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SEISMIC REEVALUATION CRITERIA

For
Yankee Nuclear Power Station
Rowe, Massachusetts
Prepared for
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1.0 INTRODUCTION

Yankee Nuclear Power Station was designed before the current technology and codes had fully evolved. In the last decade, the state-of-the-art of earthquake engineering has progressed considerably. During this same period, new codes and regulations governing the design of nuclear power plants have been developed and have undergone significant changes. This evolution, while not resulting in a change in the basic design concepts, has yielded more detailed information concerning the behavior of structures, systems and equipment during earthquakes.

Yankee Atomic Electric Company has requested Earthquake Engineering Systems, Inc. (EES) to perform a seismic evaluation of the plant's critical structures and piping systems in accordance with the NRC Systematic Evaluation Program (SEP).

This document establishes the seismic criteria and the seismic evaluation approaches to be used in the investigation.

The present criteria have been specifically developed for linear elastic analysis. If necessary, additional criteria will be developed for non-linear analysis.

2.0 SCOPE

The purpose of this document is to establish the methodology and the criteria to be used for the seismic evaluation of piping systems and structures for the Yankee Nuclear Power Station.

Within the scope of this program, Earthquake Engineering Systems, Inc. (EES) will:

(a) Perform static analyses for thermal, dead weight, anchor movement and pressure loads, and dynamic analyses for seismic inertia loads. These analyses will be based on the as-built geometry of the piping systems and structures.

(b) Perform an evaluation of the critical piping systems and structures to withstand the loading conditions specified herein.

The piping systems and the structures included in the scope of this effort are summarized in Appendices A and B respectively.

3.0 CODES AND STANDARDS

The following codes and standards shall be applicable to the appropriate sections of this document (except where noted otherwise).

(a) American National Standard Code for Pressure Piping - ANSI B31.1, 1980.

(b) Nuclear Regulatory Guides - 1.60 Rev. 1, 1.61 Rev. 0, 1.92 Rev. 1 and 1.122, Rev. 1.

(c) American Institute of Steel Construction (AISC), "Specification for the Design, Fabrication and Erection of Structural Steel for Buildings," 8th Edition.

(d) American Concrete Institute (ACI) "Building Code Requirements for Reinforced Concrete" (ACI 318-77), including 1977 commentary.

(e) American Iron and Steel Institute (AISI), "Specification for the Design of Cold Formed Steel Structural Members," 1968 Edition with 1970 commentary and 1971 supplement.

(f) American Welding Society (AWS), "Structural Welding Code," D1.1-75.

(g) American Society of Mechanical Engineers (ASME), "Boiler and Pressure Vessel Code", 1971 Edition including Code Case 1607.

(h) U. S. Nuclear Regulatory Commission, (NRC), "Development of Criteria for Seismic Review of selected Nuclear Power Plants", NUREG/CR-0098 May 1978.

(i) International Conference of Building Officials, "Uniform Building Code", 1979 Edition.

(j) U.S. Nuclear Regulatory Commission, (NRC), "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants", NUREG-75/087, Section 3.7, Washington, D.C. - Office of Nuclear Reactor Regulation, September, 1975.

(k) American Concrete Institute (ACI), "Code Requirements for Nuclear Safety Related Concrete Structures" (ACI 349-76), including supplements.

(l) American Concrete Institute (ACI), "Code for Concrete Reactor Vessels and Containments" (ACI 359-77), including 1977 commentary.

(m) N.M. Newmark, W.J. Hall, R.P. Kennedy, J.D. Stevenson, and F.J. Tokarz, Seismic Review of Dresden Nuclear Power Station--Unit 2 for the Systematic Evaluation Program U.S. Nuclear Regulatory Commission, NUREG/CR-0891 (1979).

(n) ANSI B16.10, Face-to-Face and End-to-End Dimensions of Ferrous Values, 1973.

4.0 REFERENCE DOCUMENTS

The following reference documents shall be used in carrying out the piping stress and structural analysis effort:

4.1 Documents

(a) Yankee Atomic Electric Company, "Final Hazard Summary Report, Yankee Nuclear Power Station, Rowe, Massachusetts".

(b) Specification for Piping. YS-497 (S & W, JO-9699) July 15, 1959. Yankee Atomic Electric Company, Yankee Nuclear Power Station, Rowe, Massachusetts.

(c) Hot Service Thermal Insulation for Yankee Atomic Electric Plant. YS-2304 (S & W, JO-9699) June 1, 1959. Yankee Nuclear Power Station, Rowe, Massachusetts.

(d) Piping flow Diagrams, Yankee Nuclear Power Station, Rowe, Massachusetts. (Drawing Nos. E - S).

(e) Piping Drawings (Drawing No. 9699-FP-1 through 77).

(f) Stone and Webster Contract Drawings for Yankee Nuclear Power Station, 1958, 1959.

(g) Earthquake Engineering Systems, Inc., "Seismic Analysis and Stress Report for the Steel Vapor Container Structure of Yankee Nuclear Power Station," E-Y-YR-80061, 4-3-79, Rev. 1.

(h) Earthquake Engineering Systems, Inc., "Preliminary Seismic Evaluation, Concrete Reactor Support Structure for Yankee Nuclear Power Station", E-Y-YR-80064, 8-10-79, Rev. 1.

(i) Weston Geophysical Corporation, "Geology and Seismology, Yankee Rowe Nuclear Power Plant", January 29, 1979.

(j) Wiegel, R.L., Earthquake Engineering, Prentice-Hall, Inc. (Englewood Cliffs, N.J.), 1970, 518p.

(k) Housner, G.W. (January, 1967), "Dynamic Pressures on Accelerated Fluid Containers", Bulletin, Seismic Society of America, 47(1).

(l) U.S. Atomic Energy Commission (1963). Nuclear Reactors and Earthquakes, TID-7024, Washington, D.C. - Office of Technical Services.

5.0 STRUCTURAL PERFORMANCE CRITERIA

This section describes the criteria to be used in the analysis and evaluation of the structures listed in Appendix B.

5.1 Material Properties

The following material specifications govern unless superseded by field tests.

5.1.1 Concrete

The concrete properties for each building are summarized in Table 5.1. These values are obtained from References 4.1(f) & (h).

5.1.2 Steel

The steel properties for the different structures are summarized in Table 5.1.

5.1.3 Masonry

(later)

5.1.4 Soils

Bearing capacity for the soil underneath all footings shall be assumed to be 8 ksf if wind or earthquake loads are not considered and 10.6 ksf if they are. Compacted backfills shall be assumed to have a bearing capacity of 4 ksf. For reference, see drawing no. 9699-FC-59B.

5.2 LOADS DESCRIPTION

5.2.1 Dead Loads

Dead loads and their related internal moments and forces, including fixed equipment loads, will be included in the analysis. Equipment weights less than 500 lbs. will be considered as distributed loads and equipment weights more than 500 lbs. will be applied as concentrated loads.

5.2.2 Live Loads

Live loads and their related internal moments and forces, including any moveable equipment loads, will be included in the analysis.

5.2.3 Earth Pressure and Groundwater Table

Loads due to earth pressure will be included in the analysis. Hydrostatic loads due to groundwater table will be included in the analysis.

5.2.4 Fluid Loads

Fluid loads will be treated as hydrostatic loads except under seismic conditions. For this case, the fluid loads will be computed using the Housner method. For references see 4.1(j), (k) & (l).

5.2.5 Seismic Loads

All structures shall be evaluated for the Safe Shutdown Earthquake (SSE).

5.3 Analysis Methodology

This section outlines the methodology to be utilized in order to achieve the objectives of this evaluation.

5.3.1 Analysis Procedure

Figure 5-1 shows the general structural analysis steps. These steps are described in the following paragraphs:

The SSE ground response spectra will be used to generate artificial time histories using EES' SIMQUAKE program. These time histories will then be verified by checking their generated response spectra (plotted using INSPEC program) against the recommendations of Reg. Guide 1.122.

In a parallel effort the structural models are developed.

The scope of the present evaluation involves linear elastic analysis only. The basic analysis technique will be the response spectrum modal superposition method of dynamic analysis. Soil-structure interaction effects will be neglected, since studies performed previously have shown these effects to be negligible. The inter-connected buildings will be studied on a case-by-case basis. If coupling exists between the buildings they will be considered connected and will be analyzed as one unit. With a few possible exceptions (where the floor slabs have substantial openings) the floor diaphragms will be treated as rigid in plane. Three-dimensional beam elements will be used to describe columns and other beam type components. The models will describe the stiffness and mass relationship in three-dimensional space. Torsional effects due to asymmetric characteristics are automatically considered in this procedure. In buildings where the potential for further accidental torsion is considered to be likely, accidental torsion considerations as per NUREG/CR-0098 will be included. The superstructure in the reactor concrete pedestal is very stiff and consequently it responds dynamically in a rigid body type motion. The majority of the structural deformations will take place in the base columns and especially at their connections with the superstructure and foundation. Based on this behavior, a simplified model will be developed respresenting the superstructure as a vertical cantilever with multiple lumped masses. This cantilever will be connected to the base columns with a rigid beam system. The superstructure will be subsequently analyzed for the effects generated from the above analysis in addition to its own loads.

The steel vapor container will be modeled using shell elements to represent the sphere, and beam elements to represent the columns. In developing the spherical model, care will be taken to generate a finer mesh at the locations of high stress. The base of all columns will be fixed. The thin shell elements will model the actual thickness of the plate used in the structure which ranges from 7/8 to 3 inches. Additional masses will be applied to selected node points in the model to account for concentrated loads such as hatches and platforms.

The structural dynamic properties obtained from the dynamic analyses will be used to perform a modal superposition analysis using the program MOST. Amplified time histories will be generated at designated locations in the structures. These amplified time histories will be used to generate the Amplified Response Spectra (ARS) using the program INSPEC. The ARS will be broadened in conformance with Reg Guide 1.122. These ARS will be used as input for the piping and equipment analyses.

The resulting stresses and deformations will be obtained from the modal responses using the SRSS method, except for closely spaced modes where Regulatory Guide 1.61 method will be used.

The stresses and deformations will be evaluated for their compliance with section 5.4. The relative displacements of neighboring structures will be checked for the possibility of impact. The piping between buildings will be reviewed for these displacements.

5.4 ACCEPTANCE CRITERIA

5.4.1 Load Combination

The analyses will be performed assuming that the seismic event is initiated with the plant at normal full power condition. The following load combination will be considered in evaluating the structure:

$$U = D + L + T_o + R_o + P_o + E$$

where

U = Total load to be resisted.

D = Dead loads or their related internal moments and forces, including any permanent equipment loads, hydrostatic loads, and lateral soil pressures. It also includes operating static and dynamic heads and fluid flow effects.

L = Live loads or their related internal moments and forces, including any moveable equipment loads and other loads which vary in intensity and occurrence, such as wind. For equipment supports, it also includes loads due to vibration and any support movement effects.

T_o = Thermal effects and loads during startup, normal operating or shutdown conditions, based on the most critical transient or steady-state condition.

R_o = Pipe reactions during the startup, normal operating or shutdown conditions, based on the most critical transient or steady-state condition.

P_o = Pressure equivalent static load within or across a compartment generated by normal operating or shutdown conditions, based on the most critical transient or steady-state condition.

E = Loads generated by the safe shutdown earthquake. Three earthquake directions will be considered as per NUREG/CR-0098 except for special condition as discussed in NUREG/CR-0891.

5.4.2 Allowable Stresses

This section is specifically developed for linear elastic dynamic analysis. Additional criteria will be developed for non-linear analysis if required. The allowable stresses for reinforced concrete portions of the structures will be per ACI code 318-77. In lieu of the code load factors, the factors shown in section 5.4.1 will be used.

The stresses for steel structures will be checked against Part 1 of AISC Specifications, 1980 edition. Stresses up to 0.95 of yield or buckling will be allowed. The stress limits of the vapor container steel shell elements will be based on those currently allowed by the ASME Boiler and Pressure Vessel Code for faulted conditions including membrane and bending effects.

5.4.3 Allowable Deformations

The deformations will be limited according to the existing clearances so as to prevent impact of adjacent structures.

5.4.4 Damping

Damping values for different types of structures will be based on the stress levels generated in each structure. The values to be used will be in accordance with NUREG/CR-0098 (See Table 5-2).

5.4.5 Alternate Criteria

In cases where stresses exceed the allowables given in section 5.4.2, modifications may be recommended or alternate methods of analysis may be used, taking into consideration the non-linear behavior of the structure. Special acceptance criteria for these cases will be developed on a case-by-case basis.

6.0 PIPING ANALYSIS CRITERIA

This section describes the criteria to be used in the stress analysis of the piping systems listed in Appendix A. These criteria are applicable to pipings with nominal outside diameter larger than 2".

6.1 Load Description

The following load cases shall be considered for the piping stress analysis, in addition, local stress concentration due to integral support shall be evaluated.

6.1.1 Thermal Load

Loads due to steady state temperature effect, including thermal anchor movements.

6.1.2 Weight Load

Loads due to pipe, content and insulation.

6.1.3 Pressure Load

Loads due to steady state internal pressure.

6.1.4 Seismic (SSE) Load

Loads due to earthquake excitations which include both seismic inertia effect and seismic anchor movements.

6.2 ANALYSIS METHODOLOGY

6.2.1 Geometry and Computer Modeling:

For the purpose of computer analysis, pipig system will be idealized by three dimensional linear elastic model with finite numbers of structural members interconneced at finite numbers of nodal points. All supports and anchors are assumed to be rigid. The direct stiffness method is to be used in the solution of the problem.

(a) Each problem shall be considered from anchor to anchor. If an anchor to anchor problem exceeds program limitations, the following approach shall be considered in modeling:

- Overlapping such that there is negligible migration of loads from one problem to another.

- Bracketing results of multiple computer runs to assess boundary conditions or loading conditions.

(b) The geometry and restraint conditions shall be modeled in accordance with Isometrics based on as-built conditions.

(c) The pipe material properties and analysis conditions shall be considered as per YAEC's approved information such as Yankee Piping Specification (YS-497), YAEC flow diagrams, Yankee Insulation Specifications (YS-2304) and Grinnel catalog data.

(d) Branch connections with a moment of Inertia ratio >25:1 (main line/branch line) may be decoupled for analysis purpose assuming the main line node point as an anchor for the branch line. The main line deflections and rotations shall be input as anchor movements for the branch line analysis.

(e) Equipment nozzles and penetrations shall be considered as anchor points in the analysis. All equipment are assumed to be properly supported. Loading shall be summarized and compared to allowables when available. When allowable loads are not available, the analysis loads shall be submitted to YAEC for their review. Thermal anchor movements at nozzles and penetrations shall be indicated on the "As-Built" Isometrics. Or, if necessary, they shall be calculated by conventional methods based on system design temperature.

(f) Valves shall be modeled as follows:

- Thickness of the valve body shall be assumed as twice the connecting pipe wall thickness.

- Manually operated valves and check valves shall be modeled with the mass of the valve concentrated at the centerline of the pipe at the valve node points.

- Motor and air operated valves shall be modeled as eccentric mass points. The total weight of the valve shall be concentrated at a point one-third (1/3) the distance between the centerline of the operator and valve assembly (one-third of the "stem length" measurements as noted on the valve data form).

- If not available, body length of the valve shall be as per ANSI B16.10.

- Seismic accelerations of the valves will not be summarized.

(g) Flanges shall be considered as additional lumped weights. Flange thickness shall be assumed to be the same as that of pipe for purposes of modeling stiffness.

(h) Stress intensification factors for tees, reducers, flanges, elbows and couplings (half and full) shall be considered as per code requirements, ANSI B31.1 - Power Piping, 1980 edition.

(i) For the purpose of analysis, penetrations shall be treated as follows:

- Grouted penetrations: A bilateral restrain condition shall be assumed to exist on either side of the penetration for all load cases. Axial restraint of the pipe shall not be considered unless a welded collar is indicated on the pipe and embedded in the penetration.

- Ungrouted penetrations: At ungrouted penetrations, deflection of the pipe ≤ 1/4" shall be considered acceptable. Where deflections exceed 1/4", further review of actual penetration clearances shall be initiated. Deflections shall be based on the combined thermal and seismic conditions.

(j) The Cold modulus of elasticity E_c at (70°F) room temperature shall be used. The moduli of elasticity for ferrous and non-ferrous materials shall be taken from Appendix C Tables C-1 and C-2 of the ANSI B31.1 code.

(k) The Poisson's ratio shall be taken as 0.3 for all metals at all temperature.

6.2.2 Weight Analysis

The following considerations shall be made for dead weight analysis:

Weight analysis shall be performed considering weight of the pipe, content, insulation and concentrated masses (such as pipes supported off pipe, flanges and valves).

.2.3 Thermal Analysis

Thermal analysis of the piping system shall be performed based on the maximum design temperatures as designated on YAEC flow diagrams or stress isometric drawings. Effects of thermal movements from equipment nozzles, anchors, penetrations and connecting piping shall be analyzed. The Thermal Anchor Movement stress (TAM) shall be added to thermal expansion stress to obtain the total thermal stress.

6.2.4 Seismic Analysis

(a) The basic analysis technique will be the Response Spectrum, Modal Superposition method of dynamic analysis. Lumped mass models will be employed.

For rod hanger type of supports, when the uplift due to seismic load (include Thermal Load if it is upward) is larger than 90% of weight load, the rod hanger support shall be assumed noneffective. Consequently the particular rod hanger support will not be included in the computer modeling.

Seismic Inertia analysis and Seismic Anchor Movement analysis shall be performed for the Safe Shutdown Earthquake (SSE).

The spectra for the SSE is in the process of development and will be incorporated into this document when it becomes available.

(b) Application of Spectra:

For each earthquake condition, three directions of earthquake will be considered. (Two horizontal components and one vertical component). The total response due to each of the three (3) components of earthquake shall be calculated first. These responses shall then be combined by the SRSS method (Square Root of the Sum of Squares). The procedures to be used in combining the modal responses and responses due to spatial components of earthquake shall be as follows:

1. The modal responses for each component of earthquake shall be combined by taking into consideration the modes with closely spaced frequencies in accordance with NRC Regulatory Guide 1.92 Rev. 1, Feb. 1976. Subsections 1.2.1, 1.2.2, or 1.2.3.

2. The total systems responses due to the three (3) spatial components of earthquake are then combined by the SRSS method.

The responses of the Yankee Site Specific load case shall be used to evaluate the piping system and its support. For piping systems spanning several floors or with pipe supports connected to support structures attached to different floors, the response spectra for the analysis of the piping system shall be the envelope of the floor response spectra of all the floors involved.

(c) Cut-off frequency and minimum number of modes:

A cut-off frequency of 33 cps and with no less than 10 modes shall be considered in the analysis. An equivalent Static-Seismic analysis based on a constant acceleration from the spectra at 33 cps cut-off frequency shall be performed when the contributions of higher modes (>33 cps) are significant.

(d) Damping values:

For the seismic SSE condition, a damping value of two percent (2%) of critical damping shall be used for piping with outside diameter less than or equal to 12" and a damping value of three percent (3%) of critical shall be used for piping with outside diameter larger than 12".

6.2.5 Seismic Anchor Movement Analysis (SAM)

The SSE Seismic Anchor Movement load condition shall be considered for both stress and support load evaluations.

6.2.6 Pressure Effect

The effect of internal pressure shall be considered in computing longitudinal stresses.

6.3 Acceptance Criteria

6.3.1 Stresses in the piping system must not exceed the allowable stress limits of the ANSI B31.1 - Power Piping Code, 1980. The Acceptance Criteria shall be considered satisfie when the requirements of the following equations are met.

(a) The effects of pressure, weight, and other sustained loads must meet the following requirements:

$$\frac{PDo}{4tn} + \frac{0.75i}{Z} M_A \leq K S_h \quad \text{(Eq. 6.3.1-A)}$$

Where:

K = 1.0 for Dead Weight Loading

P = Internal Design Pressure, psi

D_o = Outside Diameter of Pipe, in.

t_n = Nominal wall thickness of components, in.

M_A = Resultant moment loading on cross section of the pipe due to weight and other sustained loads, in-pounds.

Z = Section modulus of the pipe, in^3.

S_h = Basic material allowable stress at maximum temperature from allowable stress tables, psi.

i = Stress intensification factor. The product of 0.75i shall never be taken as less than 1.0.

Stress Intensification Factors, "i" shall be as per ANSI B31.1 code 1980 edition.

(b) The effects of pressure, weight, other sustained loads and occasional loads including earthquake must meet the following requirements:

$$\frac{PDo}{4tn} + \frac{0.75i\ M_A}{Z} + \frac{0.75i\ M_B}{Z} \leq K\ S_h \quad \text{(Eq. 6.3.1-B)}$$

Where:

K = 1.8 for Safe Shutdown Earthquake (SSE).

M_B = Resultant moment loading on cross section due to occasional loads such as earthquake. For earthquake use only one-half the earthquake moment range. Other terms same as 6.3.1 - A.

(c) Thermal Expansion Stress (S_E):

$$S_E = \frac{i\ Mc}{Z} \leq S_A \quad \text{(Eq. 6.3.1-C)}$$

Where:

M_C = Range of resultant moments due to thermal expansion. Also include moment effects of anchor displacement due to earthquake if anchor displacement effects were omitted from Eq. 6.3.1-B

S_A = Allowable stress range for expansion stress.

= $f\ (1.25\ Sc + 0.25\ S_h)$

Where:

S_c = Allowable stress of the specific material at 70 degrees F. (Psi)

S_h = Allowable stress of the specific material at maximum temperature in degrees Fahrenheit (Psi)

(d) <u>Sustained Plus thermal Expansion Stresses</u>:

The effects of pressure, weight, other sustained loads and thermal expansion must meet the requirements of the equation 6.3.1-D

$$\frac{PDo}{4th} + \frac{0.75iM}{Z} A + \frac{iMc}{Z} \leq (S_h + S_A) \quad \text{(Eq. 6.3.1-D)}$$

Terms as previously described.

(e) The requirements of either Equation 6.3.1-C or Equation 6.3.1-D must be met.

(f) Even though only the Response Spectrum Analysis method is considered in this criteria, we do not preclude the possibility of using time history analysis method, if the situation warrants its application. Specific criteria for time history analysis will be provided when the need arises.

6.3.2 Allowable Stresses

Allowable stress values to be used for power piping systems are given in Appendix A of ANSI B31.1 power piping code. Those values shall be used for piping stress analyses.

For material allowable stress values not available in Appendix A of ANSI B31.1, reference should be made to ASME Boiler and Pressure Vessel Code Section III, Division 1. The appropriate allowable stress values shall be taken from tables contained in Appendix I.

6.4 Small Pipe Stress Analysis

This section applies to piping with nominal outside diameter of 2" or smaller.

6.4.1 Detailed Stress Analysis

For detailed stress analysis the same procedures and methods as those for large pipe stress analysis shall be followed. (Sections 6.1 through 6.3). In addition:

- All pipe bend shall be considered to have a bend radius of five (5) times the pipe diameter.

- Connections at Elbow, Tee, Reducer, Coupling and nozzle shall be considered as socket welded.

6.4.2 <u>Simplified Stress Analysis</u>

This is an alternative method to the Detailed Stress Analysis method. Each span of a piping system (spans are generally separated by guides) is evaluated by simpliefied thermal, seismic and weight stress analyses. Span lengths and support locations are investigated to ensure the requirements of piping flexibility and high natural frequency are met.

(a) Weight stress - weight stress is kept to predetermined level by using specified support spacings. Span length tables, based on a bending stress of 1,500 psi shall be used for pipe with uniform weight. When concentrated loads such as value or risers exist, a hanger should be placed within 6 inches of the concentrated weight or the weight span spacing should be modified.
(Applicable Gravity Span tables will be provided later).

(b) Thermal stress - thermal stress shall be kept to an acceptable level by providing a minimum offset to absorb thermal movement. Offset is defined as the length of

piping in a plane perpendicular to the direction of movement. The offset piping shall be unrestrainted in the direction of movement.
(Applicable Offset tables will be provided later)

(c) Seismic stress - Seismic pipe spans shall be generated by simplified analysis method so that the actual stress will be less than the predetermined max. stress. These seismic pipe spans and restraint loads are defined as a function of unique spectra curves and pipe sizes. The basic approach is to keep the seismic acceleration of the system low and to keep the natural frequencies in the "Rigid Range". The seismic spans shall generally be separated by guides at each change of direction, at all extended massses and at each tee. (Applicable Seismic Span tables will be provided later).

(d) Pressure stress - longitudinal pressure stress shall be computed as per ANSI B31.1 code requirement. The pressure stress shall be compared with a pre-specified value.

(e) Acceptance requirements - the piping system is considered to have met the stress acceptance requirements if each span satisfies the span length, offset and pressure stress requirements mentioned above. Span length shall be adjusted to account for the effect of stress intensification factor applicable to the component under consideration. If any of the above requirements cannot be satisfied, a detailed stress analysis shall be performed for the portion of piping involved.

APPENDICES

Appendix A

A. The following piping systems are included in the scope of this evaluation.

1. Main Steam
2. Feed Water
3. Reactor (Main) Coolant
4. Pressure Control & Relief
5. Charging & Volume Control
6. Safety Injection
7. Shut Down Coolant
8. Sample and Drain System
9. Primary Plant Purification
10. Fuel Transfer
11. Vapor Containment Heating System

APPENDIX B

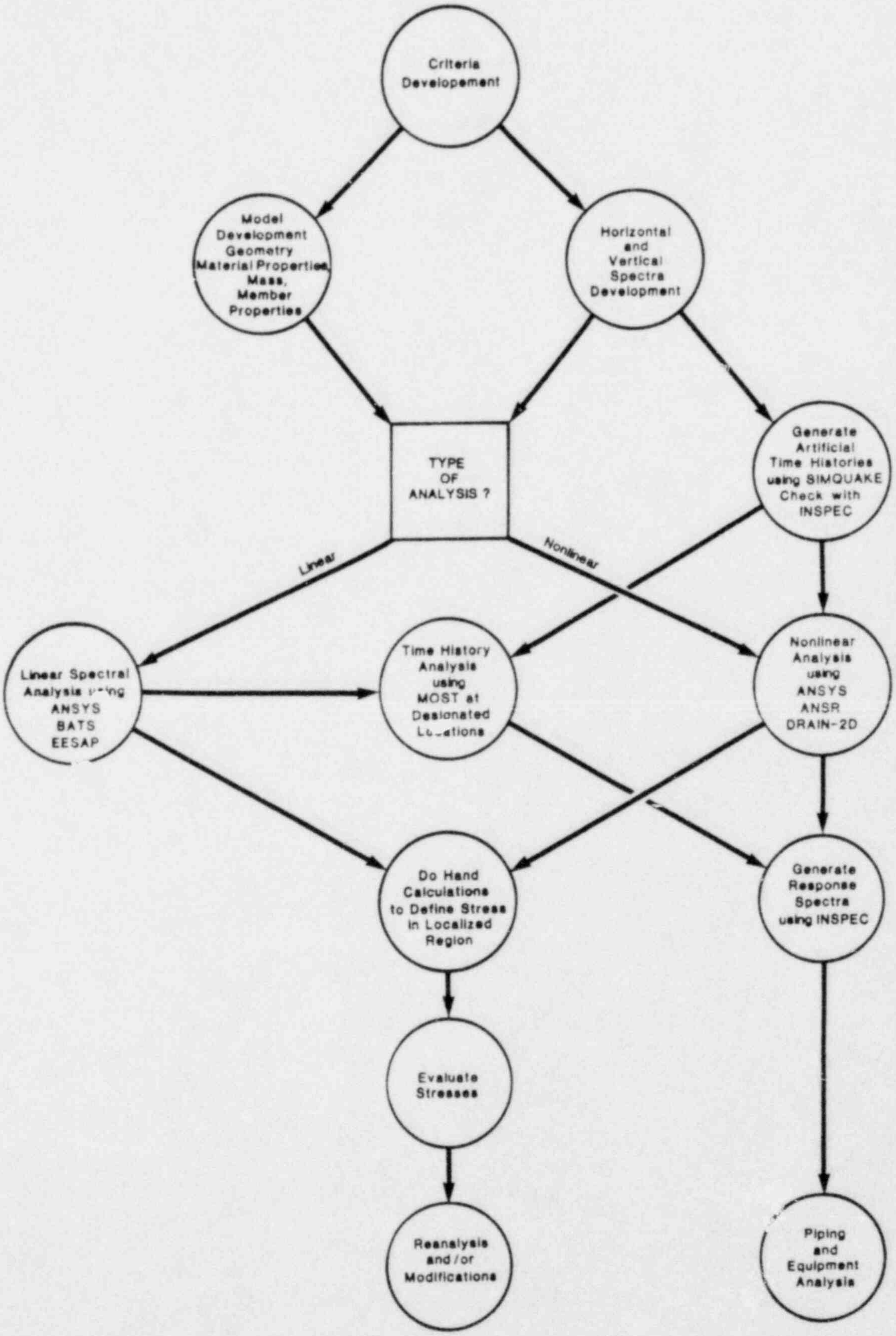
B. The following structures are included in the scope of this evaluation.

1. Concrete Reactor Support Structure
2. Vapor Container Structure
3. Diesel Generator Building and Accumulator Enclosure
4. Turbine Building and Turbine Pedestal
5. Ion Exchanger Building
6. Primary Auxiliary Building and Radioactive Tunnel
7. Screen Well and Pump House
8. Spent Fuel Pool and Spent Fuel Chute

Appendix C

FIGURE 5-1

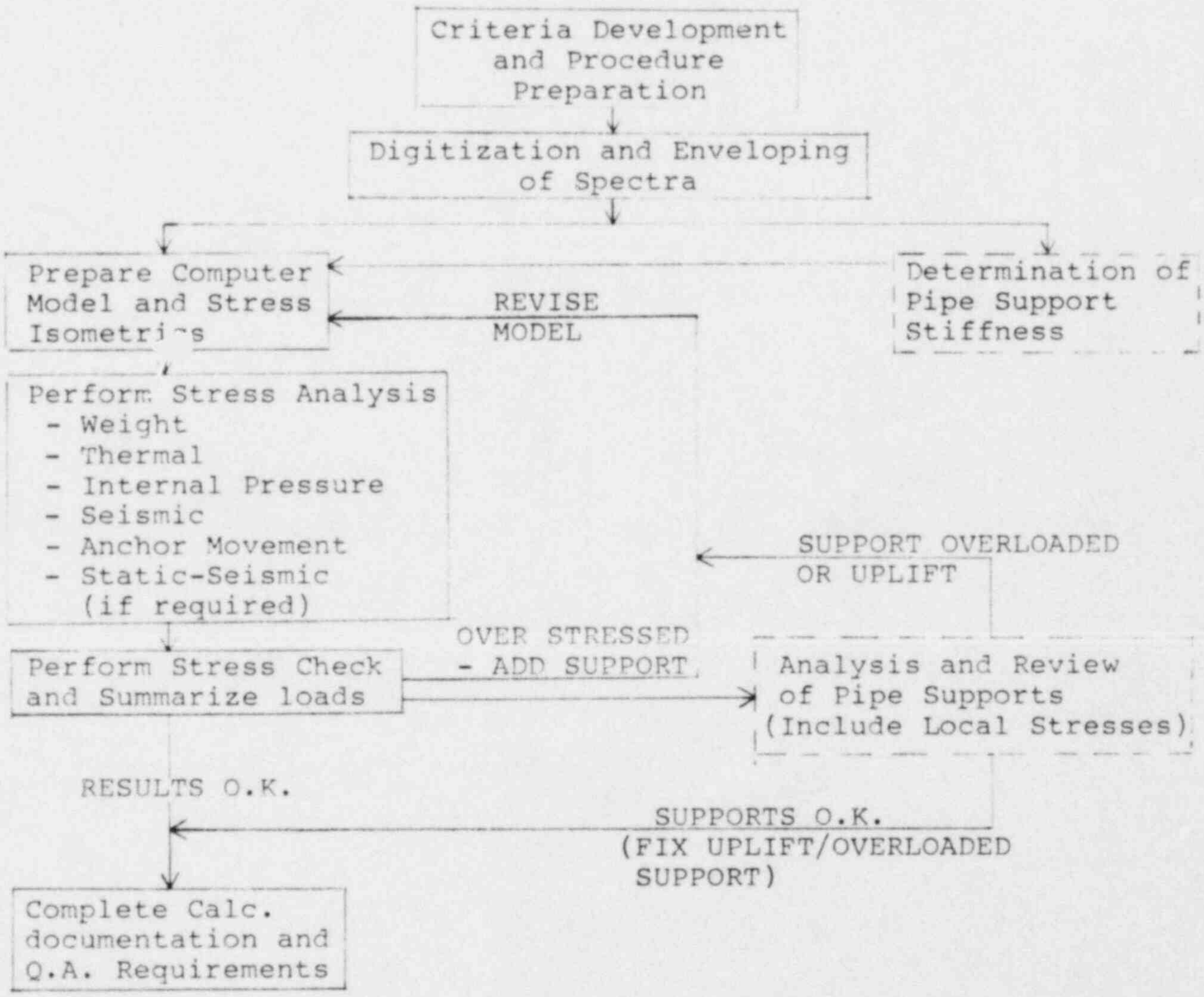
STRUCTURAL ANALYSIS FLOWCHART



<u>Appendix C</u>

Figure 6-1

PIPING STRESS ANALYSIS FLOWCHART



Appendix D

TABLE 5-1

MATERIAL PROPERTIES

BUILDING DESCRIPTION	MATERIAL		
	STRUCTURAL STEEL	CONCRETE	REINFORCING STEEL
1. DIESEL GEN. BLDG. ACCUM. TANK ENCLOS.	ASTM A7 (Fy = 33 ksi)	fc' = 3,000 psi	ASTM A 305, INT. GR. (Fy = 40 ksi)
2. TURBINE BLDG. CONTROL ROOM	ASTM A7 (FY = 33 ksi)	a) Footings, fc'= 2,500 psi. GRADE BMS. b) ALL OTHER CAST-IN PLACE fc'=3000 psi c) PRECAST BMS & WALL SHIELD fc'=2500 psi d) TURBINE SUPPORT MAT. fc'=3000 psi	ASTM A305, INT. GR. (Fy = 40 ksi)
3. SPENT FUEL POOL SPENT FUEL CHUTE	ASTM A7 (FY = 33 ksi)	fc' = 3000 psi	ASTM A 305, INT. GR. (Fy = 40 ksi
4. SCREEN WELL AND PUMPHOUSE	ASTM A7 (FY = 33 ksi)	fc' = 3000 psi	ASTM A 305, INT. GR. (Fy = 40 ksi)
5. STEEL VAPOR CONTAINER	A 201 B to F_t=60 ksi A 300 Fy = 32 ksi	PRESSURE=31 psi fc' = 3000 psi (Pedestals & Footings)	ASTM A 305, INT. GR. (Fy = 40 ksi)
6. CONCRETE CONTAINER & SUPPORT STRUC-TURES	A201 B to A300 Ft = 60 ksi Fy = 32 ksi	a) FOOTINGS & GRADE BMS, fc'=3000 psi b) PEDESTALS, COLS, WALLS, ALL OTHERS fc' = 4000 psi	ASTM A 305, INT. GRADE (Fy = 40 ksi)
7. PRIMARY AUX. BLDG.	ASTM A7 (Fy = 33 ksi)	fc' = 3000 psi	ASTM A 305, INT. GR. (Fy = 40 ksi)

* Source: NUREG/CR-0098

Appendix D

TABLE 5-2

RECOMMENDED DAMPING VALUES*

Stress Level	Type and Condition of Structure	Percentage Critical Damping
Working stress, no more than about ½ yield point	a. Vital piping	1 to 2
	b. Welded steel, prestressed concrete, well reinforced concrete (only slight cracking)	2 to 3
	c. Reinforced concrete with considerable cracking	3 to 5
	d. Bolted and/or riveted steel wood structures with nailed or bolted joints.	5 to 7
At or just below yield point	a. Vital piping	2 to 3
	b. Welded steel, prestressed concrete (without complete loss in prestress)	5 to 7
	c. Prestressed concrete with no prestress left	7 to 10
	d. Reinforced concrete	7 to 10
	e. Bolted and/or riveted steel, wood structures, with bolted joints	10 to 15
	f. Wood structures with nailed joints	15 to 20

* Source: NUREG/CR-0098

Appendix E

COMPUTER PROGRAMS

A. Earthquake Engineering Systems, Inc., INSPEC, Version 1.2, October, 1980.

B. NISEE/Computer applications ANSR-I, March and December, 1975.

C. NISEE/Computer Applications, DRAIN 2D, Version 8/75, August 1975.

D. Earthquake Engineering Systems, Inc., BATS, Version 6.1, November 1980.

E. Earthquake Engineering Systems, Inc., EESAP, Version 1.0, June 1979.

F. Swanson Analysis Systems, Inc., ANSYS, Version 3, July 1, 1979.

G. Earthquake Engineering Systems, Inc., MOST, Version 1.1, November, 1979.

H. Earthquake Engineering Systems, Inc., SIMQUAKE, Version 1.0, December, 1980.

I. Arthur D. Little, Inc. ADLPIPE, Version - ADLPIPE (FAST) February, 1977, Rev. 4C.

J. CDC, PIPESD, Version 6.0, August, 1979.

K. Mahin, S.A. and Bertero, V.V., RCCOLA, A Computer Program for Reinforced Concrete Column Analysis, Department of Civil Engineering, University of California, Berkeley, August, 1977.