Enclosure 2

NMP-1 SEISMIC UPGRADE
PROGRAM PLAN AND DESCRIPTION

Revision 1

June, 1987

CONTENTS

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FIGURES

TABLES

Section 1
INTRODUCTION

PURPOSE

The purpose of the NMP-1 Seismic Upgrade Program (SUP) is to incorporate advances in seismic design methodology and criteria to develop a more modern definition of the seismic adequacy of NMP-1. The SUP will also provide Niagara Mohawk with new, up-to-date methods and criteria for analysis and control of plant data and for future plant modifications.

BACKGROUND

This report describes the NMP-1 Seismic Upgrade Program (SUP). The SUP is a follow-on activity from the Systematic Evaluation Program (SEP) and Integrated Safety Assessment Program (ISAP), in which Niagara Mohawk voluntarily participated between 1981 and 1986. These programs involved a significant investment in the re-evaluation of the seismic design and adequacy of NMP-1, including reviews of original seismic design bases, evaluations of structures and piping, and plant walkdowns. The SEP/ISAP review has demonstrated that NMP-1 is a well-designed, safe plant, but that documentation to demonstrate the seismic design adequacy of the plant is limited. Further, there have been extensive changes in seismic design methodology and criteria since the mid-60's when NMP-1 was designed. For these reasons, Niagara Mohawk plans to complete a systematic re-assessment and upgrade, if necessary, of all important aspects of the seismic design of NMP-1. This effort, the NMP-1 SUP, will build on seismic evaluation work completed in the SEP/ISAP project and will address:

- The design ground motion response spectra,

- Seismic Class 1 and 2 structures, piping and supports, and

- Safe shutdown mechanical and electrical equipment.

As part of this effort, we plan to develop and use consistent and modern seismic design methodology and criteria, such that the seismic safety of the plant can be judged in a realistic and consistent manner and can be compared with that of more modern nuclear plants. Eventually, the criteria which evolve from this program will be NMP-1's licensing design basis and will be used for future plant modifications and additions.

OBJECTIVES

This program has several objectives:

- To provide state-of-the-art criteria and methodology to be used for future plant modifications and additions.

- To re-assess the adequacy of the NMP-1 seismic design based on up-to-date, improved methods and acceptance criteria.

- To demonstrate and document the seismic adequacy of NMP-1 compared to that of modern nuclear plants.

- To provide a comprehensive, as-built structural data base for plant structures and piping systems. This data base is intended to provide up-to-date, state-of-the-art design and computer models (three-dimensional, finite element) of Class 1 structures and important piping and support systems.

- To prepare for future seismic evaluation programs currently being developed by the USNRC.

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SCOPE

The scope of the SUP will include all seismic Class 1 and 2 structures, piping and supports as defined in the NMP-1 FSAR and listed in Appendix A of this report, so that resulting SUP criteria and methodology may form a new licensing basis for the plant. In addition, other active mechanical and electrical equipment, heat exchangers, tanks and electrical cable tray/ conduit systems will be evaluated in accordance with the USI A-46 program.

TIMING

The SUP will be undertaken by NMPC as a voluntary effort over the next several years. In the near term, the objective is to develop and obtain NRC approval of new seismic criteria for use in the Spring, 1988 Outage of NMP-1, for the USI A-46 program, and for other seismic evaluations which may be performed.

REPORT CONTENT

The sections of this report which follow provide an overview of the technical approach to be followed, a summary of the seismic re-evaluation work already completed and a description of the plans, methodology and criteria for the NMP-1 SUP.

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Section 2
APPROACH

GENERAL APPROACH

This program will approach the seismic qualification issue by developing and using new, realistic methodology and acceptance criteria to re-assess the seismic design of NMP-1 structures, systems and equipment. It is recognized that significant progress and changes have been made in the industry's refinement of seismic loads, seismic methodology and seismic acceptance criteria since NMP-1 was designed in the mid-1960's, and over the intervening years. This has led to inconsistencies in the seismic design bases for plant systems and structures and uncertainties in the seismic margins provided. It is also clear that the original seismic design bases for NMP-1 are in some cases inappropriate compared to current seismic design practice. As a result, it is considered essential that realistic, self-consistent criteria, methods and load definitions be developed and used without reference to original design bases. This approach has been successful in SEP and other seismic re-evaluation efforts underway in the industry and has been approved in the past by the USNRC. Comparison of new loading to old criteria, or vice-versa, is considered to be inconsistent and inappropriate.

In the course of SEP/ISAP work, the following studies have been completed:

- Re-evaluation of original NMP-1 seismic design bases
- Review of all existing NMP-1 design records

- Development of state-of-the-art, uniform hazard ground motion response spectra for the NMP-1 site
- Plant seismic walkthrough
- Review of NMP-1 piping analyses of record
- Review of existing structural analyses, and subsequent re-analysis of the NMP-1 vent stack
- Evaluation of anchorage of mechanical equipment
- Definition of structural loads on the plant, including earthquake
- Modeling of building structures
- Generation of preliminary floor response spectra
- Re-analysis of selected piping systems.

The SUP approach will include (1) review and up-dating, if necessary, of the completed SEP/ISAP reviews and analyses using new methodology and criteria, and (2) expansion of the scope of the seismic evaluation to cover the structures, systems and equipment defined in the SUP scope. Specifically, it is anticipated that the following tasks will be undertaken as part of the SUP:

- Development of SUP analysis methodology and criteria
- Re-evaluation and re-definition, as needed, of the seismic ground motion spectra
- Re-evaluation of Class 1 and 2 structures using new models and methodology
- Generation of new, realistic floor response spectra
- Re-evaluation of Class 1 and 2 piping systems and supports
- Seismic qualification of equipment, including mechanical and electrical equipment, heat exchangers, tanks and electrical cable and conduit raceways.

LICENSING APPROACH

It is the intent of this program to develop a realistic, self-consistent and up-to-date seismic design basis for the NMP-1 plant. The methodology and criteria developed for the SUP will be used for all re-assessments and, in the future, as the licensing basis for any plant modifications or additions.

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Section 3
DESCRIPTION OF THE SEISMIC UPGRADE PROGRAM

The main elements of the Seismic Upgrade Program (SUP) are shown in Figure 3-1 and described below. Some of this work was initiated in the SEP/ISAP effort, and will be re-evaluated and up-dated in the SUP. Other tasks are new and will be performed as part of the SUP. The status of completed tasks and planned SUP efforts are summarized below.

RE-EVALUATION OF ORIGINAL NMP-1 SEISMIC DESIGN BASES

The seismic re-evaluation of the original NMP-1 plant design was initiated in the SEP/ISAP program, and was based on the methodology developed by the USNRC for review of SEP plants of similar vintage to NMP-1. In this approach, a sampling of representative and most vulnerable equipment, systems and structures were re-evaluated for seismic adequacy. The structures, systems and equipment reviewed were selected based on (1) review of available original design records, and (2) a walk-through inspection by a team of NMPC and contractor engineers experienced in seismic design and analysis. The specific tasks undertaken in the re-evaluation are summarized below.

Design Record Review

A review was made of the seismic design basis for NMP-1 as presented in the NMP-1 Preliminary Hazards Analysis Report and the Final Safety Analysis Report. Areas reviewed included the design basis earthquake, seismic classification of structures, systems and equipment, load combinations and acceptance criteria. In addition, a substantial effort was undertaken to assimilate and review all available seismic design

MPR ASSOCIATES
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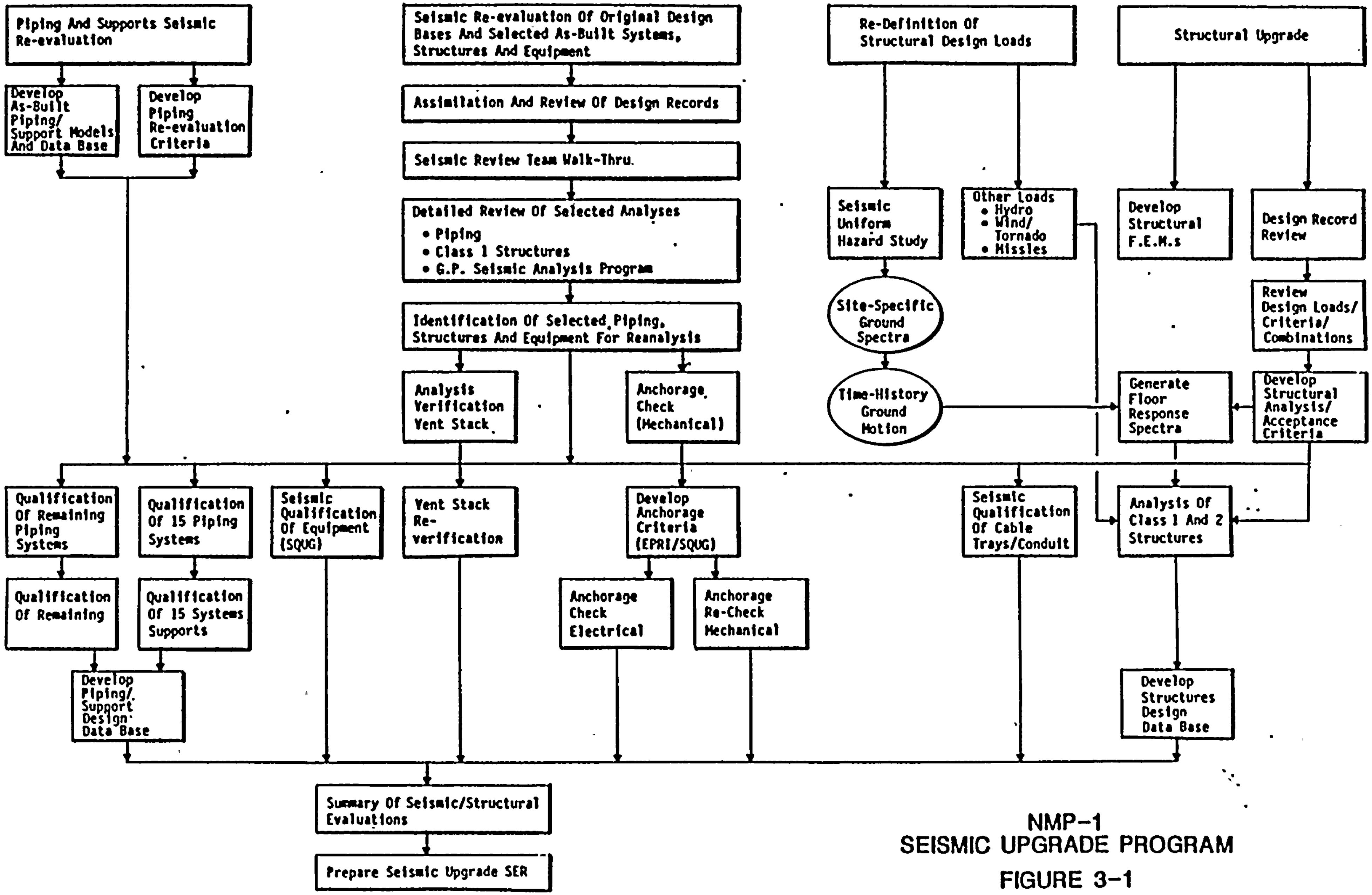

NMP-1
SEISMIC UPGRADE PROGRAM
FIGURE 3-1

records, including design calculations, analyses, procurement specifications, design specifications and pertinent letters and memoranda. Original design records were obtained from the NSSS (General Electric), the principal seismic consultant (J. A. Blume) and from Niagara Mohawk's design record data base system (Niagara Mohawk acted as its own A-E for NMP-1).

The results of this review are summarized in MPR Report No. 858, "NMP-1 Summary of Seismic Design Information". This report identified certain weaknesses in early records and also provided a basis for the seismic walk-through of the plant.

Seismic Walk-Through

A team of experienced seismic engineers, senior Niagara Mohawk design engineers and plant personnel was selected. This team included senior representatives from J. D. Stevenson and Associates, URS/J. A. Blume and Associates, and MPR Associates in addition to Niagara Mohawk personnel. The seismic walk-through was performed, after review of the compilation of original seismic design data, in November, 1982.

The scope of the walk-through included the following:

Seismic Category 1 structures
Safe-shutdown systems and equipment
Safety systems and equipment
Containment systems

The results of the walk-through inspections identified a number of areas for detailed evaluation. These areas include:

Anchorage of cabinets, tanks, and heat exchangers
Certain piping and support systems
Support of selected pumps and valves

Diesel generator supports, inlet air and exhaust ducts

Certain block walls

Ventilation stack

Gap between reactor and turbine buildings

Cable trays and duct work

Control room ceiling

Completed evaluations of the above areas are discussed in subsequent sections of this report.

Review of Piping Analyses

Based on the preliminary record reviews and the seismic walk-through, a comprehensive evaluation of all available piping system analyses was performed. This evaluation included approximately 25 piping system analyses performed over the period from 1969 through 1981. The results of the evaluation identified the need for re-analysis of selected parts of fifteen piping systems, including those systems selected as needing review based on the seismic walk-through.

Review of Structural Analyses

Review of selected structural analyses was performed. In particular, it was noted that Niagara Mohawk's General Purpose Seismic Analysis Program (developed in the 1960s) was used in the design of a number of Class 1 structures, including the ventilation stack. Since the ventilation stack was also identified for detailed evaluation in the site walk-through, the ventilation stack was selected as a representative structure for re-analysis.

Re-analysis of the ventilation stack was performed using the computer program FESAP. In order to verify the results of the Niagara Mohawk General Purpose Seismic Analysis Program, identical inputs to those of the original NMPC analyses were used. The results of the re-analyses

confirm that the original Niagara Mohawk analysis method is conservative; the original method over-estimates seismic moments, but accurately calculates the natural frequencies of the structure.

Original structural analyses performed by other methods (most notably hand calculations) will be verified by re-evaluation of Class 1 and 2 structures as part of the SUP.

Anchorage of Mechanical Equipment

Anchorage and supports for mechanical equipment identified in the seismic walk-through as most vulnerable to seismic loads were re-evaluated. These re-analyses were based on the plant licensing basis Safe Shutdown Earthquake (SSE) and available preliminary floor response spectra for NMP-1. The floor response spectra used for this analysis were generated by URS/J. A. Blume for NMP-1 in 1982. Supports were re-evaluated for the following components:

- Emergency condenser makeup tank
- Emergency condenser
- Condensate storage and surge tanks
- 275 gallon fuel oil tank
- Reactor building closed loop cooling heat exchanger (HX)
- Containment spray HX
- Shutdown cooling HX
- Service water pump
- Emergency service water pump
- Containment spray (raw water) pump
- Core spray pump motor
- Containment spray pump motor
- Emergency diesel generator and inlet ducts

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The results of these analyses are presented in Table 1. All results were acceptable. These analyses will be re-validated or revised, as necessary, upon completion of the final seismic floor response spectra (FRS) for NMP-1 as described in this report. Evaluation of other potentially active mechanical and electrical equipment anchorages required for safe shutdown will also be performed as part of the resolution of Unresolved Safety Issue (USI) A-46.

RE-DEFINITION OF SEISMIC DESIGN INPUT

The review of the original NMP-1 design bases indicated that structural design loads due to external phenomena (including earthquake) were generally not established using criteria such as are specified for newer nuclear plants. Accordingly, projects were initiated as part of the ISAP to define appropriate design loads for re-evaluation of NMP-1 structures. The projects were directed toward development of site-specific seismic response spectra, and definition of other structural loads. The latter project is not a part of SUP, but is described here for completeness.

Site-Specific Seismic Uniform Hazard Study

The NMP-1 licensing basis SSE is a site-specific ground response spectra anchored at a peak ground acceleration (PGA) of 0.11g. A 1982 seismological study performed by Geoscience Services confirms the acceptability of this PGA for the very stable seismic zone in which NMP-1 is located. However, because of the acceptance of probabilistically-based site-specific design spectra in the SEP and the use of the uniform hazard methodology in the extensive Eastern U.S. Seismicity Study currently being undertaken by the USNRC (through Lawrence Livermore Lab) and the industry (through EPRI), a site-specific, uniform hazard study has been performed for the NMP-1 site. The principal investigators in the study were Dr. Robin McGuire (Dames and Moore) and Dr. C. Allin Cornell (Stanford University). Both are acknowledged experts in this field who also have primary responsibility for the development of the uniform hazard method in the on-going Eastern Seismicity Study being performed by EPRI. Analysis support was provided by Yankee Atomic Power Company.

TABLE 3-1

SUMMARY OF SUPPORT EVALUATIONS

Equipment	Evaluations	Results
1. Emergency Condenser Makeup Water Storage Tank	° Tension and shear in saddle bolts	Acceptable
	° Tension and shear in brace anchor bolts	Acceptable
	° Tension and compression in brace	Acceptable
2. Condensate Storage and Surge Tank	° Tension, shear, and pullout of anchor bolts	Acceptable
	° Bending of anchor bolts	Acceptable
3. 275 Gallon Above Ground Fuel Oil Tank	° Tension and shear in tank to angle frame pipes	Acceptable
	° Tension, shear, and pullout of anchor bolts	Acceptable
	° Tension/compression in angle frame members	Acceptable
4. Closed Loop Cooling Water Heat Exchanger	° Tension, shear, and pullout of anchor bolts	Acceptable
5. Containment Spray Heat Exchanger	° Tension, shear, and pullout of anchor bolts	Acceptable

TABLE 3-1 (Cont'd)

SUMMARY OF SUPPORT EVALUATIONS

Equipment	Evaluations	Results
6. Shutdown Cooling Heat Exchanger	° Tension, shear, and pullout of anchor bolts	Acceptable
7. Emergency Condenser	° Tension, shear, and pullout of anchor bolts	Acceptable
8. Service Water Pump	° Tension and shear in motor to motor stand bolts	Acceptable
	° Tension, shear, and pullout of pump anchor bolts	Acceptable
	° Bending and shear in drive shaft	Acceptable
9. Emergency Service Water Pump	° Tension, shear, and pullout of anchor bolts	Acceptable
	° Bending and shear in shaft	Acceptable
	° Loads on shaft bearings	Acceptable
10. Containment Spray Service Water Pump	° Tension, shear, and pullout of anchor bolts	Acceptable
	° Bending and shear in shaft	Acceptable
	° Loads on shaft bearings	Acceptable
11. Core Spray Pump	° Bending in motor support stand	Acceptable

TABLE 3-1 (Cont'd)

SUMMARY OF SUPPORT EVALUATIONS

Equipment	Evaluations	Results
12. Containment Spray Pump	° Bending in motor support stand	Acceptable
13. Emergency Diesel Generator	° Tension, shear, and pullout of anchor bolts	Acceptable
14. Diesel Generator Intake and Exhaust Ducts	° Bending in intake and exhaust ducts	Acceptable

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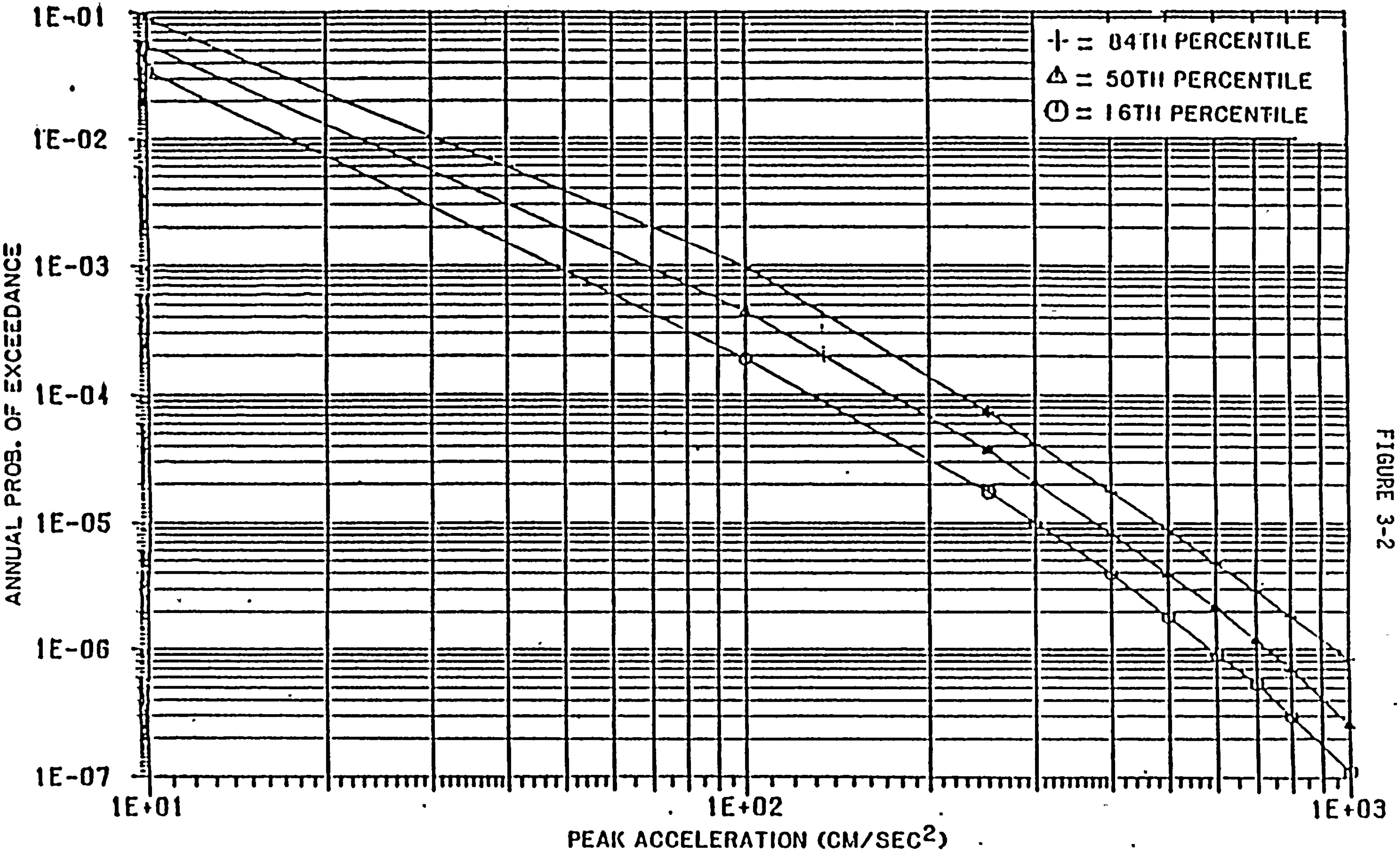
The uniform hazard study was based on a probabilistic assessment of the frequency of exceedance of various ground acceleration, velocity and response spectrum levels at the NMP-1 site. It utilized the procedures documented by Tera Corporation (1980) in the report of work for Lawrence Livermore National Laboratory and the USNRC Probalistic Risk Assessment Guide (American Nuclear Society, 1981). It relied on the expertise of Dames and Moore, a wide range of expert opinion summarized by Bernreuter et al (1984), other studies of eastern seismicity including those by Hadley and Devine (1974), Tera Corp. (1980) and others. Earthquake catelogs of Chiburis (1981) and the USGS were used.

Dr. Lynn R. Sykes (Lamont-Doherty Geological Laboratory) and Mr. James McWhorter (Dames and Moore) delineated seismogenic zones and their credibility and estimated their parameters.

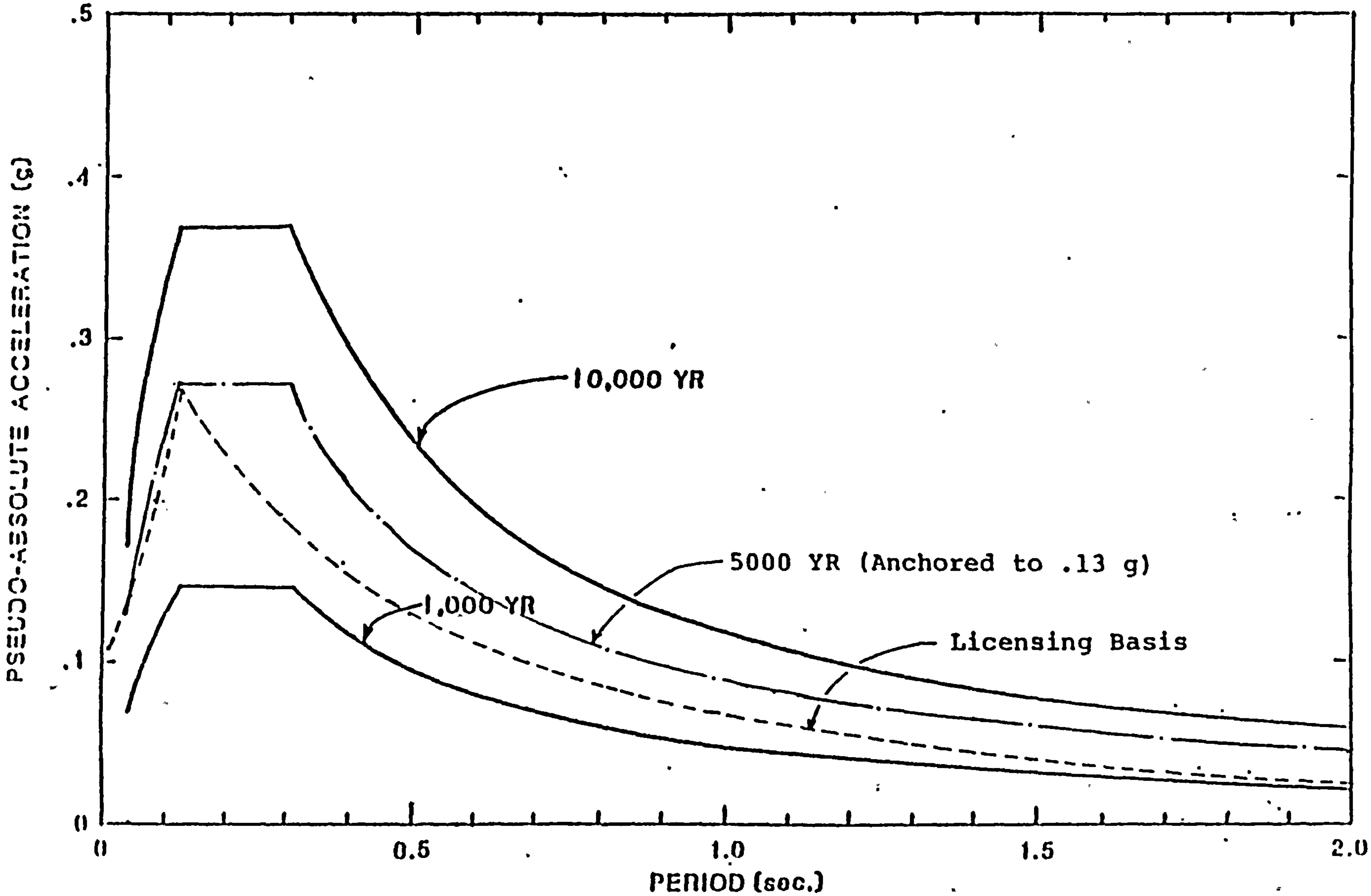
A total of 324 seismic hazard curves for acceleration were generated in this study for: four sets of zonations, times three attenuation functions, times three activity rates, times three b-values, times three values of M_b, max. The resulting fractile hazard curves are presented in Figure 3-2. These results show that the PGA of 0.11g for the NMP-1 SSE has a mean annual probability of exceedance of less than 4 X 10^{-4}. A PGA of 0.13g, in combination with the uniform hazard spectra shape given in Figure 3-3, is being used for SSE loading in the seismic/structural re-analyses undertaken as part of the SUP. This PGA has a mean annual probability of exceedance of about 2 X 10^{-4} and is considered to be an appropriate SSE level for future seismic assessments and plant modifications. The peak vertical ground acceleration is taken to be two-thirds of the peak horizontal ground acceleration.

FIGURE 3-2



ACCELERATION HAZARD: 16, 50, and 84 PERCENTILES

FIGURE 3-3



ACCELERATION RESPONSE SPECTRA (5% DAMPING)

The NMP-1 uniform hazard spectra has been used as the basis for development of synthetic time-history ground motion for subsequent structural and floor response analyses. The free-field synthetic time histories for horizontal and vertical motion were developed by URS/J.A. Blume using representative earthquake records and accepted procedures (in URS/Blume program SMSPC3).

Definition of Other Loads on Structures

Although not directly related to SUP, definition of other loads on structures due to extreme external phenomena was completed as part of evaluation of several ISAP topics. The evaluations provide loads associated with ground water, snow, ice, maximum precipitation, straight wind and tornados.

RE-EVALUATION OF CLASS 1 AND CLASS 2 STRUCTURES

Scope

The re-evaluation of Class 1 and 2 structures includes development of dynamic and static structural models and criteria to re-analyze the NMP-1 reactor and turbine buildings; specifically the following structures:

Reactor Building
Turbine Building and Extension
Off-Gas Building
Screen and Pump House
Waste Disposal Building
Radwaste Solidification Building (Dynamic model only)
Administration Building
Administration Building Extension

The Class 1 and 2 building re-analysis will concentrate on the primary structural elements of the building. To the extent possible, Niagara Mohawk/EPRI research work on soil-structure interaction (explosive testing of scale models of the NMP-1 reactor building) will be factored into the structural analyses.

Dynamic Master and Detailed Static Building Models

For each Class 1 building listed above, two types of models were developed: dynamic master models and detailed static models.

The dynamic master models are three-dimensional finite element models comprised of vertical and horizontal beam elements and concentrated masses. Three-dimensional models were developed to account for the torsional response induced by the nonconcurrence of the centers of mass and rigidity in the buildings. They are intended for use in analysis and evaluation of dynamic loadings such as seismic excitation. The models are suitable for response spectrum analysis, time history analysis by model superposition, direct integration time history analysis, and free vibration analysis.

The static models are highly detailed, three dimensional finite element models which reproduce the static load paths in each building. 1/ All structural members within each building have been explicitly included in the models. These members include steel columns, trusses, floor beams and girders and the various reinforced concrete walls, columns, floor slabs and floor beams. The static models are intended for analysis of static loads and/or equivalent static loads or displacements obtained

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1/ Note that the Radwaste Solidification Building, recently constructed, has a well documented modern design basis. Therefore, a detailed static model was not developed for this building.

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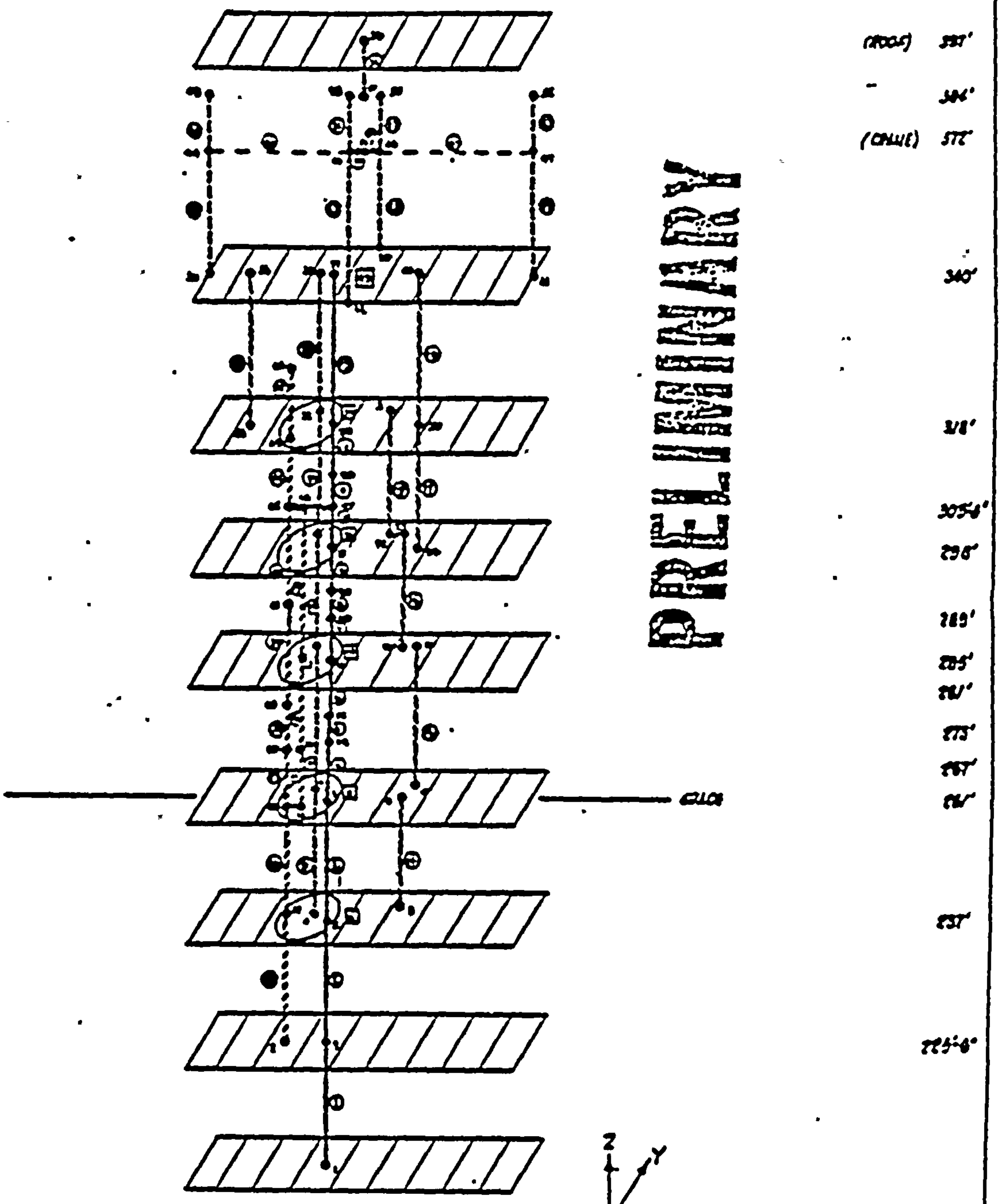
from the dynamic model results. Examples of the dynamic models are shown in Figures 3-4 through 3-10. Examples of portions of the static models are shown in Figures 3-11 through 3-13. The model development effort is essentially complete.

Methodology and Acceptance Criteria

In parallel with model development, work has proceeded to define acceptable analysis approaches, load combinations and updated acceptance criteria. In recognition of the fact that NMP-1 is an older operating nuclear plant that was not designed to current structural codes and regulatory guidance, the approach and criteria developed for the structural re-analysis are realistic and not overly conservative. They are based on methods and criteria approved by the USNRC as part of the Systematic Evaluation Program (SEP) and include recommendations made in NUREG/CR 0098 and NUREG 1061. The applicable Codes, Standards and Specifications forming the basis for evaluation of Class 1 and 2 structures are listed in Appendix B. The structural analysis approach, load combinations and acceptance criteria are summarized below.

Loads and Load Combinations. The loads to be considered include the following: dead loads from the weight of the structure (D), weight of installed equipment and distribution systems (L), earth pressure and groundwater bouyancy loads (B), operating loads (R), and safe shutdown earthquake loads (E´). Loads are combined as shown below:

FIGURE 3-4



REACTOR BUILDING MODEL

REACTOR PRESSURE VESSEL SYSTEM (PEDESTAL, RPV, SHIELD WALLS)
DRYWELL
INTERIOR WALLS
EXTERIOR WALLS / COLUMNS
BEAMS

FIGURE 3-5

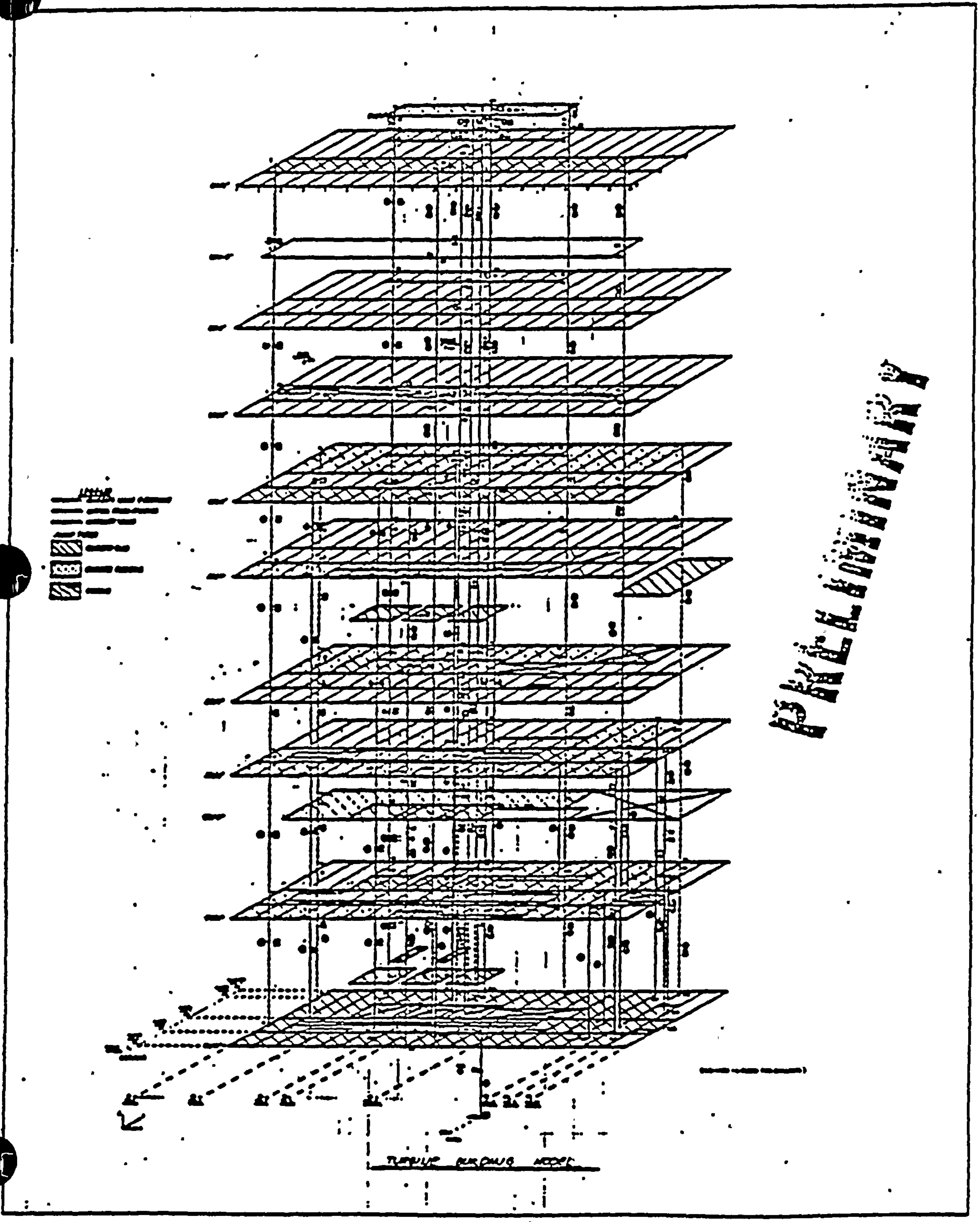
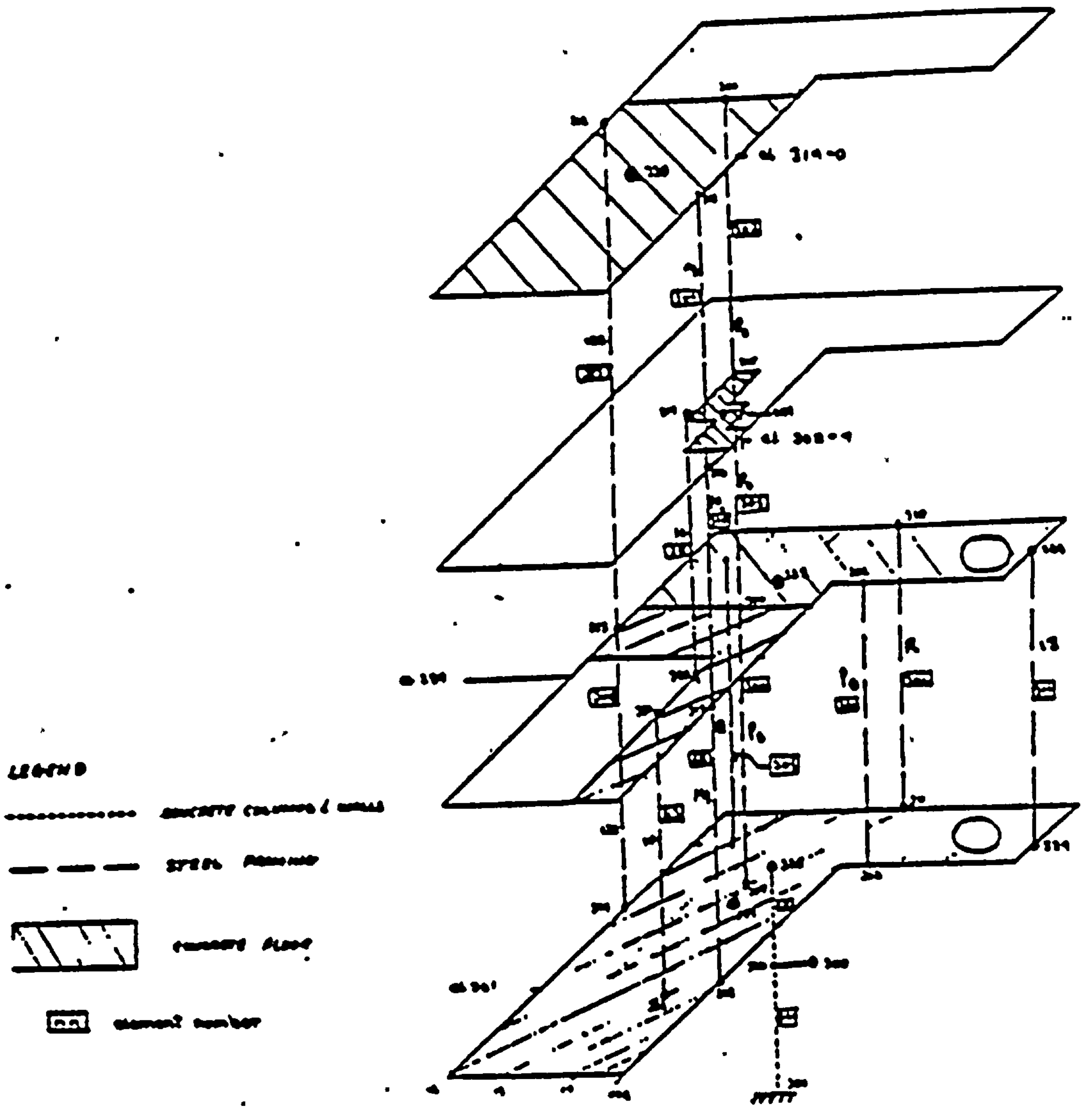


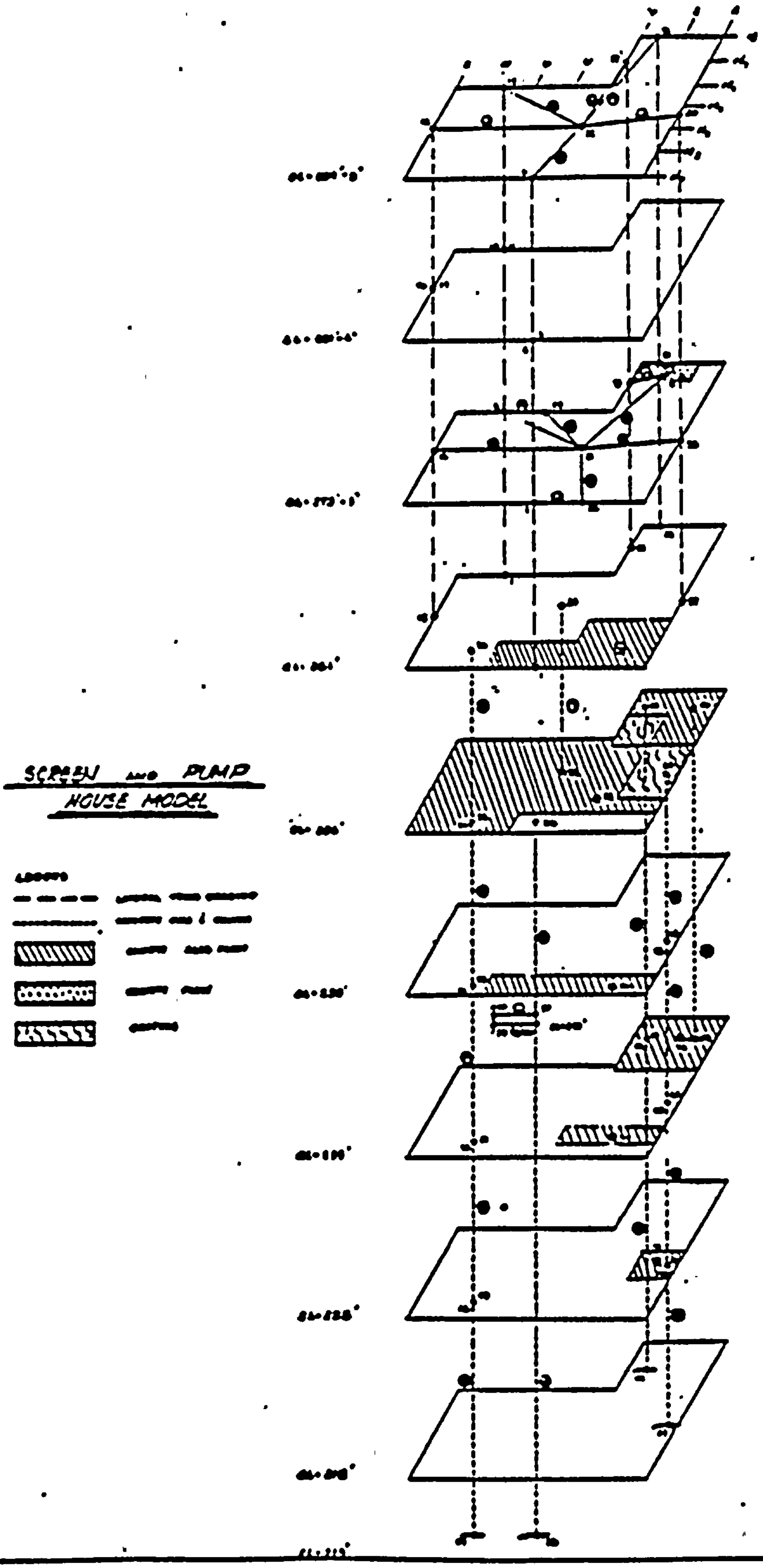
FIGURE 3-6



TURBINE BUILDING EXTENSION

PRELIMINARY

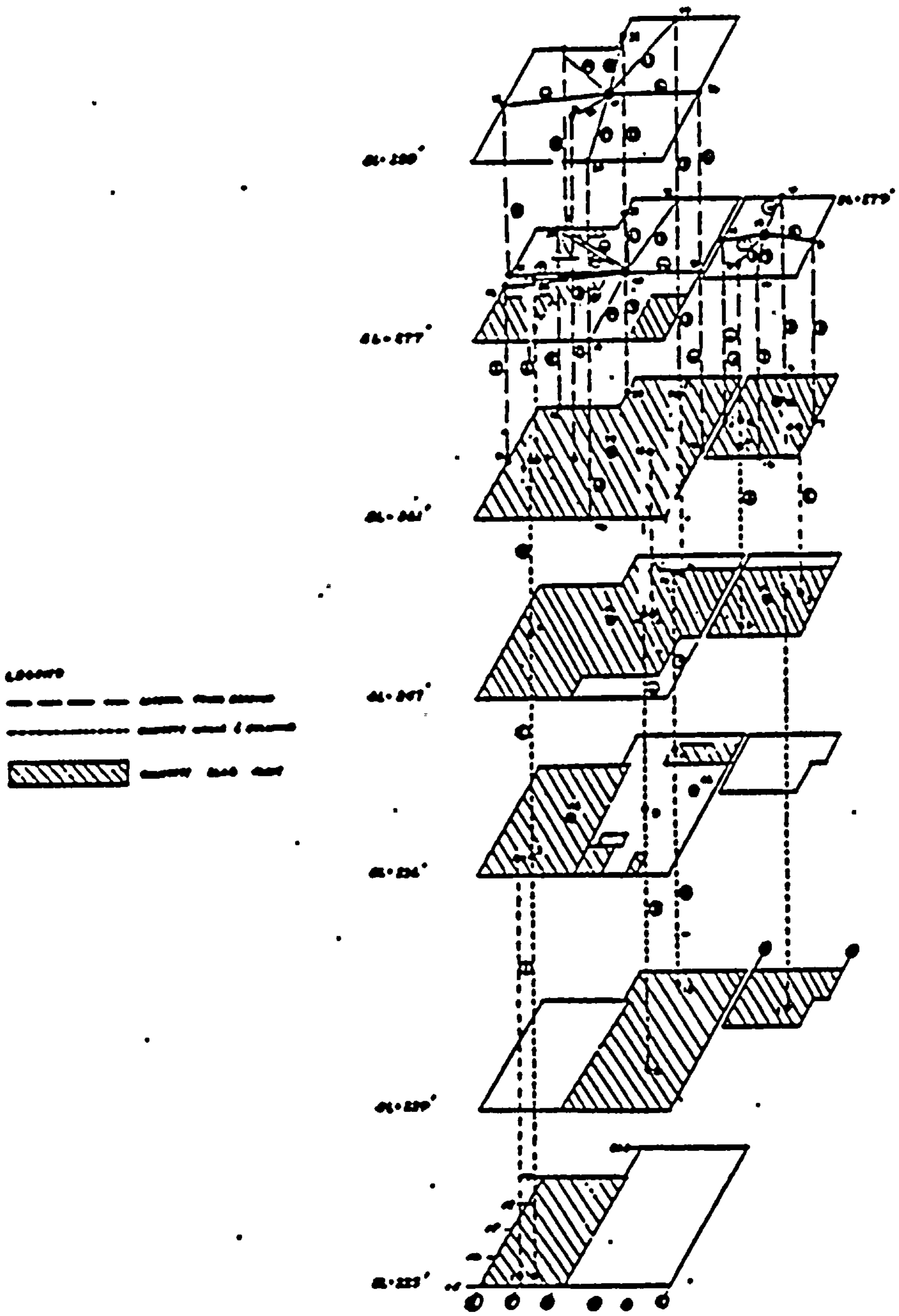
FIGURE 3-7



PRELIMINARY

FIGURE 3-8

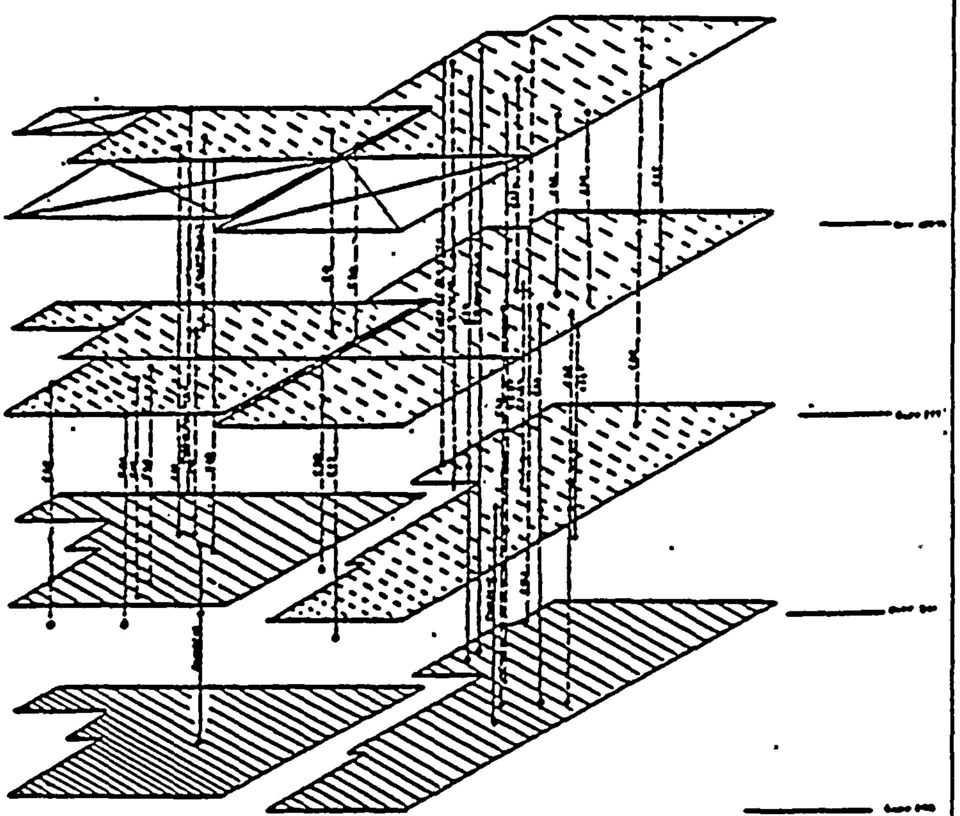
PRELIMINARY



WASTE DISPOSAL BUILDING AND EXTENSION
AND
OFF GAS BUILDING MODELS

FIGURE 3-9

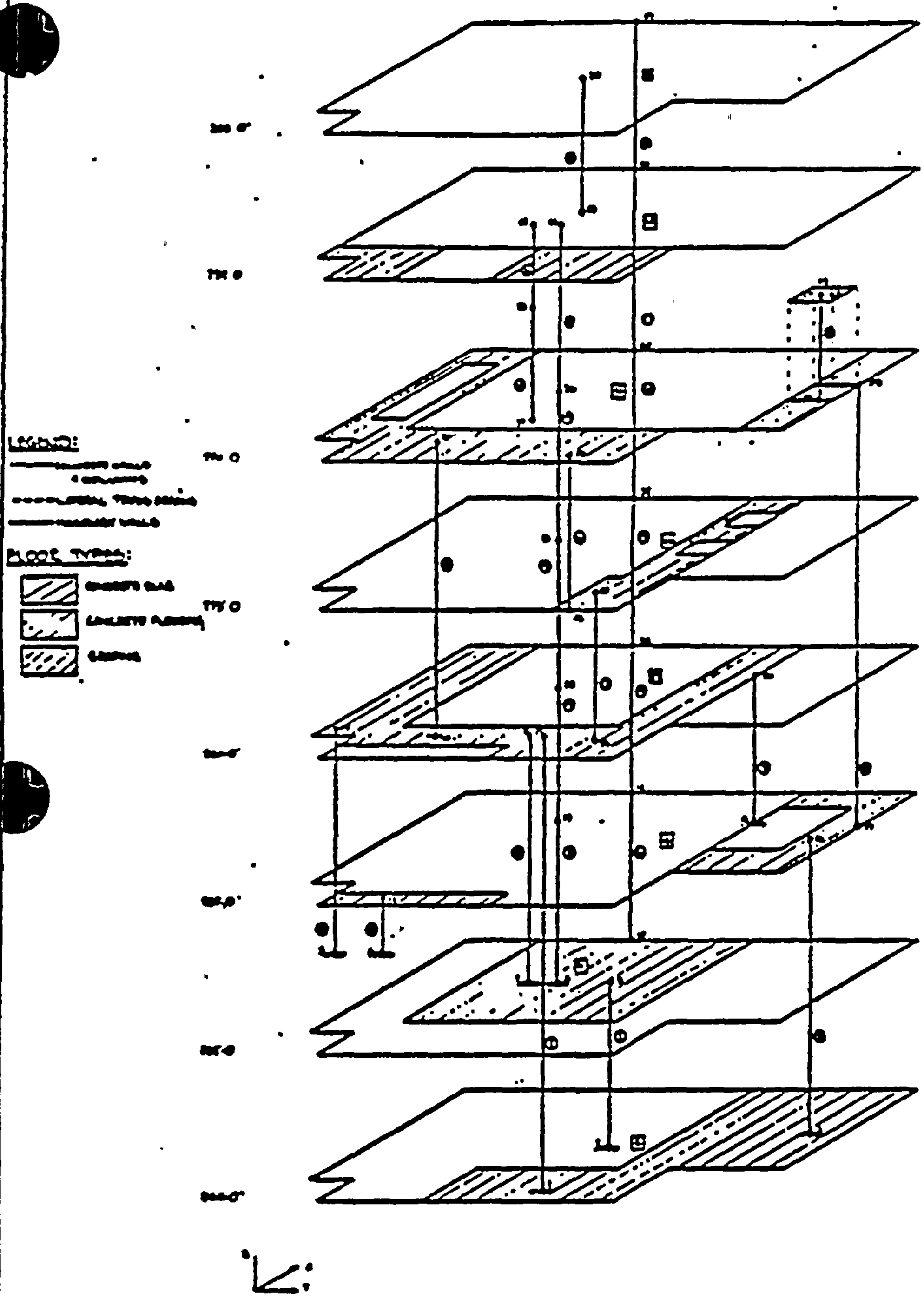
PRELIMINARY



LEGEND

ADMINISTRATION BUILDING AND EXTENSION MODEL

FIGURE 3-10



RADWASTE SOLIDIFICATION
BUILDING MODEL

PRELIMINARY

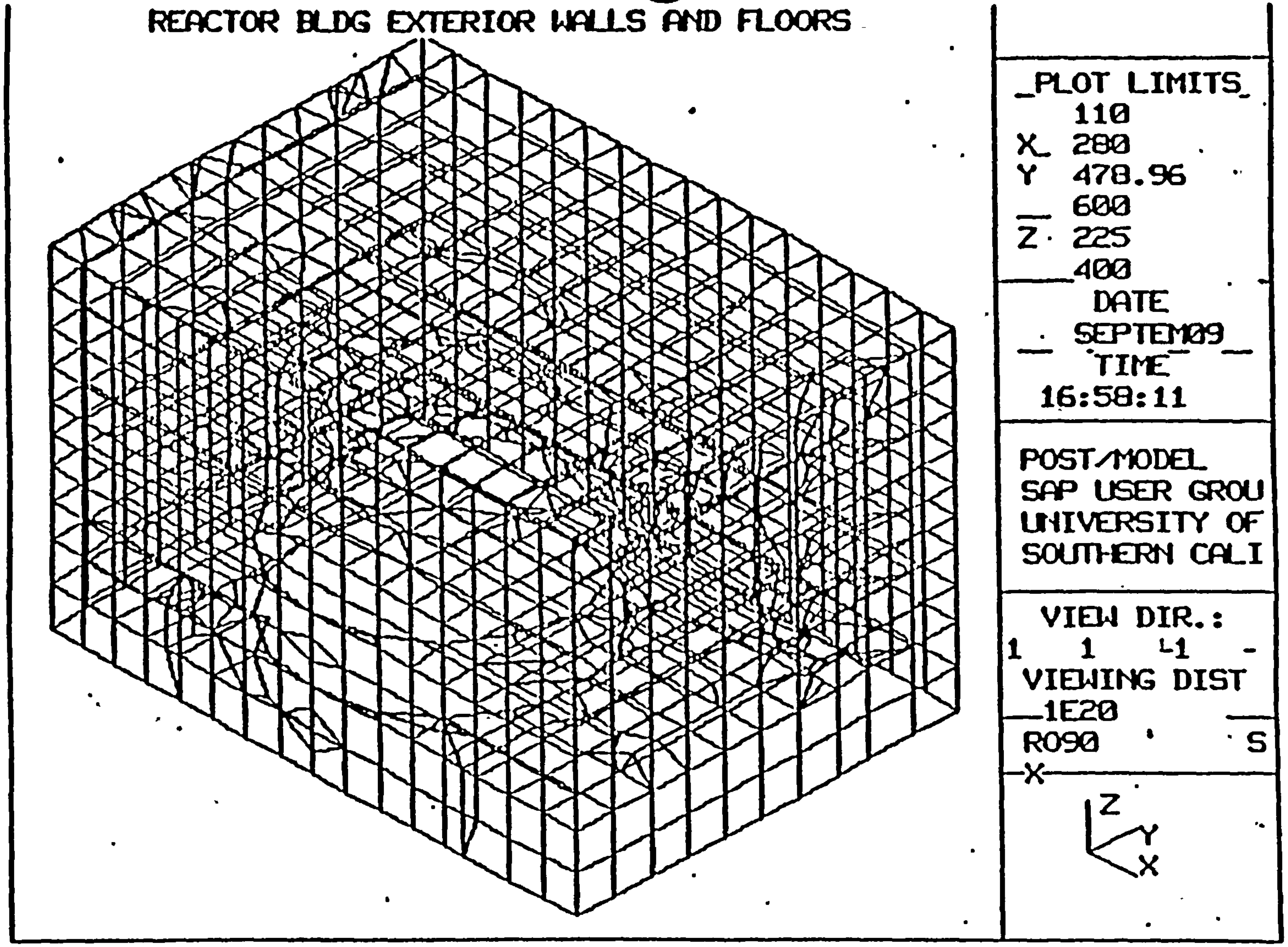


FIGURE 3-11

PRELIMINARY

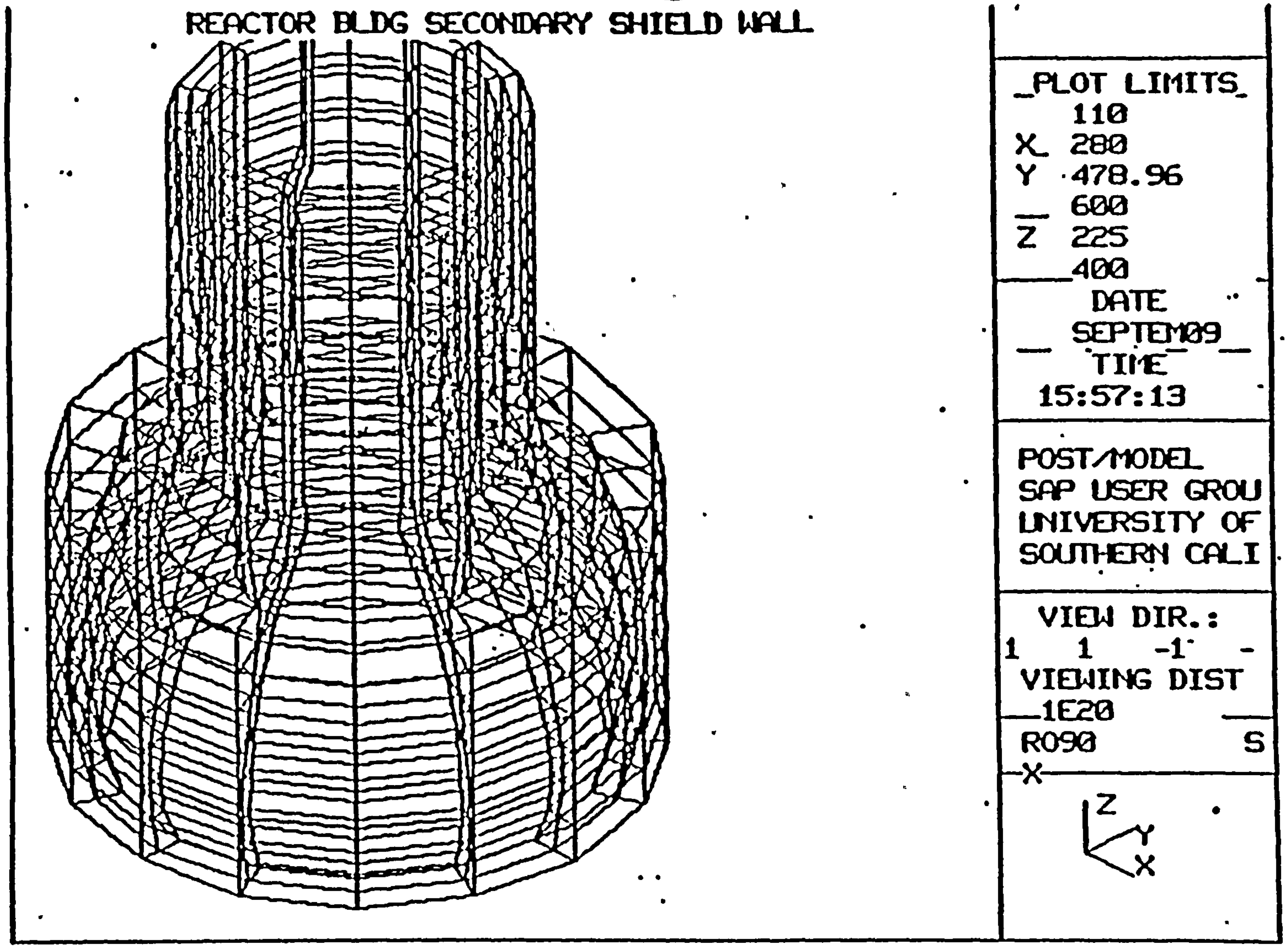


FIGURE 3-12

PRELIMINARY

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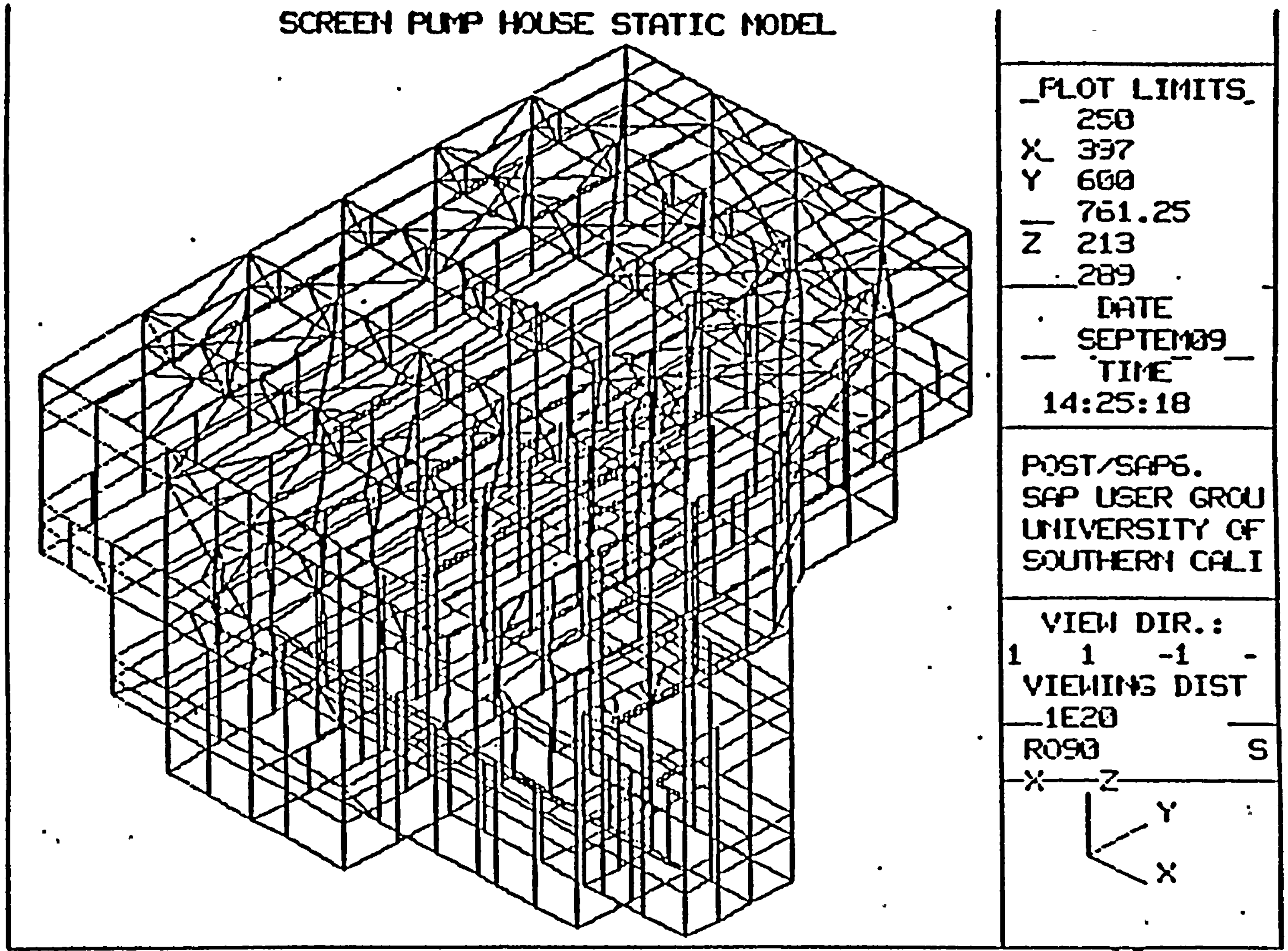

PRELIMINARY

FIGURE 3-13

$$1.6S = 1.0D + 1.0L + 1.0B + 1.0R + 1.0E' \quad (1)$$

$$U = \overset{1.0D}{\cancel{1.4D}} + 1.0L + 1.0B + 1.0R + 1.0E' \quad (2)$$

where: S = Normal Allowable Stress as permitted by the AISC Building Specification - Part 1.

U = Strength capacity or allowable stress as defined by or the AISC Building Specification - Part 2.

Acceptance Criteria. Criteria have been developed for material properties, soils and foundations, and allowable stresses, as summarized below:

Material Properties. Specified design minimum material properties will be used unless mean values at a 95% confidence level of "as built" properties of materials can be established.

Soils and Foundations. Minimum safety margins for foundation bearing capacity shall be as suggested by the ASCE Manual 58.

Allowable Stresses and Strengths. The stresses resulting from simultaneous application of the above loads will be compared to the normal allowable stress (factored by 1.6) as permitted by AISC Building Specification, Part 1. Alternatively, strength capacity U may be used; as permitted by Part 2 of the specification. Where buckling is the limiting load condition, buckling loads shall be limited to 2/3 of the critical buckling load.

Deformations shall be limited to prevent impact on, or interference with, adjacent structures or components. Beam deflections shall be limited to 1/180 of the span length when subjected to the loadings defined herein.

Analysis Guidelines. The system or subsystem analysis used to determine loads which act on structures shall assume linear elastic behavior, except in those instances when allowable behavior limits exceed yield. Use of other than linear elastic analytic procedures considering "system ductility", as defined in NUREG-0098, is permitted when yielding within allowable limits occurs.

Structure lateral load transfer due to friction and/or passive earth pressure is assumed. Damping values for Class 1 and 2 Structures and Equipment can be found in Appendix C.

GENERATION OF FLOOR RESPONSE SPECTRA

Scope

Using the building models discussed in the previous section, amplified floor response spectra are generated at all pertinent elevations of the reactor, turbine and pump and screen house buildings. Since vertical floor flexibility is considered in the models, up to several key locations per floor are chosen as response points for the generation of vertical amplified response spectra. As shown schematically in Figure 1, these spectra will be used as bases for all final equipment and system evaluations, including those for piping, supports, equipment anchorage, cable trays, equipment qualification, etc. Preliminary spectra have been developed at nine locations in the reactor building and at one location on the reactor vessel.

Seismic anchor motions (SAM's) for piping re-analysis have also been developed using a post-processor on the time-history model results to select the absolute greatest distance between structures with respect to time. Anchor motions have thus far been calculated between floors in the reactor building, between the reactor vessel and building, and between drywell concrete and drywell steel. SAM's will be addressed further in the piping re-evaluation section of this report.

Development Using Ground Motion and Building Models

The basis for the new response spectra is the probabilistic, site dependent study implemented by Cornell and McGuire, as discussed in this report. Floor acceleration response spectra are developed from time-history response records or power spectral densities at selected points within the structures. Floor response records are obtained from dynamic analyses in the time or frequency domain using mathematical lumped mass and spring models of the structures subjected to the SSE ground motion discussed above. Next, the acceleration response within the structures is used as input for the analysis of simple oscillators, each equivalent to a single-degree-of-freedom system with natural frequencies in the range of interest (0.5 to 33 Hz) for several damping ratios.

Methodology and Acceptance Criteria. As a minimum, the 75 frequencies of USNRC Reg. Guide 1.122 shall be used as the oscillator frequencies. Additional oscillator frequencies shall be included at resonances, and at their half-power points (damping x frequency points) and full-power points (2 x damping x frequency points) in the vicinity of 10 Hz and above.

Sufficient modal participation shall be achieved so that the function [1 - (participation factors)(mode shapes)] does not exceed 0.2 at any node point associated with floor levels. If it does, the inverse of the above function shall be multiplied by the ground spectrum and combined with the floor response spectrum by SRSS.

From the structural response analysis, response spectra at selected nodal points are presented for each respective translational direction; north/south, east/west and vertical. If the seismic analysis is performed separately for each of the three directions, and in the case of asymetric structures, the ordinates of the spectrum at the location of interest for a given direction shall be obtained by combining ordinates of the three co-directional spectra according to the square-root-sum-of-the-squares (SRSS) criterion.

To account for uncertainties in the structural frequencies, the computed response spectra shall be smoothed and peaks broadened in accordance with ASME Code Case N-397. Parametric studies have been performed and have removed most of the modeling and properties uncertainties. Therefore, peaks will be broadened ± 10% in accordance with SEP precedents.

Response spectra shall be generated at damping ratios of 2, 3, 4, 5, 7, 10 and 20 percent for analysis of equipment, etc. PVRC damping will be used for piping analysis, as described in ASME Code Case N-411. Alternatively, the uniform 3% damping may be used for simplicity.

Significant effective damping of the structural system is achieved when the secondary system (equipment or component) is near or in resonance with the primary system, the building. The effective modal damping ratio is proportional to the square root of the ratio of the secondary system modal effective mass to the primary system modal effective mass. The resulting effective modal damping ratio will be utilized on a case-by-case basis for the generation of floor response spectra for this program.

RE-EVALUATION OF SELECTED CLASS 1 AND 2 PIPING SYSTEMS

Because of the significant changes in seismic analysis and acceptance criteria for piping and pipe support systems over the past 10 to 15 years, Niagara Mohawk has initiated an extensive program to re-assess

the seismic adequacy of some plant piping systems believed to be sensitive to seismic loads. As in the case of the structural evaluations, analytical model preparation and development of analysis methodology and acceptance criteria have proceeded in parallel.

Scope

On the basis of the piping analysis reviews and the seismic walk-through inspections, the piping re-evaluation is focused initially on 15 piping systems believed to be representative and most sensitive to seismic loads. These target systems are as follows:

System No.	Description
81	Core Spray (suction side to topping pumps)
28, 44	CRD (pump to strainer and strainer to drywell penetration)
79	Diesel generator cooling water
301	CRD insert/withdrawal piping
05	Emergency condenser steam vent
93	Containment spray raw water cooling
80	Containment spray
39	Emergency condenser (outside drywell)
53	Condensate supply to CRD pumps
54	Spent fuel cooling
60	Emergency condenser makeup
82	Diesel fuel oil handling (buried)
72	Service water
34	Reactor head spray
36	Reactor instrument lines (typical run)

The scope of the initial piping re-analysis effort is a sample of piping comprised of one analytical model representing each of the above systems, plus any model (part of one of the above systems) considered a potential seismic concern either by engineering review of drawings or by seismic walkthrough.

Buried diesel fuel oil handling piping will be re-analyzed using appropriate methods, provided it is found to be essential for safe shutdown. In addition, any small bore piping found to be rigidly routed between tanks or large bore piping experiencing significant movement will be re-evaluated for relative anchor displacements, a concern identified in power plants which have experienced large earthquakes.

It is tentatively planned to extend piping re-analysis work to encompass all safety-related, Class 1 and 2 seismic systems (so defined in the FSAR and Appendix A) as a longer term effort. The schedule for this additional work will be dependent on the results of the analyses of the "worst-case" sample described above and availability of resources.

Piping Model Development

Niagara Mohawk has invested a large effort toward developing computer-generated isometric piping models for all NMP-1 piping systems. As-built models are being developed and verified by plant walk-through to represent piping geometry, material properties, support characteristics, and other information necessary for stress analysis of piping systems. This effort is nearly complete; piping models reside in Niagara Mohawk's data base system, allowing efficient access to computer-plotted drawings and stress analysis input decks compatible with the computer code SUPERPIPE.

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Methodology and Acceptance Criteria

Seismic re-analysis of piping is being performed using the methodology and acceptance criteria summarized below:

Loads and Load Combinations. The loads to be considered include internal pressure, moment due to dead weight, and moment due to occasional loads. This re-analysis will consider Safe Shutdown Earthquake (SSE) as the only occasional load in accordance with SEP plant re-analyses. Operating Basis Earthquake (OBE) will not be evaluated. The SSE loading has two components, seismic inertia and seismic anchor motions (SAM's).

Piping systems requiring Class 1 seismic analyses will be handled on a case basis. (None are included in the present scope of piping analysis.) For Class 2 and Class 3 piping, ASME Equation (9) (NC/ND - 3652.2) will be evaluated:

$$S_{OL} = \frac{P_{max}\, D_o}{4\, t_n} + .75\, i \left(\frac{M_A + M_B}{Z}\right) \leq 2.4\, S_H$$

where S_{OL} = stress due to occasional loading, psi.

i = stress intensification factor (NC/ND - 3673.2(b)). The product of 0.75 i shall never be taken as less than 1.0.

P_{max} = peak pressure, psig.

D_o = pipe outside diameter, in.

t_n = nominal wall thickness, in.

M_A = resultant moment loading (including torsion) due to weight, in-lb.

M_B = resultant moment loading (including torsion) due to SSE, using one-half the range, in-lb. Effects of anchor displacement due to earthquake may be evaluated in ASME Eq. (10) or (11) if not included in Eq. (9) above. If included in Eq. (9), they will be combined with inertial stresses using SRSS summation.

Z = elastic modulus of pipe, in^3.

S_h = basic material allowable stress at Design Temperature, psi.

Acceptance Criteria. The Class 2 and 3 rules of the 1980 version of the ASME Code, Section III, Division 1, Subsections NC and ND will be used, except as indicated in this report. The load combination described above will be compared to S_h, the basic material allowable stress at design temperature, multiplied by a factor of 2.4 for Service Level D. If Level D cannot be met, then an alternative pseudo-plastic method (an augmented Class 2/3 analysis method accounting for the cyclic nature of seismic loading) or time-history method may be used.

Analysis Guidelines. SUPERPIPE, a computer code for structural analysis and Code compliance checking of piping systems, is employed to apply the loads and criteria above to the as-built computer models of essential piping. SUPERPIPE will automatically combine loads using Eq. (9), and evaluate stresses in comparison to specified criteria. Some specific analysis guidelines are discussed below.

[illegible]

[illegible]

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The response due to seismic inertial loads is determined using the appropriate floor response spectra for vertical and two horizontal directions, combined by SRSS. For piping supported on multiple elevations, either of the following methods will be used: (1) envelope applicable floor response spectra or (2) apply individual support (or group of supports) spectra independently, as recommended in NUREG/CR-3811. If independent support spectra use used, the responses for each support or group will be combined by absolute summation, or, if it can be shown the supports are uncoupled, by SRSS.

The modal responses shall be combined using SRSS for modes not closely spaced, and using either the grouping method or double sum method for closely spaced modes, as described in Reg. Guide 1.92.

Piping analysis will consider only modes below 33 Hz. In some cases, modes of vibration above 33 Hz may involve significant support reactions. For example, if a node is restrained by a "rigid" anchor, then there will be no excitation of the lumped mass at that node in any of the modes considered, because the frequency of vibration will be very high there. The resulting calculated anchor reactions may be substantially lessened by neglecting this mass contribution. Therefore, a procedure is employed whereby these "missing masses" are accounted for in an additional calculated mode incorporating these masses.

Stresses due to seismic anchor motion (SAM) will be determined using displacement from seismic building analysis, only if the piping analyzed has supports attached to independently responding structures, for example the reactor and turbine buildings. Unless it can be shown that independent supports move in phase, displacements will be assumed out of phase such that the maximum possible stress is obtained. Resulting SAM loads will be combined with inertial loads by SRSS.

RE-EVALUATION OF PIPING SUPPORTS

Scope

Piping supports will be evaluated for the piping systems analyzed. Adequacy of piping supports has been considered during the seismic walk-through in the identification of seismically sensitive piping systems.

Methodology and Acceptance Criteria

Piping supports will be analyzed in accordance with ASME Subsection NF-3300, and Service Level D limits. Loads will be determined from the output of piping analyses, which consider SSE loadings, as discussed above. Piping support anchorage, including base plates and anchor bolts, is analyzed in accordance with IE Bulletin No. 79-02.

SEISMIC QUALIFICATION OF EQUIPMENT

The seismic adequacy of equipment is being pursued by the Seismic Qualification Utilities Group (SQUG). As a member of SQUG, Niagara Mohawk is a participant in the cooperative SQUG/NRC program to resolve Unresolved Safety Issue USI A-46, "Seismic Qualification of Equipment in Operating Nuclear Plants." NMP-1 will be the pilot plant for the SQUG BWR walkdown program. This effort is directed toward qualifying equipment on the basis of seismic experience data, and is expected to provide (1) bases for demonstrating the seismic adequacy of mechanical and electrical safe shutdown equipment and (2) guidelines for the evaluation of equipment and cabinet anchorage, cable and conduit raceways and essential relays. These areas are being pursued separately from the SUP until such time that the results can be factored into the SUP.

PROGRAM ADMINISTRATION

Program Management and Participants

Mr. Francis Feng and Dr. Robert Oleck, of Niagara Mohawk, are overseeing the administration of SUP schedule, budget, and coordination of participants. They will also have final review responsibility for all SUP tasks.

The SUP team is composed of engineers from Niagara Mohawk and its contractors, including Stevenson & Associates and MPR Associates. These organizations have a large amount of collective experience in seismic qualification, dynamic modelling and analysis of structures, equipment and piping.

Schedule

The NMP-1 SUP was initiated in 1985 and is expected to be completed in three to four years from this writing dependent upon resources. A preliminary schedule illustrating short term and long term milestones is presented in Figure 3-14.

Quality Assurance

The SUP is being performed in accordance with Niagara Mohawk's quality assurance requirements. Drawings are created, updated and verified by walk-down to represent the as-built condition of piping, supports and structures. The computer codes used for seismic evaluation, principally COSMOS and SUPERPIPE, are or will be verified, accepted and controlled versions. All calculations, walk-throughs and other supporting data will be checked, reviewed, documented and logged in NMPC's controlled system.

Data Base Requirements

NPMC maintains two data bases for document control: a records data base and an analytical model data base. The records data base maintains control over the design records used as reference in this study. The analytical data base stores all models and analysis results of the Niagara Mohawk system for quick reference and revision control.

Milestone Schedule

Short Term:

- SUP Program Plan Development
- SUP Program Plan Review by NMPC
- Present Program Description to NRC
- Receive NRC comments on Program
- Finalization of Criteria:
  - Ground Motion (SSE)
  - Structural
  - Floor Spectra
  - Piping
  - Supports
- Obtain NRC Approval of Proposed Methodology and Governing Criteria

Long Term:

- Re-evaluation of Ground Motion Spectra
- Re-evaluation of Class 1 Structures
- Generation of New Floor Response Spectra
- Re-evaluation of Piping & Supports
- Seismic Qualification of Equipment
- Pilot Plant Review
- Prepare SER & Present to NRC
- Finalize SER after NRC comments

Figure 3-14

APPENDIX A

SEISMIC CLASSIFICATION OF NMP-1 STRUCTURES, SYSTEMS AND EQUIPMENT

[illegible]

D. DESIGN OF STRUCTURES, COMPONENTS, EQUIPMENT, AND SYSTEMS

1.0 Classification and Seismic Criteria

Class I Structures and Components--Structures and components whose failure could cause significant release of radioactivity or which are vital to safe shutdown and isolation of the reactor.

Class II Structures and Components--Structures and components which are important to reactor operation but are not essential to safe shutdown or isolation, and whose failure could not result in substantial release of radioactive materials.

Class III Structures and Components--Structures and components that are not essential for safe shutdown and isolation of the reactor and whose failure will not result in significant release of radioactive materials.

No quantitative basis was used to determine the limit for significant release of radioactivity. The basis used was that if a system could fail such that the failure could result in a continuous, uncontrolled release of radioactivity that could not be readily terminated, the system was designated as Class I.

Thus, since release from a broken main steam line can be terminated by closing the automatic isolation valves, the parts of the system outside the isolation valves are not Class I. Similarly, rupture of a tank in the waste disposal building could result in a release not easily controlled or terminated. Therefore, these systems are Class I.

The decisions as to whether the balance of systems, components, and structures qualified for treatment as Class II or Class III were ultimately based on the best professional engineering judgment of those involved in specifying the design criteria. The prime consideration in deciding on Class II or Class III was whether or not the given system, component, or structure is necessary to continued Station operation. Where doubt existed as to which criterion should be applied, generally the resolution was made in the conservative direction, namely, to apply the Class II criterion.

A list of Class I and Class II structures and systems is provided below:

<u>Class I Structures</u>

Reactor building
Waste disposal building
Ventilation stack
Drywell
Reactor pressure vessel and its support structure
Suppression chamber
Diesel-generator support foundation

<u>Class II Structures</u>

Turbine building
Turbine-generator support foundation
Intake and discharge tunnels

<u>Combination Class I and Class II Structure</u>

Screen and pump house

<u>Class I Equipment, Systems, or Areas in Class II Structures</u>

Diesel-generator support structure
Control room
Auxiliary control room
Battery room
Battery board room
Supporting steel structure for emergency condenser, makeup, and demineralized water tanks

<u>Class I Piping Systems</u>

Main steam inside drywell
Core spray
Containment atmospheric dilution
Containment atmospheric monitoring
Containment spray
Containment spray cooling water
Emergency cooling
Liquid poison
Drywell and suppression chamber vacuum relief
Fuel pool cooling and filtering
Reactor cleanup
Reactor shutdown cooling
Reactor head spray
Condensate storage
Condensate pump suction and discharge

Class I Piping Systems (Cont'd)

Feedwater booster discharge
High pressure reactor feedwater
Reactor building closed loop cooling
Control rod drive piping
Radioactive waste disposal system
Emergency ventilation
Breathing air
Instrument air
Service water
Diesel-generator fuel oil, starting air, and cooling water

Class II Piping Systems

Main steam outside drywell
Bypass steam to condenser
Steam supply to air ejector
Extraction steam piping
Makeup demineralizer
Turbine building closed loop cooling
Reactor and turbine buildings, sump pump discharge
Seal water
Turbine oil storage
City water
Laboratory drains
Off-gas

Class I Equipment Housed in and Supported by Combination Class I and II Structures

Emergency service water pumps and piping
Containment spray cooling pumps and piping
Diesel-generator cooling water pumps and piping
Service water pumps and piping

Class I Equipment Housed in and Supported by Class II Structures

Condensate storage tanks and piping
Condensate pumps, suction and discharge piping
Feedwater booster pumps and discharge piping
High pressure reactor feed pumps and discharge piping
Diesel-generator fuel oil, starting air and cooling water piping
Emergency condenser storage tanks
Reactor building closed loop cooling piping (partial)
Breathing air piping (partial)
Instrument air compressors

Class I Equipment Housed in and Supported by Class II Structures (Cont'd)

Instrument air piping (partial)
Service water piping (partial)

1.1 Design Techniques

1.1.1 Structures

The design basis load combinations of dead load, live load (including piping, equipment, and temperature), moving loads, and incident loads are directly combined with horizontal and vertical earthquake loads for structures consisting in whole or in part of Class I elements. The resulting stress levels are within normal Code values with no increase allowed for the earthquake condition for Class I structures or components except for:

a. Suppression chamber columns, and

b. Ventilation stack,

for which a one-third increase was allowed. Although original criteria allowed a one-third increase in stress levels for Class II structures when earthquake loading was included, calculated stresses remained within the normal stress range with no increase for earthquake.

Tables XVI-20 through XVI-26 present the load combinations and allowable stresses for structures consisting in whole or in part of Class I elements.

Figures XVI-34 through XVI-41 present the computed deflections from the design earthquake excitation.

For concrete design criteria such as bar spacing, bar cover, minimum reinforcement, temperature steel, etc., ACI Code 318-63 was used. For proportioning of concrete members, Part IV-A, "Working Stress Design," of Code

APPENDIX B

APPLICABLE CODES, STANDARDS AND SPECIFICATIONS

APPENDIX B

Applicable Codes, Standards and Specifications

As a general practice the Codes, Standards and Specifications listed herein shall be periodically reviewed and updated as appropriate by NMPC Engineering Department.

The following codes, standards, specifications, and recommendations are the basis for the evaluation of Category I structures.

- American Concrete Institute (ACI)

  ACI-318-77 Building Code

  Supplemented by ACI 349-80 "Code Requirements for Nuclear Safety Related Concrete Structures - Appendix B Steel Embedments"

- American Institute of Steel Construction (AISC)

  "Specifications for the Design, Fabrication, and Erection of Structural Steel for Buildings," effective November 1, 1978.

  Supplemented by ductility and thermal load behavior criteria contained in ANSI/AISC N690 - "1984 Nuclear Facilities - Steel Safety-Related Structures for Design Fabrication and Erection".

- American Society for Testing Materials.

  1982 ASTM Standards.

- American Welding Society (AWS)

  "Structural Welding Code," AWS D1.1-82

- U.S. Nuclear Regulatory Commission

  1. NUREG/CR-0098 "Development of Criteria for Seismic Review of Selected Nuclear Power Plants," May 1978

  2. NUREG/CR 1161, "Recommended Revisions to Nuclear Regulatory Commission Seismic Design Criteria," May 1980

  3. NUREG 1061, "Evaluation of Seismic Designs - A review of Seismic Design Requirements for Nuclear Power Plant Piping," April 1985

4. NUREG 0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants, LWR Edition," July 1981.

o International Atomic Energy Agency

DOE 2882n, "A Seismic Design of Nuclear Facilities with Limited Radioactive Inventory," October 1984

o American Society of Civil Engineers

1. Manual of Professional Practice No. 58, "Structural Analysis and Design of Nuclear Plant Facilities" August 1980.

2. ANSI A58.1 "Building Code Requirements for Minimum Design Loads in Building and Other Structures," 1982.

APPENDIX C

DAMPING VALUES FOR STRUCTURES AND EQUIPMENT

APPENDIX C

DAMPING VALUES FOR STRUCTURES AND EQUIPMENT

(Percent of Critical Damping)

Structure or Component	Safe Shutdown Earthquake
Equipment	3
Welded steel structures	4
Bolted steel structures	7
Prestressed concrete structures	5
Reinforced concrete structures	7
Electrical Raceways - Empty	7
Electrical Raceways - Full	20
Sloshing Mode in Tanks	0.5
Impulse Mode in Tanks	4

Enclosure 3

NINE MILE POINT UNIT NO. 1 (NMP-1) SEISMIC UPGRADE PROGRAM

JUNE, 1987

NMP-1 SEISMIC UPGRADE PROGRAM (SUP)
OUTLINE OF DISCUSSION

- INTRODUCTION
  - PURPOSE
  - BACKGROUND
  - OBJECTIVES
  - SCOPE
  - TIMING
- APPROACH
- MAIN ELEMENTS OF SUP
  - RE-EVALUATION OF ORIGINAL SEISMIC DESIGN BASES
  - RE-DEFINITION OF SEISMIC DESIGN INPUT
  - RE-EVALUATION OF CLASS 1 AND 2 STRUCTURES
  - GENERATION OF FLOOR RESPONSE SPECTRA
  - RE-EVALUATION OF PIPING SYSTEMS & SUPPORTS
  - SEISMIC QUALIFICATION OF EQUIPMENT
  - PROGRAM ADMINISTRATION

INTRODUCTION TO THE SUP

- o PURPOSE

  - DEVELOP MODERN DEFINITION OF SEISMIC ADEQUACY OF NMP-1 AND PROVIDE NEW METHODS AND ACCEPTANCE CRITERIA FOR FUTURE ANALYSES/MODIFICATIONS

- o BACKGROUND

  - FOLLOW-ON ACTIVITY FROM SEP/ISAP

  - INCORPORATES EXTENSIVE CHANGES IN SEISMIC DESIGN METHODOLOGY AND CRITERIA, TO BECOME NEW LICENSING BASIS

  - BUILDS ON SEP/ISAP WORK AND ADDRESSES:

    - DESIGN GROUND MOTION RESPONSE SPECTRA

    - CATEGORY 1 AND 2 STRUCTURES, PIPING AND SUPPORTS

    - SAFE SHUTDOWN EQUIPMENT

INTRODUCTION TO THE SUP (CONT'D)

o OBJECTIVES

- PROVIDE STATE-OF-THE-ART CRITERIA AND METHODOLOGY FOR FUTURE PLANT MODIFICATIONS
- RE-ASSESS ADEQUACY OF NMP-1 SEISMIC DESIGN BASED ON UP-TO-DATE METHODS AND CRITERIA
- DEMONSTRATE AND DOCUMENT SEISMIC ADEQUACY OF NMP-1 COMPARED TO MODERN PLANTS
- PROVIDE COMPREHENSIVE DATA BASE FOR STRUCTURES AND PIPING
- PREPARE FOR FUTURE USNRC SEISMIC PROGRAMS

INTRODUCTION TO THE SUP (CONT'D)

- SCOPE

  - ALL SEISMIC CLASS 1 AND 2 STRUCTURES, PIPING AND SUPPORTS AS DEFINED IN NMP-1 FSAR

  - OTHER ACTIVE MECHANICAL/ELECTRICAL EQUIPMENT, HX, TANKS, CABLE TRAY/CONDUIT SYSTEMS IN ACCORDANCE WITH USI A-46

- TIMING

  - NMPC WILL UNDERTAKE SUP AS A VOLUNTARY EFFORT OVER NEXT SEVERAL YEARS

  - SHORT-TERM OBJECTIVE TO OBTAIN NRC APPROVAL OF NEW SEISMIC CRITERIA FOR USE IN 1988 NMP-1 OUTAGE, USI A-46 AND SEISMIC EVALUATIONS

APPROACH

- o DEVELOP REALISTIC, SELF-CONSISTENT CRITERIA, METHODS AND LOAD DEFINITIONS TO BECOME PLANT LICENSING BASIS

- o RE-ASSESS SEISMIC DESIGN USING NEW METHODS AND CRITERIA

  - REVIEW AND UP-DATE, IF NECESSARY, COMPLETED SEP/ISAP WORK USING NEW METHODS AND CRITERIA

  - EXPAND SCOPE OF SEISMIC RE-EVALUATION TO COVER STRUCTURES, SYSTEMS AND EQUIPMENT IN SUP SCOPE

- o TASKS COMPLETED AS PART OF SEP AND ISAP:
  - RE-EVALUATION OF ORIGINAL SEISMIC DESIGN BASES
  - DESIGN RECORD REVIEW
  - DEVELOPMENT OF UNIFORM HAZARD GROUND MOTION SPECTRA
  - REVIEW OF PIPING ANALYSES OF RECORD
  - REVIEW OF STRUCTURAL ANALYSES
  - EVALUATION OF EQUIPMENT ANCHORAGE
  - RE-DEFINITION OF LOADS ON PLANT STRUCTURES
  - MODELING OF BUILDING STRUCTURES
  - GENERATION OF PRELIMINARY FLOOR RESPONSE SPECTRA
  - RE-ANALYSIS OF SELECTED PIPING SYSTEMS

- SPECIFIC SUP TASKS:
  - DEVELOPMENT OF UP-TO-DATE METHODOLOGY AND ACCEPTANCE CRITERIA
  - RE-EVALUATION AND RE-DEFINITION, AS NEEDED, OF SEISMIC GROUND MOTION SPECTRA AND OTHER STRUCTURAL LOADS PREVIOUSLY DEFINED
  - RE-EVALUATION OF CLASS 1 AND 2 STRUCTURES USING NEW METHODS
  - GENERATION OF NEW FLOOR RESPONSE SPECTRA
  - RE-EVALUATION OF SELECTED PIPING SYSTEMS AND SUPPORTS
  - SEISMIC QUALIFICATION OF EQUIPMENT

[illegible]

MAIN ELEMENTS OF SUP

- RE-EVALUATION OF ORIGINAL SEISMIC DESIGN BASES, COMPLETED AS PART OF ISAP:

  - DESIGN RECORD REVIEW
  - PLANT SEISMIC WALK-THROUGH
  - REVIEW OF PIPING ANALYSES OF RECORD
  - REVIEW OF STRUCTURAL ANALYSES
  - EVALUATION OF EQUIPMENT ANCHORAGE

- RE-DEFINITION OF SEISMIC DESIGN INPUT, COMPLETED AS PART OF ISAP

  - SITE-SPECIFIC SEISMIC UNIFORM HAZARD STUDY

    - BASED ON PROBABILISTIC ASSESSMENT OF FREQUENCY OF EXCEEDANCE

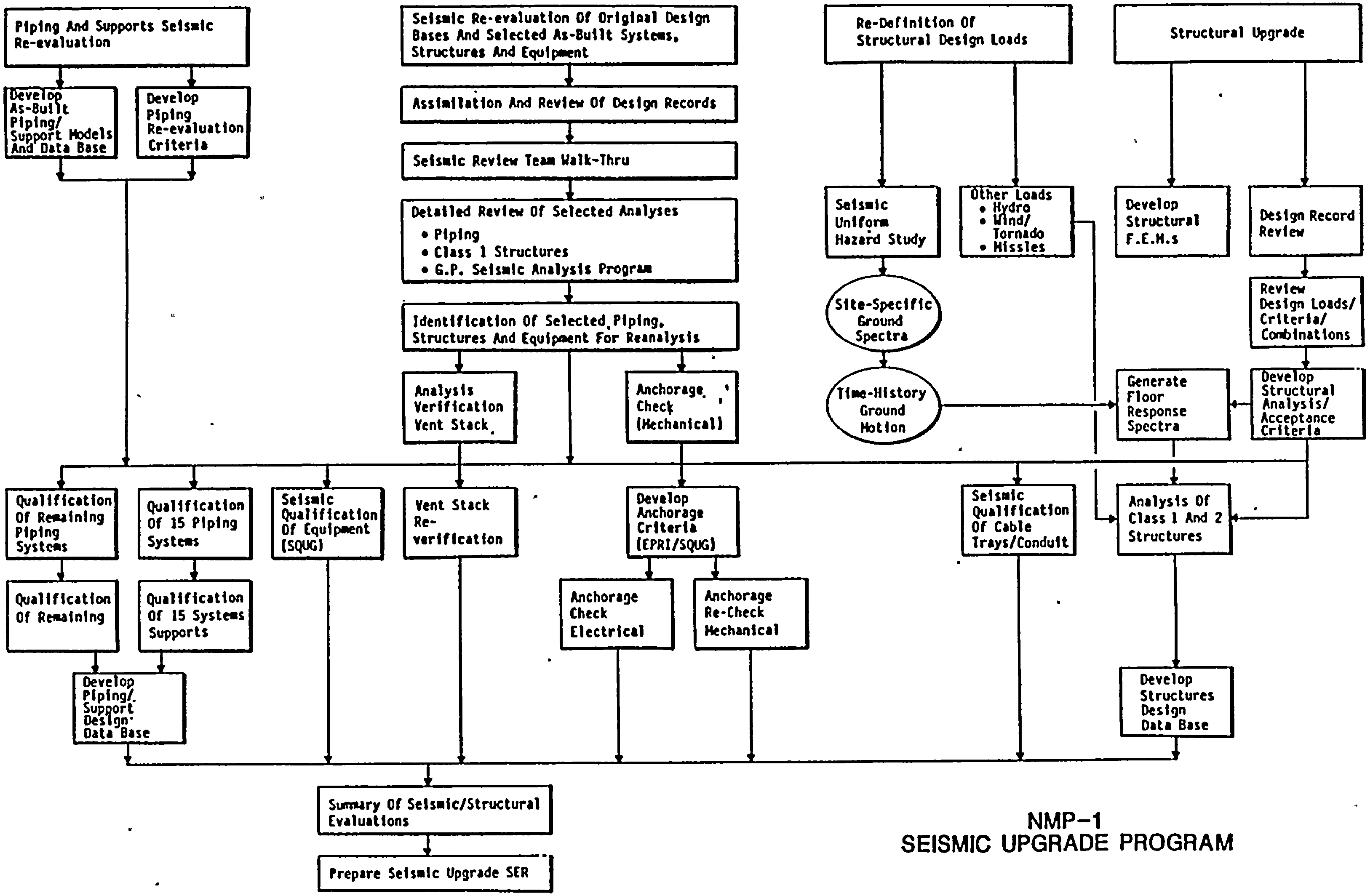
    - RELIED ON EXPERT OPINION SUMMARIZED BY BERNREUTER, AND EXPERTISE OF SYKES, McWHORTER, HADLEY & DEVINE, TERA CORP. AND OTHERS

    - PGA OF .13 COMBINED WITH UNIFORM HAZARD SPECTRA SHAPE

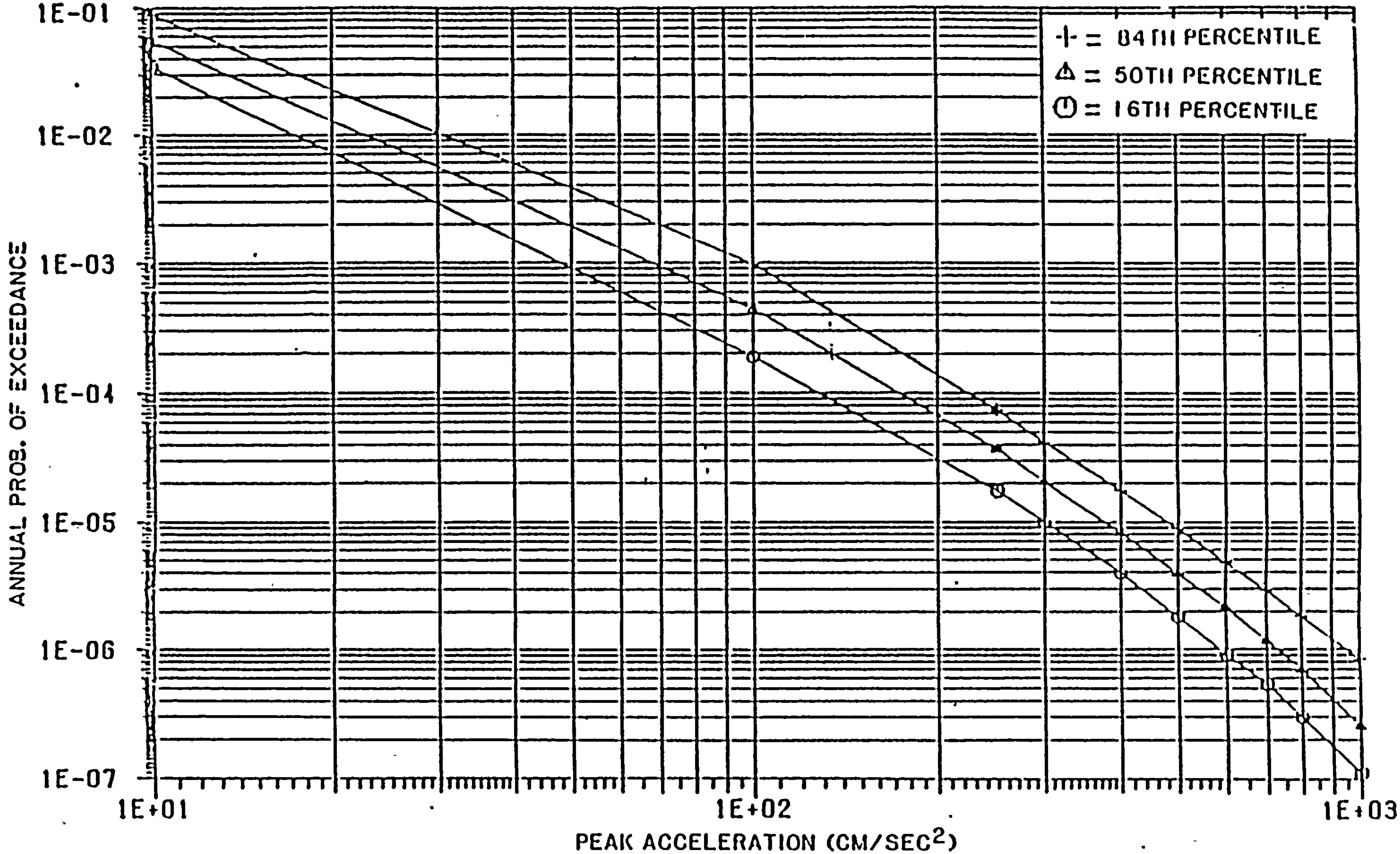
    - MEAN PROBABILITY OF EXCEEDANCE OF 2×10^{-4}

  - RE-DEFINITION OF OTHER STRUCTURAL LOADS DEFINED AS PART OF SEP

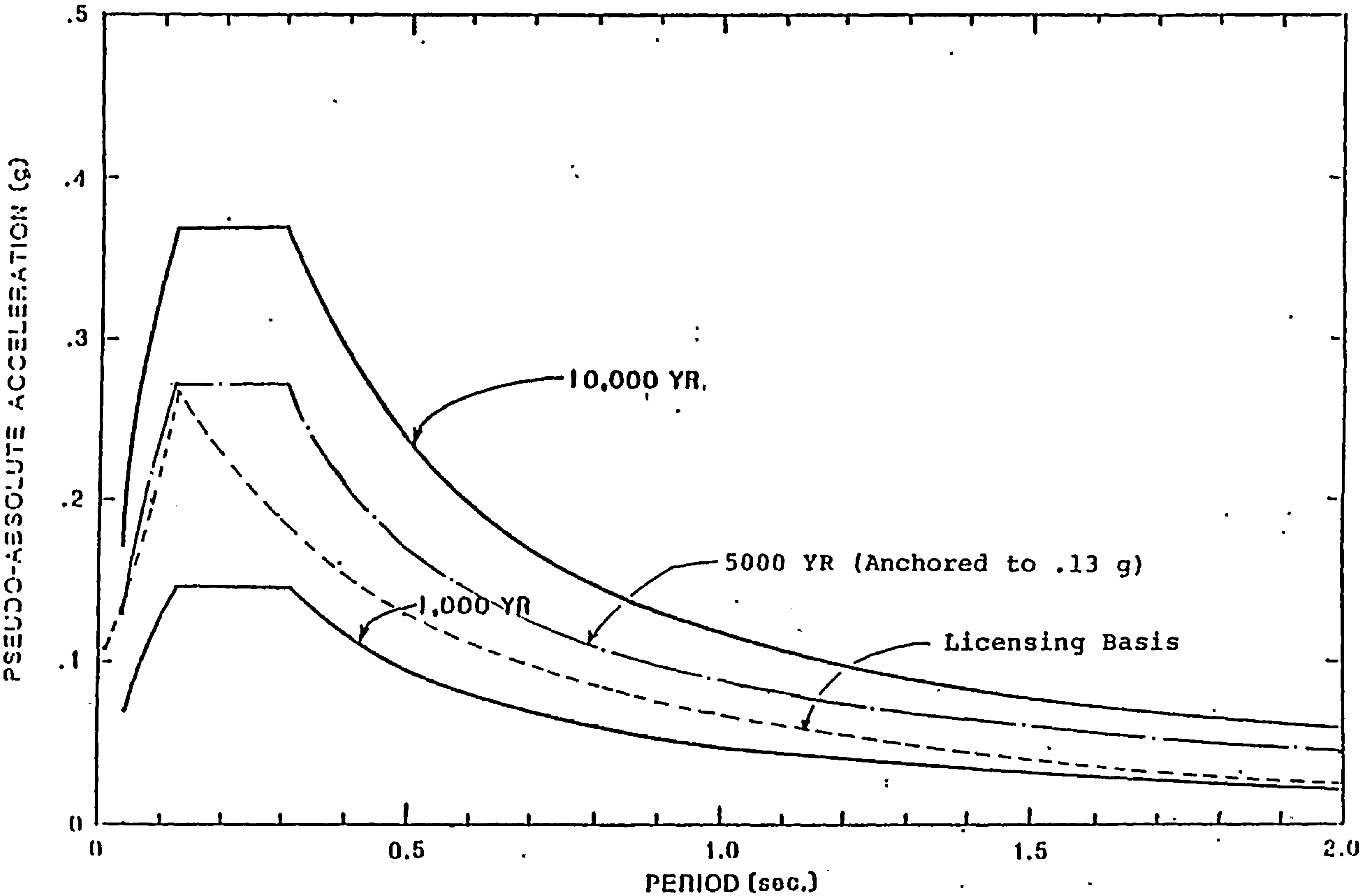
MPR ASSOCIATES
F-85-29-10
6/8/87



NMP-1
SEISMIC UPGRADE PROGRAM



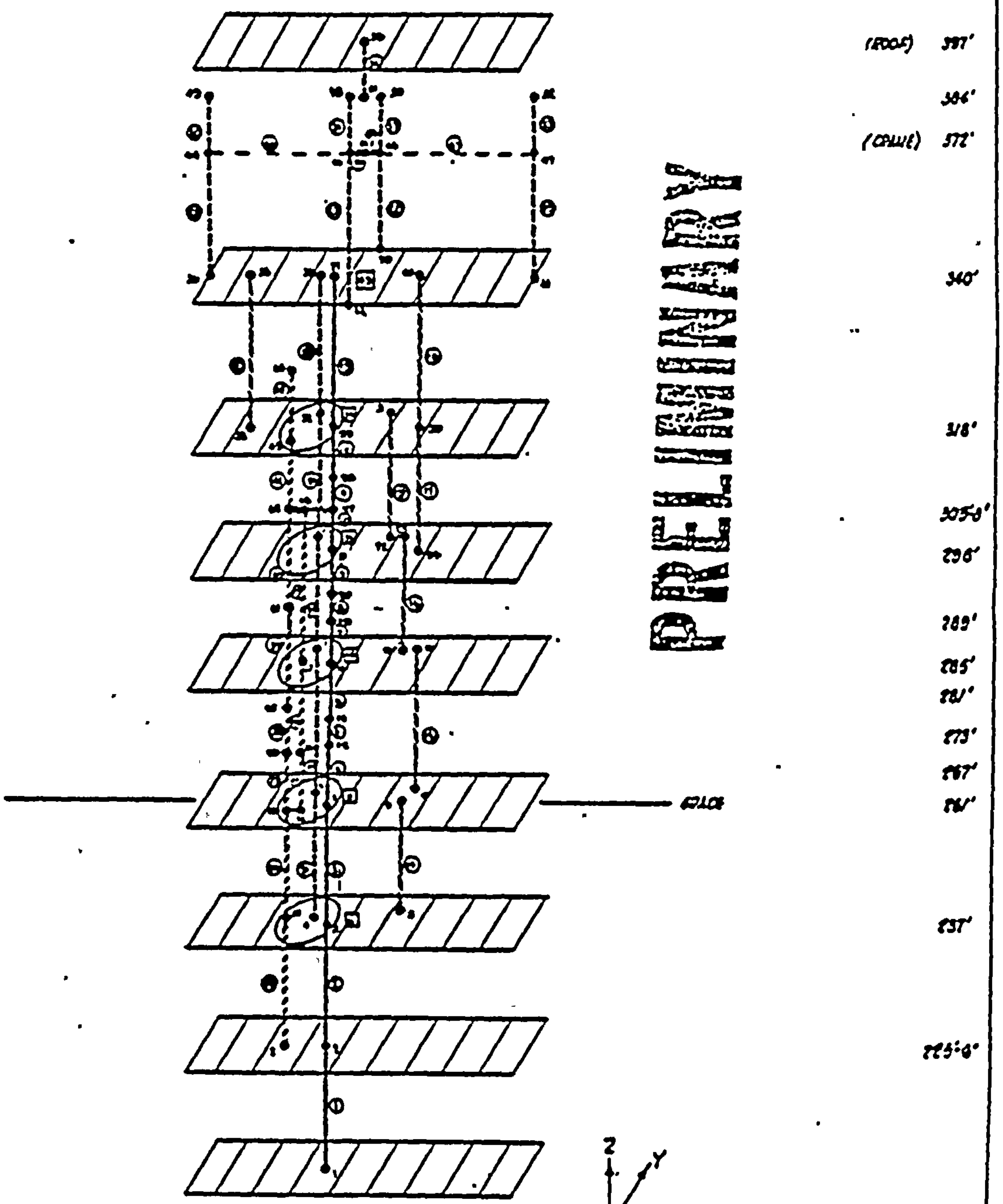
ACCELERATION HAZARD: 16, 50, and 84 PERCENTILES



ACCELERATION RESPONSE SPECTRA (5% DAMPING)

MAIN ELEMENTS OF SUP (CONT'D)

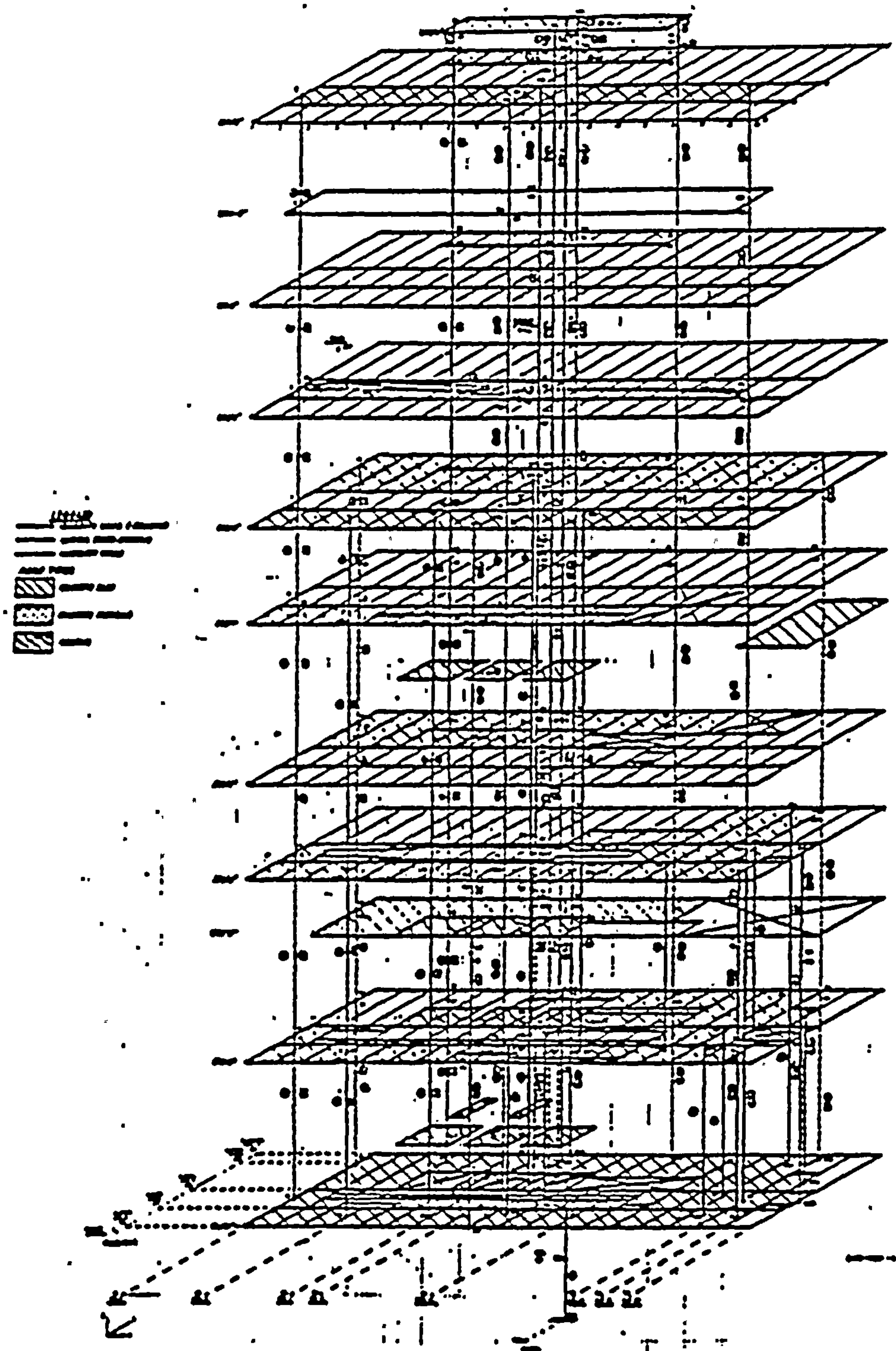
- RE-EVALUATION OF CLASS 1 AND CLASS 2 STRUCTURES
  - SCOPE: PRIMARY STRUCTURAL ELEMENTS OF REACTOR, TURBINE AND SCREEN HOUSE BUILDINGS
  - DYNAMIC MASTER AND DETAILED STATIC BUILDING MODELS DEVELOPED
  - METHODOLOGY AND ACCEPTANCE CRITERIA
    - LOADS AND LOAD COMBINATIONS
    - ACCEPTANCE CRITERIA
    - ANALYSIS GUIDELINES
- GENERATION OF FLOOR RESPONSE SPECTRA
  - SCOPE: KEY LOCATIONS ON ALL PERTINENT ELEVATIONS OF REACTOR, TURBINE, AND SCREEN HOUSE BUILDINGS
  - DEVELOPMENT USING GROUND MOTION AND BUILDING MODELS
  - METHODOLOGY AND ACCEPTANCE CRITERIA



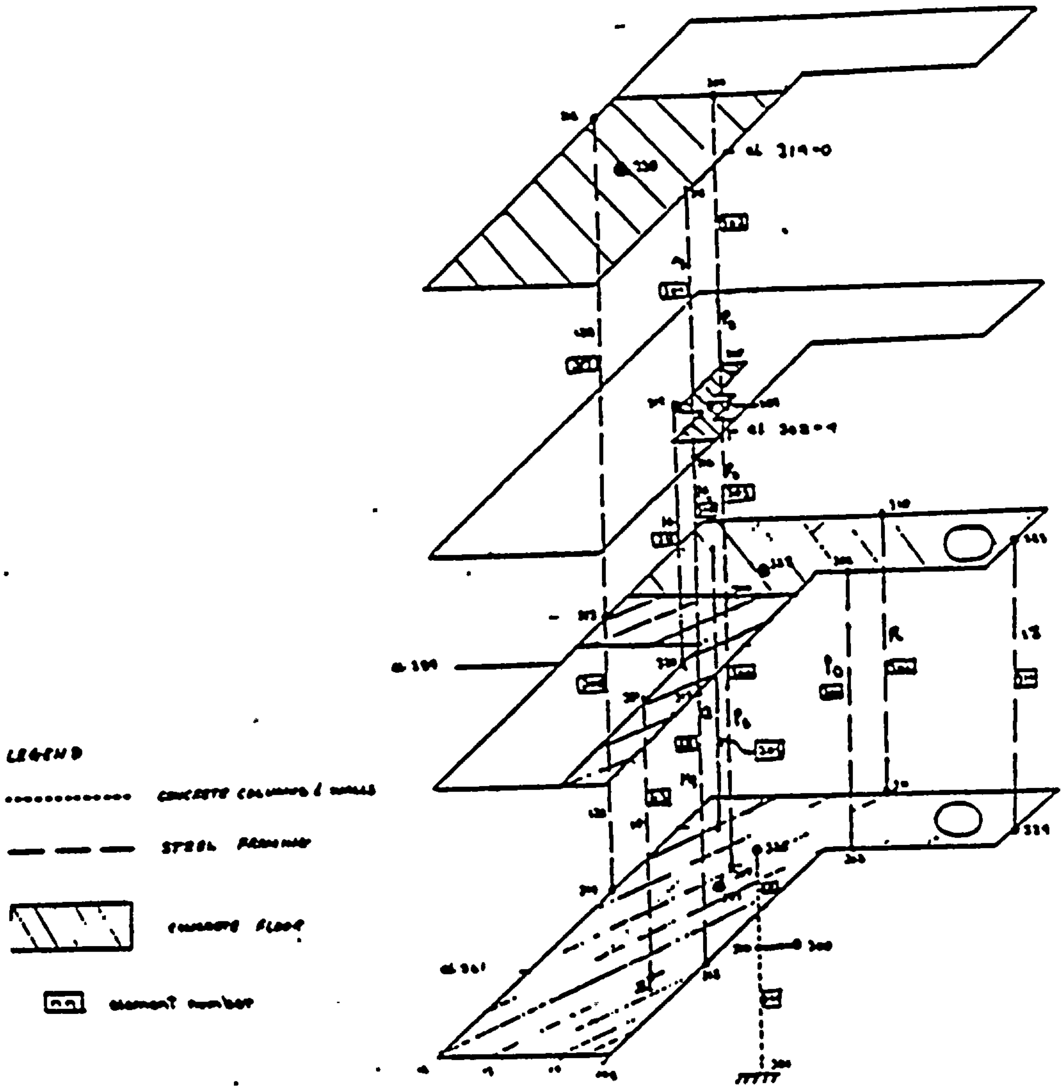
REACTOR BUILDING MODEL

- ·········· REACTOR PRESSURE VESSEL SYSTEM (PEDESTAL, RPV, SHIELD WALLS)
- ———— DRYWELL
- ———— INTERIOR WALLS
- ———— EXTERIOR WALLS / COLUMNS
- — — — BEAMS

PRELIMINARY



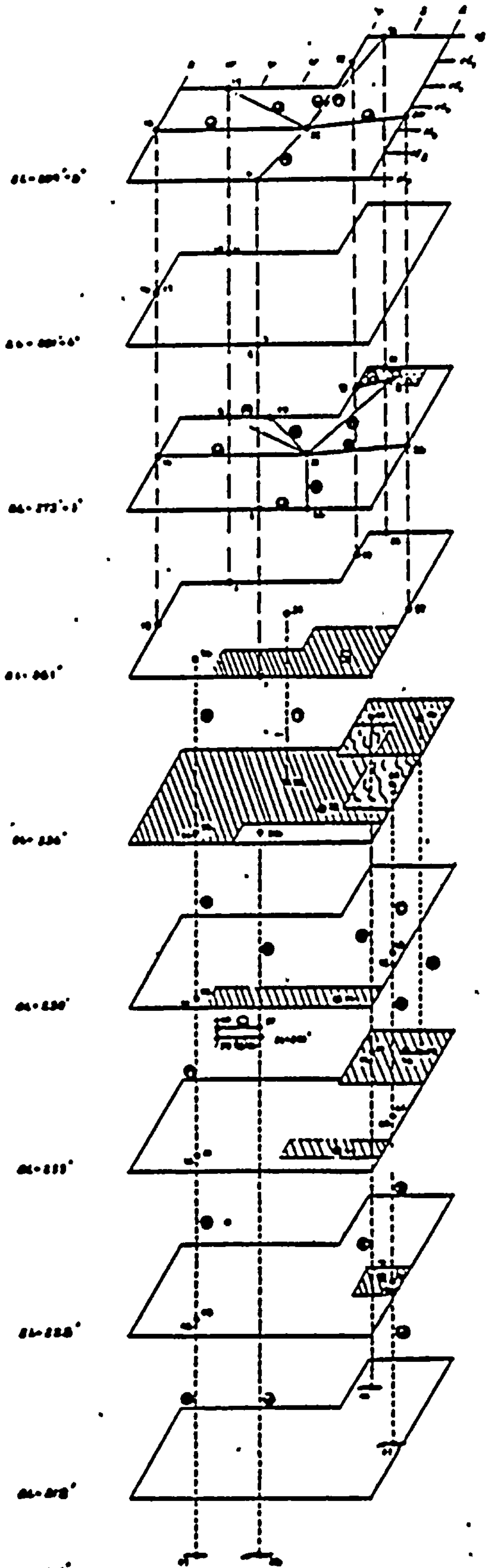
TYPICAL BUILDING MODEL

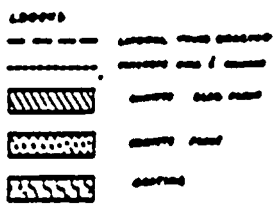


TURBINE BUILDING EXTENSION

PRELIMINARY

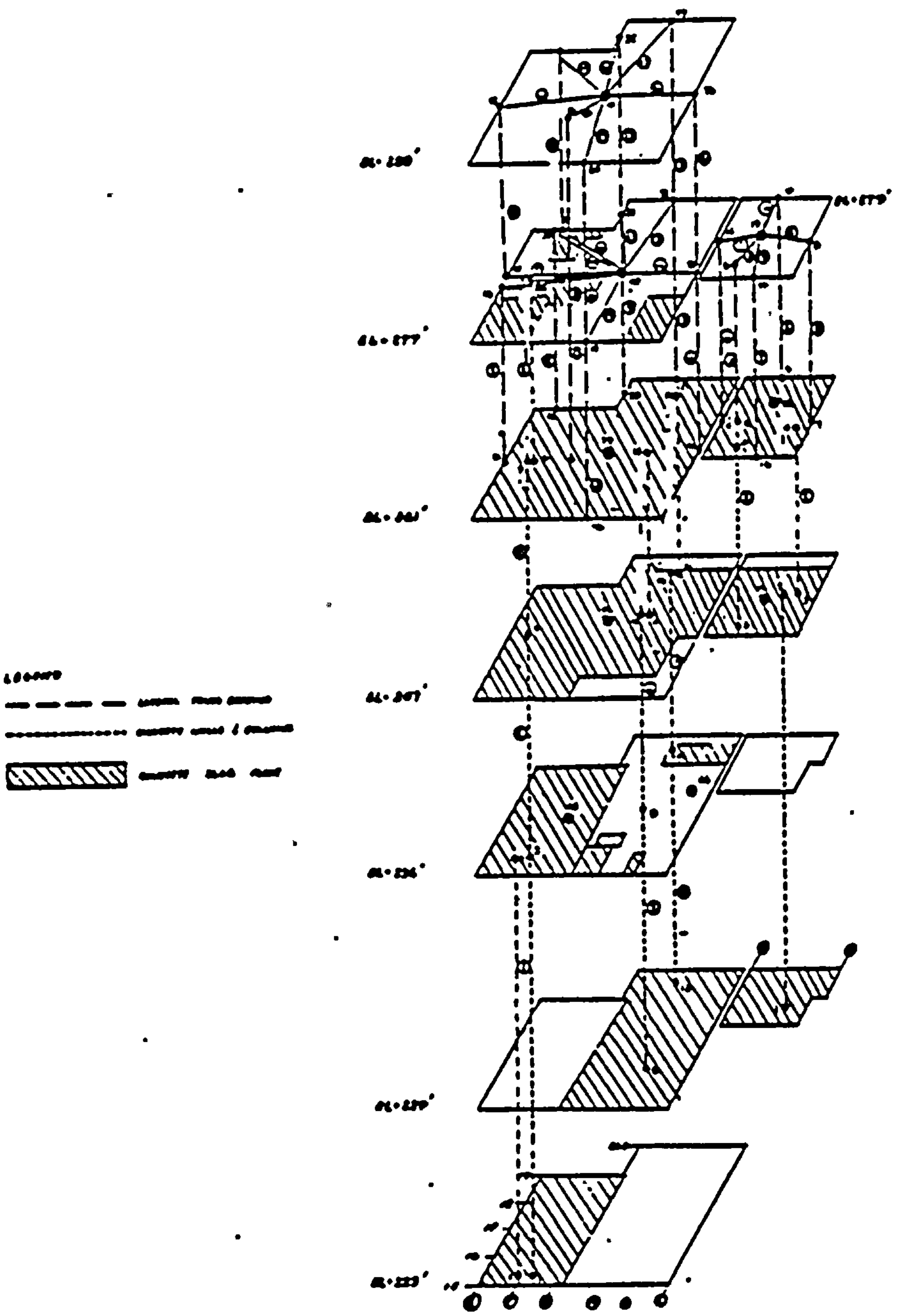
SCREEN AND PUMP HOUSE MODEL





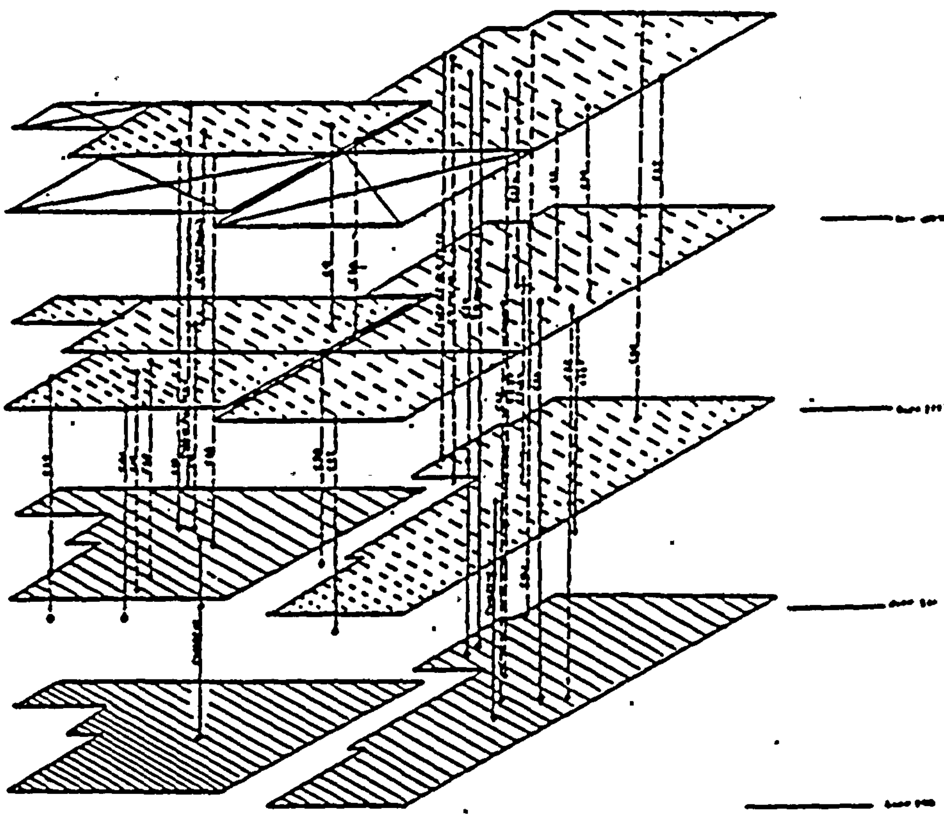
PRELIMINARY

PRELIMINARY



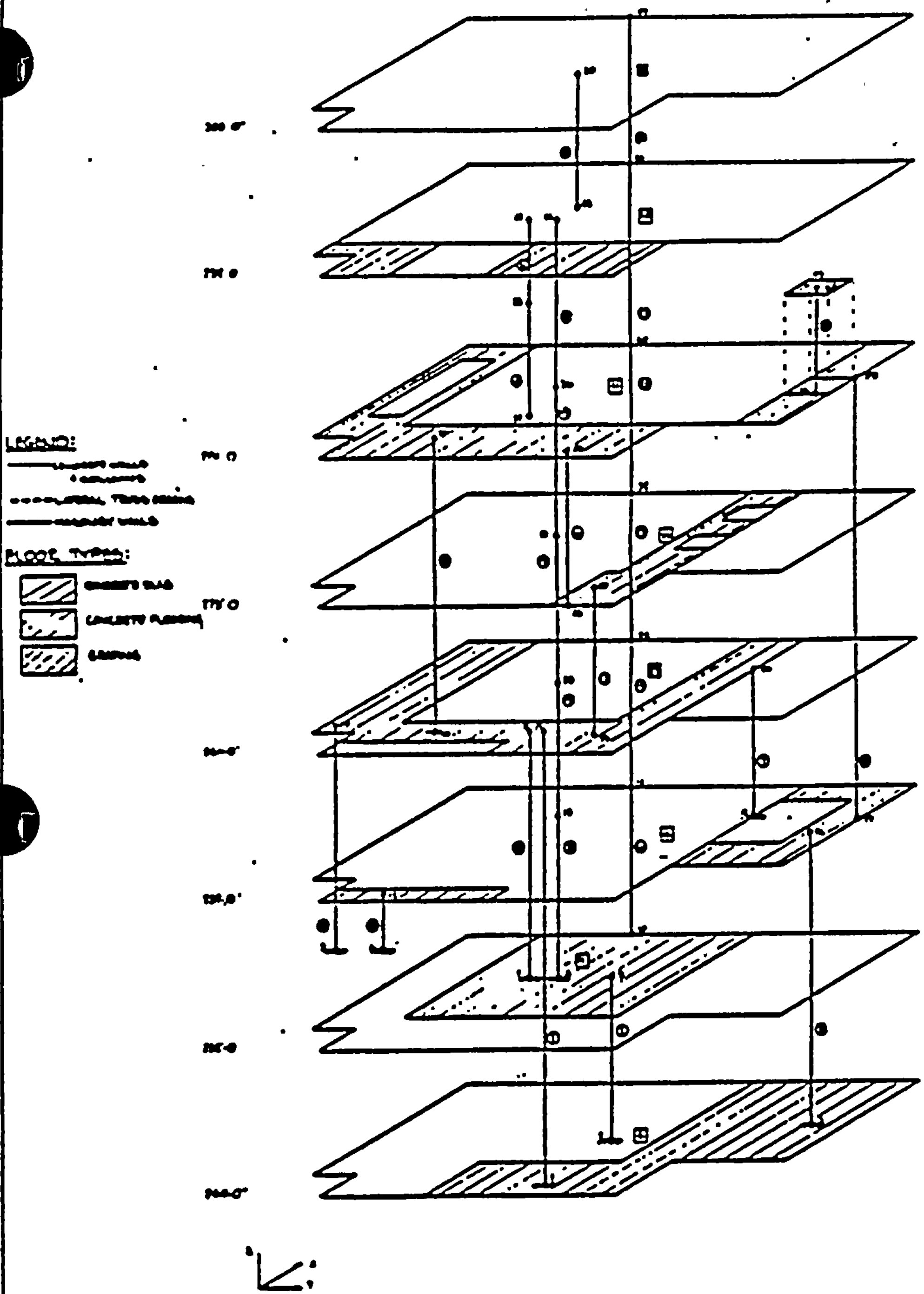
WASTE DISPOSAL BUILDING AND EXTENSION
AND
OFF GAS BUILDING MODELS

PRELIMINARY



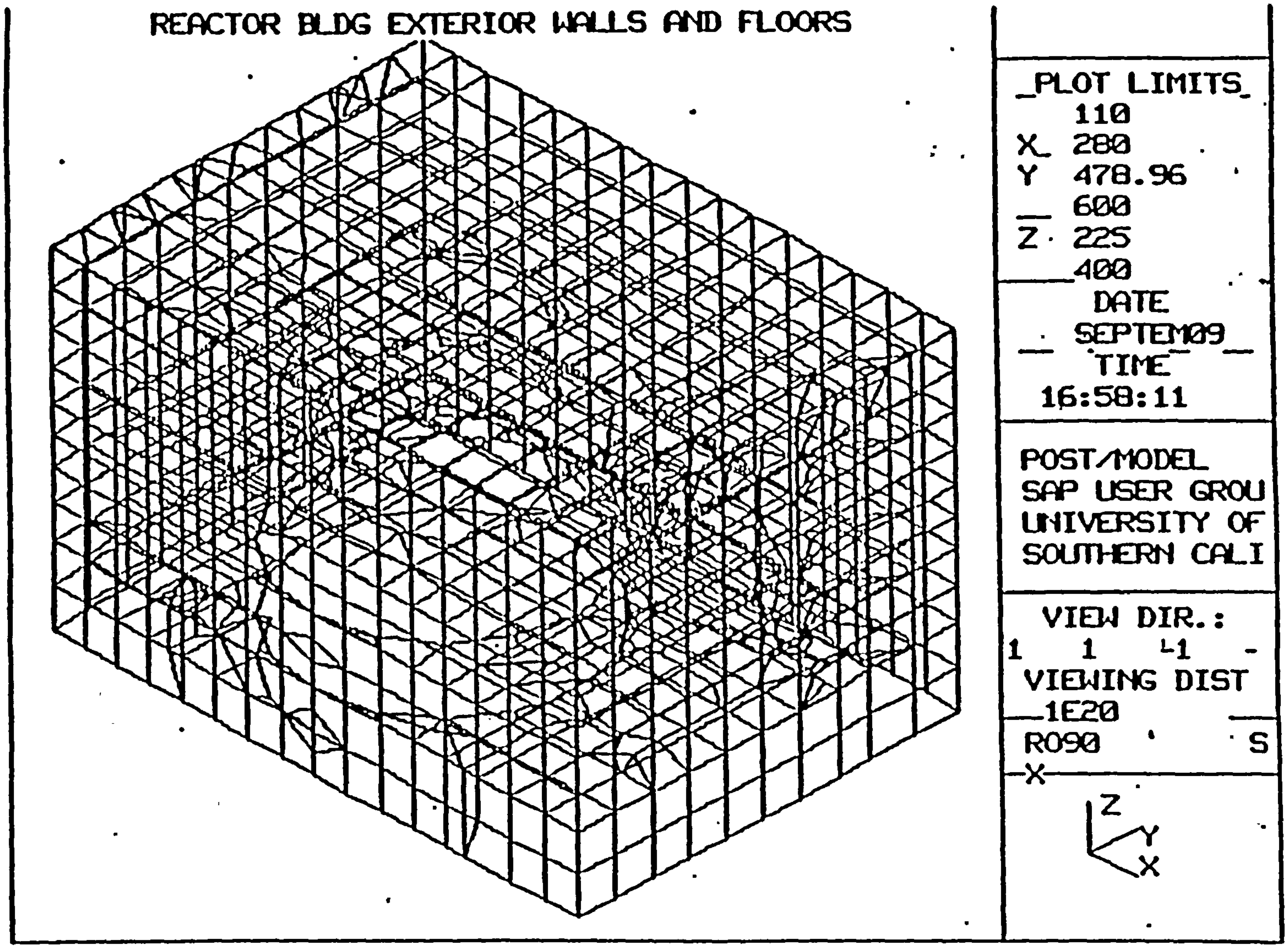
LEGEND

ADMINISTRATION BUILDING AND EXTENSION MODEL

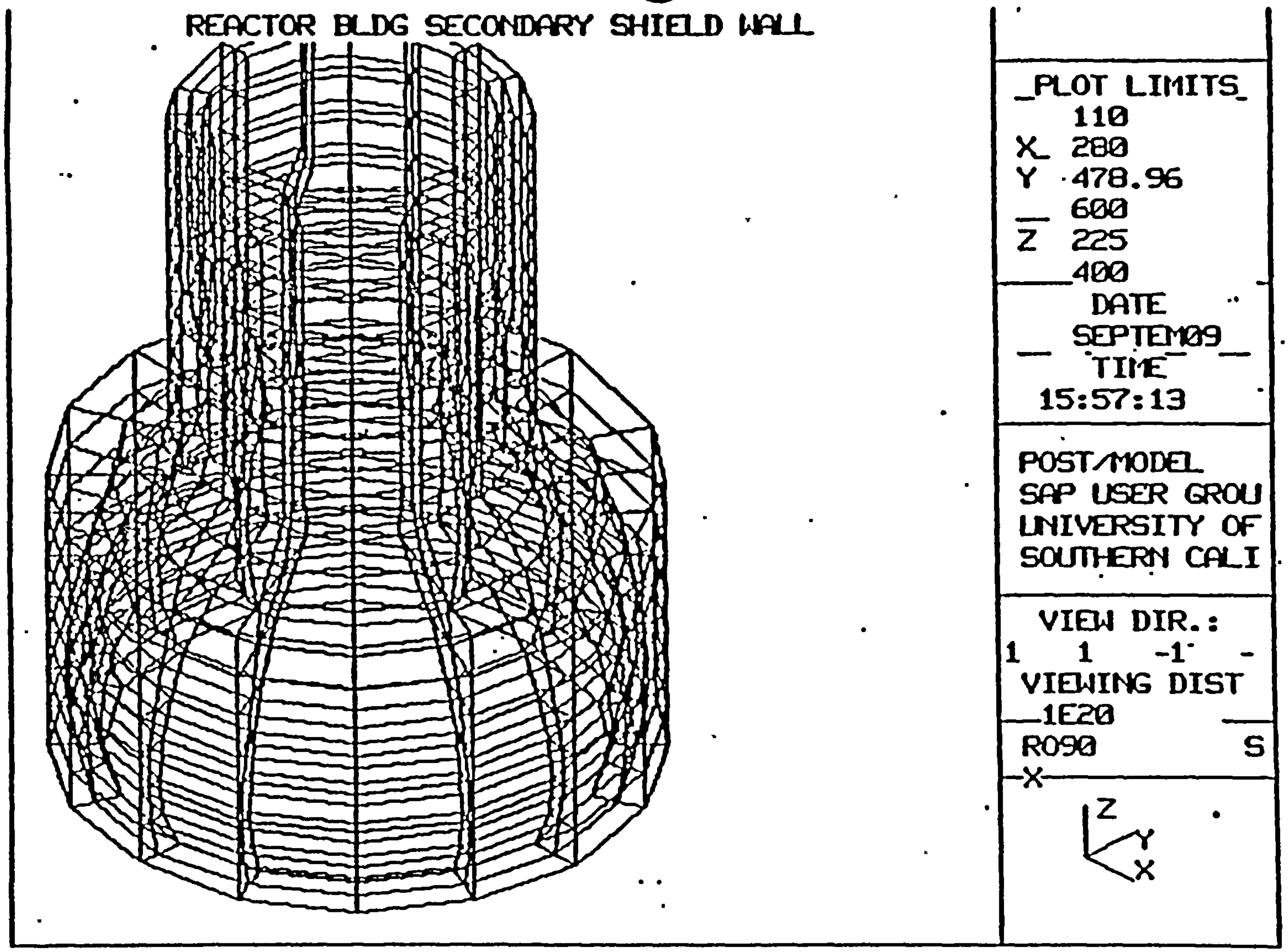


RADWASTE SOLIDIFICATION
BUILDING MODEL

PRELIMINARY



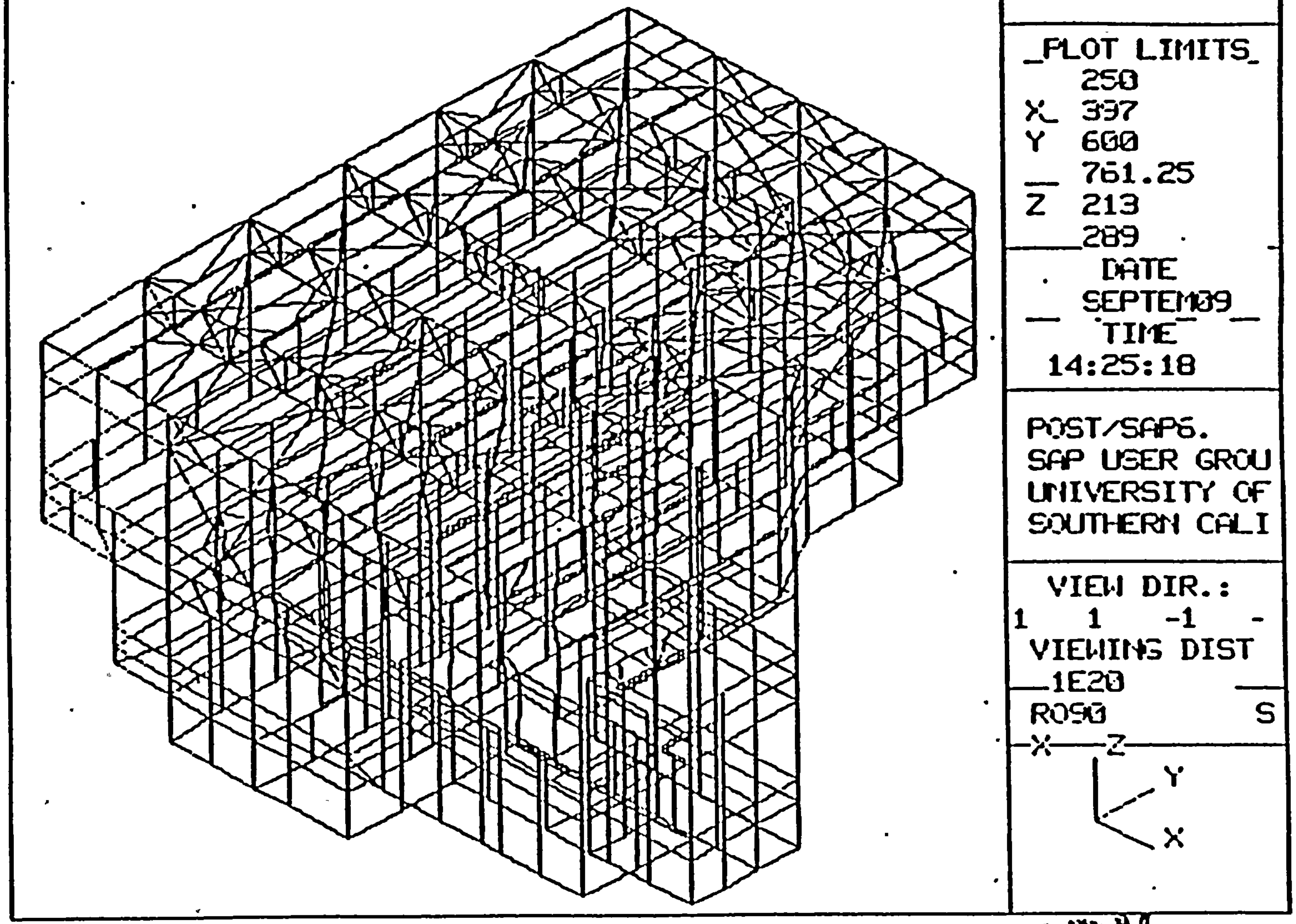
PRELIMINARY



PRELIMINARY

[illegible]

SCREEN PUMP HOUSE STATIC MODEL



PRELIMINARY

RE-EVALUATION OF CLASS 1 AND 2 STRUCTURES
LOADS AND ACCEPTANCE CRITERIA

o LOADS CONSIDERED:

- DEAD LOADS (D)
- LIVE LOADS & PRESSURE (L)
- EARTH PRESSURE & BOUYANCY (B)
- OPERATING LOADS (R)
- SSE LOADS (E')

o LOAD COMBINATIONS AND ALLOWABLES:

$$1.6S = D + L + B + R + E' \quad (1)$$

$$U = \text{[redacted]}\ D + L + B + R + E' \quad (2)$$

S = NORMAL ALLOWABLE FROM AISC PART 1

U = STRENGTH CAPACITY FROM AISC PART 2 OR ACI 349

o OTHER ACCEPTANCE CRITERIA:

- SPECIFIED DESIGN MIN MAT'L PROPERTIES
- MIN SAFETY MARGINS FOR BEARING CAPACITY - ASCE 58
- DEFORMATIONS LIMITED TO PREVENT IMPACT
- BEAM DEFLECTIONS < 1/180 SPAN LENGTH

FLOOR RESPONSE SPECTRA GENERATION METHODS AND ACCEPTANCE CRITERIA

- AS A MINIMUM, 75 OSCILLATOR FREQUENCIES FROM USNRC REG. GUIDE 1.122 SHALL BE USED

- THREE DIRECTIONS OF SPECTRA COMBINED USING SRSS

- PEAK BROADENING ACCORDING TO CODE CASE N-397, BUT ONLY ± 10%

- PVRC DAMPING ACCORDING TO CODE CASE N-411 FOR PIPING ANALYSIS; DAMPING RATIOS OF 2, 3, 4, 5, 7, 10 AND 20 PERCENT FOR EQUIPMENT, ETC.

- EFFECTIVE MODAL DAMPING RATIO TO BE USED ON CASE-BY-CASE BASIS

MAIN ELEMENTS OF SUP (CONT'D)

- o RE-EVALUATION OF SELECTED PIPING SYSTEMS
  - SCOPE: INITIALLY 15 TARGET SYSTEMS, EVENTUALLY ALL FSAR SEISMIC CLASS 1 AND 2 SYSTEMS
  - PIPING MODEL DEVELOPMENT
  - METHODOLOGY AND ACCEPTANCE CRITERIA
    - LOADS AND LOAD COMBINATIONS
    - ACCEPTANCE CRITERIA
    - ANALYSIS GUIDELINES
- o RE-EVALUATION OF PIPING SUPPORTS
  - SCOPE: SUPPORTS FOR TARGET PIPING SYSTEMS
  - METHODOLOGY AND ACCEPTANCE CRITERIA
- o SEISMIC QUALIFICATION OF EQUIPMENT
  - BEING PURSUED BY SQUG, NMPC IS A MEMBER
  - NMP-1 IS BWR PILOT PLANT FOR SQUG PROGRAM
  - PROVIDES
    - BASIS FOR SEISMIC ADEQUACY OF MECHANICAL AND ELECTRICAL SAFE SHUTDOWN EQUIPMENT

[illegible] 十 [illegible]

PIPING RE-EVALUATION
LOADS AND ACCEPTANCE CRITERIA

- o LOADS CONSIDERED:
  - DEAD WEIGHT
  - INTERNAL PRESSURE
  - SSE INERTIA
  - SSE SEISMIC ANCHOR MOTIONS (SAM'S)

- o LOAD COMBINATION AND ALLOWABLES:

(9) $$\frac{P_{MAX}\, D_O}{4\, T_N} + .75\ i\ \left(\frac{M_A + M_B}{Z}\right) \leq 2.4\ S_H$$

S_H = BASIC MATERIAL ALLOWABLE AT DESIGN TEMPERATURE

- o ACCEPTANCE CRITERIA
  - CLASS 2 AND CLASS 3 RULES OF 1980 ASME CODE, SECTION III, DIVISION 1, SUBSECTIONS NC & ND, EXCEPT AS INDICATED.

PIPING RE-EVALUATION
ACCEPTANCE CRITERIA (CONT'D)

- SINGLE ENVELOPED OR MULTIPLE LEVEL SPECTRA MAY BE APPLIED
- GROUPING OR DOUBLE SUM METHOD FOR COMBINING CLOSELY-SPACED MODES
- SAM'S CONSIDERED ONLY IF PIPING HAS SUPPORTS ATTACHED TO INDEPENDENTLY RESPONDING STRUCTURES
- SAM LOADS COMBINED WITH INERTIAL LOADS USING SRSS

[illegible]

PIPING SUPPORTS
METHODS AND ACCEPTANCE CRITERIA

- o ANALYZED ACCORDING TO 1980 ASME CODE SUBSECTION NF-3300 TO SERVICE LEVEL D LIMITS

- o LOADS DETERMINED FROM PIPING ANALYSES, USING SSE

- o SUPPORT ANCHORAGE ANALYZED IN ACCORDANCE WITH IE BULLETIN 79-02

MAIN ELEMENTS OF SUP (CONT'D)

- GUIDELINES FOR EVALUATION OF:
  - EQUIPMENT ANCHORAGE
  - CABINET ANCHORAGE
  - CABLE AND CONDUIT RACEWAYS
  - ESSENTIAL RELAYS

o PROGRAM ADMINISTRATION

- MANAGED BY NMPC, TEAM INCLUDES STEVENSON & ASSOCIATES, MPR ASSOCIATES
- PRELIMINARY MILESTONE SCHEDULE
- QUALITY ASSURANCE
  - DRAWINGS
  - COMPUTER PROGRAMS
  - CALCULATIONS
- DATA BASE REQUIREMENTS
  - RECORDS
  - ANALYTICAL MODELS

[illegible]

MILESTONE SCHEDULE

SHORT TERM:

- SUP PROGRAM PLAN DEVELOPMENT
- SUP PROGRAM PLAN REVIEW BY NMPC
- PRESENT PROGRAM DESCRIPTION TO NRC
- RECEIVE NRC COMMENTS ON PROGRAM
- FINALIZATION OF CRITERIA:
    - GROUND MOTION (SSE)
    - STRUCTURAL
    - FLOOR SPECTRA
    - PIPING
    - SUPPORTS
- OBTAIN NRC APPROVAL OF PROPOSED METHODOLOGY AND GOVERNING CRITERIA

LONG TERM:

- RE-EVALUATION OF GROUND MOTION SPECTRA
- RE-EVALUATION OF CLASS 1 STRUCTURES
- GENERATION OF NEW FLOOR RESPONSE SPECTRA
- RE-EVALUATION OF PIPING & SUPPORTS
- SEISMIC QUALIFICATION OF EQUIPMENT
- PILOT PLANT REVIEW
- PREPARE SER & PRESENT TO NRC
- FINALIZE SER AFTER NRC COMMENTS

[illegible]

DAMPING VALUES FOR STRUCTURES AND EQUIPMENT
(PERCENT OF CRITICAL DAMPING)

STRUCTURE OR COMPONENT	SAFE SHUTDOWN EARTHQUAKE
EQUIPMENT	3
WELDED STEEL STRUCTURES	4
BOLTED STEEL STRUCTURES	7
PRESTRESSED CONCRETE STRUCTURES	5
REINFORCED CONCRETE STRUCTURES	7
ELECTRICAL RACEWAYS - EMPTY	7
ELECTRICAL RACEWAYS - FULL	20
SLOSHING MODE IN TANKS	0.5
IMPULSE MODE IN TANKS	4

CLASS I STRUCTURES

REACTOR BUILDING

WASTE DISPOSAL BUILDING

VENTILATION STACK

DRYWELL

REACTOR PRESSURE VESSEL AND ITS SUPPORT STRUCTURE

SUPPRESSION CHAMBER

DIESEL-GENERATOR SUPPORT FOUNDATION

CLASS II STRUCTURES

TURBINE BUILDING

TURBINE-GENERATOR SUPPORT FOUNDATION

INTAKE AND DISCHARGE TUNNELS

COMBINATION CLASS I AND CLASS II STRUCTURES

SCREEN AND PUMP HOUSE

[illegible]

[illegible]

[illegible]

CLASS I EQUIPMENT, SYSTEMS, OR AREAS IN CLASS II STRUCTURES

DIESEL-GENERATOR SUPPORT STRUCTURE

CONTROL ROOM

AUXILIARY CONTROL ROOM

BATTERY ROOM

BATTERY BOARD ROOM

SUPPORTING STEEL STRUCTURE FOR EMERGENCY
CONDENSER, MAKEUP, AND DEMINIERALIZED WATER TANKS

CLASS I EQUIPMENT HOUSED IN AND SUPPORTED BY COMBINATION I/II STRUCTURES

EMERGENCY SERVICE WATER PUMPS AND PIPING

CONTAINMENT SPRAY COOLING PUMPS AND PIPING

DIESEL-GENERATOR COOLING WATER PUMPS AND PIPING

SERVICE WATER PUMPS AND PIPING

CLASS I EQUIPMENT HOUSED IN AND SUPPORTED BY CLASS II STRUCTURES

CONDENSATE STORAGE TANKS AND PIPING

CONDENSATE PUMPS, SUCTION AND DISCHARGE PIPING

FEEDWATER BOOSTER PUMPS AND DISCHARGE PIPING

HIGH PRESSURE REACTOR FEED PUMPS AND DISCHARGE PIPING

DIESEL-GENERATOR FUEL OIL, STARTING AIR AND COOLING WATER PIPING

EMERGENCY CONDENSER STORAGE TANKS

REACTOR BUILDING CLOSED LOOP COOLING PIPING (PARTIAL)

BREATHING AIR PIPING (PARTIAL)

INSTRUMENT AIR COMPRESSORS

INSTRUMENT AIR PIPING (PARTIAL)

SERVICE WATER PIPING (PARTIAL)

CLASS I PIPING SYSTEMS

MAIN STEAM INSIDE DRYWELL

CORE SPRAY

CONTAINMENT ATMOSPHERIC DILUTION

CONTAINMENT ATMOSPHERIC MONITORING

CONTAINMENT SPRAY

CONTAINMENT SPRAY COOLING WATER

EMERGENCY COOLING

LIQUID POISON

DRYWELL AND SUPPRESSION CHAMBER VACUUM RELIEF

FUEL POOL COOLING AND FILTERING

REACTOR CLEANUP

REACTOR SHUTDOWN COOLING

REACTOR HEAD SPRAY

CONDENSATE STORAGE

CONDENSATE PUMP SUCTION AND DISCHARGE

CLASS I PIPING SYSTEMS (CONT'D)

FEEDWATER BOOSTER DISCHARGE

HIGH PRESSURE REACTOR FEEDWATER

REACTOR BUILDING CLOSED LOOP COOLING

CONTROL ROD DRIVE PIPING

RADIOACTIVE WASTE DISPOSAL SYSTEM

EMERGENCY VENTILATION

BREATHING AIR

INSTRUMENT AIR

SERVICE WATER

DIESEL-GENERATOR FUEL OIL, STARTING AIR, AND
COOLING WATER

CLASS II PIPING SYSTEMS

MAIN STEAM OUTSIDE DRYWELL

BYPASS STEAM TO CONDENSER

STEAM SUPPLY TO AIR EJECTOR

EXTRACTION STEAM PIPING

MAKEUP DEMINERALIZER

TURBINE BUILDING CLOSED LOOP COOLING

REACTOR AND TURBINE BUILDINGS, SUMP PUMP DISCHARGE

SEAL WATER

TURBINE OIL STORAGE

CITY WATER

LABORATORY DRAINS

OFF-GAS