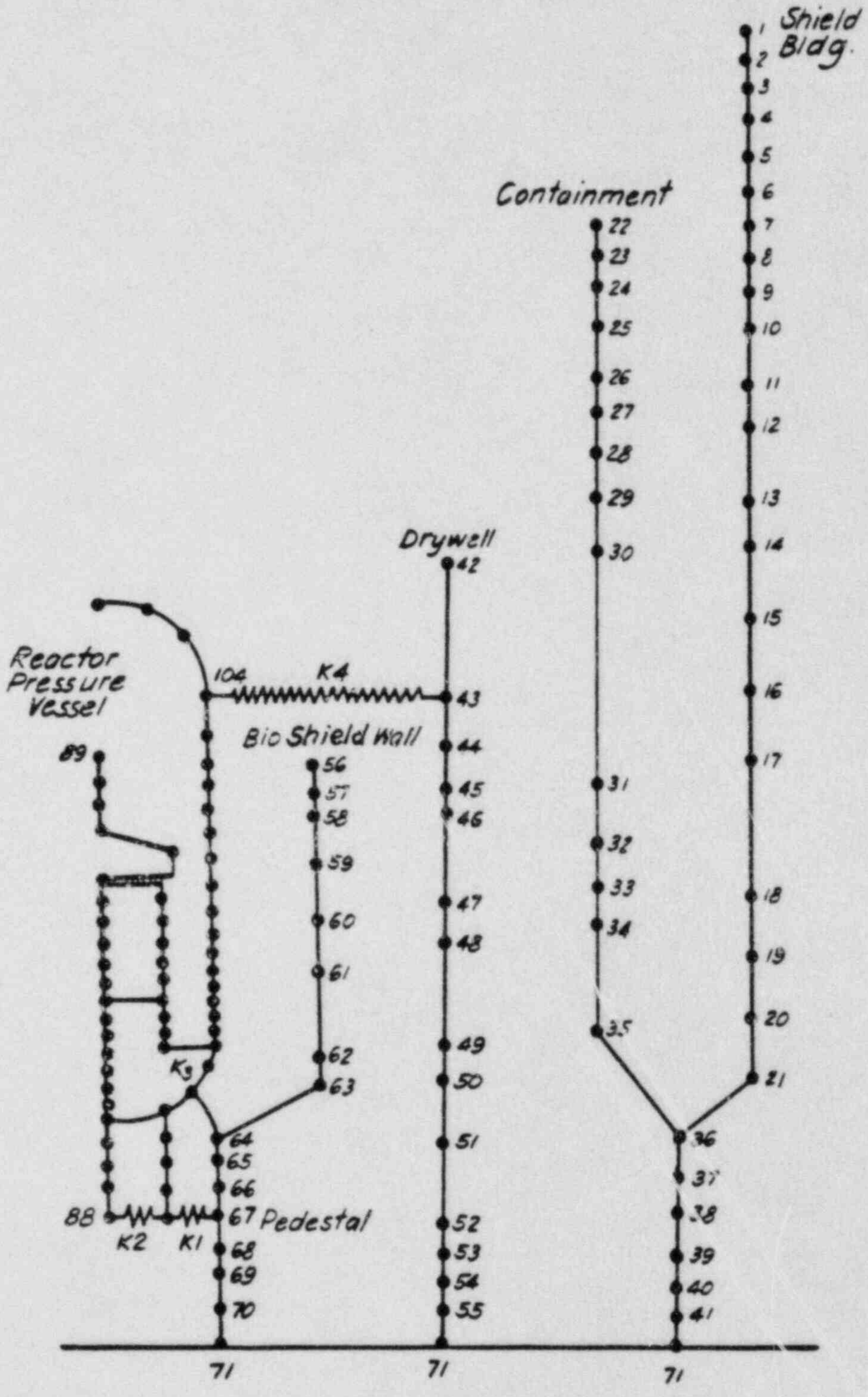


Figure 2.2 Reactor Building Model for Horizontal Analyses

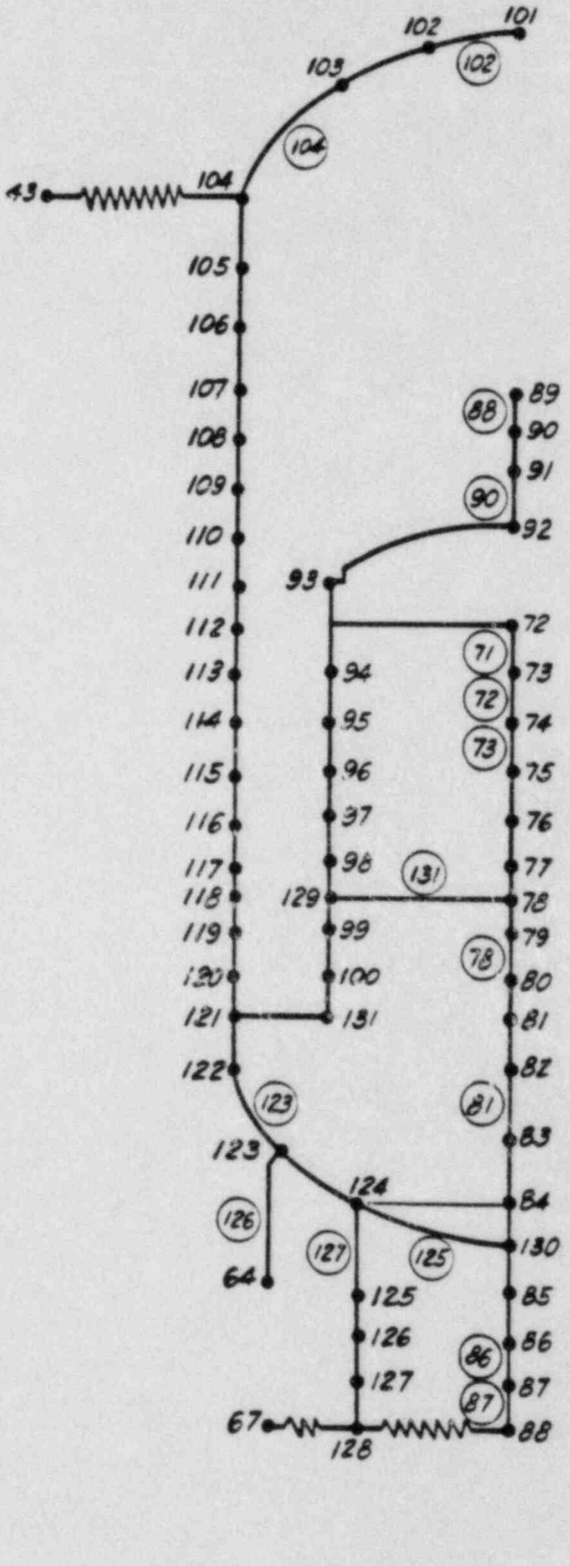


Figure 2.3 Detailed Portion of Horizontal Model Corresponding to RPV Section

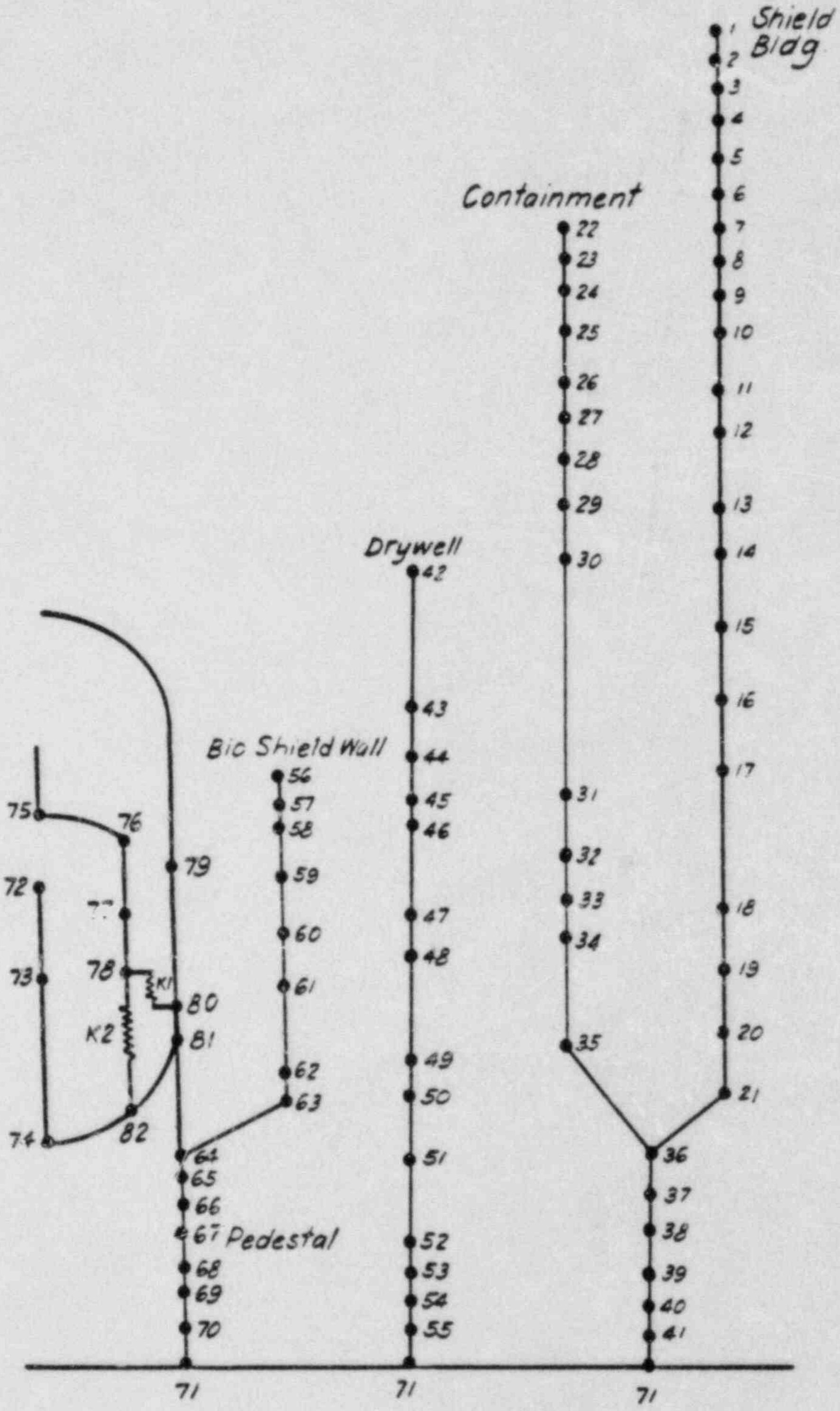


Figure 2.4 Reactor Building Model for Vertical Analysis

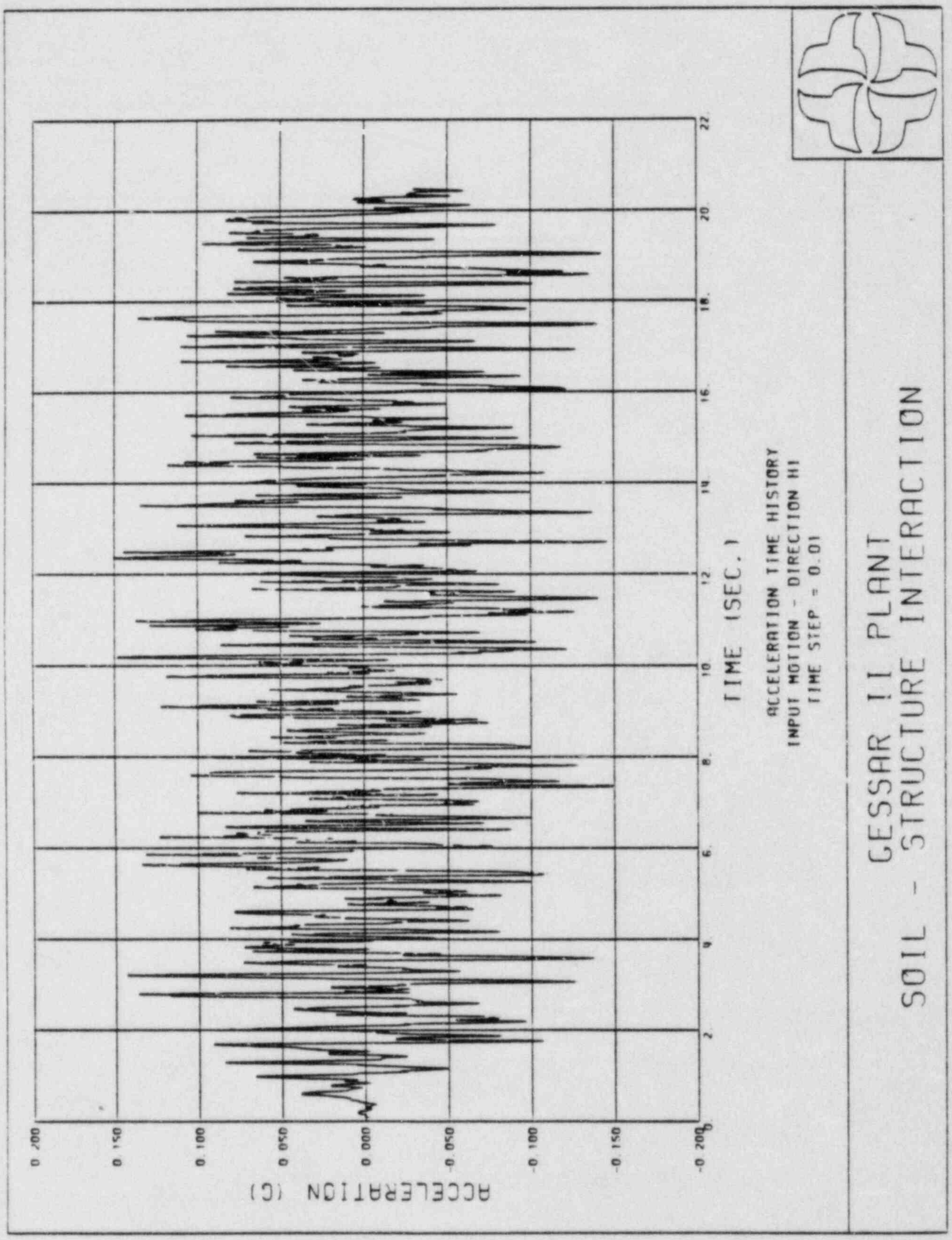


Figure 2.5 Input Acceleration Time Histor' - Direction H1

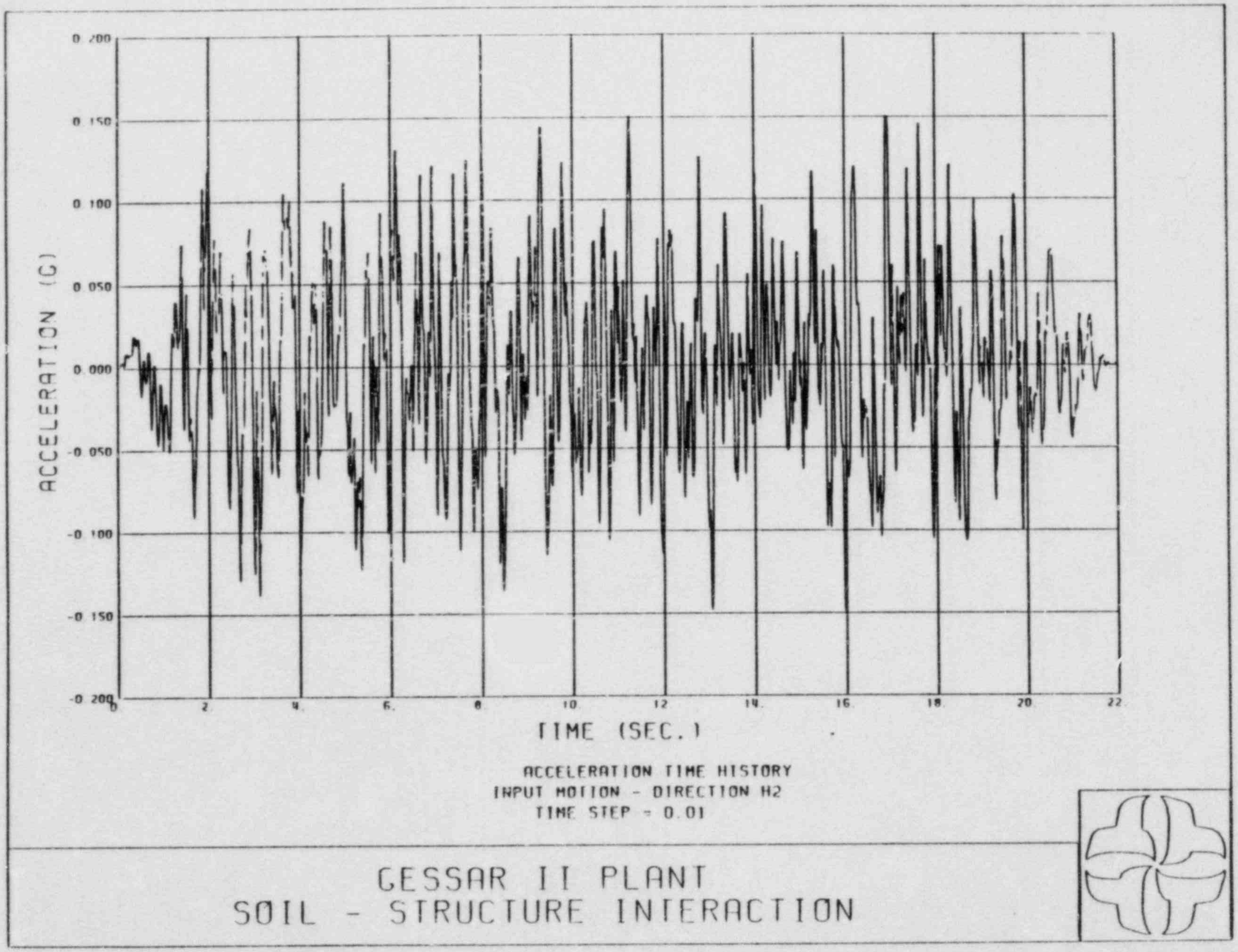


Figure 2.6 Input Acceleration Time History - Direction H2

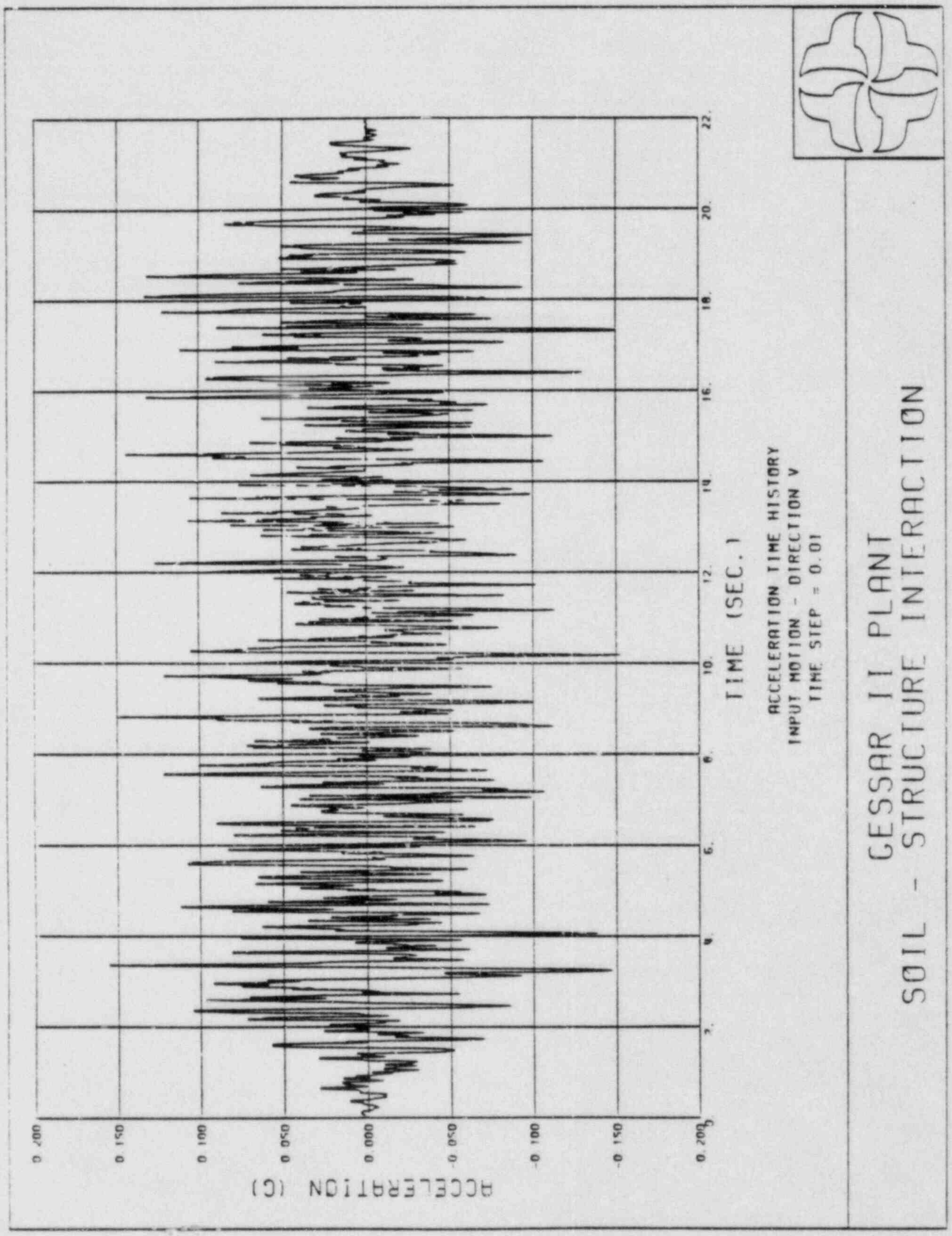


Figure 2.7 Input Acceleration Time History - Direction V

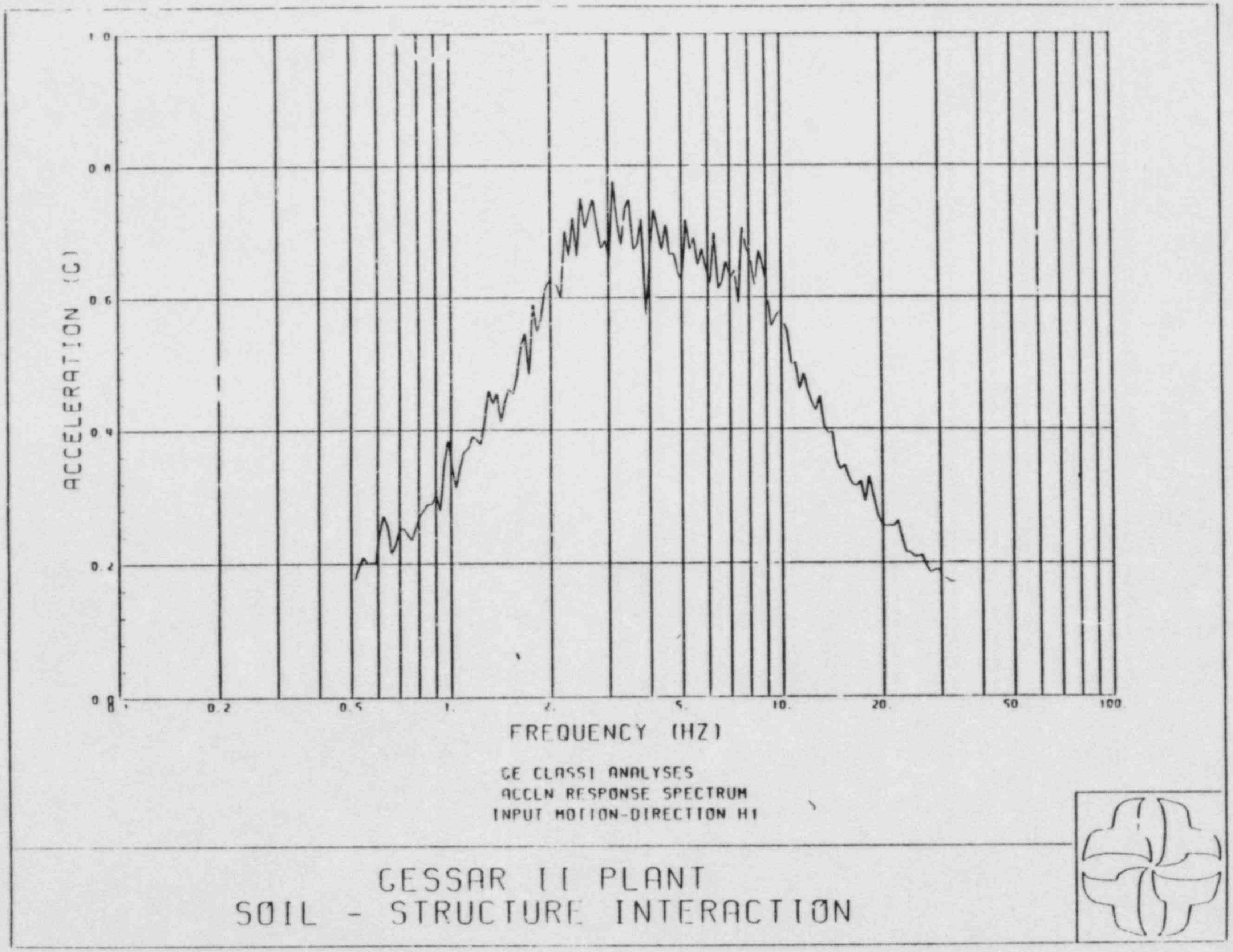


Figure 2.8 Response Spectrum of Input Motion - Direction H1

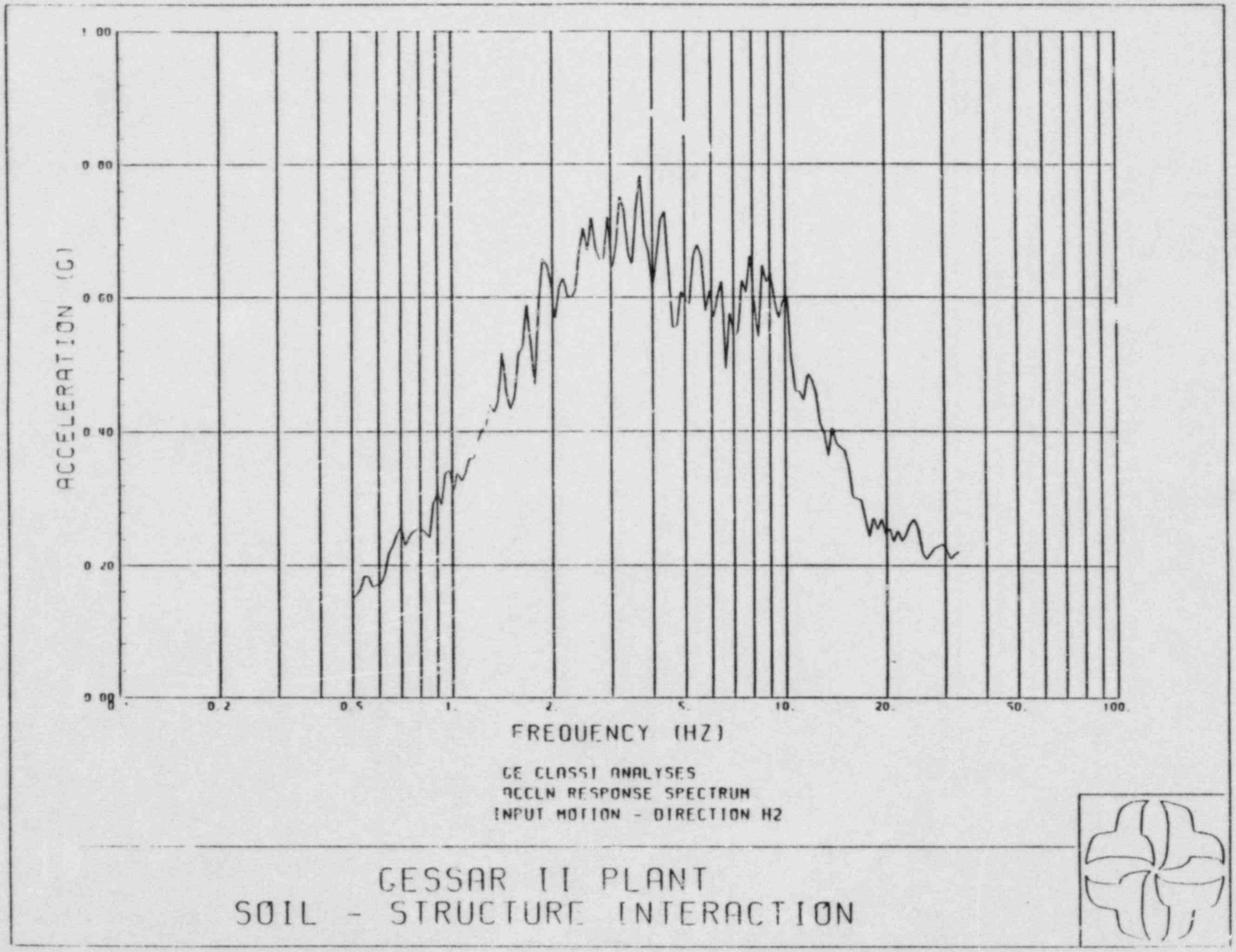


Figure 2.9 Response Spectrum of Input Motion - Direction H2

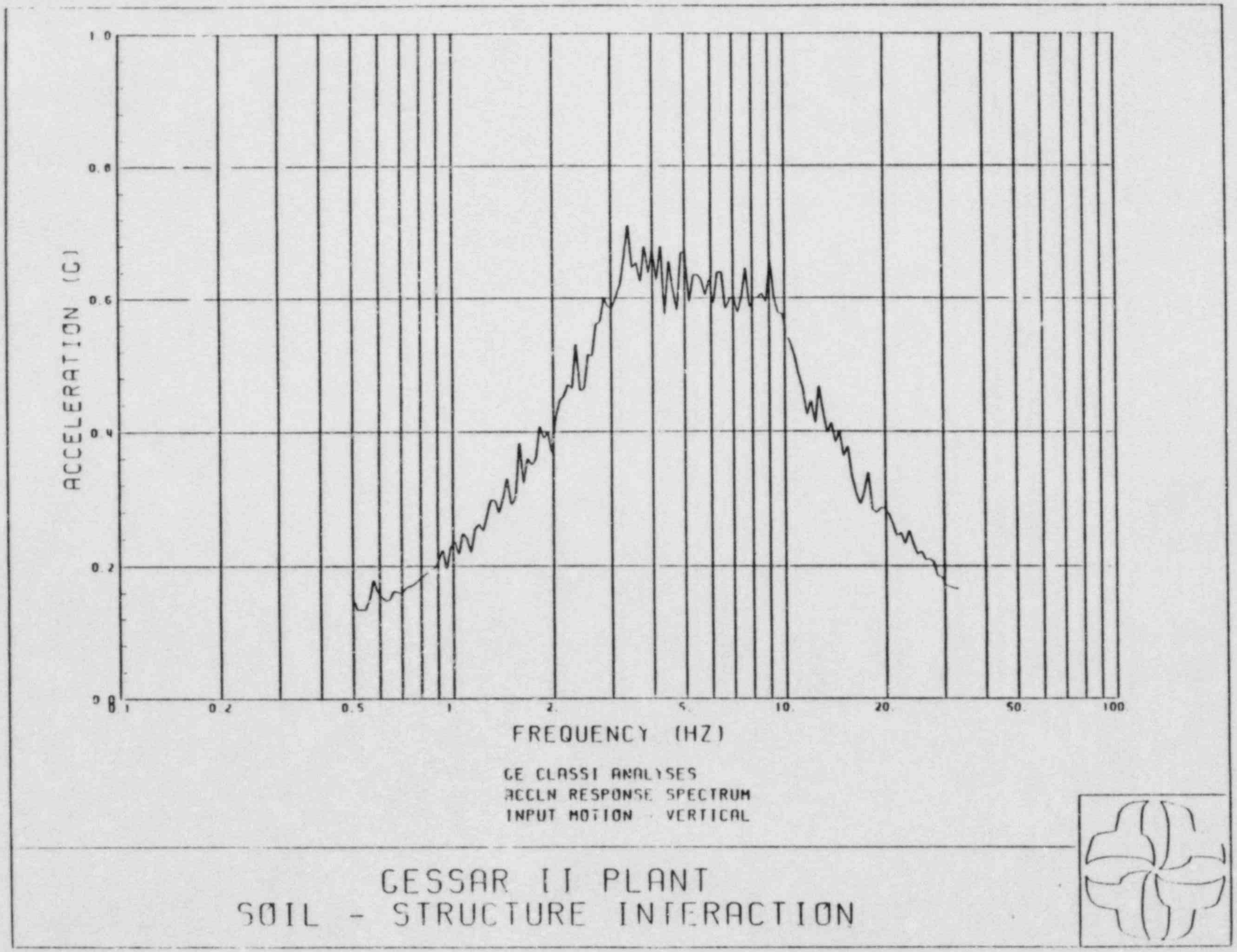


Figure 2.10 Response Spectrum of Input Motion - Direction V

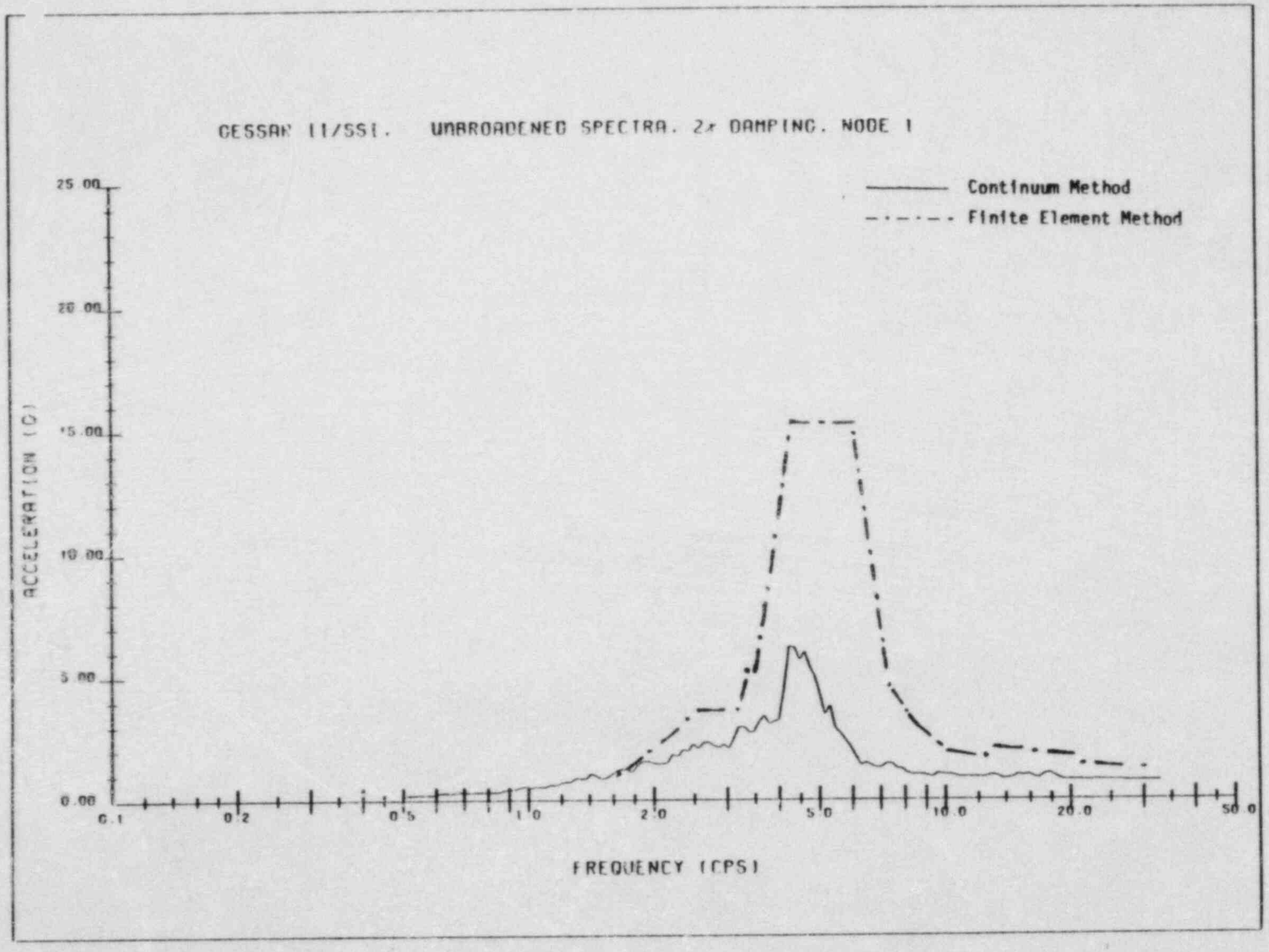


FIGURE 4.1 Comparison of Spectra Envelopes for Horizontal SSI Analyses, Node 1

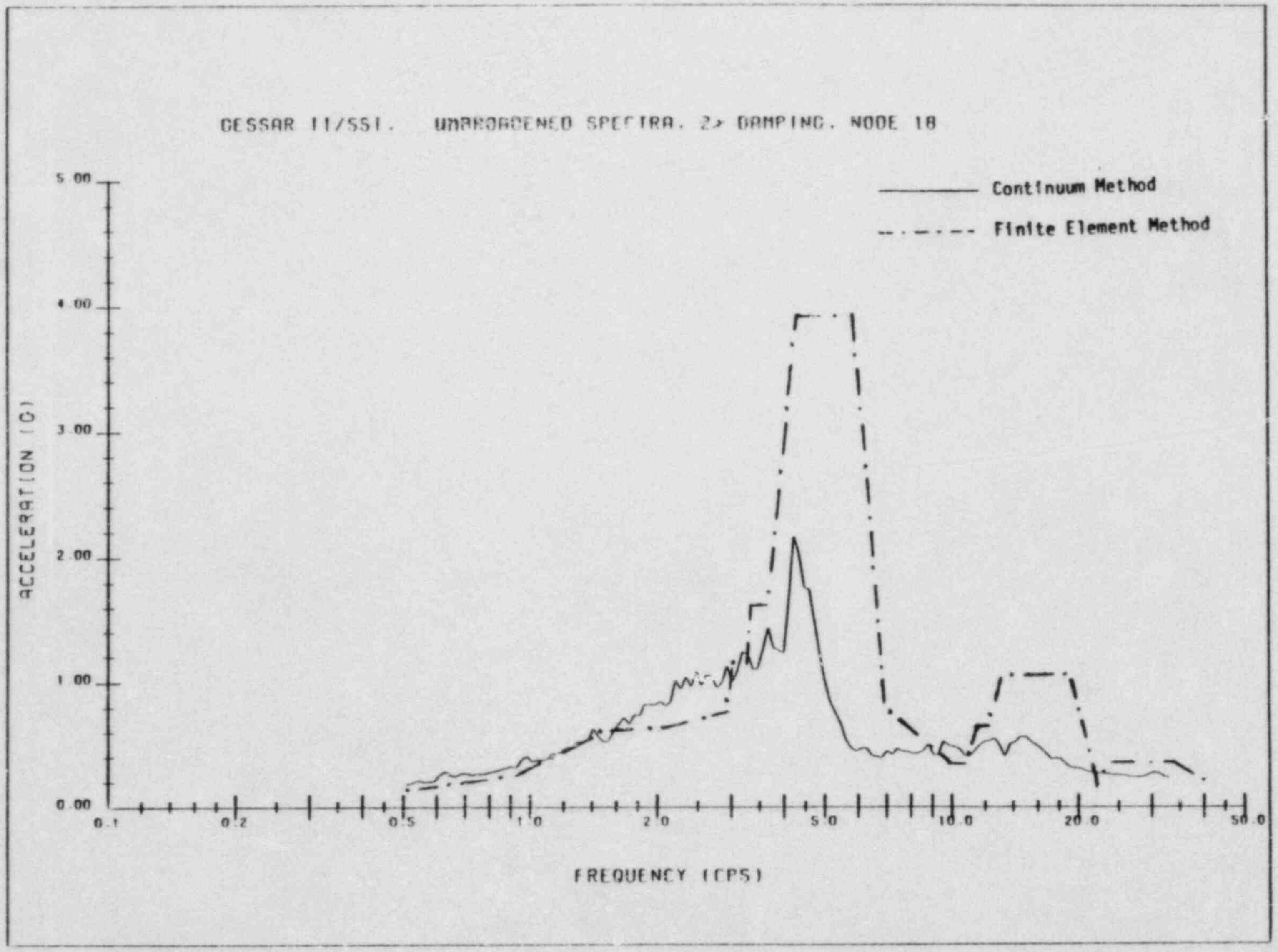


FIGURE 4.2 Comparison of Spectra Envelopes for Horizontal SSI Analyses, Node 18

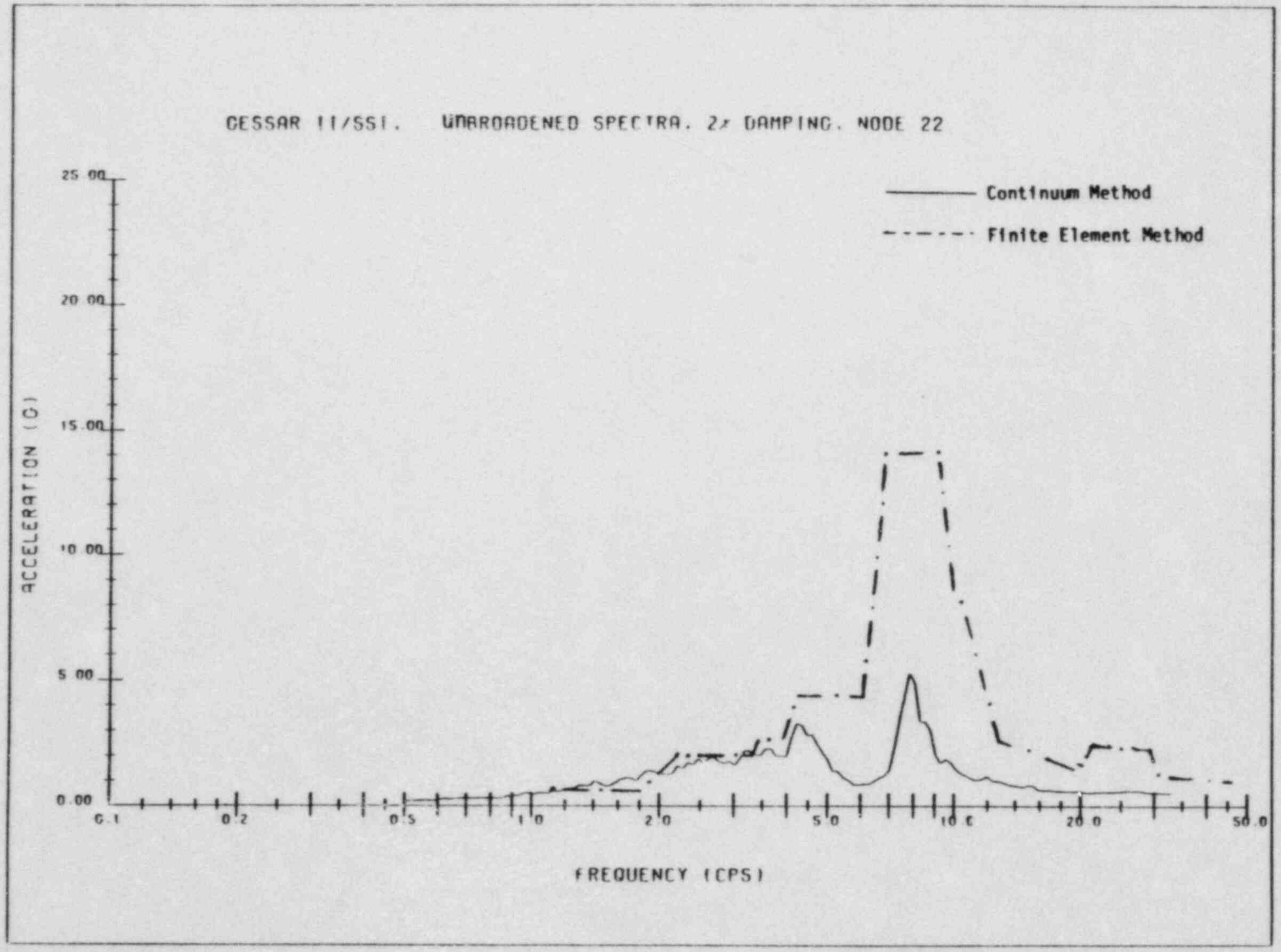


FIGURE 4.3 Comparison of Spectra Envelopes for Horizontal SSI Analyses, Node 22

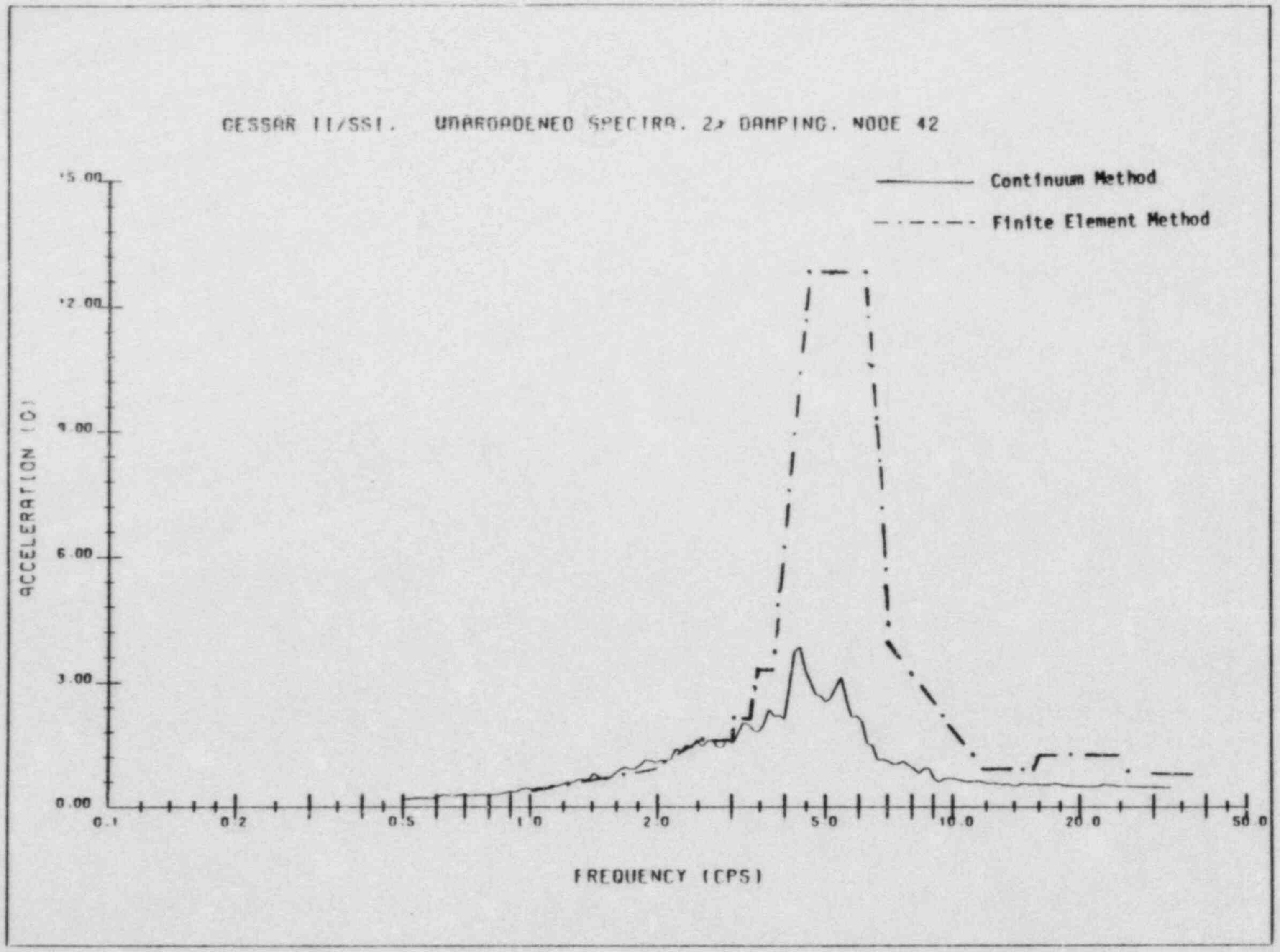


FIGURE 4.4 Comparison of Spectra Envelopes for Horizontal SSI Analyses, Node 42

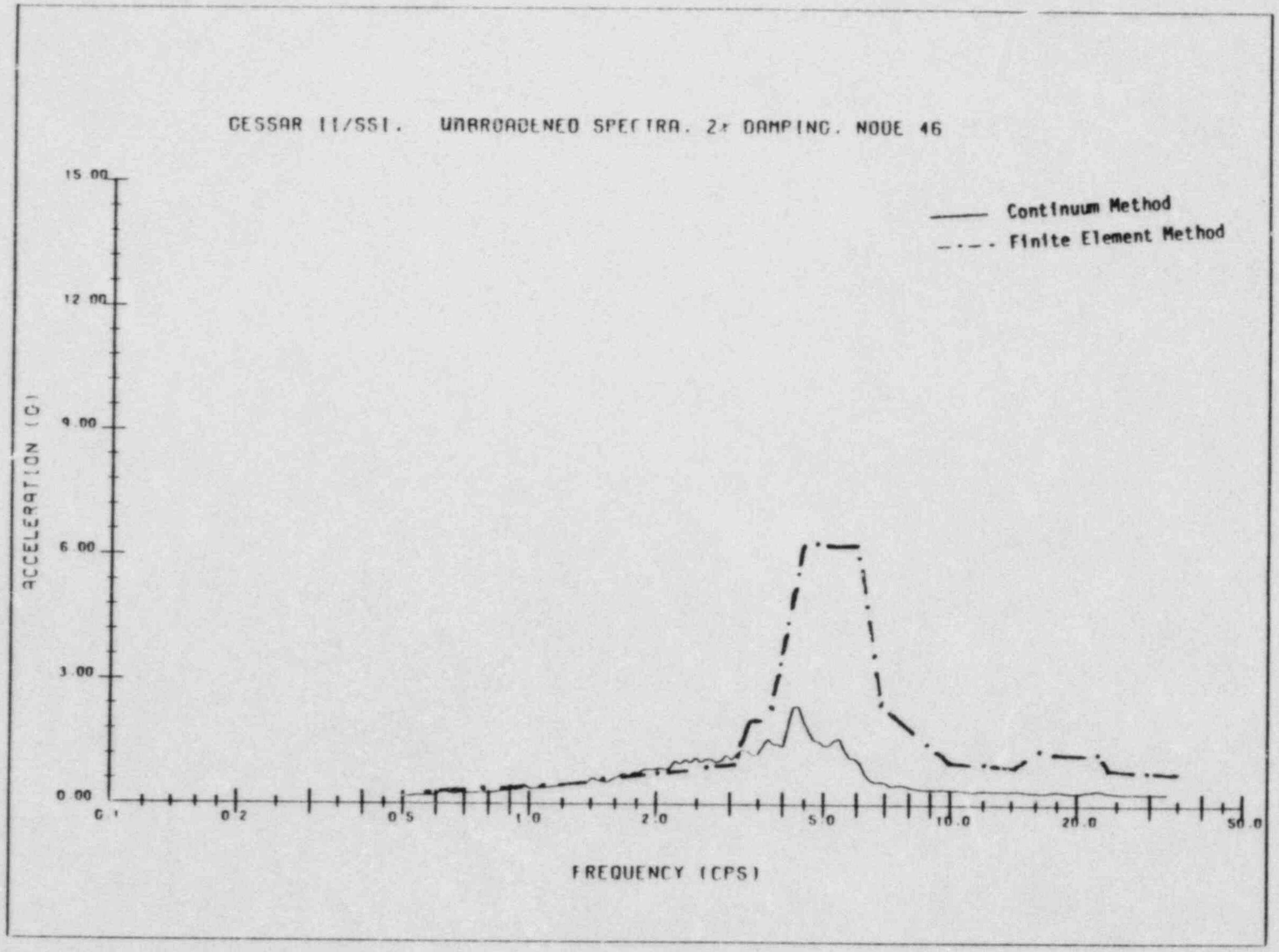


FIGURE 4.5 Comparison of Spectra Envelopes for Horizontal SSI Analyses, Node 46

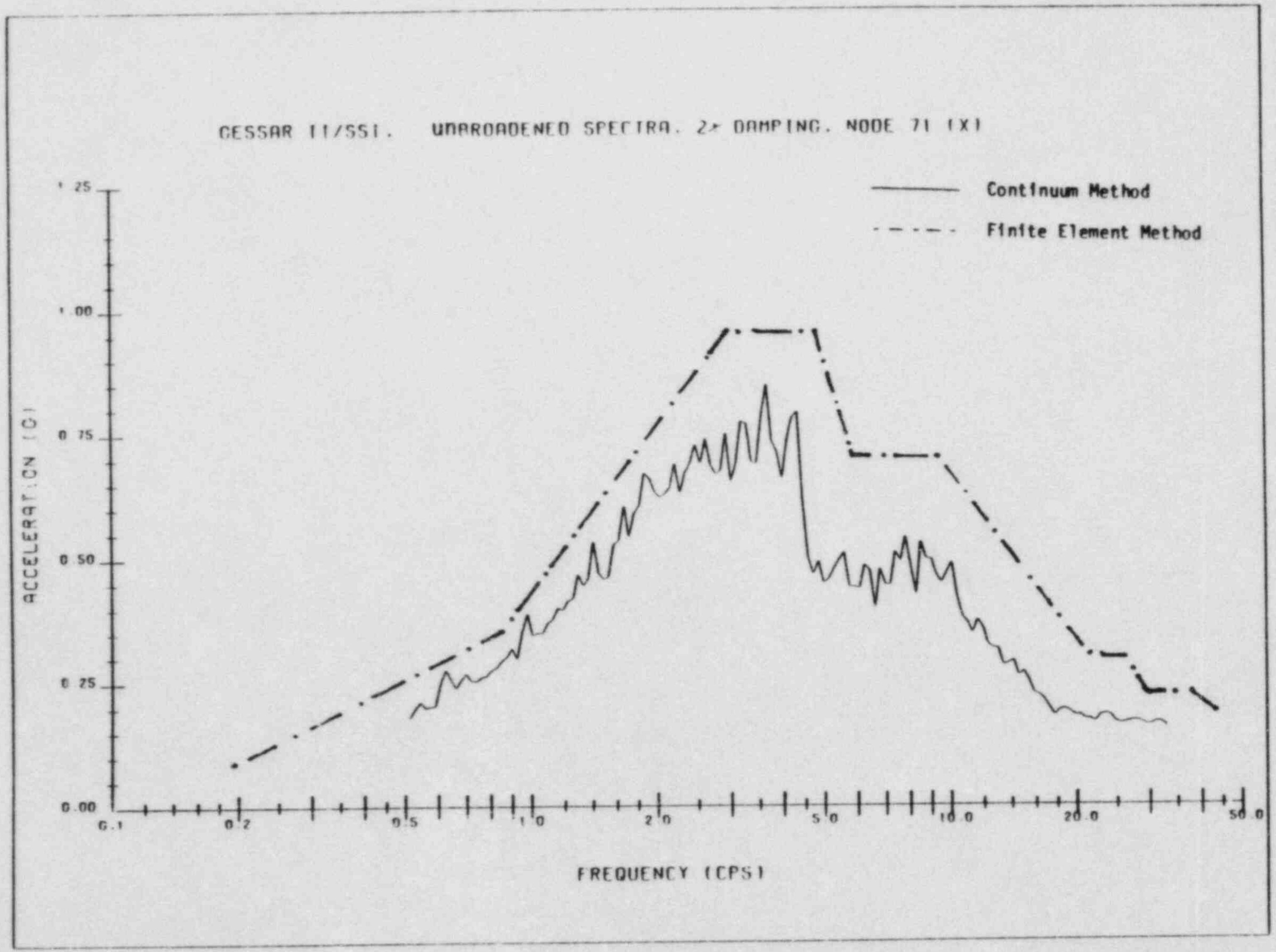


FIGURE 4.6 Comparison of Spectra Envelopes for Horizontal SSI Analyses, Node 71

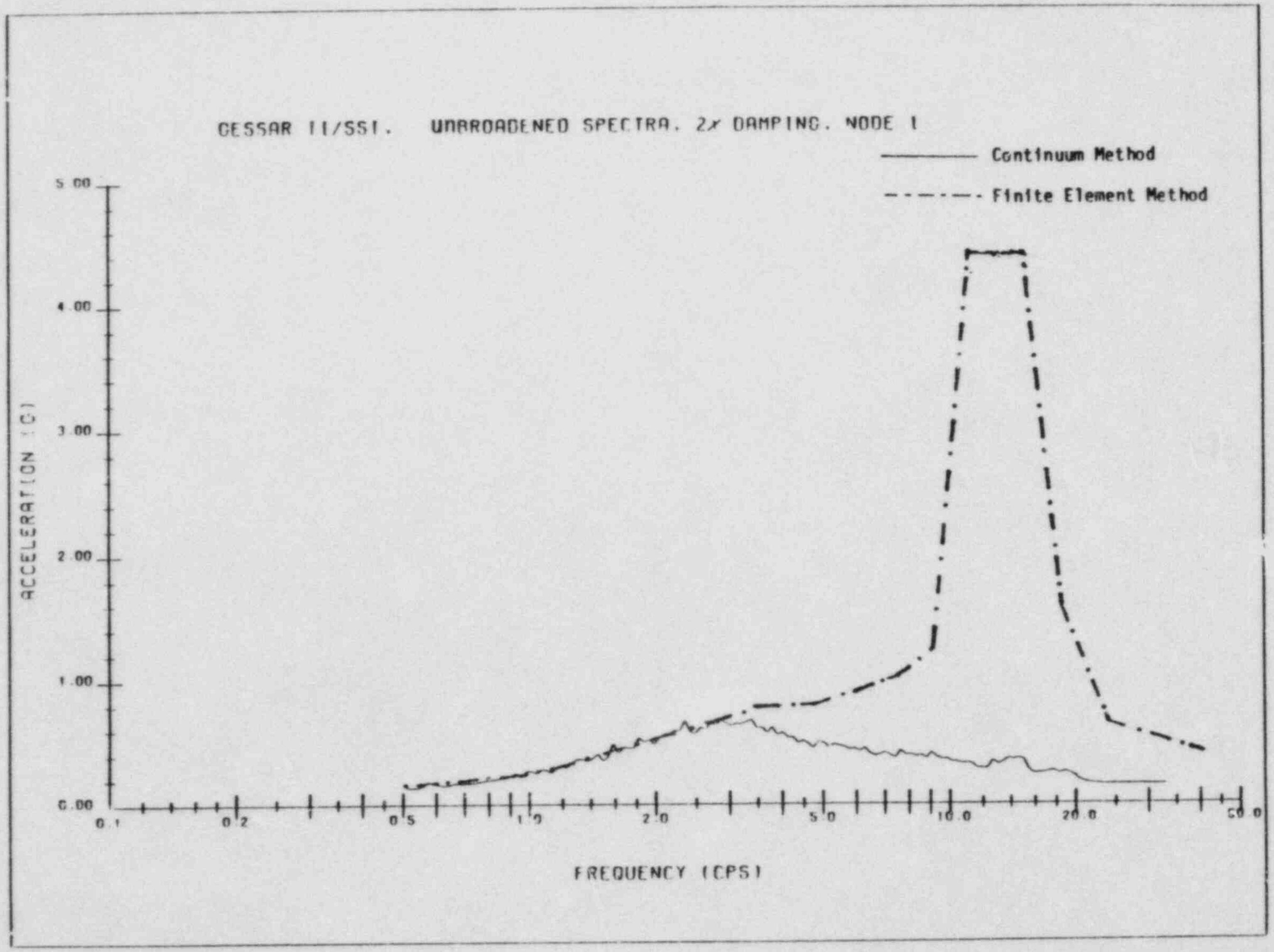


FIGURE 4.7 Comparison of Spectra Envelopes for Vertical SSI Analysis, Node 1

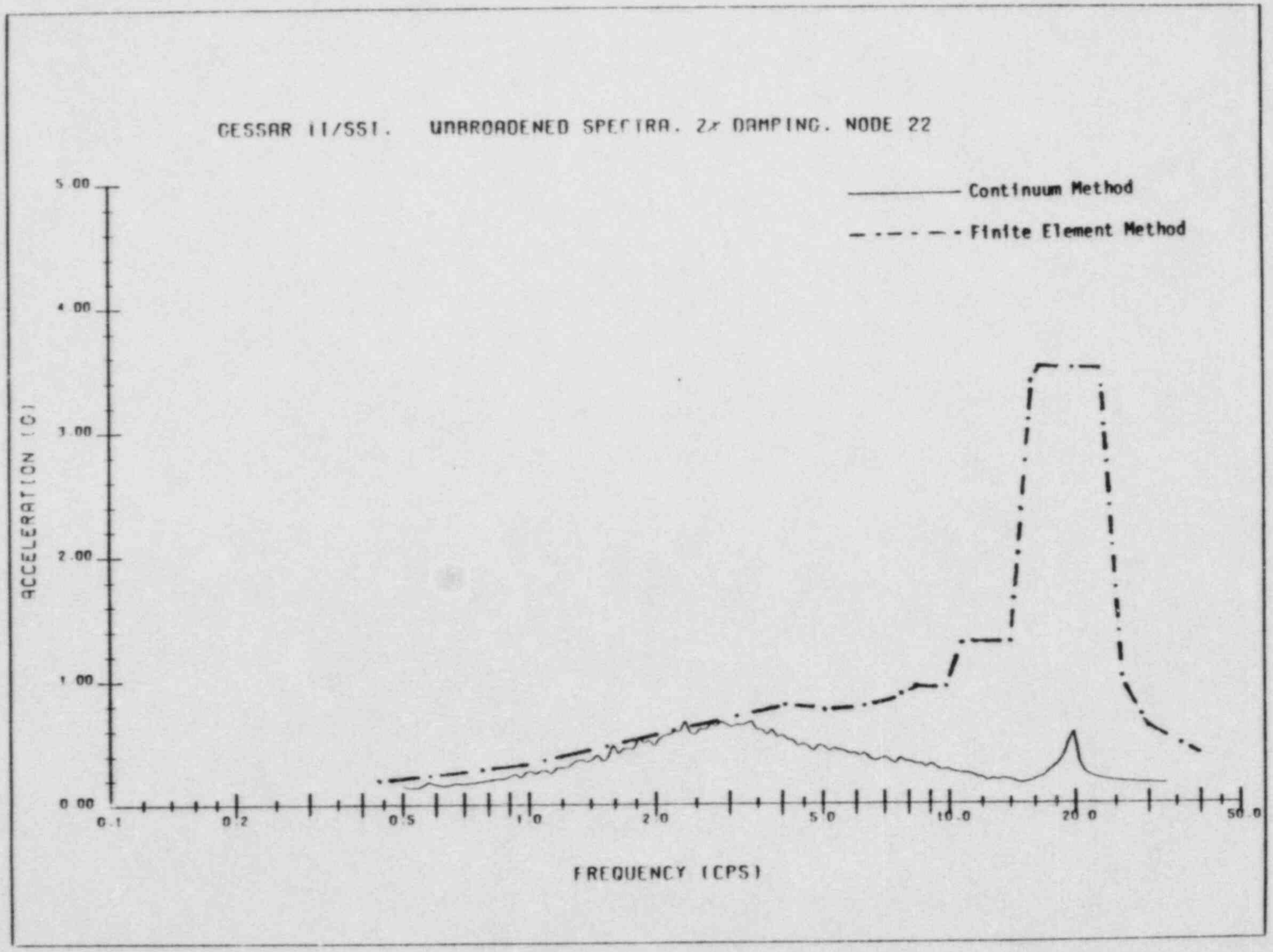


FIGURE 4.8 Comparison of Spectra Envelopes for Vertical SSI Analysis, Node 22

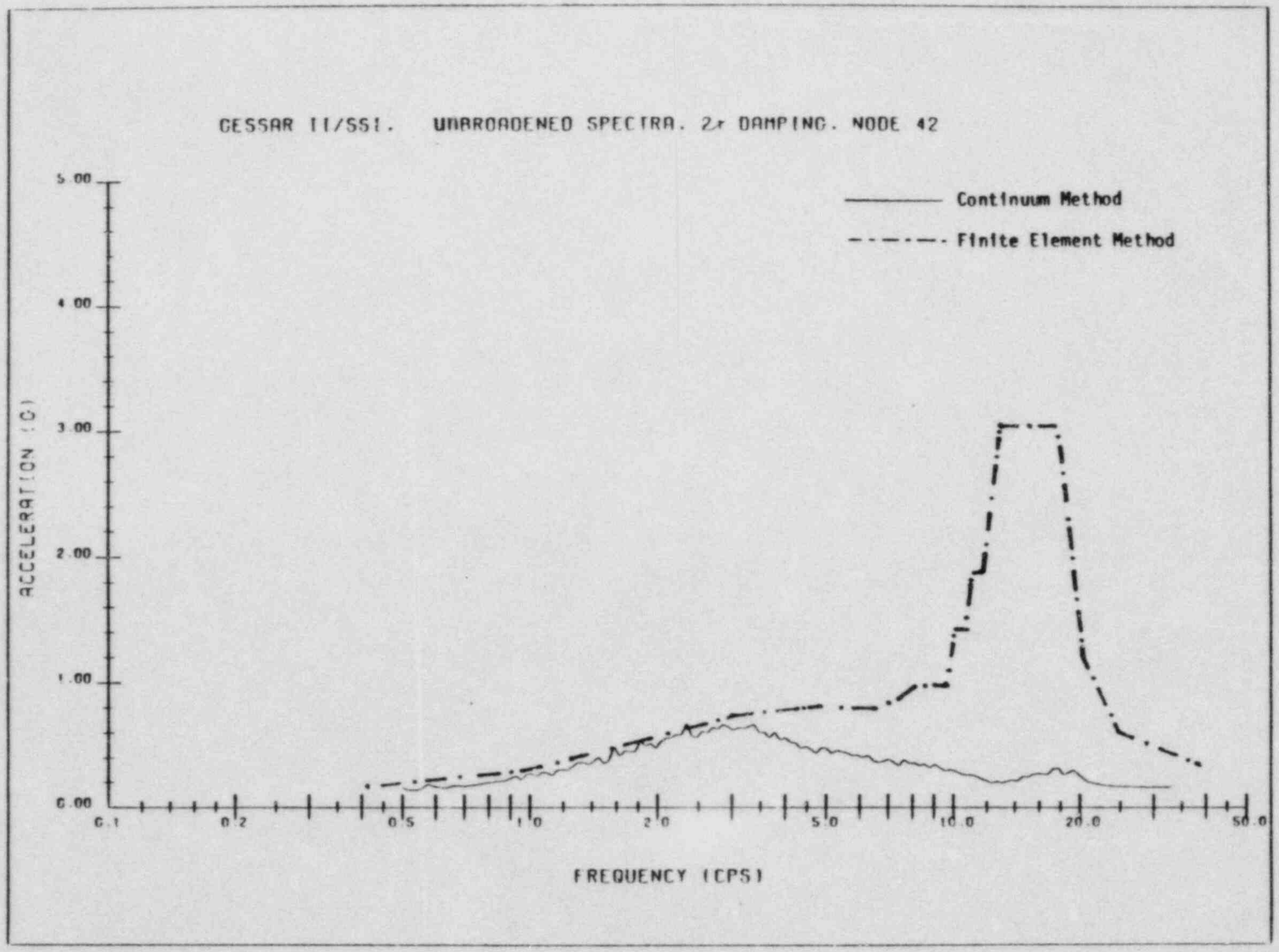


FIGURE 4.9 Comparison of Spectra Envelopes for Vertical SSI Analysis, Node 42

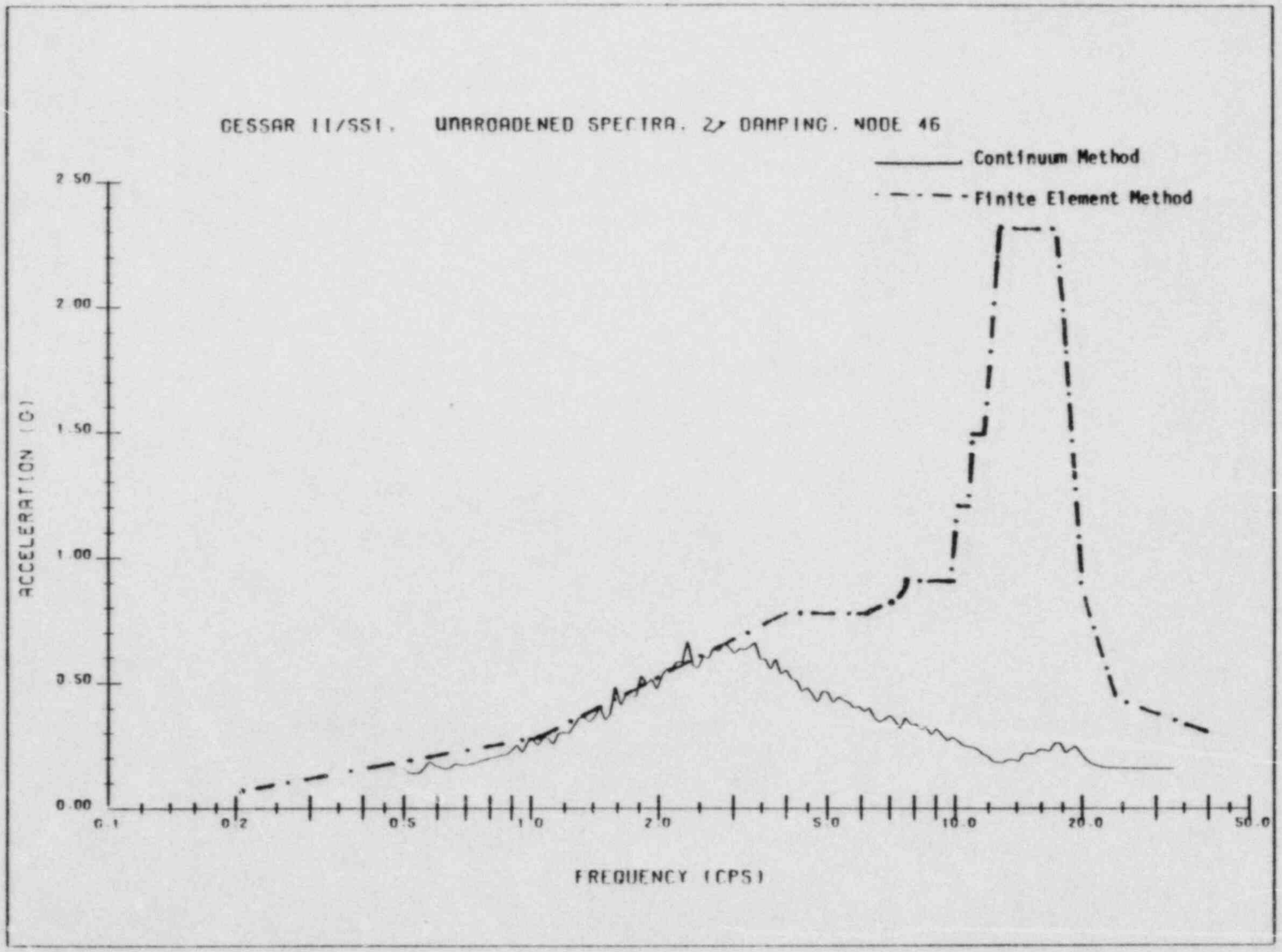


FIGURE 4.10 Comparison of Spectra Envelopes for Vertical SSI Analysis, Node 46

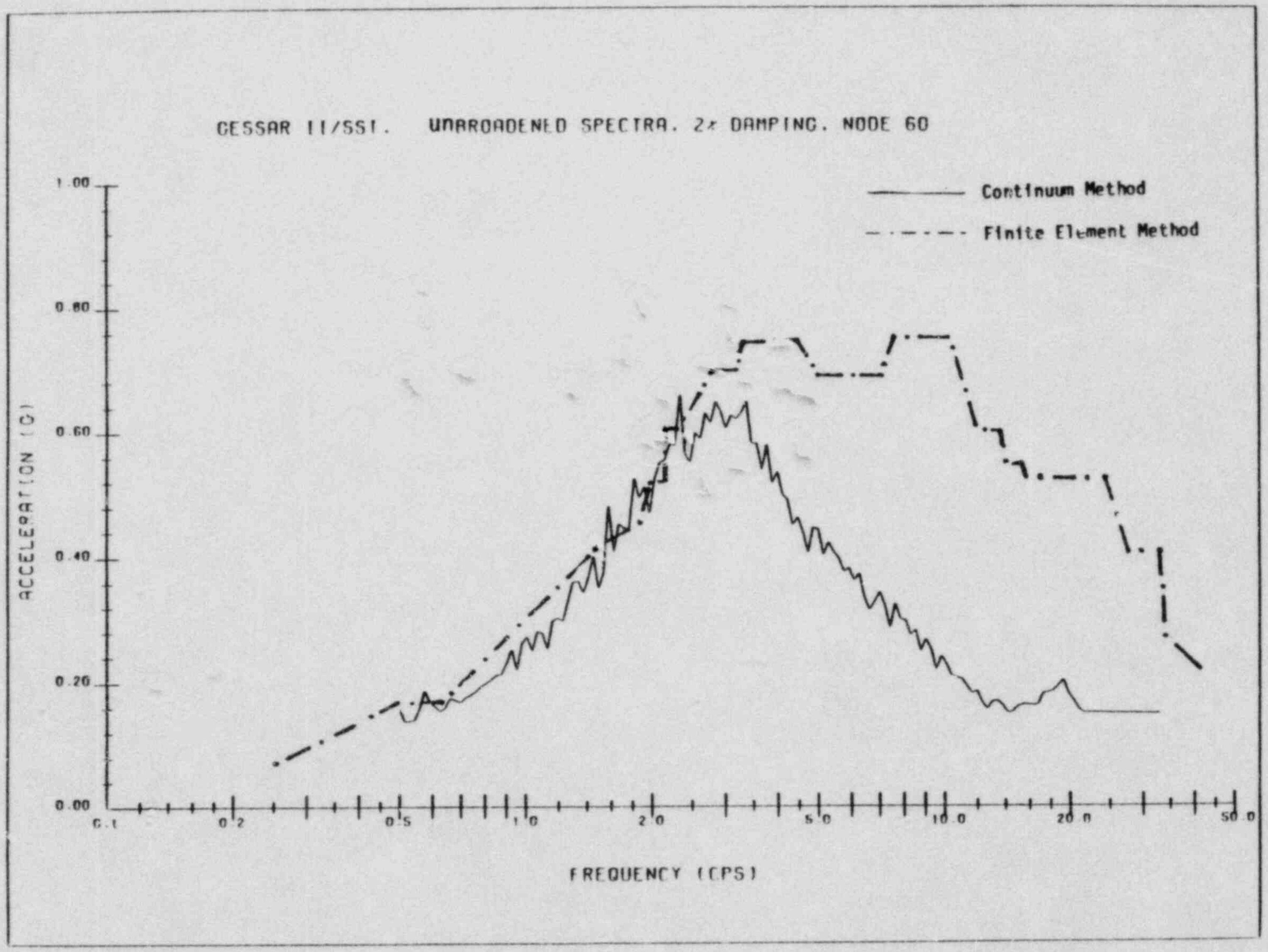


FIGURE 4.11 Comparison of Spectra Envelopes for Vertical SSI Analysis, Node 60

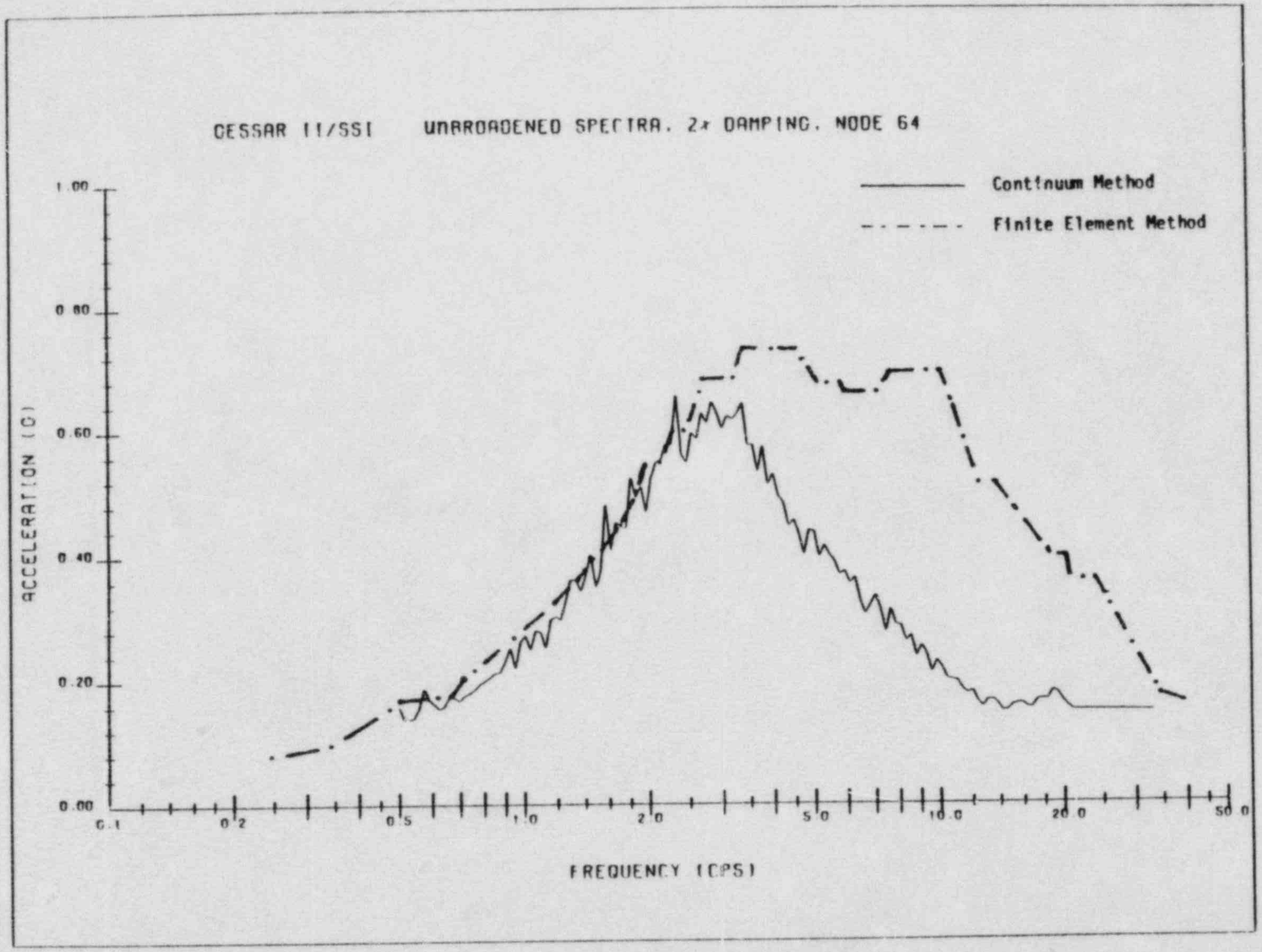


FIGURE 4.12 Comparison of Spectra Envelopes for Vertical SSI Analysis, Node 64

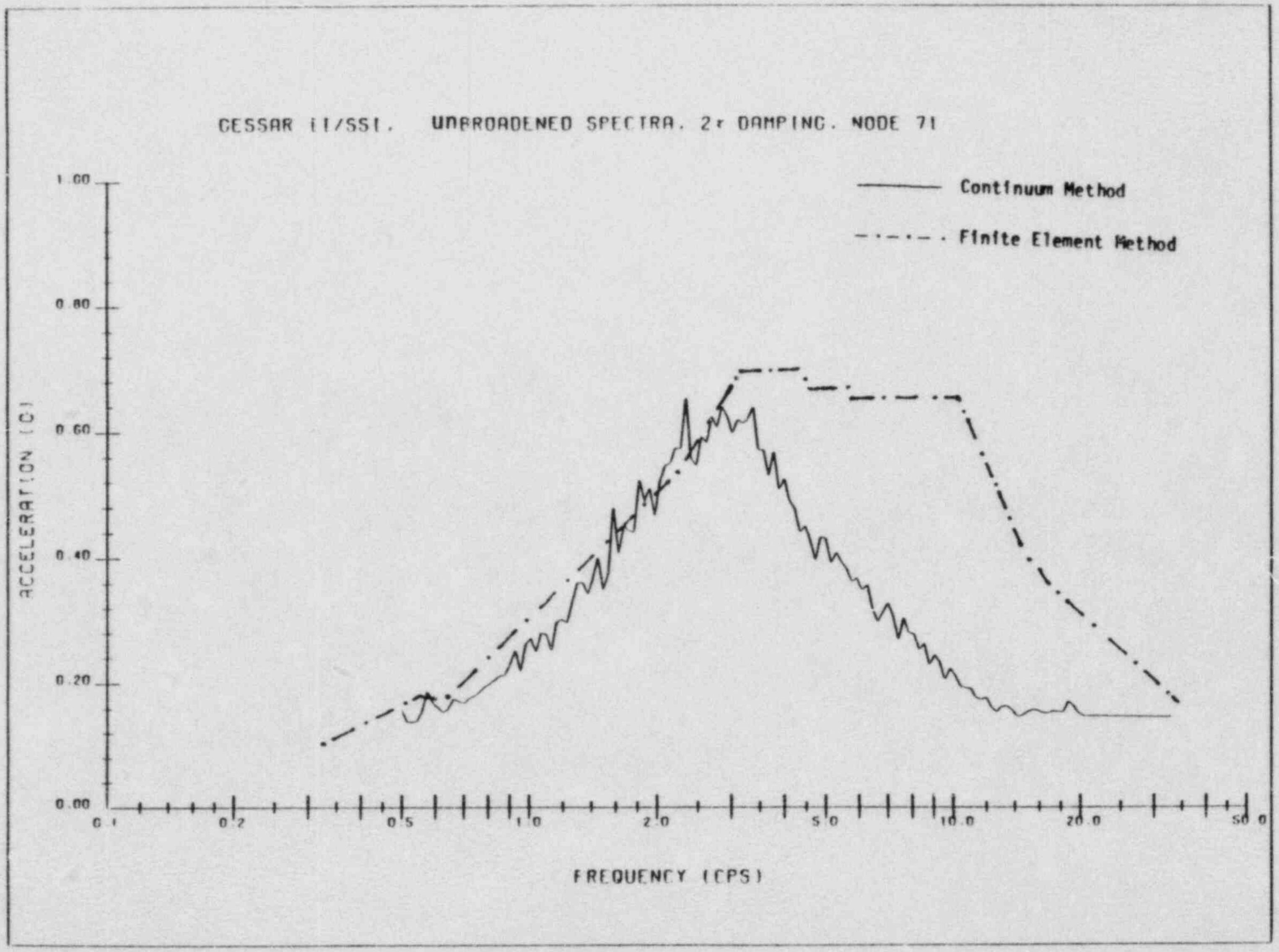


FIGURE 4.13 Comparison of Spectra Envelopes for Vertical SSI Analysis, Node 71

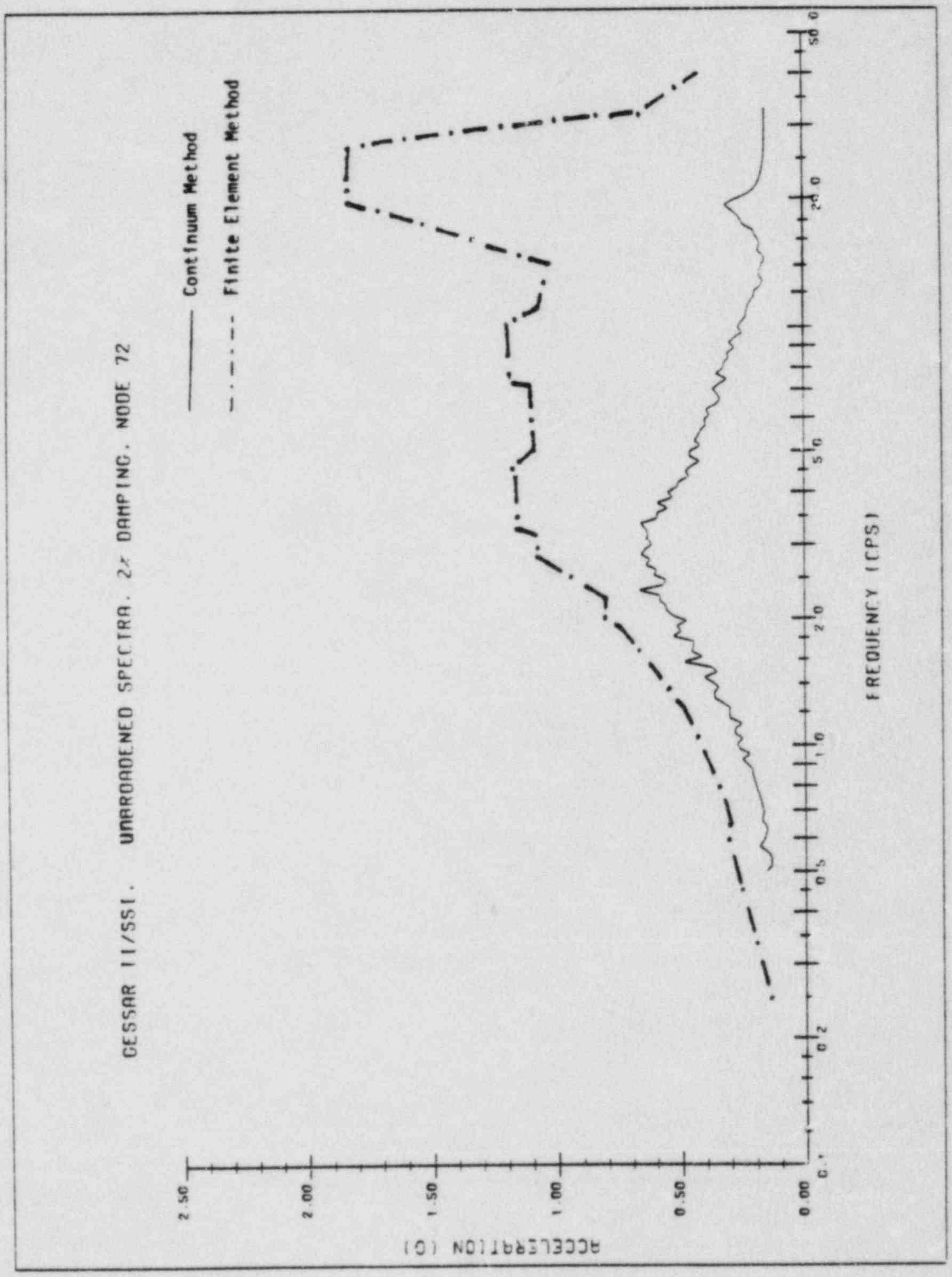


FIGURE 4.14 Comparison of Spectra Envelopes for Vertical SSI Analysis, Node 72

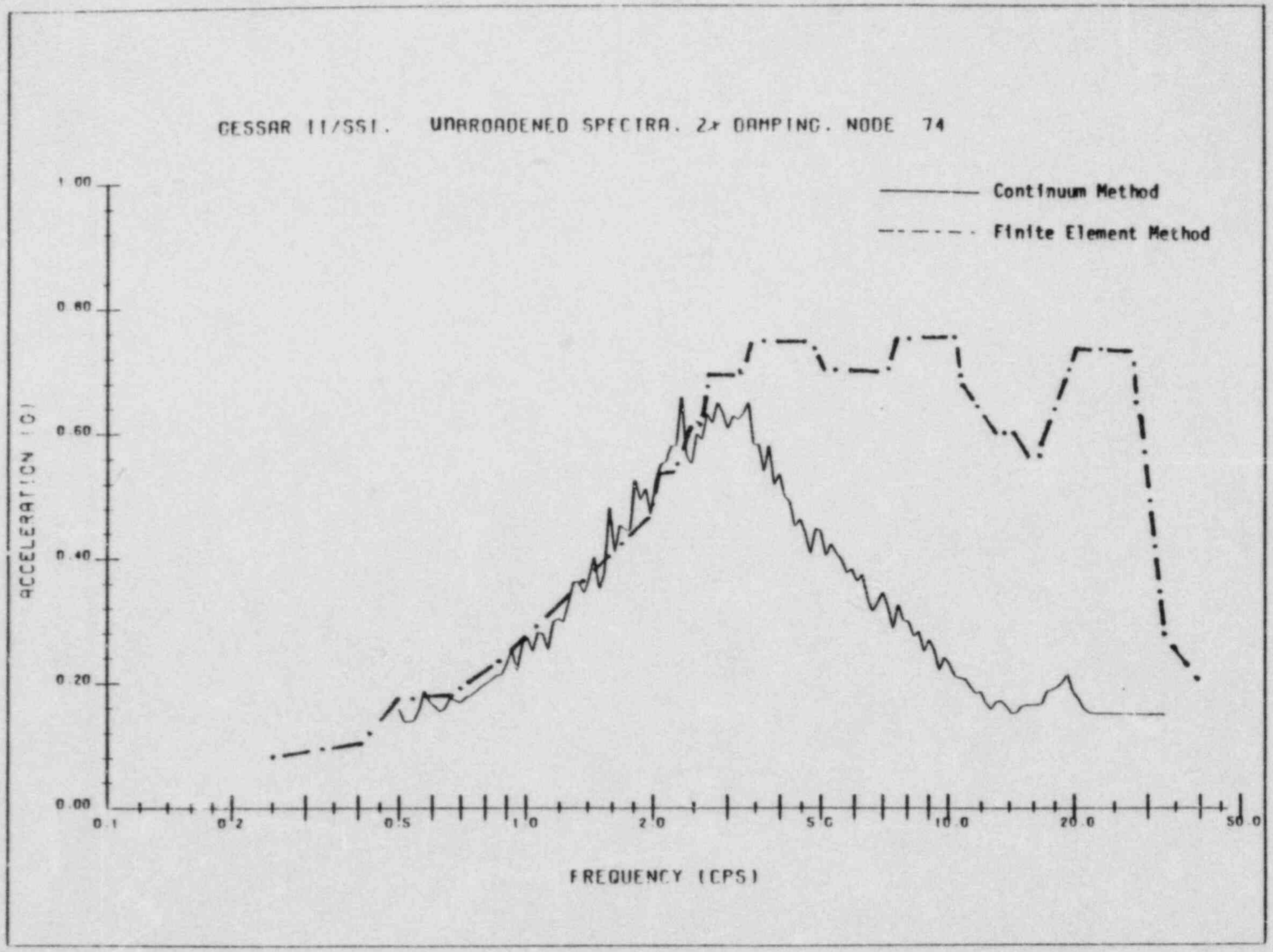


FIGURE 4.15 Comparison of Spectra Envelopes for Vertical SSI Analysis, Node 74

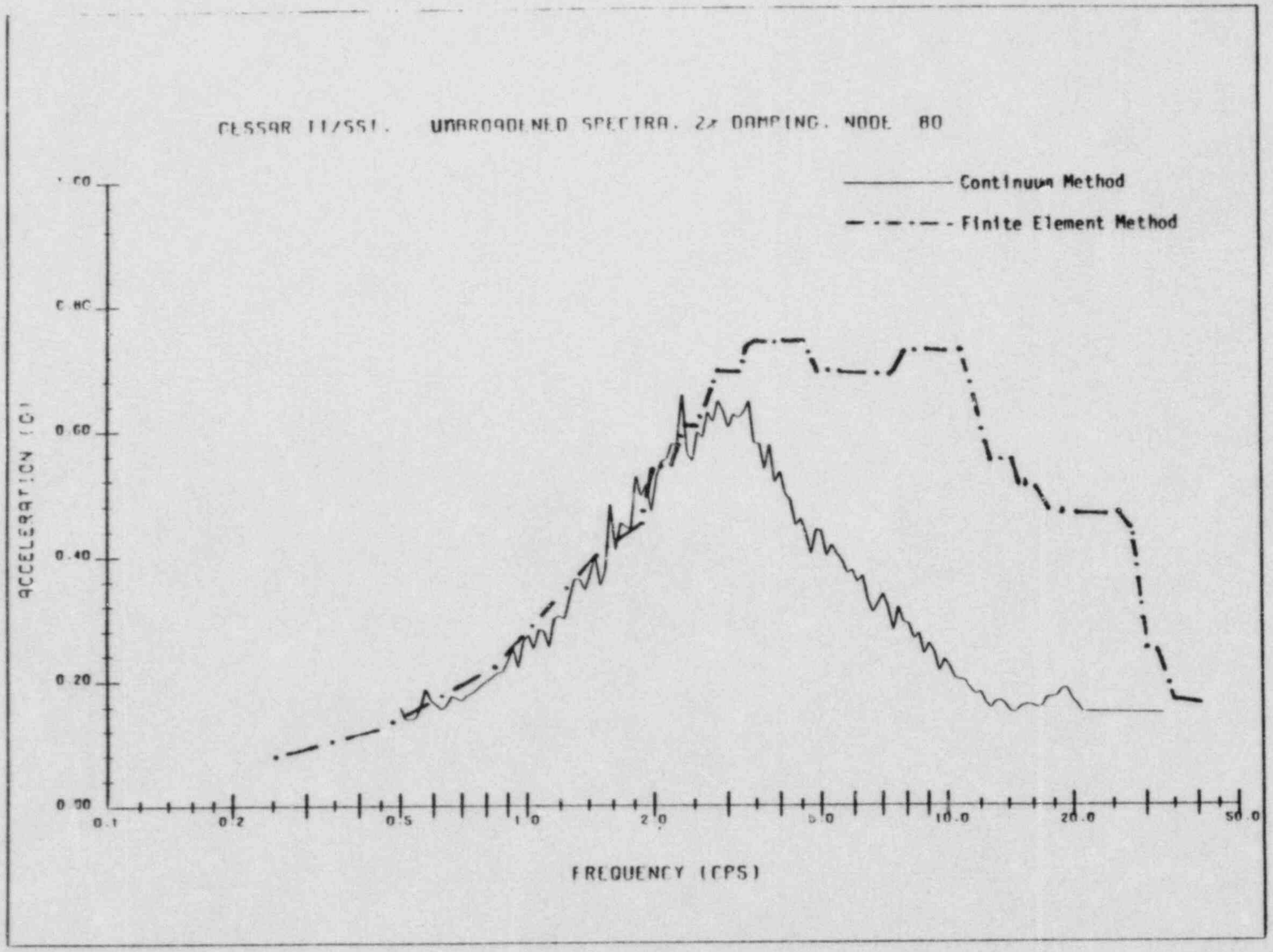


FIGURE 4.16 Comparison of Spectra Envelopes for Vertical SSI Analysis, Node 80

CONFIRMATORY SSI ANALYSES
FOR GESSAR II

04-0030-0077
Revision 0
Appendix

DESCRIPTION OF CONTENTS

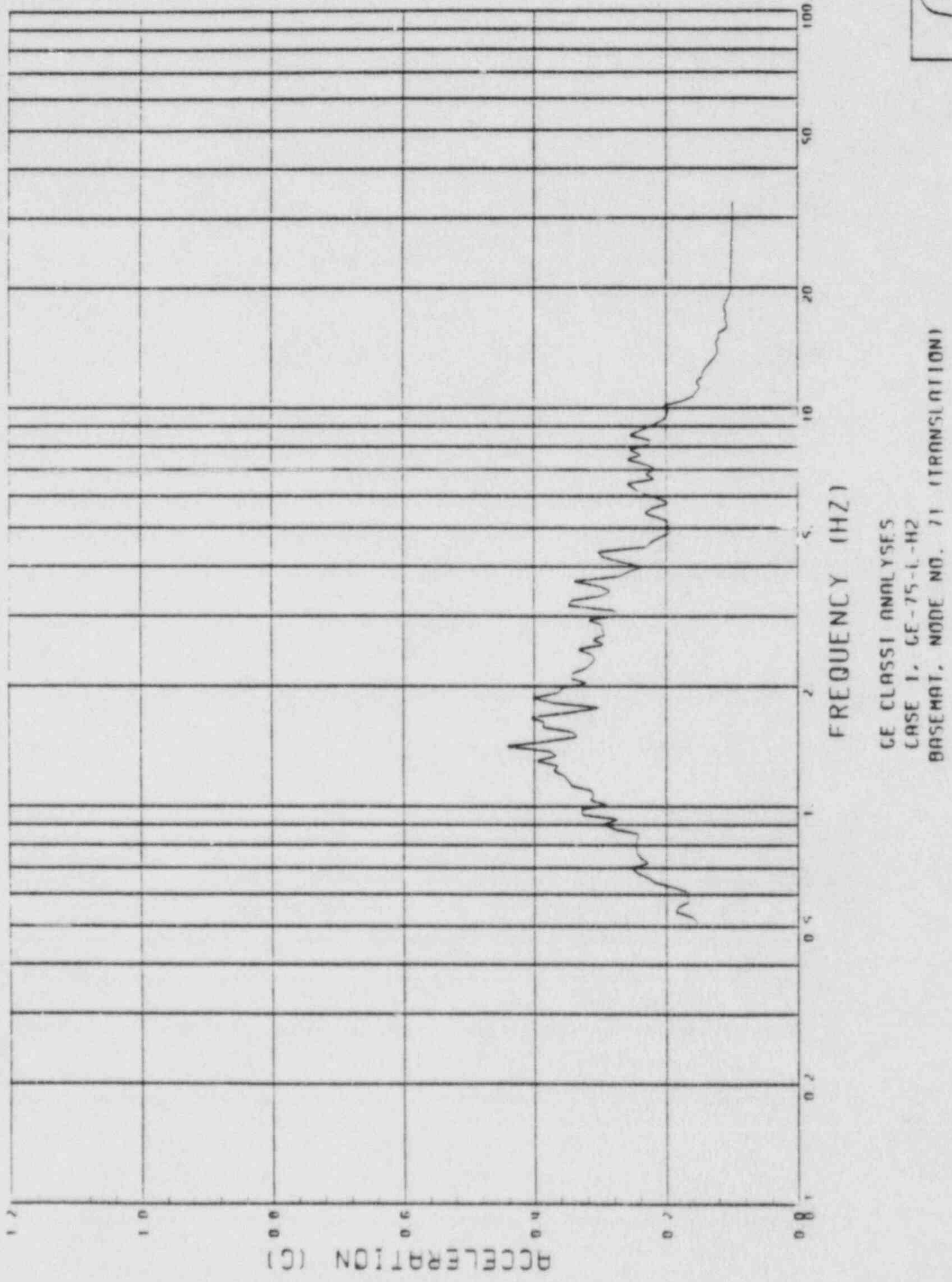
This appendix to Impell Report No. 04-0030-0077, prepared for General Electric Company, contains partial results corresponding to the series of confirmatory soil-structure interaction (SSI) analyses performed for the GESSAR II Standard Plant using the CLASSI series of computer codes.

The results presented consist of plots of acceleration response spectra, at 2 percent damping value, for a total of 10 locations throughout the GESSAR II Reactor Building structure. In addition, the rocking acceleration spectrum at the basemat level is included.

Figures A.1 through A.77 correspond to acceleration response spectra for the horizontal analyses. Figures A.78 through A.87 correspond to response spectra for the vertical analysis case.

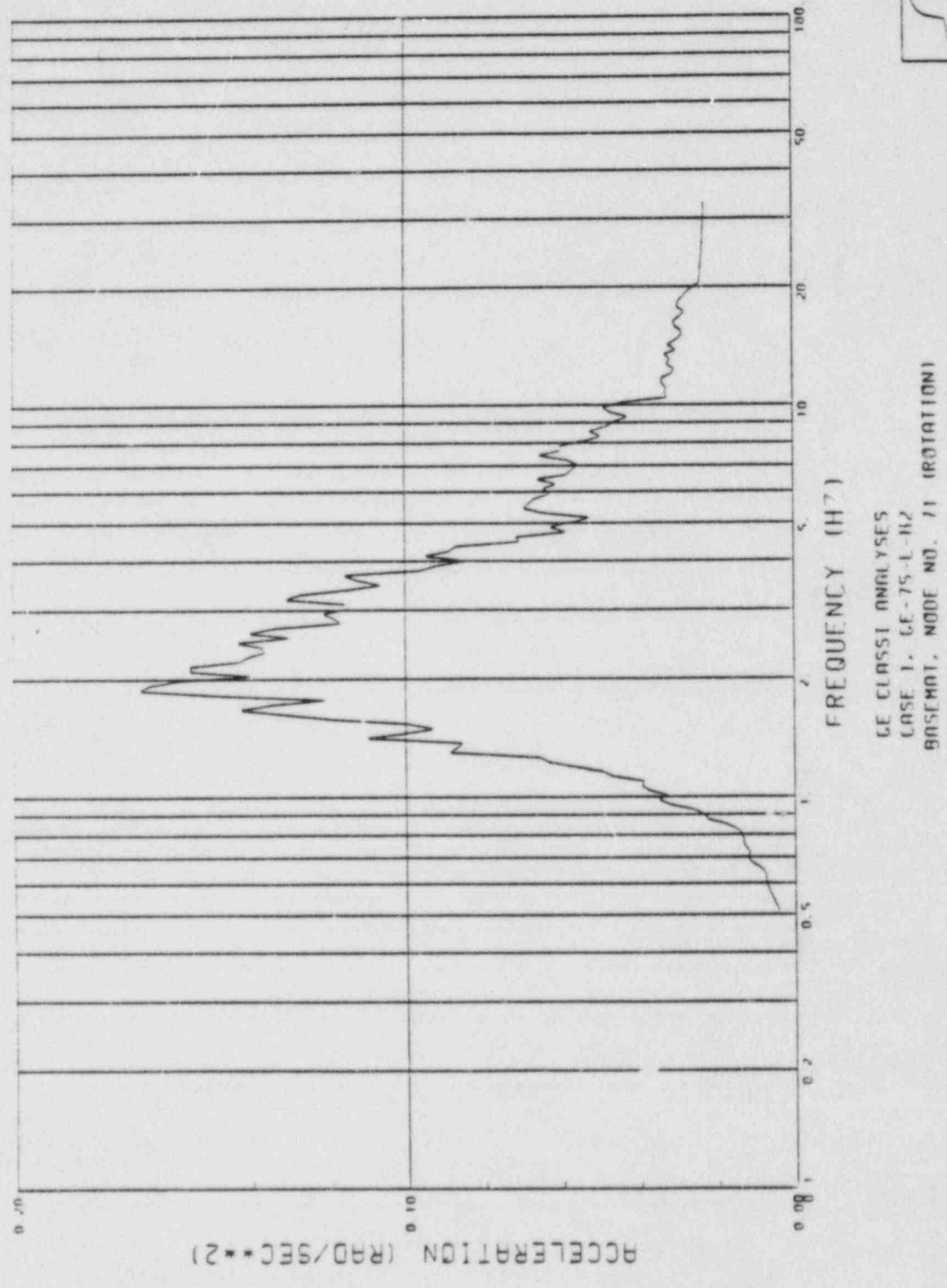
APPENDIX A

ACCELERATION RESPONSE SPECTRA FOR THE GESSAR II HORIZONTAL AND VERTICAL ANALYSES



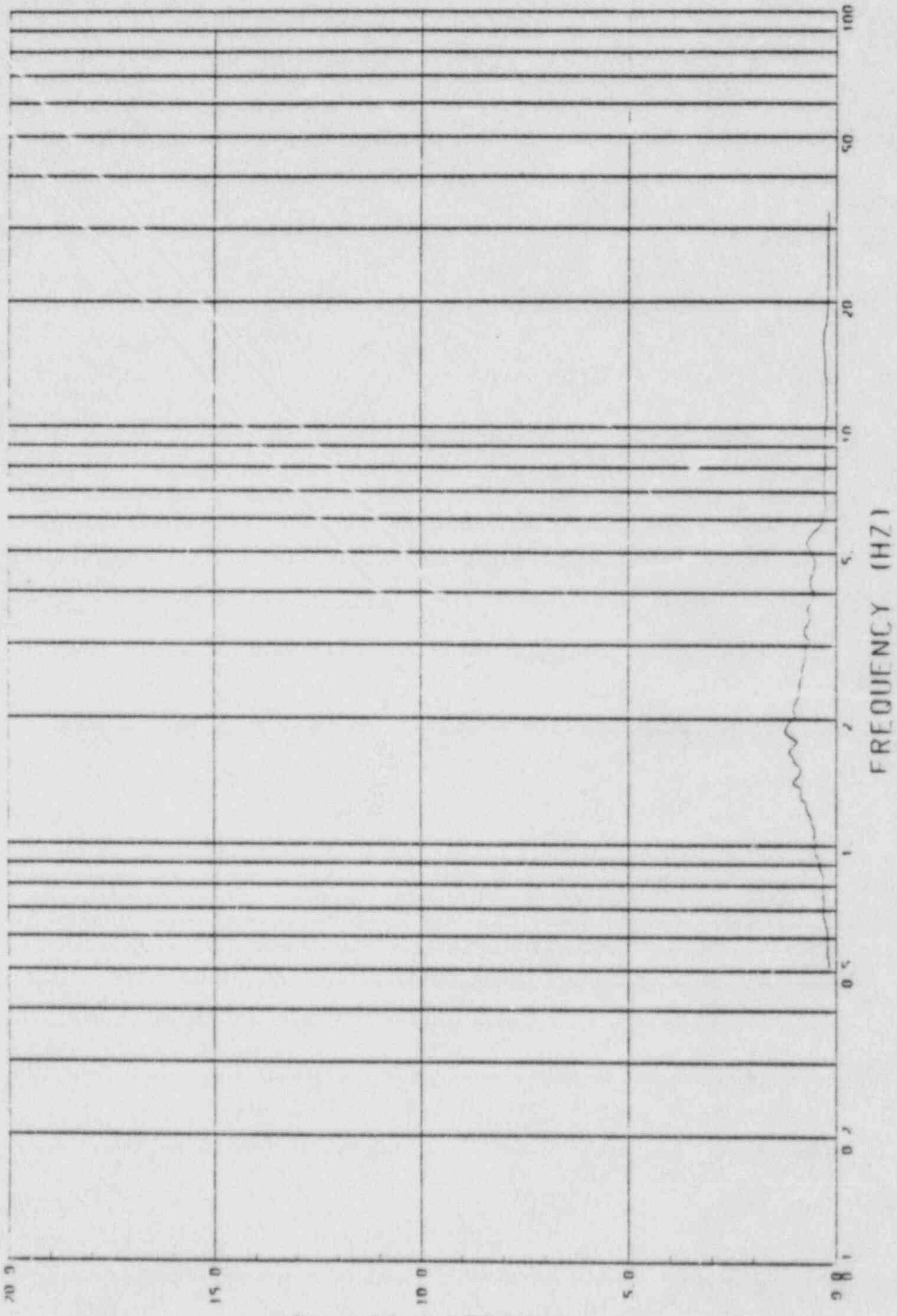
GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

Figure A.1



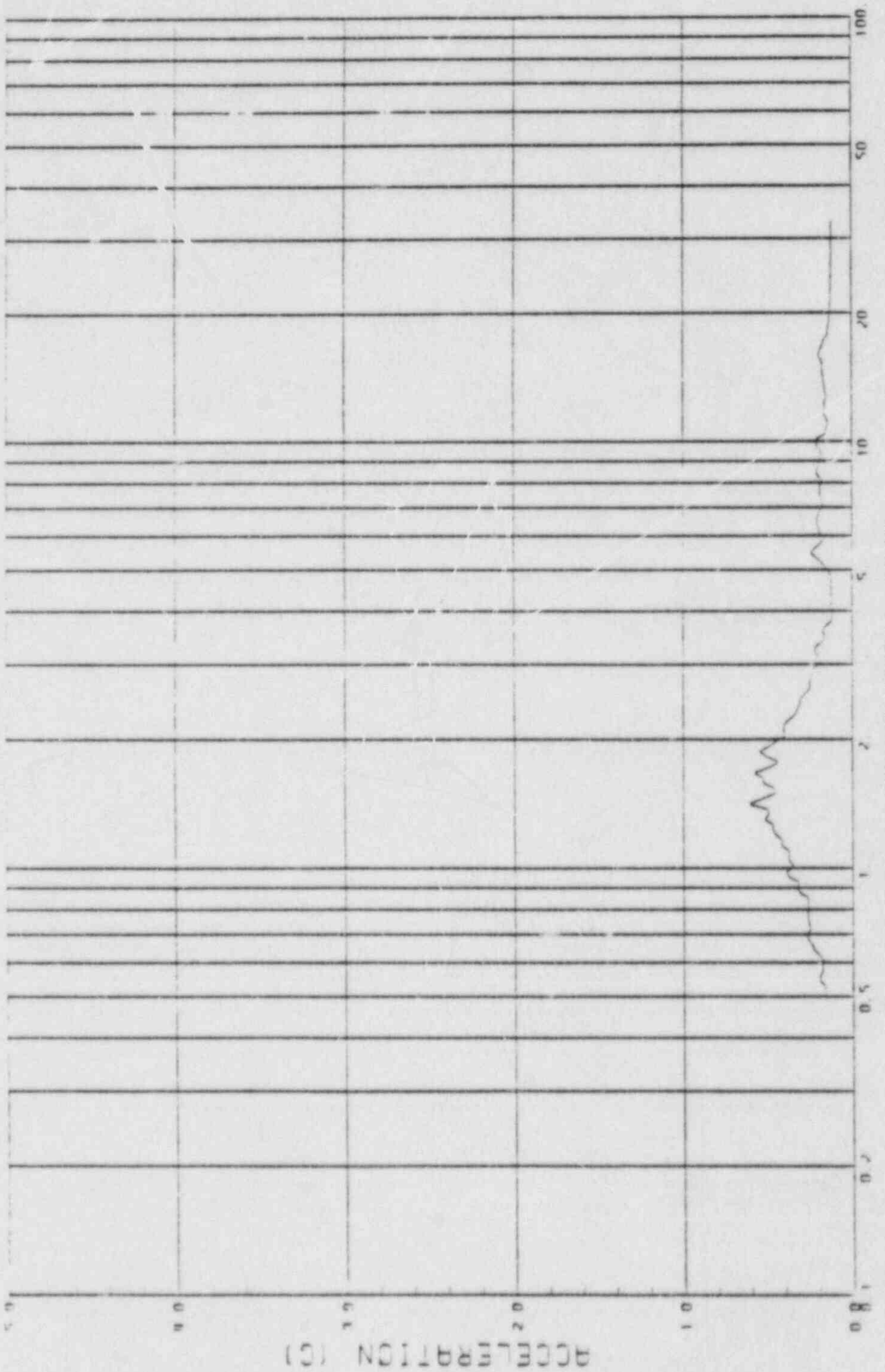
GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

Figure A.2



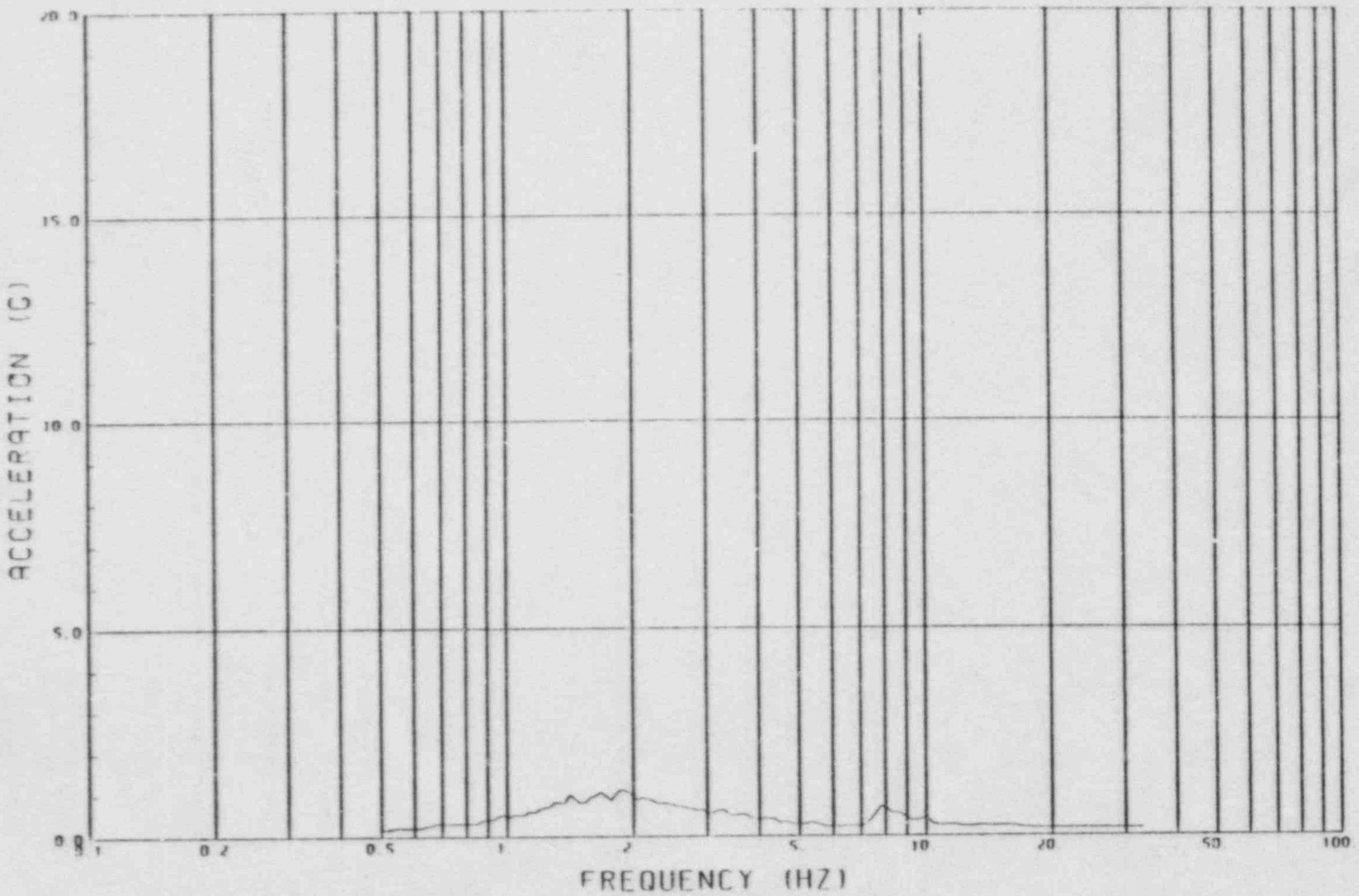
GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

Figure A.3



GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

Figure A.4



GE CLASSI ANALYSES
CASE 1, GE-75-L-H2
NODE NO. 22

GESSAR II PLANT
SØIL - STRUCTURE INTERACTION

Figure A.5

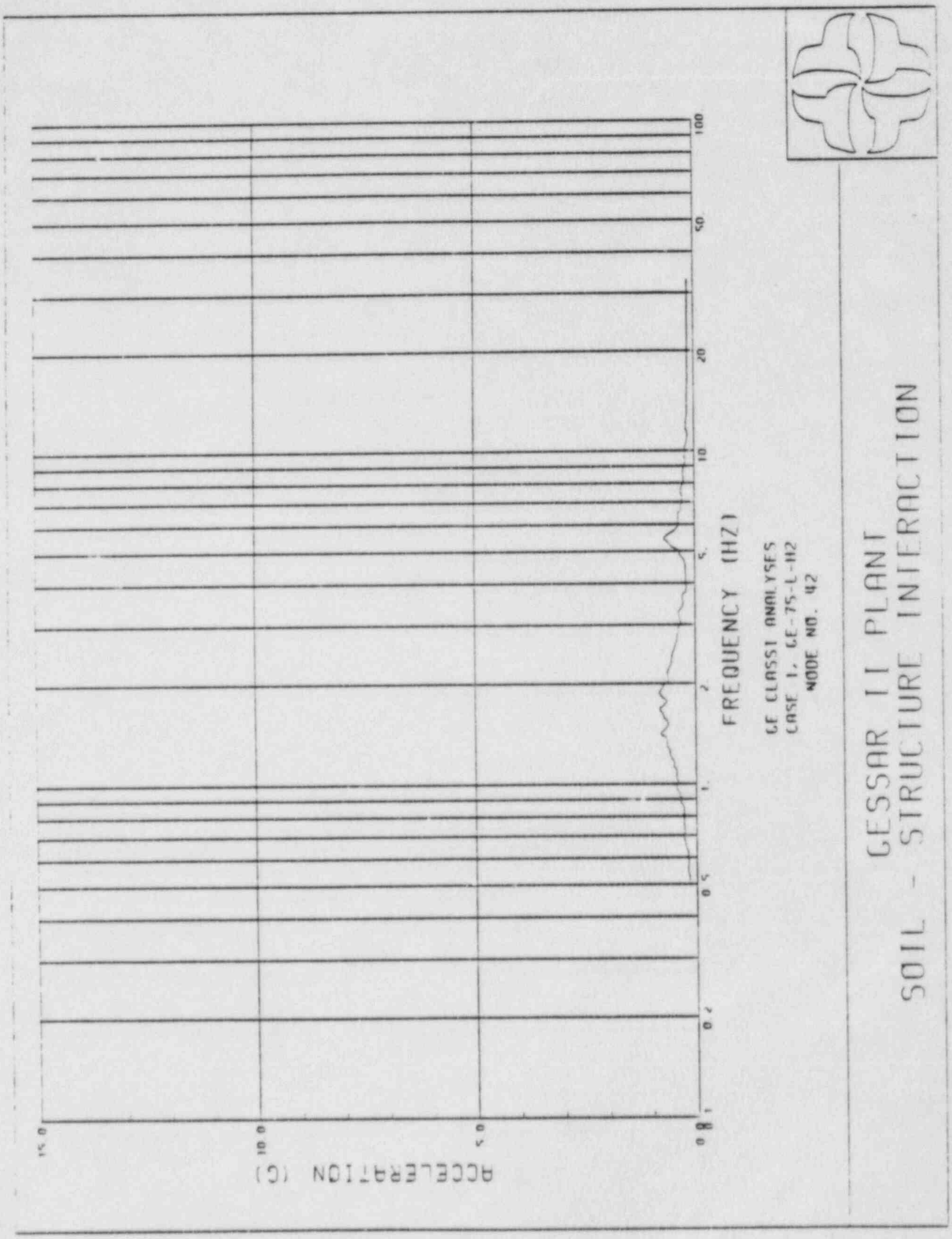
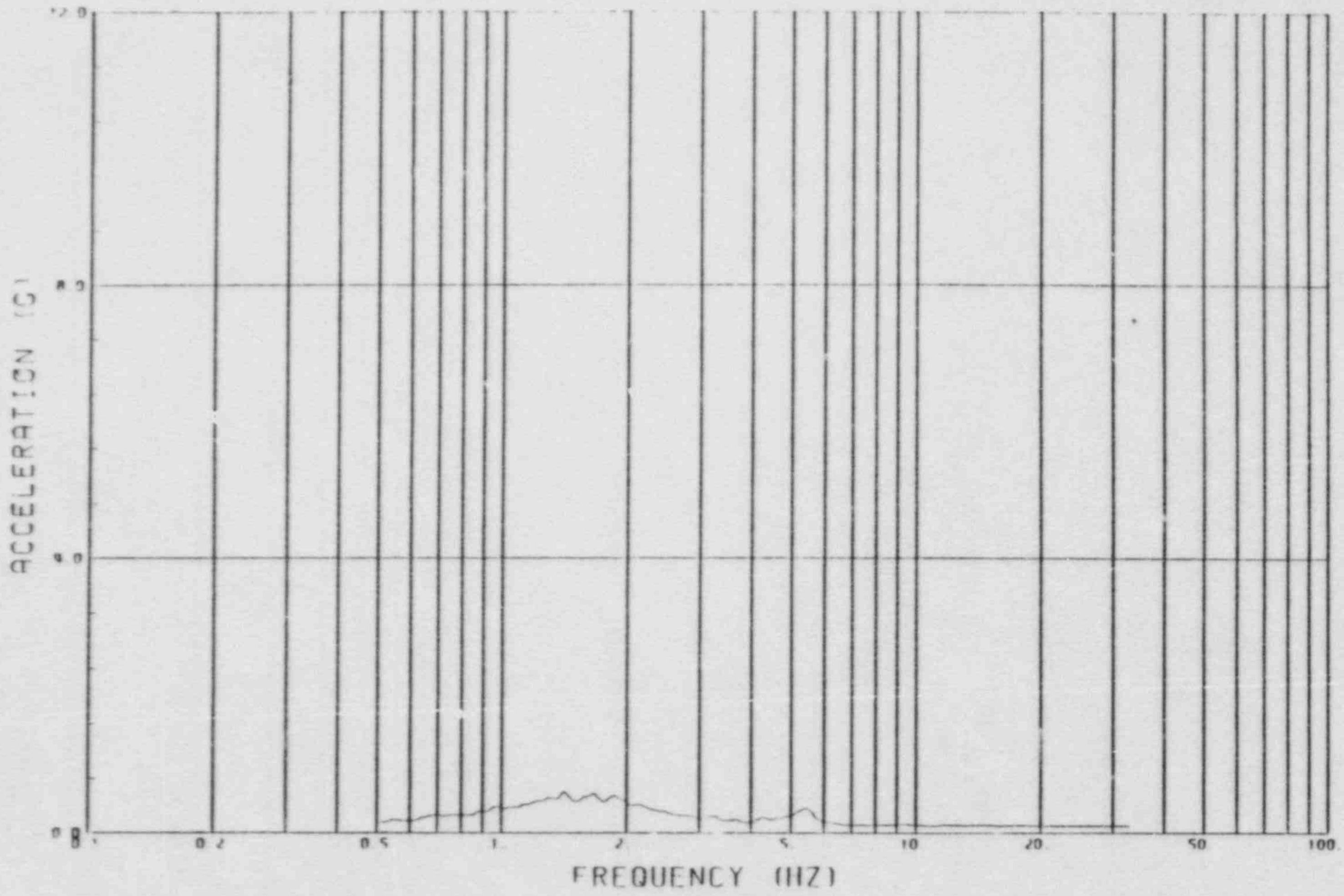

ACCELERATION (G)
0.0
5.0
10.0
15.0
FREQUENCY (HZ)
.1
.2
.5
1
2
5
10
20
50
100
GE CLASS1 ANALYSES
CASE 1, GE-75-L-H2
NODE NO. 42
GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

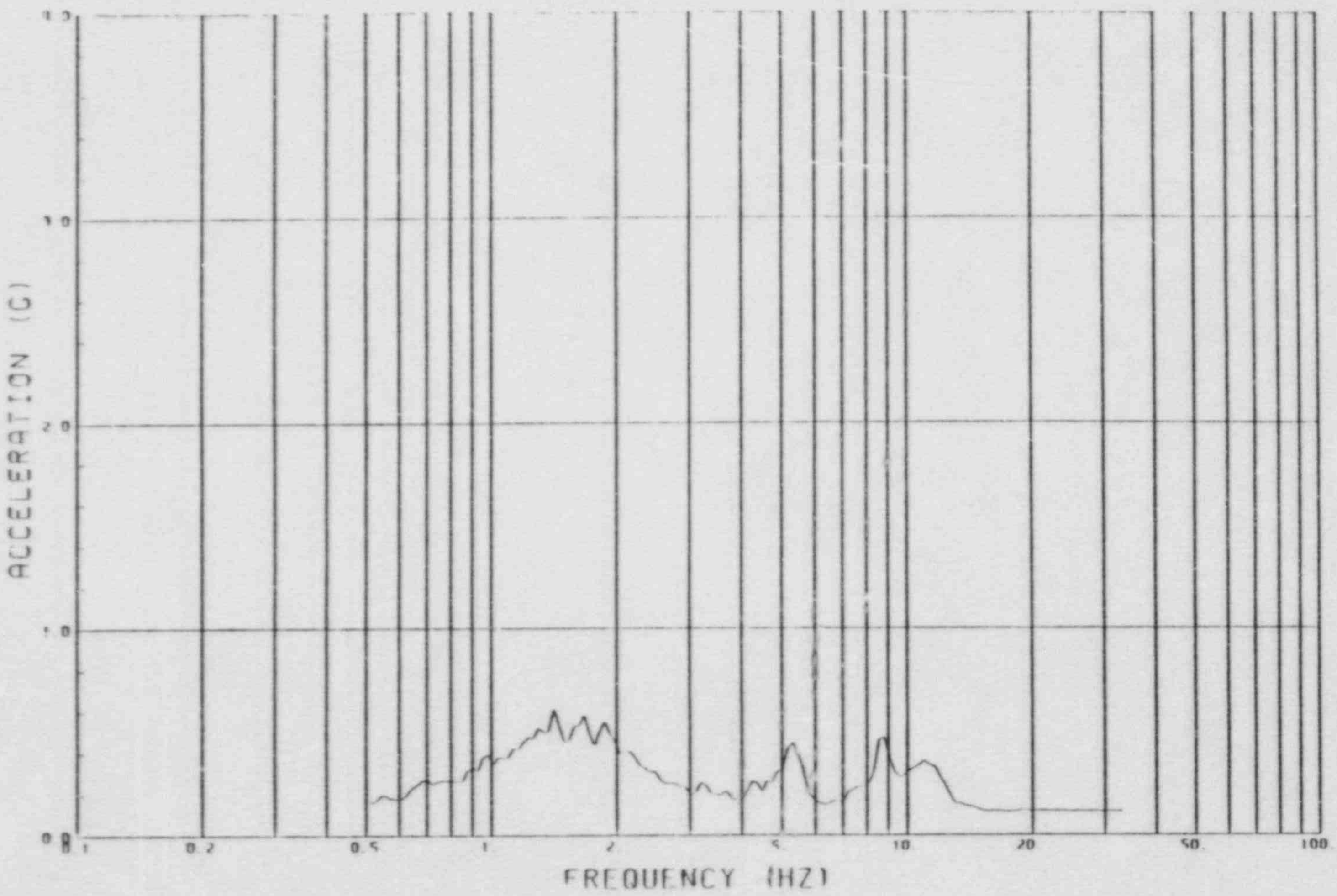
Figure A.6



GE CLASSI ANALYSES
CASE 1, GE-75-L-H2
NODE NO. 46

GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

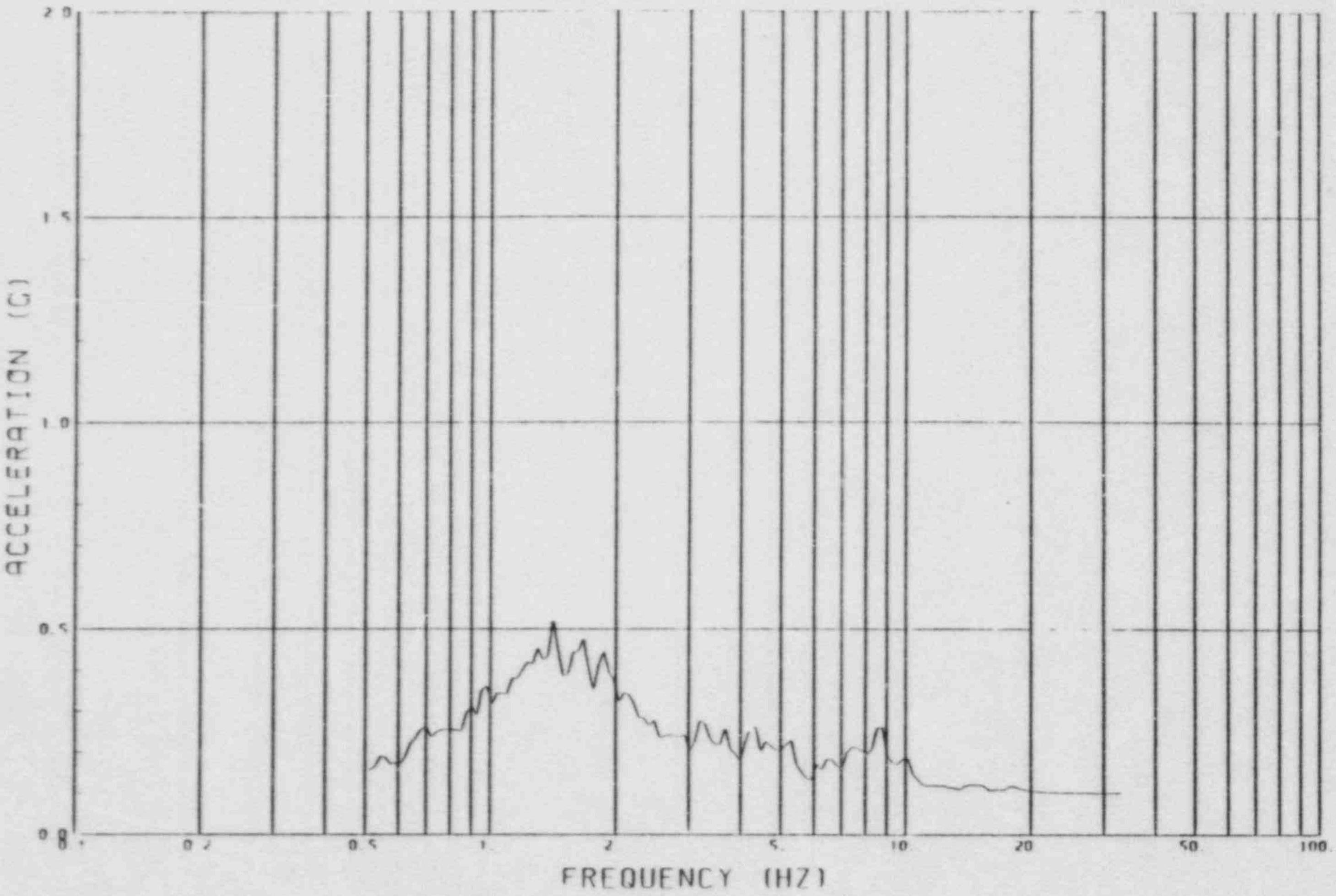
Figure A.7



GE CLASSI ANALYSES
CASE 1. GE-3S-L-H2
NODE NO. 60

GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

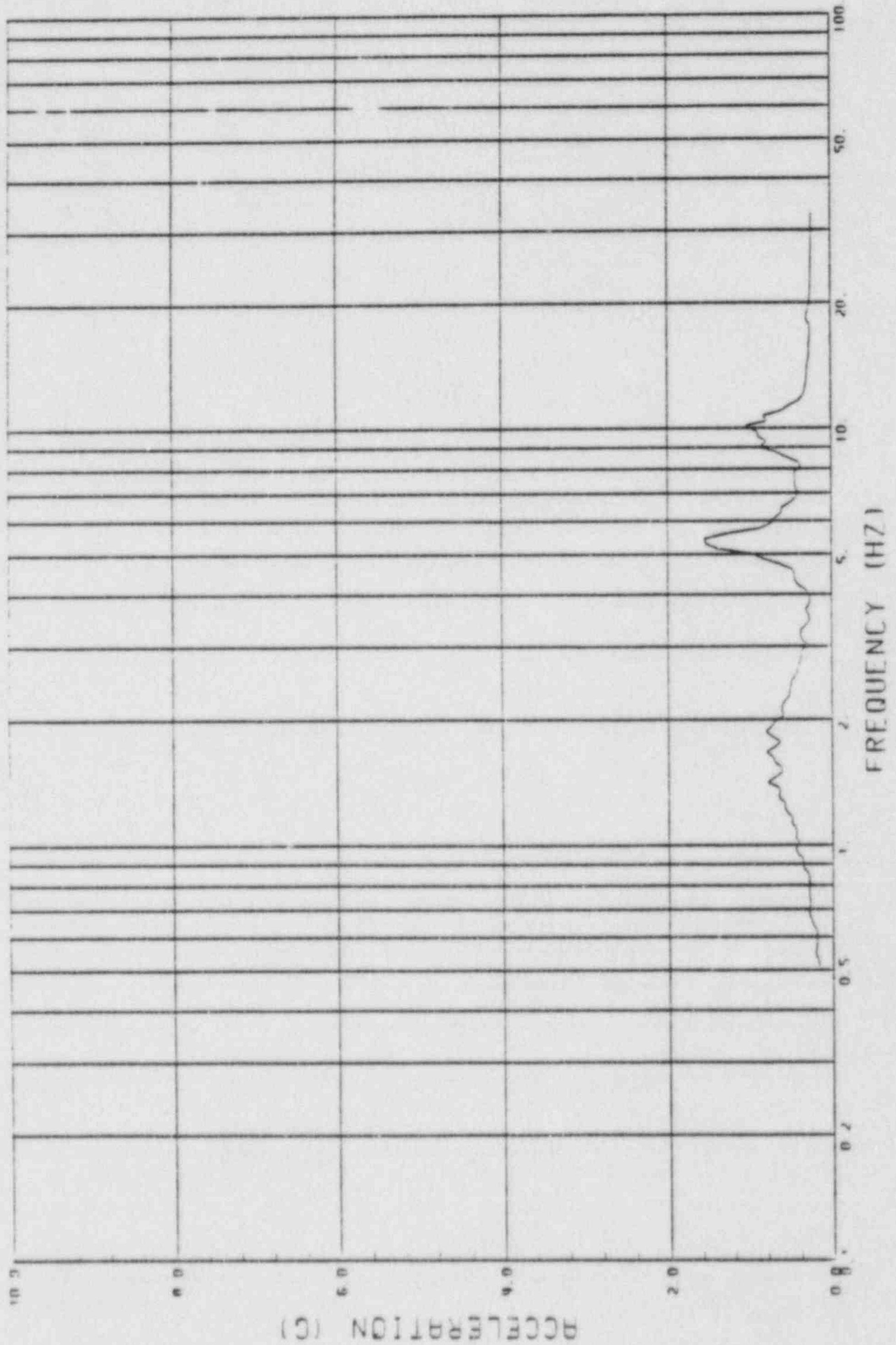
Figure A.8



GE CLASSI ANALYSES
CASE 1. GE-75-L-H2
NODE NO. 64

GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

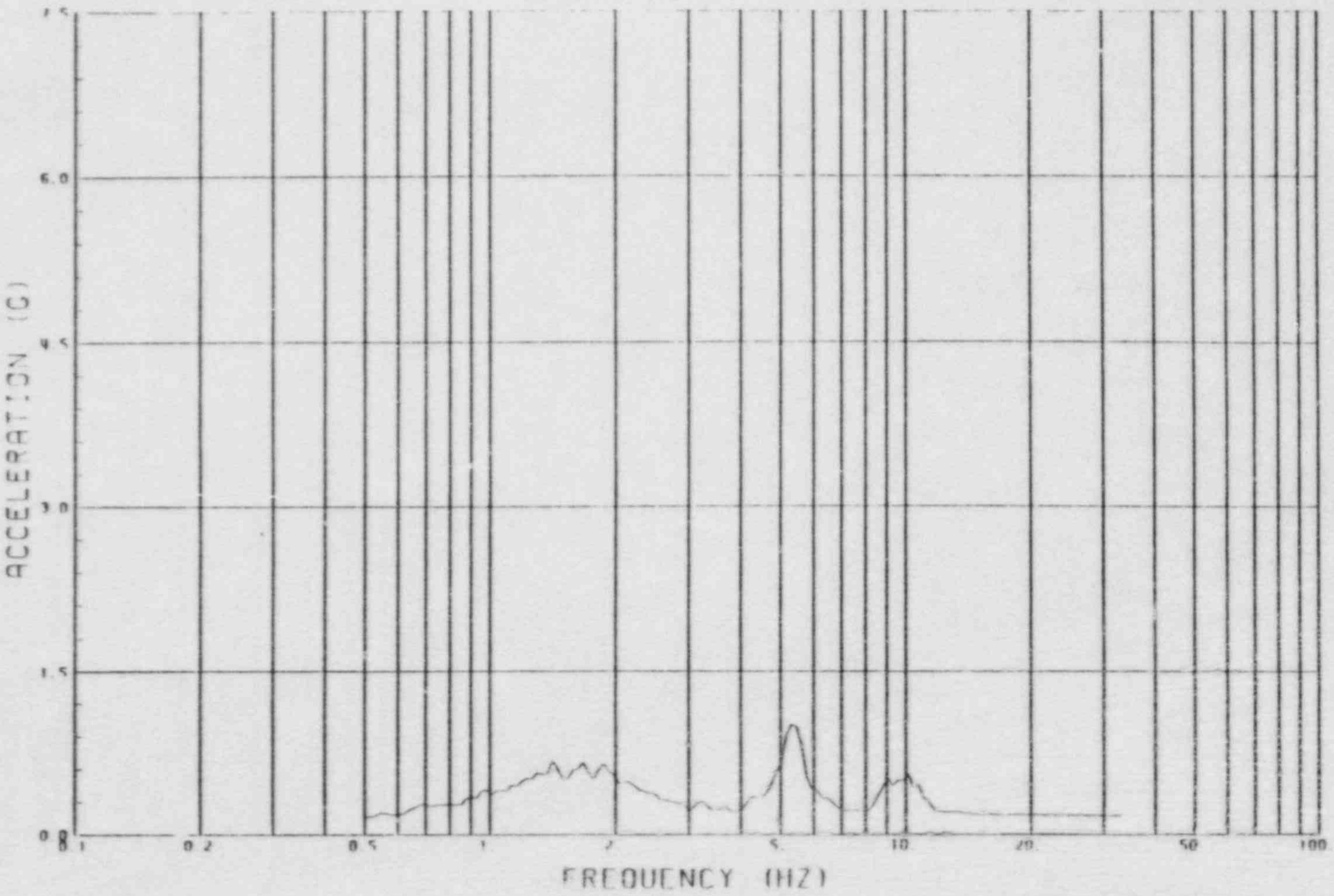
Figure A.9



GE CLASSI ANALYSES
CASE 1, GF-75-L-H2
NODE NO. 101

GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

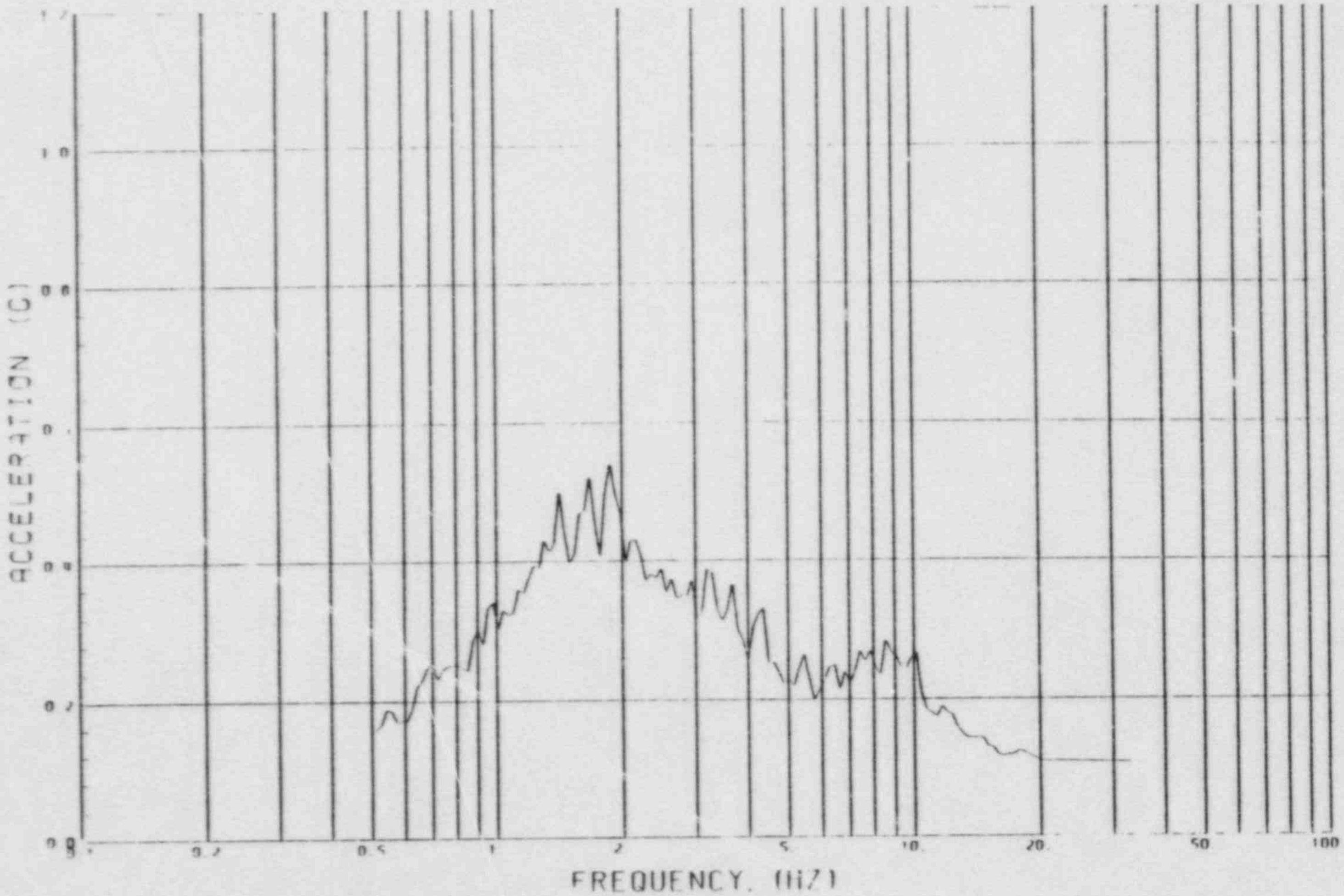
Figure A.10



GE CLASSI ANALYSES
CASE 1, GE-75-L-H2
NODE NO. 109

GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

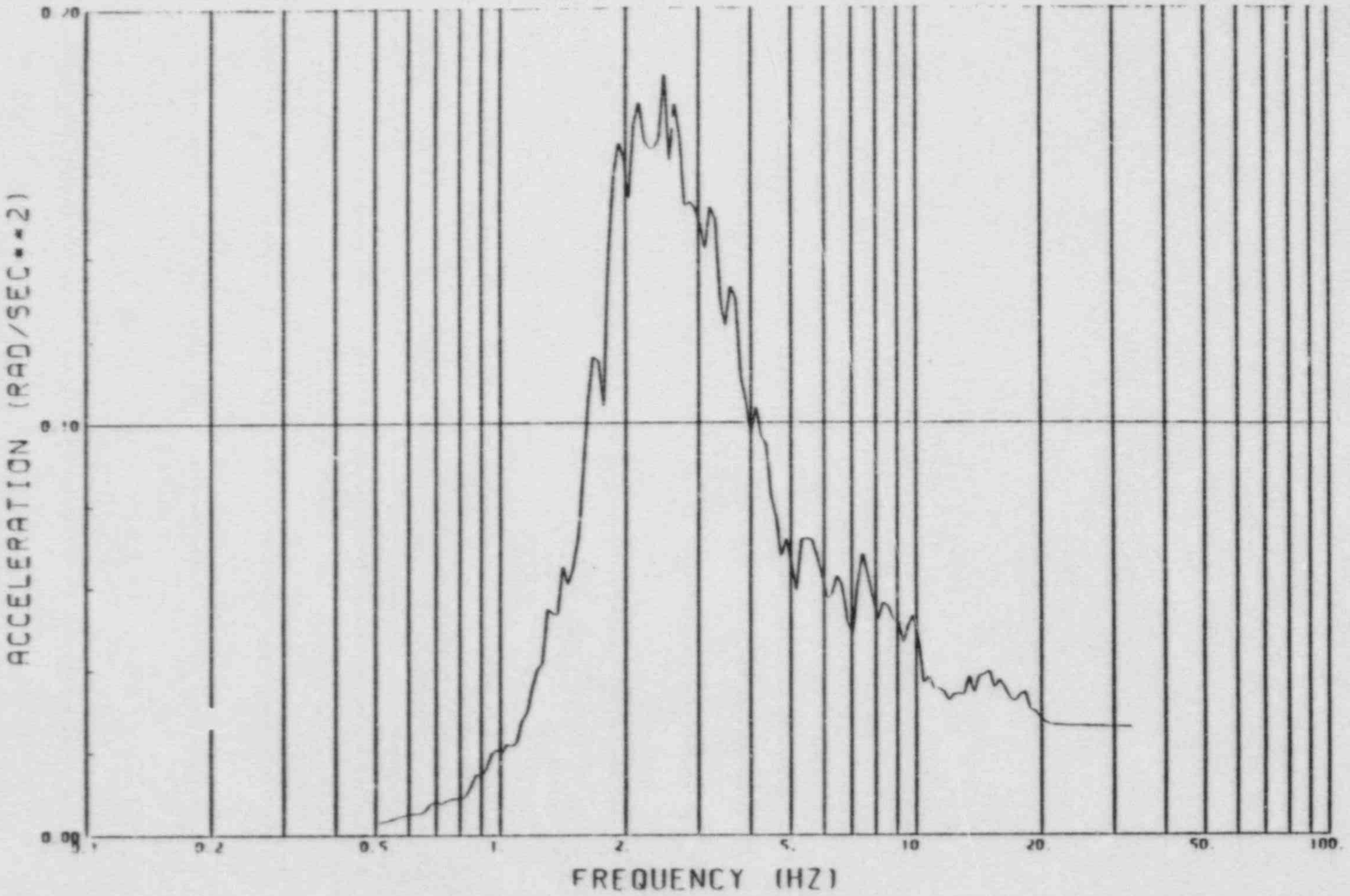
Figure A.11



GE CLASSI ANALYSES
CASE 2, GE-75-A-H2
BASEMAT, NODE NO. 71 (TRANSLATION)

GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

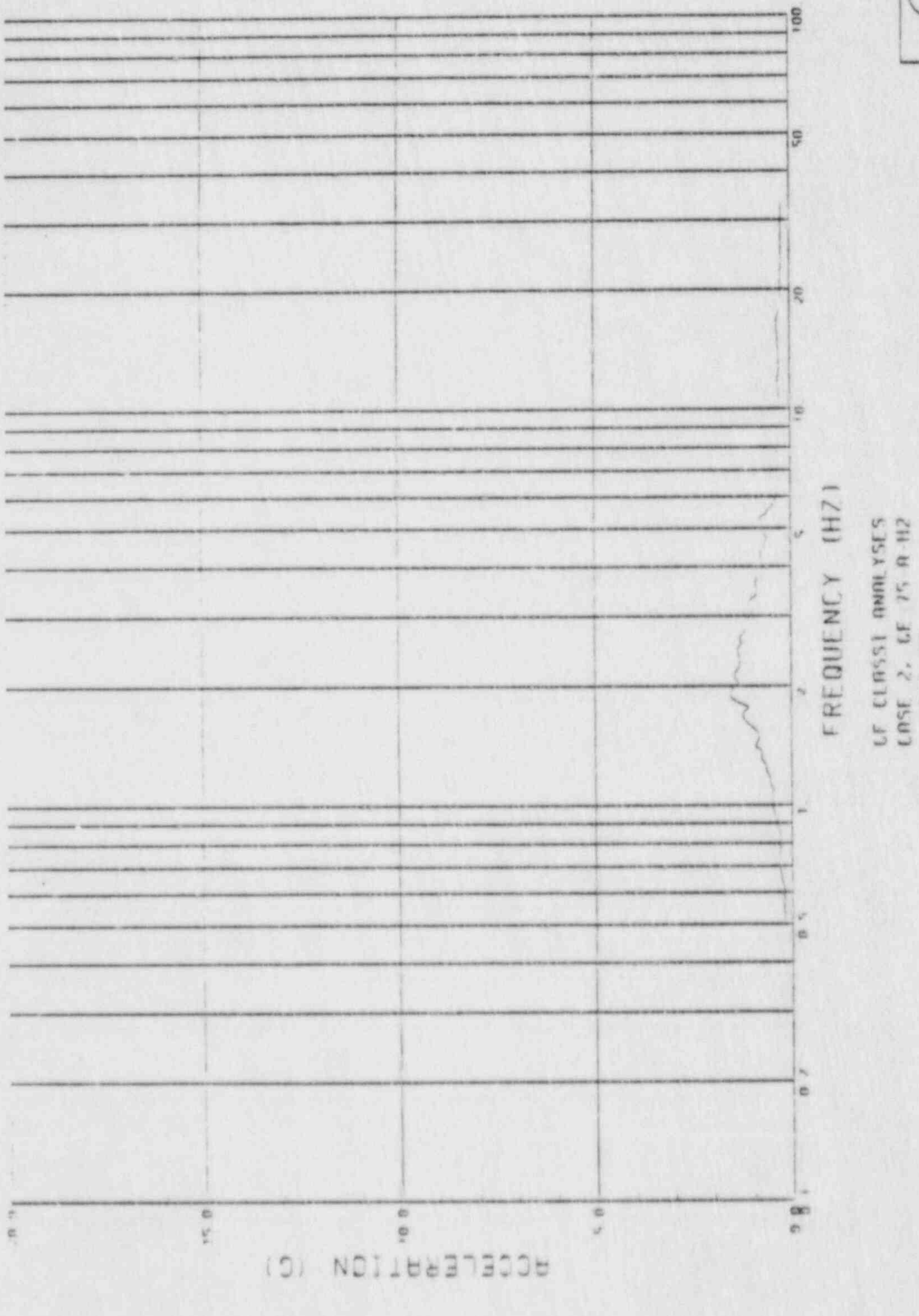
Figure A.12



GE CLASSI ANALYSES
CASE 2, GE-75-A-H2
BASEMAT, NODE NO. 71 (ROTATION)

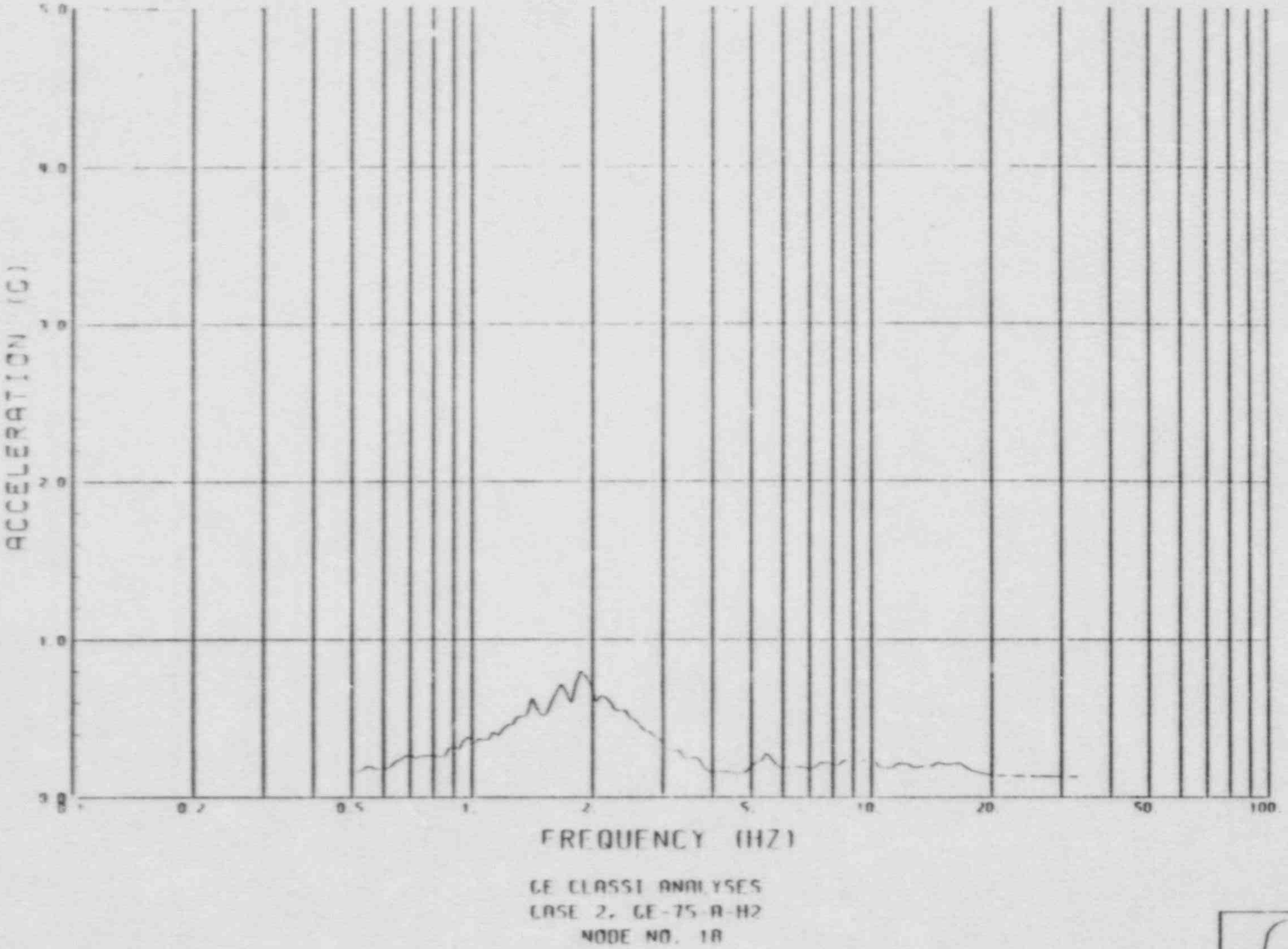
GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

Figure A.13



GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

Figure A.14

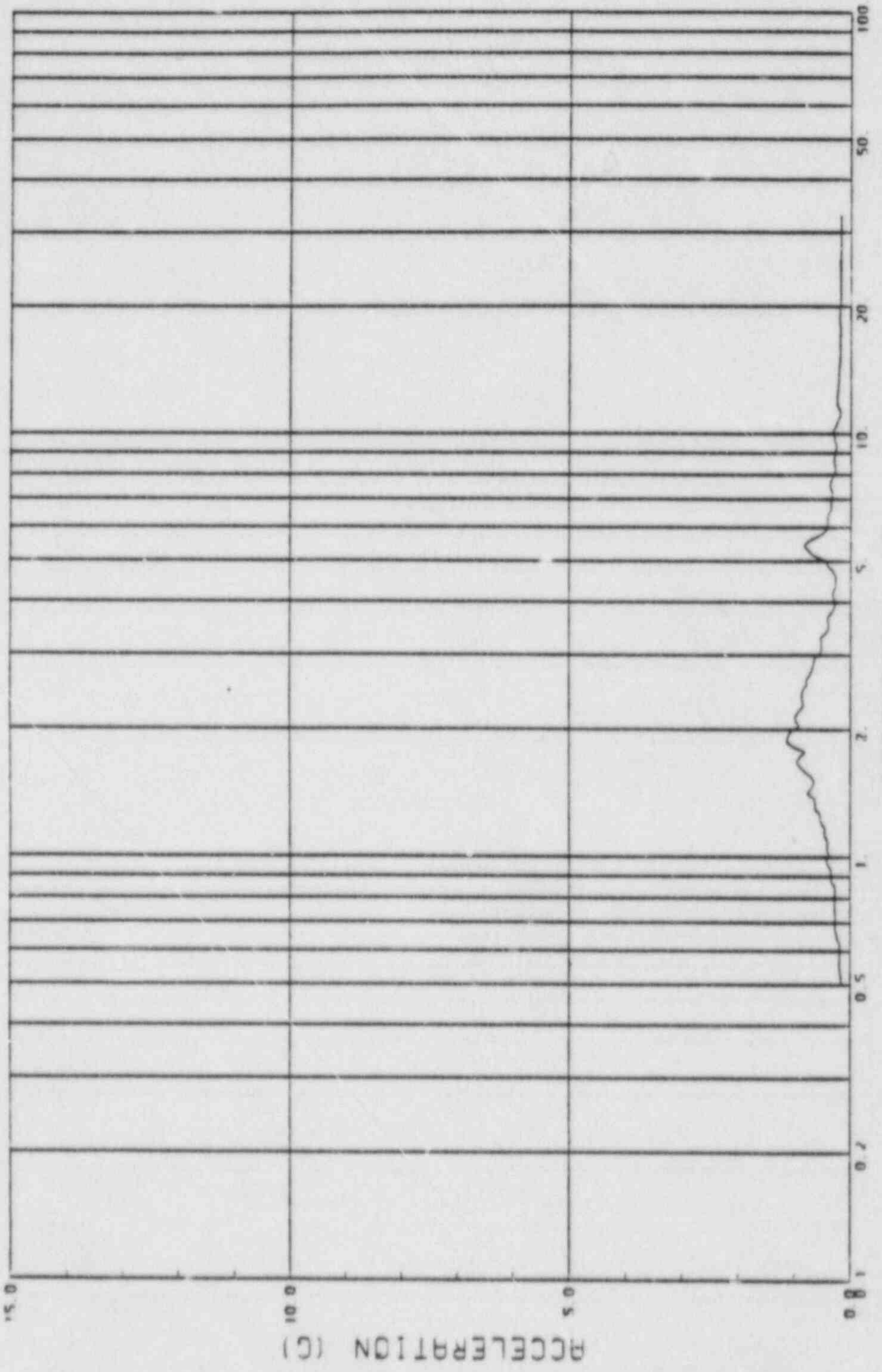


GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

Figure A.15

GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

Figure A.16



GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

Figure A.17

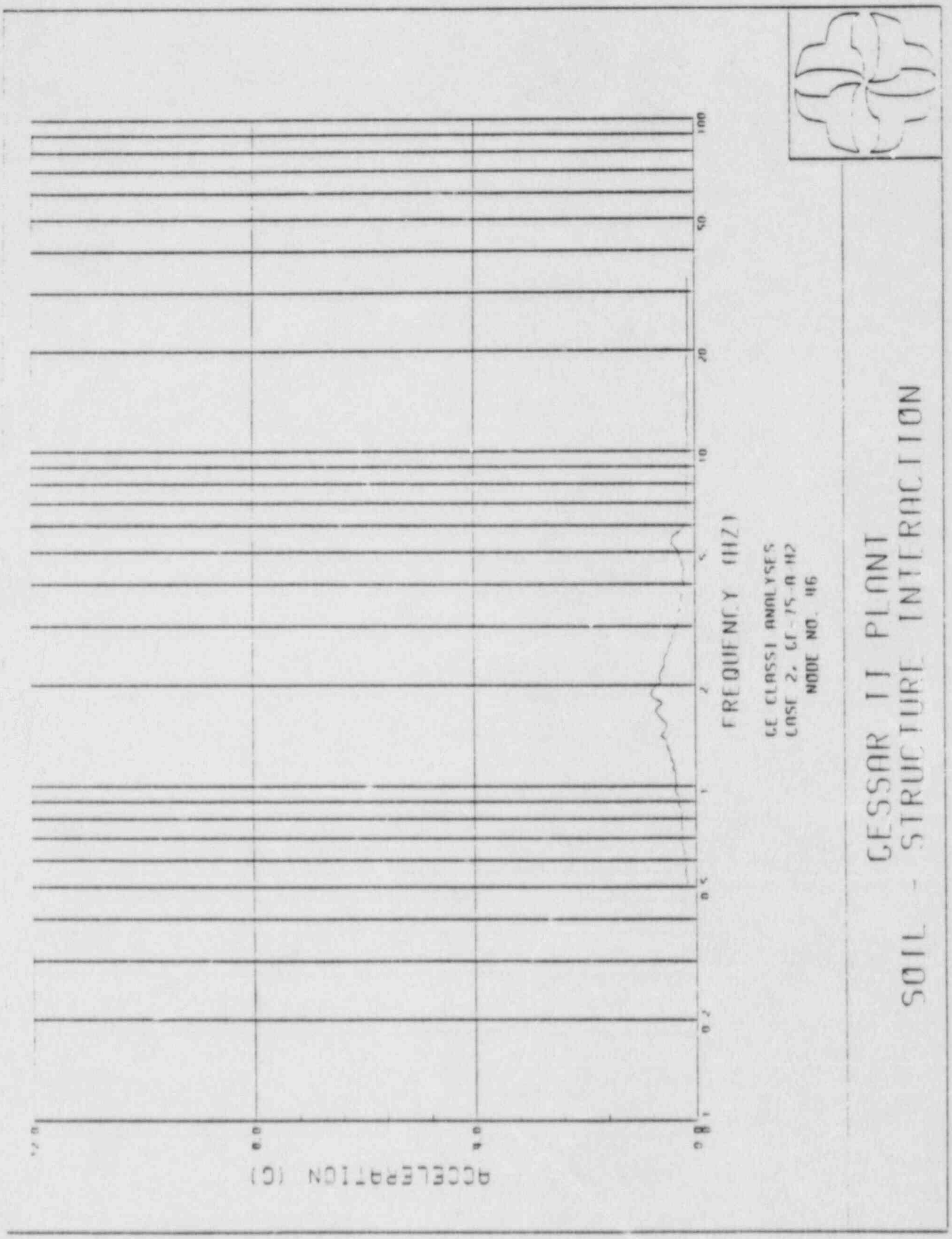
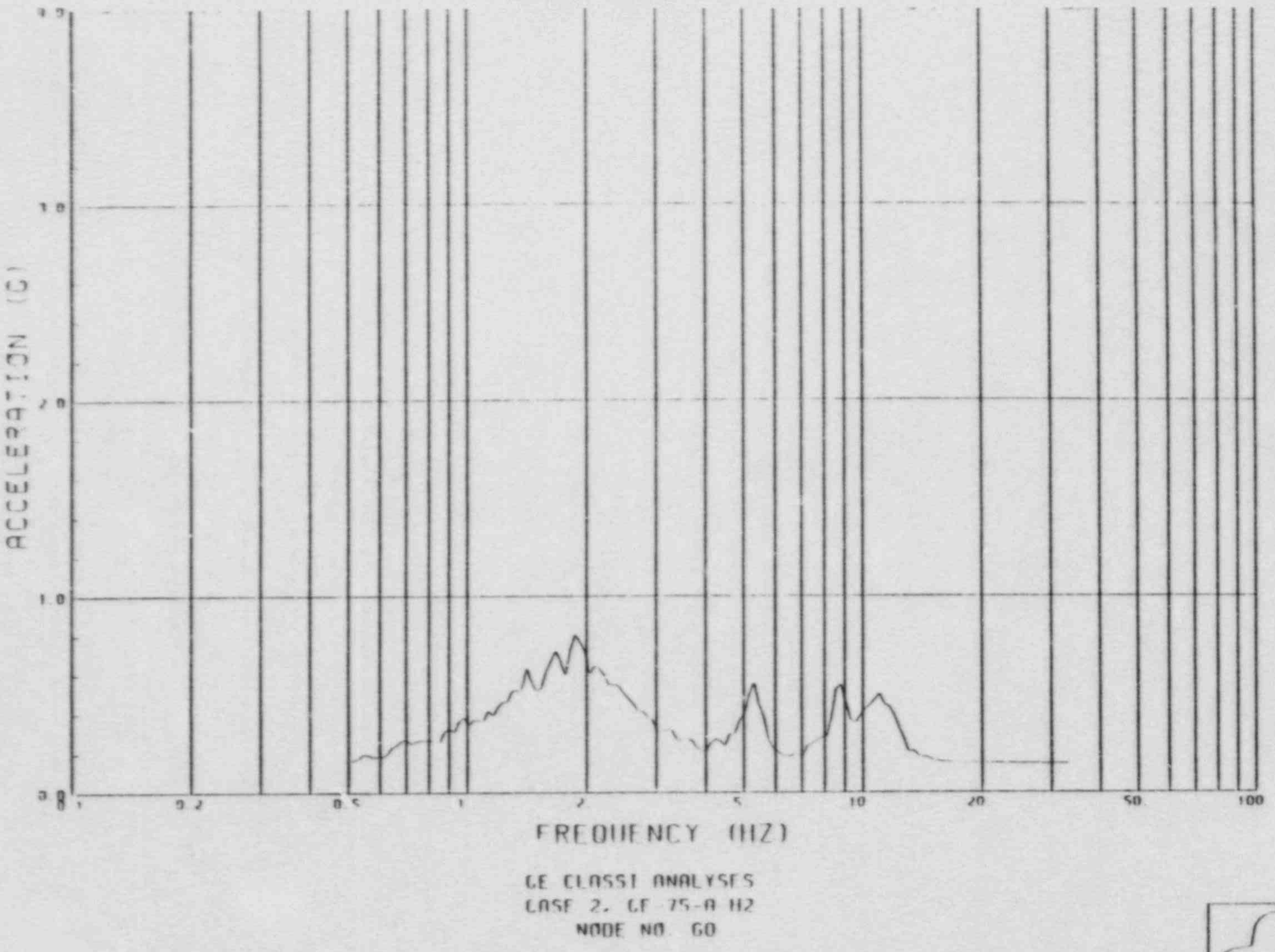
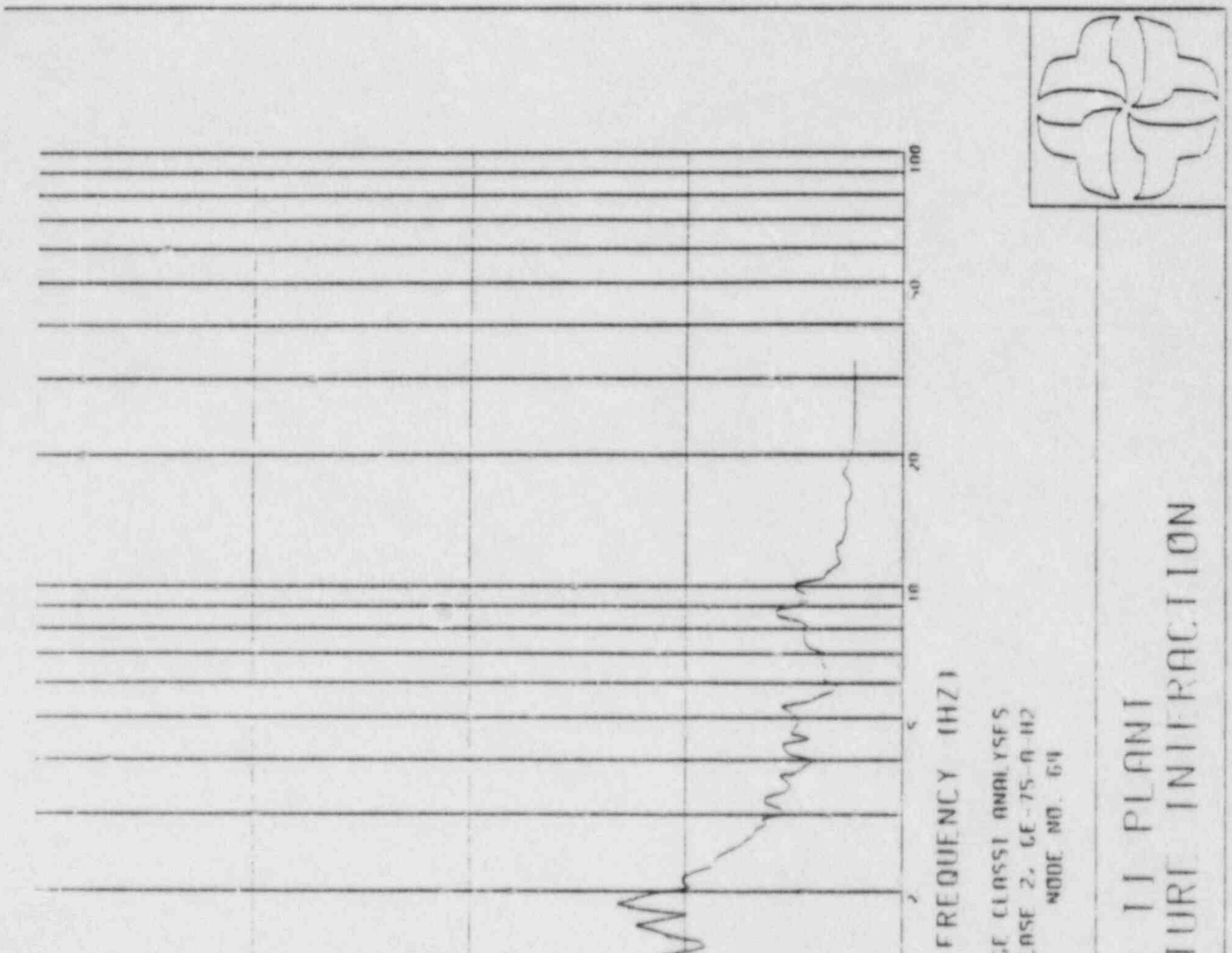

FREQUENCY (HZ)
GE CLASSI ANALYSES
CASE 2, GE-75-0 H2
NODE NO. 46
ACCELERATION (G)
0.0
0.4
0.8
1.2
.1
.2
.5
1
2
5
10
20
50
100
GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

Figure A.18



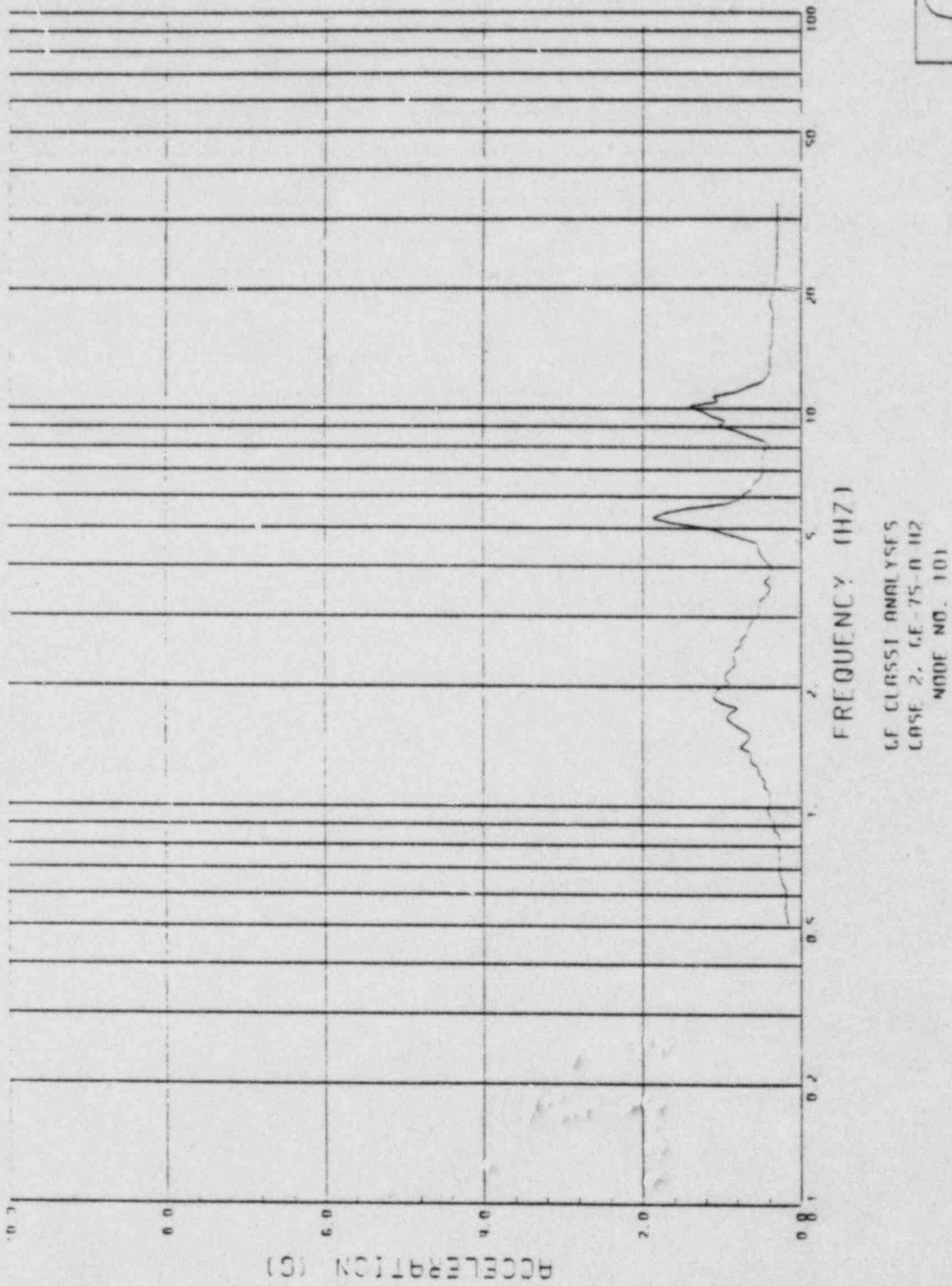
GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

Figure A.19



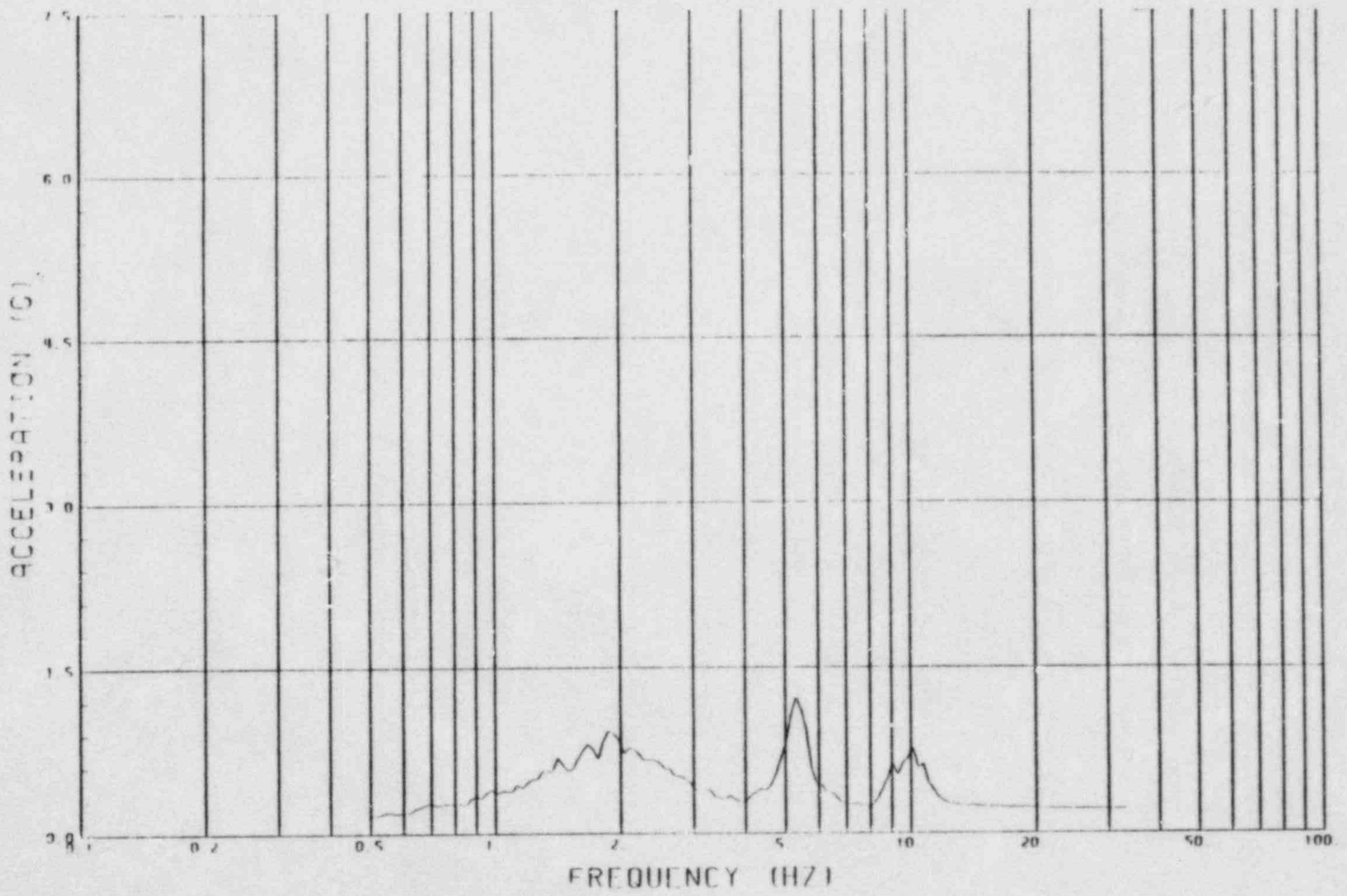
GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

Figure A.20



GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

Figure A.21



GE CLASSI ANALYSES
CASE 2, GE-75-A-H2
NODE NO. 109

GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

Figure A.22

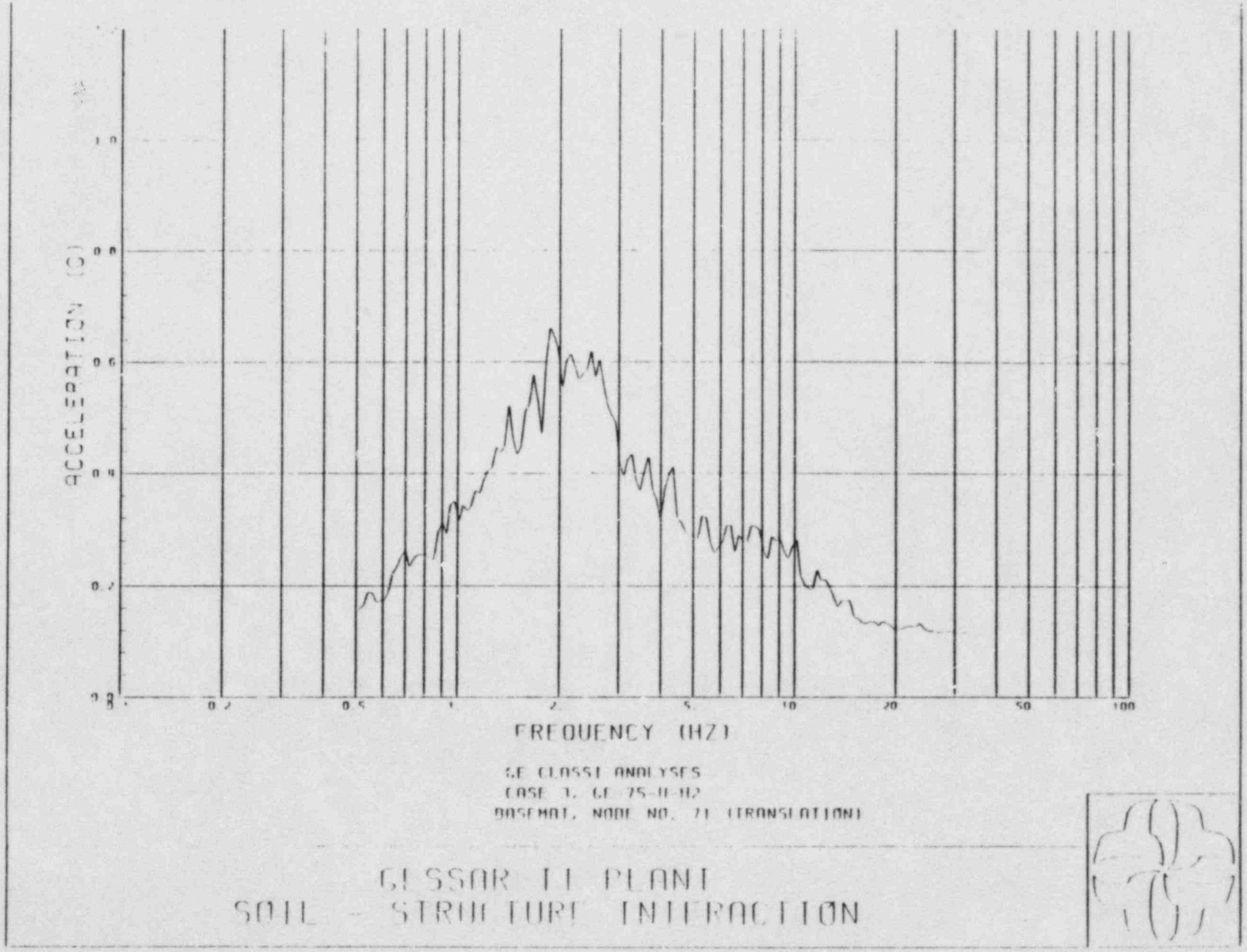
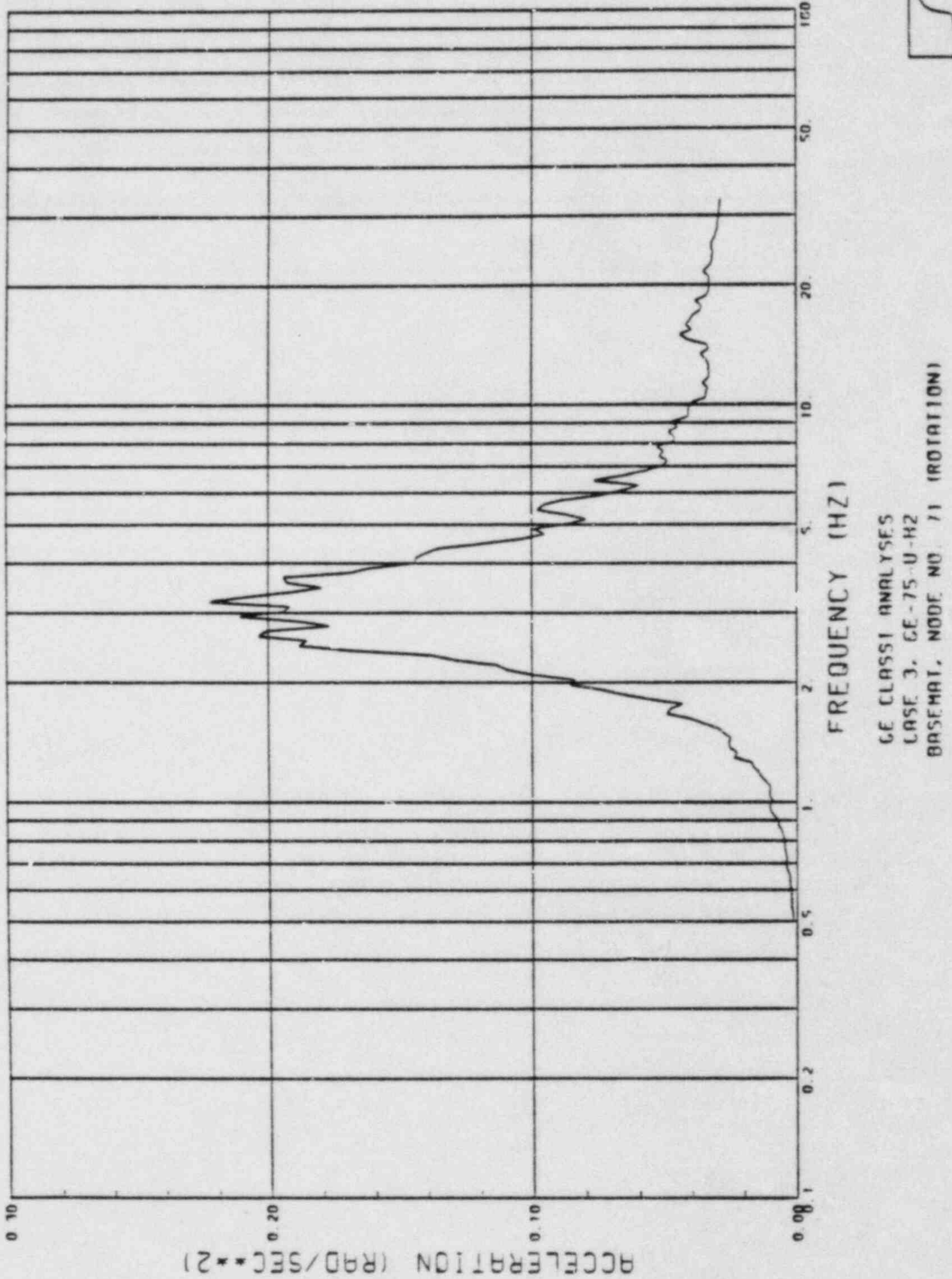

ACCELERATION (G)
0.0
0.2
0.4
0.6
0.8
1.0
0.2
0.5
1
2
5
10
20
50
100
FREQUENCY (HZ)
GE CLASSI ANALYSES
CASE 3, GE 75-II-H2
BASEMAT, NODE NO. 71 (TRANSLATION)
GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

Figure A.23



GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

Figure A.24

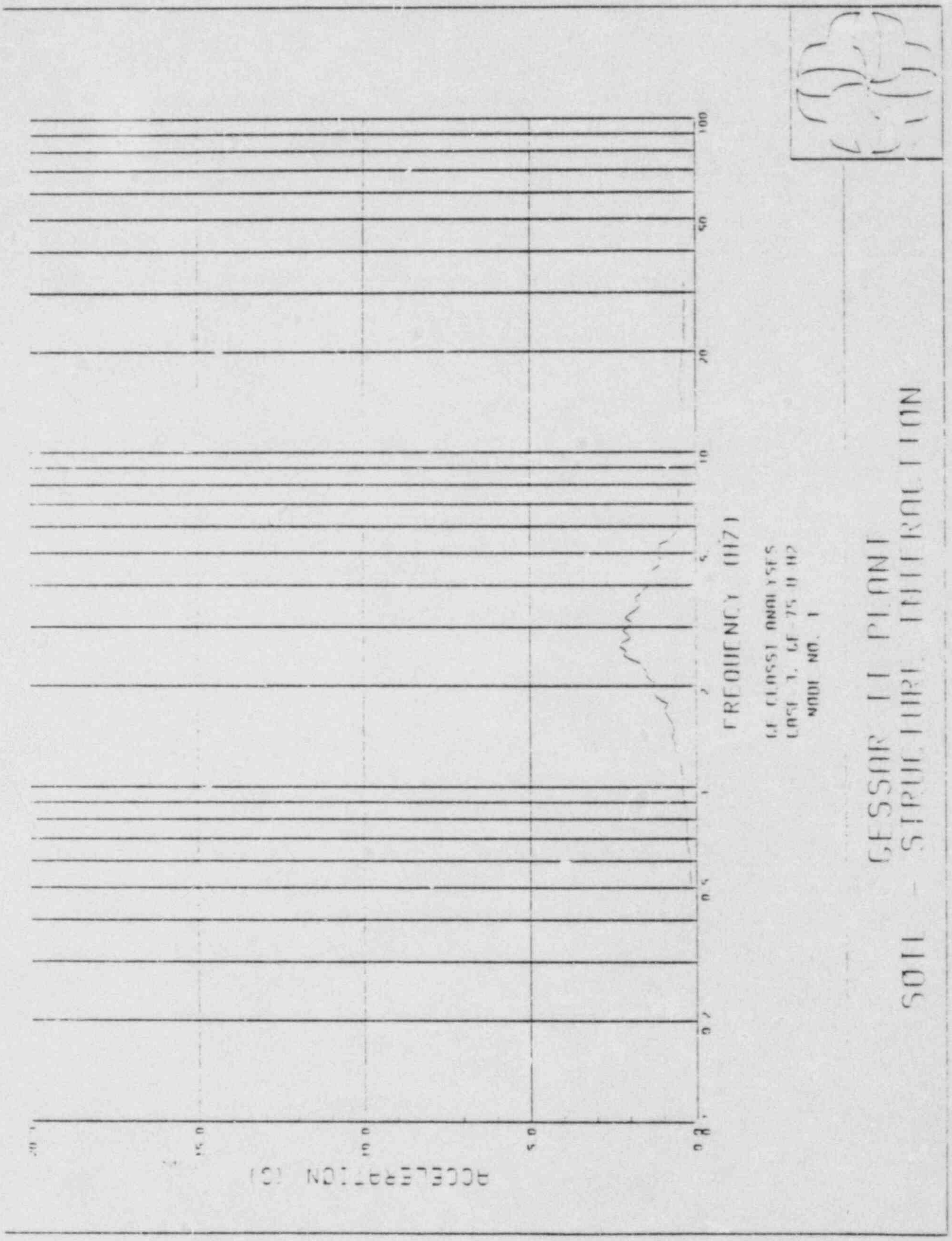
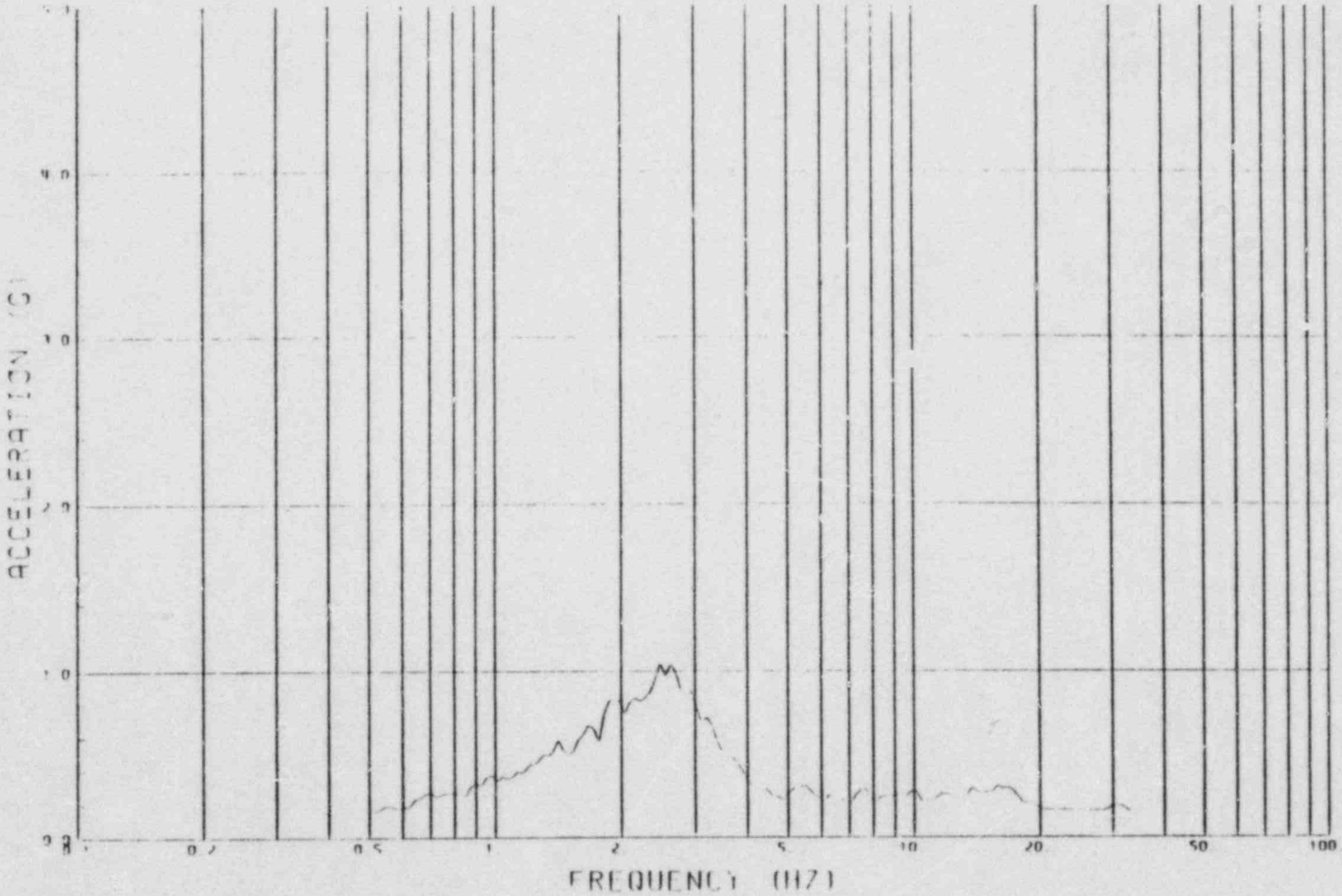

ACCELERATION (G)
0.0
5.0
10.0
15.0
20.0
FREQUENCY (HZ)
0.1
0.2
0.5
1
2
5
10
20
50
100
GE CLASSI ANALYSES
CASE 1, GE-75 H HZ
NODE NO. 1
GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

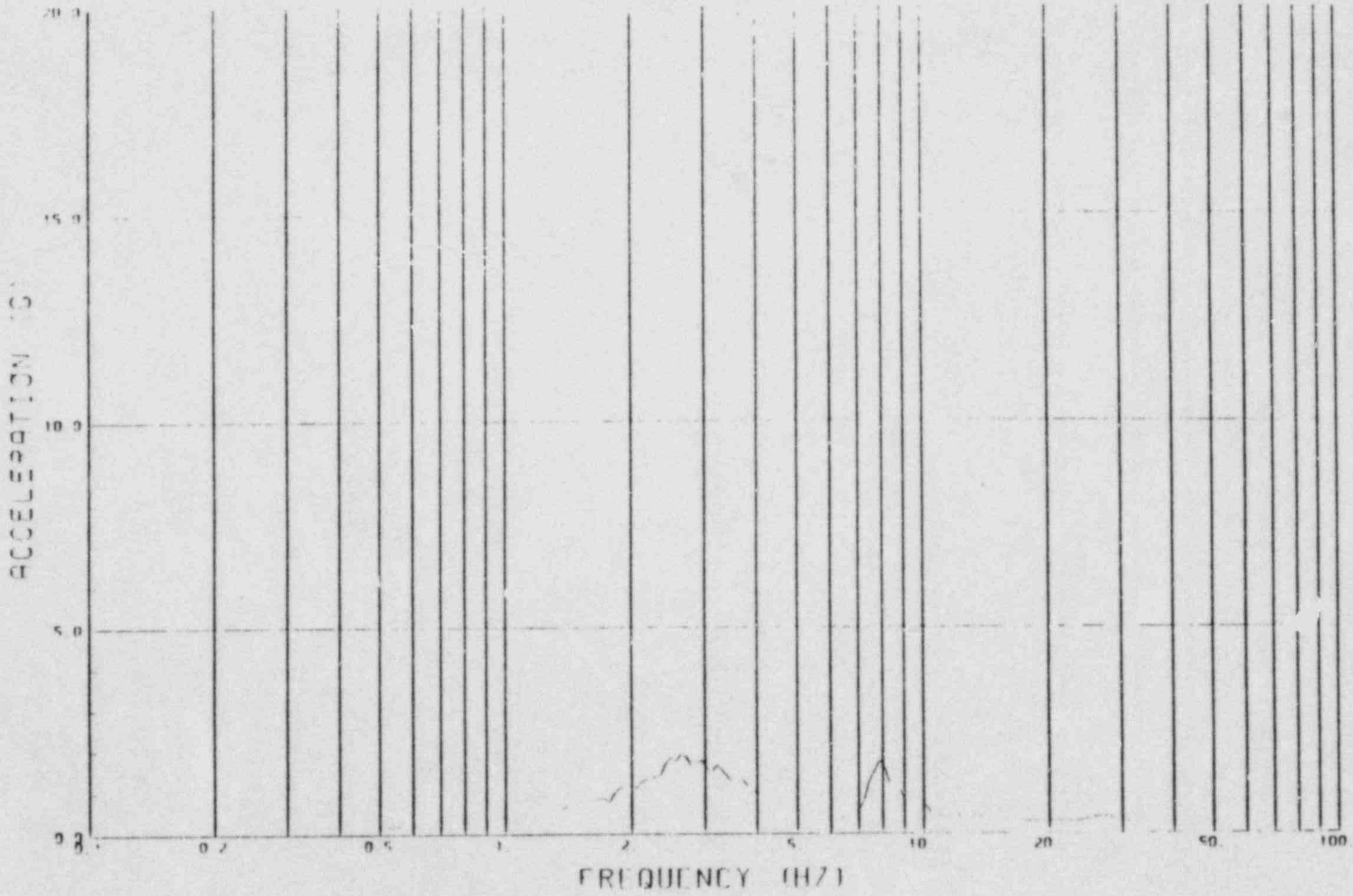
Figure A.25



GE CLASSI ANALYSES
CASE 3, GE-75 U-H2
NODE NO. 18

GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

Figure A.26



GE CLASSI ANALYSES
CASE 3, GE-75 U-H2
NODE NO. 22

GESSAR II PLANT
SOIL STRUCTURE INTERACTION

Figure A.27

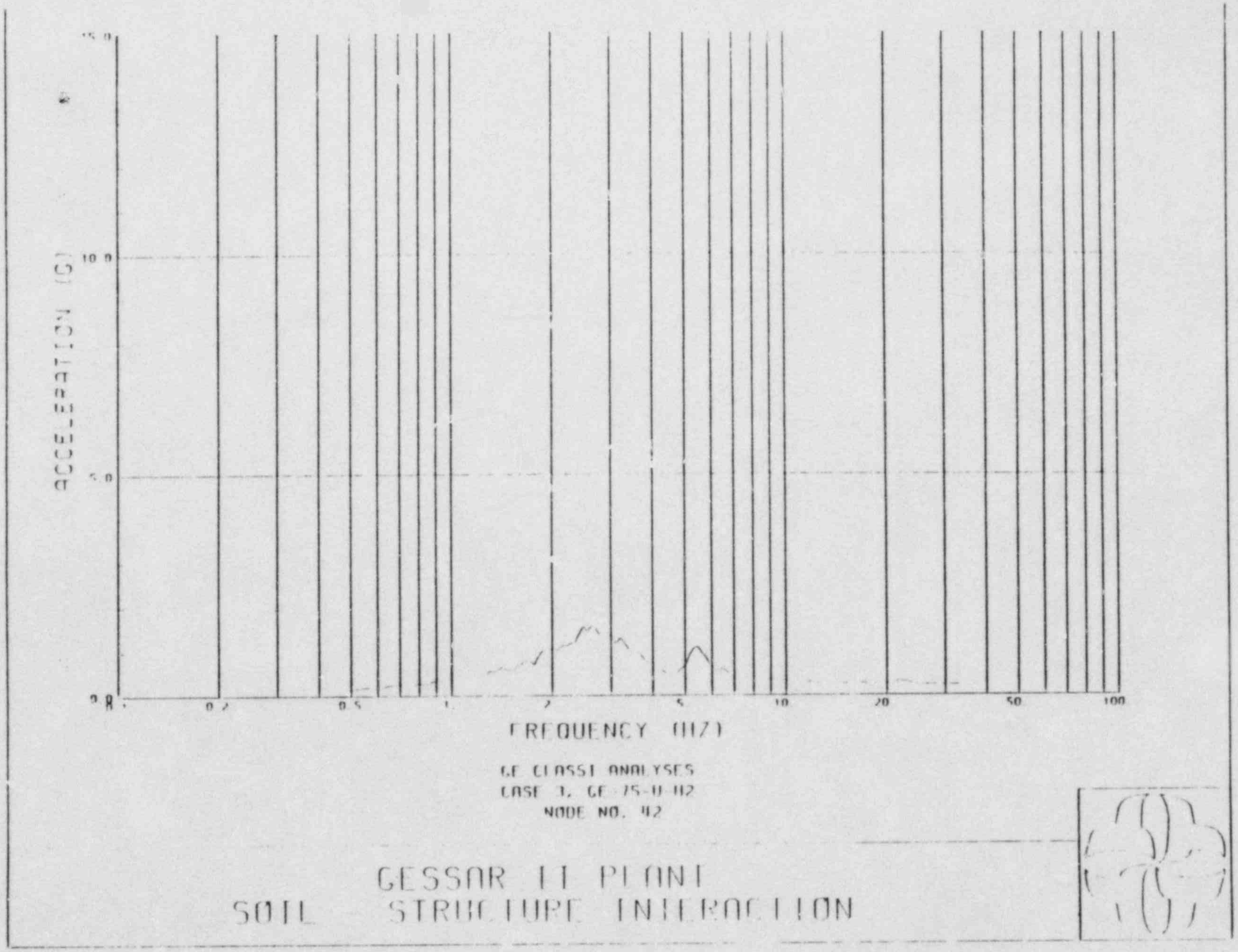

ACCELERATION (G)
15.0
10.0
5.0
0.0
0.2
0.5
1
2
5
10
20
50
100
FREQUENCY (HZ)
GE CLASSI ANALYSES
CASE 3, GE-75-U-H2
NODE NO. 42
GESSAR II PLANT
SOIL STRUCTURE INTERACTION

Figure A.28

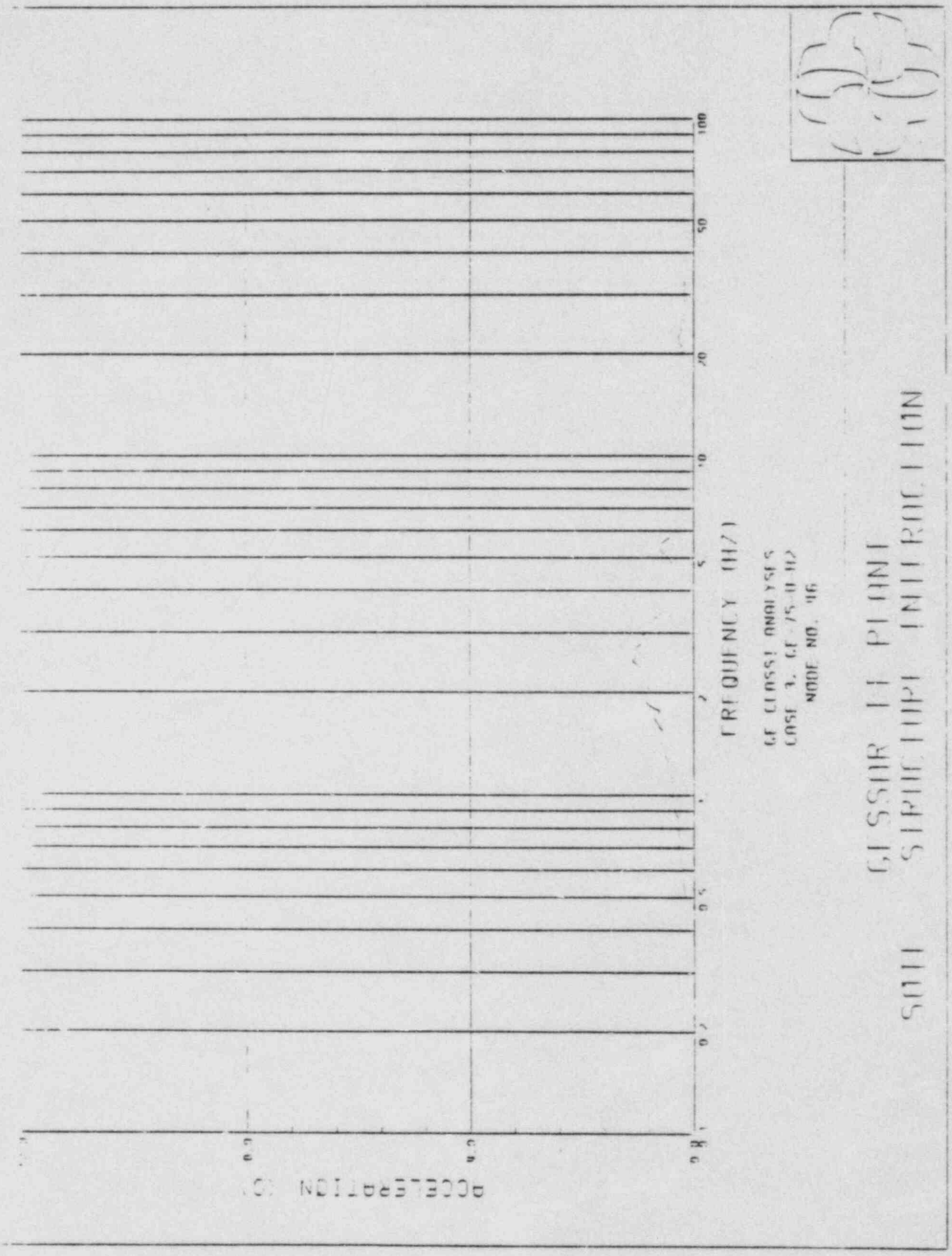

GESSAR II PLANT
SOIL STRUCTURE INTERACTION
FREQUENCY (HZ)
GE CLASSI ANALYSES
CASE 3, GE 75-II-H2
NODE NO. 46
ACCELERATION (G)
0.2
0.5
1
2
5
10
20
50
100

Figure A.29

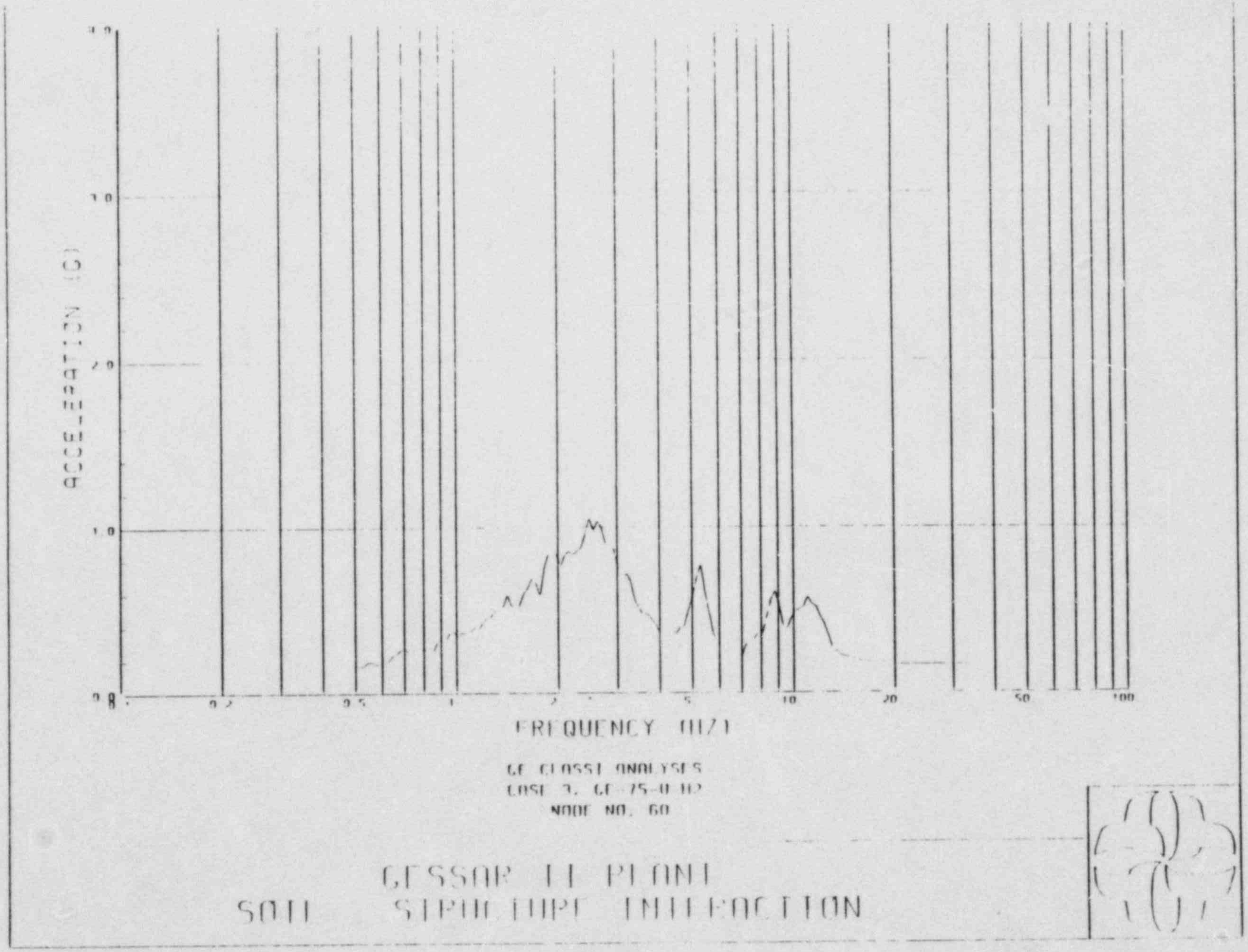

ACCELERATION (G)
0.0
1.0
2.0
3.0
4.0
0.1
0.2
0.5
1
2
5
10
20
50
100
FREQUENCY (HZ)
GE CLASSI ANALYSES
CASE 3, GE-75-0.1Q
NODE NO. 60
GESSAR II PLANT
SOIL STRUCTURE INTERACTION

Figure A.30

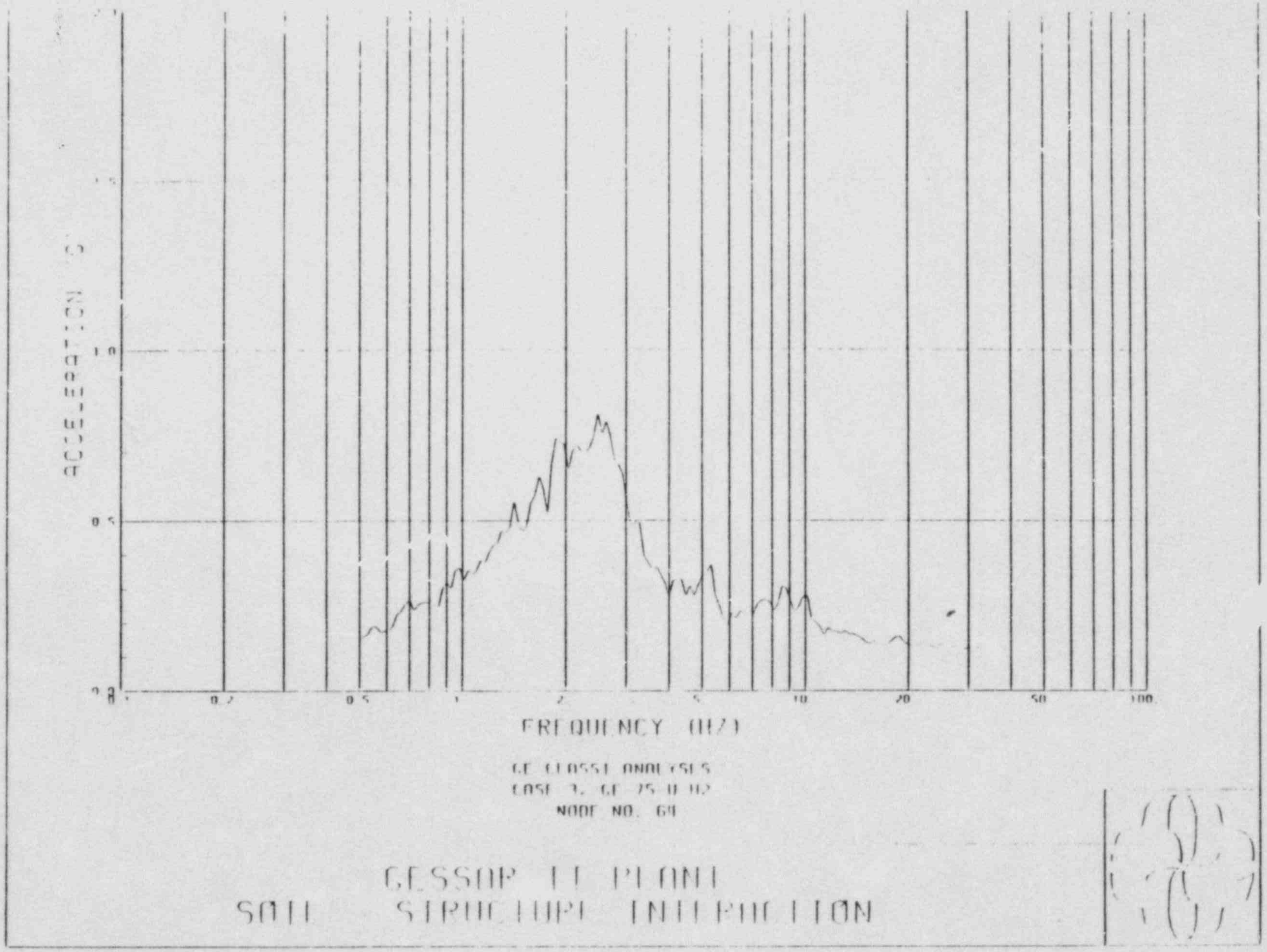

ACCELERATION G
0.0
0.5
1.0
1.5
2.0
0.1
0.2
0.5
1
2
5
10
20
50
100
FREQUENCY (HZ)
GE CLASSI ANALYSES
CASE 3, GE 75 H HZ
NODE NO. 64
GESSAR II PLANT
SOIL STRUCTURE INTERACTION

Figure A.31

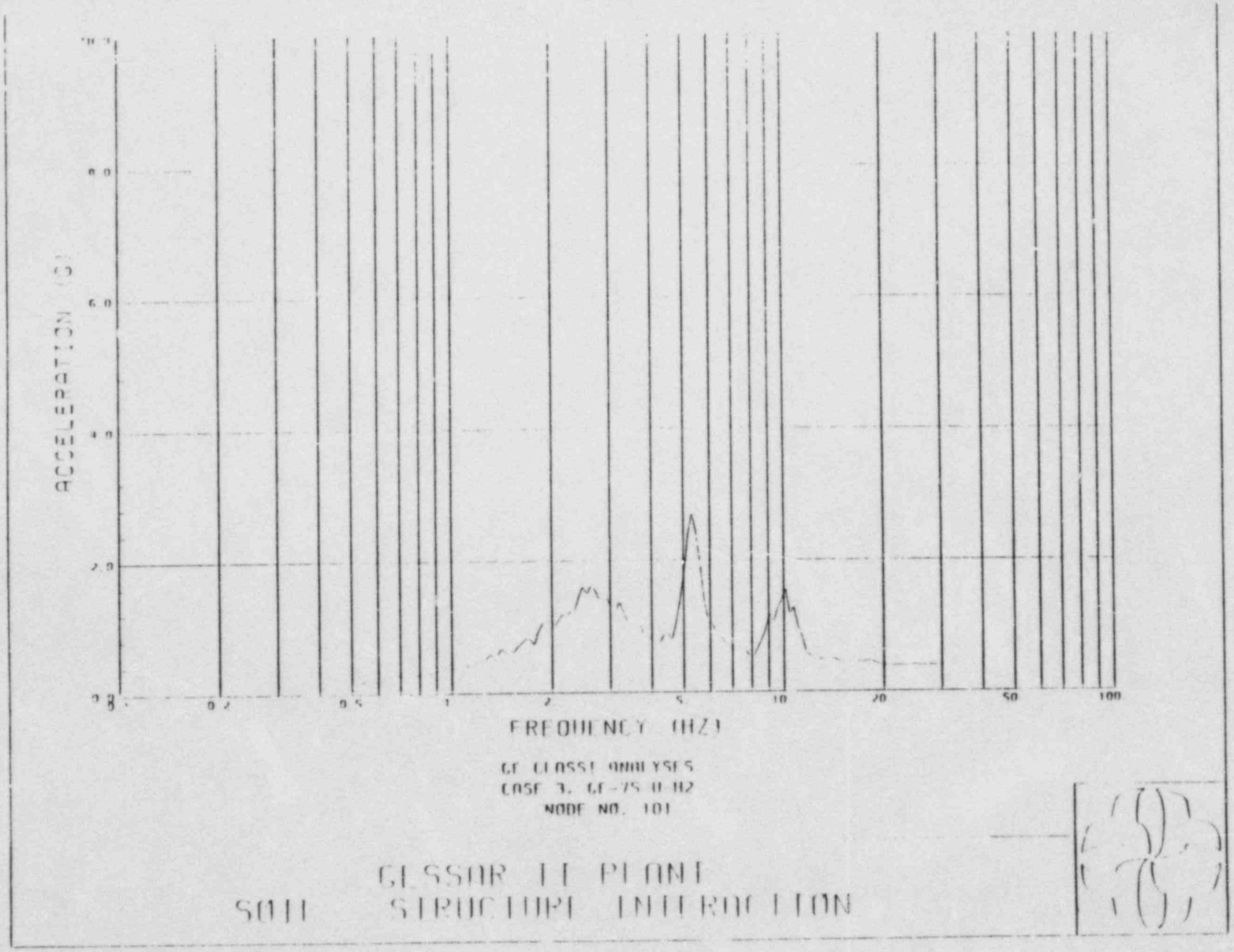

ACCELERATION (G)
0.0
2.0
4.0
6.0
8.0
10.0
0.2
0.5
1
2
5
10
20
50
100
FREQUENCY (HZ)
GE CLASSI ANALYSES
CASE 3. GE-75 U H2
NODE NO. 101
GESSAR II PLANT
SOIL STRUCTURE INTERACTION

Figure A.32

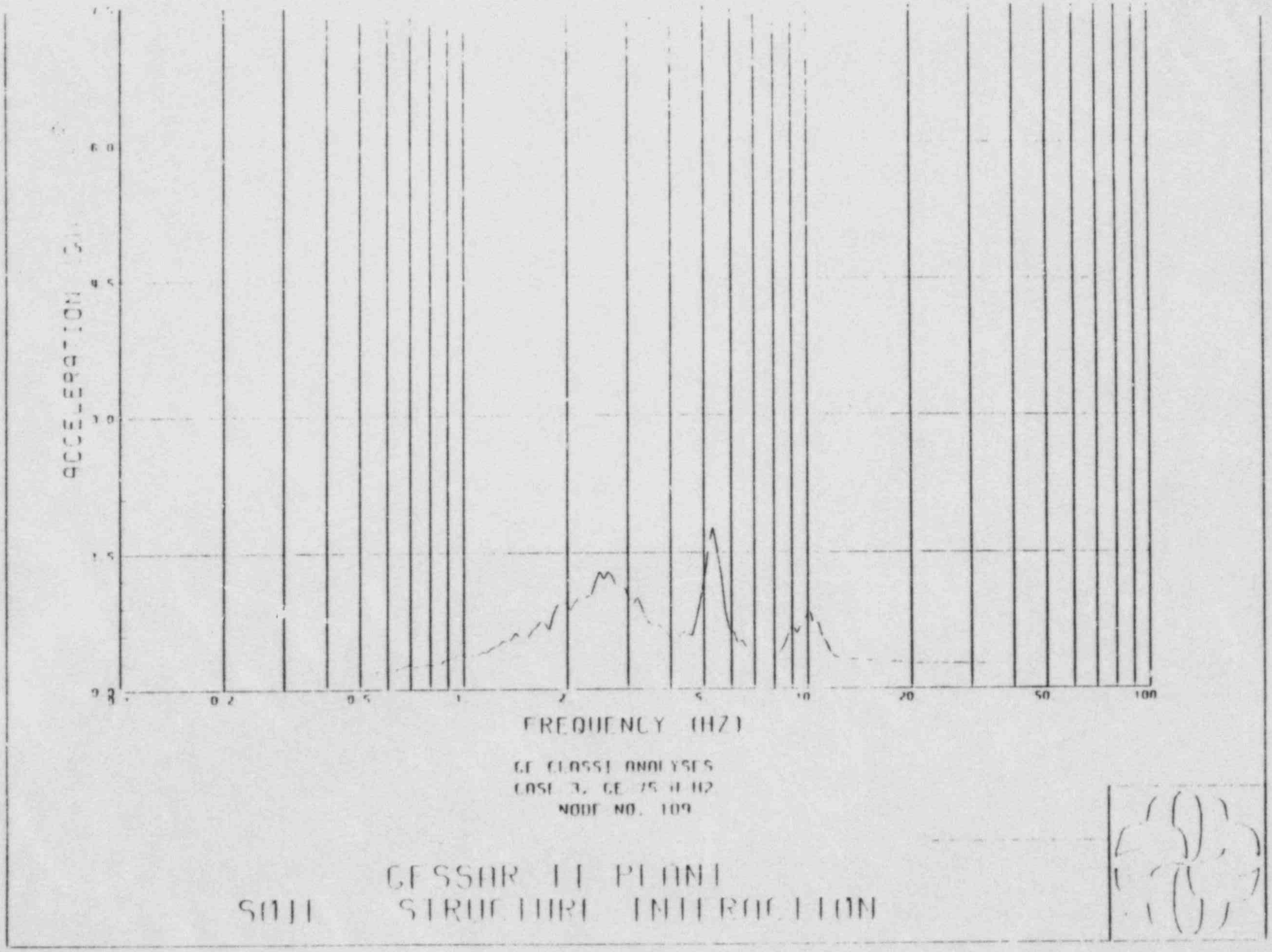
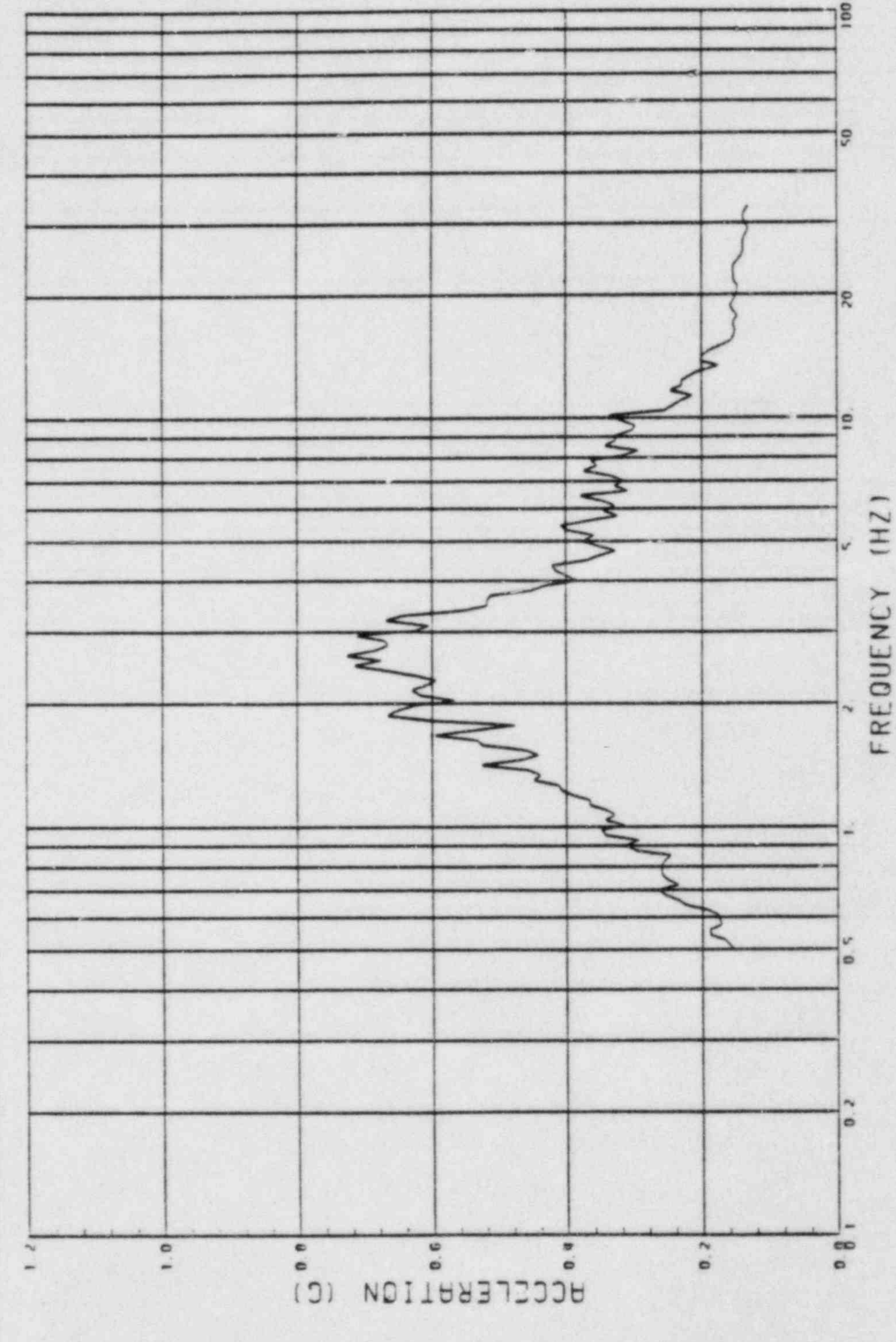

ACCELERATION (G)
0.0
1.5
3.0
4.5
6.0
7.5
0.2
0.5
1
2
5
10
20
50
100
FREQUENCY (HZ)
GE CLASSI ANALYSES
CASE 3, GE 75 H HZ
NODE NO. 109
GESSAR II PLANT
SOIL STRUCTURE INTERACTION

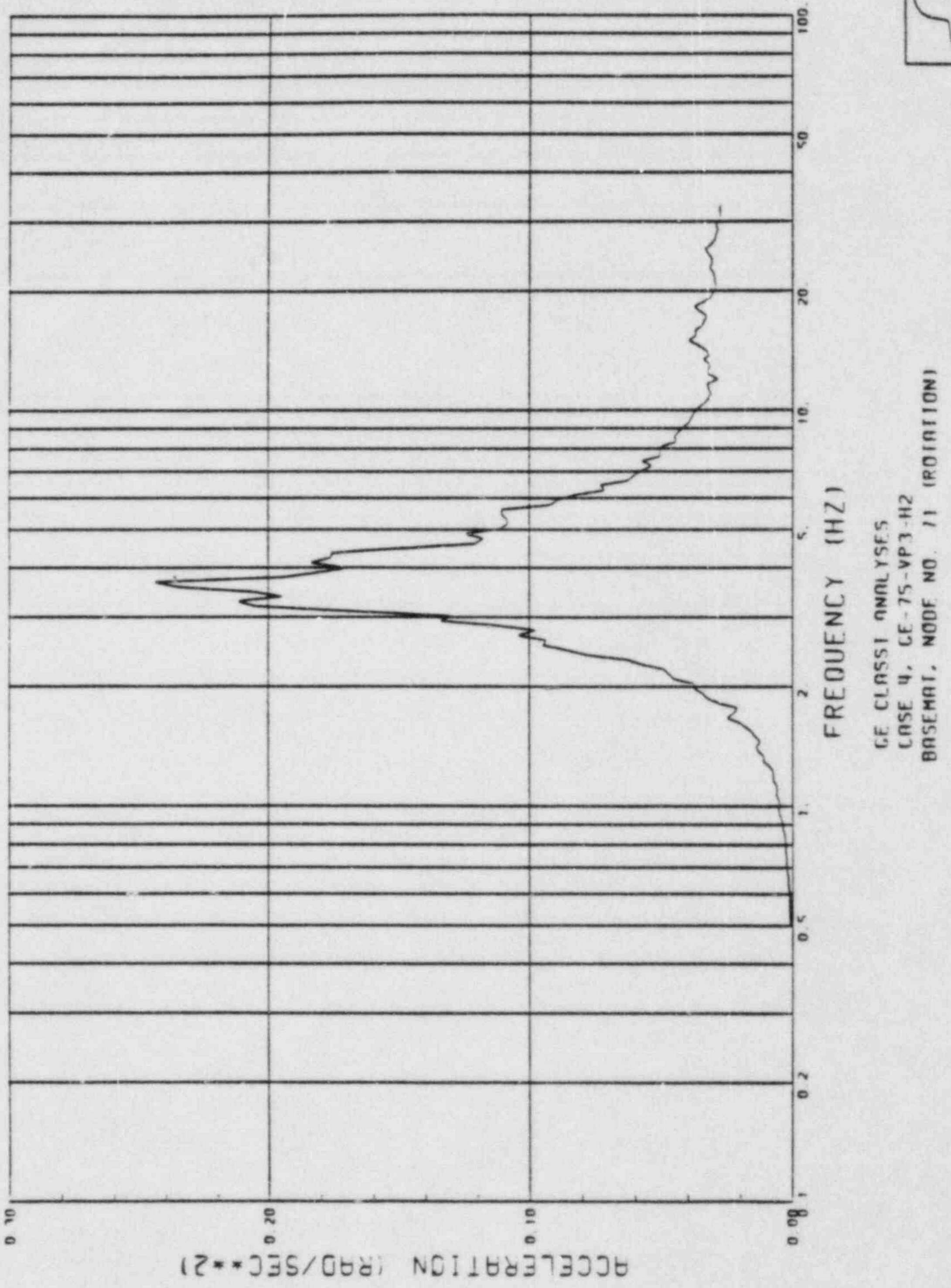
Figure A.33



GE CLASSI ANALYSES
CASE 4, GE-75-VP3-H2
BASEMAT, NODE NO. 71 (TRANSLATION)

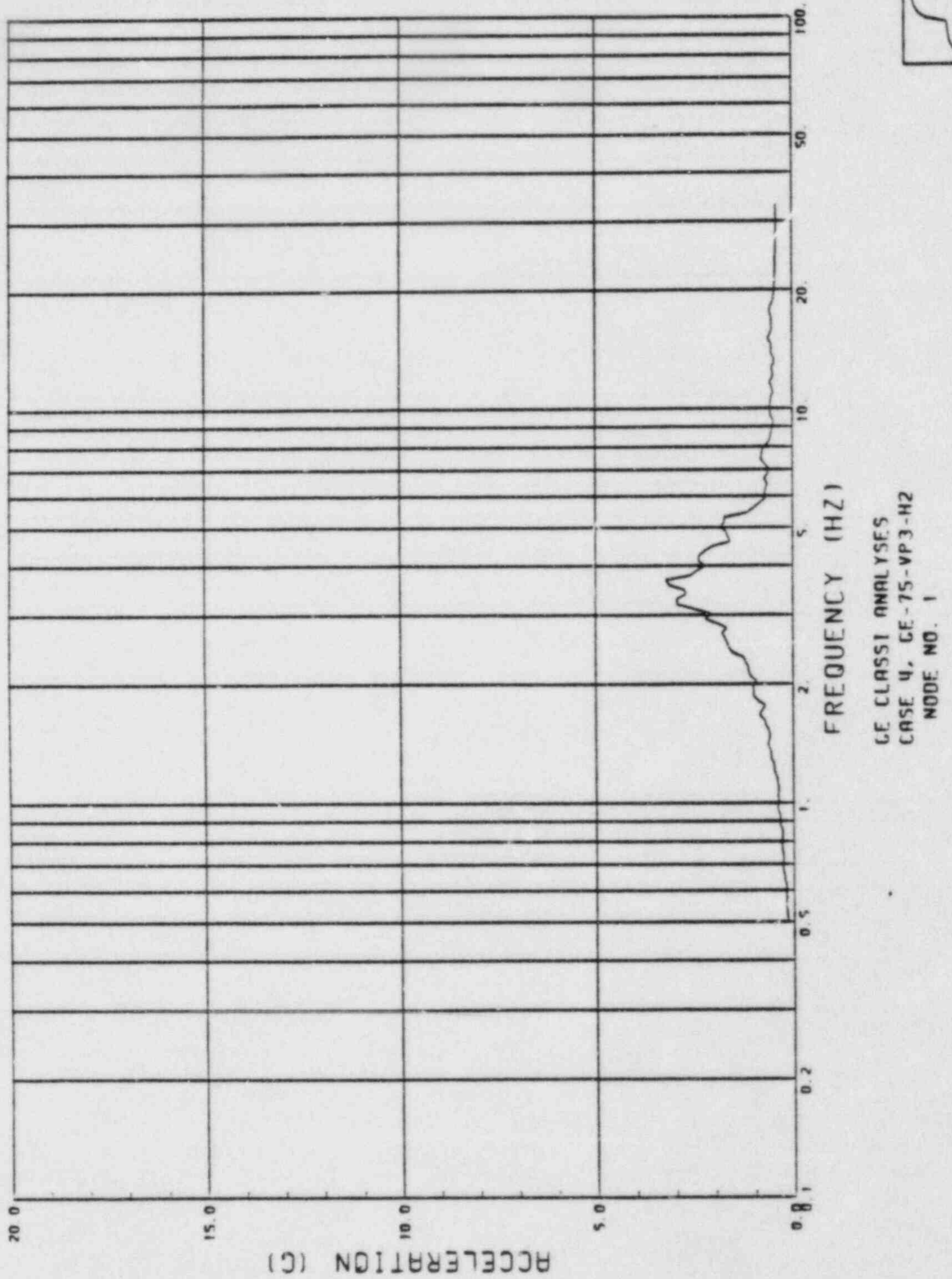
GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

Figure A.34



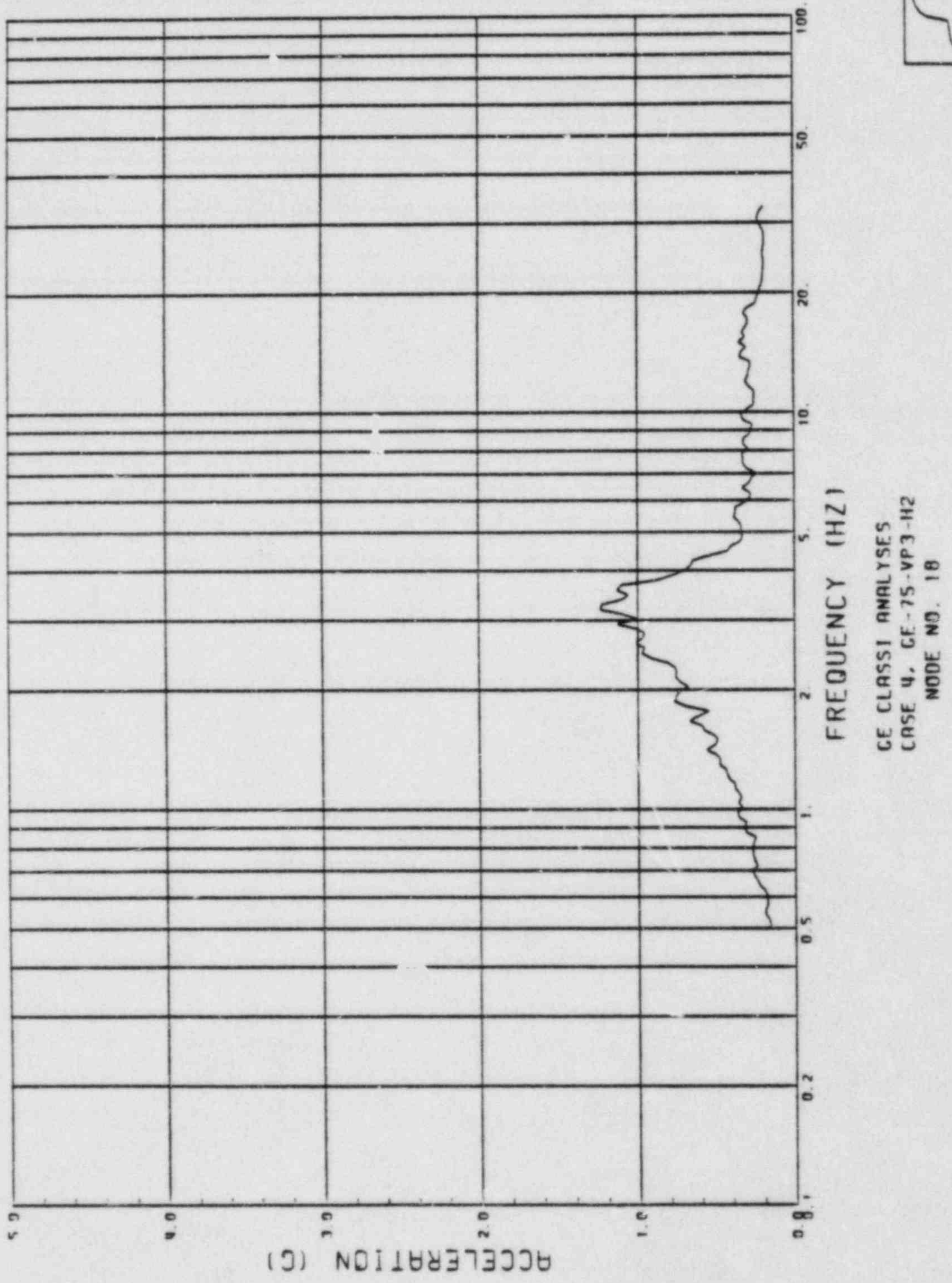
GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

Figure A.35



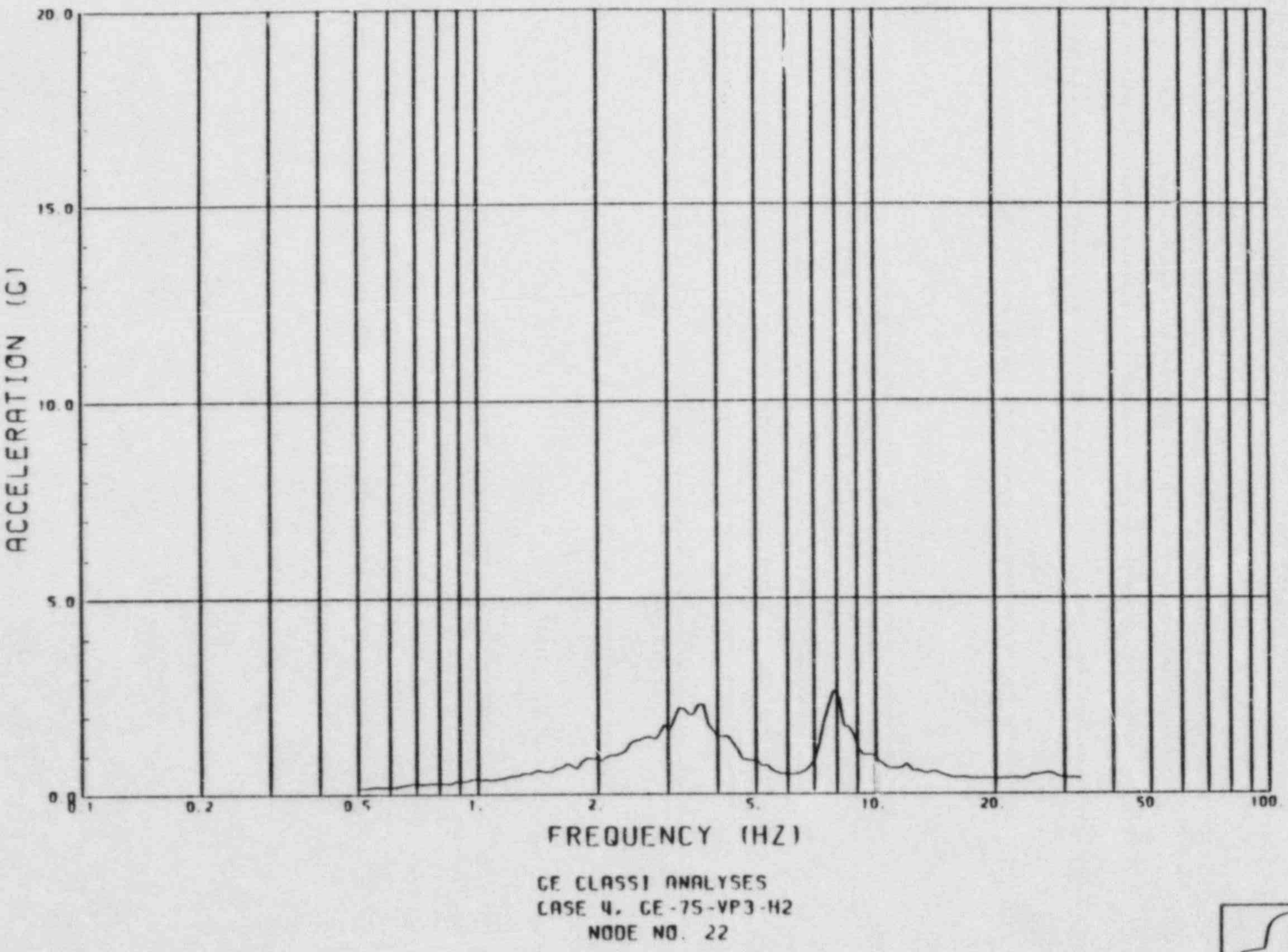
GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

Figure A.36



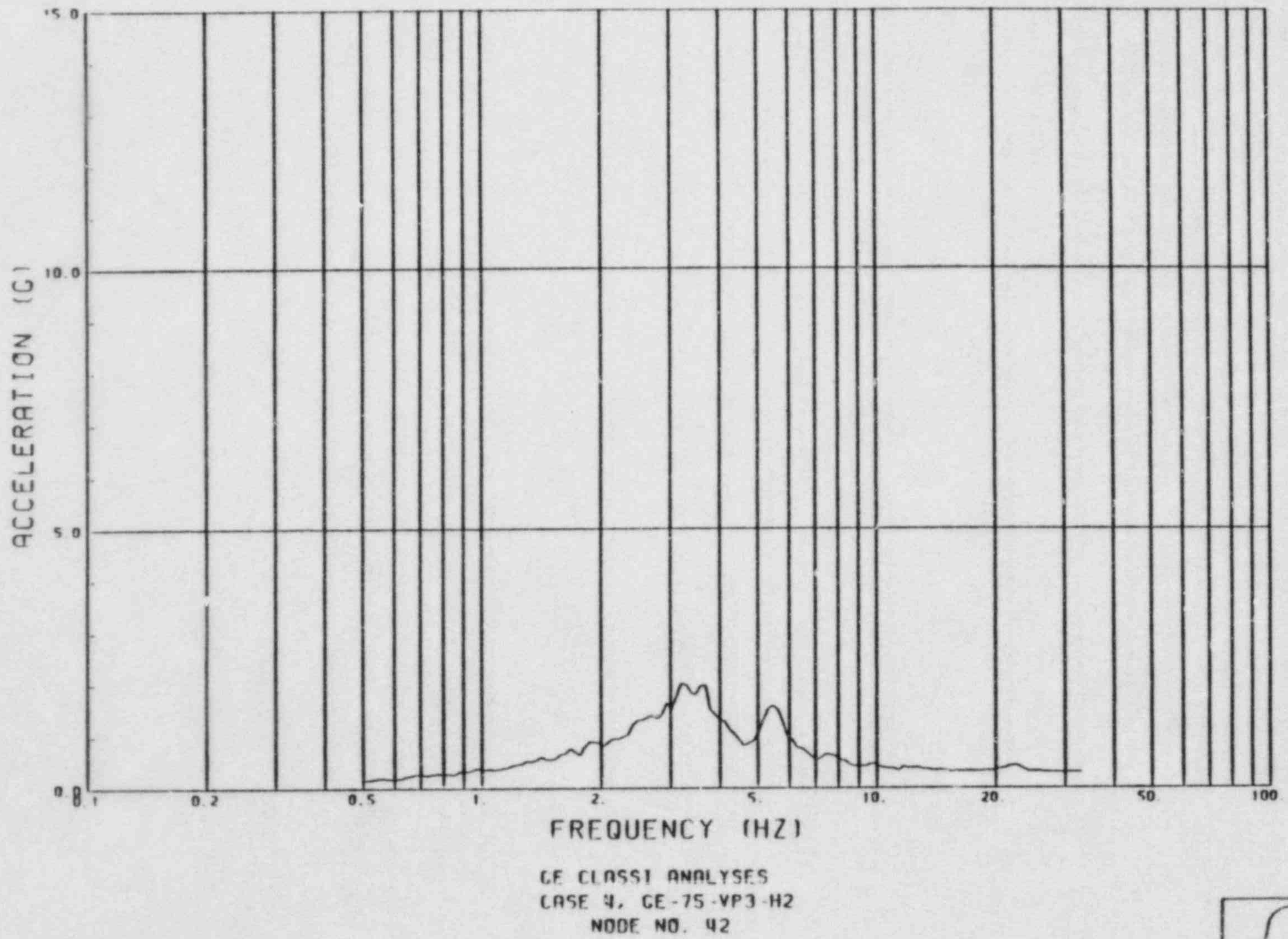
GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

Figure A.37



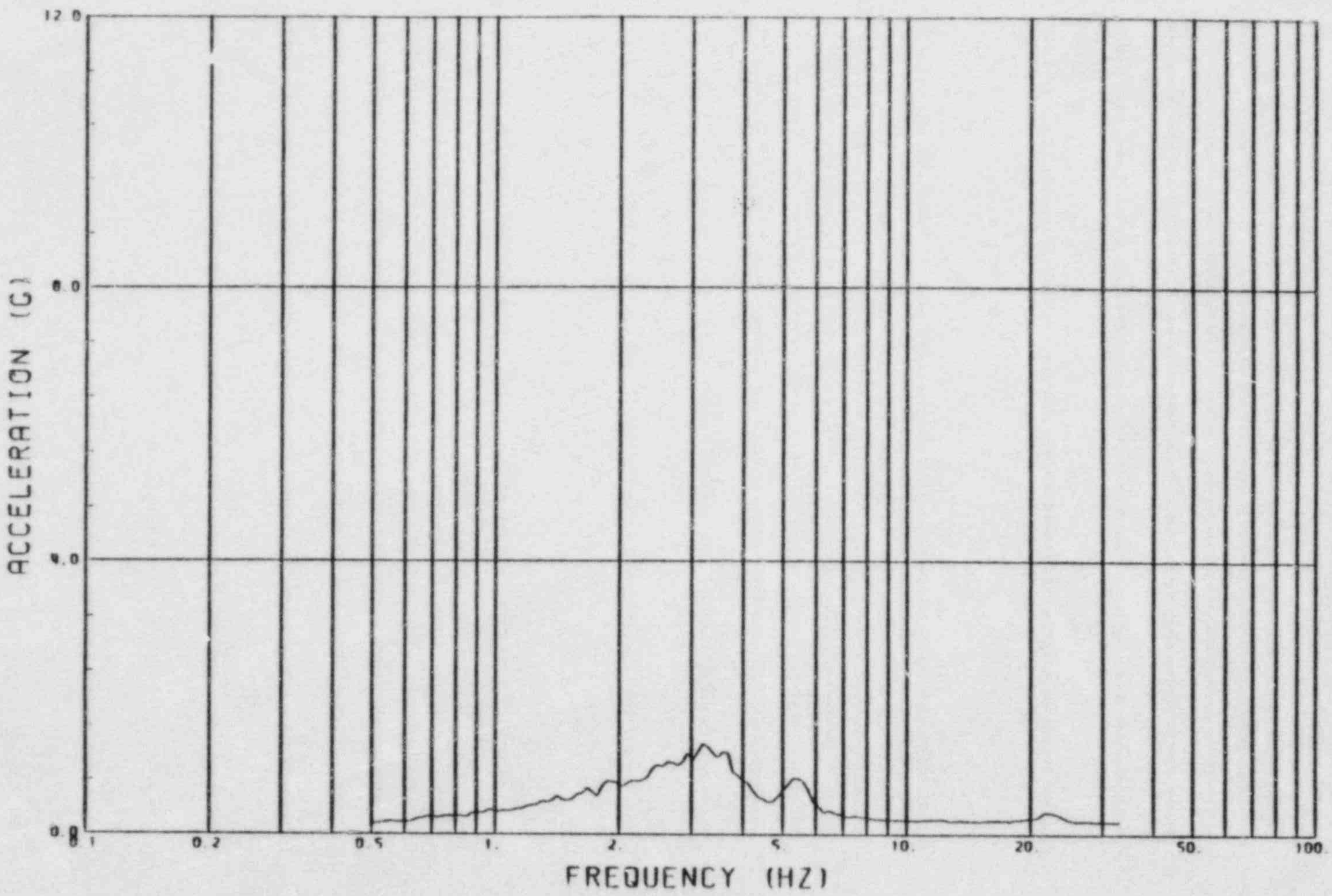
GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

Figure A.38



GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

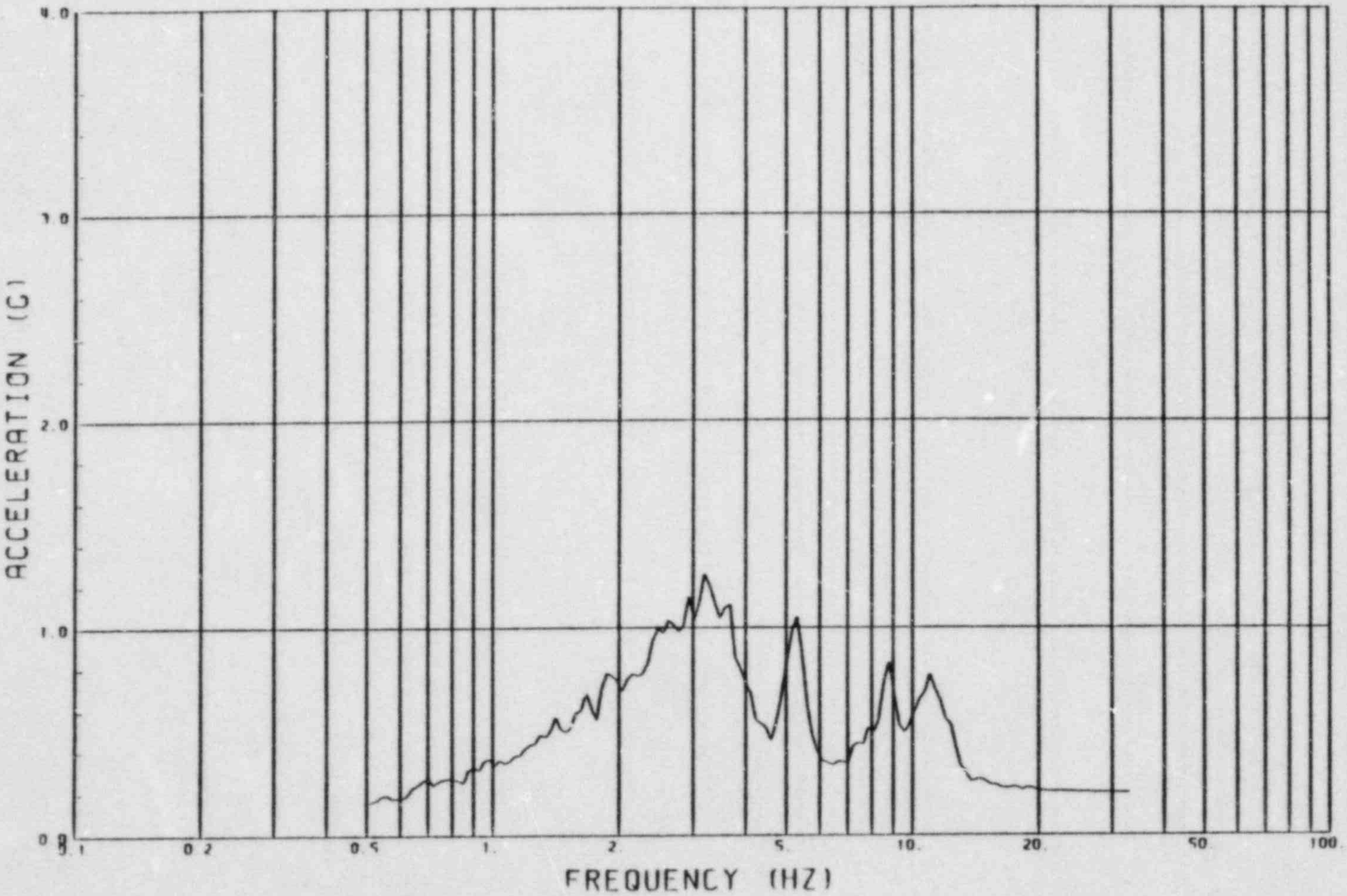
Figure A.39



GE CLASSI ANALYSES
CASE 4, GE-75-VP3-H2
NODE NO. 46

GESSAR II PLANT
SØIL - STRUCTURE INTERACTIØN

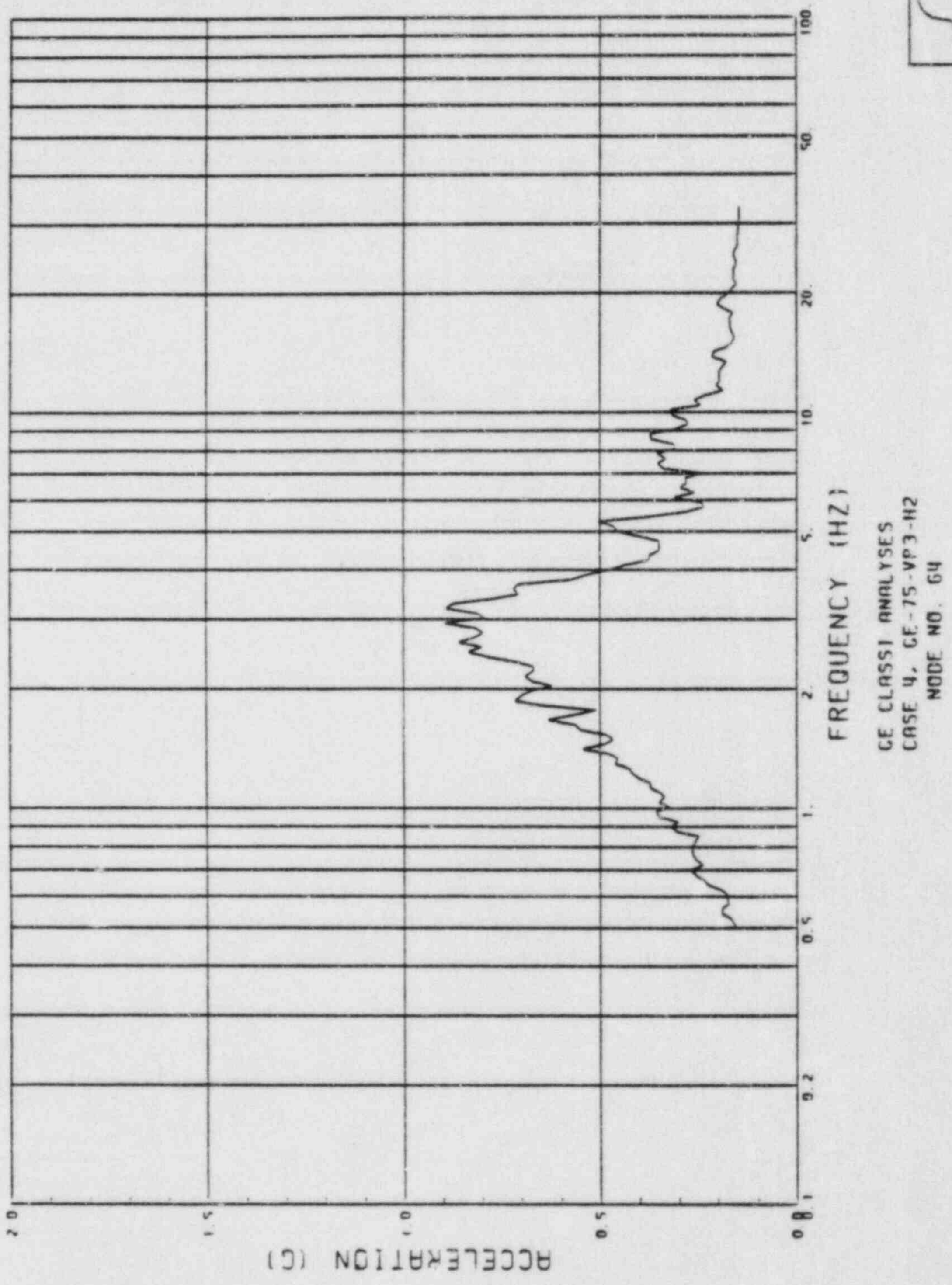
Figure A.40



GE CLASSI ANALYSES
CASE 4, GE-75-VP3-H2
NODE NO. 60

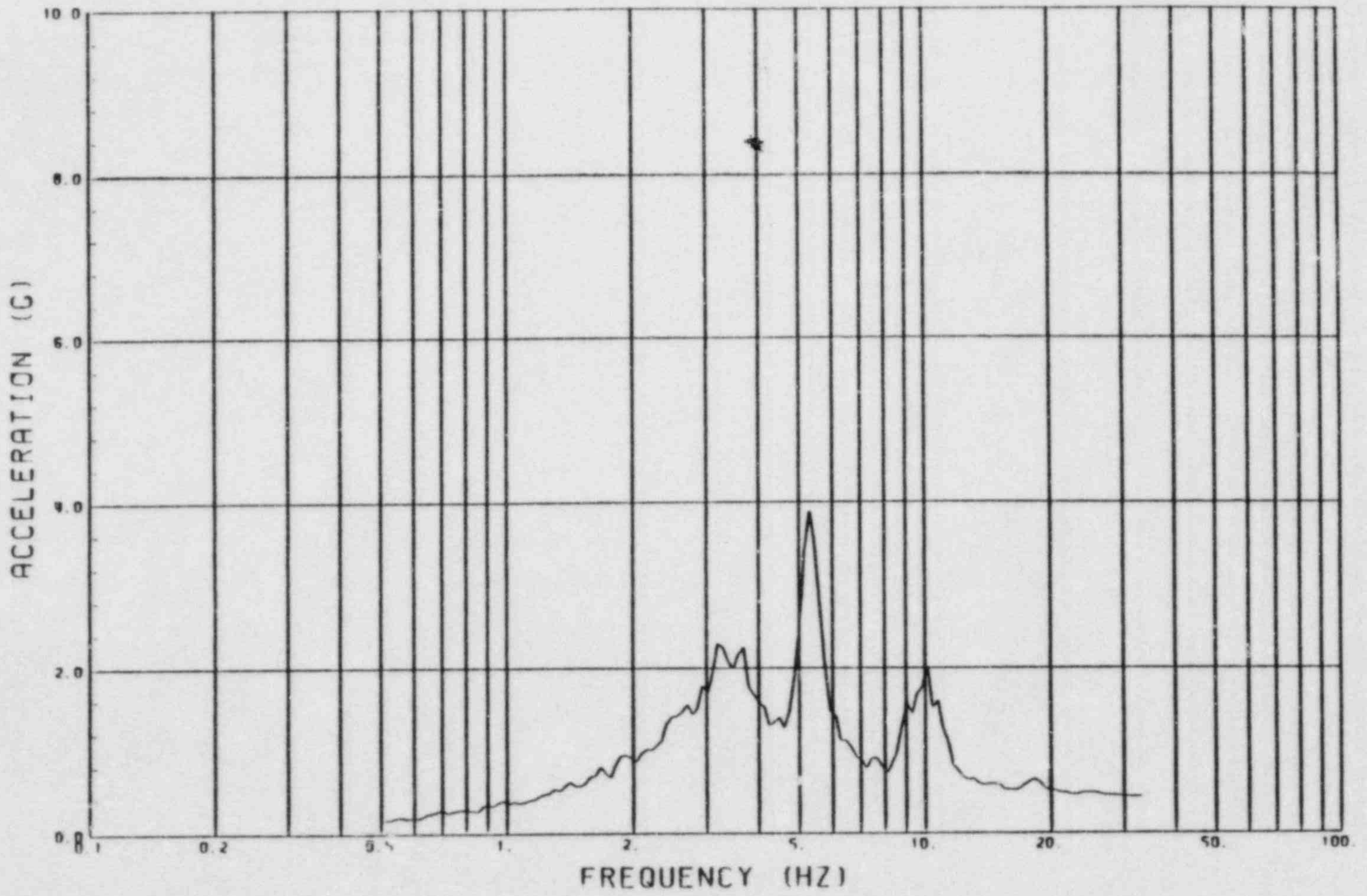
GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

Figure A.41



GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

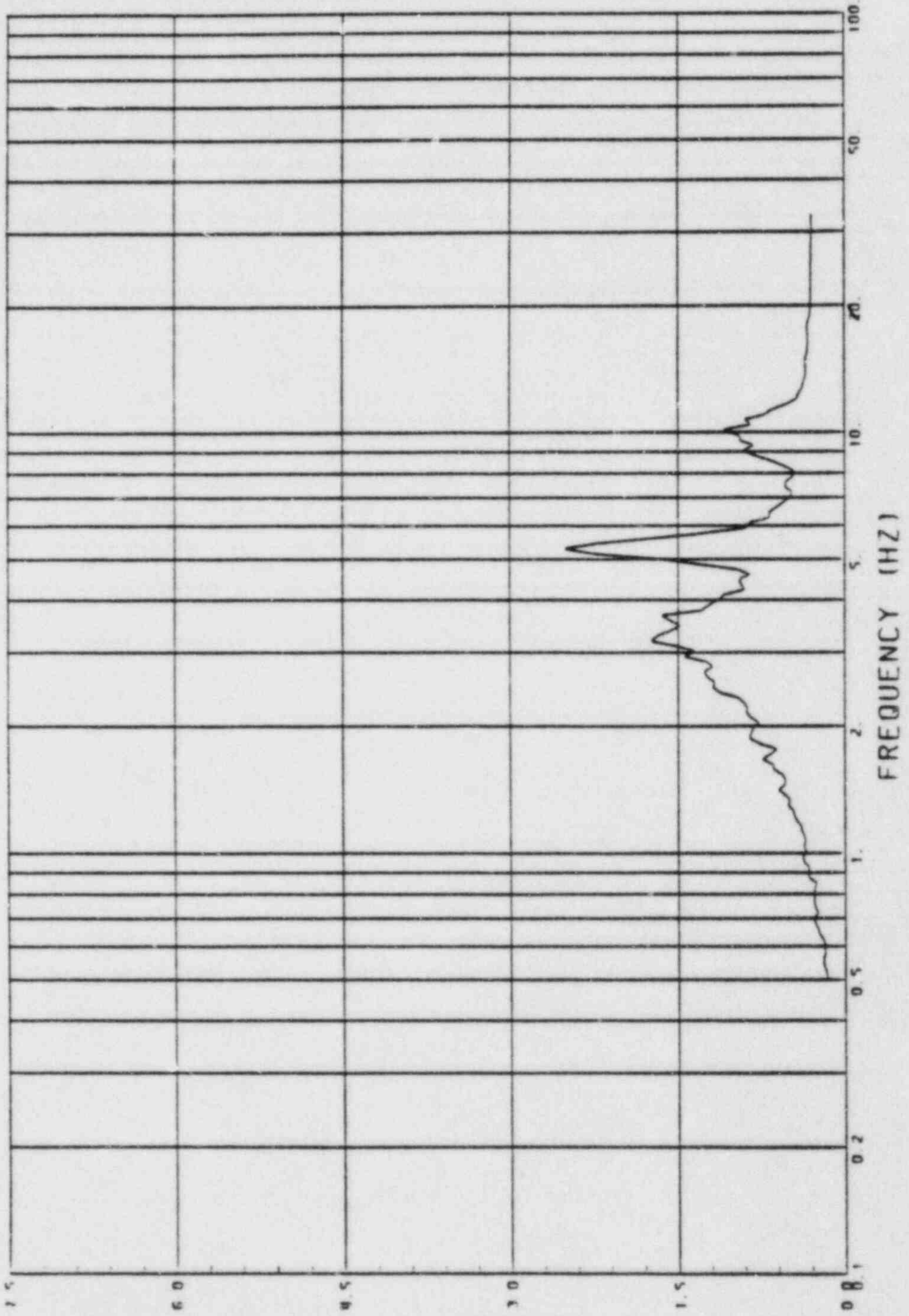
Figure A.42



GE CLASSI ANALYSES
CASE 4, GE-75-VP3-H2
NODE NO. 101

GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

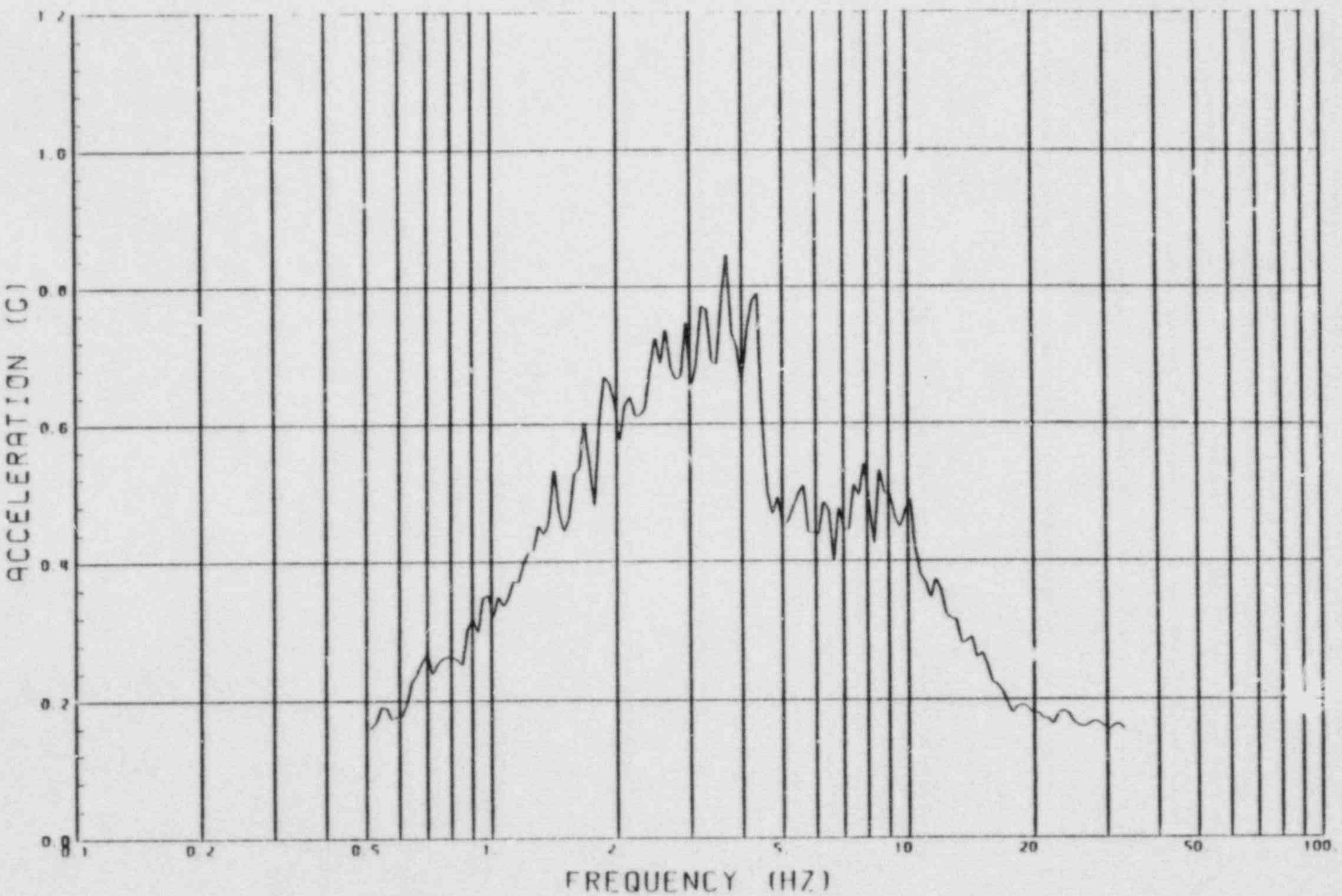
Figure A.43



GE CLASSI ANALYSES
CASE 4, GE-75-VP3-H2
NODE NO. 109

GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

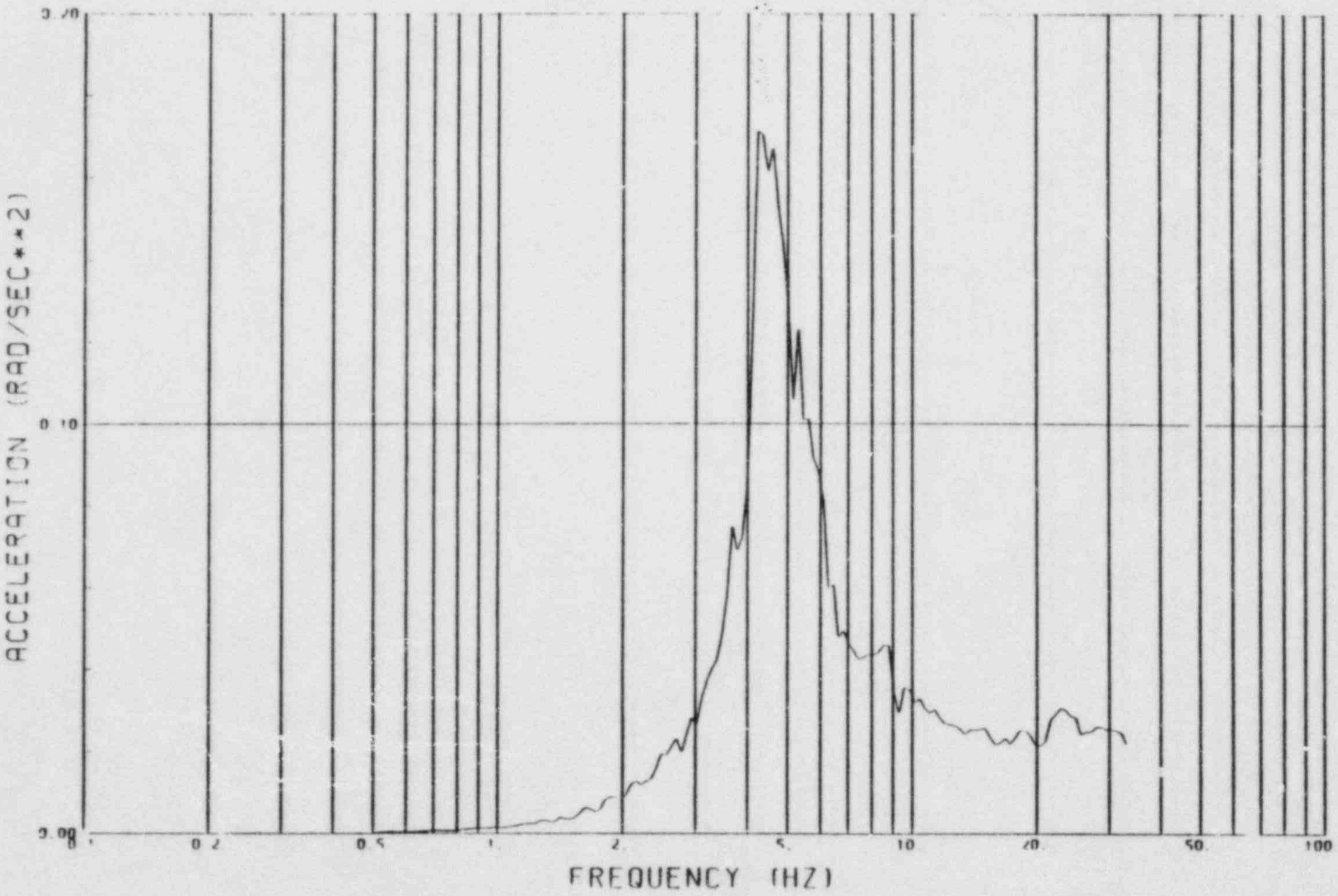
Figure A.44



GE CLASSI ANALYSES
CASE 5, GE-75-HR-H2
BASEMAT, NODE NO. 71 (TRANSLATION)

GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

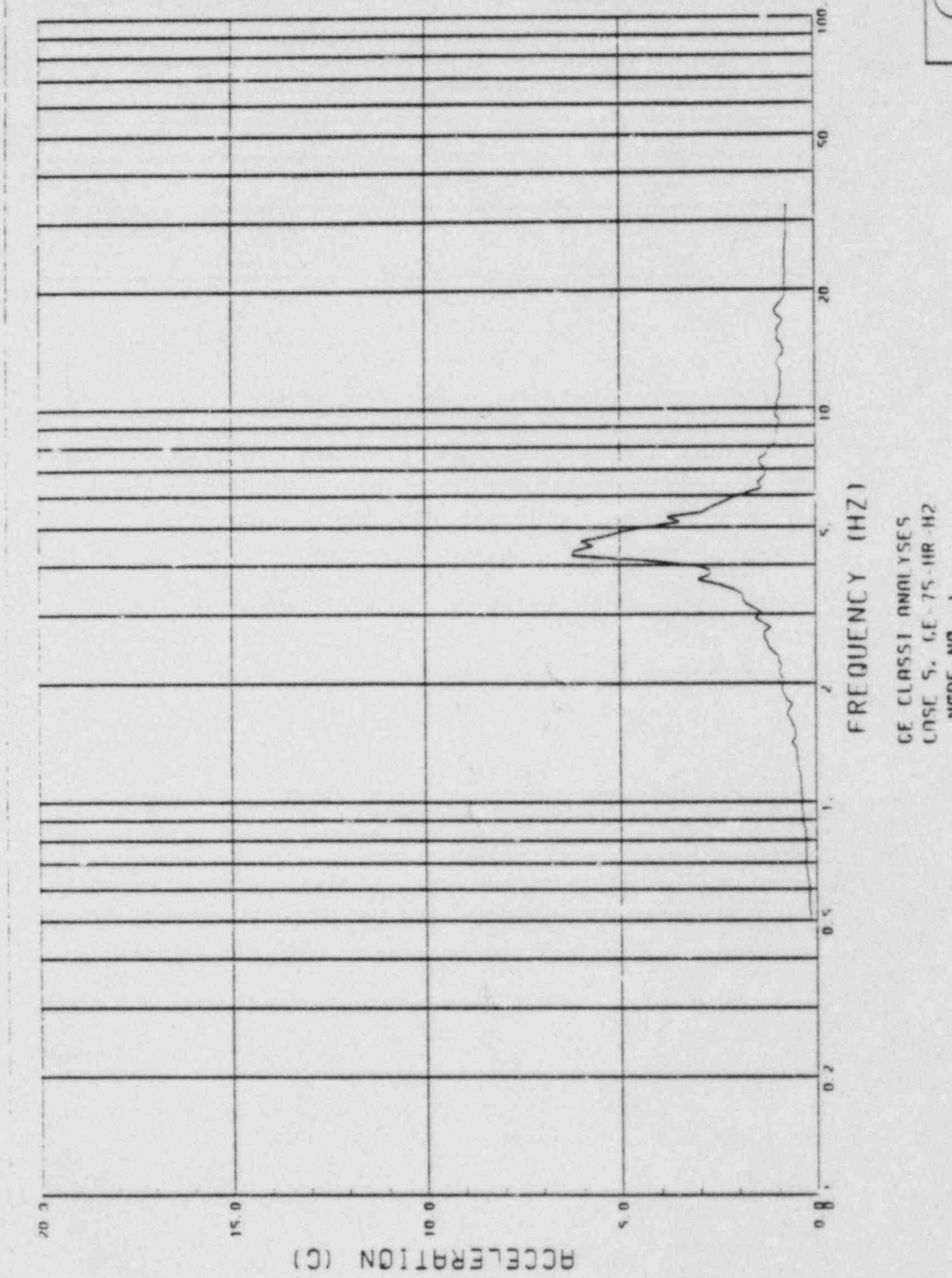
Figure A.45



GE CLASSI ANALYSES
CASE 5, GE-75-HR-H2
BASEMAT, NODE NO. 71 (ROTATION)

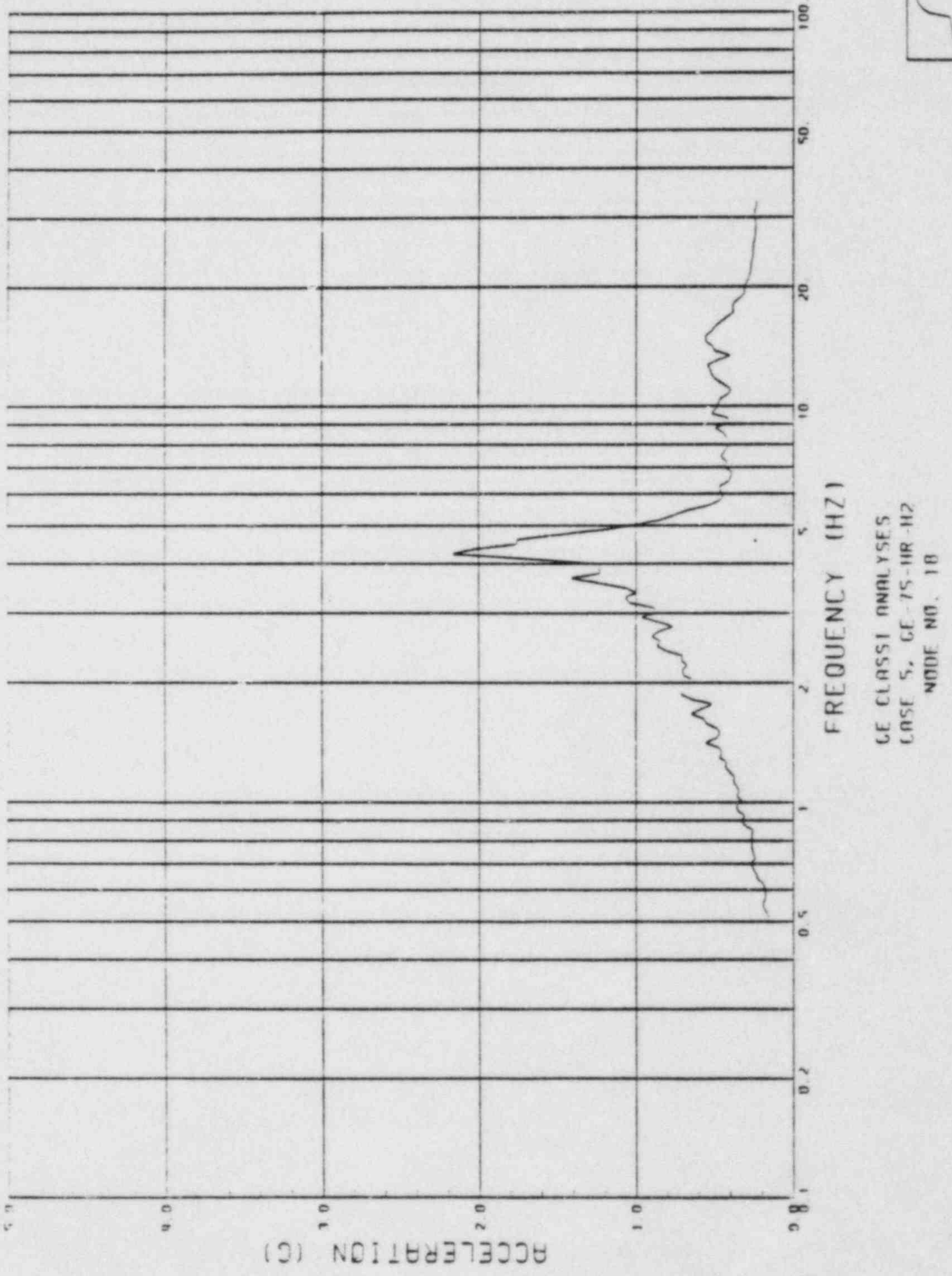
GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

Figure A.46



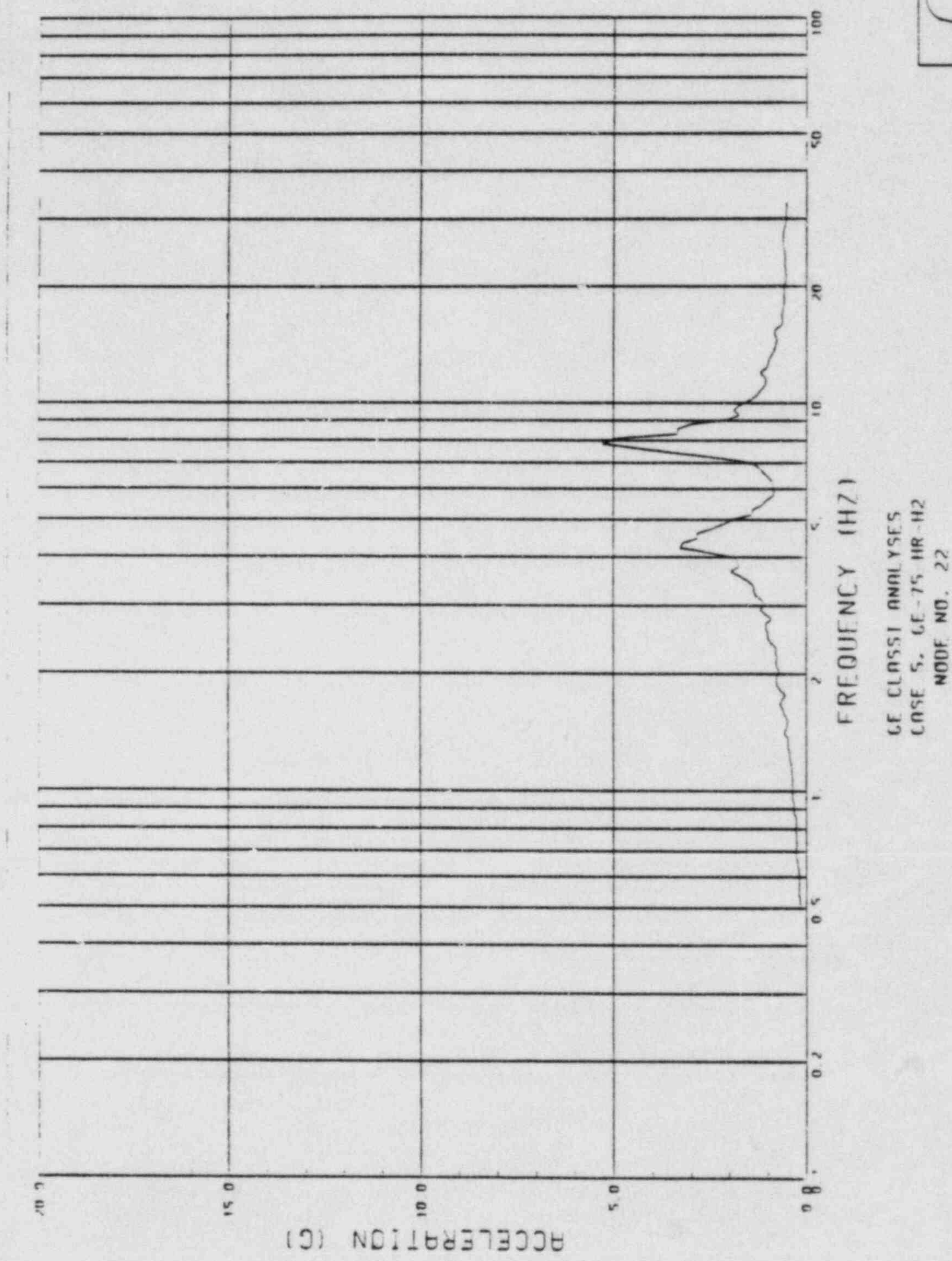
GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

Figure A.47



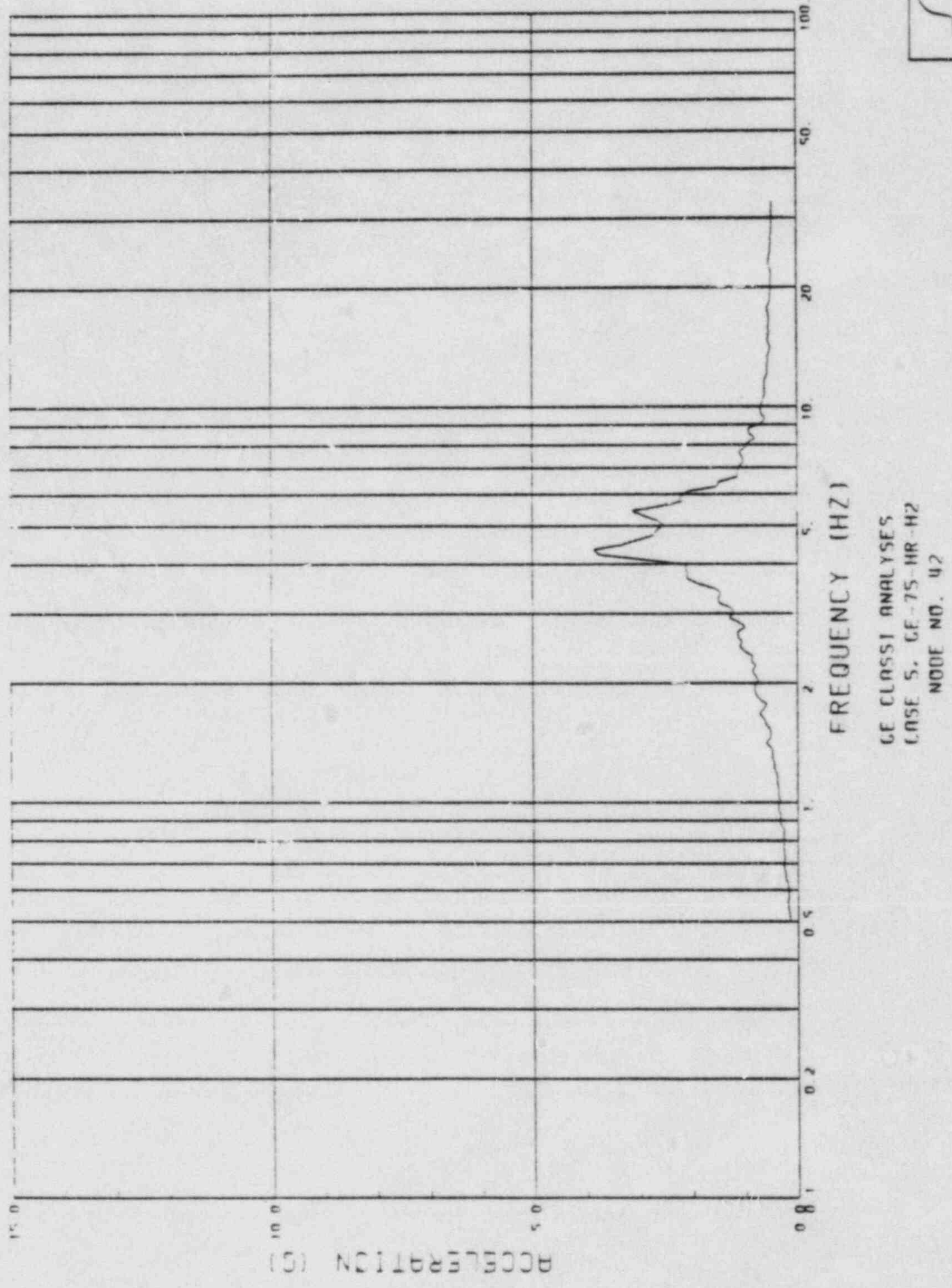
GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

Figure A.48



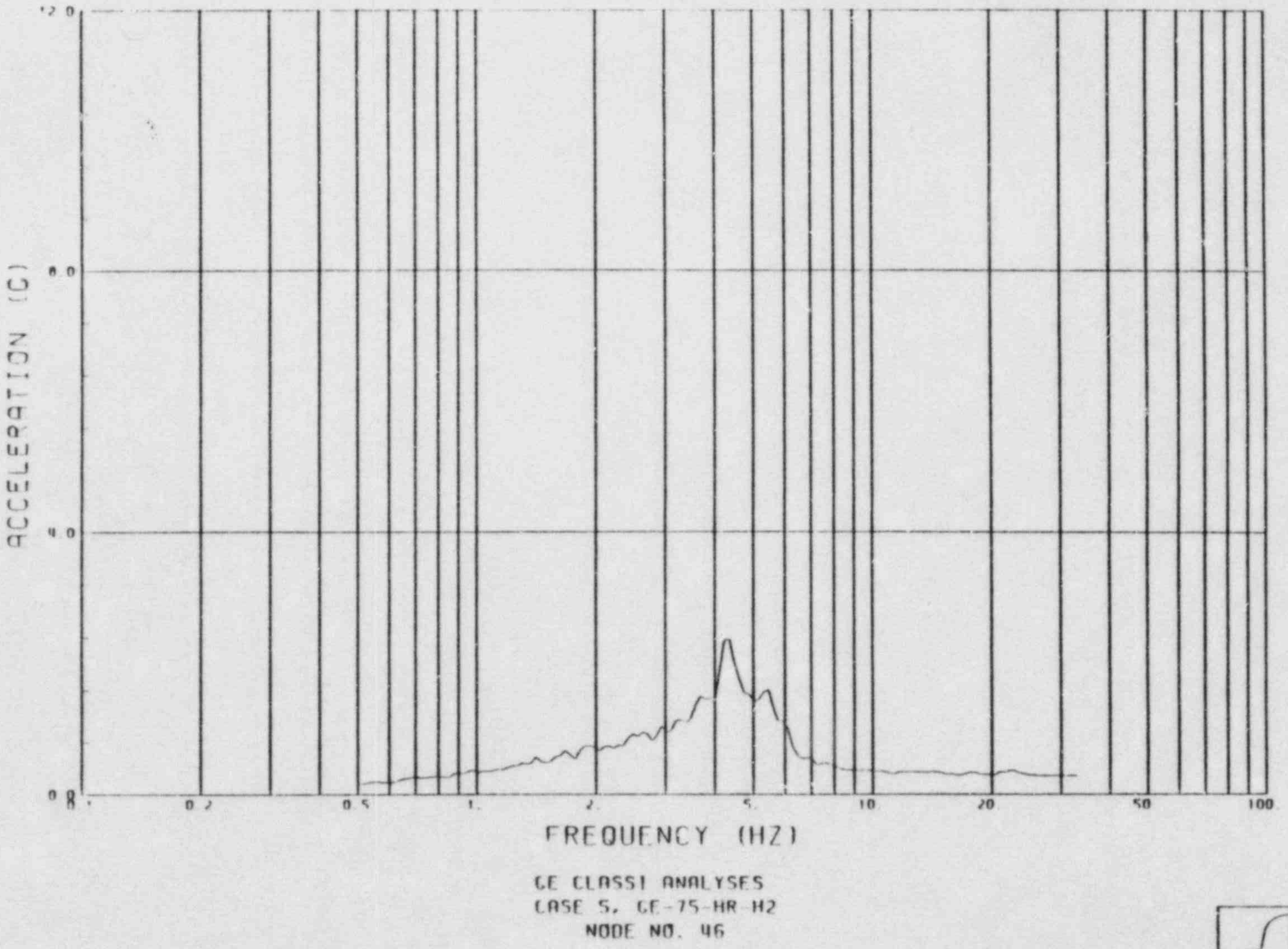
GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

Figure A.49



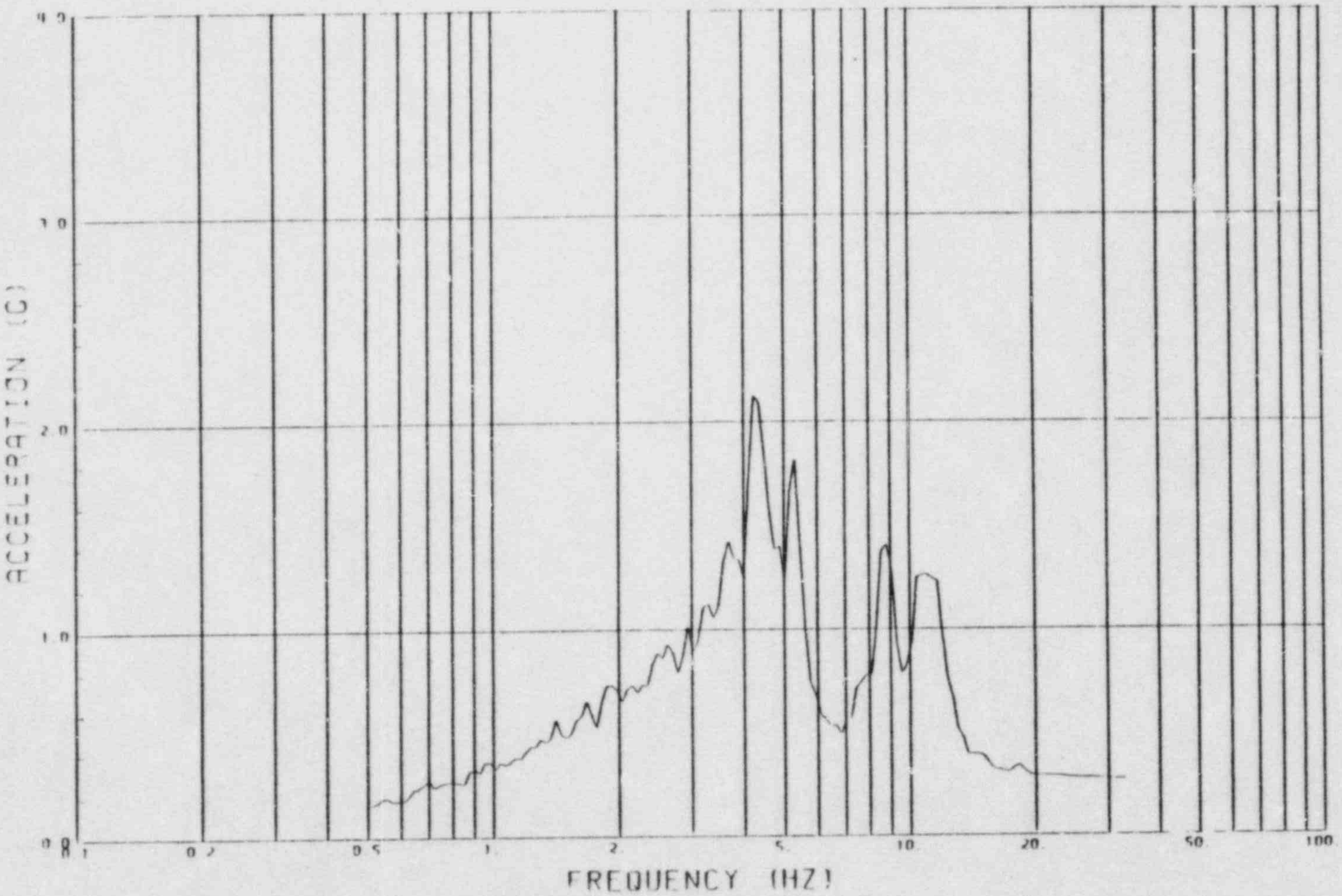
GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

Figure A.50



GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

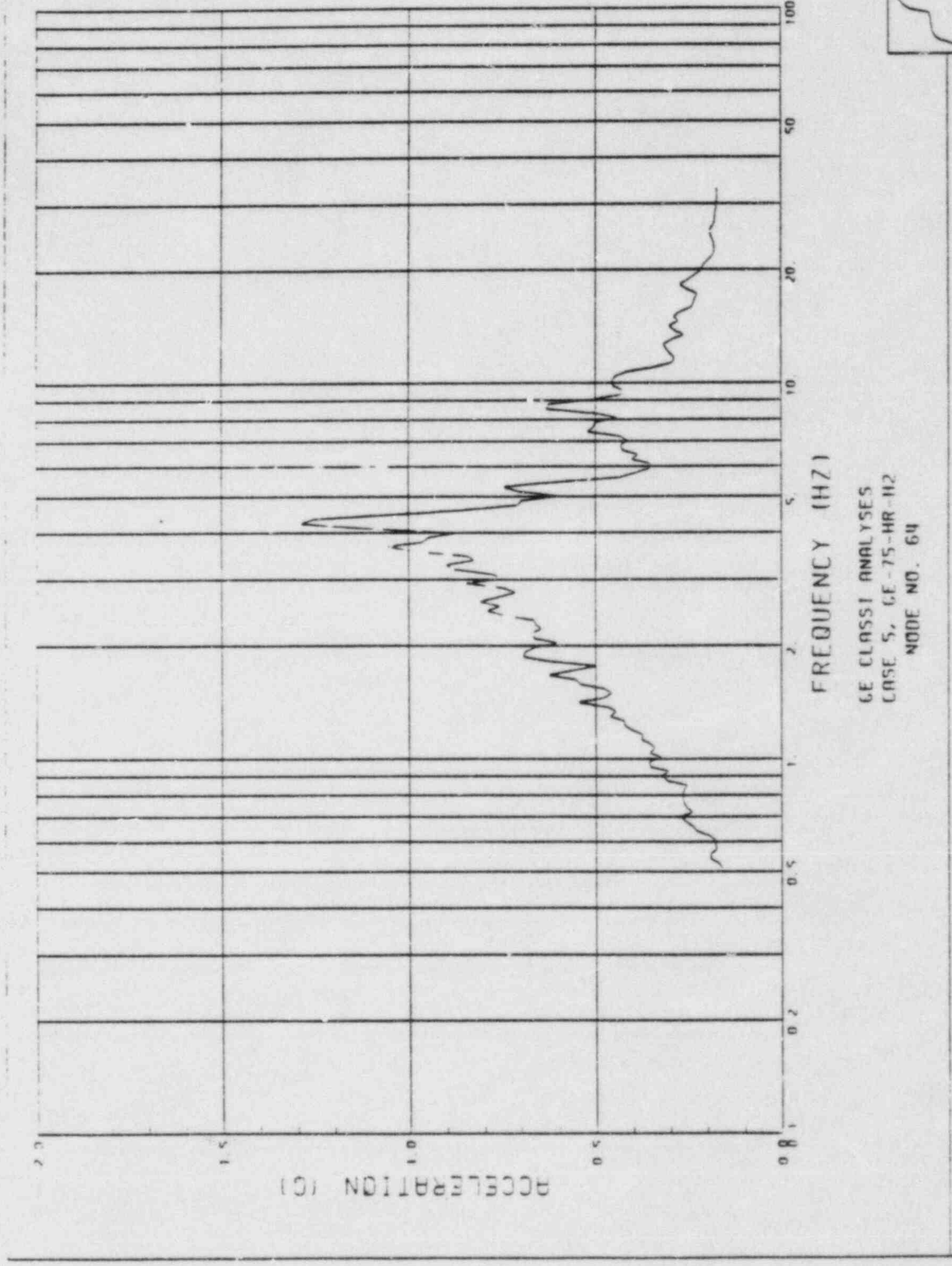
Figure A.51



GE CLASSI ANALYSES
CASE 5, GE-75-HR-H2
NODE NO. 60

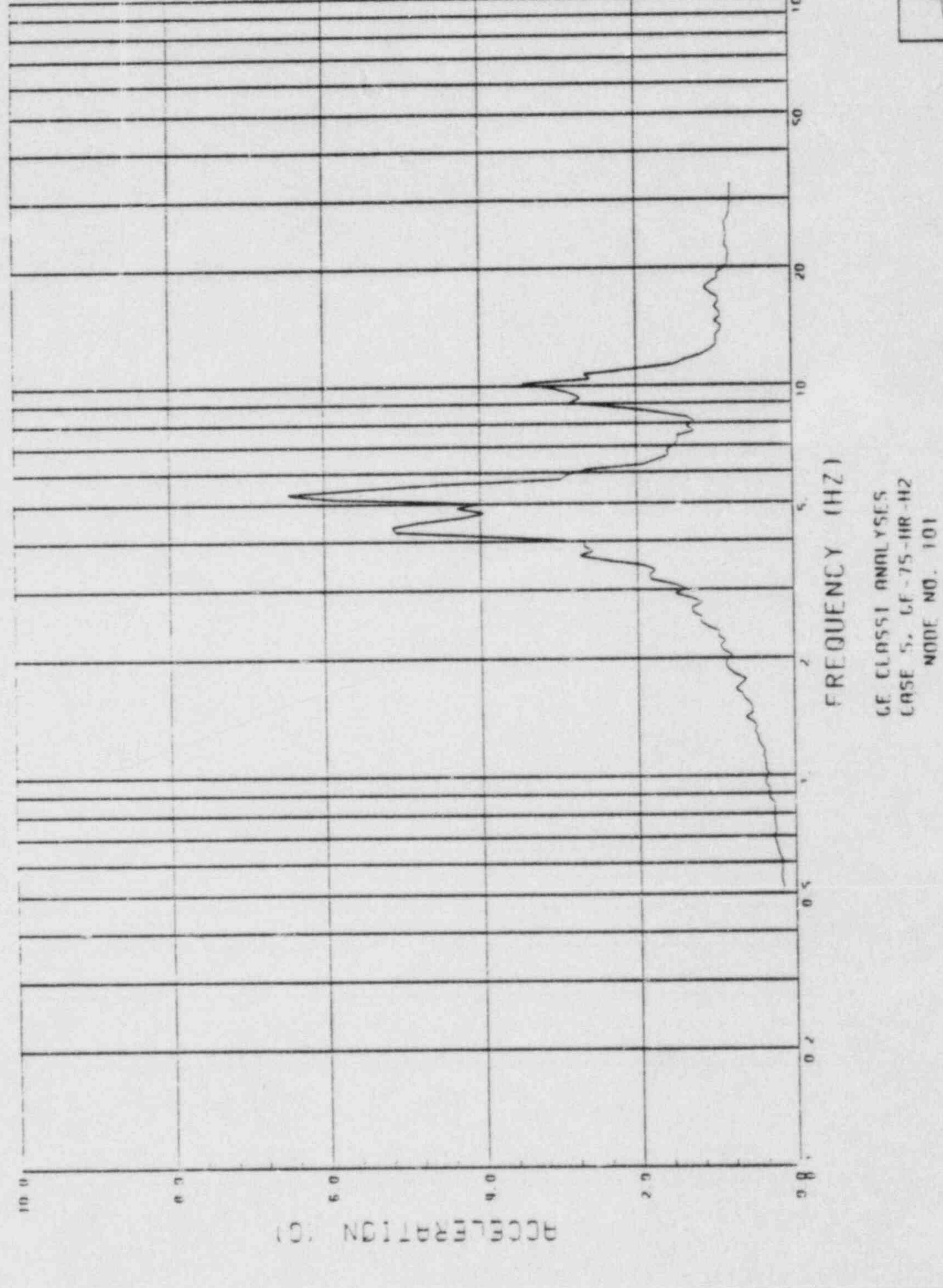
GESSAR II PLANT
SØIL - STRUCTURE INTERACTIØN

Figure A.52



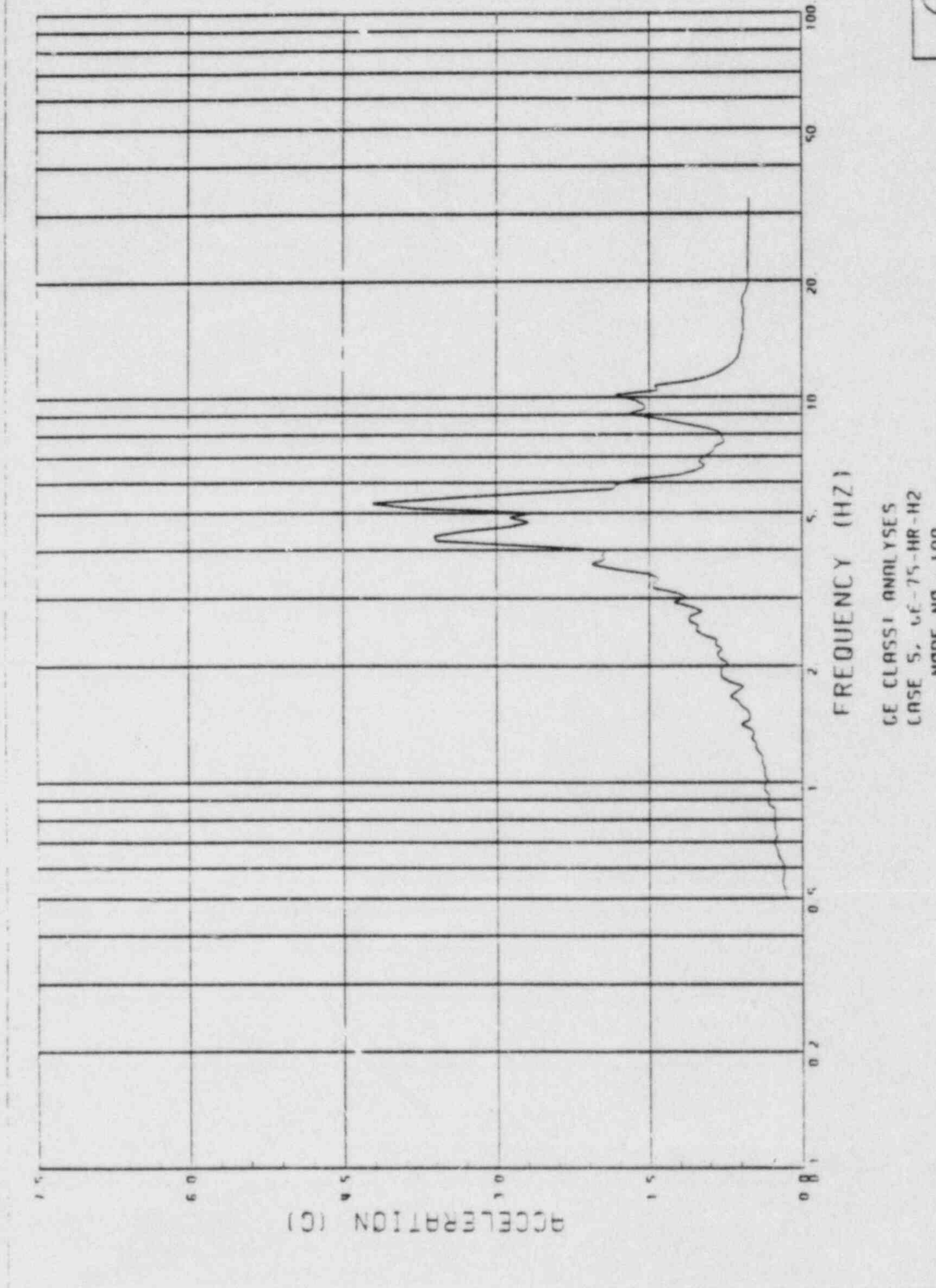
GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

Figure A.53



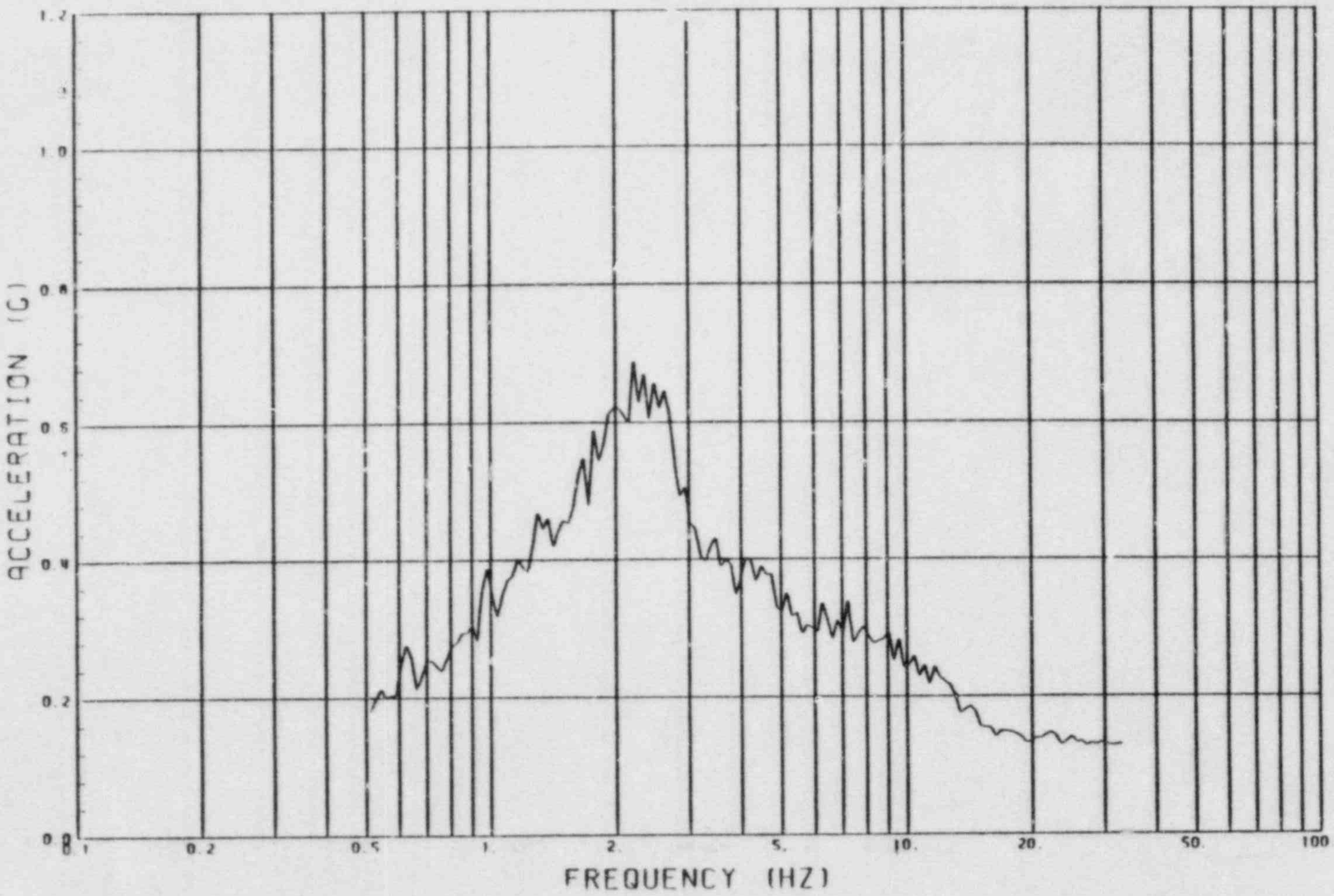
GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

Figure A.54



GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

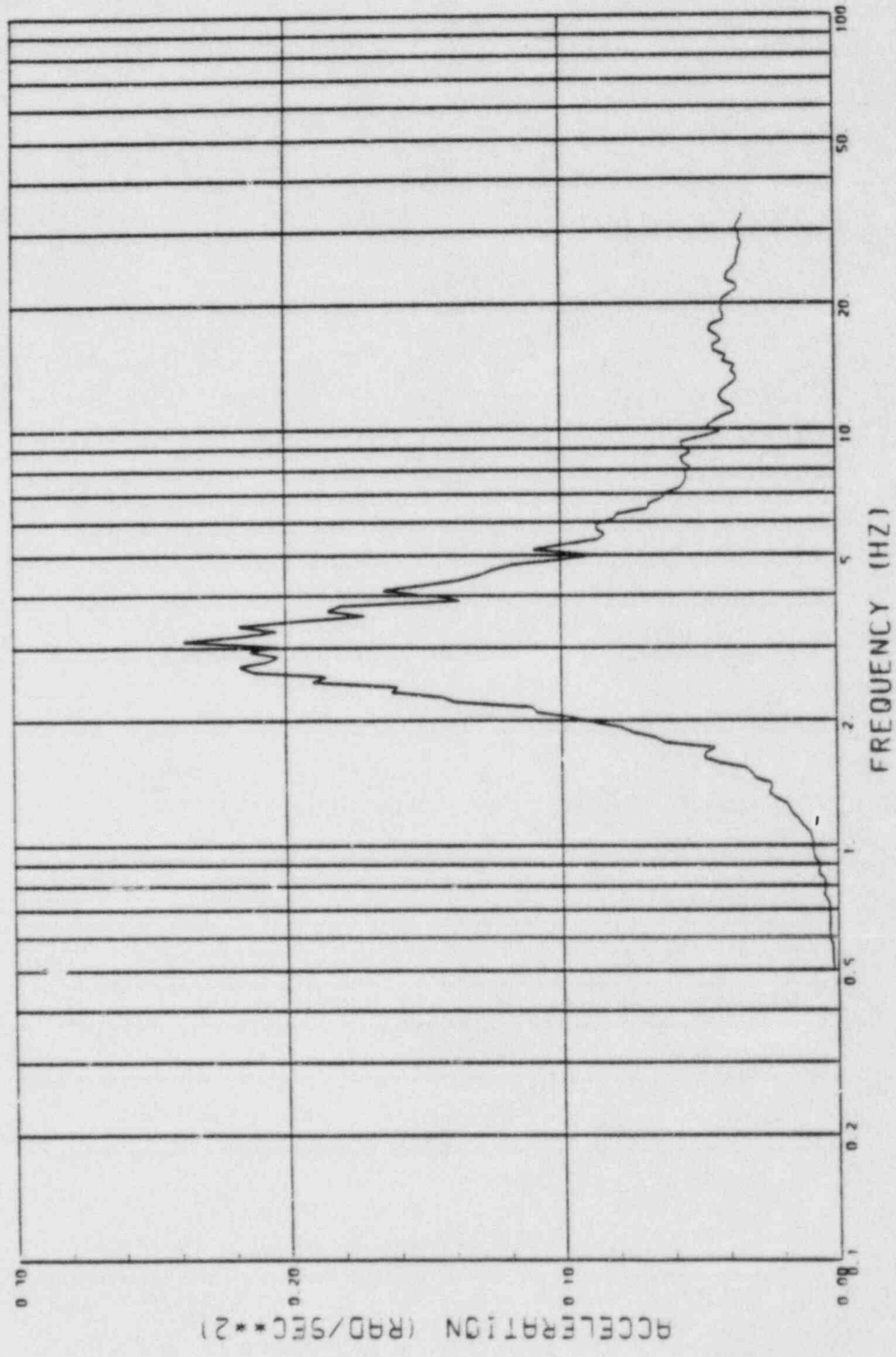
Figure A.55



GE CLASSI ANALYSES
CASE 6, GE-75-U-HI
BASEMAT, NODE NO. 71 (TRANSLATION)

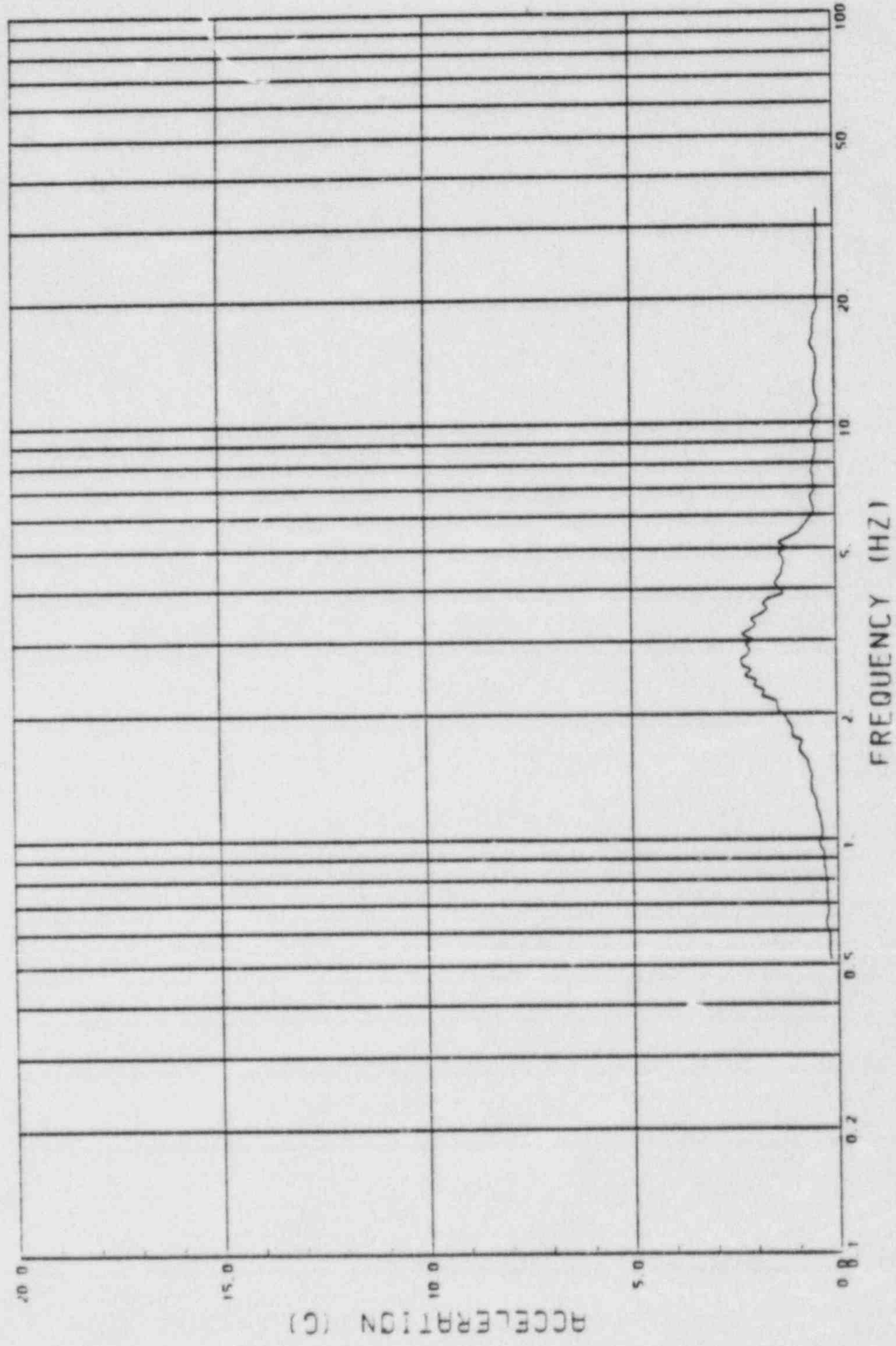
GESSAR II PLANT
SØIL - STRUCTURE INTERACTION

Figure A.56



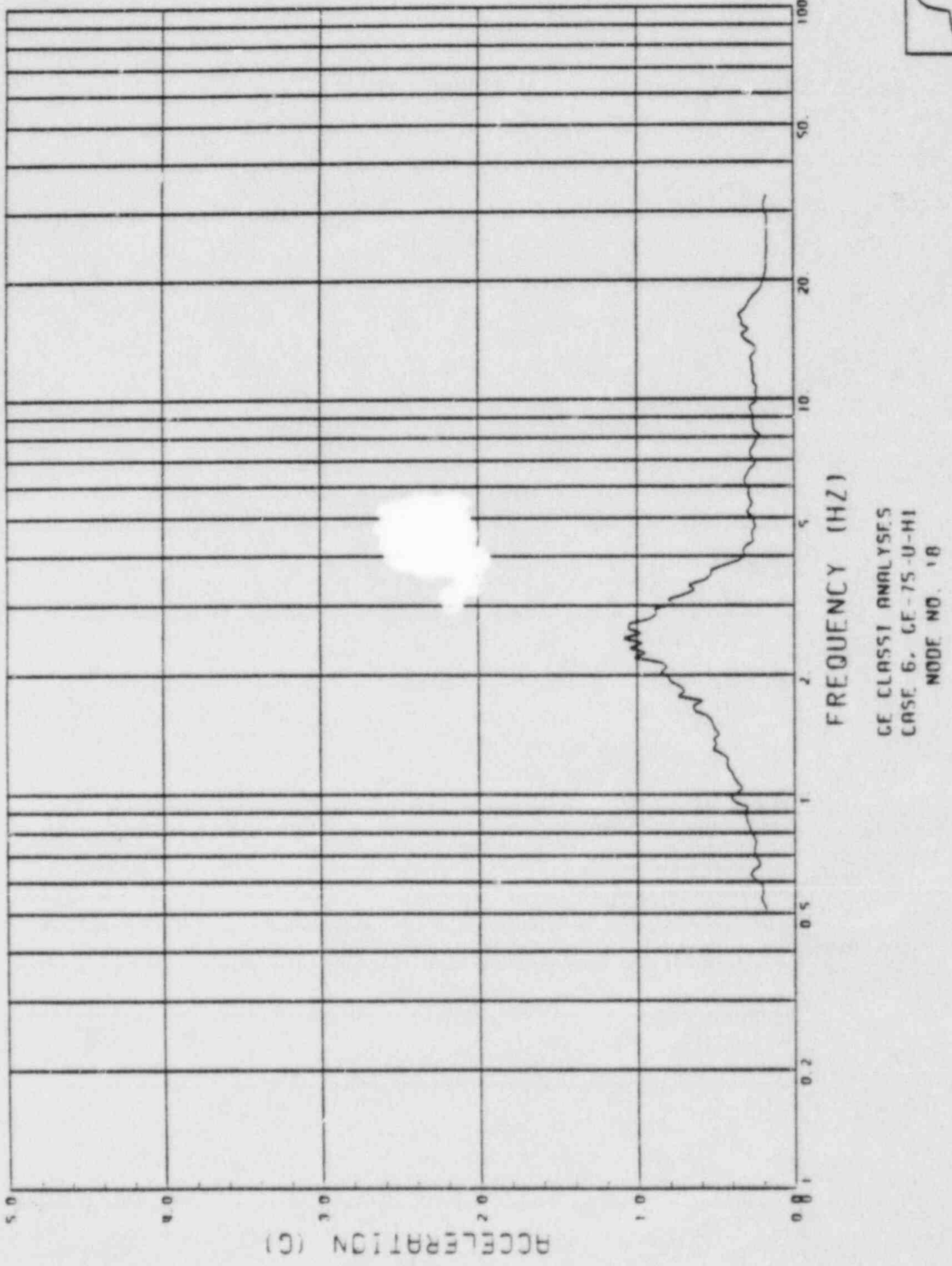
GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

Figure A.57



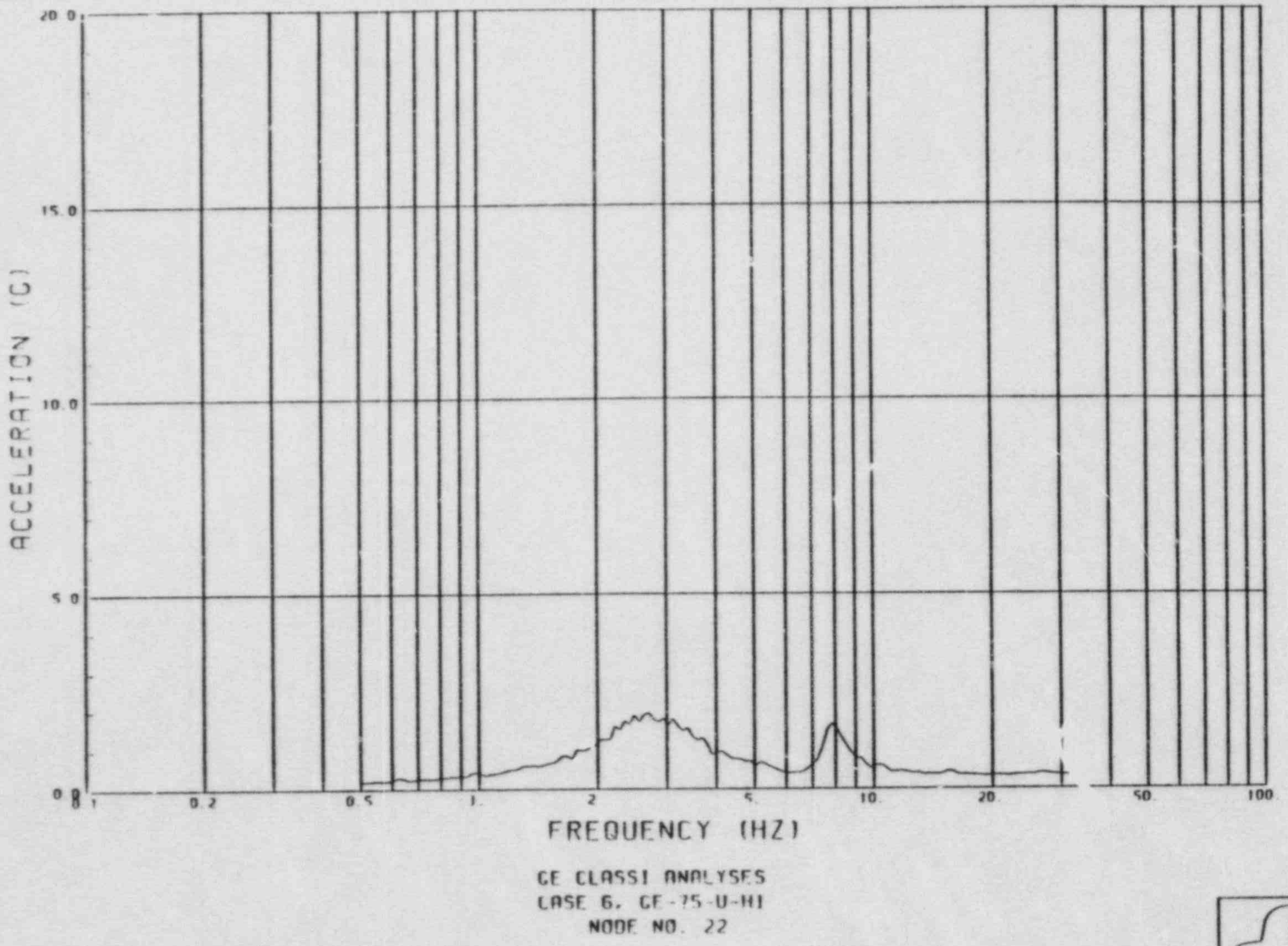
GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

Figure A.58



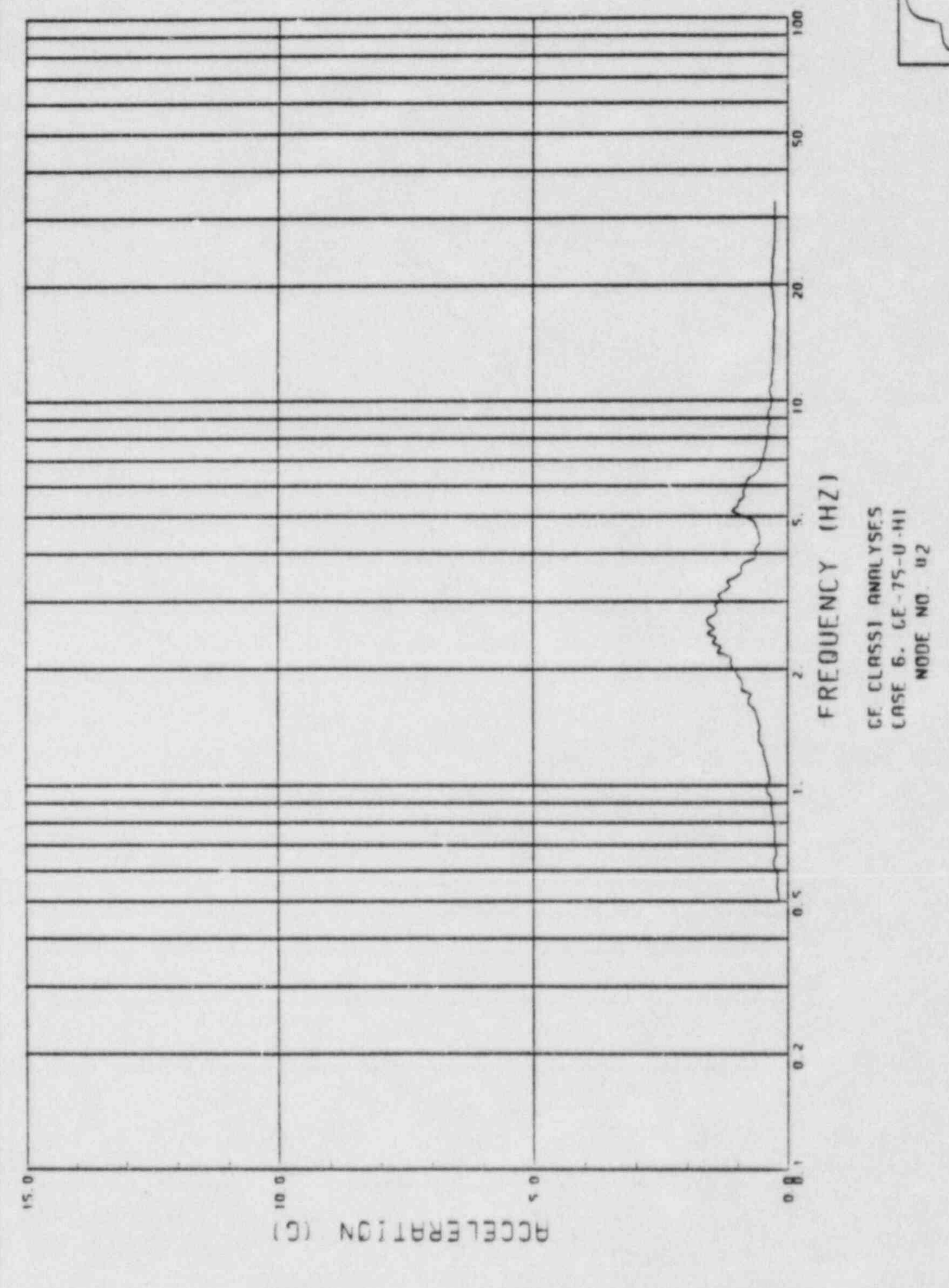
GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

Figure A.59



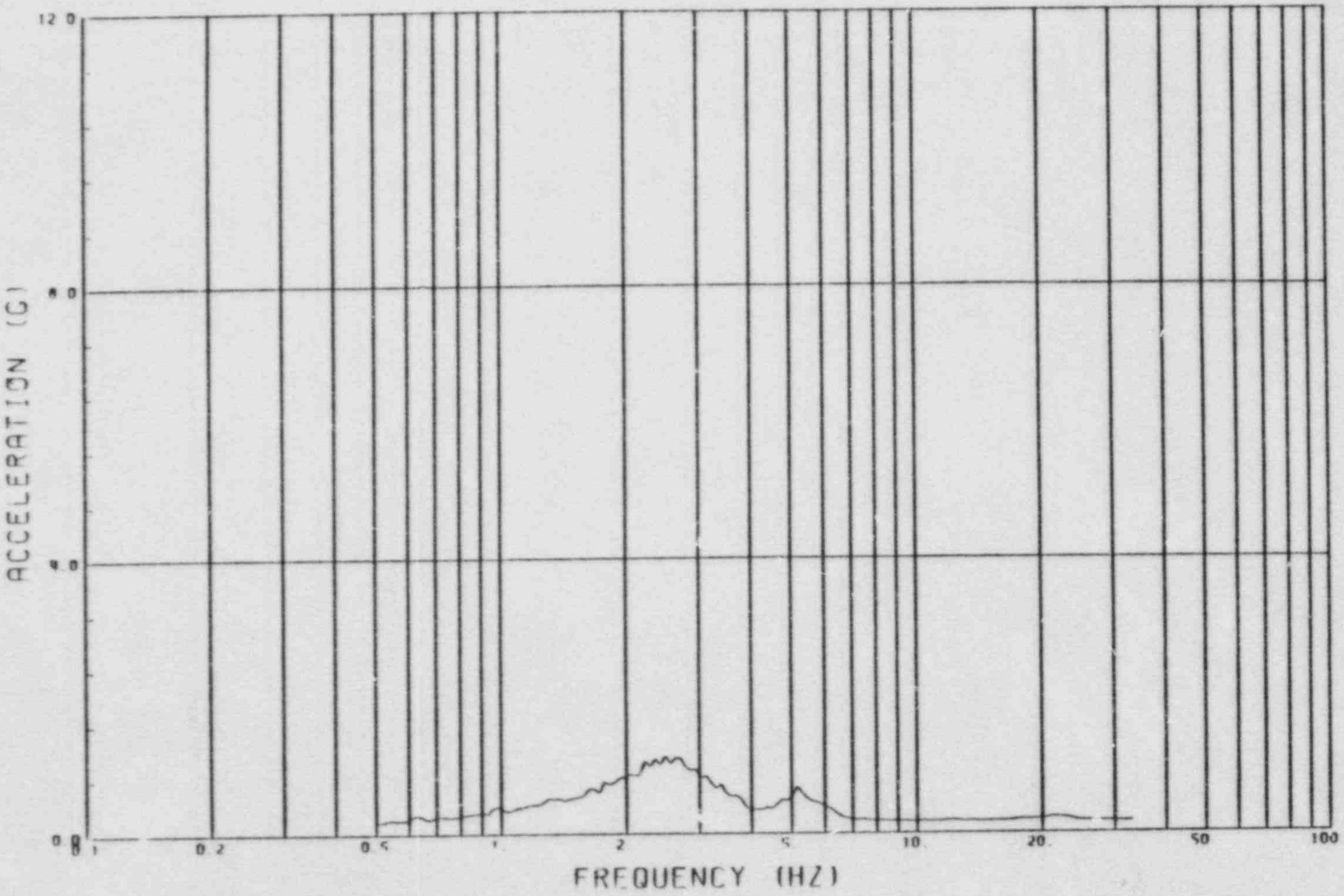
GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

Figure A.60



GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

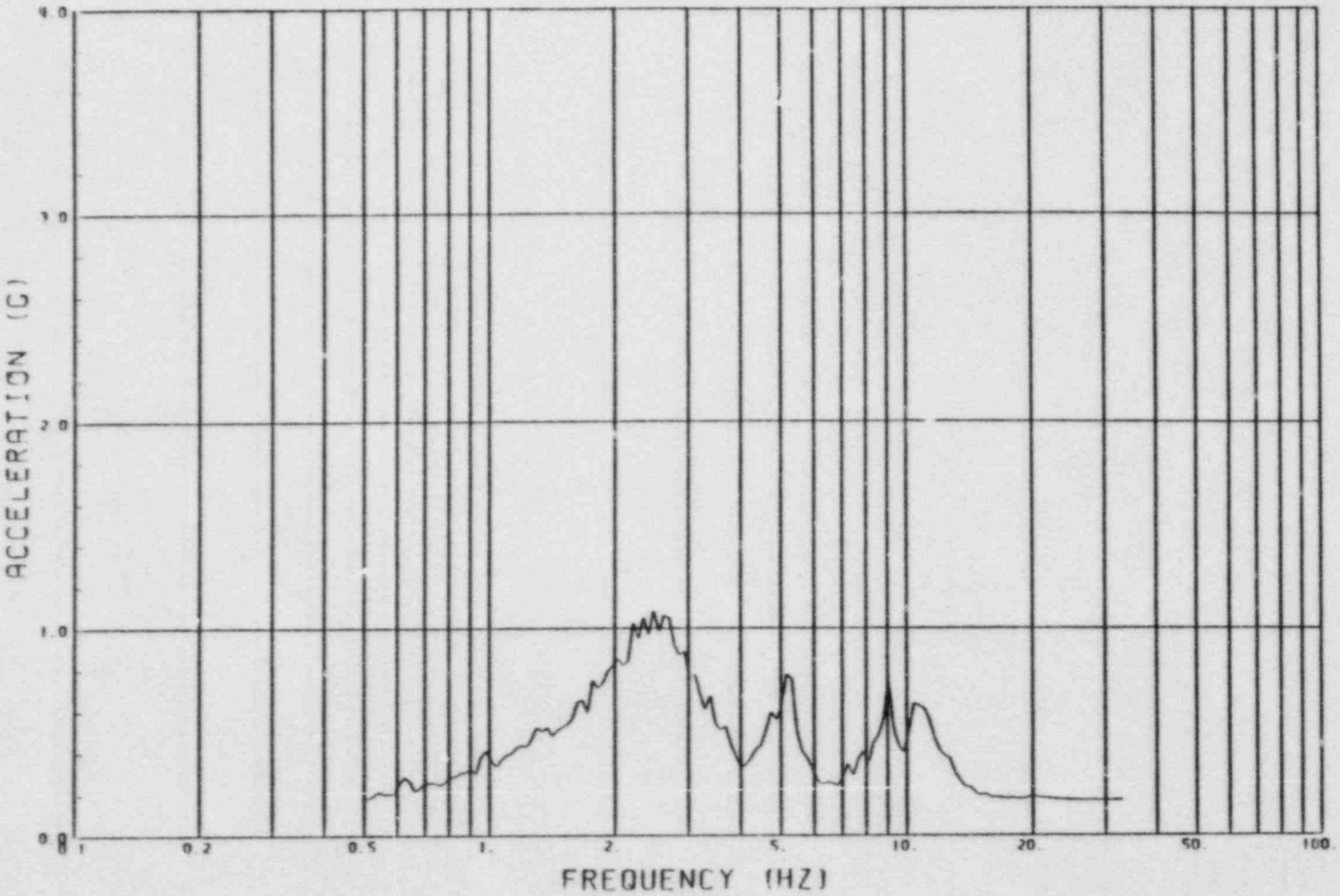
Figure A.61



GE CLASSI ANALYSES
CASE 6, GE-75-U-H1
NODE NO. 46

GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

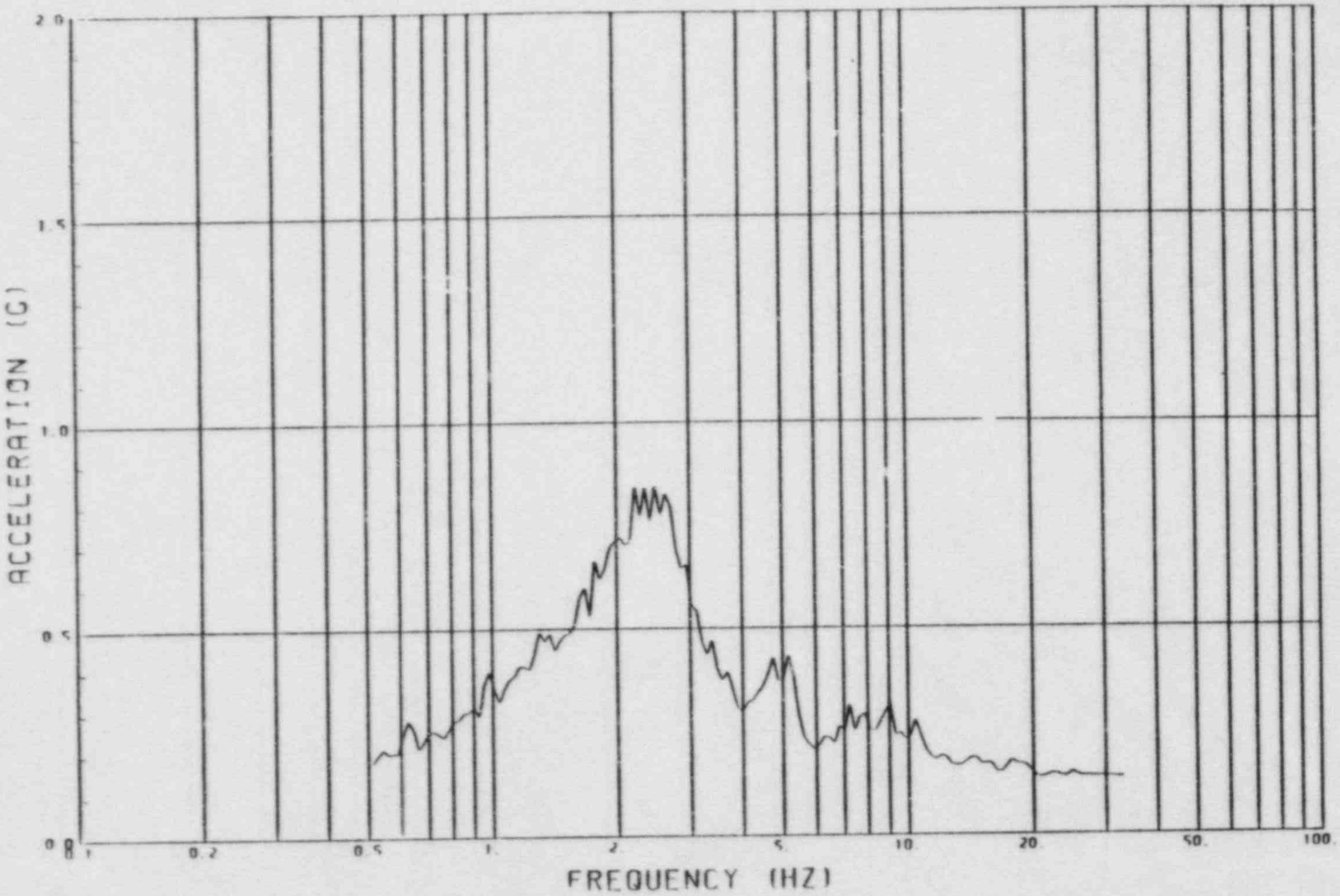
Figure A.62



GE CLASSI ANALYSES
CASE 6, GE-75-U-HI
NODE NO. 60

GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

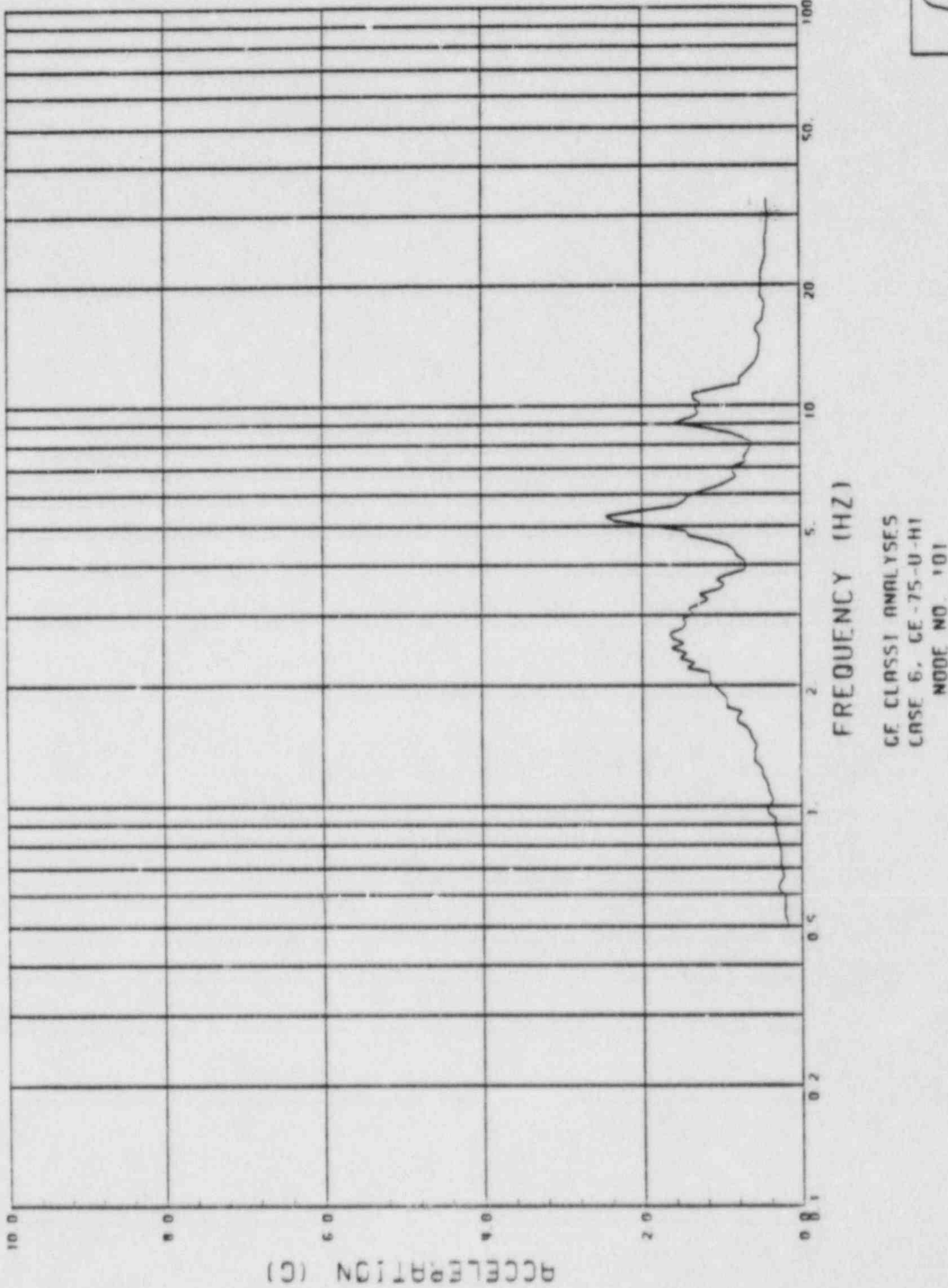
Figure A.63



GE CLASSI ANALYSES
CASE 6, GE-75-U-H1
NODE NO. 64

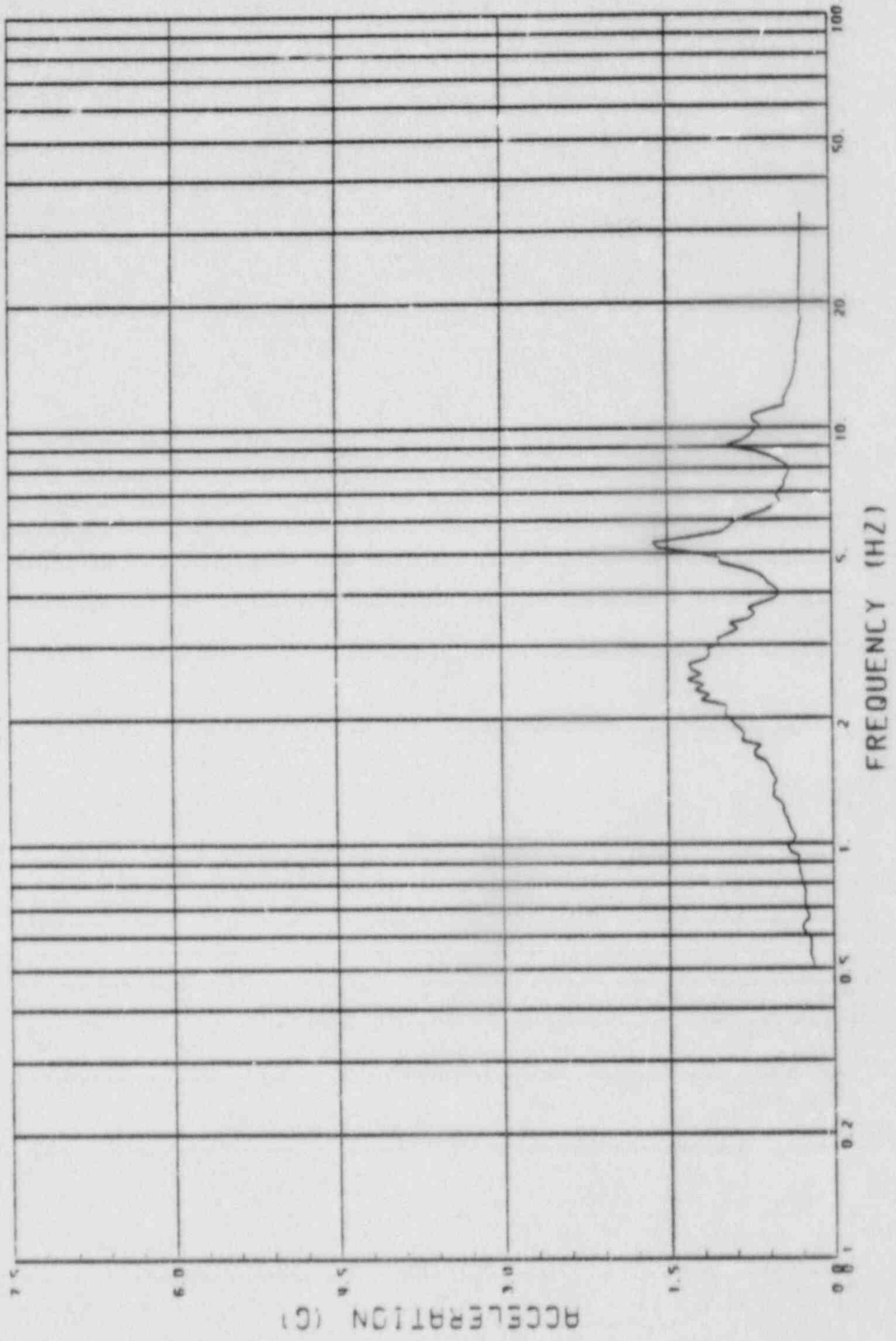
GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

Figure A.64



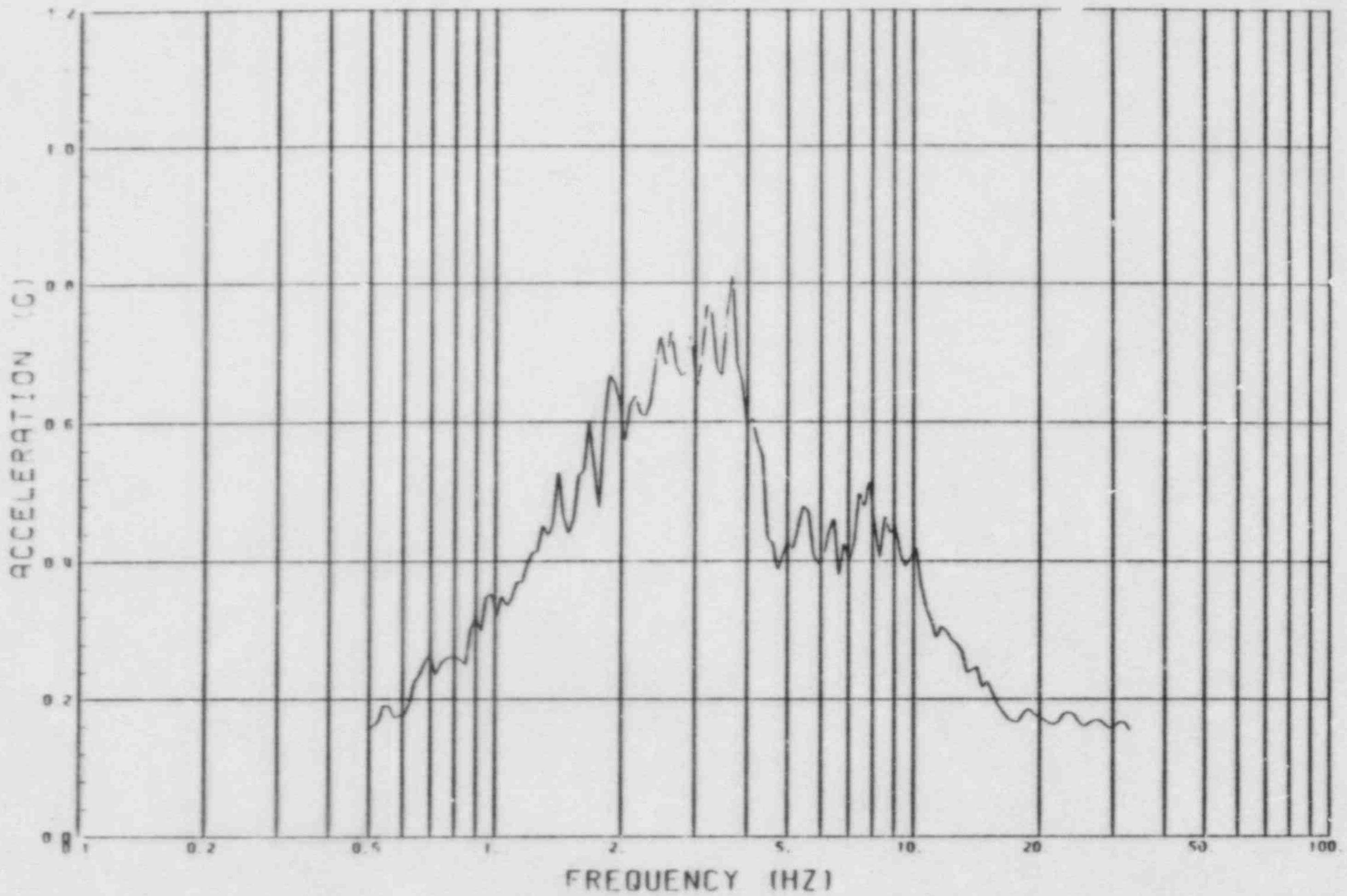
GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

Figure A.65



GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

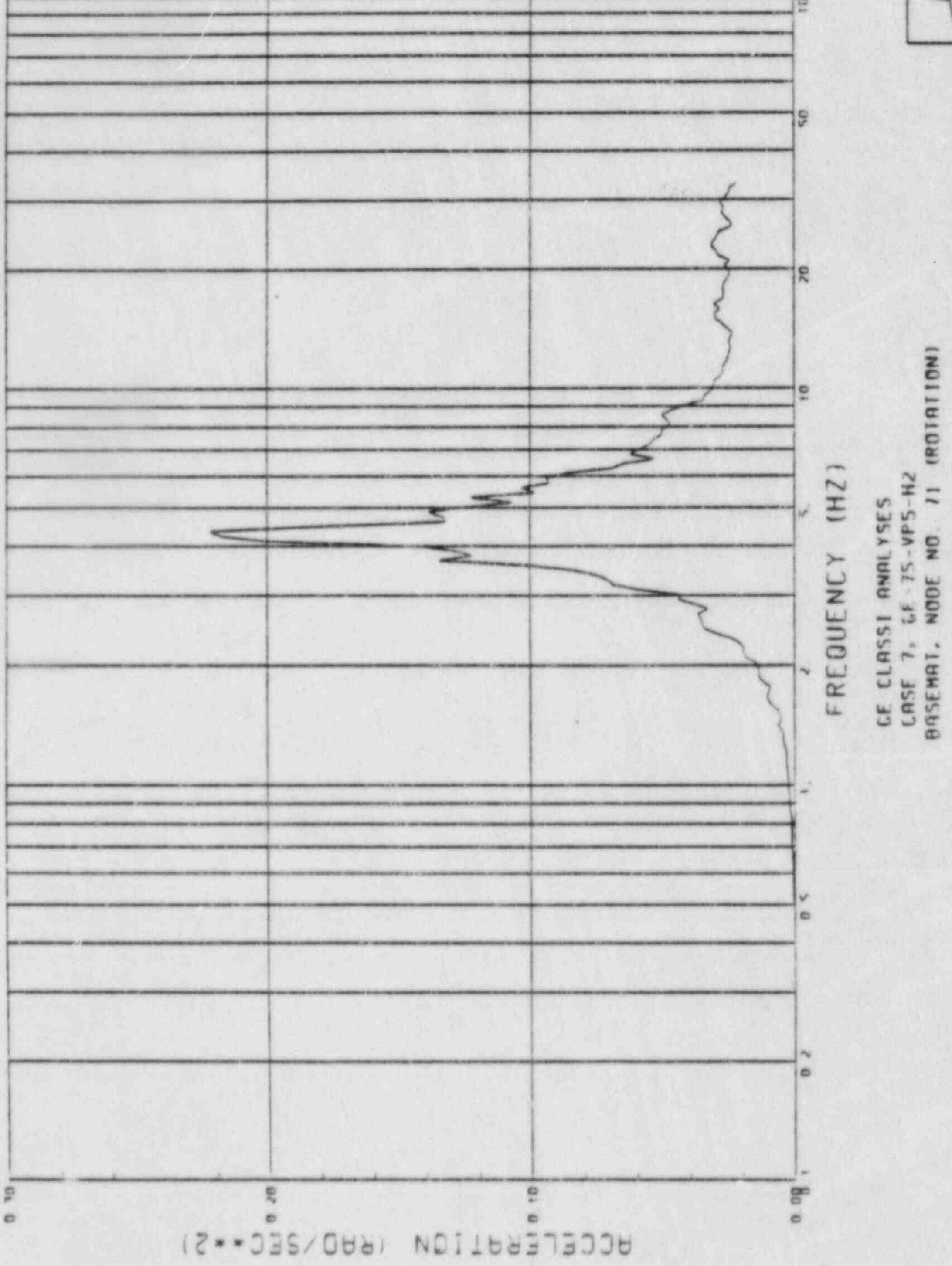
Figure A.66



GE CLASSI ANALYSES
CASE 7. GE-7S-VPS-H2
BASEMAT, NODE NO. 71 (TRANSLATION)

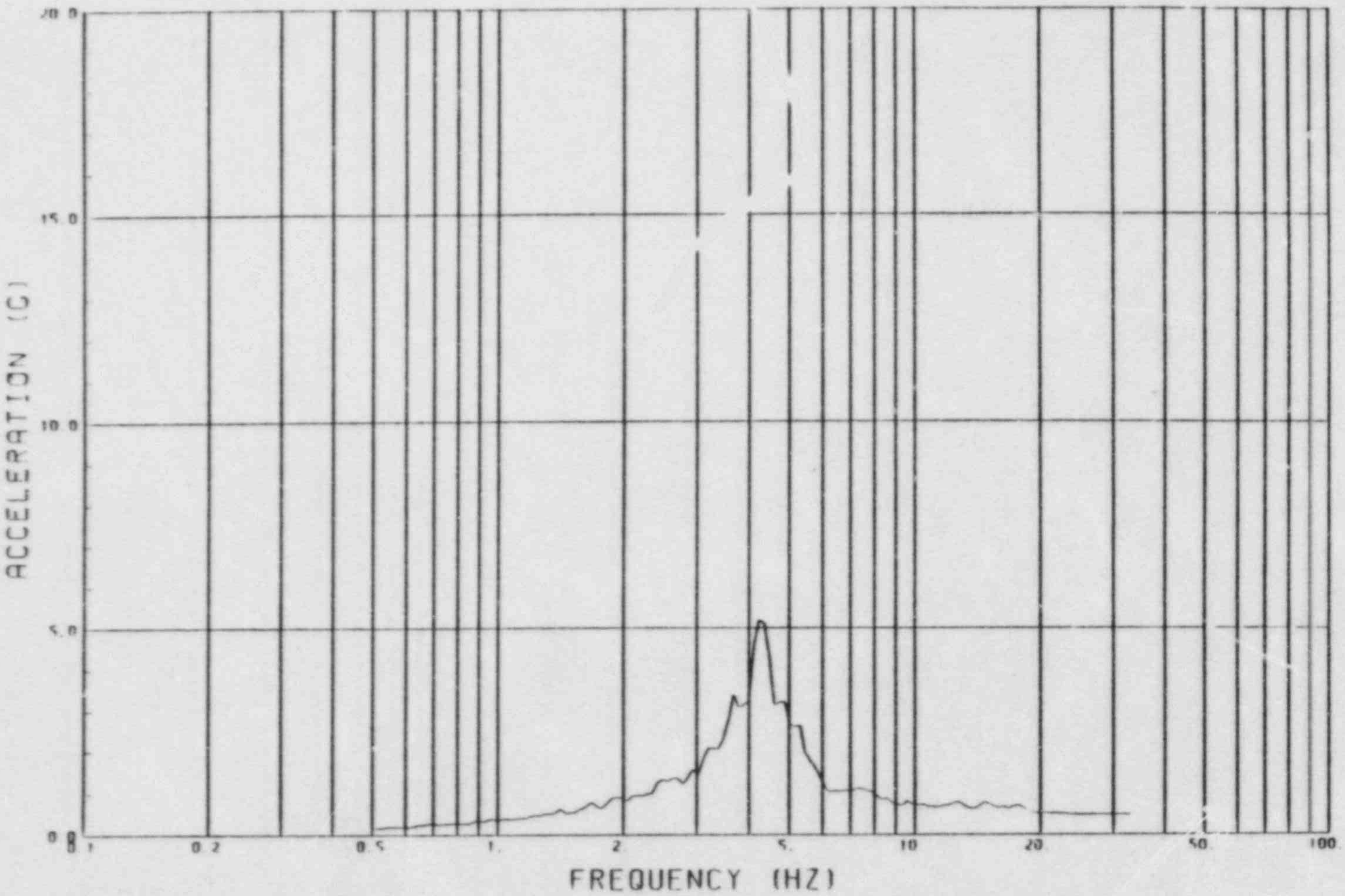
GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

Figure A.67



GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

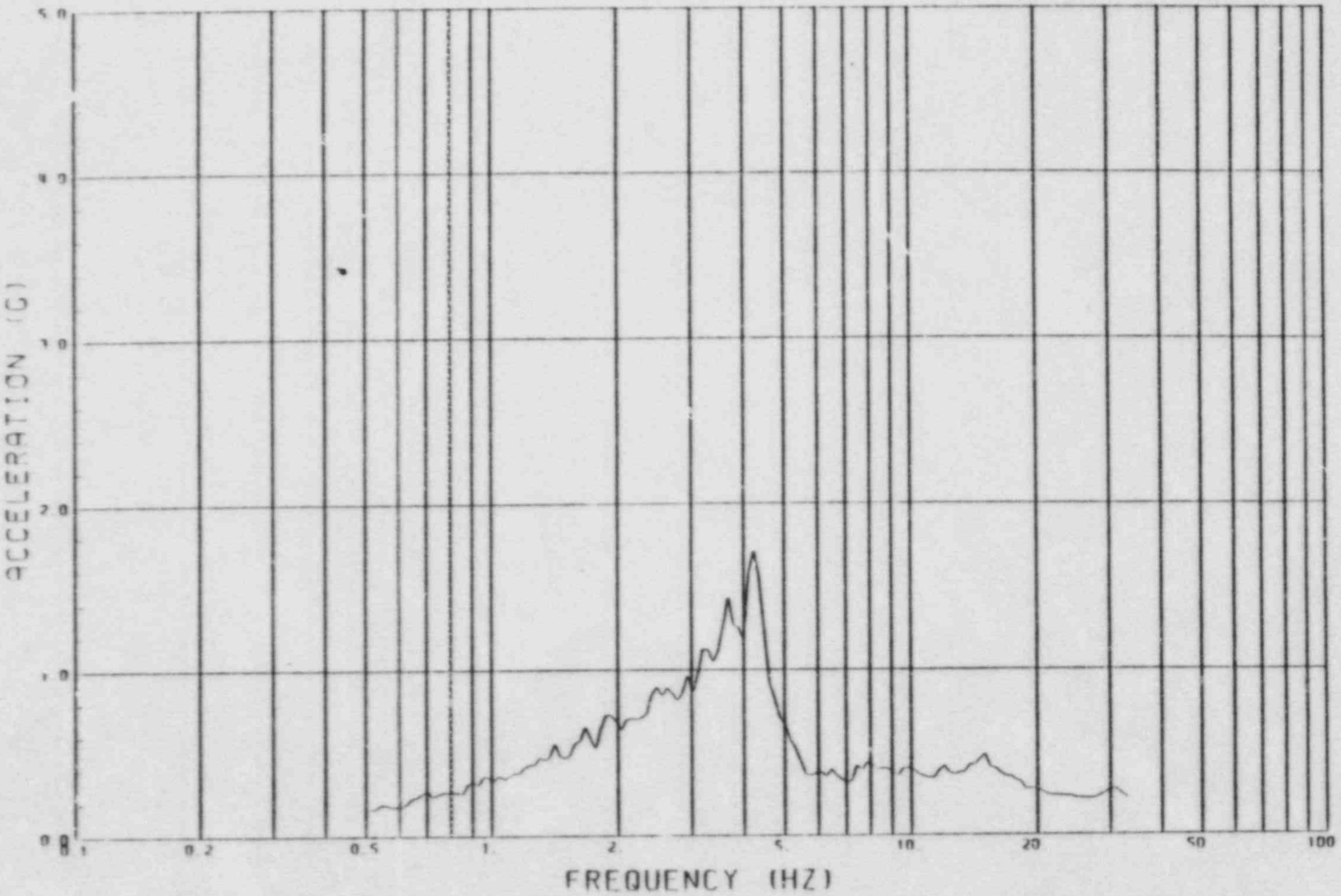
Figure A.68



GE CLASSI ANALYSES
CASE 7, GE-75-VPS-H2
NODE NO. 1

GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

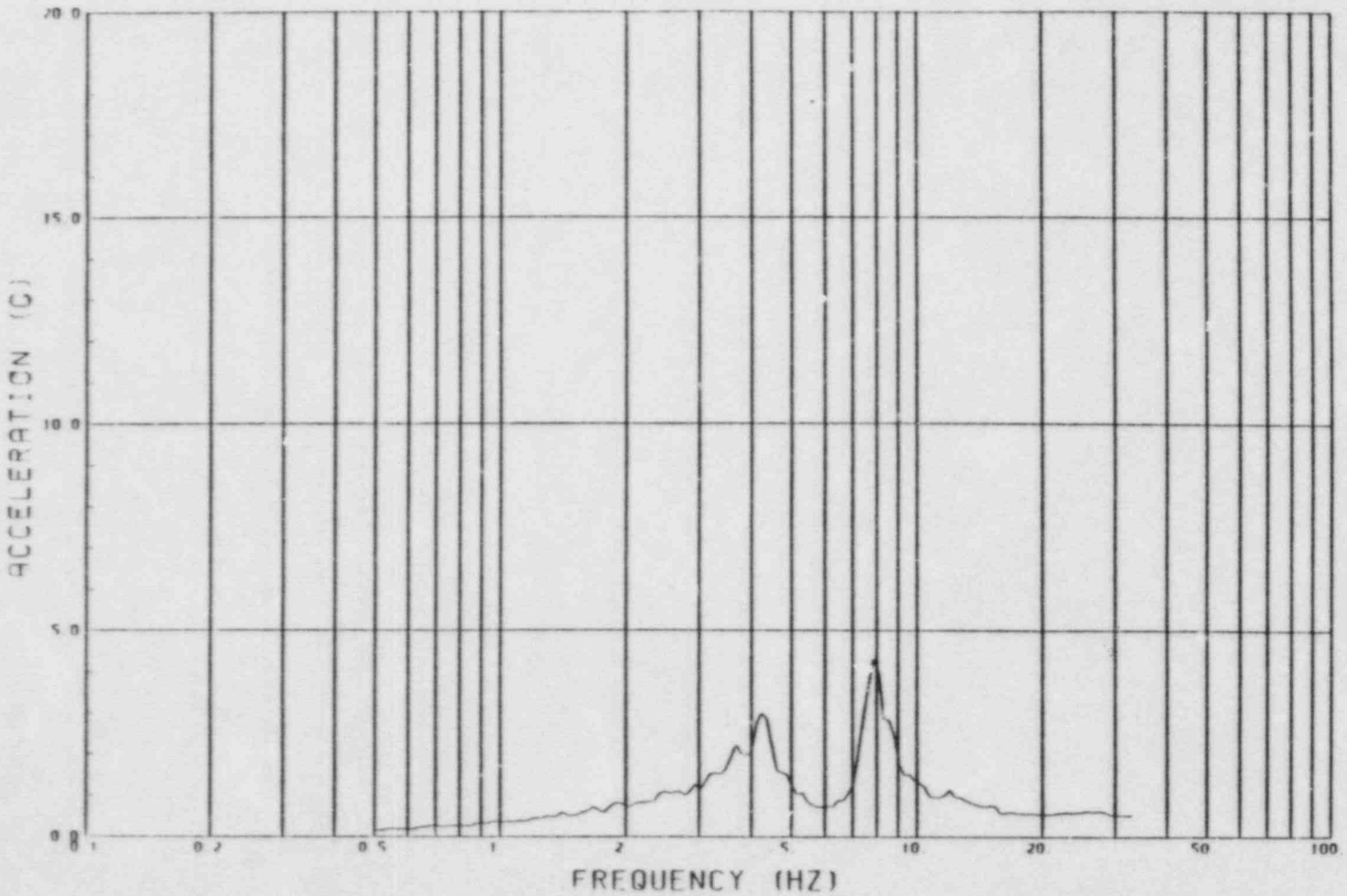
Figure A.69



GE CLASSI ANALYSES
CASE 7. GE-75-VPS-H2
NODE NO. 18

GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

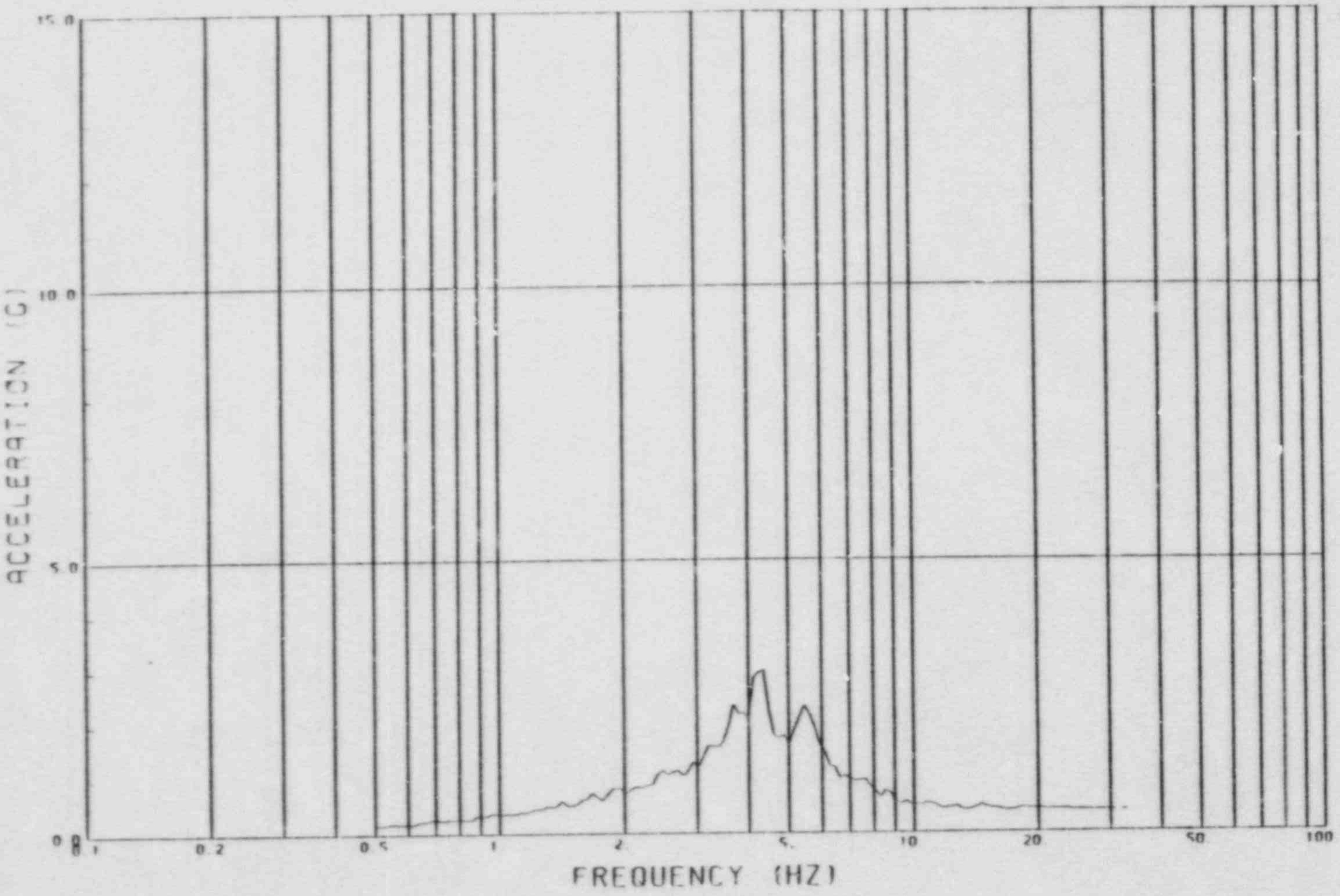
Figure A.70



GE CLASSI ANALYSES
CASE 7. GE-75-VPS-H2
NODE NO. 22

GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

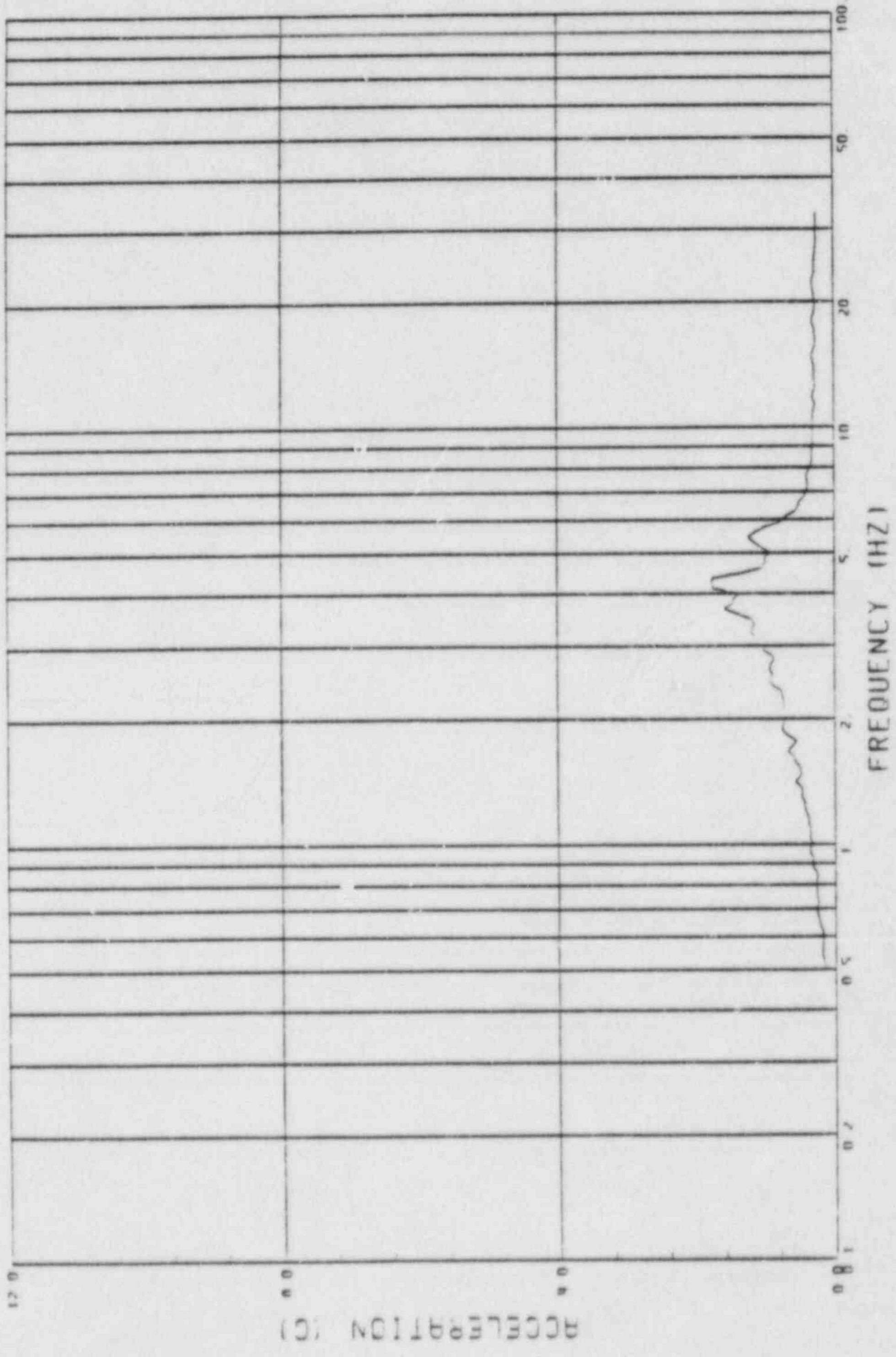
Figure A.71



GE CLASSI ANALYSES
CASE 7, GE-75-VPS-H2
NODE NO. 42

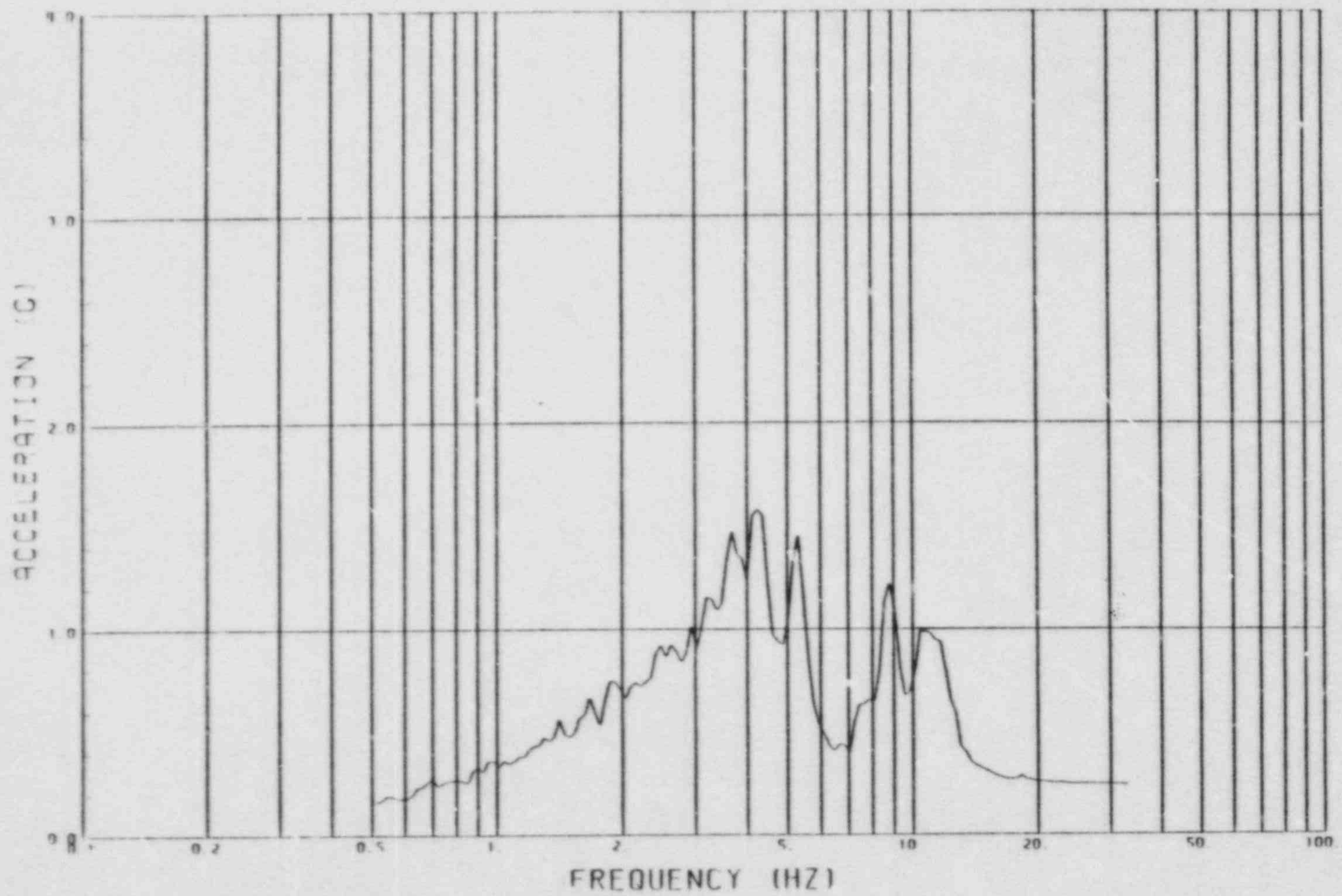
GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

Figure A.72



GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

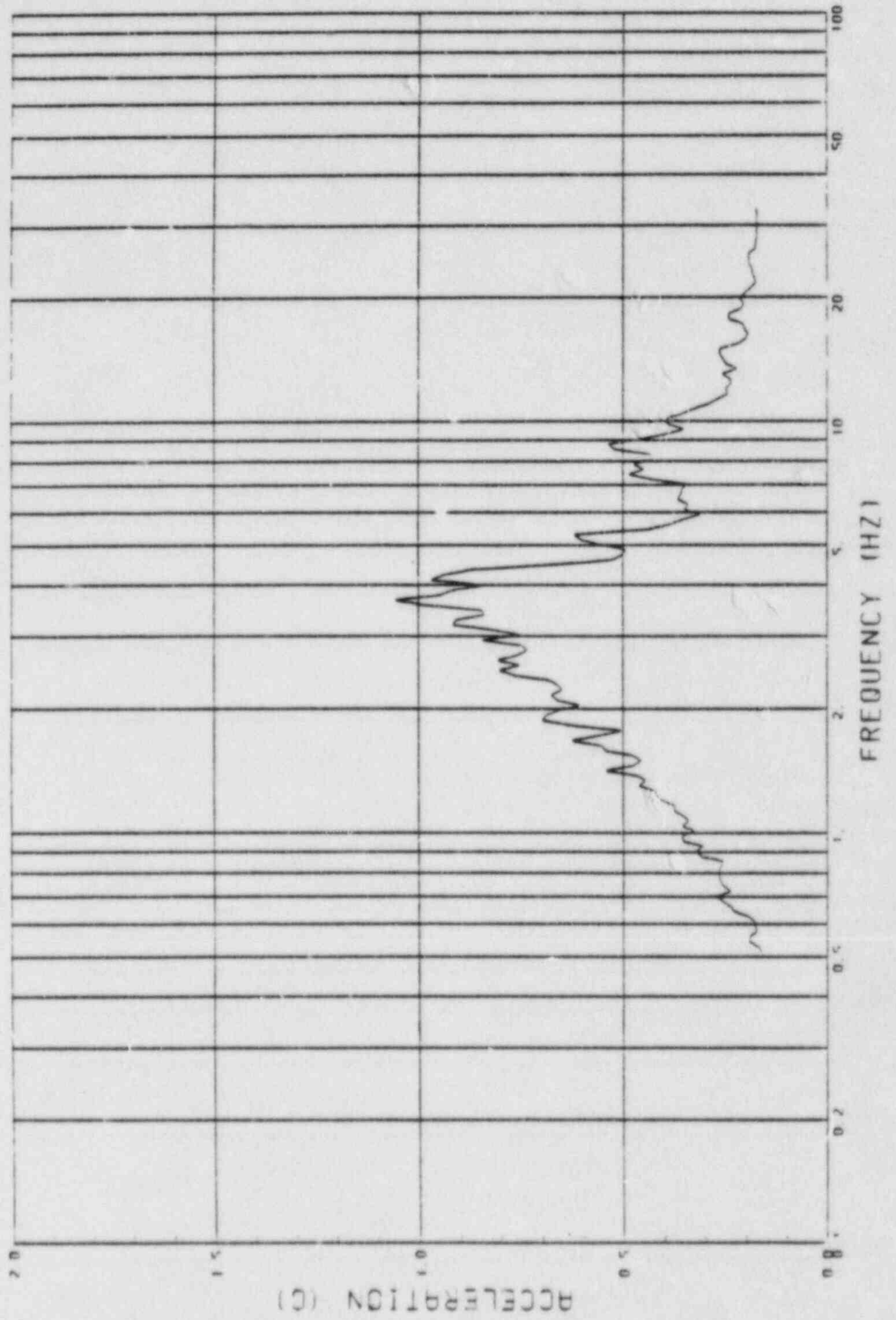
Figure A.73



GE CLASSI ANALYSES
CASE 7. GE-75-VPS-H2
NODE NO. 60

GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

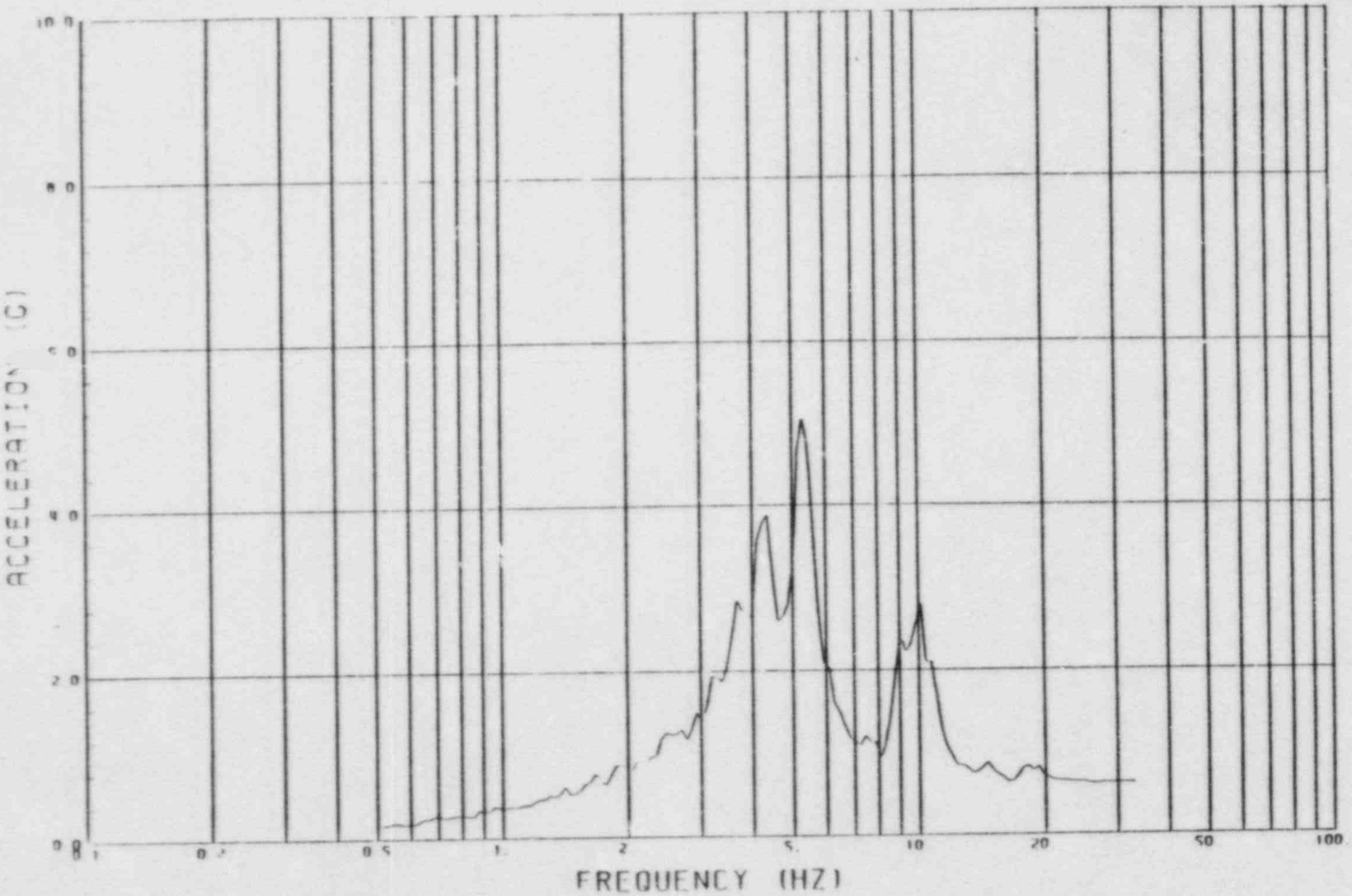
Figure A.74



GE CLASSI ANALYSES
CASE 7, GE-75-VPS-H2
NODE NO. 64

GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

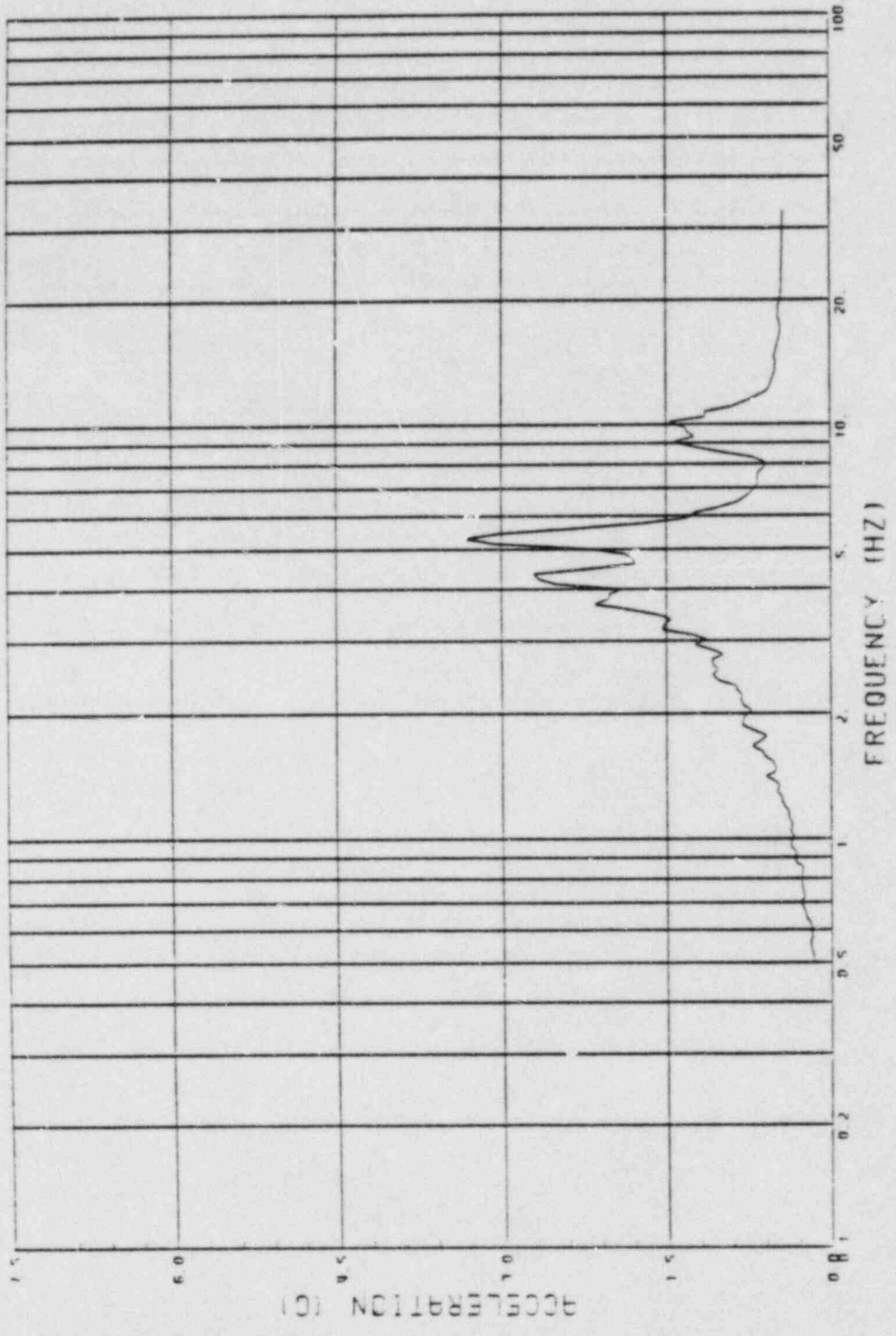
Figure A.75



GE CLASSI ANALYSES
CASE 7, GE-75-VPS-H2
NODE NO. 101

GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

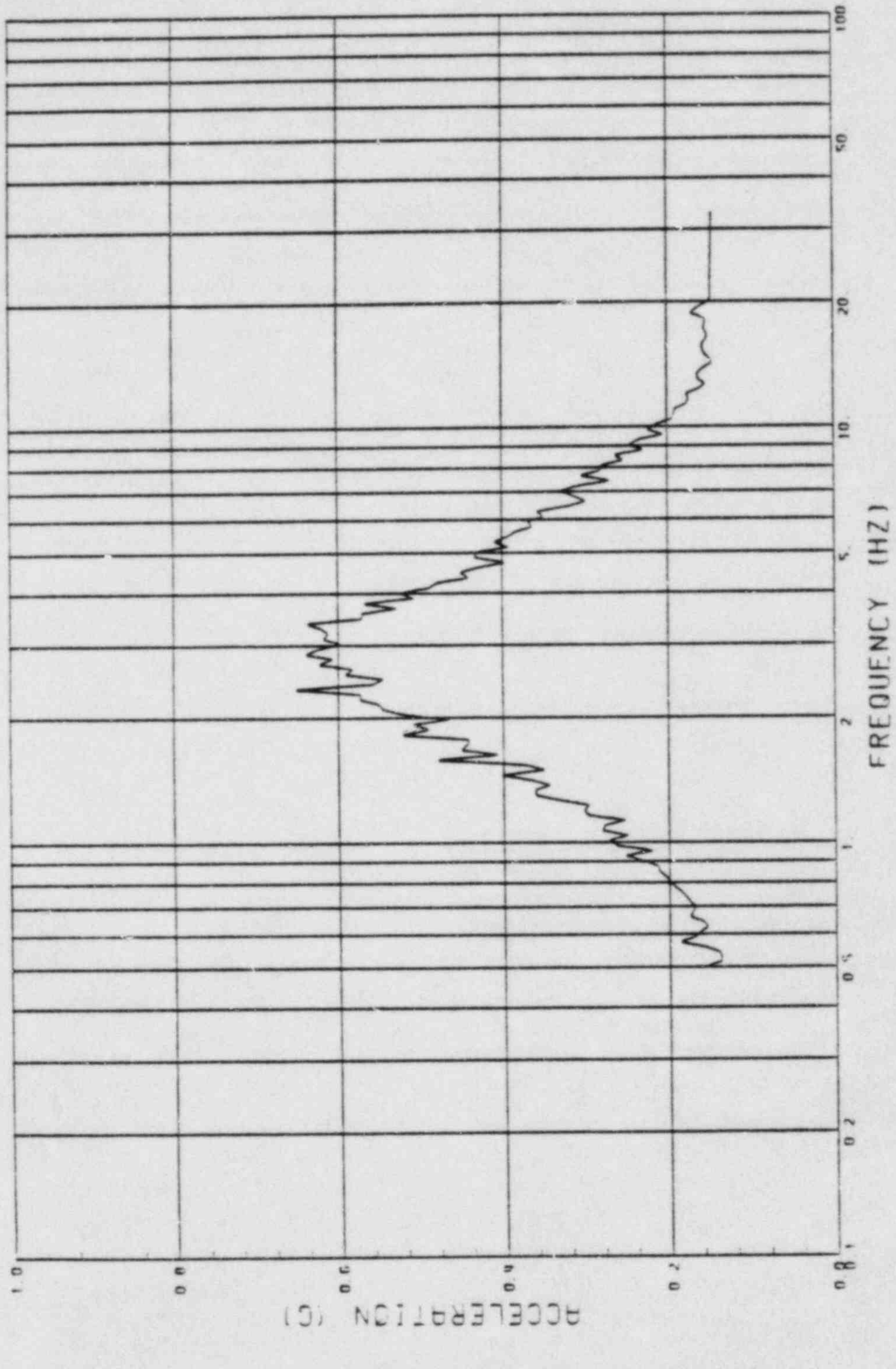
Figure A.76



GE CLASSI ANALYSES
CASE 7, GE-75-VPS-H2
NODE NO. 109

GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

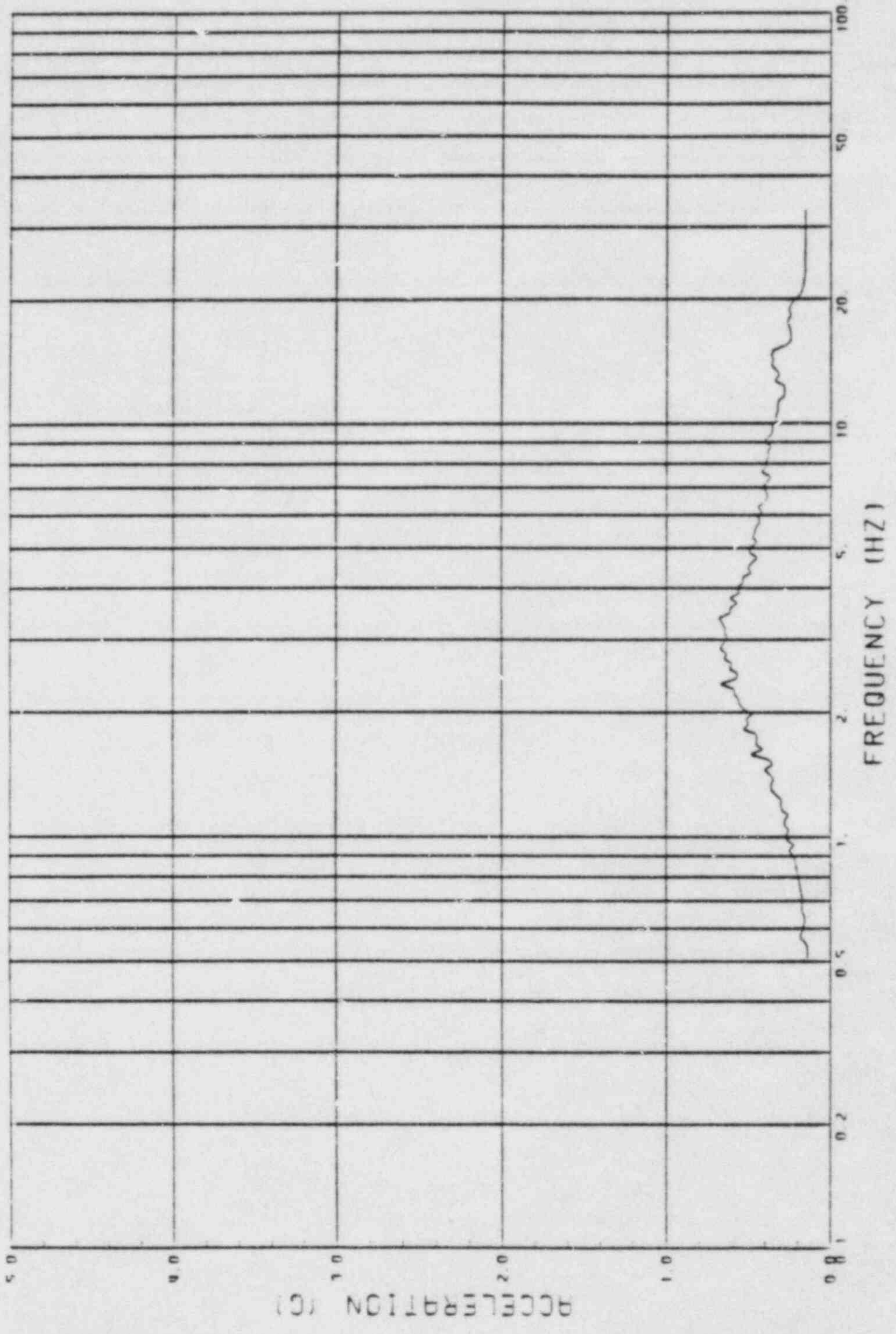
Figure A.77



GE CLASSI ANALYSES
CASE B, GE-75-A-V
BASEMAT, NODE NO. 71 (TRANSLATION)

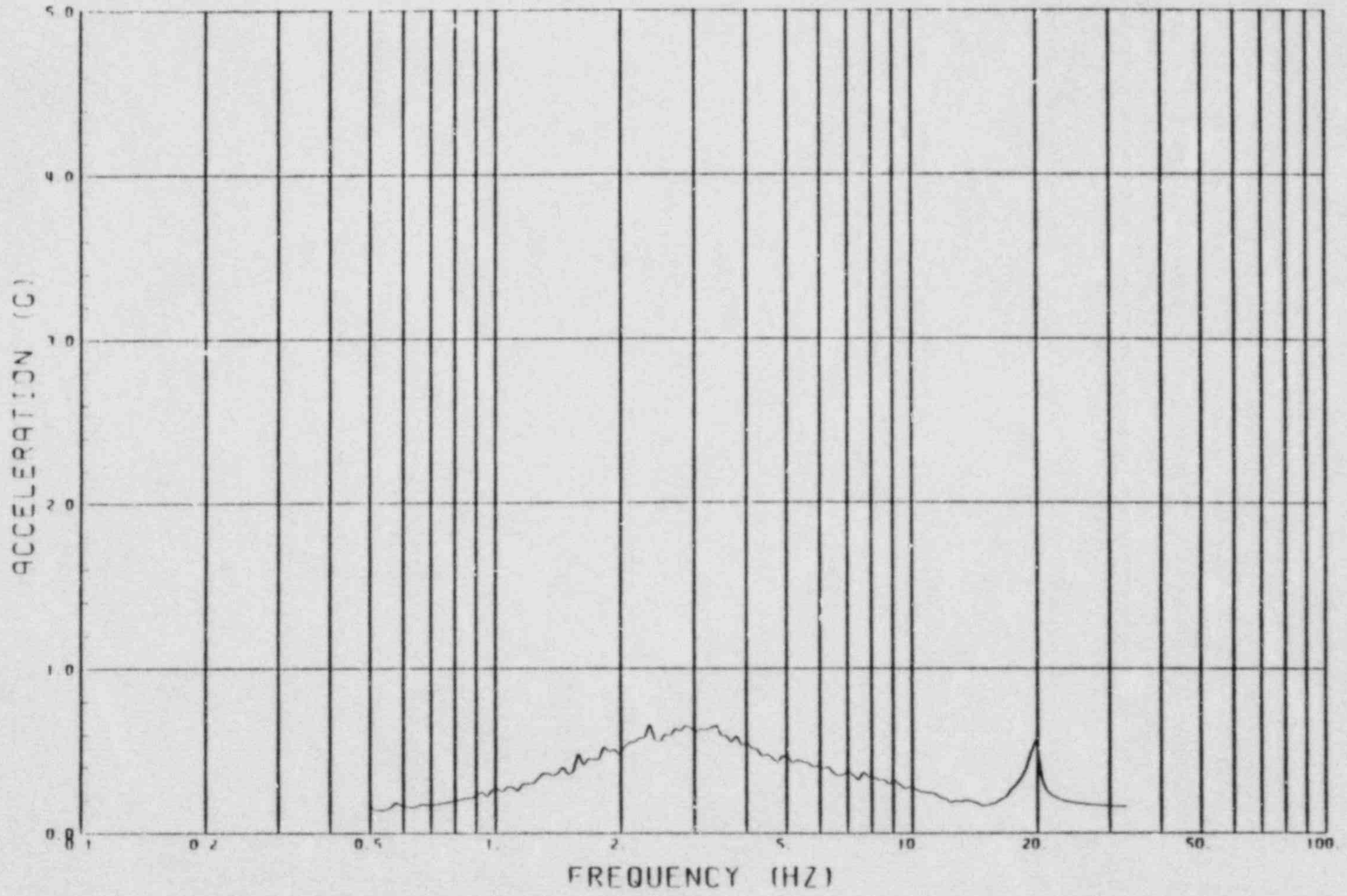
GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

Figure A.78



GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

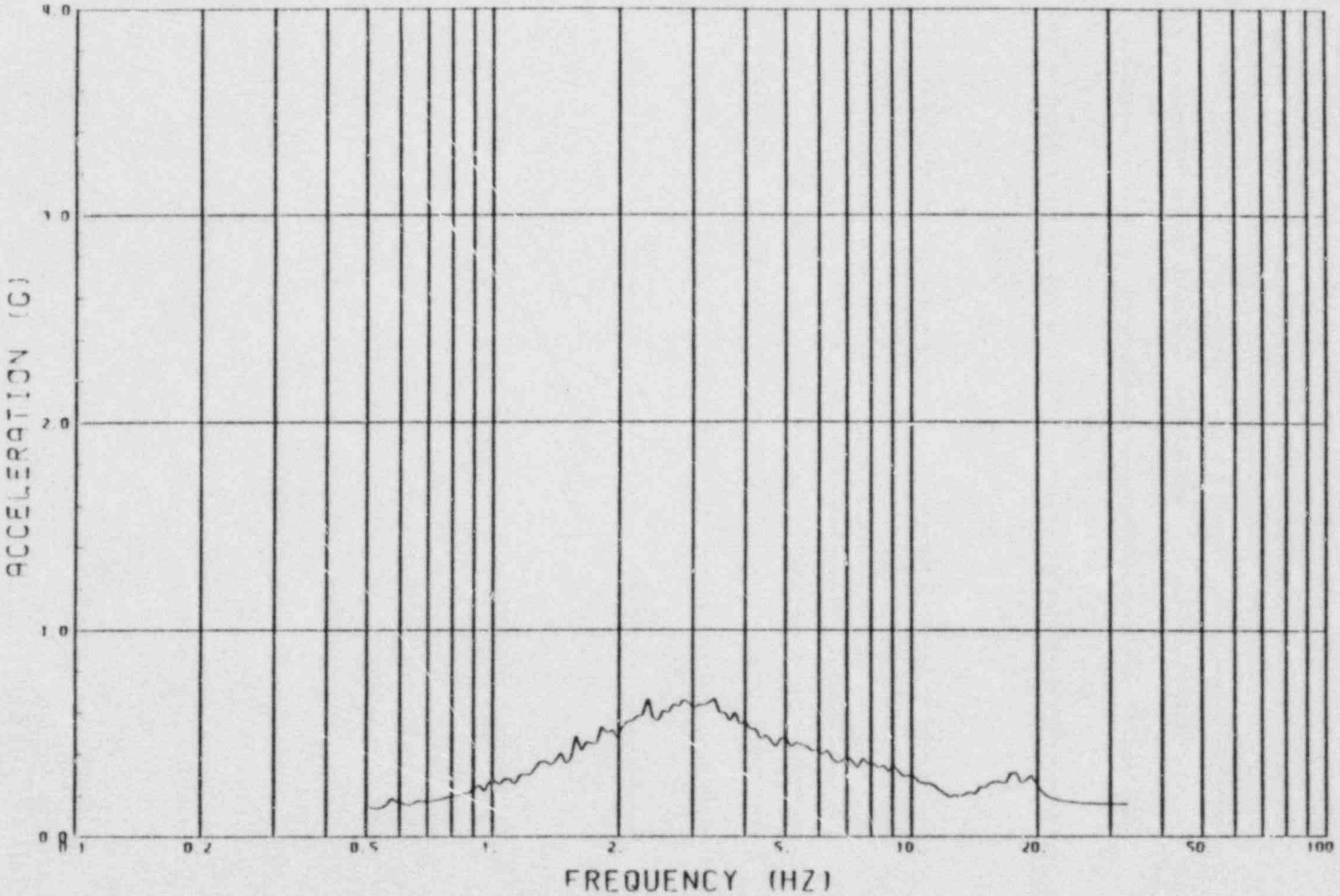
Figure A.79



GE CLASSI ANALYSES
CASE B, GE-75-A-V
NODE NO. 22

GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

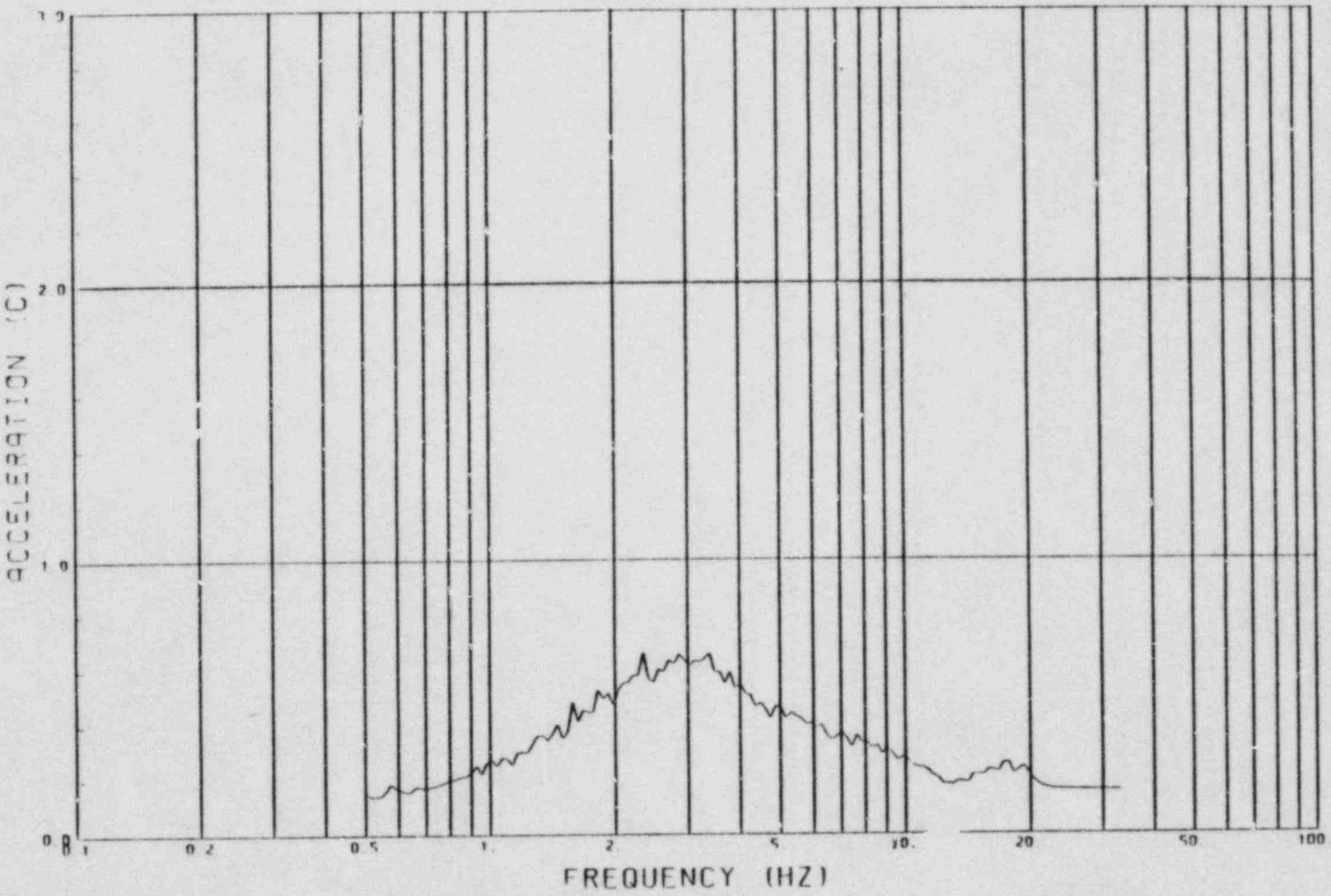
Figure A.80



GE CLASSI ANALYSES
CASE B, GE-75-A-V
NODE NO. 42

GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

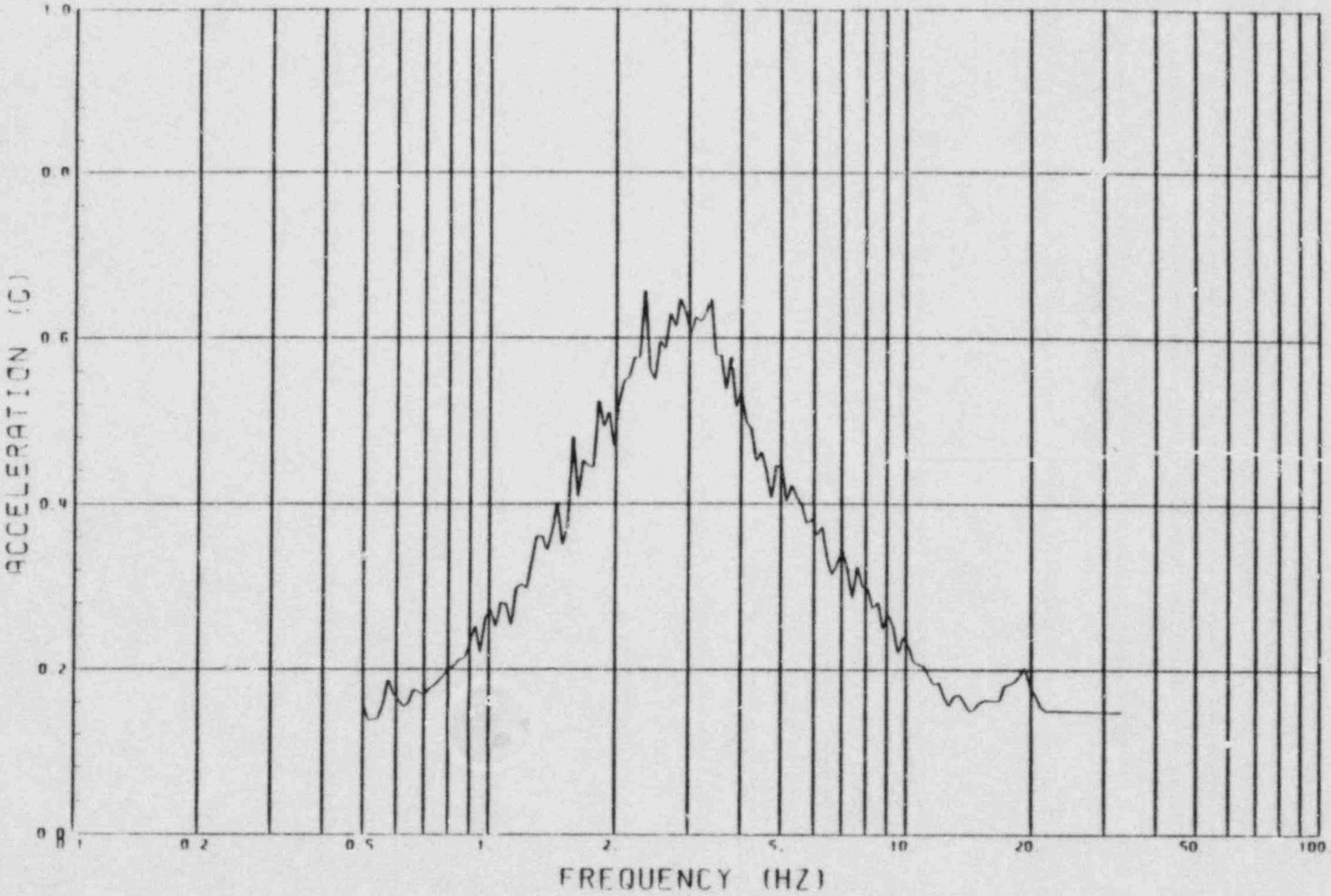
Figure A.81



GE CLASSI ANALYSES
CASE 8, GE-75-A-V
NODE NO. 46

GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

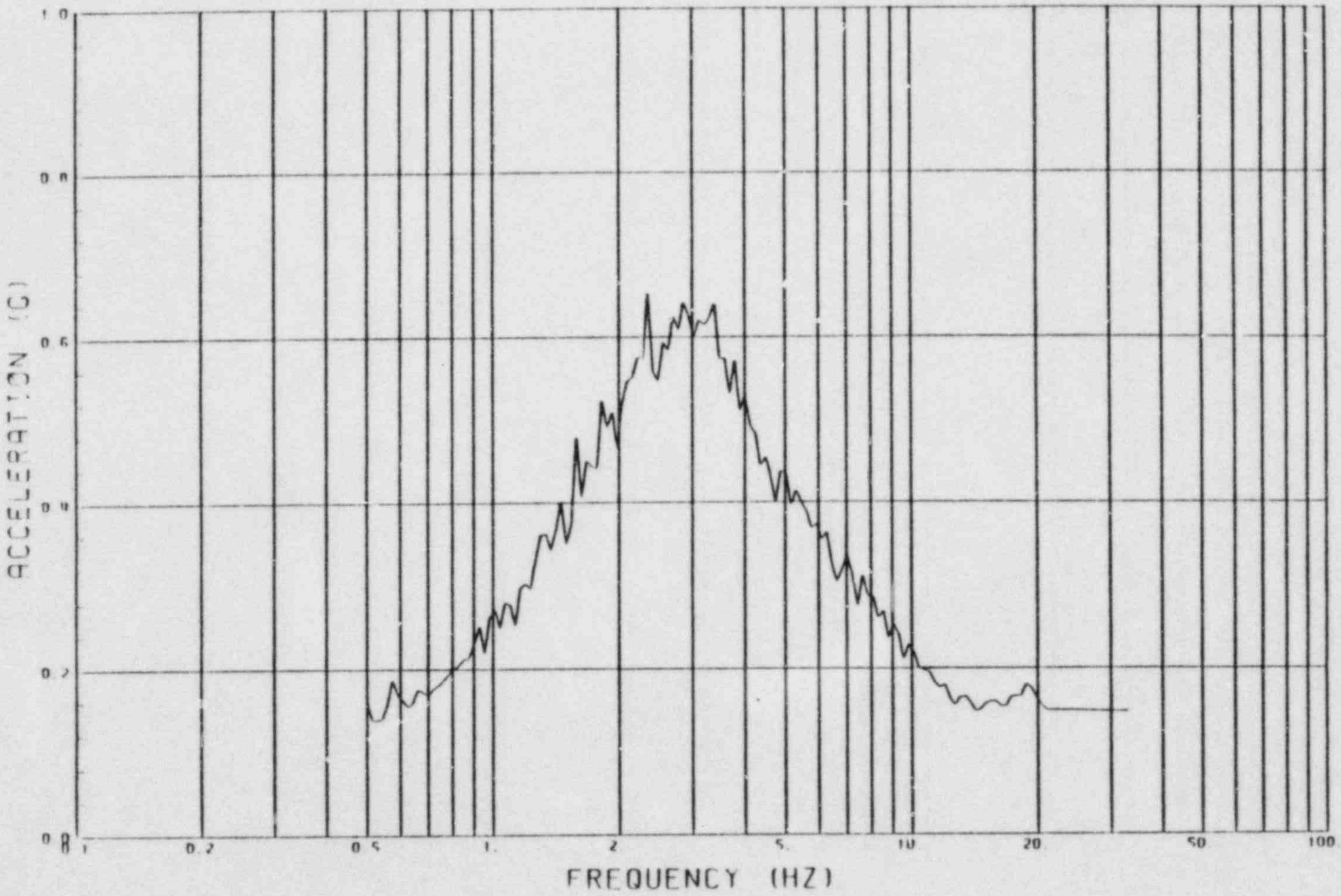
Figure A.82



GE CLASSI ANALYSES
CASE B, GE-75-A-V
NODE NO. 60

GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

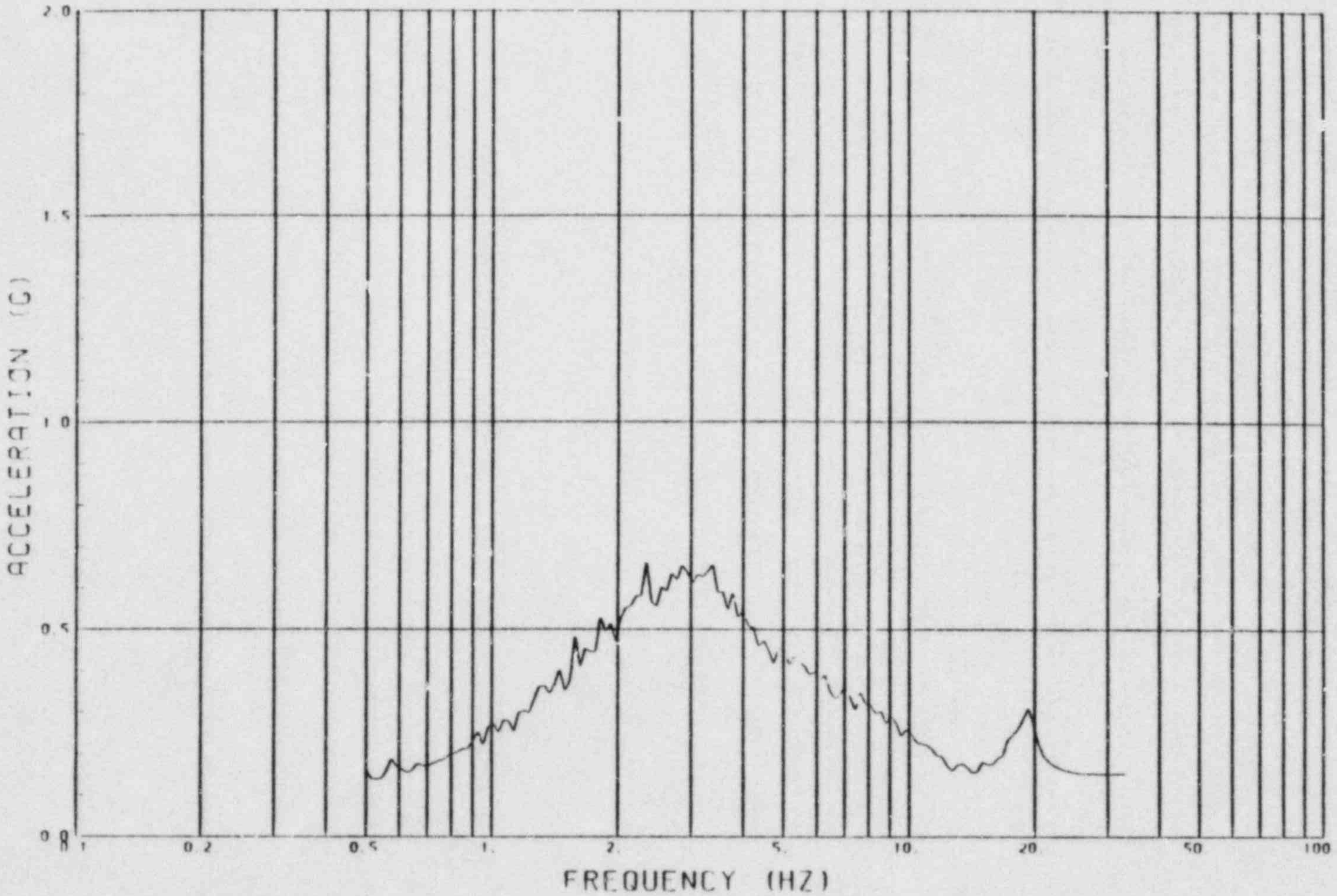
Figure A.83



CE CLASSI ANALYSES
CASE 8, CE-75-A-V
NODE NO. 64

GESSAR II PLANT
SØIL - STRUCTURE INTERACTIØN

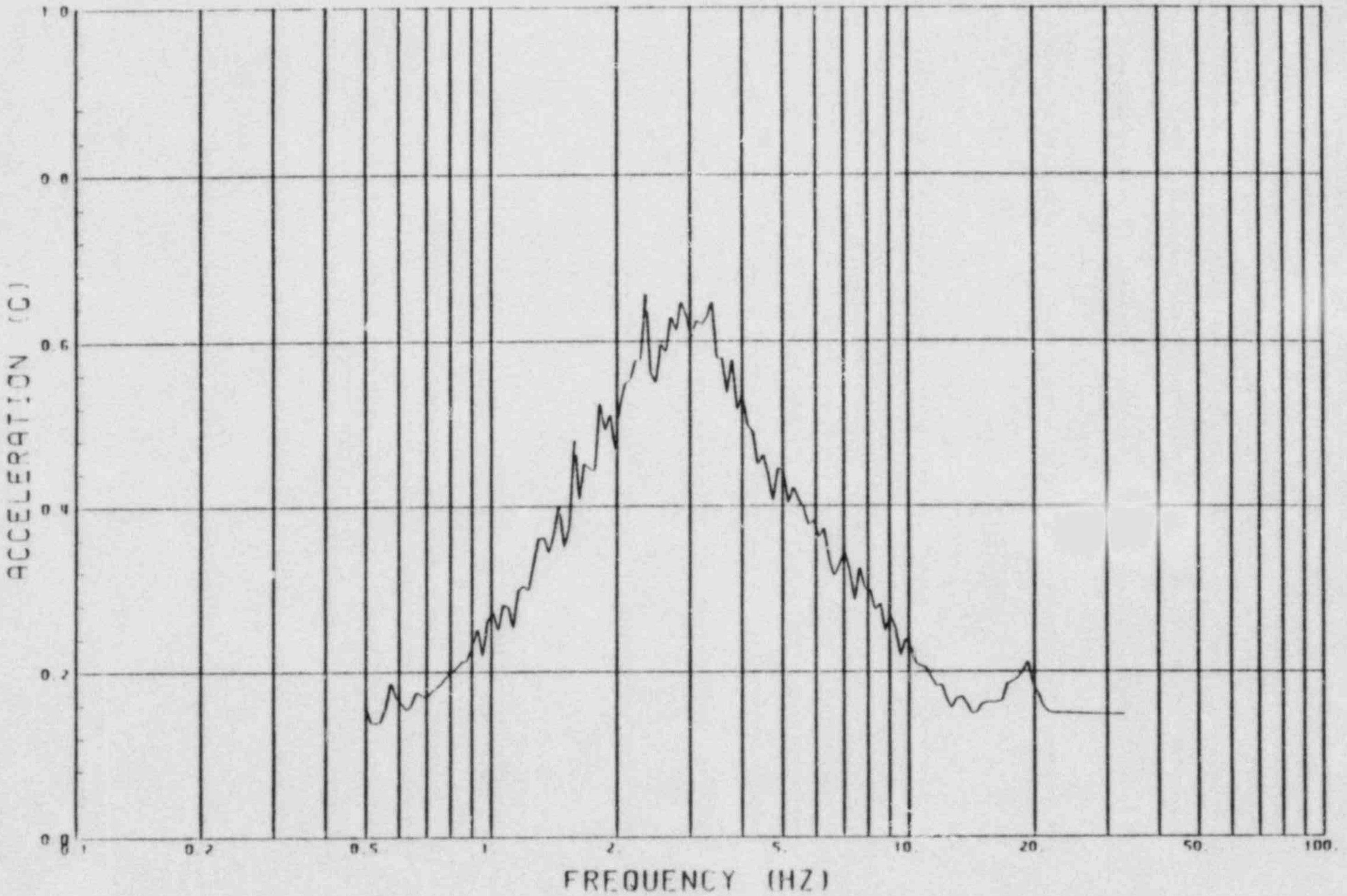
Figure A.84



GE CLASSI ANALYSES
CASE 8, GE-75-A-V
NODE NO. 72

GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

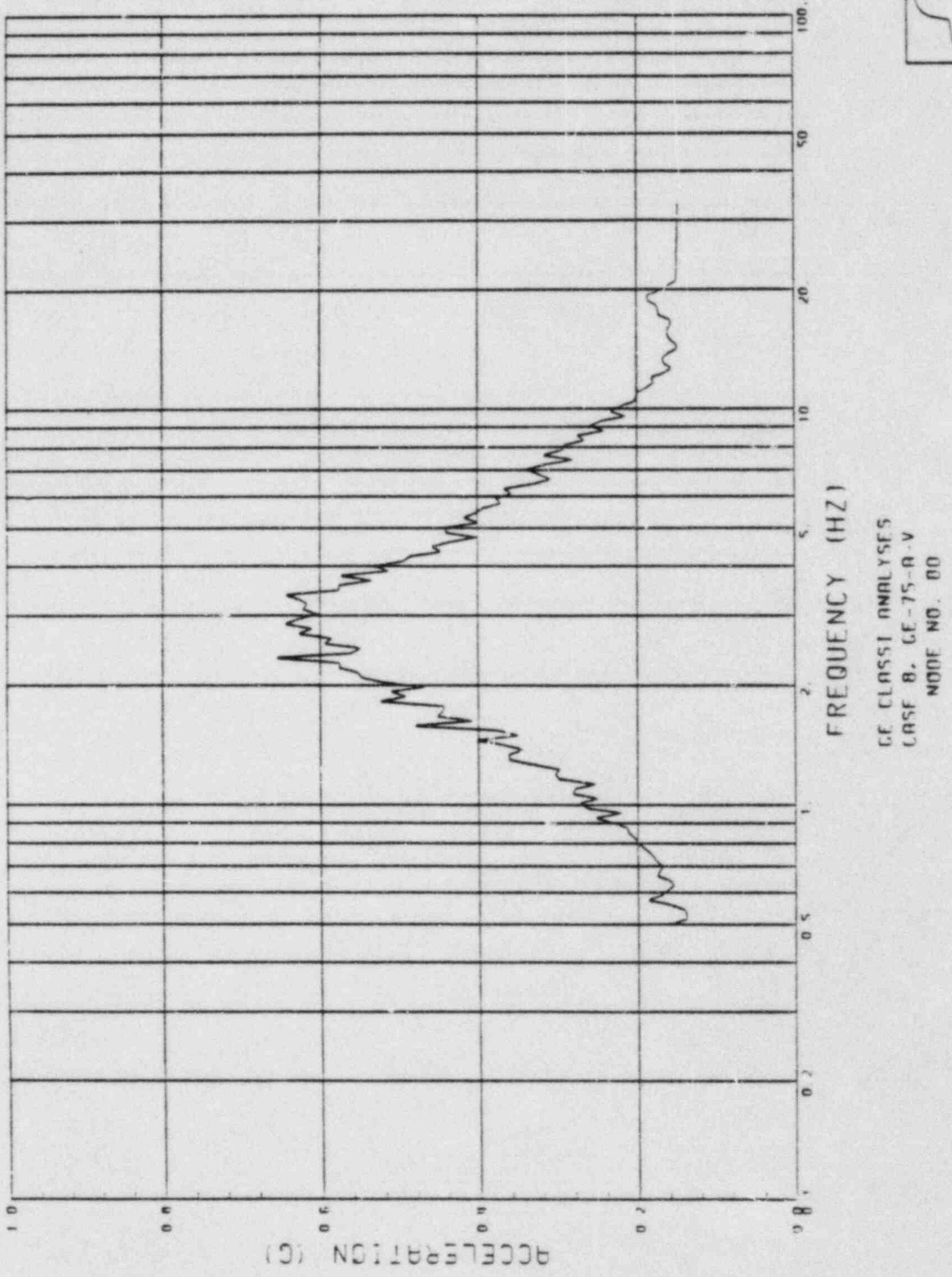
Figure A.85



GE CLASSI ANALYSES
CASE 8, GE-75-A-V
NODE NO. 74

GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

Figure A.86



GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

Figure A.87

APPENDIX 15.E.6

RESPONSES TO REQUEST FOR ADDITIONAL INFORMATION

APPENDIX 15.E.7

SEISMIC EVENT ANALYSIS

APPENDIX 15.E.8

GESSAR II FIRE AND FLOOD EXTERNAL EVENT ANALYSIS

APPENDIX 15.E.9

GESSAR II INTERNAL EVENT PRA UNCERTAINTY ANALYSIS

GE PROPRIETARY - provided under separate cover

APPENDIX 15.E.10

STATION BLACKOUT CAPABILITY

APPENDIX 15.E.10

CONTENTS

APPENDIX 15.E.10

CONTENTS (Continued)

APPENDIX 15.E.10

TABLES

APPENDIX 15.E.10

ILLUSTRATIONS

15.E.10.1 INTRODUCTION AND CONCLUSIONS

15.E.10.1.1 Introduction

This appendix is provided to demonstrate that the GESSAR II design has substantial capability to prevent a core damaging event well beyond the 2-hr value recommended by NUREG-0626 and assumed in the Probabilistic Risk Assessment (Section 15D.3), without the addition of an Ultimate Plant Protection System (UPPS).

Contained in Attachment A are responses to pertinent questions on station blackout of interest to the Staff. They are addressed in more detail in other parts of this appendix.

15.E.10.1.2 Conclusions

The GESSAR II station blackout capability exceeds 10 hours. The assessed capability assumes credit for operator actions that are straightforward and where means exist to enable the operator to execute the action. Where features and/or equipment are not present, potential design improvements are recommended. These operator actions and potential design improvements are summarized below, without the inclusion of UPPS:

(1) Operator Actions

   (a) Manual reactor pressure vessel (RPV) water level control with the reactor core isolation cooling (RCIC) pump.

   (b) Shift of RCIC pump suction to the condensate storage tank (CST).

   (c) Vessel depressurization with safety relief valves (SRVs) to about 200 psig. Maintain vessel pressure above 150 psig with manual SRV control.

15.E.10.1.2 Conclusions (Continued)

(2) Potential Design Improvements

*(a) Provide manual logic override of the RCIC suction transfer signal and test line closure signal from the control room.

*(b) Provide Enhanced Level Instrument (ELI) System (currently under review for Appendix 1D).

*(c) Provide alternate power supply to RCIC gland compressor.

*(d) Provide dc backed power for CST level (by Applicant).

(e) Provide local control room temperature indication (by Applicant).

Preliminary estimates of the 125 Vdc battery capability support the 10 hr capability. However, the final plant design may include dc loads not known at this time which will be added by the Applicant. Therefore, the Applicant will provide a reassessment of the 125 Vdc battery capability. If necessary to ensure 10-hr capability, emergency dc bus crossties, or larger battery capacity, or other methods will be identified by the Applicant.

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*These potential improvements are not needed if the UPPS is implemented.

15.E.10.1.2 Conclusions (Continued)

In addition to the above actions, the following contingency actions could be taken to provide even longer duration capability:

(1) Provide override capability for the RCIC room high temperature isolation logic to be used if room temperature exceeds about 150°F.

(2) Extend SRV pneumatic supply by replacing air bottles if depleted. A connection outside the Fuel Building would be more convenient.

15.E.10.2 DEFINITION OF STATION BLACKOUT

Station blackout refers to the total loss of both offsite and onsite ac electrical power. In draft information pertaining to proposed Regulatory Guides, the NRC consultants refer to "Emergency ac" loss in addition to offsite power loss. This could be interpreted as the Division 1 and 2 Standby Emergency Diesel Generators. Both high pressure core spray (HPCS) and RCIC operate at high pressure and can be considered redundant water sources available for maintaining core cooling during a loss of emergency ac and offsite power event. However, for purposes of this assessment, a failure of the HPCS diesel generator has been assumed in addition to loss of offsite power and the Division 1 and 2 diesel generators, thus providing a more severe impact on plant systems and the station battery.

A one-line diagram of the GESSAR II design is shown in Figure 8.3-1. Three divisions of 6.9 kV onsite ac power are provided: two by standby emergency diesel generators (in addition to preferred and alternate off-site power sources); the third by an offsite power source and a separate and diverse diesel generator dedicated to Division 3 electrical power. Division 3 supports the HPCS System and all of its supporting auxiliaries.

The GESSAR II design also includes a steam turbine driven RCIC System which operates in an emergency, independently of ac electrical power. This sytem is designed to provide high pressure makeup to the RPV during isolation events and would thus be initiated automatically during a postulated blackout event. The plant response with RCIC alone has been reviewed, and the duration capability of the GESSAR II plant in excess of 10 hours has been judged to be realistically available. This configuration is consistent with the station blackout definition in the Probabilistic Risk Assessment (Section 15D.3), although the Probabilistic Risk Assessment conservatively assumed a duration capability.

15.E.10.2 DEFINITION OF STATION BLACKOUT (Continued)

In the evaluation, certain assumptions have been made:

(1) No loss-of-coolant accident (LOCA), stuck-open relief valve (SORV) or failure to scram concurrent with the station blackout is considered.

(2) In evaluation of equipment, some capability beyond environmental qualification limits has been assumed. In assessing the ultimate failure capability of equipment, the judgment of senior General Electric engineering personnel has been relied upon to provide guidance. Such judgments are explicitly called out in the following sections.

(3) Operator actions are identified where adequate time and skills would be expected to be available to a typical operating plant staff. No extraordinary actions on the part of the operator are assumed; rather, only straightforward, simple actions are allowed.

(4) No credit for offsite assistance from a utility maintenance crew using portable electric generators or batteries has been assumed for this assessment, even though this possibility may exist within the time frame of interest. Such a capability might be considered by an Applicant to improve the restoration time for onsite emergency ac power.

15.E.10.3 INDICATION OF STATION BLACKOUT

The staion blackout event is characterized by a loss of all offsite power (preferred and alternate feeders) and a loss of Divisions 1, 2 and 3 of onsite ac power. As noted in Section 1D.2.3.33 of the assessment against Regulatory Guide 1.97, the Class 1E power distribution system monitors voltage on the three 6.9 kV ac buses and the four 125 Vdc buses. This indication is displayed on Panel P800 in the main control room. A potential station blackout event would be first noticed by a plant operator by a change in the control room lighting which would alert him to evaluate both the plant and the electrical distribution system status. By observation of the loss of bus voltage on 6.9 kV buses "E", "F" and "G" and the breaker position for incoming voltage to these buses, the operator would be alerted to the presence of a potential blackout event. Voltage indication on dc Buses E, F, G and H would assure the operator that power is available to control the event.

Before conducting the various operator actions needed to mitigate a blackout event, the operator must distinguish between a short duration event and a prolonged blackout. A short duration event would be one in which restoration of an offsite or onsite ac power source would occur before development of conditions requiring the operator actions defined later in this appendix. Minimizing the time to recognize this event is important so that the potential drain on the batteries is controlled.

Upon recognition of the ac power source failure, an auxiliary operator would be sent to each of the diesel generator rooms to attempt a manual start. Simultaneously, the control room operator should attempt to start each diesel from the main control room. In addition, the system dispatcher would be contacted by the shift supervisor to determine the status and likelihood of offsite power restoration. Accomplishment of these activities,

15.E.10.3 INDICATION OF STATION BLACKOUT (Continued)

in addition to those related to controlling vessel water level and pressure, is expected to take about 30 minutes.

Thus, recognition of a station blackout event and the initiation of any blackout specific operator actions is expected to be delayed for about 30 minutes.

15.E.10.4 INSTRUMENTATION REQUIREMENTS

Instrumentation required to monitor plant status during a blackout event has been selected from a review of the Type A through E variables discussed in Appendix 1D which is the response to Regulatory Guide 1.97 requirements. This list has been augmented slightly to account for specific variables such as room temperatures and certain valve and breaker position indications needed to determine plant conditions.

The variables considered and whether or not they are needed for the blackout sequence are listed in Table 15.E.10-1. The basis for selection generally is based on the need for the operator to follow Emergency Procedure Guidelines (EPGs) (or take other actions which may be established later) during the period of interest. As such, Type A variables are identified as needing indication during the blackout event, while variables which are more representative of monitoring core damage or breaks of the reactor coolant boundary or effluent release are excluded.* System operation variables for systems without power are also excluded.

The power supplies in the GESSAR II design for the instruments needed are shown in Table 15.E.10-2. All indications needed to follow the blackout event are or will be powered from 125 Vdc sources.

The Applicant must provide a dc backup power to the CST level indicator and ensure local control room temperature indication as available.

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*The latter variables are excluded since releases stemming from a postulated station blackout event are within existing design bases events for upset conditions.

15.E.10.5 PLANT RESPONSE FOLLOWING A STATION BLACKOUT

The key plant areas which require ac power could potentially affect the ability of the plant design to accommodate a station blackout are as follows:

(1) RCIC room

(2) Remote shutdown panel area

(3) Suppression pool (SP) and containment

(4) Drywell

(5) Control room

(6) Fuel pool

In addition, the following non-ac power plant energy supplies will be consumed and need to be addressed to assess the plant capability:

(1) Automatic Depressurization System (ADS) of the Pneumatic Air Supply System

(2) dc Power Distribution System

These areas and energy supplies will be discussed in subsequent subsections. An estimate of limiting conditions, design improvements or operator actions needed are noted in each.

15.E.10.5.1 Areas

15.E.10.5.1.1 RCIC Room

(1) Reason for Concern

(a) Room temperature increase without area cooling could cause a loss of RCIC control due to equipment failure.

15.F.10.5.1.1 RCIC Room (Continued)

(b) Isolation and turbine trip due to leak detection system trip (Trip setpoint approximating 170°F) could prevent RCIC from operating.

(c) Steam line drain valves may fail after air supply becomes exhausted causing system damage on restart.

(2) Plant Response

(a) Approximately 122°F in 12 hours (w/CST suction)

(b) Approximately 133°F in 12 hours (w/SP suction)

(c) Approximately 101°F in 12 hours (w/10 lb/hr steam

See Attachment B

Critical Components	Limitation
Electro-Hydraulic EH Differential Coil	Approximately 170°F water temperature
Magnetic Speed Sensor Instrumentation	225°F 212°F

Capability >12 hours

(3) Operator Actions to Extend Duration

(a) Manual switch of RCIC suction to CST at about 30 minutes.

15.E.10.5.1.1 RCIC Room (Continued)

(b) Override RCIC high temperature isolation if room temperature > approximately 150°F (not expected)

(c) Manual RPV level control of RCIC to avoid L8 trip and restart.

(4) Potential Modifications

(a) Ensure override capability for RCIC room isolation signal.

(b) Ensure override capability for RCIC suction transfer.

(c) Provide logic changes to permit low flow RCIC injection. Requires override capability on test line to CST to obtain flow split between CST return and vessel.

15.E.10.5.1.2 Remote Shutdown Panel Area

(1) Reason for Concern

(a) RCIC electronics could fail if area temperature exceeds 150°F.

(b) Access needed if control room uncomfortable or electronics erratic.

(2) Plant Response

(a) Not evaluated, but very little heat source since Remote Shutdown Station (RSS) panel is deenergized until control transfer switch is thrown.

15.E.10.5.1.2 Remote Shutdown Panel Area (Continued)

(b) Expect area temperature to remain <150°F for 20 hours

Capability >20 hours

Critical Components	Limitation
RCIC Control Electronics	150°F

(3) Operator Actions to Extend Duration

None.

(4) Potential Modifications

None.

15.E.10.5.1.3 Suppression Pool

(1) Reason for Concern

(a) High suppression pool temperature could cause net positive suction head (NPSH) limits (approximately 175°F) and reduced lube oil cooling to RCIC.

(b) High suppression pool level causes suction transfer.

(c) High containment air temperature may cause erratic RPV indication.

(d) High suppression pool temperature and level increases containment loads.

15.E.10.5.1.3 Suppression Pool (Continued)

(2) Plant Response

Time (hr)	T_{sp} [a] (°F)	T_c [a] (°F)	L_{sp} [a] (ft)
1	135	100	+2
5	190	175	+5
10	220	220	at weir
15	225	225	at weir
20	230	230	at weir

Capability >10 hours

[a] T_{sp} is suppression pool temperature based on Table 15D.2-2 and calculations.

T_c is containment air temperature based on T_{sp} and judgment.

L_{sp} is suppression pool level.

Critical Components	Limitation
Containment instrument Transmitters	250°F
RCIC Suction Temperature	175°F

15.E.10.5.1.3 Suppression Pool (Continued)

(3) Operator Actions to Extend Duration

(a) Manual switchover back to CST within 1 hour eliminates potential NPSH problem.

(b) Maintain vessel pressure below heat capacity temperature limit according to EPGs; ensure written procedures contain heat capacity temperature limit curve. May need to exceed heat capacity temperature limit slightly after approximately 6 hours, but acceptable because no additional depressurization required. Consistent with EPGs.

(4) Potential Modifications

Ensure manual override capability for RCIC suction transfer.

15.E.10.5.1.4 Drywell

(1) Reason for Concern

(a) High drywell temperature could cause RPV level instrument reference leg boiloff.

(b) High drywell temperature might exceed qualification levels for drywell equipment

(c) High drywell temperature could cause SRV solenoid failure.

15.E.10.5.1.4 Drywell (Continued)

(2) Plant Response

Approximately 135°F during plant operation

<270°F prior to depressurization at 30 minutes

Capability: unlimited

<200°F after depressurization to 200 psi

Critical Components	Limitation
SRV Solenoids	330°F

(3) Operator Actions to Extend Duration

(a) Depressurization to approximately 200 psi to limit drywell heatup.

(b) Maintain pressure >118 psi to avoid reference leg flooding.

(c) Maintain RPV water level at approximately +20 inches on ELI.

(4) Recommended Modifications

ELI compensates for drywell and containment temperature effects. (Previously recommended. See Appendix 1D.)

15.E.10.5.1.5 Control Room

(1) Reason for Concern

(a) High control room temperature could cause computer/microprocessor controls to fail.

(b) High temperature could make the control room uninhabitable.

(2) Plant Response

Capability: unlimited.

(a) Power Generation Control Complex (PGCC) floor section heat sinks expected to prevent heatup above 105°F.

(b) Humidity could become uncomfortable but not uninhabitable.

Critical Components	Limitation
Microprocessors	105°

(3) Operator Actions to Extend Duration

Transfer control to RSS if control room becomes uninhabitable. (Not expected.)

(4) Potential Modifications

None.

15.E.10.5.1.6 Fuel Pool

(1) Reason for Concern

Loss of fuel pool cooling could cause fuel pool to boil away.

(2) Plant Response

(a) Approximately 14 hours to boiling — Basis: Judgment

(b) Approximately 77 hours to fuel uncovery

Capability
>77 hours

Critical Components	Limitation
Fuel Bundles	Dryout

(3) Operator Actions to Extend Duration

None, but SRV air bottle replacement (see pneumatic supply) could be hampered by fuel building environment after approximately 14 hours.

(4) Potential Modifications

Consideration of moving extra air bottles to corridor outside fuel building. Not required for station blackout.

15.E.10.5.2 Energy Supplies

15.E.10.5.2.1 Pneumatic Supply

(1) Major Sources of Consumption

(a) ADS/SRV

(b) Drywell and containment vacuum breakers

(2) Estimated Duration (5000 CF available)

SRV depressurization approximately 50 actuations at 8 CF actuation = 400 CF

Ongoing SRV uses approximately 1 actuation/2 min x 60 min/hr x 8 CF = 240 CFH

Leakage at 1 CFH/valve x 8 valves = 8 CFH

DW Vacuum Breakers approximately 1 act/7 hrs at 15 CF/act x 2 VB = 4 CFH

Total approximately 250 CFH

$$\frac{5000 - 400}{250} = 18 \text{ hours}$$

Capacity > 18 hours

(3) Operator Actions to Extend Duration

(a) Air bottle replacement after depletion possible if necessary (not expected).

(b) Rotate use of ADS/SRV valves to permit time for accumulators to recharge and give preference to Division 2 ADS/SRV valves.

15.E.10.5.2.1 Pneumatic Supplies (Continued)

(c) Monitor SRV position indication to indicate need for switch to other valves (valves close when air supply lost).

(4) Potential Modifications

None.

15.E.10.5.2.2 125 VDC Bus E

(1) Major Sources of Consumption

See Table 8.3-6

(2) Estimated Duration

Load Profile Estimate

	Table 8.3-6	Estimated[a] Blackout Loads
0 - 1 min	818A	420A
1 - 2 min	422A	265A
2 - 30 min	251A	200A
30 - 120 min	251A	120A
120 - 600 min	N/A	120A

Capability
>10 hours*

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[a] With operator actions and potential modifications as defined in Paragraphs (3) and (4) this subsection.

*Capability is based on a battery sized to meet current estimated design basis loads. The same battery under blackout conditions was evaluated to confirm the 10-hr capability. The Applicant will need to confirm battery loading and size based on final plant design. If the estimated duration is less than about 10 hours, the addition of crossties or expanded battery size will be reviewed to determine the optimum configuration for achieving a 10-hr capability.

15.E.10.5.2.2 125 Vdc Bus E (Continued)

(3) Operator Actions to Extend Duration

Shed the following loads (at approximately 30 minutes)

(a) Neutron Monitoring System (NMS) panel H13-P669 [Nuclear Systems Protection System (NSPS)]

Justified on the basis that no SRM or IRM neutron flux instrumentation is available and Reactor shutdown would have been previously confirmed.

(b) Emergency Lighting (Fuel Building)

Justified on the basis that other Emergency Lighting exists (i.e., battle lanterns) and access not needed during blackout.

(4) Potential Modifications

(a) Power RCIC gland compressor from an alternate source.

- Reduces steady-state load by 58A and transient load by 130A.

(b) Delete 125 Vdc emergency lighting system except for Control Building or move to Bus J.

- Reduces steady-state load by 28A.

15.E.10.5.2.2 125 Vdc Bus E (Continued)

(c) Provide special load shed switch if needed to avoid shedding desired loads. Preserving Neutron Monitoring System shedding capability reduces steady-state load by 21A.

15.E.10.5.2.3 125 Vdc Bus F

(1) <u>Major Sources of Consumption</u>

See Table 8.3-7.

(2) <u>Estimated Duration</u>

<u>Load Profile Estimate</u>

	Table 8.3-7	Estimated[a] Blackout Loads	
0 - 1 min	393	288	
1 - 2 min	175	140	Capability Not Limiting*
2 - 30 min	175	140	
30 - 120 min	175	94	
120 - 600 min	N/A	94	

---

[a] With operator actions and potential modifications of this subsection as defined in Paragraphs (3) and (4).

*Failure of this battery supply will result in loss of redundant instrumentation and half of the SRV control power. This failure is not limiting.

15.E.10.5.2.3 125 Vdc Bus F (Continued)

(3) Operator Actions to Extend Duration

Shed the following loads at approximately 30 minutes.

(a) NMS panel H13-P670 (NSPS)

Justified as discussed in Subsection 15E.5.2.2

(b) Emergency Lighting - 15A

Justified as discussed in Subsection 15E.5.2.2

(4) Potential Modifications

(a) Delete 125 Vdc emergency lighting in Auxiliary Building; reduces steady-state load by 15A.

(b) Provide load shedding switch; reduces steady-state loads by 21A.

15.E.10.5.2.4 125 Vdc Bus G

(1) Major Sources of Consumption

See Table 8.3-8.

15.E.10.5.2.4 125 Vdc Bus G (Continued)

(2) Estimated Duration (400 AH, 6 hours)

Load Profile Estimate

	Table 8.3-8	Estimated[a] Blackout Loads
0 - 1 min	128	90
1 - 2 min	78	58
2 - 30 min	78	58
30 - 120 min	78	23
120 - 600 min	N/A	23

Capability Not Limiting*

---

[a] With operator actions and potential modifications as defined in Paragraphs (3) and (4) of this subsection.

*Failure of this battery supply will result in the loss of some redundant instrumentation. This failure is not limiting.

(3) Operator Actions to Extend Duration

Shed the following load at approximately 30 minutes

NMS panel H13-P671 - Justified as discussed in Subsection 15.E.10.5.2.2

(4) Potential Modifications

Provide load shedding switch for Neutron Monitoring System loads; reduces steady-state loads by 21A.

15.E.10.5.2.5 125 Vdc Bus H

(1) Major Sources of Consumption

See Table 8.3-9.

(2) Estimated Duration

Load Profile Estimate

	Table 8.3-9	Estimated[a] Blackout Loads	
0 - 1 min	100	70	Capability Not Limiting*
1 - 2 min	100	70	
2 - 30 min	100	70	
30 - 120 min	100	50	
120 - 600 min	N/A	50	

---

[a] With operator actions and potential modifications as defined in Paragraphs (3) and (4) of this subsection.

*The failure of this battery does not affect the ability to continue operation under blackout conditions. No operator actions or design modifications are planned.

(3) Operator Actions to Extend Duration

Shed the following load at approximately 30 minutes

Shed NMS Panel H13-P672 (NSPS) -25A

(4) Potential Modifications

None.

Table 15.E.10-1

VARIABLES ASSESSED FOR STATION BLACKOUT ASSESSMENT

Variable	RG 1.97 Type	RG 1.97 Category	Discussion Subsection	Needed in Blackout Sequence?
Reactivity Control				
Neutron Flux (value, rate, trend)	A,B	1	1D.2.3.1	No[a]
Control Rod Position	B	3	1D.2.3.2	No[a]
Boron Concentration (sample)	B	3	1D.2.3.3	No
Core Cooling				
Coolant Level in the Reactor (value, trend)	A,B,C	1	1D.2.3.4	Yes
Maintaining Reactor Coolant System Integrity				
Reactor Coolant System (RCS) Pressure (value + alarm)	A,B,C	1	1D.2.3.5	Yes
Drywell Sump Level (value + alarm)	B,C	3	1D.2.3.6	No
Drywell Pressure	B,C,D	1,2	1D.2.3.7	No
Primary Containment	E	1	1D.2.3.8	No
Area Radiation	C	3		
Suppression Pool Water Level	A,B.C	1.2	1D.2.3.9	Yes

See footnotes at end of table.

Table 15.E.10-1

VARIABLES ASSESSED FOR STATION BLACKOUT ASSESSMENT (Continued)

Variable	RG 1.97 Type	RG 1.97 Category	Discussion Subsection	Needed in Blackout Sequence?
Maintaining Containment Integrity				
Primary Containment Isolation Valve Position (Excluding Check Valves)	B	1	1D.2.3.10	Yes[b]
Primary Containment Temperature	A	1	1D.2.3.11	Yes
Primary Containment Pressure (value, rate, trend, + alarm)	A,B,C	1	1D.2.3.12	Yes
Drywell/Containment Hydrogen Concentration (value)	A,C	1	1D.2.3.13	No
Secondary Containment Area Radiation (value)	C,E	2	1D.2.3.14	No
Secondary Containment Noble Gas Effluent	C,E	2	1D.2.3.15	No
Primary Containment Noble Gas Effluent	C	3	1D.2.3.16	No
Suppression Pool Temperature	A,D	1,2	1D.2.3.17	Yes
Drywell Air Temperature	A,D	1,2	1D.2.3.18	Yes
Fuel Cladding Barrier Monitoring				
Coolant Radiation (value + alarm)	N/A	N/A	1D.2.3.19	-
Coolant Gamma (1 sample-6 hours) results within 72 hours	C	3	1D.2.3.20	No

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See footnotes at end of table.

Table 15.E.10-1

VARIABLES ASSESSED FOR STATION BLACKOUT ASSESSMENT (Continued)

Variable	RG 1.97 Type	RG 1.97 Category	Discussion Subsection	Needed in Blackout Sequence?
System Operation				
Main Steam Line Isolation Valve Leakage Control System Pressure	D	2	1D.2.3.21	No
Containment Spray Flow	D	2	1D.2.3.22	No
Residual Heat Removal (RHR) System Flow	D	2	1D.2.3.22	No
RHR Service Water Flow	D	2	1D.2.3.23	No
Low Pressure Coolant Injection System Flow	D	2	1D.2.3.22	No
Reactor Core Isolation Cooling System Flow	D	2	1D.2.3.24	Yes
RCIC Room Temp.	-	-	-	Yes
Control Room Temp.	-	-	-	Yes
High Pressure Coolant Spray System Flow	D	2	1D.2.3.24	No
Core Spray System Flow	D	2	1D.2.3.24	No
Standby Liquid Control System (SLCS) Flow	D	2	1D.2.3.25	No
SLCS Storage Tank Level	D	3	1D.2.3.26	No
SRV Position	D	2	1D.2.3.27	Yes
Feedwater Flow	D	3	1D.2.3.28	No

See footnotes at end of table.

Table 15.E.10-1

VARIABLES ASSESSED FOR STATION BLACKOUT ASSESSMENT (Continued)

Variable	RG 1.97 Type	RG 1.97 Category	Discussion Subsection	Needed in Blackout Sequence?
System Operation (Continued)				
CST Level	D	3	1D.2.3.29	Yes
Engineered Safety Feature (ESF) Cooling Water Flow	D	2	1D.2.3.30	No
ESF Cooling Water Temperature	D	2	1D.2.3.30	No
High Radioactivity Tank Level	D	3	1D.2.3.31	No
Emergency Vent Damper Position	D	2	1D.2.3.32	Yes
Standby Energy Status	D	2	1D.2.3.33	Yes[c]
Effluent Monitoring				
SGTS Ventilation Flow Rate	E	2	1D.2.3.34	No
Other Ventilation Flow Rates	E	3	1D.2.3.34	No
Particulate/Halogen Release (sample)	E	3	1D.2.3.35	No
Environs Radioactivity Monitoring	E	3	1D.2.3.36	No
Meteorology	E	3	1D.2.3.37	No
Post-Accident Sampling (sample)	E	3	1D.2.3.38	No

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[a] Anticipated Transient Without Scram (ATWS) plus blackout is not considered in this study. Failure to scram can be inferred from abnormal water level and pressure response.

[b] Plus RCIC minimum flow.

[c] Including breaker position.

Table 15.E.10-2

POWER SUPPLIES TO INSTRUMENTS NEEDED FOR A BLACKOUT

Variable	Control Room Indicator	Power Supply	Available?	Notes
RPV Level	B21 R623A	120 Vac Inst. Bus A	Yes	1
	R623B	120 Vac Inst. Bus B		
RPV Pressure	B21 R623A	120 Vac Inst. Bus A	Yes	1
	R623B	120 Vac Inst. Bus B	Yes	1
Suppression Pool Water Level	P50-R600A,B	125 Vdc	Yes	3
Primary Containment Isolation Valve Position	Indication Lights	RPS	Yes	
Primary Containment Temperature	T41-RR613A,B	125 Vdc	Yes	3
Primary Containment Pressure	T41-RR618A,B	125 Vdc	Yes	3
Suppression Pool Temperature	P50-R600A,B	125 Vdc	Yes	3
Drywell Air Temperature	T41-RR611A,B	125 Vdc	Yes	3
RCIC Flow	E51-R606	RPS	Yes	
RCIC Room Temperature	E31-R608	RPS	Yes	
Control Room Temperature	-	-	Yes	4
SRV Position	Indicating Lights	125 Vdc	Yes	
CST Level	By Applicant	By Applicant	Yes	2
Emergency Vent Damper Position	Indicating Lights	125 Vdc	Yes	3
Standby Energy Status 619 kV ac	Voltmeters	Source	Yes	
dc	Voltmeters	Source	Yes	
Air	P53-R606A,B	125 Vdc	Yes	3

Table 15.E.10-2

NOTES

1. Enhanced Water Level Instrument to be powered from dc power.

2. dc power to be provided by Applicant.

3. Power supply from 125 Vdc to Reactor Island Logic Panels P881 or P882.

4. Exhaust air measurement may be unreliable. Local thermometer to be supplied by Applicant.

ATTACHMENT A TO APPENDIX 15.E.10

ACRS QUESTIONS PERTAINING TO AC/DC POWER SYSTEM RELIABILITY

ATTACHMENT A

ACRS QUESTIONS PERTAINING TO AC/DC POWER SYSTEM RELIABILITY

15.E.10A.1 dc RELIABILITY

Question: The NRC Staff has issued a report (NUREG-0666) on the reliability of a dc power system in which a 2-train dc system which meets minimum NRC requirements was evaluated. As a result, the dc power system was identified as a potentially high contributor to core melt. The Applicant could be asked what his assessment of his dc system is and what consideration he has given to the recommendations of NUREG-0666.

Response: We do not favor the use of such a minimum system as considered in NUREG-0666. For example, it has a single bus tie breaker with too much potential for common cause failure. The original GESSAR II design allowed dc cross-connection capability with dual crosstie breakers and double key interlocks. GE agreed to delete the dc cross-connection capability from the GESSAR II design until it can be shown that this capability does not contribute to dc system unreliability. The following additional comments are provided:

(1) NUREG-0666 prohibits certain design and operational features of the dc power system such as use of a tie breaker which could compromise divisional independence. As noted above, GESSAR II complies, although we believe cross-connection capability is appropriate for specific conditions during shutdown and occurrences which require last resort flexibility (such as station blackout). GESSAR II has four safety-related batteries, each of which has two chargers so that charger maintenance does not require use of cross-connections nor cause draw-down on the battery.

15.E.10A.1 dc RELIABILITY (Continued)

(2) NUREG-0666 addresses testing and maintenance activities. These are accomplished by the Applicant. We agree with these recommendations, and the GESSAR II design allows their implementation.

(3) NUREG-0666 requires staggered test and maintenance activities to minimize the potential for human error related common cause failure. This is controlled in the field, but we agree that these actions are appropriate.

(4) NUREG-0666 requires design and operational features adequate enough to maintain reactor core cooling in the hot standby condition following the loss of any one dc power bus and a single independent failure of any other system required for shutdown cooling. Although we cannot disagree with the intent of this recommendation, a judgment as to what features are needed should be tempered with an assessment of the reliability of the dc power loads and sources. We have concentrated on maintaining full separation and independence between Division 1 and Division 2 dc systems to provide this reliability. With four independent dc systems and with three independent ac systems, the GESSAR II design shows substantial capability in meeting the NUREG-0666 recommendation. For example, a potentially adverse capability loss would follow from the loss of both residual heat removal (RHR) Systems, but the suppression pool can store decay heat for several hours, during which time it may be possible to recover active decay heat removal.

15.E.10A.2 GRID RELIABILITY

Question: What is the Applicant's assessment of grid reliability and what procedures exist for restoring off-site power to the plant in the event of this loss.

Response: The grid is the responsibility of the Applicant, and we assume he will meet the NRC requirements in this area. On loss of normal preferred off-site power, there is automatic transfer to the alternate off-site power source and, if necessary, to the on-site diesel generators. Restoring preferred power is accomplished manually by the control room operator. The specific procedures for restoration of power in the switchyard of transmission systems would be developed by the Applicant.

Station Blackout Analysis

Question: What are the results of the Applicant's station blackout analyses? Has the Applicant made a best-estimate analysis of the accident sequence and evaluated what might be done to improve the plant, or has a conservative analysis been made with a core melt assumed after some specified degradation of the battery?

Response: This evaluation responds to both questions. Our best-estimate analysis to the extent that it is complete is the primary subject of this supplement. We have identified potential system design and procedural improvements, and we will implement them upon concurrence from the NRC that these improvements satisfactorily resolve the issue. Our probabilistic risk assessment considered station blackout capability in a conservative manner [core cooling lost in 2 hours because of battery depletion and loss of reactor core isolation cooling (RCIC) control]. We believe that the more realistic treatment considering automatic and manual dc load shedding shows a substantially longer capability.

15.E.10A.3 DIESEL GENERATORS

Question: What is the Applicant's assessment of his diesel generator system? To what extent has License Event Report (LER) and operating experiences been used to improve the design?

Response: Our high pressure core spray (HPCS) diesel generator has undergone extensive testing (including 300 tests without failure) which has been documented for the NRC. From this testing and from field experience we have high confidence in the design. Extensive review of the design specification, the installation design and the auxiliary system design for the larger diesel generators (Divisions 1 and 2) demonstrates high availability from these units.

15.E.10A.4 LOW POWER TESTING/SIMULATED LOSS OF OFF-SITE POWER

Question: Has the Applicant performed low power testing and a simulated loss of off-site power test? If so, what are the results and what has the Applicant learned?

Response: This is the responsibility of the Applicant.

ATTACHMENT B TO APPENDIX 15.E.10

RCIC ROOM HEATUP DURING A STATION BLACKOUT

ATTACHMENT B

RCIC ROOM HEATUP DURING A STATION BLACKOUT

15.E.10B.1 PURPOSE

The purpose of this attachment is to document the results of analysis of the Reactor Core Isolation Cooling (RCIC) System room temperature response during a station blackout for GESSAR II. The results indicate that a station blackout imposes no threat to the operation of RCIC with the RCIC room temperature reaching 122°F 12 hours into the transient, well below the point above which RCIC performance would be degraded. Sensitivity results for some of the most important parameters are also given.

15.E.10B.2 INTRODUCTION

A station blackout results in loss of all ac power (both off-site and on-site sources), initiating reactor isolation and scram. For this analysis all three diesel generators of a BWR plant are assumed inoperative, i.e., no Emergency Core Cooling System (ECCS) pumps are available: this leaves the battery operated RCIC as the only system available for core cooling. Thus, it is essential that the RCIC remains operational. An important requirement for the proper functioning of the RCIC is that the RCIC room temperature be maintained below the level at which the RCIC equipment has been qualified (212°F from 0 to 6 hours; 150°F from 6 to 12 hours).

The loss of all ac power also means the loss of lighting, auxiliary equipment operation, area HVAC and drywell fan coolers, resulting in a drywell heatup. At some point, reactor depressurization will be initiated to reduce the heat input to the drywell, although the reactor is assumed to be depressurized only to the point sufficiently above the RCIC shutoff pressure so that operation of the RCIC can be maintained.

15.E.10B.2 INTRODUCTION (Continued)

The RCIC initially draws water from the condensate storage tank (CST). However, an automatic switchover to the suppression pool as the water source would occur if the CST water level drops too low or the suppression pool water level rises above a certain point. Since the suppression pool heats up as a result of SRV discharges and subsequent reactor depressurization, and since the design temperature for the RCIC pump is 140°F, a manual switch back to the CST from the suppression pool as the RCIC water source is required when the pool temperature approaches 140°F. Since the time period when the RCIC takes suction from the suppression pool is relatively short (about 30 minutes) compared to the transient period of interest (up to 20 hours), the impact on RCIC room temperature, assuming that RCIC draws all water from the CST, is insignificant.

15.E.10B.3 MODELING AND ASSUMPTIONS

To model the RCIC room temperature response, thermodynamic properties of steam and air in the room are evaluated based on mass and energy balances. Heat sources and heat sinks were considered. In addition, some steam has leaked into the room through the RCI turbine gland seal. The room is conservatively assumed to be isolated from the adjacent rooms.

15.E.10B.3.1 Heat Sources

The following heat sources are modeled:

(1) Steam Pipes. There is a 6-in. steam pipe upstream of the RCIC turbine, 60-ft long, with 3 inches of insulation with the pipe temperature assumed equal to the reactor steam temperature of 552°F under normal operating conditions, and 388°F after reactor depressurization to 200 psig. There is also a 16-in. exhaust steam pipe downstream of the RCIC turbine, 40-ft long, with 2 inches of insulation, with pipe temperature at 250°F because steam pressure downstream of the turbine is held at 25 psia.

(2) Water Pipes. Two uninsulated water pipes, one suction pipe and the other discharge pipe, with dimensions of 8 in. x 38 ft and 6 in. x 36 ft, carry water from the water source and inject it into the reactor. As mentioned previously, the water source may be either the CST or the suppression pool, thus the water temperature may vary from the CST temperature of 90°F up to the suppression pool temperature. Depending on the RCIC room temperature at a particular time, these water pipes may be either heat sources or heat sinks.

15.E.10B.3.1 Heat Sources (Continued)

(3) Turbine. The RCIC turbine is insulated. The turbine temperature is taken as the average upstream and downstream steam temperatures. Small portions of turbine that are not insulated are not modeled.

(4) RCIC Pump. The RCIC pump weighs 6600 lbm and is not insulated. As in the case of water pipes, the RCIC pump may become a heat sink depending on the room temperature and the water temperature.

15.E.10B.3.2 Heat Sinks

The following heat sinks are modeled:

(1) Concrete Walls, Floor and Ceiling. The walls are 26-ft tall, with widths varying from 18 to 31 feet. Thicknesses vary from 1 to 3 feet. These structures were conservatively assumed to be insulated on the outer surface.

(2) Turbine Base Plate. It weighs 900 lbm and is uninsulated.

(3) Room Cooler. It weighs 2000 lbm and is uninsulated.

(4) As mentioned previously, the water pipes and RCIC pump become heat sinks if the RCIC room temperature is higher than the RCIC water temperature.

15.E.10B.3.3 Analytical Assumptions

The following assumptions were made in the analysis, with justifications for these assumptions given subsequently:

(1) Air and steam are uniformly mixed at all times.

(2) Air behaves like an ideal gas.

(3) No condensation on structural surfaces.

(4) The RCIC room is isolated from the surroundings.

(5) Heat conduction is one-dimensional through structures and walls.

Since the period of interest is several hours, steam leaked into the room has sufficient time to diffuse and mix with air; therefore, the uniform mixing assumption is a good approximation. Also, since only low pressures and temperatures are encountered, the ideal gas law holds true for air.

Assumption of no condensation on structural surfaces is conservative because the free-convection heat transfer coefficient used in the absence of condensation is smaller than the condensing heat transfer coefficient. Isolating the RCIC room is another conservatism, because mass and energy are prevented from leaving the room through conduction, convection and radiation. Finally, the one-dimensional heat conduction assumption is correct, except at the corners of the walls, but the impact is negligible.

15.E.10B.4 INPUT PARAMETERS

The following initial conditions and key parameters were used in the analysis:

(1) Initial room temperature was 90°F.

(2) Steam leakage rate was 70 lbm/hr.

(3) No reactor depressurization for the first 30 minutes (as the operator is trying to determine appropriate actions) and the reactor was cooled down at 100°F/hr.

(4) Temperature of RCIC water was 90°F, which is the technical specification CST temperature, because the RCIC can take suction from the suppression pool for only a short period of time and the operator will switch the suction back to the CST as the pool approaches 140°F.

15.E.10B.5 RESULTS AND DISCUSSIONS

The RCIC room temperature response following a station blackout is given in Figure 15.E.10B-1. The temperature increases rapidly during the first hour of the transient, then the rate of increase levels off subsequently. The room temperature rises to 119°F at 8 hours of transient and 122°F at 12 hours of transient.

Shown in Figures 15.E.10B-2 and 15.E.10B-3 are the sensitivity results at high water temperature and low steam leakage rate, respectively. With the water temperature at 140°F, the RCIC room temperature rises to 133°F at 12 hours, while at the steam leakage rate of 10 lbm/hr (which corresponds to new turbine gland seal condition) the room temperature reaches only 101°F at 12 hours. The high sensitivity to the steam leakage rate is due to the large latent heat of steam which is released upon

15.E.10B.5 RESULTS AND DISCUSSIONS (Continued)

condensing in the RCIC room. The sensitivity study also indicates that there is no impact of reactor cooldown rate on the RCIC room temperature response.

The above results indicate that the RCIC room temperature 12 hours following a station blackout is substantially below the equipment qualification limits of 212°F for the first 6 hours and 150°F between 6 and 12 hours following a station blackout. This shows that proper operation of the RCIC can be maintained for many hours during a station blackout to provide adequate core cooling.

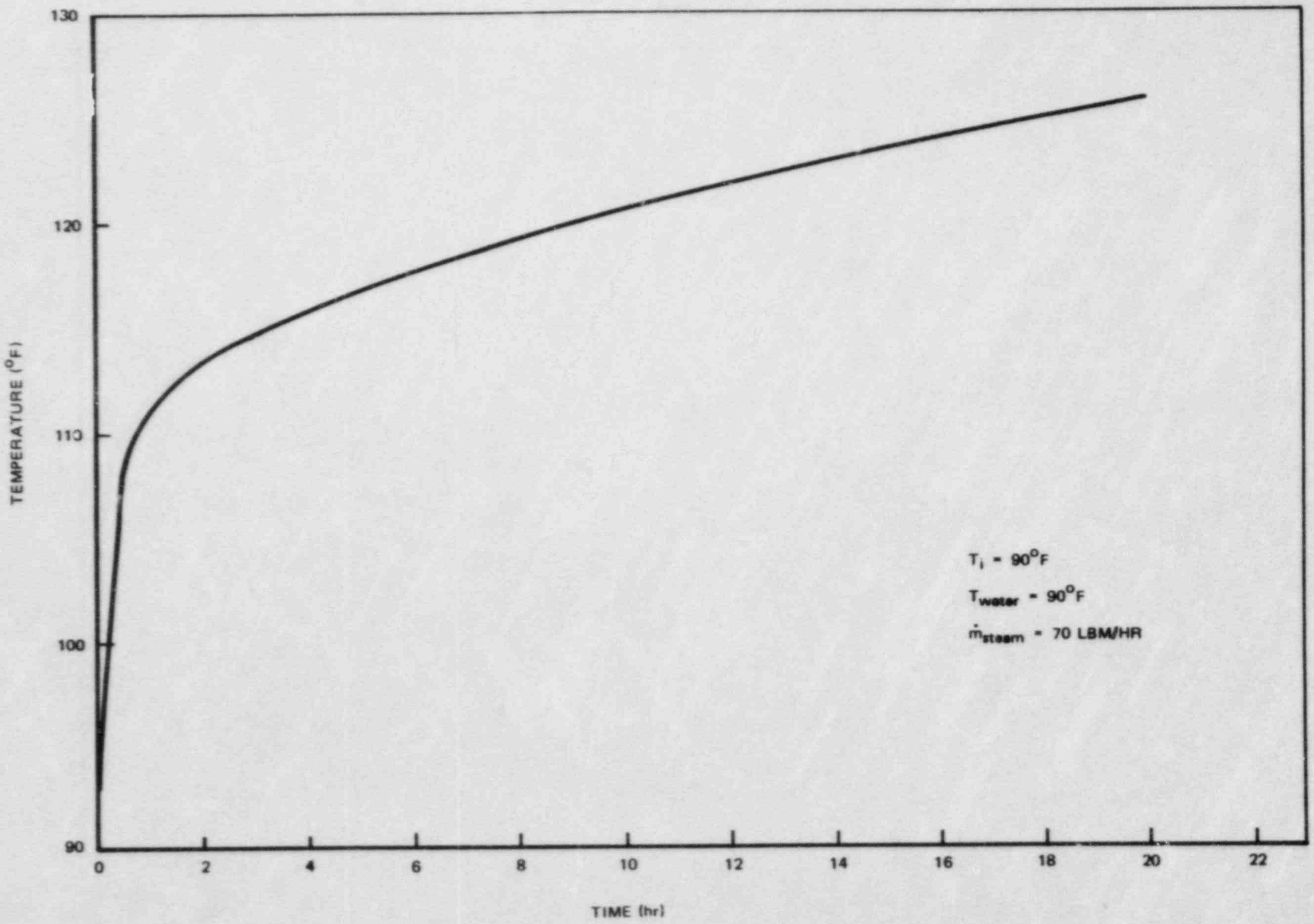

Figure 15.E.10B-1. RCIC Room Temperature Response Following a Station Blackout

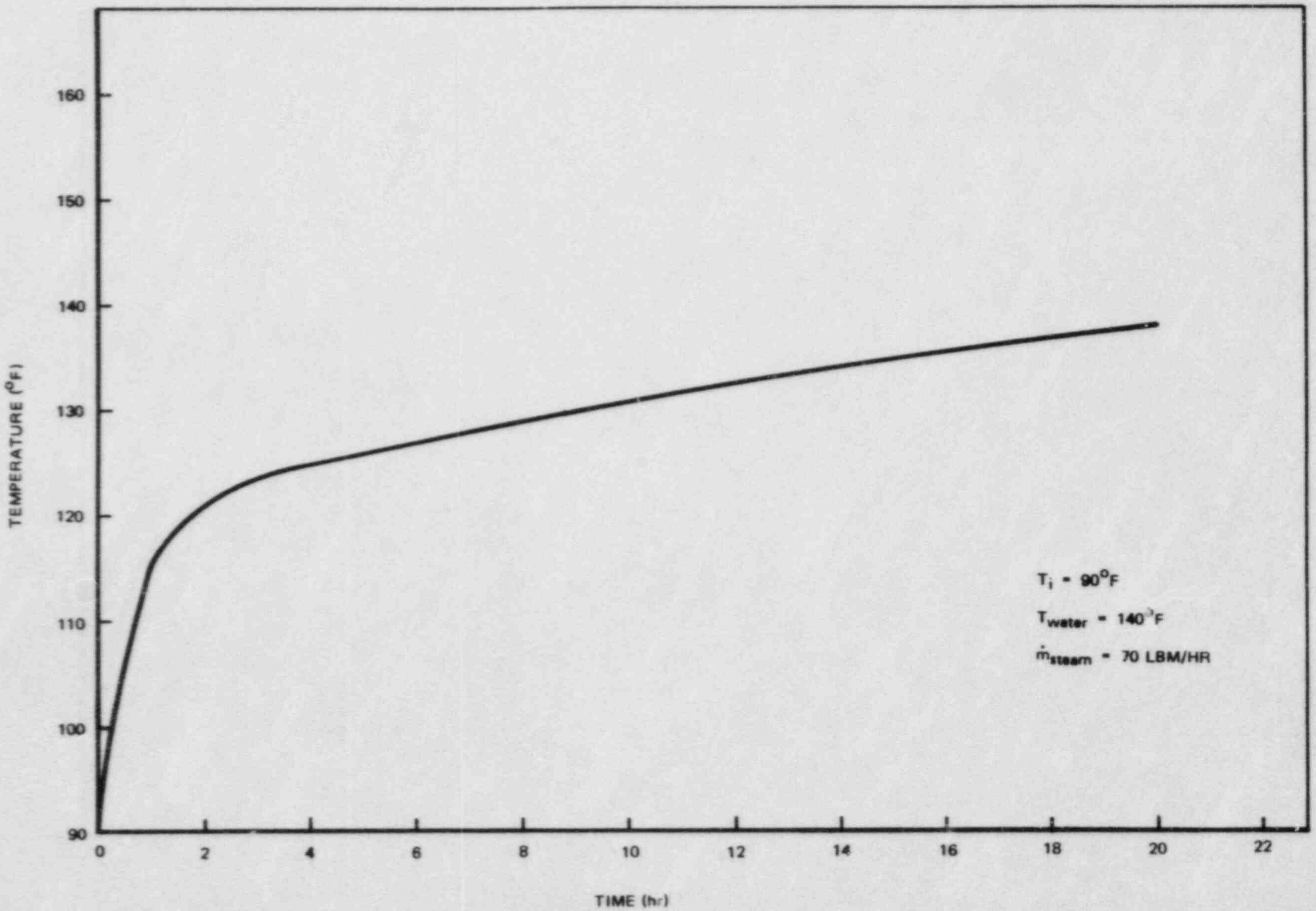

Figure 15.E.10B-2. RCIC Room Temperature Response Following a Station Blackout - Sensitivity to High Water Temperature

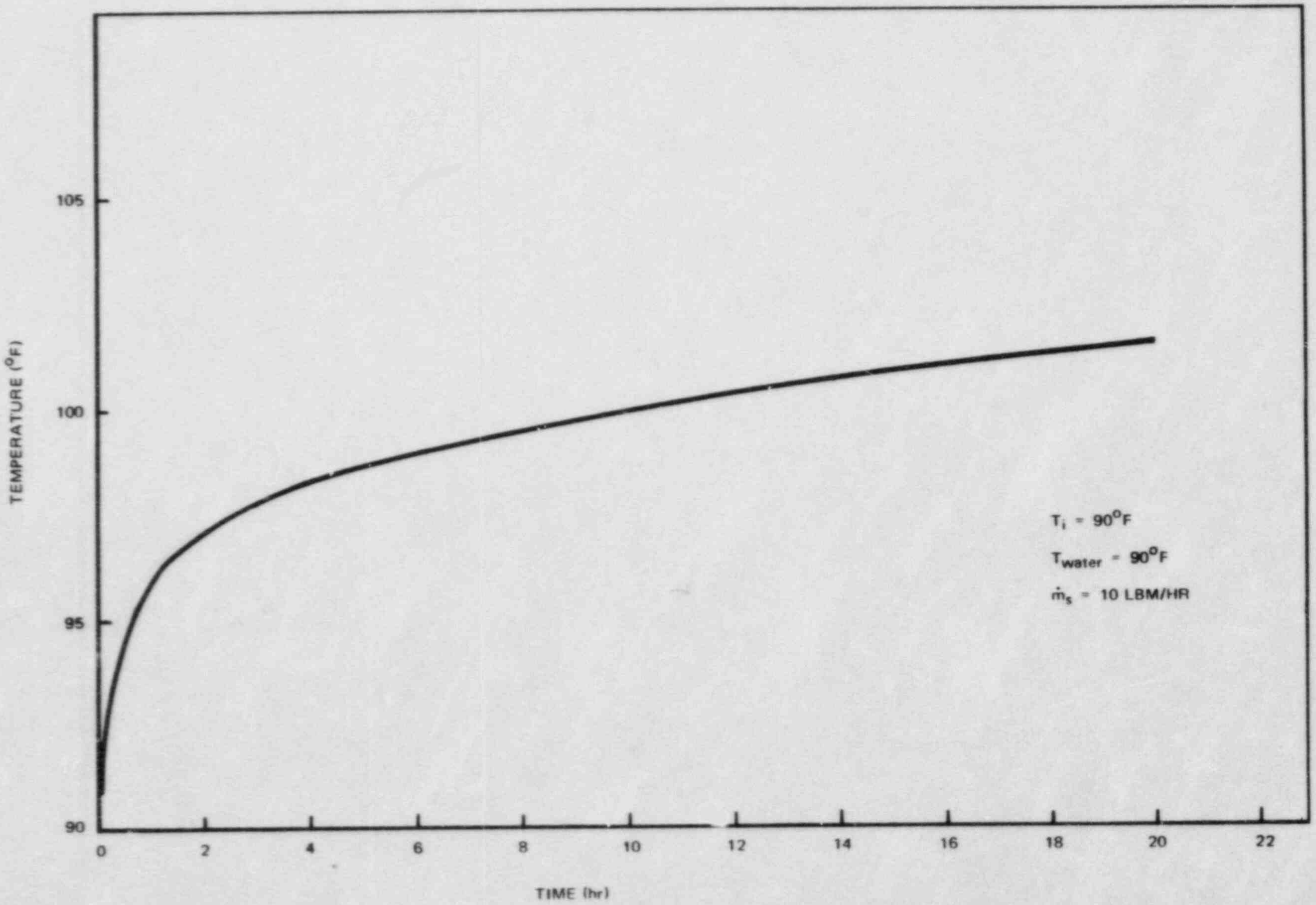

Figure 15.E.10B-3. RCIC Room Temperature Response Following a Station Blackout - Sensitivity to Low Steam Leakage Rate

GESSAR II SESIMIC EVENT
UNCERTAINTY ANALYSIS

GENERAL ELECTRIC COMPANY

DECEMBER 1983

GE PROPRIETARY - provided under separate cover

Table 2-1

PARTICIPANTS IN SURVEY

(in alphabetical, not numerical, order)

Professor Bruce A. Bolt

Department of Geology and Geophysics
University of California, Berkeley

Professor David M. Boore

Department of Geophysics
Stanford University

Professor Nathan M. Newmark

Department of Civil Engineering
University of Illinois at Urbana

Professor Benjamin M. Page

Department of Geology
Stanford University

Professor Stewart W. Smith

Graduate Program in Geophysics
University of Washington, Seattle

Professor George Thompson

Department of Geology
Stanford University

Professor James T. Wilson

Institute of Science and Technology
University of Michigan, Ann Arbor

Table 2-2

LIST OF SITES

No.	Site Name	(State)
1	Brunswick	(North Carolina)
2	Cooper	(Nebraska)
3	Davis Besse	(Ohio)
4	Diablo Canyon	(California)
5	Grand Gulf	(Mississippi)
6	Pilgrim	(Massachusetts)
7	Rancho Seco	(California)
8	River Bend	(Louisiana)
9	Summer	(South Carolina)
10	Summit	(Delaware)
11	Trojan	(Oregon)

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1.5 EXTRACT FROM UCLA-ENG-7515

This portion of the Appendix contains an extract from a report by D. Okrent entitled "A Survey of Expert Opinion on Low Probability Earthquakes (UCLA-ENG-7515)" and dated February 1975. Tables 1 and 2 give the names of the experts participating in the survey and the sites studied. Table 3 provides the site questionaire used in the survey. The site-by-site probability estimates are included in the remaining tables.

Table 1

PARTICIPANTS IN SURVEY

(in alphabetical, not numerical, order)

Professor Bruce A. Bolt

Department of Geology and Geophysics
University of California, Berkeley

Professor David M. Boore

Department of Geophysics
Stanford University

Professor Nathan M. Newmark

Department of Civil Engineering
University of Illinois at Urbana

Professor Benjamin M. Page

Department of Geology
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Professor Stewart W. Smith

Graduate Program in Geophysics
University of Washington, Seattle

Professor George Thompson

Department of Geology
Stanford University

Professor James T. Wilson

Institute of Science and Technology
University of Michigan, Ann Arbor

Table 2

LIST OF SITES

No.	Site Name	(State)
1	Brunswick	(North Carolina)
2	Cooper	(Nebraska)
3	Davis Besse	(Ohio)
4	Diablo Canyon	(California)
5	Grand Gulf	(Mississippi)
6	Pilgrim	(Massachusetts)
7	Rancho Seco	(California)
8	River Bend	(Louisiana)
9	Summer	(South Carolina)
10	Summit	(Delaware)
11	Trojan	(Oregon)

Table 3

SITE QUESTIONNAIRE[†]

1. Name of Site.
2. What are the probabilities of occurrence per year (or recurrence interval) of a free field earthquake at foundation level?

a)

MM Intensity	Probability/Year	Uncertainty
V		
VI		
VII		
VIII		
IX		
X		
XI		
XII		

b)

Peak Horizontal Ground Acceleration	Probability/Year	Uncertainty
0.05 g[*]		
0.10 g		
0.15 g		
0.20 g		
0.25 g		
0.30 g		
0.40 g		
0.50 g		
0.60 g		
0.80 g		
1.0 g		
> 1.1 g		

3. a) What is the dominant frequency band of the earthquake having a probability of one in 10^6/year that produces the largest vibratory effects at the site?

   b) What is the probable duration of that frequency band?
4. What relation between MM intensity and ground acceleration would you suggest or have you used for this site?
5. Was the presence of a nearby fault dominant in your evaluation of the site? Comment.
6. Was a particular tectonic structure or province significant in your evaluation of the site? Comment.
7. Was seismic history significant or dominant in your evaluation of the site? Comment.
8. Are your lower probability earthquakes (e.g., one in 10^6/year) determined by the geology and seismic activity of the region or by other considerations? Comment.
9. What ratio of peak vertical to peak horizontal acceleration would you estimate to be applicable (with what uncertainty)?
10. What information not included in the site geologic and seismic description was important to your evaluation?

---

[*] For example, 0.05 g could be taken as representing the interval $0.025\ g < a < 0.075\ g$.

[†] Some participants will choose to omit some categories (or even some sites) in their responses.

BRUNSWICK

Respondent No.	1	2*	3	4	5	6	7
MM Intensity	Probability per Year						
V	10^{-2}		10^{-2}	7×10^{-2}			10^{-2}
VI	10^{-2}		10^{-4}	10^{-2}	5×10^{-3}		10^{-3}
VII	10^{-3}		10^{-6}	10^{-3}	3×10^{-3}		10^{-5}
VIII	10^{-5}			5×10^{-7}	10^{-3}	10^{-6}	10^{-6}
IX	10^{-7}				10^{-4}		10^{-7}
X	10^{-8}				10^{-5}		10^{-8}
XI	10^{-8}				10^{-6}		$<10^{-8}$
XII	10^{-8}						$<10^{-8}$
Peak Horizontal Acceleration	Probability per Year						
.05G	10^{-2}		10^{-4}	8×10^{-3}			10^{-2}
.1g	10^{-3}		10^{-5}	2×10^{-3}			10^{-3}
.15g	10^{-4}		10^{-6}	3×10^{-4}			10^{-5}
.2g	10^{-5}	$<3\times10^{-5}$		6×10^{-5}	2×10^{-3}	10^{-6}	10^{-5}
.25g	3×10^{-6}			6×10^{-6}	10^{-3}		10^{-6}
.3g	10^{-6}			8×10^{-7}	5×10^{-4}		10^{-6}
.4g	4×10^{-7}	$<2\times10^{-5}$					10^{-7}
.5g	10^{-7}				10^{-4}		10^{-7}
.6g	3×10^{-8}	$<10^{-5}$					10^{-7}
.8g	10^{-8}	$<7\times10^{-6}$					10^{-7}
1.0g	10^{-8}	$<3\times10^{-6}$			10^{-5}		10^{-8}
>1.1g	10^{-8}				10^{-6}		10^{-8}
Dominant Frequency and Duration for 10^{-6}/year Earthquake							
Cycles/sec	2		1-2	2-5		1/3-10	
Seconds	10		5	15		20	

*Probabilities per year are for accelerations greater than the size indicated.

COOPER

Respondent No.	1	2*	3	4	5	6	7
MM Intensity	Probability per Year						
V	10^{-2}			10^{-1}	10^{-2}		10^{-3}
VI	10^{-3}		10^{-2}	3×10^{-2}	5×10^{-3}		10^{-5}
VII	10^{-4}		10^{-6}	5×10^{-3}	2×10^{-3}	10^{-6}	10^{-7}
VIII	10^{-6}			5×10^{-5}	10^{-4}		10^{-8}
IX	10^{-8}			5×10^{-9}	10^{-6}		$<10^{-8}$
X	10^{-8}						$<10^{-8}$
XI	10^{-8}						$<10^{-8}$
XII	10^{-8}						$<10^{-8}$
Peak Horizontal Acceleration	Probability per Year						
.05g	10^{-2}		10^{-3}	2×10^{-2}	5×10^{-3}		10^{-3}
.1g	10^{-3}	10^{-4}	10^{-6}	4×10^{-3}			10^{-5}
.15g	10^{-4}			10^{-3}	2×10^{-3}	10^{-6}	10^{-5}
.2g	10^{-5}	6×10^{-5}		4×10^{-4}	5×10^{-4}		10^{-6}
.25g	3×10^{-6}			10^{-4}	1×10^{-4}		10^{-7}
.3g	10^{-6}			4×10^{-5}			10^{-7}
.4g	4×10^{-7}	4×10^{-5}		8×10^{-7}			10^{-7}
.5g	10^{-7}				10^{-6}		10^{-8}
.6g	3×10^{-8}	2×10^{-5}					10^{-8}
.8g	10^{-8}	10^{-5}					$<10^{-8}$
1.0g	10^{-8}	$<3\times10^{-6}$					$<10^{-8}$
>1.1g	10^{-8}						$<10^{-8}$
Dominant Frequency and Duration for 10^{-6}/year Earthquake							
Cycles/sec	3	3-5	2-5	2-5		1/3-10	
Seconds	5		3-5	15		20	

*Probabilities per year are for accelerations greater than the size indicated.

DAVIS BESSE

Respondent No.	1	2*	3	4	5	6	7
MM Intensity	Probability per Year						
V	10^{-1}		10^{-2}	7×10^{-2}	10^{-2}		10^{-2}
VI	10^{-2}		10^{-3}	10^{-2}	5×10^{-3}		10^{-4}
VII	10^{-2}		10^{-6}	10^{-3}	10^{-3}	10^{-6}	10^{-6}
VIII	10^{-3}			5×10^{-7}	10^{-5}		10^{-7}
IX	10^{-5}				10^{-6}		10^{-8}
X	10^{-6}						$<10^{-8}$
XI	10^{-8}						$<10^{-8}$
XII	10^{-8}						$<10^{-8}$
Peak Horizontal Acceleration	Probability per Year						
.05g	10^{-1}		10^{-5}	8×10^{-3}	5×10^{-3}		10^{-2}
.1g	10^{-1}	10^{-4}	10^{-6}	2×10^{-3}			10^{-4}
.15g	10^{-1}			3×10^{-4}	10^{-3}	10^{-6}	10^{-5}
.2g	10^{-1}	8×10^{-5}		6×10^{-5}			10^{-6}
.25g	10^{-2}			6×10^{-6}	10^{-5}		10^{-6}
.3g	10^{-2}			8×10^{-7}			10^{-7}
.4g	10^{-3}	5×10^{-5}					10^{-7}
.5g	10^{-5}				10^{-6}		10^{-8}
.6g	10^{-6}	3×10^{-5}					$<10^{-8}$
.8g	10^{-7}	2×10^{-5}					$<10^{-8}$
1.0g	10^{-8}	1×10^{-5}					$<10^{-8}$
>1.1g	10^{-8}						$<10^{-8}$
Dominant Frequency and Duration for 10^{-6}/year Earthquake							
Cycles/sec	2	1-3	1-3	2-15		1/3-10	
Seconds	10	5	5	15		<20	

*Probabilities per year are for accelerations greater than the size indicated.

DIABLO CANYON

Respondent No.	1	2*	3	4	5	6	7
MM Intensity				**Probability per Year**			
V				10^{-1}			10^{-1}
VI			10^{-1}	4×10^{-2}	10^{-6}		10^{-1}
VII			10^{-2}	2×10^{-2}	5×10^{-3}		10^{-2}
VIII			10^{-3}	5×10^{-3}	3×10^{-3}		10^{-3}
IX			10^{-5}	10^{-4}	10^{-4}		10^{-6}
X			10^{-6}	10^{-5}	2×10^{-6}		10^{-7}
XI				2×10^{-6}	10^{-6}		$<10^{-7}$
XII							$<10^{-7}$
Peak Horizontal Acceleration				**Probability per Year**			
.05g		5×10^{-3}	10^{-2}	4×10^{-2}			10^{-1}
.1g		2×10^{-3}	10^{-3}	2×10^{-2}	10^{-2}		10^{-1}
.15g			10^{-3}	7×10^{-3}	5×10^{-3}		10^{-2}
.20g		1×10^{-3}	10^{-3}	3×10^{-3}	3×10^{-3}		10^{-2}
.25g			10^{-3}	2×10^{-3}	3×10^{-3}		10^{-3}
.3g			10^{-4}	10^{-3}	10^{-3}		10^{-3}
.4g		6×10^{-4}	10^{-4}	3×10^{-4}	2×10^{-4}		10^{-5}
.5g			10^{-6}	7×10^{-5}	10^{-4}		10^{-6}
.6g		3×10^{-4}		10^{-6}	2×10^{-5}		10^{-7}
.8g		2×10^{-4}		10^{-8}	10^{-5}		$<10^{-7}$
1.0g		10^{-5}			2×10^{-6}		$<10^{-7}$
>1.1g					10^{-6}		$<10^{-7}$
Dominant Frequency and Duration for 10^{-6}/year Earthquake							
Cycles/sec		5	5-8	2-5			
Seconds			17	15			

*Probabilities per year are for accelerations greater than the size indicated.

GRAND GULF

Respondent No.	1	2*	3	4	5	6	7
MM Intensity				Probability per Year			
V	10^{-2}			2×10^{-2}	5×10^{-3}		10^{-2}
VI	3×10^{-3}		10^{-3}	5×10^{-3}	3×10^{-3}		10^{-4}
VII	10^{-3}		10^{-5}	5×10^{-5}	10^{-3}		10^{-6}
VIII	3×10^{-5}		10^{-6}	5×10^{-8}	10^{-5}		10^{-7}
IX	10^{-6}				10^{-6}		10^{-8}
X	10^{-7}						$<10^{-8}$
XI	10^{-8}						$<10^{-8}$
XII	10^{-8}						$<10^{-8}$
Peak Horizontal Acceleration				Probability per Year			
.05g	10^{-2}	2×10^{-4}	10^{-3}	4×10^{-3}	3×10^{-3}		10^{-2}
.1g	10^{-3}	2×10^{-5}	10^{-4}	4×10^{-4}			10^{-4}
.15g	10^{-4}		10^{-6}	4×10^{-5}	10^{-3}		10^{-5}
.2g	10^{-5}		10^{-6}	10^{-6}	10^{-4}		10^{-6}
.25g	10^{-6}		10^{-6}	6×10^{-8}	10^{-5}		10^{-6}
.3g	5×10^{-7}						10^{-7}
.4g	10^{-7}						10^{-7}
.5g	5×10^{-8}				10^{-6}		10^{-7}
.6g	3×10^{-8}						10^{-8}
.8g	10^{-8}						$<10^{-8}$
1.0g	10^{-8}						$<10^{-8}$
>1.1g	10^{-8}						$<10^{-8}$
Dominant Frequency and Duration for 10^{-6}/year Earthquake							
Cycles/sec	1		1-2	1-3			
Seconds	15			20			

*Probabilities per year are for accelerations greater than the size indicated.

PILGRIM

Respondent No.	1	2*	3	4	5	6	7
MM Intensity	**Probability per Year**						
V	10^{-3}		10^{-2}	7×10^{-2}			10^{-2}
VI	10^{-4}		10^{-4}	10^{-2}	5×10^{-3}		10^{-3}
VII	3×10^{-5}		10^{-6}	10^{-3}	3×10^{-3}		10^{-6}
VIII	10^{-5}		10^{-6}	5×10^{-7}	2×10^{-3}	10^{-6}	10^{-7}
IX	10^{-7}				10^{-3}		10^{-8}
X	2×10^{-8}				10^{-5}		$<10^{-8}$
XI	10^{-8}				10^{-6}		$<10^{-8}$
XII	10^{-8}						$<10^{-8}$
Peak Horizontal Acceleration	**Probability per Year**						
.05g	10^{-1}		10^{-4}	8×10^{-3}	5×10^{-3}		10^{-2}
.1g	10^{-2}		10^{-6}	2×10^{-3}			10^{-3}
.15g	10^{-3}			3×10^{-4}	3×10^{-3}		10^{-4}
.2g	10^{-4}	2×10^{-4}		6×10^{-5}			10^{-6}
.25g	10^{-5}			6×10^{-6}	2×10^{-3}	10^{-6}	10^{-6}
.3g	4×10^{-6}			8×10^{-7}			10^{-7}
.4g	3×10^{-7}	1×10^{-4}					10^{-7}
.5g	10^{-7}				10^{-3}		10^{-8}
.6g	2×10^{-8}	8×10^{-5}			3×10^{-4}		$<10^{-8}$
.8g	10^{-8}	4×10^{-5}			10^{-4}		$<10^{-8}$
1.0g	10^{-8}	2×10^{-5}			10^{-5}		$<10^{-8}$
>1.1g	10^{-8}				10^{-6}		$<10^{-8}$
Dominant Frequency and Duration for 10^{-6}/year Earthquake							
Cycles/sec	3	5	2-5	2-15		1/3-10	
Seconds	25		5-10	15		20-30	

*Probabilities per year are for accelerations greater than the size indicated.

RANCHO SECO

Respondent No.	1	2*	3	4	5	6	7
MM Intensity			**Probability per Year**				
V	10^{-1}		10^{-2}	3×10^{-1}	2×10^{-1}		10^{-1}
VI	3×10^{-2}		10^{-3}	7×10^{-2}	4×10^{-2}		10^{-1}
VII	10^{-2}		10^{-5}	10^{-2}	3×10^{-3}	10^{-6}	10^{-4}
VIII	2×10^{-4}		10^{-6}	10^{-4}	10^{-4}		10^{-6}
IX	2×10^{-7}		10^{-6}	10^{-8}	10^{-5}		10^{-7}
X	5×10^{-8}				10^{-6}		10^{-8}
XI	10^{-8}						10^{-8}
XII	10^{-8}						10^{-8}
Peak Horizontal Acceleration			**Probability per Year**				
.05g	10^{-1}	6×10^{-3}	10^{-2}	3×10^{-2}	2×10^{-1}		10^{-1}
.1g	5×10^{-2}	2×10^{-3}	10^{-3}	7×10^{-3}	4×10^{-1}		10^{-1}
.15g	10^{-2}		10^{-3}	3×10^{-3}	3×10^{-3}	10^{-6}	10^{-3}
.2g	2×10^{-3}	10^{-4}	10^{-4}	8×10^{-4}	10^{-3}		10^{-4}
.25g	2×10^{-4}		10^{-6}	3×10^{-4}	10^{-4}		10^{-5}
.3g	2×10^{-5}			8×10^{-5}	5×10^{-5}		10^{-6}
.4g	10^{-6}	3×10^{-5}		2×10^{-8}	2×10^{-5}		10^{-6}
.5g	2×10^{-7}				10^{-5}		10^{-7}
.6g	5×10^{-8}	10^{-5}			5×10^{-6}		10^{-7}
.8g	10^{-8}				2×10^{-6}		$<10^{-7}$
1.0g	10^{-8}				10^{-6}		$<10^{-7}$
>1.1g	10^{-8}						$<10^{-7}$
Dominant Frequency and Duration for 10^{-6}/year Earthquake							
Cycles/sec	1		2-5	2-15		1/6-10	
Seconds	25		16-20	15		50	

*Probabilities per year are for accelerations greater than the size indicated.

RIVER BEND

Respondent No.	1	2*	3	4	5	6	7
MM Intensity	Probability per Year						
V	10^{-3}		10^{-3}	2×10^{-2}	10^{-2}		10^{-2}
VI	10^{-4}		10^{-5}	5×10^{-3}	3×10^{-3}	10^{-6}	10^{-4}
VII	3×10^{-5}		10^{-6}	5×10^{-5}	10^{-3}		10^{-6}
VIII	10^{-5}		10^{-6}	5×10^{-8}	10^{-5}		10^{-7}
IX	10^{-7}				10^{-6}		10^{-8}
X	5×10^{-8}						$<10^{-8}$
XI	10^{-8}						$<10^{-8}$
XII	10^{-8}						$<10^{-8}$
Peak Horizontal Acceleration	Probability per Year						
.05g	10^{-1}	2×10^{-4}	10^{-5}	4×10^{-3}	3×10^{-3}		10^{-2}
.1g	10^{-2}	2×10^{-5}	10^{-6}	4×10^{-4}		10^{-6}	10^{-4}
.15g	10^{-3}		10^{-6}	4×10^{-5}	10^{-3}		10^{-5}
.20g	10^{-4}			10^{-6}	10^{-4}		10^{-6}
.25g	10^{-5}			6×10^{-8}	10^{-5}		10^{-6}
.3g	3×10^{-6}						10^{-7}
.4g	4×10^{-7}						10^{-7}
.5g	10^{-7}				10^{-6}		10^{-7}
.6g	5×10^{-8}						10^{-8}
.8g	10^{-8}						10^{-8}
1.0g	10^{-8}						$<10^{-8}$
>1.1g	10^{-8}						$<10^{-8}$
Dominant Frequency and Duration for 10^{-6}/year Earthquake							
Cycles/sec	2	3-5	8-15	1-3		1/6-10	
Seconds	10		5-8	20		50	

*Probabilities per year are for accelerations greater than the size indicated.

SUMMER

Respondent No.	1	2*	3	4	5	6	7
MM Intensity			Probability per Year				
V	10^{-2}		10^{-2}	10^{-1}			10^{-2}
VI	10^{-4}		10^{-3}	3×10^{-2}	5×10^{-3}		10^{-2}
VII	3×10^{-6}		10^{-4}	5×10^{-3}	10^{-3}		10^{-3}
VIII	5×10^{-7}		10^{-6}	5×10^{-5}	10^{-4}	10^{-6}	10^{-4}
IX	10^{-7}			5×10^{-9}	10^{-6}		10^{-7}
X	10^{-8}						10^{-8}
XI	10^{-8}						$<10^{-8}$
XII	10^{-8}						$<10^{-8}$
Peak Horizontal Acceleration			Probability per Year				
.05g	10^{-1}		10^{-3}	2×10^{-2}	5×10^{-3}		10^{-2}
.1g	10^{-2}		10^{-6}	4×10^{-3}			10^{-3}
.15g	10^{-3}			10^{-3}	10^{-3}		10^{-3}
.2g	10^{-4}	3×10^{-5}		4×10^{-4}			10^{-4}
.25g	10^{-5}			10^{-4}	10^{-4}	10^{-6}	10^{-4}
.3g	3×10^{-6}			4×10^{-5}			10^{-4}
.4g	4×10^{-7}	2×10^{-5}		8×10^{-7}	10^{-5}		10^{-5}
.5g	10^{-7}				10^{-6}		10^{-6}
.6g	5×10^{-8}	1×10^{-5}					10^{-8}
.8g	10^{-8}	7×10^{-6}					$<10^{-8}$
1.0g	10^{-8}	3×10^{-6}					$<10^{-8}$
>1.1g	10^{-8}						$<10^{-8}$
Dominant Frequency and Duration for 10^{-6}/year Earthquakes							
Cycles/sec	3	5	5-8	2-5		1/3-15	
Seconds	10		10-15	15		15-20	

*Probabilities per year are for accelerations greater than the size indicated.

SUMMIT

Respondent No.	1	2*	3	4	5	6	7
MM Intensity	Probability per Year						
V	10^{-2}		10^{-3}	10^{-1}	10^{-2}		10^{-2}
VI	10^{-2}		10^{-3}	3×10^{-2}	5×10^{-3}		10^{-3}
VII	10^{-3}		10^{-6}	5×10^{-3}	3×10^{-3}	10^{-6}	10^{-6}
VIII	10^{-5}		10^{-6}	5×10^{-5}	10^{-3}		10^{-7}
IX	10^{-7}			5×10^{-9}	10^{-5}		10^{-8}
X	10^{-8}				10^{-6}		$<10^{-8}$
XI	10^{-8}						$<10^{-8}$
XII	10^{-8}						$<10^{-8}$
Peak Horizontal Acceleration	Probability per Year						
.05g	10^{-2}		10^{-3}	2×10^{-2}	10^{-2}		10^{-2}
.1g	10^{-3}		10^{-5}	4×10^{-3}			10^{-3}
.15g	10^{-4}		10^{-6}	10^{-3}	3×10^{-3}		10^{-4}
.2g	10^{-5}	2×10^{-5}	10^{-6}	4×10^{-4}		10^{-6}	10^{-6}
.25g	3×10^{-6}			10^{-4}	10^{-3}		10^{-6}
.3g	10^{-6}			4×10^{-5}	5×10^{-4}		10^{-7}
.4g	4×10^{-7}	1×10^{-5}		8×10^{-7}	2×10^{-4}		10^{-7}
.5g	10^{-7}				10^{-5}		10^{-7}
.6g	3×10^{-8}	7×10^{-6}					10^{-8}
.8g	10^{-8}	4×10^{-6}					10^{-8}
1.0g	10^{-8}	2×10^{-6}			10^{-6}		$<10^{-8}$
>1.1g	10^{-8}						$<10^{-8}$
Dominant Frequency and Duration for 10^{-6}/year Earthquake							
Cycles/sec	2	3	5-8	2-5		1/3-15	
Seconds	10		10-15	15		30	

*Probabilities per year are for accelerations greater than the size indicated.

TROJAN

Respondent No.	1	2*	3	4	5	6	7
MM Intensity				**Probability per Year**			
V	10^{-1}		10^{-2}	3×10^{-1}	5×10^{-2}		10^{-1}
VI	10^{-2}		10^{-3}	7×10^{-2}	3×10^{-2}		10^{-2}
VII	10^{-3}		10^{-3}	10^{-2}	5×10^{-3}		10^{-3}
VIII	10^{-5}		10^{-6}	10^{-4}	2×10^{-3}	10^{-6}	10^{-4}
IX	10^{-6}		10^{-6}	10^{-9}	10^{-4}		10^{-6}
X	10^{-7}				10^{-6}		10^{-8}
XI	10^{-8}						$<10^{-8}$
XII	10^{-8}						$<10^{-8}$
Peak Horizontal Acceleration				**Probability per Year**			
.05g	10^{-1}		10^{-2}	3×10^{-1}	5×10^{-2}		10^{-2}
.1g	10^{-1}	10^{-3}	10^{-3}	7×10^{-3}	3×10^{-2}		10^{-3}
.15g	10^{-2}	10^{-4}	10^{-4}	3×10^{-3}	5×10^{-3}		10^{-3}
.2g	10^{-2}		10^{-6}	8×10^{-4}	3×10^{-3}		10^{-3}
.25g	3×10^{-3}		10^{-6}	3×10^{-4}	2×10^{-3}	10^{-6}	10^{-4}
.3g	10^{-3}			8×10^{-5}	1×10^{-3}		10^{-4}
.4g	10^{-5}	4×10^{-5}		1.6×10^{-8}	2×10^{-4}		10^{-5}
.5g	10^{-6}				10^{-4}		10^{-6}
.6g	10^{-7}	2×10^{-5}					10^{-7}
.8g	10^{-8}	7×10^{-6}					10^{-8}
1.0g	10^{-8}	3×10^{-6}					$<10^{-8}$
>1.1g	10^{-8}						$<10^{-8}$
Dominant Frequency and Duration for 10^{-6}/year Earthquake							
Cycles/sec	1	5	1-5	2-5		1/4-10	
Seconds	15		few	15		30	

*Probabilities per year are for accelerations greater than the size indicated.

GE PROPRIETARY - provided under separate cover

APPENDIX 15.E.12

RESPONSES TO REQUEST FOR ADDITIONAL INFORMATION

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DRAFT FOR PUBLIC REVIEW

NUREG/CR-1278

SAND80-0200

HANDBOOK OF HUMAN RELIABILITY ANALYSIS WITH EMPHASIS ON NUCLEAR POWER PLANT APPLICATIONS

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This work was prepared for and supported by
Office of Nuclear Regulatory Research
United States Nuclear Regulatory Commission
Washington, DC 20555

Under Interagency Agreement DOE40-550-75
NRC FIN No. A-1188

For information on obtaining copies, contact Division of Technical Information and Document Control, U.S. NRC, Wash. D.C. 20555

Manual Operation of Controls (Chapter 12)

Manual operation of controls includes the operation of all kinds of switches, connectors, and valves. Table 20-13 applies to controls other than valves and lists errors of commission only. For errors of omission, use the applicable HEPs in the subsequent tables on valves. If controls are handled as pairs, assume CD between them. The effects of tagging are described in the following section, "Valves."

Table 20-13. Probabilities of Errors of Commission in Operating Manual Controls (from Table 12-1)

Task	HEP
Select wrong control in a group of identical controls identified by labels only	.003 (.001 to .01)
Select wrong controls from a functionally grouped set of controls	.001 (.0005 to .005)
Select wrong control from a panel with clearly drawn mimic lines	.0005 (.0001 to .001)
Turn control in wrong direction (no violation of populational stereotypes)	.0005 (.0001 to .001)
Turn control in wrong direction under normal operating conditions (violation of a strong populational stereotype)	.05 (.01 to .1)
Turn control in wrong direction under high stress (violation of a strong populational stereotype)	.5 (.1 to .9)
Set a multiposition selector switch to an incorrect setting	.001 (.0001 to .1)
Improperly mate a connector	.01 (.005 to .05)

GE PROPRIETARY - provided under separate cover

APPENDIX 15.E.13

RESPONSES TO REQUEST FOR ADDITIONAL INFORMATION

GE PROPRIETARY - provided under separate cover

QUESTION 16. What are the capacities of 3 hour fire walls planned for GESSAR II plants? What are their locations with respect to the nearby safety-related equipment?

RESPONSE

The 3 hour fire walls in GESSAR II are primarily concrete walls as noted in Appendix 3A of GESSAR II. There are also Type 1 3 hour walls described in A.3.6 of GESSAR II. These walls are primarily located in the building corridors and are designed with 6-in. metal studs of 12 in. on center with three layers of 5/8-in. firecode gypsum board on each side of the studs. The design is adapted from ICBO 1495 for a 3-hr partition. The only deviation from the standard is that the gage thickness of the structural members has been increased to meet the plant seismic requirements.

GE PROPRIETARY - provided under separate cover

APPENDIX 15.E.14

SOURCE TERM SENSITIVITY STUDY

GE PROPRIETARY - provided under separate cover

GESSAR II EXTERNAL EVENT RISK

1. INTRODUCTION

In Reference 1, closure activities for the GESSAR II review in accordance with the proposed Commission Policy on Severe Accidents (Reference 2) were enumerated. One of the issues defined in Reference 1 for additional input by General Electric (GE) included consideration of external events which were not evaluated quantitatively. Heretofore, the NRC staff direction had been to provide quantitative risk evaluation of seismic events and internal fires and floods. GE responded with References 3-5 which provided the required information. In Reference 1 the staff required a qualitative assessment of the risk inherent from such events as hurricanes, tornadoes, external flooding, aircraft strike, hazardous materials impact, and sabotage.

It should be noted that sabotage has already been addressed by GE in Appendix 1F of GESSAR II and, in fact, the staff has already provided draft Safety Evaluation Report (SER) input in Reference 6 for review. In addition, GE provided a summary of sabotage considerations in the review of GESSAR II relative to Unresolved Safety Issue A-29 in Reference 7. Therefore, no further discussion of sabotage will be provided herein.

It is the purpose of this report to provide a qualitative assessment of risk from hurricanes, tornadoes, external floods, aircraft strike and hazardous materials. In performing this assessment, heavy reliance was placed on the information presented in Sections 2 and 3 of GESSAR II which provide the definition of the envelope of site-related parameters and the design bases for structures, components, equipment and systems. Compliance with the requirements in these sections of GESSAR II aids in minimizing the risk from external events.

2. CONSIDERATION OF EXTERNAL EVENTS

This section provides a qualitative assessment of risk of hurricanes, tornadoes, external floods, aircraft strike and hazardous materials.

In the Probabilistic Risk Assessment (PRA) Procedures Guide (Reference 8), screening criteria are suggested for the inclusion of external events into PRA studies. An external event is excluded from PRA studies if it is included in the definition of another event, or events, if the event can be shown not to occur close enough to the plant to affect it, if the event has a significantly lower mean frequency of occurrence than other events with similar uncertainties and could not result in worse consequences than those events, or if the event is of equal or less damage potential than the events for which the plant has been designed. These screening criteria have been utilized in the qualitative assessments contained herein.

2.1 Hurricanes

In Table 10-1 of Reference 8, hurricane events are considered to be included under external flooding and the wind forces are covered under external winds and tornadoes. Since external flooding and tornadoes are covered in Sections 2.3 and 2.2, respectively, hurricanes are not separately addressed in this subsection. This follows the direction of Reference 8 to exclude treatment of a specific event that can be included in the definition of another event or events.

2.2 Tornadoes

Design information on wind and tornado loadings is contained in Section 3.3 of GESSAR II. In Subsection 2.3.1.2 of GESSAR II, the discussion of regional meteorological conditions for design and operating bases contains the specific considerations for high winds and tornadoes. These include:

(1) The structures are designed to withstand wind velocities of 130 mph at 30 ft. above plant grade with a velocity distribution and gust factor as described in ASCE 3269 (Wind Forces on Structures - Reference 9).

(2) The safety-related structures and equipment are designed for the Design Basis Tornado described in NRC Regulatory Guide 1.76 for Region I. The characteristics of this tornado are:

Maximum Wind Speed (mph)	360
Rotational Speed (mph)	290
Translational Speed:	
Maximum (mph)	70
Minimum (mph)	5
Radius of Maximum Rotational Speed (ft.)	150
Pressure Drop (psi)	3.0
Rate of Pressure Drop (psi/sec)	2.0

Using the relationships provided in Reference 10, the tornado wind velocity probability of a maximum velocity of 360 mph is estimated to be less than 10^{-5}.

A discussion of design considerations for missiles generated by natural phenomena is contained in Section 3.5 of GESSAR II. Due to the compartmentalization and separation inherent in the GESSAR II design, it is highly unlikely that given an event that exceeds the design capability, all safety related equipment would be unavailable, especially considering that the ECCS equipment is located below grade level. Assuming a conservative probability estimate for the loss of core cooling capability of $\sim 10^{-4}$, and combining an event frequency of $<10^{-5}$ results in a probability of core damage of $<10^{-9}$. This value is clearly insignificant compared with other events.

2.3 External Floods

Subsection 2.4.2.1 of GESSAR II commits the Applicant to provide site specific flood data. This includes the date, level, peak discharge and related information for major flood events in the site region.

The GESSAR II plant design includes consideration for the probable maximum flood potential. Seismic Category I structures that may be affected by floods are designed to withstand floods using the "hardened" flood protection approach. Through the hardened protection approach, structural provisions are incorporated in the plant's design to protect safety-related structures, systems and components from postulated flooding. Seismic Category I structures required for safe shutdown remain accessible during all flood conditions.

Safety-related systems and components are flood protected either because of their location above the design flood level, or because they are enclosed in reinforced concrete Seismic Category I structures which have the following requirements:

(1) wall thicknesses below flood level of not less than 2 ft;

(2) water-stops provided in all construction joints below flood level;

(3) watertight doors and equipment hatches installed below design flood level; and

(4) waterproof coating.

Additional flood protection from external sources is discussed in Subsection 3.4.1 of GESSAR II.

The structures of safety significance are designed for a design basis flood, as defined in Regulatory Guide 1.59, up to an elevation 1 ft. below plant grade including allowance for the effects of coincident waves and the resultant runup as calculated from site unique parameters.

Based on the above information, and the results obtained from the evaluation of internal flood events (Reference 4), the probability of core melt from external flood sources is believed to be an insignificant contributor to core melt risk.

2.4 Aircraft Strike

The GESSAR II design is intended for use at sites where the probability of an aircraft impact is $\leq 10^{-7}$ per year. It is the responsibility of the Applicant to show compliance with this requirement. If the Applicant's plant is located at a site where this probability is not $\leq 10^{-7}$ per year, the Applicant will provide an evaluation of the consequences of an aircraft crash considering the type and frequency of aircraft germane to his site in his safety analysis report. It is believed that the criteria used for aircraft crash will include at least 90% of the sites in the United States.

With the use of this aircraft strike criteria, the frequency is much less than the event frequency for tornadoes or hurricanes with missiles, with similar core damage probabilities given the event. Thus the contribution of aircraft strikes to incremental plant risk is negligible.

2.5 Hazardous Material

In assessing the risk from hazardous material, Reference 8 suggests including the risks from industrial or military facilities, pipeline accidents, release of chemicals in onsite storage, and transportation accidents. All of these are site dependent, and require site specific information to quantify any potential impact. This information will be provided by the Applicant as noted in Section 2.2 of GESSAR. Specific information will include:

1) Location and routes of any nearby industrial, transportation, and military facilities.

2) Descriptions of nearby industrial, transportation, and military facilities.

3) Descriptions of the products and materials regularly manufactured, stored, used, or transported in the vicinity of the plant.

4) Descriptions of nearby pipelines.

5) Information on navigable waterways adjacent to the site.

6) Projections of growth of current and new industrial activities in the vicinity of the plant.

Furthermore, the Applicant will provide a determination of design basis events (i.e. probability of occurrence $>10^{-7}$ per year and potential consequences serious enough to affect the safety of the plant to the extent that 10CFR100 guidelines could be exceeded) for each of the following accident categories: explosions, flammable vapor clouds (delayed ignition), toxic chemicals, fires, collisions with intake structures and liquid spills. Subsection 2.2.3.2 of GESSAR II commits the Applicant to provide an assessment of the effects of any potential design basis events included in these accident categories.

For those events not defined by the Applicant as design bases and separately evaluated, the low occurrence frequencies resulting in even smaller core melt risk is negligible.

3. CONCLUSIONS

For the reasons discussed in Section 2, which are summarized below, the probability of core damage and incremental plant risk from external events for the GESSAR II design is believed to be insignificant.

External Event	Basis for Conclusion
Hurricanes	• Included under Tornadoes and External Floods
Tornadoes	• GESSAR II design capability to withstand missile impact from maximum wind velocity • Low event probability with low core damage probability
External Floods	• GESSAR II design basis flood capability • Demonstrated capability in internal flood evaluation
Aircraft Strike	• GESSAR II aircraft strike criteria of $\leq 10^{-7}$ events per year
Hazardous Material	• GESSAR II commitment for Applicant determination of hazardous material design bases events ($>10^{-7}$ probability of occurrence per year) and assessment of consequences

4. REFERENCES

1. Memorandum for C. O. Thomas from D. C. Scaletti, "GESSAR II Meeting Summmary," June 7, 1984.

2. NUREG-1070, "NRC Policy on Future Reactor Designs: Decisions on Severe Accident Issues in Nuclear Power Plant Regulation", April 18, 1984 (Draft).

3. Letter for D. G. Eisenhut from J. F. Quirk, "GESSAR II Seismic Event Analysis in Support of the Severe Accident Review of GESSAR II," September 21, 1983.

4. Letter for D. G. Eisenhut from J. F. Quirk, "GESSAR II Fire and Flood External Event Analysis in Support of the Severe Accident Review of GESSAR II", November 7, 1983.

5. Letter for D. G. Eisenhut from J. F. Quirk, "In the Matter of 238 Nuclear Island General Electric Standard Safety Analysis Report (GESSAR II) Severe Accident Review of GESSAR II, December 29, 1983.

6. Memorandum for Roger J. Mattson from Olan D. Parr, "Status of Generic Issue A-29," March 23, 1984.

7. J. N. Fox, et.al., "Resolution of Applicable Unresolved Safety Issues and Generic Issues for GESSAR II," NEDO-30670, June 1984 (Draft).

8. NUREG/CR-2300, "PRA Procedures Guide - A Guide to the Performance of Probabilistic Risk Assessments for Nuclear Power Plants", January 1983.

9. ASCE Paper No. 3269, Wind Forces on Structures, Transactions of the American Society of Civil Engineers, Vol. 126, Part II (1961).

10. R. G. Garson, J. Morla-Catalan, and C. Allin Cornell, "Tornado Risk Evaluation Using Wind Speed Profiles," Technical Note, Journal of the Structural Division, ASCE, Vol. 101, ST5, 1975.

APPENDIX 15.E.16

CONTROL OF NUCLEAR ISLAND/BALANCE OF PLANT INTERFACES

15.E.16.1 CONTROL OF NUCLEAR ISLAND/BALANCE OF PLANT INTERFACES

Background

The Nuclear Island (NI)/balance of plant (BOP) interfaces are illustrated in Figure 1. The complex interfaces that existed between the Nuclear Steam Supply System (NSSS) and BOP when the GE scope of supply was limited to the NSSS are practically eliminated by the NI scope. The only remaining BOP interface areas are those between the NI and Turbine Island (TI) and between the NI and service facilities. This change in scope reduces the magnitude of interfaces from tens of thousands to no more than hundreds.

Interfaces

In GESSAR II, the interfaces are classified as either GESSAR II/FSAR interfaces (GESSAR II, Tables 1.9-1 through 1.9-19) or NI/BOP design interfaces (GESSAR II, Tables 1.9-20 through 1.9-23 and Figures 1.9-1 through 1.9-5). The GESSAR II/FSAR interfaces fall into one of the following five categories:

1. BOP scope (difference between Regulatory Guide 1.70 and NI scope)
2. Equipment vendor dependent
3. Applicant dependent
4. Site dependent
5. Deferred until first Applicant references GESSAR II

Strictly speaking, only the Category 1 GESSAR II/FSAR interfaces and NI/BOP design interfaces are "NI/BOP Interfaces." However, GE chose to include all of the interfaces as NI/BOP interfaces to assure that the Applicant will provide compatible design features and meet reliability objectives.

As a final measure in meeting reliability objectives, the key probability risk assessment (PRA) interfaces shown in new GESSAR II Table 1.9-24 are included as NI/BOP interfaces. The specific PRA interfaces in this table are the result of a review of the PRA assumptions (such as reliability or operability assumptions) and an exclusion of those assumptions which met one or more of the following:

1. Characteristics well defined by the GESSAR II design documentation.

2. Recognized industry data base (component reliability or operator action time).

3. Little importance to the PRA conclusions (e.g., 100% change in reliability changes the corresponding overall PRA results by less than 1%).

Any borderline or questionable PRA interface was retained as a key PRA interface.

Control

The levels of requirements imposed on the Applicant are the same ones used by GE for the design of the NI proper, and GE has formal documentation in place to control these NI/BOP interfaces. General Electric assures compliance by periodically reviewing all of the interfaces by GE teams that visit the Applicant. The Applicant audits his own AE (architect engineer) which provides further verification of conformance to the interface requirements. The AE is also subject to independent QA verifications within his own in-house procedures. General Electric ensures compliance with the NRC licensing reviews by verifying that the NI/BOP interfaces are met.

To further assure that reliability objectives are met during procurement, construction, preoperational testing, startup testing, operations and maintenance, GESSAR II Table 1.9-17, Subsection 17.1.2 and Section 17.2 will be modified as indicated to require that the Applicant's performance specifications and monitoring procedures include the applicable interface requirements of Tables 1.9-1 through 1.9-24 and of Figures 1.9-1 through 1.9-5. For completeness, these GESSAR II Chapter 17 interface requirements were also added to Table 1.9-17.

In terms of construction controls, GE has procedures to control the interfaces and has approval of non-conformance and approval of as-built documentations.

Site controls are provided by the licensing process itself in that the GESSAR II SER (NUREG-0979) requires the NRC to perform a site specific review of the reference plant site characteristics (meteorology, hydrology and seismology) to demonstrate that they are compatible with the GESSAR II siting envelope assumptions (GESSAR II, Table 2.0-1).

NRC Review

Some of the major systems that were reviewed for interface consistency by the Staff are the fuel oil, the essential service water supply, instrumentation controls, condensate storage, power feeders, liquid radwaste, fire protection and feedwater.

As noted in the GESSAR II SER, the NRC's review and evaluation addressed the interface requirements either from the standpoint of general design provisions (i.e., qualitative); specific design provisions (i.e., quantitative), by incorporation or reference to the interface requirements in GESSAR II; or, by a description of the interface mechanism between GESSAR II and the BOP.

Also noted in the GESSAR II SER is that the NRC audited detailed interface information that is supplied to reference plant applicants. The NRC acknowledged that this interface information has always been part of the contractual arrangements between the NSSS designer and the BOP designer; however, for the purpose of a standard NI design, the safety-related, interface requirements are significant for reference by Applicants in the future.

Finally, as noted in the GESSAR II SER, the NRC determined that the interface requirements provided in GESSAR II are adequately descriptive to ensure compatibility of the GESSAR II design with the BOP designs that would be submitted in individual applications referencing GESSAR II.

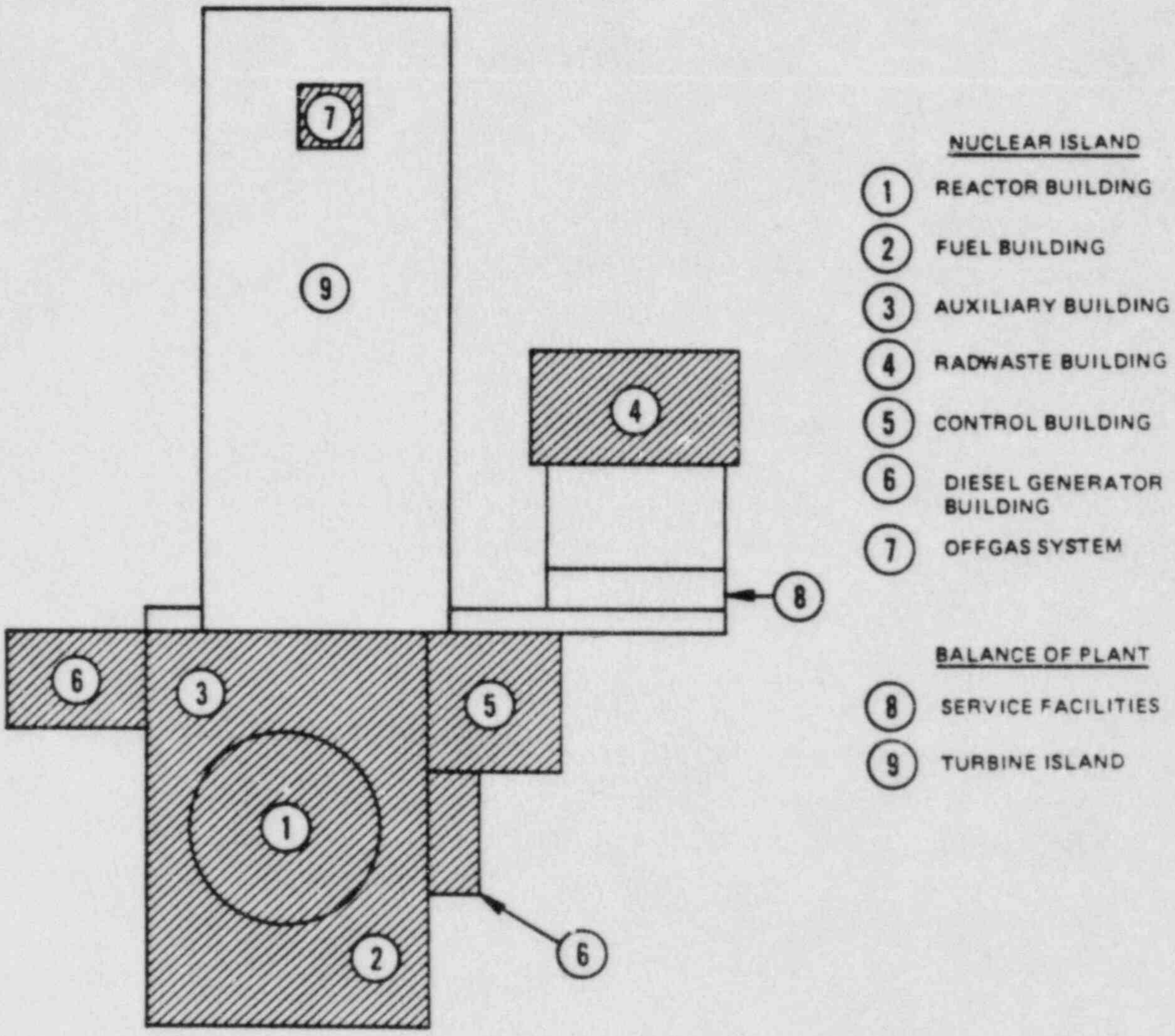


Figure 1. Nuclear Island/Balance of Plant Interfaces

APPENDIX 15.E.17

CONFIRMATORY SOIL STRUCTURE INTERACTION ANALYSIS RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

GESSAR II CONFIRMATORY SSI ANALYSIS

GE RESPONSE TO
NRC REQUEST FOR ADDITIONAL INFORMATION

NRC REQUEST:

ITEM 1. In your analysis, you have used kinematic interaction and therefore reduced the input motion at foundation level. The staff does not approve of any reduction of the input motion in the free-field at the foundation level. Also, the reactor building is not in direct contact with soil as assumed in the analysis. In view of these two facts, provide your assessment if no kinematic interaction was considered.

GE RESPONSE:

Kinematic interaction occurs as a result of wave scattering at the soil-foundation interface; i.e., as a result of the kinematic constraints imposed by the geometry of the problem and the differences in stiffness between the structure and the soil. For an embedded structure subjected to vertically propagating shear waves, the net effect is typically a reduction in rigid body translational response, accompanied by the introduction of a rigid body rocking component. Whether kinematic interaction results in a net increase or decrease in response at any given point in the structure is dependent upon the phasing between the translational and rocking components, the location of the center of rocking, and the degree to which the rocking and translational frequencies are tuned to the natural frequencies of the structure.

When performing an SSI analysis using a direct finite element approach, kinematic interaction effects are automatically included and, in fact, can not be suppressed. When using a continuum mechanics approach, however, the consideration of kinematic interaction can be a difficult problem. At present, only a limited number of cases involving simplified geometries (e.g., embedded cylinders and semi-ellipsoids) have been solved in a rigorous fashion -- and those only in a research setting.

Publicly available computer codes which use the continuum mechanics approach (e.g., CLASSI) can not presently address kinematic effects or any other aspect of embedment. In order to properly account for the actual geometry of the problem, it is necessary to adjust the impedance and driving force matrices generated by CLASSI. That is, the matrices generated on the basis of a surface-founded structure are replaced by those applicable to an embedded structure.

In the case of GESSAR II, this replacement was accomplished by selecting from the limited pool of research work, the data that was judged most appropriate to the case at hand; i.e., a cylindrical Reactor Building with an embeddment ratio of 0.58. As noted by the NRC, however, the GESSAR II Reactor Building is not an isolated embedded cylinder in direct

Item 1 Continued
Page Two

contact with the soil. Rather, it is simply the largest building of an embedded structural complex. For this configuration, there is some question as to the embedment ratio that should actually be used in the analysis.

In order to resolve this uncertainty, an assessment of SSI behavior was made which completely disregarded kinematic interaction effects; i.e., no adjustment at all was made to the driving force matrix generated by CLASSI. This corresponds to the use of an embedment ratio of zero in solving the wave scattering problem and is clearly a bounding solution.

This parametric analysis was performed using the site properties corresponding to Case 5 described in the main report. This case was selected because it was shown to dominate the response envelopes generated using the CLASSI approach -- particularly so for frequencies above 4 Hertz, the primary region of interest for the GESSAR II design.

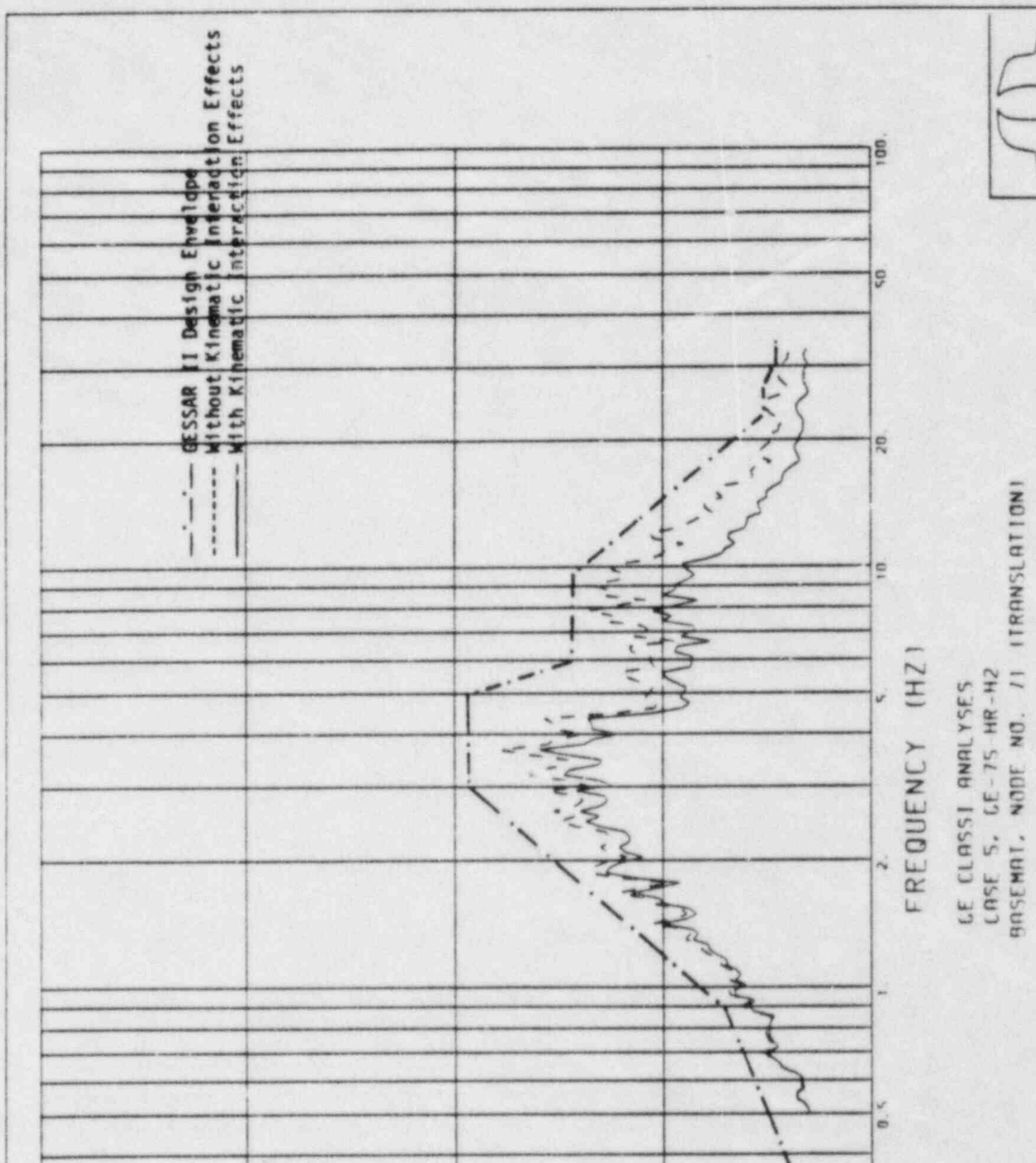
Comparison of the response spectra obtained with and without kinematic interaction effects at the basemat and various locations throughout the Reactor Building, are shown in Figures 1.1 through 1.6. In addition, the corresponding GESSAR II design envelopes are shown in the same figures.

An evaluation of the results indicates that the spectral peaks for the case of no kinematic interaction are, in general, slightly higher than the corresponding case with interaction. However, these results are still enveloped by the existing GESSAR II design envelopes.

A comparison of the maximum accelerations at similar locations is shown in Table 1.1. This Table indicates that if no kinematic interaction is considered, the responses are increased between 3 to 18 percent. Again, however, the GESSAR II design values are generally higher and envelope the corresponding CLASSI responses. Thus, it can be concluded that, even for the bounding case where kinematic interaction is disregarded, the GESSAR II design envelopes are still a conservative design basis.

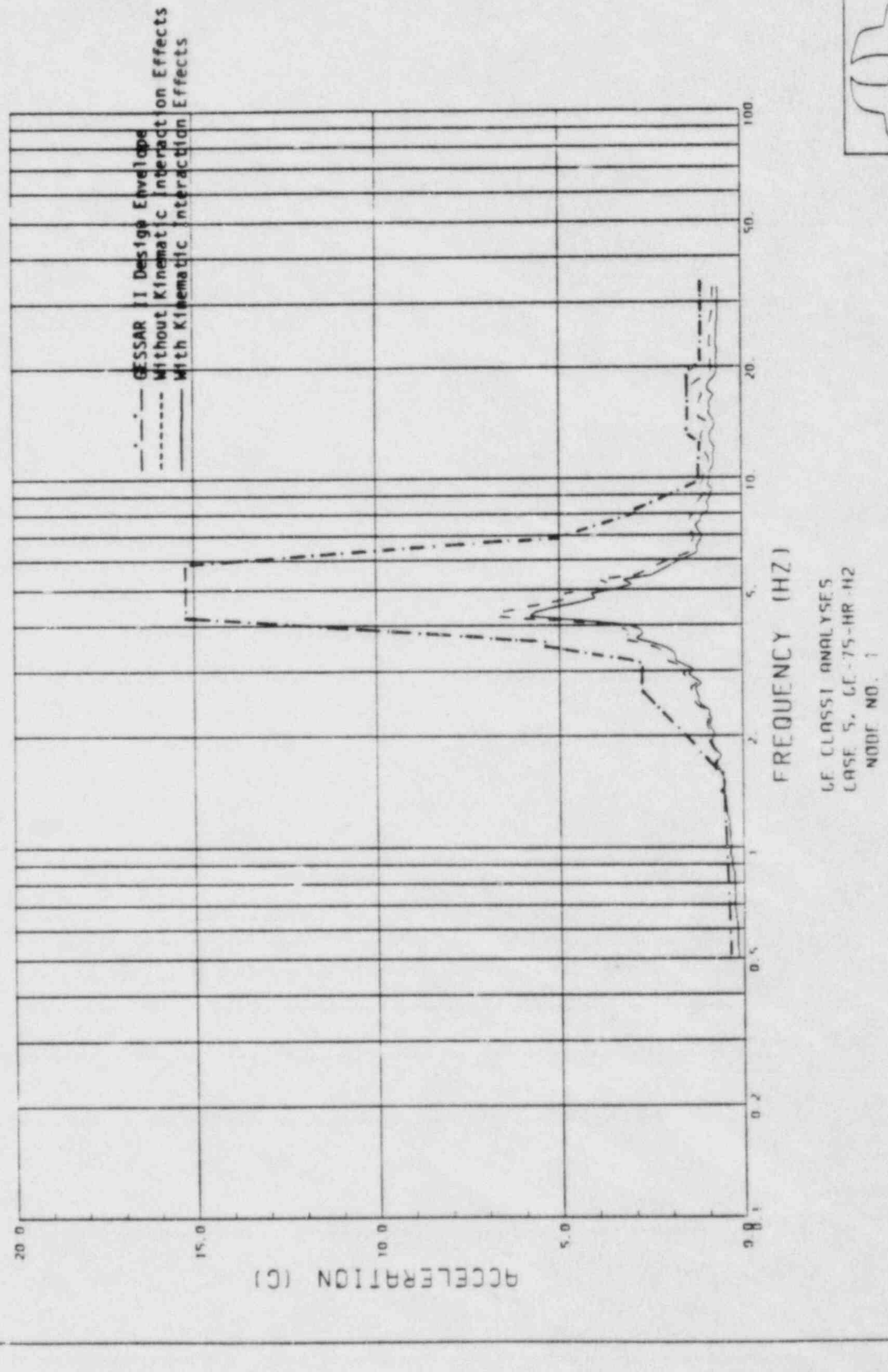
TABLE 1.1

Node	Location	Maximum Acceleration (g) Without Kinematic Interaction	With Kinematic Interaction	GESSAR II Design
71	Basemat	0.16	0.15	0.15
1	Top of Shield Bldg.	0.74	0.72	1.01
18	Middle of Shield Bldg.	0.26	0.22	0.31
22	Top of Containment	0.58	0.51	0.59
42	Top of Drywell	0.48	0.46	0.76
46	Middle of Drywell	0.30	0.28	0.45



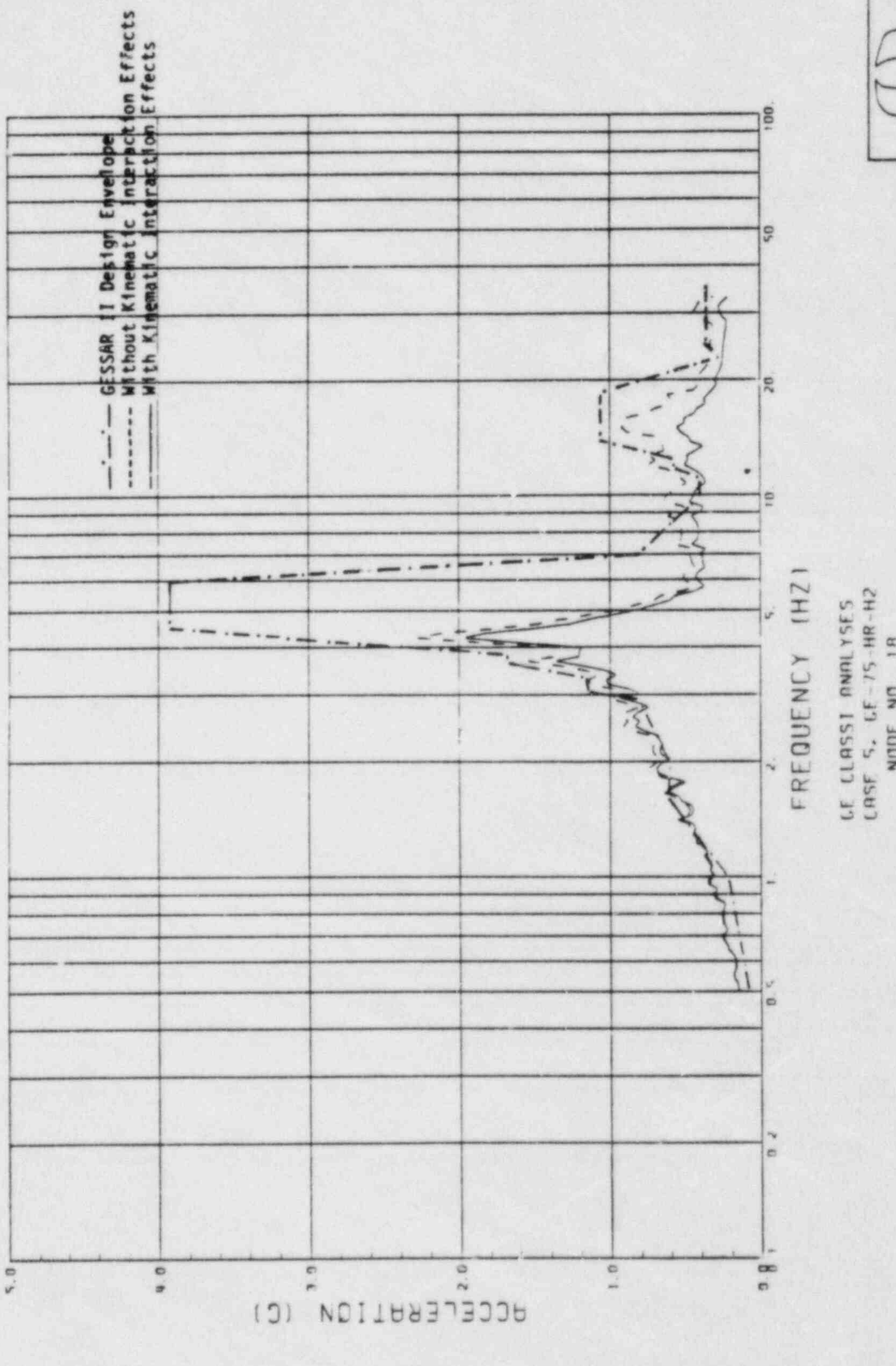
GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

Figure 1.1



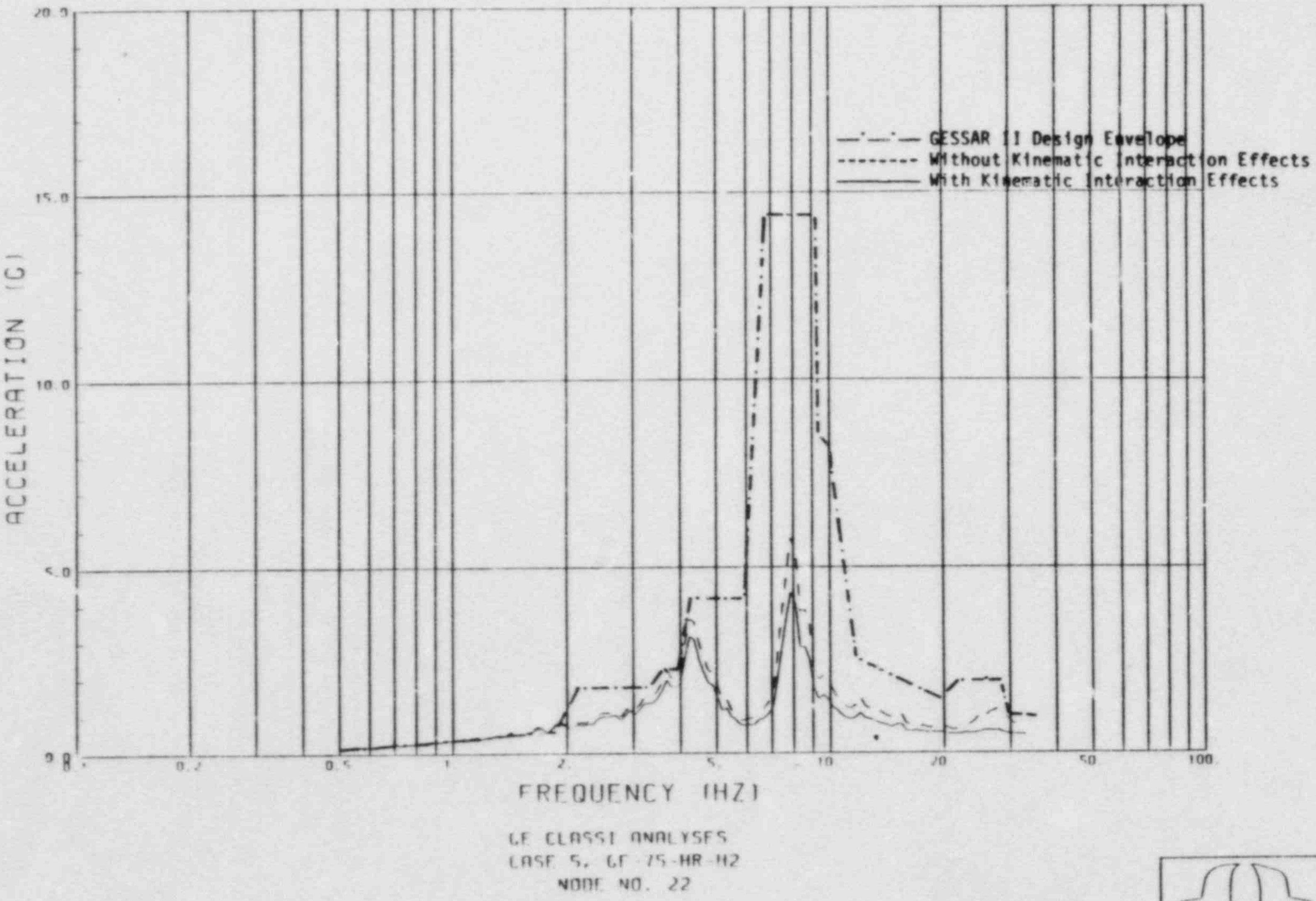
GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

Figure 1.2



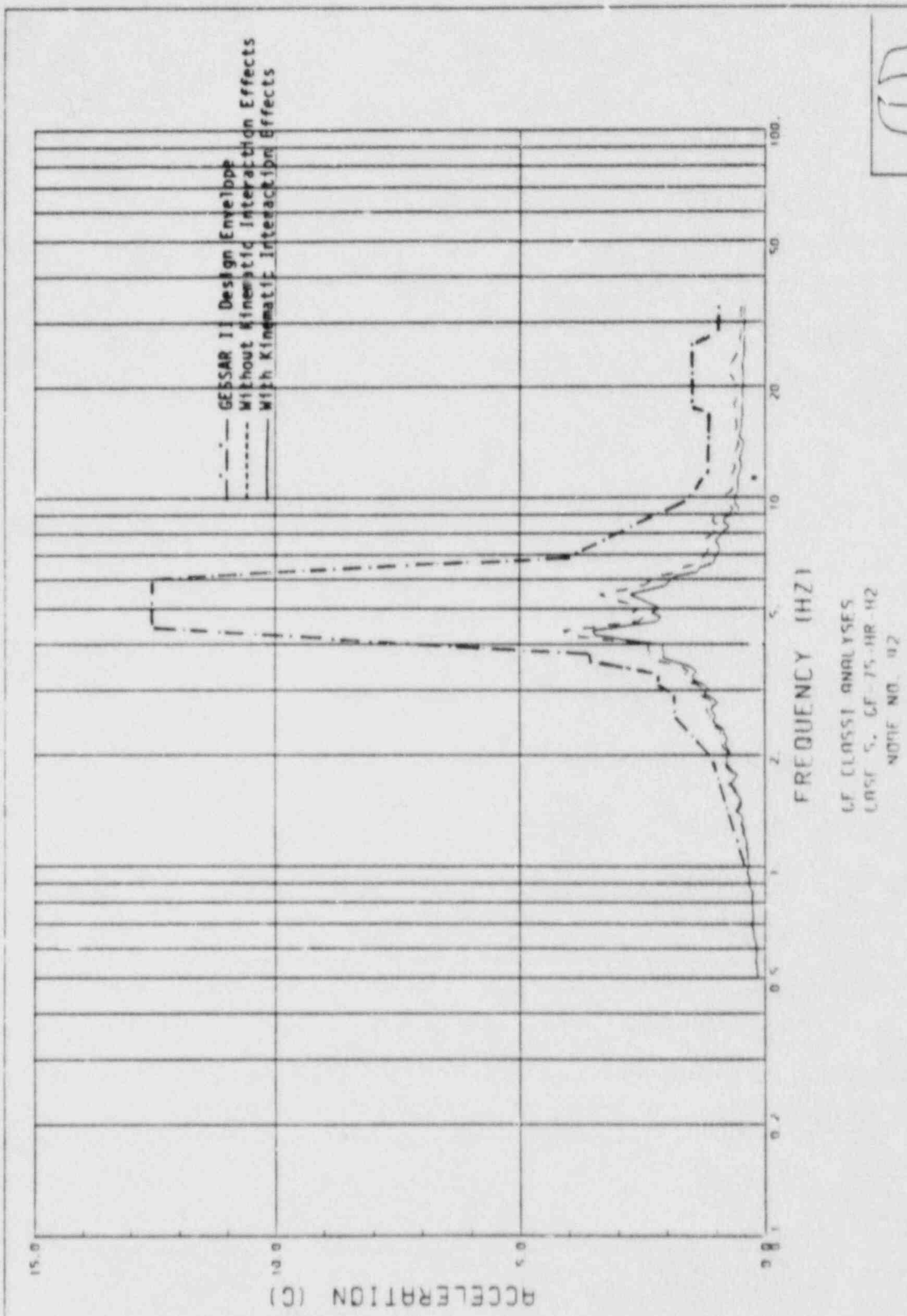
GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

Figure 1.3



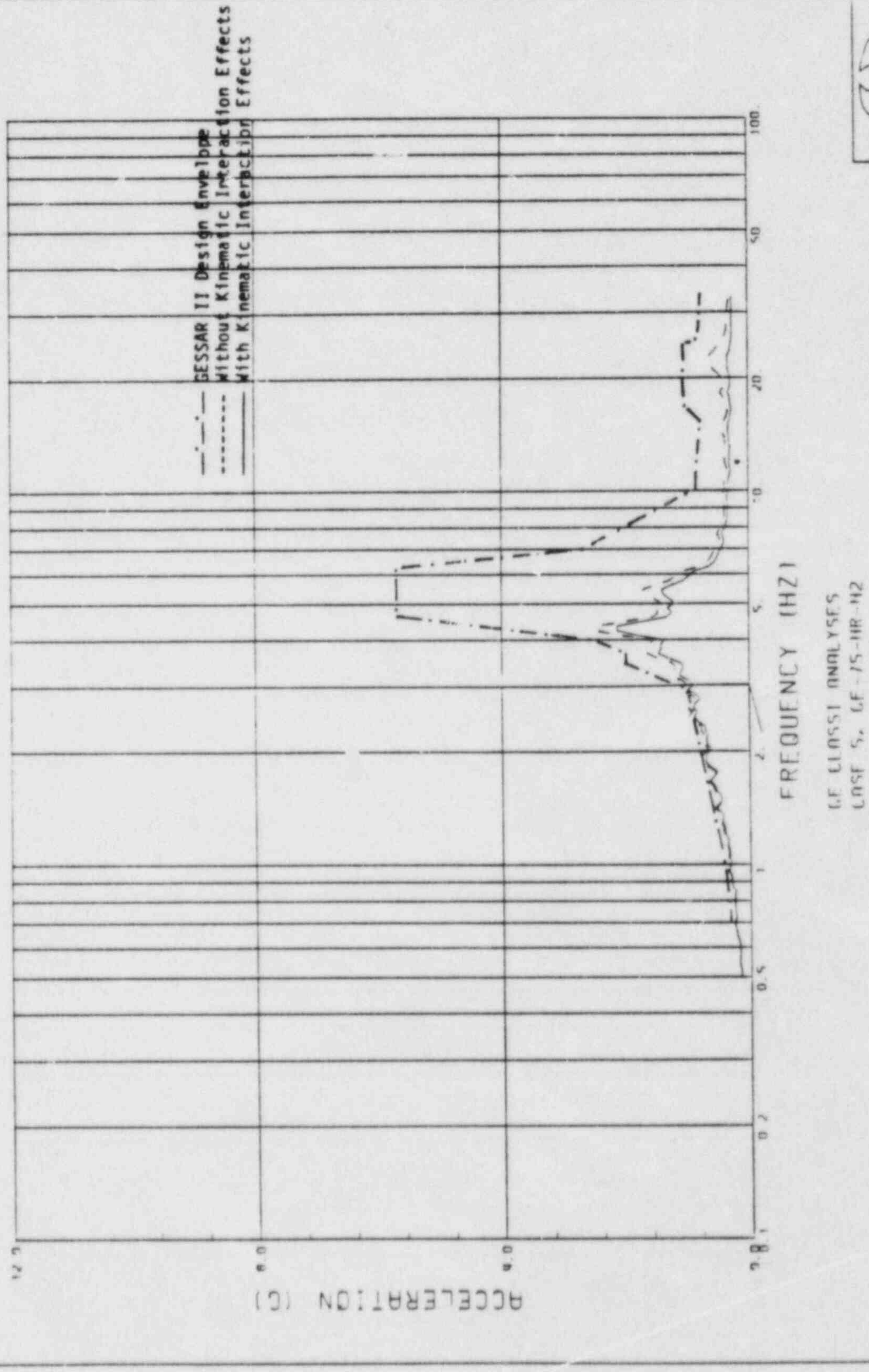
GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

Figure 1.4



GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

Figure 1.5



GESSAR II PLANT
SOIL STRUCTURE INTERACTION

Figure 1.6

GESSAR II CONFIRMATORY SSI ANALYSIS

GE RESPONSE TO NRC REQUEST FOR ADDITIONAL INFORMATION

NRC REQUEST:

ITEM 2. In your evaluation of impedance functions, the embedment effects have been considered. However, the Reactor Building is surrounded by the Control and Auxiliary Building and separated from the soil. Provide assessment if no embedment effects were considered in the impedance evaluation.

GE RESPONSE:

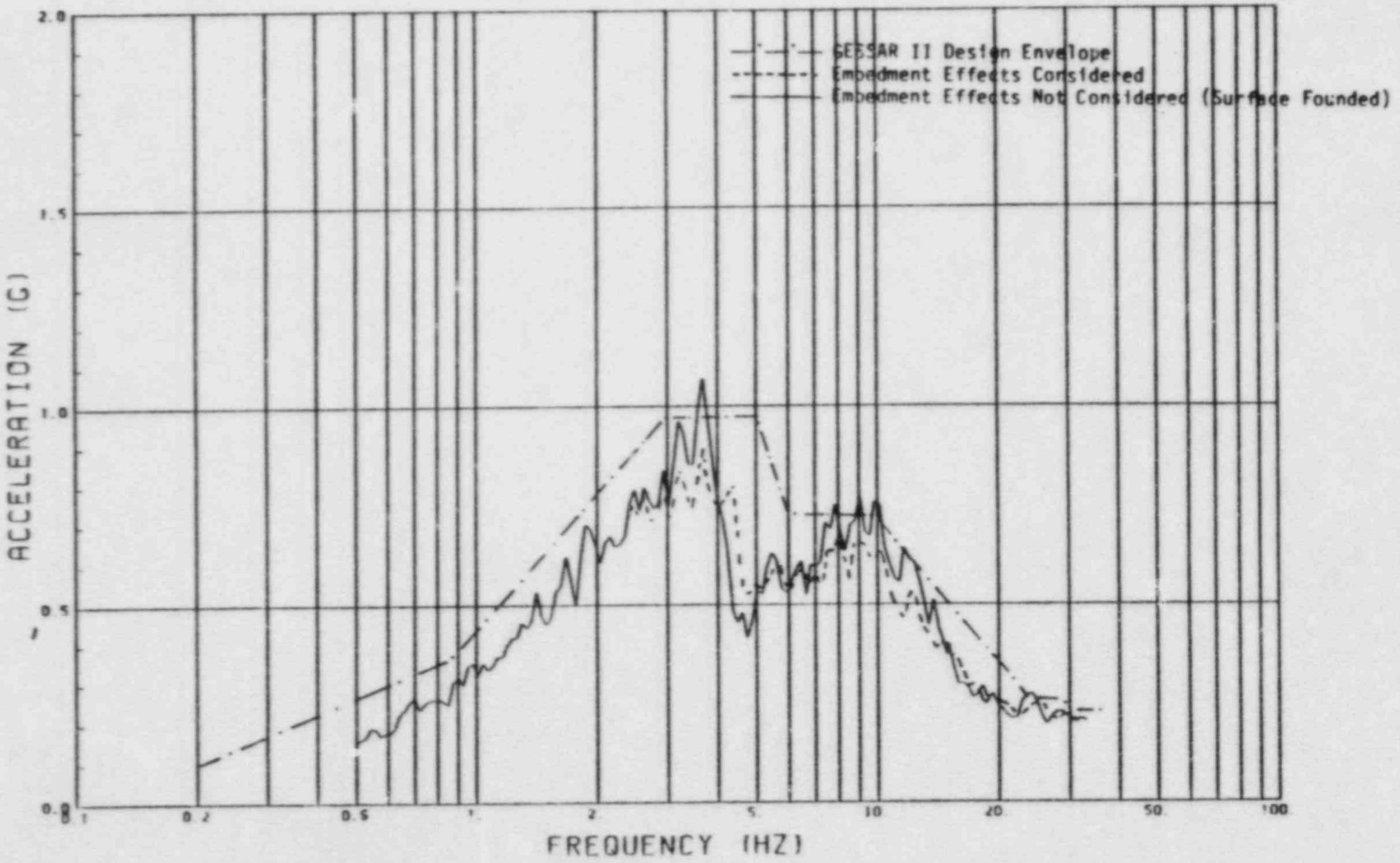
As noted in the response to Item 1 above, the GESSAR II site-structure geometry was treated in a manner that was believed to be reasonable for a confirmatory analysis. The CLASSI analyses, as agreed upon with the NRC, were performed under the assumption that the Reactor Building could be idealized as an isolated, embedded cylinder. It is recognized, however, that the proper embedment ratio to use is subject to different interpretations.

In order to assess the effect of embedment on the computed response of the Reactor Building, an analysis was made considering the structure to be surface founded. Note that this is the most extreme condition and does not reflect the real plant configuration. The fact remains that even though the Reactor Building is not in direct contact with the soil, it is still part of a complex of embedded structures in the power block area.

The analysis case analyzed (Case 5) is the same as that considered to address Item No. 1. Again, this is the controlling case as it clearly dominates the responses of all the cases previously analyzed.

Figures 2.1 through 2.6 show the comparison of the GESSAR II design envelopes, the surface founded results, and the results considering an embedment ratio of 0.58 (depth of embedment = 40.0 ft., radius of Reactor Building structure = 69.0 ft.). These results show that, in general, the surface founded spectral peaks are higher, in some cases significantly so. For example at node 1, the major peak for the surface founded case is at approximately 10g. The major peak for the embedded case is 6.5g. However, the GESSAR II design curve envelopes both responses in its entirety. In some cases, the spectral peaks for the surface founded cases fall outside of the design envelope. However, this generally occurs at frequencies below 5 Hz which is of no consequence for the design of GESSAR II standard plant.

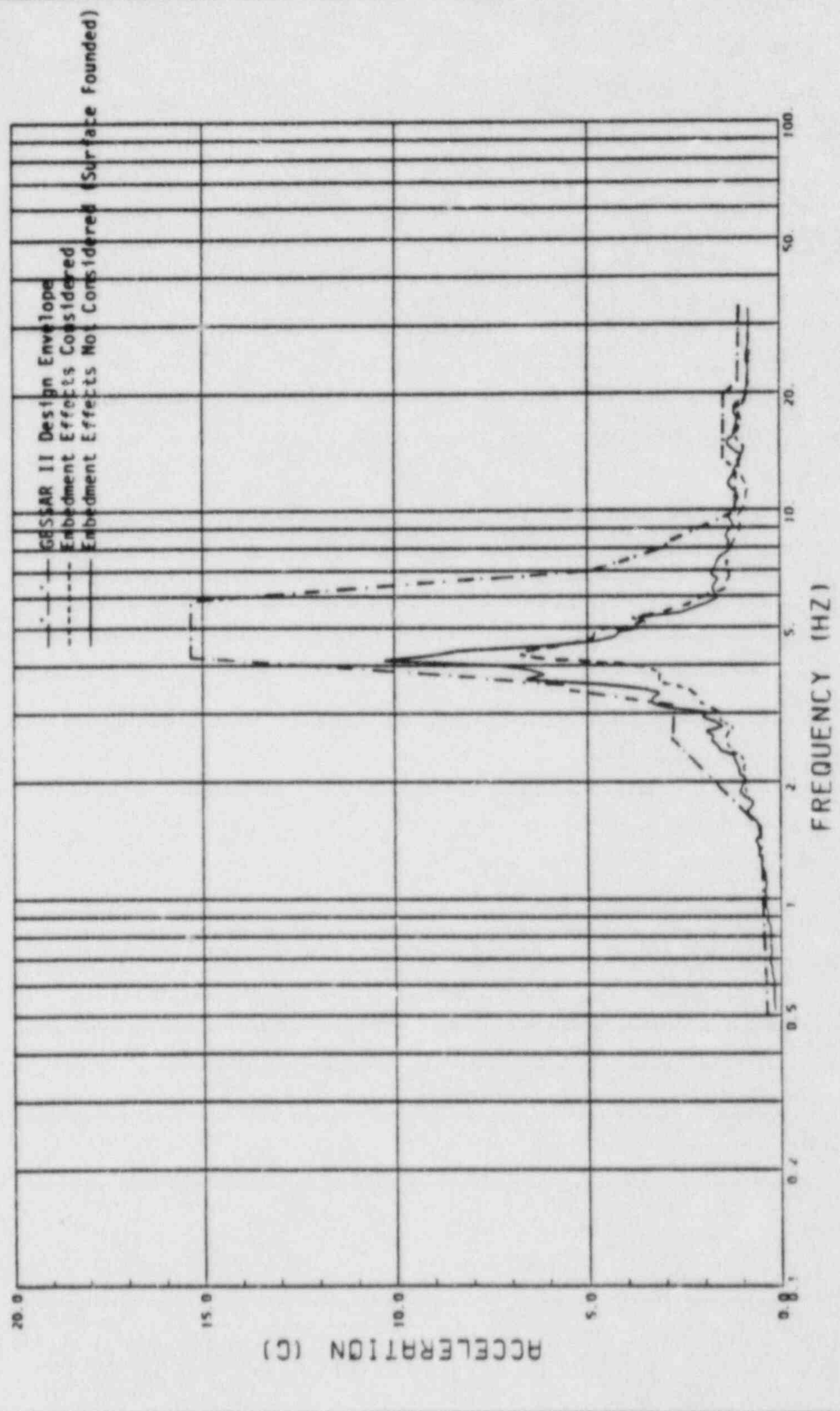
Thus, it can be concluded that even for the most extreme condition that has been considered (surface founded), the GESSAR II design envelopes provide a conservative design basis.



GE CLASSI ANALYSES
CASE 5, GE-75-HR-H2
BASEMAT, NODE NO. 71 (TRANSLATION)

GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

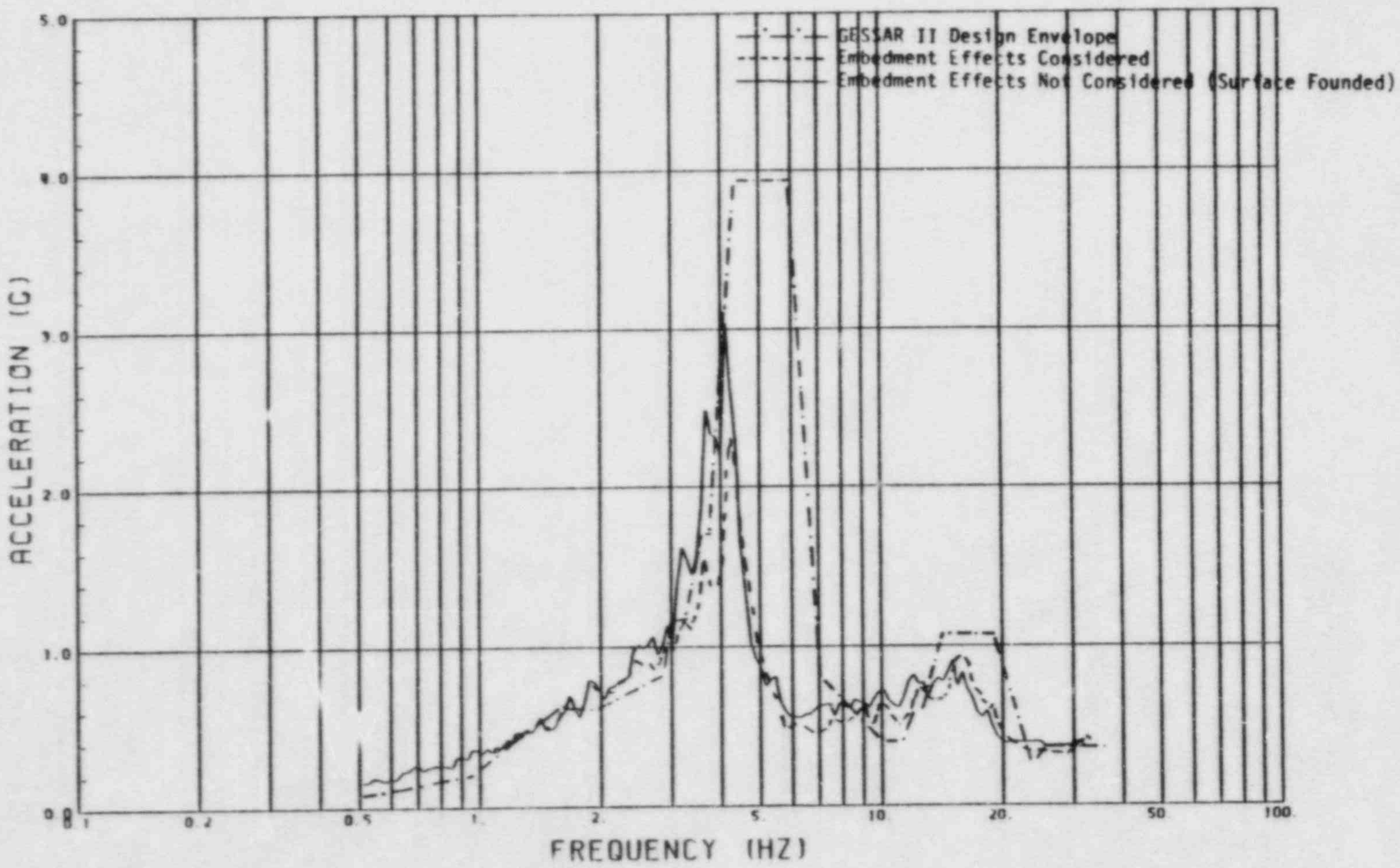
Figure 2.1



GE CLASSI ANALYSES
CASE 5, CE-75-HR-H2
NODE NO. 1

GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

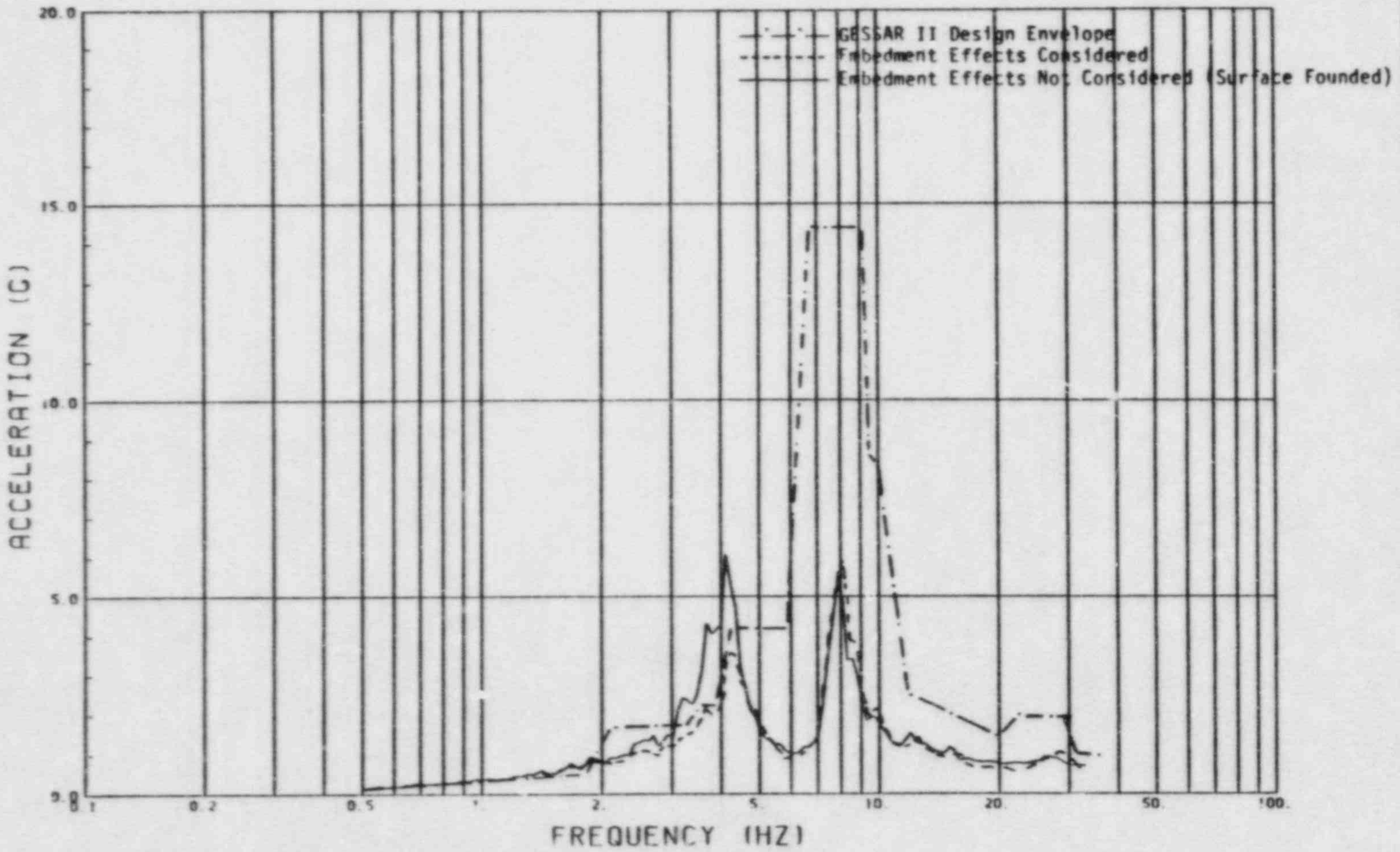
Figure 2.2



GE CLASSI ANALYSES
CASE 5, GE-75-HR-H2
NODE NO. 18

GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

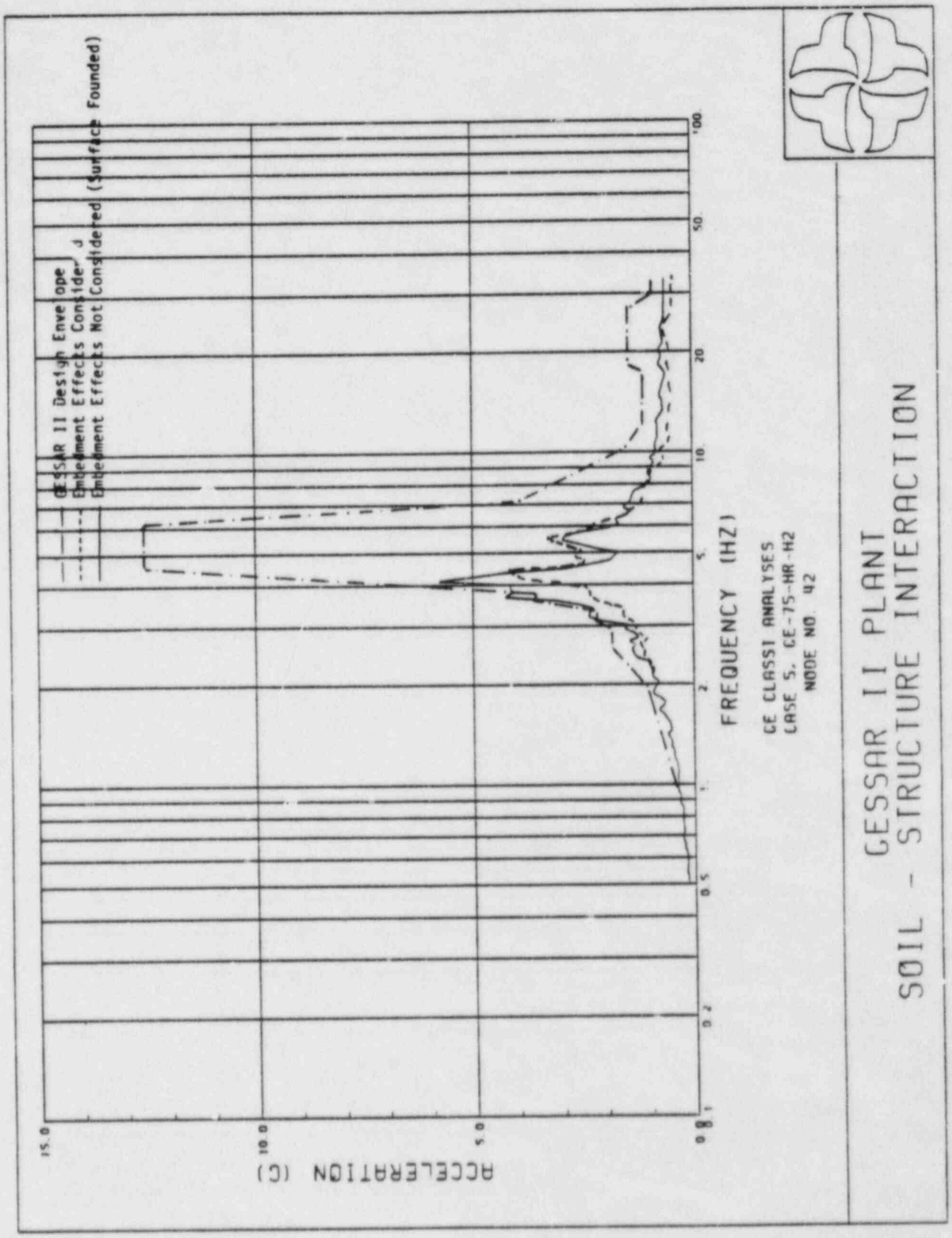
Figure 2.3



GE CLASSI ANALYSES
CASE 5. CE-75-HR-H2
NODE NO. 22

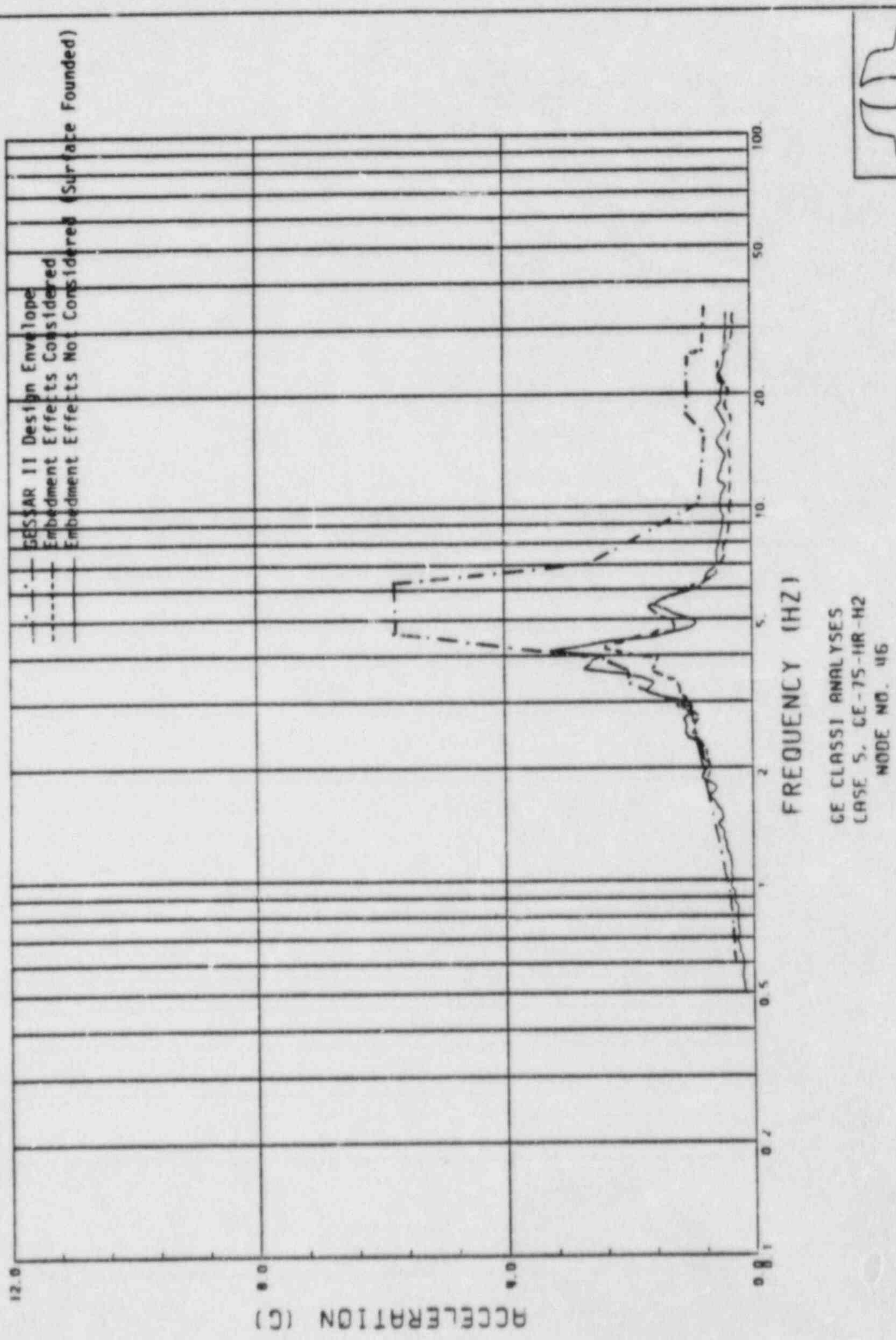
GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

Figure 2.4



GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

Figure 2.5



GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

Figure 2.6

GESSAR II CONFIRMATORY SSI ANALYSIS

GE RESPONSE TO NRC REQUEST FOR ADDITIONAL INFORMATION

NRC REQUEST:

ITEM 3. Provide a summary of verification of CLASSI version used in the analysis.

GE RESPONSE:

CONTINUUM LINEAR ANALYSIS OF SOIL-STRUCTURE INTERACTION (CLASSI)

Description

The program CLASSI is comprised of a series of computer codes developed to calculate the three-dimensional soil-structure interaction response of surface-founded structures using a frequency-dependent continuum impedance approach. The basic version of the CLASSI family of computer programs was developed by Professor J. E. Luco of the University of California at San Diego, and Professor H. L. Wong of the University of Southern California. Additional development effort was contributed by Dr. R. J. Apsel of the University of California at San Diego.

In the CLASSI methodology, the continuum mechanics approach is used to characterize the site-foundation system and the incident seismic waves in terms of complex, frequency-dependent impedance matrices and driving force vectors. The superstructure is represented in terms of its fixed-base mass matrix, mode shapes and frequencies, and its modal damping coefficients. These structural dynamic properties can be calculated using any standard finite element formulation. Compatibility and dynamic equilibrium requirements at the superstructure-foundation interface are then used to determine the three-dimensional response of the complete superstructure-foundation system.

Verification

The Impell version of the CLASSI program was verified in accordance with the Impell Quality Assurance Program and requirements of 10CFR50.

The verification program consisted of:

A) Benchmarking of results obtained by the Impell version of CLASSI with those obtained using other commercially available and independently verified versions of CLASSI. This included benchmarking of CLASSI results with those obtained by various investigators and published in the technical literature. Identical results were obtained in all cases.

Item 3 Continued
Page Two

B) Benchmarking of CLASSI results with those obtained by other SSI programs such as SASSI. SASSI is a finite element based code for the solution of three-dimensional SSI problems, developed at the University of California at Berkeley. Responses obtained by the two codes were within 2% of each other.

c) In addition, the CLASSI code was verified by solving the following two special cases:

1. Response of the rigid massless basemat. No structure was incorporated in the analysis. For vertically propagating shear waves, the basemat motion should be nearly identical to the free-field motion. This was in fact confirmed by this analysis.

2. Response of a structure sitting on very stiff soil, such that in effect the structure can be assumed fixed at its base. The results of the CLASSI analysis were compared with the fixed-base analysis results obtained from Impell program EDSGAP and found to be within 1%. EDSGAP is based on the SAP computer program developed at the University of California at Berkeley.

Extent of Application

The CLASSI program was used only for the confirmatory soil-structure interaction analysis of the GESSAR II design envelopes.

GESSAR II CONFIRMATORY SSI ANALYSIS

GE RESPONSE TO
NRC REQUEST FOR ADDITIONAL INFORMATION

NRC REQUEST:

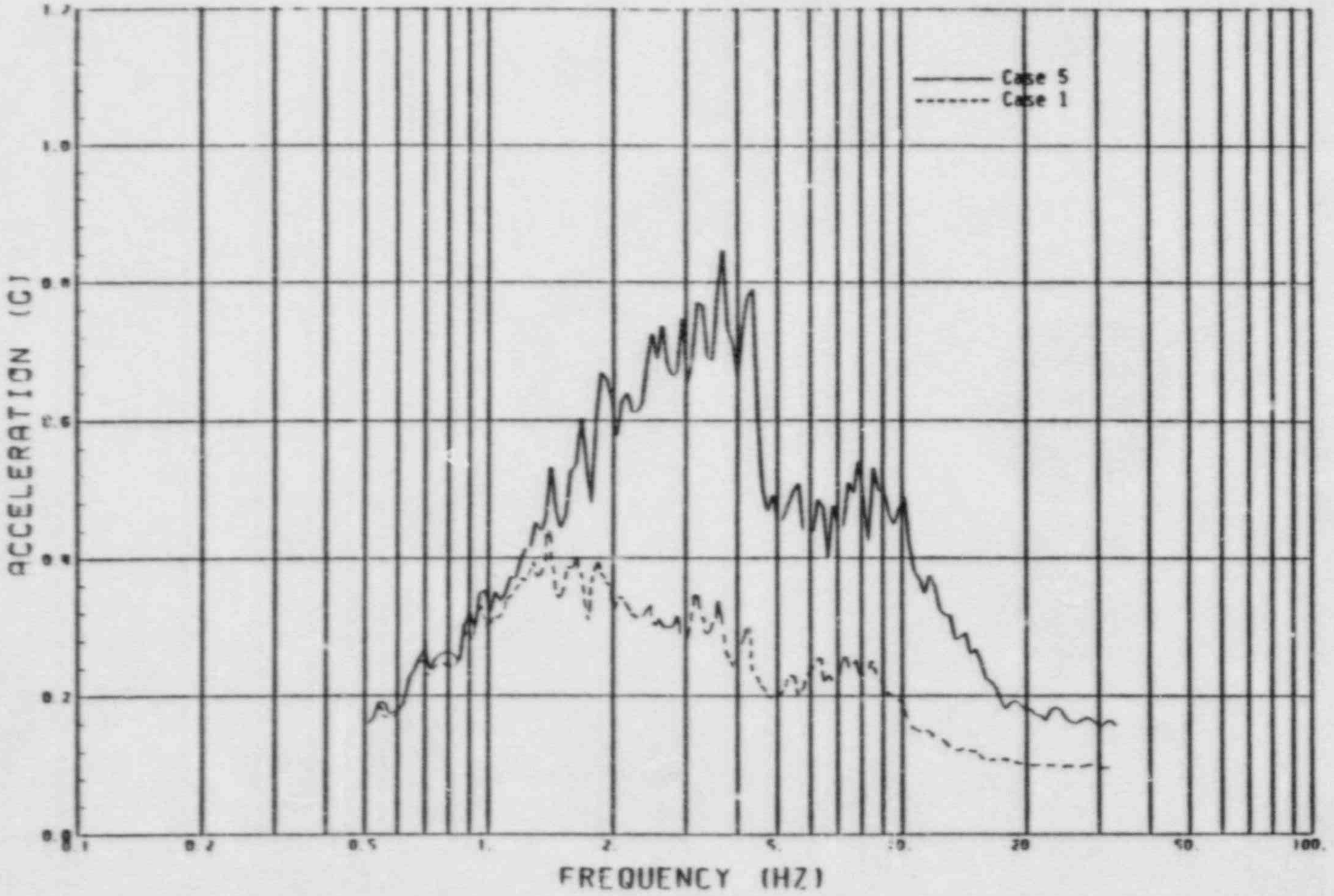
ITEM 4. Discuss how you have accounted for the soil properties at the lower range of shear modulus. Discuss the effects of using higher strains and corresponding soil properties on the analysis results.

GE RESPONSE:

The range of soil shear moduli used for the various SSI analysis ranged from 1.63 x 10^6 psf to 45.5 x 10^6 psf. This represents a variation in soil shear wave velocities from 648 ft./sec. (Case 1) to 3422 ft./sec. (Case 5). Thus, soil properties varying from "soft" to "very stiff" were covered.

The effect of this variation in soil properties on the structural responses is shown in Figures 4.1 and 4.2. Figure 4.1 is a comparison of response spectra at the basemat elevation for Cases 1 and 5. Figure 4.2 is a similar comparison at the top of the Reactor Building structure. Note that these comparisons correspond to the extreme soil cases considered. Analysis results for the other intermediate cases will be in between these two.

The comparisons show that at the basemat elevation Case 1 results are completely enveloped by Case 5 results. Furthermore, any further softening of the soil (use of higher soil strains) will result in the response being shifted further into the lower frequency range, which is of no significance in the GESSAR II design. Similar conclusions can be derived from the comparison of the response spectra at node 1, as shown in Figure 4.2.

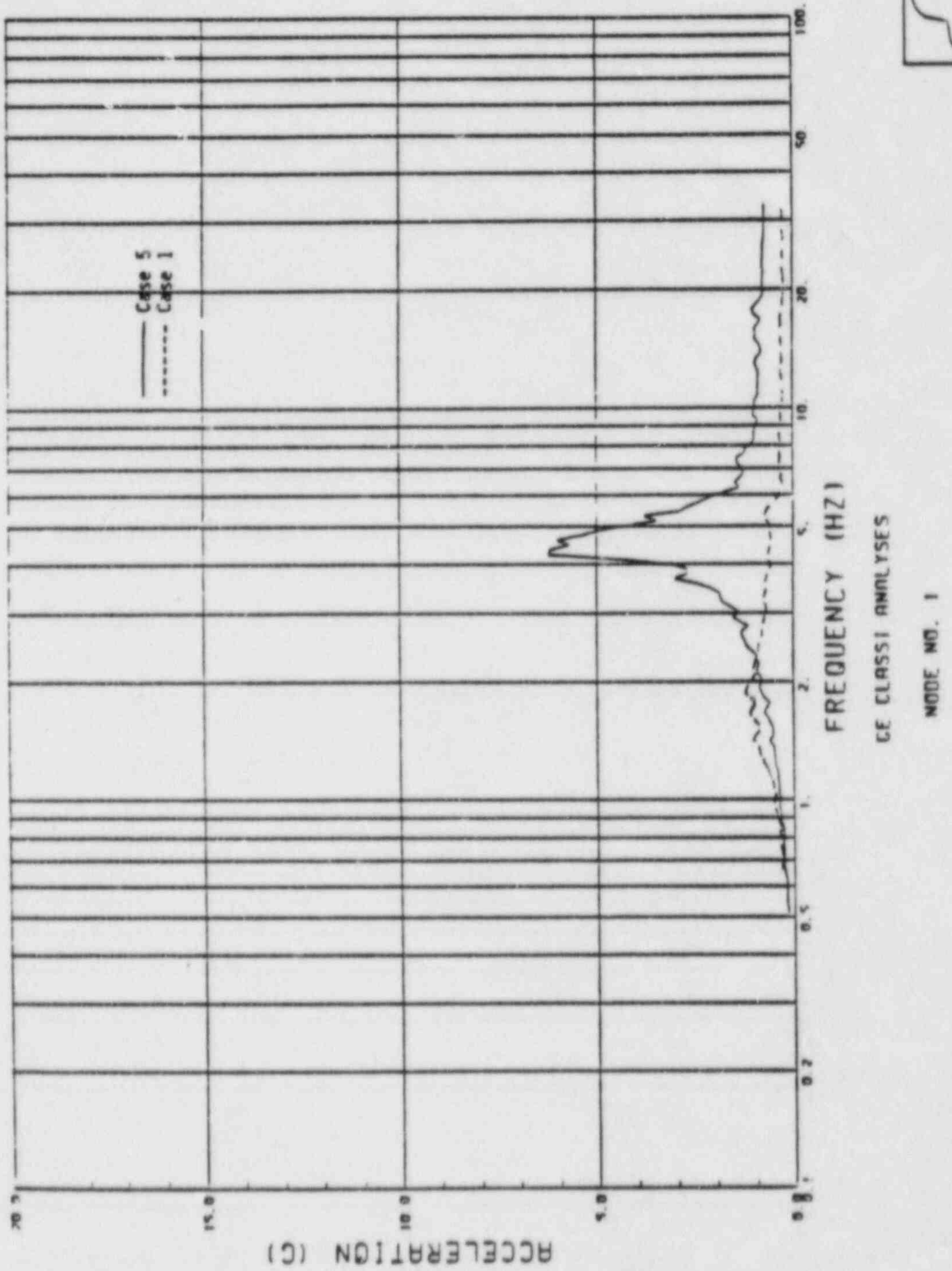


GE CLASSI ANALYSES

BASEMAT. NODE NO. 71 (TRANSLATION)

GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

Figure 4.1



GESSAR II PLANT
SOIL - STRUCTURE INTERACTION

Figure 4.2

17.1 QUALITY ASSURANCE DURING DESIGN AND CONSTRUCTION

17.1.1 Organization

See Section 1 of Reference 1.

17.1.2 Quality Assurance Program

The identification of safety-related structures, systems, and components (Q-list) to be controlled by the quality assurance program is the responsibility of the Applicant. The Applicant will supplement and clarify its Q-list in accordance with Question 17.3. The appropriate items will be added to Table 3.2-1. The reamining items will be subject to the pertinent requirements of GE's and/or the Applicant's QA programs unless otherwise justified.

17.3

The Applicant's performance specifications and monitoring procedures will include the applicable interface requirements of Tables 1.9-1 through 1.9-24 and of Figures 1.9-1 through 1.9-5 to assure that reliability objectives are met during procurement, construction, preoperational testing, startup testing and the formulation of procedures for operations and maintenance.

The remainder of this subsection is covered in Section 2 of Reference 1.

17.1.3 Design Control

See Section 3 of Reference 1.

17.1.4 Procurement Document Control

See Section 4 of Reference 1.

17.1.5 Instructions, Procedures, and Drawings

See Section 5 of Reference 1.

17.1.6 Document Control

See Section 6 of Reference 1.

17.1.7 Control of Purchased Material, Equipment, and Services

See Section 7 of Reference 1.

17.1.8 Identification and Control of Materials, Parts, and Components

See Section 8 of Reference 1.

17.1.9 Control and Special Processes

See Section 9 of Reference 1.

17.1.10 Inspection

See Section 10 of Reference 1.

17.1.11 Test Control

See Section 11 of Reference 1.

17.1.12 Control of Measuring and Test Equipment

See Section 12 of Reference 1.

17.1.13 Handling, Storage, and Shipping

See Section 13 of Reference 1.

17.1.14 Inspection, Test, and Operating Status

See Section 14 of Reference 1.

17.1.15 Nonconforming Materials, Parts, or Components

See Section 15 of Reference 1.

17.1.16 Corrective Action

See Section 16 of Reference 1.

17.2 QUALITY ASSURANCE DURING THE OPERATIONS PHASE

The Applicant's performance specifications and monitoring procedures will include the applicable interface requirements of Tables 1.9-1 through 1.9-24 and of Figures 1.9-1 through 1.9-5 to assure reliability objectives are met and to prevent degradation of the reliability during operation and maintenance.

The remainder of this section will be provided by the Applicant.