MISSISSIPPI POWER & LIGHT COMPANY
Helping Build Mississippi
P. O. BOX 1640, JACKSON, MISSISSIPPI 39205

July 31, 1981

NUCLEAR PRODUCTION DEPARTMENT

U.S. Nuclear Regulatory Commission
Office of Nuclear Reactor Regulation
Washington, D.C. 20555

Attention: Mr. Harold R. Denton, Director

Dear Mr. Denton:

SUBJECT: Grand Gulf Nuclear Station
Units 1 and 2
Docket Nos. 50-416 and 50-417
File 0260/L-860.0/L-380.0
NRC Structural Audit Checklist
AECM-81/272

As requested by Mr. Rom Lipinski of the Structural Engineering Branch (SEB), Mississippi Power & Light Company (MP&L) is submitting the attached completed Structural Audit Checklist. The checklist was provided to MP&L during an audit of our architect-engineer, Bechtel Power Corporation, Gaithersbrug, Maryland. The audit was conducted by SEB on March 17-21, 1980.

The attached checklist items are answered by reference to FSAR sections, calculations and drawings. These references were reviewed during the audit or were sent under proprietary or non-proprietary cover as a result of the audit.

Yours truly,

L. F. Dale
Manager of Nuclear Services

JGC/JDR:lm
Attachments

cc: Mr. N. L. Stampley
Mr. G. B. Taylor
Mr. R. B. McGehee
Mr. T. B. Conner

Mr. Victor Stello, Jr., Director
Office of Inspection & Enforcement
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

B001
S1/1

DRAFT A, WCB3

STRUCTURAL AUDIT CHECKLIST

Plant GRAND GULF

Structure CONTROL BUILDING

Applicant _____

Architect/Engineer _____

Auditor _____

The purpose of the audit is to review and assess the techniques and methodology employed by the applicant to demonstrate compliance of all Category I structures with the applicable SRP's, Reg. Guides, Codes and Standards.

The general procedure of the audit will be to review some structures in considerable detail and others will be spot checked. Emphasis will be placed upon verifying the validity of the methods used and compliance with the applicable codes and standards; however, actual mathematical computations may also be checked and should be available at the audit.

The following audit sheets are intended to be used for the following purposes:

1. A checklist to be used by the auditor in reviewing the procedures and computations of the A-E.

2. A guideline to help the A-E prepare for the audit.

STRUCTURAL AUDIT OF GRAND GULF

SEISMIC CATEGORY 1 STRUCTURES

OTHER THAN CONTAINMENT

Structured Audited Control Building

Part I General Analysis

I. BASIC DESIGN CRITERIA

See Plant Assignment, FSAR Fig. 3.4-1

A. Dear Load (Items included, method of determining)

See Design Criteria Part B, Sect. II, Para. 7.1
Equip. Loads from Supplier Dwgs.
Pipe Loads from hanger drawings.

Material:		
	Calc.	150 PCF
	Steel	490 PCF
	CMU	105 PCF

B. Live Load (Values for operating floors, base slab, etc., also method for determination.)

Design Criteria Part B, Sect. II, Para. 7.2.3.1 & 7.2.3.3
See Arch. floor load dwgs. A-0010 thru A-0017

C. Thermal Loads

N/A

D. Pressure (Internal and external)

N/A

E. Wind Loads

1. Design basis wind

See Design Criteria Par. 3.8.1 & FSAR Sect. 3.3.1

$= 0.00256V^2$ = 20.7 psf (v = 90 mph)

2. Tornado loads

See Design Criteria Par. 3.8.2 & FSAR Sect. 3.3.2

$= 0.00256V^2$ = 332 psf (v = 360 mph)

Exterior Walls & Roof Designed for Δp = 3 psi

Interior walls designed for depressurization due to partial venting (temp. condition during Unit 2 const.) 25 psf

F. Seismic Criteria

1. "g" value free field

	Horiz.	Vert.	
SSE	0.15g	0.10g	(FSAR: 3.7.1.1.1)
OBE	0.075g	0.05g	(FSAR: 3.7.1.1.2)

2. Spectra

SSE: FSAR Fig. 3.7-1
OBE: FSAR Fig. 3.7-2

3. Damping

See FSAR Table 3.7-3

4. Artifical time history and corresponding spectra

See FSAR Par. 3.7.1.2 &
FSAR Figs. 3.7-3 thru 3.7-15

5. Motion duration

24 seconds per FSAR Par. 2.5.2 & 3.7.1.2

6. Components of motion

Three orthogonal components in the E-W, N-S, & vertical directions
Components combined by SRSS.
FSAR Par. 3.7.2.6

G. Hydrostatic and Hydrodynamic Loads (Groundwater Only)

Design Criteria 3.4 & 7.6
FSAR Fig. 2.5-91 & Table 3.4-3
Hydrostatic: See Calc. C-T-320.0
Hydrodynamic: None

H. Earth Pressure

Design Criteria 3.10 & 7.5
Exterior Walls Calc. C-T-300.0
FSAR Fig. 2.5-91 (Lateral Earth Pressure & Groundwater)

I. Abnormal Plant Loads

1. Missiles (Impact)

Internally Generated: FSAR 3.5.1.1 & Table 3.5-1, 3.5-2
(Rotating and Pressurized Components)
Turbine : FSAR 3.5.1.3 & Table 3.5-7
Natural Phenomena : FSAR 3.5.1.4

2. Pressure

Not applicable. No high energy lines in Control Building. No pipe break phenomena. (No breaks identified in FSAR Section 3.6)

3. Local Reactions

Not applicable. No high energy lines in Control Building-no pipe whip or jet impingement loads. (No breaks identified in FSAR Sect. 3.6)

4. Other special loads

None

J. Misc. Loads (Example: crane loads)

15 ton bridge crane (calculation C-T-270.0) located at El. 93'-0" for hot machine shop.

K. Load Combinations Conformance with ACI 349 and/or 318

ACI 318 combinations used
Design Criteria Paragraph 8.2.2

II. Analysis Method

A. Seismic Analysis

1. Mathematical model - general description with sketch

FSAR Paragraph 3.7.2.1.1.3.3, Figure 3.7-22
Lumped Mass Model
Soil - Structure interaction considered

a. Parameters used

(i) Concrete modulus

$E_c = W^{1.5}\ 33\ \sqrt{f'c}$ (W = 150 pcf) (f'c = 4000 psi)

$= 3834$ Ksi

(ii) Rebar modulus and yield strength

$E_s = 29000$ Ksi; $F_y = 60$ Ksi (A615, Gr 60)

(iii) Poisson's ratio (Concrete)

$\nu = 0.17$

(iv) Damping

FSAR Table 3.7-3
Concrete: OBE = 0.02; SSE = 0.05

(v) Structural steel modulus and yield strength

E_s = 29000 Ksi; F_y = 36 Ksi

(vi) Properties of foundation materials (Shear modulus, subgrade reactions, bearing capabilities, etc.)

Shear modulus = 8393 KSF (FSAR Table 3.7-7)
Ult bearing capacity = 93 KSF (FSAR Figure 2.5-90)

(vii) Other parameters

Density of soil = 120 PCF
Poisson's Ratio = 0.47
Shearwave velocity = 1500 ft/sec — Catahoula
Young's modulus = 24692 KSF — Formation
Damping Ratio = 0.02
(Calculation C-T008.0)
(Above values in agreement with FSAR Table 3.7-7)

b. Stiffness calculations

(i) Exterior walls

Program CE-650 used to compute the sectional moment of inertia and shear areas in both N-S and E-W directions (Calculation C-T-007).

Gross sections used for moments of inertia and effective sections used for shear areas.

(ii) Interior walls

Not included. Interior walls are CMU and are isolated from floors and walls.

(iii) Floors

Considered as lumped masses. Mass moment of inertia for each horizontal direction was considered.

(iv) Columns

Not considered in stiffness calculations

2. Method of Analysis

a. Method of analysis used (Time history, response spectrum methods, etc.) and consideration of torsional and translational response

FSAR 3.7.2.1

(ii) Findings and comments

FSAR 3.7.2.2 (Calculation C-T-050.)

b. Selection of number of masses and degrees of freedom

FSAR Section 3.7.2.1.1.3.3 and Figure 3.7-2

(i) General description

See FSAR 3.7.2.3.1-a for modeling procedure
7 masses (6 floors + base mat) and 8 dynamic degrees of freedom for flexible base model for each horizontal direction.

(ii) Findings and comments

c. Number of modes considered

5 modes for N-S and E-W
2 modes for Vert.
See calculation C-T-013.0 and FSAR Table 3.7-11

(i) General description

Higher modes corresponding to f = 33cps or more were neglected

(ii) Findings and comments

d. Combining modal responses

(i) Actual procedures used

SRSS used for each 3 orthagonal directions (CE918)
FSAR 3.7.2.7

(ii) General findings

e. Consideration of three components of motion

(i) Actual procedures used

SRSS used for combining 3 orthagonal directions
FSAR 3.7.2.6

(ii) General findings

f. Consideration of soil-strucutre interaction and interaction among adjacent buildings

Interaction between buildings was considered and determined to be negligible.

(i) General description

FSAR 3.7.1.3.2 and Tables 3.7-4, 3.7-5
FSAR 3.7.2.4 and Tables 3.7-7 and 3.7-8

FSAR 3.7.2.1.1.4,
3.7.2.8

(ii) Findings and comments

g. Decoupling criteria for subsystems

(i) General procedure

FSAR 3.7.3 - No significant subsystems exist that required analysis.

(ii) Key examples

A) Systems (cable trays, HVAC ducts, conduit, etc.) designed by using appropriate floor response spectra.

B) Equipment (elect., HVAC and other components) were analyzed and designed by vendors.

(iii) General findings and comments

h. Modeling of hydrodynamic effects in spent fuel pool

Not Applicable

i. Modeling of spent fuel pool walls and interior floor slabs and equipment thereof.

Not Applicable

3. Development of in-structure response spectra

FSAR Section 3.7.2.5, Programs CE-920 and
CE-921

a. General procedures

(i) Smoothing (describe specific smoothing method used)

Envelope of maximum peaks for each direction.
FSAR Paragraph 3.7.2.5

(ii) Peak widening

FSAR Paragraph 3.7.2.5

b. Typical results (attach figures)

(i) Basemat spectra

Calculations T-016.0 thru T-021.0

(ii) Interior floors spectra (Key floors with floor elevations identified).

Calculations T-016.0 thru T-021.0

4. Vertical Dynamic Analysis

a. Mathematical Model - general description with sketch

FSAR Figure 3.7-22

b. Development of stiffnesses, including floor stiffness, as applicable. Wall axial stiffness computed by Program CE-650. Floors considered rigid (lumped masses). Mass moments of inertia for each floor were considered.

c. Method of Analysis (Description of method used as well as each item considered in the analysis.)

Modal response CE 917, CE 918 (Load input for stress analysis)
Time history CE 920, CE 921 (Floor response spectra)
Soil-Structure interaction was considered

FSAR 3.7.2.1

B. Stress Analysis

1. Shear Walls and Floors

a. Mathematical model (General description w/sketch)

FSAR Figures 3.8-101 thru 110
FSAR Paragraph 3.8.4.1.1.5
3.8.4.4.5

b. Method of analysis (Incorporation of torsion)

FSAR Paragraph 3.7.2.11
Torsion considered by long-hand calculations (C-T-050.0)

c. Load combinations

FSAR Paragraph 3.8.6.2 for seismic Category I structures other than containment.

d. Key results

2. Foundation mat

   a. Mathematical model (Description of boundary conditions)

      FSAR Paragraph 3.8.5.4.3 and Figure 3.8-101
      Calculation T-240.0 - base slab supported on soil with wall fixity on four sides taken into account along with 6 interior columns supported on base mat.

   b. Method of analysis

      Hand calculations using linear distribution of soil bearing pressures and checked by finite element methods.

   c. Load combinations

      FSAR Paragraph 3.8.6.2

   d. Key results (Figures, etc.)

   Drawings C-061A, C-061B

3. Material to protect against structure-to-structure interaction

   Rodofoam II used between Control-Auxiliary and Control and Turbine Buildings (cellular plastic filler)

   a. Mechanical properties

      Under seismic testing, load transfer at 50% compression was 17.8 psi.

   b. Additional pressure on walls

      Negligible interaction per FSAR Paragraph 3.7.2.1.1.3.2. 3D model for Control and Auxiliary Buildings, see FSAR Figure 3.7-21.

   c. Findings and comments

4. Computer programs used in analysis

ICES-STEUDL (McDonnel-Douglas)	CE-917	CE-921
CE-650	CE-918	CE-931
CE-901	CE-920	

   a. Assumptions and limitations

      FSAR Appendix 3D

   b. Applicability

      FSAR Appendix 3D

c. Verification (Sensitivity study in case of numerical solutions; e.g., finite element analysis)

FSAR Appendix 3D

d. Load input (Include all cases)

FSAR Appendix 3D

e. Output (Include all cases)

FSAR Appendix 3D

f. Other discussions

FSAR Appendix 3D

5. Overall stability

a. Forces and moments from seismic analysis

FSAR Figures 3.7-44 E-W and N-S SSE
3.7-45 E-W and N-S OBE
3.7-46 VERT SSE and OBE

b. Various cases considered

Sliding, overturning buoyancy calculation C-T-050.0

c. Bearing pressure versus bearing capacity and safety factor against bearing failure

FSAR Figure 2.5-90
Maximum Bearing = 24.0 Ksf
Ult. Bearing Capacity = 93 Ksf

$$FS = \frac{93}{24.0} = 3.9$$

d. Factors of safety

FSAR Table 3.8-1

(i) Sliding

1.18

(ii) Overturning (Vertical displacement)

2.35

6. Interaction of Non-Category I structures with the structure considered.

No interaction considered
Adjacent Non-Category I structure (Turbine Building) designed to Category I (See FSAR 3.8.4.1)

a. Identification of pertinent Non-Category I structures
FSAR 3.7.2.8
FSAR 3.8.4.1

b. Consideration given to potential failure of Non-Category I systems on Category I systems.

See above

c. General findings and comments

7. Design Consideration for Tornado Missiles

a. Design requirements

FSAR 3.5.1.4 and Figure 3.5-1
Design Procedures, FSAR Section 3.5.3.1

b. Models for

(i) Local damage

Penetration, perforation and spalling criteria is satisfied per FSAR 3.5.3.1.

(ii) Overall response

FSAR 3.5.3.1
Calculation E-020.0

c. Load combinations

FSAR 3.8.6.2
BC-TOP-3A

d. Forces

FSAR 3.5.3.1

e. General comments and preliminary audit findings

III. CONFORMANCE TO ACCEPTABLE CRITERIA

A. Identification of deviations, if any.

None

B. Justification of deviations and disposition of the deviations.

C. General comments

Part II - AUDIT OF KEY DESIGNS

For each key design area audited, the design calculations should be reviewed. together with applicable drawings, sketches, etc. Also, key details and/or sections, as appropriate in this audit report, should be included.

I. SPECIFIC CHECK OF KEY LOCATIONS

A. Exterior Shear Walls

1. Design requirements

FSAR Paragraphs 3.8.4.3, 3.8.4.4, 3.8.4.5

2. Design loads (from general analysis)

See Part I of this audit
Dead, Live, OBE and SSE, Wind and Tornado, and Tornado Missiles

3. Forces and moments at key sections

Calculations C-T-320 and C-T-330

4. Detailed design of rebar placement at key sections

Calculations T-280.0, T-320.0, T-330.0
Reference: Drawing C-0604A&B C-0622
C-0612
C-0609

5. General comments and preliminary audit findings

B. Interior Shear Walls - Not Applicable

Interior walls are CMU and are designed as "partition walls" only. Interior CMU walls have a gap between top of wall and underside of slab. Walls are doweled into floor slab at bottom and braced laterally at top by attachments connected to the floor slab above. Therefore, walls cannot transmit in-plane shear forces between floors.

1. Design requirements

Not Applicable

2. Design loads (from general analysis)

Not Applicable

3. Forces and moments at key sections

Not Applicable

4. Detailed design of rebar placement at key sections

Not Applicable

5. General comments and preliminary audit findings

C. Main Floors and Roofs (Elevation)

1. Design requirements

FSAR Paragraphs 3.8.4.3, 3.8.4.4 and 3.8.4.5

2. Design loads (from general analysis)

See Part I of this audit
Dead, Live, Tornado and Tornado Missile

3. Forces and moments at key sections

Calculations C-T-160, C-T-170 and C-T-187

4. Detailed design of rebar placement at key sections

Calculations: C-T-160, C-T-161, C-T-170
Drawings: C-0608 C-0634
C-0609 C-0638

5. General comments and preliminary audit findings

D. Steel Structural Bracing Systems (if any) Interior Columns

1. Design requirements

FSAR Paragraphs 3.8.4.3, 3.8.4.4 and 3.8.4.5

2. Design loads

See Part I of this audit
Dead, Live, SSE

3. Forces and moments at key sections

Calculation C-T-200
Drawing C-0632

4. General comments and preliminary audit findings

E. Foundation Mat

1. Design requirements

FSAR Paragraphs 3.8.4.3, 3.8.4.4 and 3.8.4.5

2. Design loads (from general analysis)

See Part I of this audit
Dead, Live, SSE

3. Forces and moments at key sections

Calculation C-T-240.0

4. Detailed design of rebar placement at key sections

   Calculation C-T-240.0
   Drawings C-0604A and C-0604B

5. General comments and preliminary audit findings

F. Main Frame Concrete Column Design (Key Columns)

Not Applicable
No conc. columns

1. Design requirements

   Not Applicable

2. Design loads (from general analysis)

   Not Applicable

3. Forces and moments at key sections

   Not Applicable

4. Detailed design of rebar placement at key sections

   Not Applicable

5. General comments and preliminary audit findings

G. Secondary Floors El. 177'-0", Mezzanine Floor and Viewing Gallery

1. Design requirements

   FSAR Paragraphs 3.8.4.3, 3.8.4.4 and 3.8.4.5

2. Design loads (from general analysis)

   See Part I of this audit
   Dead, Live

3. Forces and moments at key sections

   Calculations C-T-183 and C-T-185

4. Detailed design of rebar placement at key sections

   Calculation T-183
   Drawings C-0617 C-0641
   C-0618 C-0642

5. General comments and preliminary audit findings

H. Detailing at Floor-Wall Joints

1. Design requirements

Same as floor and wall systems, above.

2. Design loads (from general analysis)

Same as floor and wall systems, above.

3. Forces and moments at key sections

Calculations C-T-160, C-T-170, C-T-187, C-T-320, C-T-330

4. Detailed design of rebar placement at key sections

See drawings C-0604A C-0609 C-0620
C-0604B C-0612 C-0622
C-0605 C-0613 C-0625
C-0608 C-0619 C-0204 for typical details

5. General comments and preliminary audit findings

I. Dynamic Effects Applied to Floors and Walls by Machinery

Control Building houses electrical and HVAC equipment which have negligible dynamic effects.

1. Design requirements

Not Applicable

2. Design loads (from general analysis)

Not Applicable

3. Forces and moments at key sections

Not Applicable

4. Detailed design

Not Applicable

5. General comments and preliminary audit findings

J. Crane and Supports - The only crane in the Control Building is at El. 93. Crane has 15 ton capacity with a span of 30 feet.

1. Design of bents (columns and roof trusses)

Not Applicable. No special support structures were required for this crane.

a. Design requirements

Not Applicable

b. Design loads (from general analysis)

Not Applicable

c. Forces and moments at key sections

Not Applicable

d. Detailed design

Not Applicable

e. General comments and preliminary audit findings

2. Design of girders supporting crane rails

a. Design requirements

FSAR 3.8.4.3, 3.8.4.4 and 3.8.4.5
Min. deflection criteria

b. Design loads (from general analysis)

From crane manufacturer
Dead and Live Loads

c. Forces and moments at key sections

F_B = 17 ksi

f_b = 16 ksi

d. Detailed design

See calculation C-T-270
Drawing C-0648

e. General comments and preliminary audit findings

K. Design of spent fuel bridge

Not Applicable. No spent fuel bridge.

1. Design requirements

Not Applicable

2. Design loads (from general analysis)

Not Applicable

3. Forces and moments at key sections

Not Applicable

4. Detailed design

Not Applicable

5. General comments and preliminary audit findings

L. Fuel Pool Liner Design, No Fuel Pools

Not Applicable

1. Stresses and strain controls

Not Applicable

2. Conformance to code requirements

Not Applicable

3. Analysis procedure and results

Not Applicable

4. Consideration of accidental drop of crane loads

Not Applicable

5. Corrosion effects (e.g., pitting) on liner integrity

Not Applicable

6. Preliminary findings of audit results

DRAFT A, WCB3

STRUCTURAL AUDIT CHECKLIST

Plant GRAND GULF

Structure Containment and Internals

Applicant _____

Architect/Engineer _____

Auditor _____

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2. A guideline to help the A-E prepare for the audit.

DRAFT A, WCB3

STRUCTURAL AUDIT OF GRAND GULF CONTAINMENT

Part I General Analysis

I. BASIC DESIGN CRITERIA

A. Dead Load (Items included, method of determining)
See FSAR Sections 3.8.1.3, 3.8.1.3.1 for Containment
See FSAR Sections 3.8.3.3, 3.8.3.3.1 for Containment Internal Structures

B. Live Load (Values for operating floors, base slab, etc., also method for determination)
See FSAR Sections 3.8.1.3, 3.8.1.3.1 for Containment
See FSAR Sections 3.8.3.3, 3.8.3.3.1 for Containment Internal Structures

C. Thermal Loads
See FSAR Sections 3.8.1.3, 3.8.1.3.1 for Containment
See FSAR Sections 3.8.3.3, 3.8.3.3.1 for Containment Internal Structures

D. Pressure (Internal and external)
See FSAR Sections 3.8.1.3, 3.8.1.3.1 for Containment
See FSAR Sections 3.8.3.3, 3.8.3.3.1 for Containment Internal Structures

E. Wind Loads

See FSAR Section 3.8.1.3

1. Design basis wind

See FSAR Section 3.8.1.3.3.b

2. Tornado loads

See FSAR Section 3.8.1.3.4.b

F. Seismic Criteria

See FSAR Sections 3.8.1.3, 3.8.1.3.3.a, 3.8.1.3.4.a, 3.8.3.3 and 3.8.3.3.1

1. "g" value free field

See FSAR Section 3.7.1.1.1, 3.7.1.1.2

2. Spectra

See FSAR Section 3.7.1, 3.7.1.1

3. Damping
See FSAR Section 3.7.1.3.1

4. Artificial time history and corresponding spectra
See FSAR Section 3.7.1.2

5. Motion duration
See FSAR Section 3.7.1.2

6. Components of motion
See FSAR Section 3.7.2.6

G. Hydrstatic and Hydrodynamic Loads
See FSAR Section 3.7.2.1.1.2.2, 3.8.1.3.1

H. Earth Pressure
Not Applicable

I. Abnormal Plant Loads
See FSAR Section 3.8.1.3.5 for Containment
See FSAR Section 3.8.3.3.1.5 for Containment Internal Structures

1. Missiles (Impact)
See FSAR Sections 3.8.1.3.4.b, 3.8.1.3.5 for Containment
See FSAR Section 3.8.3.3.1.5 for Containment Internal Structures

2. Pressure
See FSAR Section 3.8.1.3.5.b for Containment
See FSAR Section 3.8.3.3.1.5 for Containment Internal Structures

3. Local Reactions
See FSAR Section 3.8.1.3.5 for Containment
See FSAR Section 3.8.3.3.1.5 for Containment Internal Structures

4. Other special loads
See FSAR Section 3.8.1.3.5 for Containment
See FSAR Section 3.8.3.3.1.5 for Containment Internal Structures

J. Misc. Loads (Example: crane loads)
See FSAR Section 3.8.1.3.1

K. Load Combinations Conformance with ACI 359 and SRP
See FSAR Section 3.8.1.3.8 for Containment
See FSAR Section 3.8.3.3.2 for Containment Internal Structures
See Response to NRC Questions 130.29, 130.30, 130.33

II. ANALYSIS METHOD

A. Seismic Analysis
See FSAR Section 3.7.2.1

1. Mathematical model including mat, shell, liner, and internals-general description with sketch.
See FSAR Section 3.7.2.1.1.3, 3.7.2.1.1.3.1

a. Parameters used

(i) Concrete modulus
See FSAR Section 3.8.1.4.1.1.4

(ii) Rebar modulus and yield strength
See FSAR Section 3.8.1.4.1.2

(iii) Poisson's ratio
See FSAR Section 3.8.1.4.1.1.4

(iv) Damping
See Section 3.7.1.3.1

(v) Structural steel modulus and yield strength
See Section 3.8.1.6.4 for Containment
See Section 3.8.3.6.4 for Containment Internal Structures

(vi) Properties of foundation materials (Shear modulus, subgrade reactions, bearing capabilities, etc.)
See Section 3.7.1.3.2, 3.7.2.4, 3.7.1.4; FSAR Table 3.7-7

(vii) Other parameters
See FSAR Section 3.7

b. Stiffness calculations

(i) Concrete shell (Method of incorporating different layers of materials--concrete, rebars, and slip

surface. State the method used to account for containment shell cracking due to preoperational pressure tests.)

See FSAR Sections 3.7.2.1.1.3.1 and 3.7.2.3.1

(ii) Internals
See FSAR Section 3.7.2.3.1, 3.7.2.3.2

2. Method of Analysis

a. Method of analysis used (Time history, response spectrum methods, etc.) and consideration of torsional and translational response

(i) General description
See FSAR Section 3.7.2.1.1, 3.7.2.1.1.1, 3.7.2.1.1.2, 3.7.2.1.2

(ii) Findings and comments

b. Selection of number of masses and degrees of freedom

(i) General description

See FSAR Section 3.7.2.3, 3.7.2.4

(ii) Findings and comments

c. Number of modes considered

(i) General description

See FSAR Section 3.7.1.1.1

(ii) Findings and comments

d. Combining modal responses

(i) Actual procedures used

See FSAR Sections 3.7.2.1.1.4, 3.7.2.1.2.3, 3.7.2.7, 3.7.3.7

(ii) General findings

e. Consideration of three components of motion

(i) Actual procedures used

See FSAR Section 3.7.2.6

(ii) General findings

f. Consideration of soil-structure interaction and interaction among adjacent buildings

(i) General description

See FSAR Sections 3.7.1.4, 3.7.1.3.2, 3.7.2.1.1.4, 3.7.2.4, 3.7.2.15, 3.7.2.8

(ii) Findings and comments

g. Decoupling criteria for subsystems

(i) General procedure

See FSAR Section 3.7.3.1

(ii) Key examples

See FSAR Section 3.7.3.3.2

(iii) General findings and comments

3. Development of in-structure response spectra

a. General procedures
See FSAR Section 3.7.2.5

(i) Smoothing (describe specific smoothing method used)
See FSAR Section 3.7.2.5

(ii) Peak widening
See FSAR Section 3.7.2.5

b. Typical results (attach figures)

(i) Basemat spectra
See FSAR Section 3.7.2.5

(ii) Reactor supports spectra
See FSAR Section 3.7.2.5

(iii) Drywell spectra
See FSAR Section 3.7.2.5

(iv) Weir wall spectra
See FSAR Section 3.7.2.5

(v) Operating floor and crane support spectra
See FSAR Section 3.7.2.5

(vi) Interior floors spectra (Key floors with floor elevations identified)
See FSAR Section 3.7.2.5

4. Vertical Dynamic Analysis
See Part II A.1

a. Mathematical Model - general description with sketch
See Part II A.1

b. Development of stiffnesses, including floor stiffness, as applicable.
See Part II, A.1

c. Method of Analysis (Description of method used as well as each item considered in the analysis)
See Part II, A.1

5. Seismic Analysis for Buried Piping and/or Electrical Conduits

a. Method of Analysis
See FSAR Section 3.7.3.12; Calc C-X51, Rev. 2; Calc C-C100.0, Rev. 2

b. Stiffness calculations
See FSAR Section 3.7.3.12; Calc C-X51, Rev. 2; Calc C-C100.0, Rev. 2

c. Inputs
See FSAR Section 3.7.3.12; Calc C-X51, Rev. 2; Calc C-C100.0, Rev. 2

d. Key analysis results.
See Calc C-X51, Rev. 2; Calc C-C100.0, Rev. 2

B. Stress Analysis

1. Containment shell

a. Mathematical model (General description w/sketch)
Fi..el Model, Calc. C-G100 Pg. 45, 46
ASHSD Analysis Model, Calc. C-G100 Pg. 48 and drawing SKC-375
FSAR Section 3.8.1.1

b. Method of anlysis (Incorporation of torsion)
Finite Element Computer Analysis
FSAR Sections 3.8.1.4, 3.8.1.5

c. Load combinations
Calc. C-G100 Pg. 47-51B-2 & Design Criteria
FSAR Sections 3.8.1.3, 3.8.1.3.8

d. Key results
Calc. C-G125 & FSAR Tables 3.8-2, 3, 3a, 3b

2. Drywell

a. Mathematical model (General description w/sketch)
"SAP" Model, FSAR Fig. 3.8-73, 3.8-74; FSAR Sections 3.8.3.1, 3.8.3.4,
"Finel" Model, FSAR Fig. 3.8-56 3.8.3.4.1
"ASHSD" Model, FSAR Fig. 3.8-54

b. Method of analysis (Incorporation of torsion)
See FSAR Section 3.8.3.4.1 and Calc C-G291.1, Rev. 0

c. Load combinations
See FSAR Section 3.8.3.3.2.1

d. Key results (Figures, etc.)
FSAR Fig. 3.8-75
FSAR Stress Tables 3.8-7, 3.8-8 & 3.8-9

3. Weir Wall

a. Mathematical model (General description w/sketch)
Calc. G478 (Axi-Symmetric FINEL); Calc. G479 (Asymmetric ASHSD)
FSAR Section 3.8.3.1.2; FSAR Fig. 3.8-1, 3.8-60, 3.8-76
Torsion not considered

b. Method of analysis (Incorporation of torsion)
Calc. G-506
FSAR Sections 3.8.3.4.2, 3.8.3.5.2
FSAR Fig. 3.8-1, 3.8-60, 3.8-76

c. Load combinations
Project Design Criteria
FSAR Section 3.8.3.3.2.2

d. Key results (Figures, etc.)
Drawing C-1048A, C-1052
See FSAR Section 3.8.3.4.2 and Stress Table 3.8-13

4. Reactor Pedestal and Shield Wall

a. Mathematical model (General description w/sketch)

RPV Pedestal	Shield Wall
Calcs. C-G478.0 (Axisymmetric) & C-G479.0 (Asymmetric)	Calcs. C-G460.0, C-G460.1 & C-G463.0
FSAR Sections 3.8.3.1.5 & 3.8.3.4.5	FSAR Sections 3.8.3.1.6 & 3.8.3.4.5; FSAR Figures 3.8-1, 3.8-60 & 3.8-54
FSAR Figures 3.8-1, 3.8-60, 3.8-76 & 3.8-54	

b. Method of analysis (Incorporation of torsion)

RPV Pedestal	Shield Wall
FSAR Section 3.8.3.4.5	FSAR Sections 3.8.3.1.6 & 3.8.3.4.5 (torsion is not applicable)
FSAR Section 3.8.3.5.3	FSAR Figures 3.8-1 & 3.8-60
Calc C-G480.0	Calcs C-G460.0, C-G460.1 & C-G460.2
Calc C-G490.0	Calcs C-G461.0, C-G462.0
FSAR Figure 3.8-1	Calcs C-G463.0, C-G463.1 & C-G463.2
FSAR Figure 3.8-60	
FSAR Figure 3.8-76	

c. Load combinations

RPV Pedestal	Shield Wall
Project Design Criteria	Project Design Criteria
FSAR Section 3.8.3.3.2.2	FSAR Section 3.8.3.3.2.3

d. Key results (Figures, etc.)

RPV Pedestal	Shield Wall
FSAR Tables 3.8-14 & 3.8-15	FSAR Table 3.8-16
Drawings C-1048A, C-1070A, C-1070B, C-1071 & C-1057	Drawings C-1068A & C-1068B

5. Foundation mat

a. Mathematical model (Description of boundary conditions)
Full containment structure model, Calc. C-G100 Pg. 45, 46 (Fine1); Pg. 48 (ASHSD), SKC-375, FSAR Section 3.8.1.1, FSAR Fig. 3.8-1
Drawings C-1022, C-1023, C-1024, C-1026

b. Method of analysis
Finite Element Computer Analysis
See Calculation C-G100, C-G102
See FSAR Section 3.8.1.4

c. Load combinations
Calc. C-G100 pg. 47-51B-2
See FSAR Sections 3.8.1.3 and 3.8.1.3.8
Project Design Criteria

d. Key results (Figures, etc.)
Calc C-G125 & FSAR Table 3.8-3
FSAR Section 3.8.1.5

6. Computer programs used in analysis
See FSAR Appendix 3B

a. Assumptions and limitations
See FSAR Appendix 3B

b. Applicability
See FSAR Appendix 3B. See FSAR Sections 3.7, 3.8.1, 3.8.3

c. Verification (Sensitivity study in case of numerical solutions; e.g., finite element analysis)

See FSAR Appendix 3B

d. Load input (Include all cases)
See FSAR Sections 3.8.1 3 and 3.8.3.3

e. Output (Include all cases)
FSAR Stress Tables 3.8-2 through 3.8-34 report the maximum resultants for all cases listed in part d above.

f. Other discussions

7. Overall stability

a. Forces and moments from seismic analysis
Loads used in design:
Calc. C-G102 Pg. 3-8H; Calc. C-G120 Pg. 3-6; Calc. C-G110 Pg. 3-8

b. Various cases considered
SSE, OBE, OBE (Flooded)
FSAR Section 3.8.1.3.8

c. Bearing pressure versus bearing capacity and safety factor against bearing failure
FSAR Fig. 2.5-90; Geotech Calc. No. 51

d. Factors of safety

(i) Sliding
F.S. 1.313 Ref: Calc. C-G040 Pg. 4 (1.10 Required)
F.S. 1.17 Ref: Calc. C-G040 Pg. 4a (Unit 2)

(ii) Overturning (Vertical displacement)
F.S. 2.073 Ref: Calc. C-G040 Pg. 5 (1.50 Required)

8. Interaction of non-category I structures with the containment

a. Identification of pertinent non-category I structures
See FSAR Section 3.7.2.8

b. Consideration given to potential failure of non-category I systems on Category I systems
See FSAR Section 3.7.2.8

c. General findings and comments

III. CONFORMANCE TO CC-3000 AND SRP

A. Identification of deviations, if any
Containment complys with ACI 349 Title 69-2 (1/72)
See Response to NRC Questions 130.29 and 130.33

B. Justification of deviations and disposition of the deviations
See Response to NRC Questions 130.29 and 130.33

C. Comparison of reevaluation results with the original design bas s and discussions.
See Response to NRC Questions 130.29 and 130.33

D. General comments

PART II - AUDIT OF KEY DESIGNS

For each key design area audited, the design calculations should be reviewed together with applicable drawings, sketches, etc. Also, key details and/or sections, as appropriate, in this audit report should be included.

I. Specific Check of Key Locations

A. Containment liner design

1. Cylinder-base mat junction
Calc. G130
Calc. G130.1

a. Sketch
Drawings C-1007B, C-1009, C-1010, C-1011
See FSAR Section 3.8.1.1.2

b. Forces and displacements obtained from computer analysis
Calc. G21 Calc. G130.0
Calc. G31
Calc. G110

c. Controlling stress, strain from analysis considering various load combinations
Calc. G130 FSAR Stress Table 3.8-4, 3.8-5
Calc. G130.1 FSAR Fig. 3.8-2
Calc. G130.2 FSAR Section 3.8.1.3.8

2. Anchorage between the liner and interior concrete slab
Calc. G130.0
Drawing C-1006 A&B
Drawing C-1007 A&B

3. Liner anchor design (Model, analysis, procedure, assumptions)
BC-TOP-1 Calc. G130.2
Calc. G130
Calc. G130.1 FSAR Sections 3.8.1.4.2, 3.8.1.5.2

4. Other embedment design
Calc. G160.0
Calc. G170.0

5. Key penetration design
Calc. G141 Calc. G150.0 Calc. G154.0-154.3
Calc. G142 Calc. G151.1-G151.6 FSAR Section 3.8.1.1, 3.8.1.4.1.1.3
Calc. G143 Calc. G153.0-153.4

6. Conformance with Div. 2 - Article CC-3000
Art. CC-3000 not used for this design
See Response to NRC Question 130.30

7. Preliminary audit findings

B. Foundation slab design

1. Design requirements
Load combinations in Calc. C-G100 Pg. 47-51B-2
Updated load combinations in FSAR Section 3.8.1.3.8 (incorporating SRV & Dynamic Loadings). See FSAR Section 3.8.1.1 & Figures 3.8-2, 3.8-3, and 3.8-4

2. Forces and Moments at key sections
Calc. C-G125

3. Elastic deformation curve of the slab
none plotted

4. Detailed design of rebar placement at key section.
Summary of Rebar Requirements - Calc. C-G102 Pg. 108-109, 124-125
Key Section Designs Calc. C-G102 Pg. 47-107, 119-124

5. Conformance to CC-3000

   Containment Designed to ACI Title No. 69-2
   See FSAR Question 130.29

6. General comments and preliminary audit findings

C. Containment cylinder design

1. Design requirements

   Load combinations in Calc. C-G100 Pg. 47-51B-2; updated load combinations in FSAR Section 3.8.1.3.8 (incorporates SRV & LOCA Dynamic Loading)

2. Forces and moments at key sections

   Calc. C-G125 & FSAR Fig. 3.8-5, FSAR Table 3.8-2

3. Detailed design of rebar. Summary of rebar requirements Calc. C-G110 Pg. 72E, 104, 105 (diag. & vert. & EPT); Pg. 122, 124, 528 (meridional); Pg. 140, 536 (diag.); Pg. 185, 513 (Hoop); Pg. 196 (Shear); Pg. 530. Key Section Designs, Calc. C-G110 Pg. 46-72 (Meridional); Pg. 74-103 (Diag.) Pg. 107-122 (Meridional); Pg. 125-139 (Diagonal); Pg. 515-527 (Meridonal) Pg. 532-535 (Diagonal); Pg. 194-197 (Shear); Pg. 491-512 (Hoop); Pg. 529-530 (Shear)

4. Conformance to CC-3000
   Containment Designed to ACI Title No. 69-2

5. General comments and preliminary audit findings.

6. Design for tangential shear

   a. Criteria used

      2 Methods used — See Calc. C-G110 Pg. 90
      ACI/ASME 359 Code — See Calc. C-G110 Pg. 97
      ACI 349 Code

   b. Comparison with SRP criteria
      containment designed to ACI Title 69-2
      See Response to NRC Question 130.29

   c. Actual tangential shear
      Shear envelope tabulation C-G110 Pg. 88A, 532. Max. Rebar Stress 64100 psi; Reference: Calc. C-G110 Pg. 102A

   d. Allowable tangential shear

      Allowable rebar stress 68800 psi; Reference: Calc. C-G110 Pg. 102C

   e. Factor of safety obtained

      $$F.S. = \frac{68.8}{64.1} = 1.07$$

D. Containment dome design

1. Design requirements and model
Full containment structure model, Calc. C-G100; Finel Pg. 45, 46; ASHSD, Pg 48 and SKC-375. Load combinations in Calc. C-G100 Pg. 47-51B-2 Updated load combinations in FSAR Section 3.8.1.3.8 (incorporated SRV & LOCA Dynamic Loads)

2. Forces and moments at key sections

Calc. C-G125 & FSAR Fig. 3.8-3a

3. Detailed design of rebar. Calc. C-G120

Summary:	Meridional Pg. 55,56	Key Section Designs Merional Pg. 32-54
	Hoop Pg. 116 Diagonal Pg. 126	Hoop Pg. 58-115
	Shear Pg. 120	Shear Pg. 118-120

5. General comments and preliminary audit findings

E. Drywell design

1. Design requirements and model
Calc. C-G350.0
Calc. C-G352.0
FSAR Section 3.8.3.4.1

2. Forces and moments at key sections
Calc. C-G351.0, C-G390.0 & C-G391.0
Calc. C-G353.0, C-G350.1, C-G360.0, FSAR Section 3.8.3.4.1

3. Detailed design of rebar.
Calc. C-G351.0 & C-G351.1
Calc. C-G390.0, C-G391.0 & C-G392.0
Calc. C-G353.0, C-G360.0

4. Conformance to CC-3000
FSAR Sections 3.8.3.5.1, 3.8.3.4
Design conforms to ACI 349 Title 69-2 (1/72)
See Response to NRC Question 130.33

5. General comments and preliminary audit findings

F. Weir Wall design

1. Design requirements and model
Calc. G478 FSAR Section 3.8.3.4.2; Drawing C-1048A
Calc. G479 FSAR Fig. 3.8-1, 3.8-60; FSAR Stress Table 3.8-13
Calc. G500

2. Forces and moments at key sections
   Calc. G500 FSAR Fig. 3.8-60
   Drawing C-1048A FSAR Table 3.8-13
   FSAR Section 3.8.3.4.2
3. Detailed design of rebar.
   Calc. G500

4. Conformance to CC-3000
   CC 3000 Not used for the design

5. General comments and preliminary audit findings

G. Reactor Vessel Pedestal design

1. Design requirements and model
   Calc. G478 Calc. G490 Drawing C-1048A
   Calc. G479 FSAR Sections 3.8.3.4.3, 3.8.3.1.5
   Calc. G480 FSAR Figures 3.8-60, 3.8-76
2. Forces and moments at key sections
   Calc. G480 FSAR Stress Table 3.8-14
   Calc. G490
   FSAR Fig. 3.8-1, 3.8-60, 3.8-76
3. Detailed design of rebar
   Calc. G480
   Calc. G490
   Drawing, C-1048A, C1057
4. Conformance with SRP requirements
   FSAR Section 3.8.3.1.5, 3.8.3.4.3
   FSAR Fig. 3.8-1, 3.8-60, 3.8-76
   FSAR Stress Tables 3.8-14, 3.8-15
5. General comments and preliminary audit findings

H. Containment wall-base mat junction design

1. Design requirements and model. Full containment structurel model Calc. C-G100; Finel Pg. 45, 46, ASHSD Pg. 48 and SKC 375. Load combinations in Calc. C-G100 Pg. 47-51B-2. Updated load combinations in FSAR Section 3.8.1.3.8 (incorporates SRV & LOCA Dynamic Loads).
2. Forces and moments at key sections
   Calc. C-G102 Pg. 105-107

3. Detailed design of rebar
   Calc. C-G102 Pg. 105-107
   Drawing C-1024

4. Waterstop membranes at the joint, their design considerations and installations
none provided at wall-base slab interface; waterstop at base slab-Aux. Bldg. interface shown on drawing C-1026.

5. Conformance to CC-3000
Containment Designed to ACI Title No. 69-2

I. Dome-to-cylinder junction design

1. Design requirements and model. Full containment structural model, Calc. C-G100 Pg. 45, 46 (Finel) Pg. 48 (ASHSD) SKC-375. Load combinations in Calc. C-G100 Pg. 47-51B-2. Updated load combinations in FSAR Section 3.8.1.3.8 (incorporates SRV & LOCA Dynamic Loads).
2. Forces and moments at key sections

Calc. C-G120.0, Pg. 3-27

3. Detailed design of rebar placement at key sections

Calc. C-G120.0, Pg. 28-436.

4. Conformance to CC-3000

Containment designed to ACI titled No. 69-2

5. General comments and preliminary audit findings

J. Primary shield wall design

1. Design requirements and model

FSAR 3.8.3.1.6, FSAR 3.8.3.4.5.4 & FSAR Fig. 3.8-60
Calc. C-G463.0, C-G463.1, C-G463.2

2. Forces and moments at key sections

FSAR Stress Table 3.8-16
Calcs. C-G460 & Calcs. C-G463.2

3. Detailed design of rebar placement at key sections

Calc. C-G464

4. Code jurisdiction, boundary definition and anchor treatment at interface

Shield wall design conforms to AISC code.

5. Conformance to SRP requirements
   Shield wall designed to AISC "Manual of Steel Construction," 1969.
   FSAR Sections 3.8.3.1.6, 3.8.3.4.5.4

6. General comments and preliminary audit findings

K. Operating floor design

1. Design requirements and model

   FSAR 3.8.3.1.3 (b); FSAR 3.8.3.4.5.2
   FSAR 3.8.3.5.5.3; FSAR Fig. 3.8-60

2. Forces and moments at key sections

   Calc. C-G230
   FSAR Stress Table 3.8-24

L. Containment hatch design

1. Design requirements and assumptions

   Spec. C-153.0 Drawing C-1015A&B
   Calc. G150.0
   Calc. G151.1-G151.6

2. Model
   Calc. G150
   Calc. G151.1-151.6
   Drawing C-1015A

3. Analysis procedure and results
   Spec. C-153.0
   Calc. G150
   Calc. G151.1-G151.6

4. Key controlling loads including appropriate load combinations
   Spec. C-153.0
   Calc. G150
   Calc. G151.1-G151.6

5. Key stresses and strains for section designs
   Calc. G150
   Calc. G151.1-G151.6

6. Conformance to CC-3000
   CC 3000 not used for design

7. General comments and preliminary audit findings

M. Crane support design

1. Design requirements and model
   Calc. G-170.0
   Drawing C-1098, C-1099
   Calc. G160 FSAR Sections 3.8.1.1.3, 3.8.1.5.3, 3.8.1.4.3
2. Forces and moments at key sections
   Calc. G-170.0
   Drawing C-1098, C-1099
   Calc. G160
3. Detailed design of rebar placement at key sections
   Calc. C-G110.0
   Calc. C-G120.0
4. Interface with containment shell, if applicable
   Calc. G160
5. Conformance with SRP requirements and re-evaluation criteria
   FSAR Section 3.8.1.1.3, 3.8.1.5.3, 3.8.1.4.3
6. General comments and preliminary audit findings.

DRAFT A, WCB3

STRUCTURAL AUDIT CHECKLIST

Plant GRAND GULF

Structure DIESEL GENERATOR BUILDING

Applicant _____

Architect/Engineer _____

Auditor _____

The purpose of the audit is to review and assess the techniques and methodology employed by the applicant to demonstrate compliance of all Category I structures with the applicable SRP's, Reg. Guides, Codes and Standards.

The general procedure of the audit will be to review some structures in considerable detail and others will be spot checked. Emphasis will be placed upon verifying the validity of the methods used and compliance with the applicable codes and standards; however, actual mathematical computations may also be checked and should be available at the audit.

The following audit sheets are intended to be used for the following purposes:

1. A checklist to be used by the auditor in reviewing the procedures and computations of the A-E.

2. A guideline to help the A-E prepare for the audit.

STRUCTURAL AUDIT OF GRAND GULF

SEISMIC CATEGORY I STRUCTURES

OTHER THAN CONTAINMENT

Structure Audited Diesel Generator Building

Part I General Analysis

I. BASIC DESIGN CRITERIA

See FSAR Figure 3.4-1 "Plant Arrangement".

A. Dead Load (Items included, method of determining)

Items included: Civil design criteria Paragraph 7.1.
Method of Determining: Concrete 150 lbs./cu. ft., steel 490 lb./cu. ft.
Equipment weight: Vendor drawings
Pipe loads: Hanger drawings

B. Live Load (Values for operating floors, base slab, etc., also method for determination)

Base slab or operating floor	El 133':	250 psf]	See Live Load
Mezzanine	El 158':	100 psf]	Drawings C-0355
Roof	El 172':	30 psf]	through C-0361

C. Thermal Loads

Not Applicable.

D. Pressure (Internal and external)

Not Applicable.

E. Wind Loads

1. Design basis wind

See Civil Design Criteria Paragraph 3.8.1 and FSAR Section 3.3.1
$q = 0.00256\ V^2 = 20.7$ psf (V=90 mph).

2. Tornado loads

See Civil Design Criteria Paragraph 3.8.2 and FSAR Section 3.3.2
$q = 0.00256\ V^2 = 332$ psf (V=360 mph). In addition, tornado depressurization load of 3 psig was applied to all walls and roof.

DRAFT A, WCB3, 2

F. Seismic Criteria

1. "g" value free field (seismic accelerations)

	Horizontal	Vertical	
SSE	0.15 g	0.10 g	(FSAR: 3.7.1.1.1)
OBE	0.075 g	0.05 g	(FSAR: 3.7.1.1.2)

2. Spectra

See FSAR Section 3.7.1, 3.7.1.1.

3. Damping

FSAR Table 3.7-3 and Section 3.7.1.3.1

4. Artificial time history and corresponding spectra

FSAR Section 3.7.1.2 and Figures 3.7-3 through 3.7-15.

5. Motion duration

24 seconds (FSAR Section 3.7.1.2)

6. Components of motion

FSAR Section 3.7.2.6: 3 components of motion; 2 horizontal, 1 vertical and SRSS combination.

G. Hydrostatic and Hydrodynamic Loads

Not Applicable.

H. Earth Pressure

Not Applicable.

I. Abnormal Plant Loads

1. Missiles (Impact)

Internally generated missiles FSAR Paragraph 3.5.1.1 and Table 3.5-1.
Turbine missiles FSAR Section 3.5.1.3 and Table 3.5-7.
Natural missiles FSAR Section 3.5.1.4.

2. Pressure

No pipe breaks inside D.G. building. See FSAR Paragraph 3.6.

3. Local Reactions

Pipe attachments to walls or floors are checked by structural adequacy program.

4. Other special loads

Not applicable.

J. Misc. Loads (Example: crane loads)

6 ton bridge crane supported from roof framing.

K. Load Combinations Conformance with ACI 349 and/or 318

ACI-318 combinations used. See Civil design Criteria Paragraph 8.2.2.

II. Analysis Method

A. Seismic Analysis

1. Mathematical model - general description with sketch

Refer to FSAR Figure 3.7-23 shows mathematical model. Lumped parameter, geometrically coupled, sort structure interaction on two layers of sort.

a. Parameters used

(i) Concrete modulus

$E_c = w^{1.5}\ 33\ \sqrt{f'c}$ = 3834 ksi w=150 pcf f'c=4000 psi

(ii) Rebar modulus and yeild strength

$E = 29 \times 10^6$ psi; Fy = 60,000 psi (A 615, GR 60)

(iii) Poisson's ratio

$\nu = 0.17$ Reference, Theory of Plates and Shells, Timoshenko , Woinowski-Krieger.

(iv) Damping

FSAR Table 3.7-3. Concrete: OBE: 0.02, SSE: 0.05

(v) Structural steel modulus and yield strength

$E = 29 \times 10^6$ psi; Fy=36,000 psi

(vi) Properties of foundation materials (Shear modulus, subgrade reactions, bearing capabilities, etc.)

FSAR Table 3.7-7: shear modulus 1850±550 KSF
Maximum bearing pressure=2.7 KSF; Allow. bearing pressure= 6.0 KSF (on compacted fill).

(vii) Other parameters

FSAR Table 3.7-7 (for backfill material; 60' high)
Density of soil = 125 pcf
Poisson ratio (soil) = 0.4
Shear wave velocity = 690 fps
Young modulus (soil) = 4440 ± 1320 ksf
Damping ratio (soil) = 0.08 ± 0.02

b. Stiffness calculations

(i) Exterior walls

Program CE-650 for sectional properties was used. Moments of inertia were found by gross concrete sections. Shear areas were found by considering effect of shear areas for N-S and E-W directions.

(ii) Interior walls

Same as exterior walls.

(iii) Floors

Weight of floors was taken as lumped mass; mass moment of inertias for each horizontal direction were considered.

(iv) Columns

Not Applicable.

2. Method of Analysis

See FSAR Table 3.7-9.

a. Method of analysis (Time history, response spectrum methods, etc.) and consideration of torsional and translational response

CE-920 & 921; Time history method was used for floor response spectra. CE-917 & 918; Modal response spectra method for stress analysis. CE-931 was used for composite damping for soil structure interaction.

(i) General description

FSAR Section 3.7.2.1.1.3.4., Figure 3.7-16. Torsional effects were examined by hand methods.

(ii) Findings and comments

b. Selection of number of masses and degrees of freedom

(Base mat, mezzanine and roof level) 3 masses and 8 degrees of freedom for flexible base model for each horizontal direction.

(i) General description

Refer to: FSAR 3.7.2.1.1.3.4, Figure 3.7-16 and Para. 3.7.2.3.1.a for modeling procedure.

(ii) Findings and comments

c. Number of modes considered (for modal response spectra analysis)

4 - modes for N-S direction
3 - modes for E-W direction
2 - modes for Vertical direction

(i) General description

In general, higher modes corresponding to f=33 cps or more were neglected.

(ii) Findings and comments

d. Combining modal responses

FSAR Paragraph 3.7.2.7

(i) Actual procedures used

See FSAR Sections 3.7.2.1.1.4, 3.7.2.1.2.3, 3.7.2.7, 3.7.3.7.

(ii) General findings

e. Consideration of three components of motion

(i) Actual procedures used

FSAR Paragraph 3.7.2.6

(ii) General findings

f. Consideration of soil-structure interaction and interaction among adjacent buildings

FSAR Paragraph: 3.7.1.3.2 and Tables: 3.7-4 and 3.7-5.
No interaction between buildings due to isolation gsp.

(i) General description

FSAR Paragraph: 3.7.2.4, Tables: 3.7-7 and 3.7-8

(ii) Findings and comments

g. Decoupling criteria for subsystems

FSAR Paragraphs: 3.7.2.3.1 and BC-TOP 4, Page 3-3

(i) General procedure

FSAR Paragraph 3.7.3

There are no significant subsystems that were accounted for in seismic analysis.

(ii) Key examples

1-Electrical tray, conduit and HVAC systems were designed by using floor response spectra curve.
2-Subsystem analysis for diesel generator Units and other equipment were performed by vendors.

(iii) General findings and comments

h. Modeling of hydrodynamic effects in spent fuel pool

Not applicable.

i. Modeling of spent fuel pool wells and interior floor slabs and equipment thereof

Not applicable.

3. Development of in-structure response spectra

a. General procedures

FSAR Section 3.7.2.5, CE-920 and CE-921

(i) Smoothing (describe specific smoothing method used)

Smoothed floor response spectra curves represent an envelope of the maximum peaks.

(ii) Peak widening

FSAR, Paragraph 3.7.2.9, minimum 10% of peak frequency.

b. Typical results (attach figures)

See calculations U-471.0 through U-476.0 (Volume 4) for floor response spectra curves.

(i) Basemat spectra

Calculations U-471.0 through U-476.0

(ii) Interior floors spectra (key floors with floor elevations identified)

Calculations U-471.0 through U-476.0

4. Vertical Dynamic Analysis

a. Mathematical Model - general description with sketch

FSAR Figure 3.7-23
Calculation U-90.0 (Vol. 1)

b. Development of stiffnesses, including floor stiffness, as applicable

Program CE-650 was used for wall areas to account for axial stiffness. Floors considered rigid; their weights were taken into account as lumped masses. Mass moments of inertia for floors were considered.

c. Method of Analysis (Description of method used, as well as each item considered in the analysis)

Modal response for stress analysis - (CE-917, -918).
Time history for floor response spectra - (CE-920, -921).
Soil structure interaction was considered.

B. Stress Analysis

1. Shear Walls and Floors

a. Mathematical model (General description w/sketch)

FSAR Figure 3.8-111, paragraph 3.8.4.1.1.6

b. Method of analysis (Incorporation of torsion)

FSAR Paragraph 3.8.4.4.6 (wall calculations U-100.0; floor calculations U-120.0 and U-125.0). Calculation U-105.0-Torsion due to seismic by hand calculations FSAR Paragraph 3.7.2.11.

c. Load combinations

FSAR Paragraph 3.8.6.2 for seismic Category I structures.

d. Key results

See Part II.

2. Foundation mat

a. Mathematical model (Description of boundary conditions)

FSAR Paragraphs 3.8.5.1.4 and 3.8.5.4.4 and Figure 3.8-111.
$\frac{P}{A} \pm \frac{Mc}{I}$ Base slab supported on soil, linear pressure distribution. Simply supported slab on 4 sides plus 2 intermediate supports under interior walls.

b. Method of analysis

Hand methods were used for load combinations plus rigidity requirements for vendor equipment was satisfied. See calculation U-110.0.

c. Load combinations

FSAR Paragraph 3.8.6.2.

d. Key results (Figures, etc.)

See Part II.

3. Material to protect against structure-to-structure interaction

Rodofoam II was used between auxiliary and diesel generator buildings.

a. Mechanical properties

Seismic testing: load transfer @ 50% compression was 17.8 psi.

b. Additional pressure on walls

FSAR Figure 3.7-21, 3-D model for auxiliary and control buildings; also Paragraph 3.7.2.1.1.3.2 for negligible interaction.

4. Computer programs used in analysis

CE-917, 918, 920, 921 and 931 and Lucon, CE-650. See FSAR Appendix 3D.

a. Assumptions and limitations

FSAR Appendix 3D.

b. Applicability

FSAR Appendix 3D.

c. Verification (Sensitivity study in case of numerical solutions; e.g., finite element analysis)

FSAR Appendix 3D.

d. Load input (Include all cases)

FSAR Appendix 3D.

e. Output (Include all cases)

FSAR Appendix 3D.

f. Other discussions

FSAR Appendix 3D.

5. Overall stability

   a. Forces and moments from seismic analysis

      FSAR Figure 3.7-49 N-S, SSE
      FSAR Figure 3.7-50 N-S, OBE
      FSAR Figure 3.7-51 E-W, SSE
      FSAR Figure 3.7-52 E-W, OBE
      FSAR Figure 3.7-53 Vertical, SSE
      FSAR Figure 3.7-54 Vertical, OBE

   b. Various cases considered

      Sliding, overturning and stresses for bearing were considered. (Calculation U-117.0).

   c. Bearing pressure versus bearing capacity and safety factor against bearing failure

      Maximum bearing pressure = 2.7 ksf; allowable bearing pressure = 6 ksf. $SF = \frac{6.0}{2.7} = 2.22$

   d. Factors of safety

      FSAR Table 3.8-1.

      (i) Sliding

          S.F. = 1.53

      (ii) Overturning (Vertical displacement)

          S.F. = 7.70

6. Interaction of non-Category I structures with the structure considered

   Not applicable.

   a. Identification of pertinent non-Category I structures

   b. Consideration given to potential failure of non-Category I systems on Category I systems

   c. General findings and comments

7. Design Consideration for Tornado Missiles

   a. Design requirements

      FSAR Paragraph 3.5.1.4
      Design procedures 3.5.3.1

b. Models for

(i) Local damage

Penetration, perforation and spalling criteria is satisfied as per FSAR Paragraph 3.5.3.1.

(ii) Overall response

Structural response is satisfied as per FSAR Paragraph 3.5.3.1 and Calculation E-020.0.

c. Load combinations

FSAR Paragraph 3.8.6.2 and BC-TOP 3A.

d. Forces

FSAR Paragraph 3.5.3.1.

e. General comments and preliminary audit findings

III. CONFORMANCE TO ACCEPTABLE CRITERIA

A. Identification of deviations, if any

None

B. Justification of deviations and disposition of the deviations

-

C. General comments

Part II - AUDIT OF KEY DESIGNS

For each key design area audited, the design calculations should be reviewed together with applicable drawings, sketches, etc. Also, key details and/or sections, as appropriate, in this audit report should be included.

DRAFT A, WCB3, 11

I. SPECIFIC CHECK OF KEY LOCATIONS

A. Exterior Shear Walls

1. Design requirements

FSAR Paragraphs 3.8.4.3, 3.8.4.4 and 3.8.4.5; also Sections 3.8.4.4.6 and 3.8.4.1.1.6.

2. Design loads (from general analysis)

1) Dead Loads
2) Live Loads
3) OBE and SSE Loads
4) Tornado Missiles
5) Wind and Tornado Loads (Includes Depressurization)

3. Forces and moments at key sections

Calculation U-100.0.

4. Detailed design of rebar placement at key sections

Drawings: C-1503, C-1504, C-1505 A&B, C-0204.

5. General comments and preliminary audit findings

B. Interior Shear Walls

1. Design requirements

FSAR Paragraphs 3.8.4.3, 3.8.4.4 and 3.8.4.5; also see 3.8.4.4.6 and 3.8.4.1.1.6.

2. Design loads (from general analysis)

1) Dead Loads
2) Live Loads
3) OBE and SSE Loads
4) Wind and Tornado Loads (Includes Depressurization)

3. Forces and moments at key sections

See attached Table 3 and Calculation U-100.0.

4. Detailed design of rebar placement at key sections

Drawings: C-0204; C-1503.

5. General comments and preliminary audit findings

C. Main Floors and Roofs (Elevation)

No main floor exists, only roof slab of 2'-0". This satisfies minimum thickness for tornado missiles.

1. Design requirements

FSAR Paragraphs 3.8.4.3, 3.8.4.4, and 3.8.4.5. Also see 3.8.4.4.6 and 3.8.4.1.1.6.

2. Design loads (from general analysis)

1) Dead Load
2) Live Load
3) Crane Load (7.5 T)
4) SSE and OBE Loads
5) Wind and Tornado Loads (Includes Depressurization)
6) Tornado Missile Loads

3. Forces and moments at key sections

See Calculation No. U-125.0.

4. Detailed design of rebar placement at key sections

Drawings: C-1506B, C-1506C

5. General comments and preliminary audit findings

D. Steel Structural Bracing Systems (if any)

Not applicable (structural steel framing is discussed elsewhere).

1. Design requirements

-

2. Design loads

-

3. Forces and moments at key sections

-

4. General comments and preliminary audit findings

-

E. Foundation Mat

1. Design requirements

FSAR Paragraph 3.8.5.4.4.

2. Design loads (from general analysis)

    1) Dead Load Including Equipment
    2) Live Load
    3) OBE and SSE Loads
    4) Wind and Tornado Loads
    5) Equipment Load

3. Forces and moments at key sections

    Calculation No. U-110.0.

4. Detailed design of rebar placement at key sections

    Drawings: C-1500, C-1501, C-0204

5. General comments and preliminary audit findings

F. Main Frame Concrete Column Design (Key Columns)

Not applicable.

1. Design requirements

    -

2. Design loads (from general analysis)

    -

3. Forces and moments at key sections

    -

4. Detailed design of rebar placement at key sections

    -

5. General comments and preliminary audit findings

    -

G. Secondary Floors

1. Design requirements

    FSAR Paragraphs 3.8.4.3, 3.8.4.4 and 3.8.4.5. Also see 3.8.4.4.6 and 3.8.4.1.1.6.

2. Design loads (from general analysis)

   1) Dead Load
   2) Live Load
   3) OBE and SSE Loads

3. Forces and moments at key sections

   Mezzanine slab at elevation 158'-0" is 6" thick concrete supported on structural steel beams at 6'-10" spacings. South side is supported by the interior/exterior walls. North side of mezzanine is hung from roof beams. Maximum M=227'k. f_b = 21 ksi. Maximum V = 26 k. Actual shear stress is much less than the allowable shear stress for E-W girders (non-composite design).

4. Detailed design of rebar placement at key sections

   Drawing: C-1506A

5. General comments and preliminary audit findings

H. Detailing at Floor-Wall Joints

Not applicable.

1. Design requirements

   -

2. Design loads (from general analysis)

   -

3. Forces and moments at key sections

   -

4. Detailed design of rebar placement at key sections

   -

5. General comments and preliminary audit findings

   -

I. Dynamic Effects Applied to Floors and Walls by Machinery

1. Design requirements

Vendor rigidity criteria. See Foundation Material Section for general analysis.

2. Design loads (from general analysis)

Vendor rigidity criteria. See Calculation No. U-110.0.

3. Forces and moments at key sections

Not applicable.

4. Detailed design

Drawing: C-1502A

5. General comments and preliminary audit findings

J. Crane and Supports

1. Design of bents (columns and roof trusses)

Not applicable.

a. Design requirements

-

b. Design loads (from general analysis)

-

c. Forces and moments at key sections

-

d. Detailed design

-

e. General comments and preliminary audit findings

-

2. Design of girders supporting crane rails

7.5 T capacity crane. See roof floor section for general analyses.

a. Design requirements

-

b. Design loads (from general analysis)

-

c. Forces and moments at key sections

-

d. Detailed design

-

e. General comments and preliminary audit findings

K. Design of spent fuel bridge

Not applicable.

1. Design requirements.

-

2. Design loads (from general analysis)

-

3. Forces and moments at key sections

-

4. Detailed design

-

5. General comments and preliminary audit findings

L. Fuel Pool Liner Design

Not applicable.

1. Stresses and strain controls

-

2. Conformance to code requirements

   -

3. Analysis procedure and results

   -

4. Consideration of accidental drop of crane loads

   -

5. Corrosion effects (e.g., pitting) on liner integrity

   -

6. Preliminary findings of audit results

STRUCTURAL AUDIT CHECKLIST

Plant GRAND GULF

Structure AUXILIARY BUILDING

Applicant _____

Architect/Engineer _____

Auditor _____

The purpose of the audit is to review and assess the techniques and methodology employed by the applicant to demonstrate compliance of all Category I structures with the applicable SRP's, Reg. Guides, Codes and Standards.

The general procedure of the audit will be to review some structures in considerable detail and others will be spot checked. Emphasis will be placed upon verifying the validity of the methods used and compliance with the applicable codes and standards; however, actual mathematical computations may also be checked and should be available at the audit.

The following audit sheets are intended to be used for the following purposes:

1. A checklist to be used by the auditor in reviewing the procedures and computations of the A-E.

2. A guideline to help the A-E prepare for the audit.

STRUCTURAL AUDIT OF GRAND GULF

SEISMIC CATEGORY I STRUCTURES

OTHER THAN CONTAINMENT

Structure Audited Auxiliary Building

Part I General Analysis

I. BASIC DESIGN CRITERIA

A. Dead Load (Items included, method of determining
Items included - Ref. Civil Design Criteria, Sec. 7.1
Method of determination - Conc = 150 lbs/cu. ft; Stl=490 lbs/cu. ft.; CMU= 145 lbs/cf (Normal)
Equip. Wt. - From approved Vendor drawings
Pipe Loads - From Hanger drawing for structural adequacy.

B. Live Load (Values for operating floors, base slab, etc., also method for determination)

Design Criteria Sect. 7.2 & 7.2.3.4 and Live Load Drawings C-0355 thru C-0361
Crane Loads - by Vendors
Fuel & Fuel Handling Equipment - by G.E. Section 7.2.3.4

C. Thermal Loads
Design Criteria - Sect. 7.10; Paragraph C;f
Paragragh C - Steam pipe tunnel; 70° F differential temperature
Paragraph f - Spent fuel pool; Unit - 1 - 150° F Design Accident Temp.
Unit - 2 - 165° F Design Accident Temp.

D. Pressure (Internal and external)
See Section I, Abnormal plant loads for "Pressure."

E. Wind Loads

1. Design basis wind
Design Criteria - Section 3.8.1 & F.S.A.R. Sect. 3.3.1
0 to 50 Ft. above grade = 90 MPH
50 to 150 Ft. above grade = 105 MPH

2. Tornado loads
Design Criteria - Sect. 3.8.2 & FSAR Sect. 3.3.2
Tornado force - Design criteria Sect. 3.8.2. a (1); 360 MPH ($q=0.00256V^2$
Depressurization - Design criteria Sect. 3.8.2 a (2); 3 psig

F. Seismic Criteria

1. "g" value free field

	Horz.	Vertical
SSE -	0.15g	0.10g : FSAR - 3.7.1.1.1
OBE -	0.075g	0.05g : FSAR - 3.7.1.1.2

2. Spectra
See FSAR Sect. 3.7.1, 3.7.1.1.

3. Damping
FSAR: Table 3.7-3 and Sect. 3.7.1.3.1

4. Artificial time history and corresponding spectra
FSAR: Sect. 3.7.1.2 & Fig. 3.7-3 thru 3.7-15

5. Motion duration
24 seconds: FSAR - Sect. 3.7.1.2

6. Components of motion
FSAR. Sect. 3.7.2.6 - 3 Components of motion: 2 Horizontal & 1 Vertical and SRSS Combination.

G. Hydrostatic and Hydrodynamic Loads
Ground Water Pressure - Design Criteria Sect. 3.4 & 7.6 & FSAR: Table 3.4-1 & Figure 2.5-91. Hydrodynamic Load on Exterial Wall - See Calc. C-H013.0
Refueling Pools - Hydrodynamic Load - See Calc. C-H031.0: Based on TID-7024 by MTIS.

H. Earth Pressure
Design Criteria - Sect. 3.10 & Sect. 7.5
FSAR: Figure -2.5-91 (Laterial earth pressure design)

I. Abnormal Plant Loads

1. Missiles (Impact)
Design Criteria - Sect. 3.8.2 a (3) & 3.8.2.b and
FSAR: Sect. 3.5.1.1; Table 3.5-1 Internally generated missiles
FSAR: Sect. 3.5.1.3; Table 3.5-7 Turbine missiles
FSAR: Sect. 3.5.1.4: Natural missiles, FSAR: Figure 3.5-8, Calc.C-H044.1

2. Pressure
Design criteria: Sect. 7.10 & FSAR: Appendix-3E, Figure: 3E-1 through 16
Steam tunnel = 15.4 psig
RWCU pipechase = 15.4 psig
S.T. blowout shaft = 11.0 psig
RCIC pipechase = 5.12 psig
For all other rooms see Calcs. C-H017.2

3. Local Reactions
Pipe attachments: Structural adequacy check-Calcs. C-H078.0 thru C-H078.9
MSL & FWL Moment guide: FSAR:Figure 3.6A-2; 3.6A-34;Calcs.C-H045.0; Dwg. C-1310E; Other pipe restraints: FSAR: Figure 3.6A-4;3.6A-6; 3.6A-8; 3.6A-13B. Calc. C-H047 & C-H047.1; Dwg. C-1310H; C-1356E & C-1356G.

4. Other special loads
Construction loads - Design criteria 7.3
Heavy Hauling and Rigging - RPV erection. See calcs. C-H013.0 & C-H113.0 (Ext. Walls)

Jet impingement loads: FSAR: Sect. 3.6

(i) General description

In general higher modes correcsponding to f=33cps or more were neglected.

(ii) Findings and comments

d. Combining modal responses

FSAR: Sect. 3.7.2.7

(i) Actual procedures used

See FSAR Sections 3.7.2.1.1.4, 3.7.2.1.2.3, 3.7.2.7, 3.7.3.7

(ii) General findings

e. Consideration of three components of motion

(i) Actual procedures used

FSAR: Section 3.7.2.6

(ii) General findings

f. Consideration of soil-structure interaction and

interaction among adjacent buildings

FSAR: Sect. 3.7.1.3.2 & Tables 3.7-4; 3.7-5
No interaction between buildings due to isolation gap.

(i) General description

FSAR: Sect. 3.7.2.4 & Tables 3.7-7; 3.7-8

(ii) Findings and comments

g. Decoupling criteria for subsystems

FSAR: Sect. 3.7.2.3.1 and BC - Top 4 page 3-3

(i) General procedure

There are no significant and heavy subsystems that were included in seismic analysis.
(Refer to Bechtel's response to Structural Audit-Action Item Question #3 to quantify the effect of coupled subsystems or a response spectra basis for a vertical earthquake)
Calc. C-H010.2

(ii) Key examples
a) System (Cable trays, HVAC ducts, conduits, etc.) designed by using appropriate floor response spectra.
b) Equipment (Control system, elect.HVAC & other components) were analyzed and designed by vendors.

(iii) General findings and comments

h. Modeling of hydrodynamic effects in spent fuel pool
Hand calculations were performed to determine hydrodynamic pressure on walls. Based on "TID-7024" NTIS publication. See calcs. C-H031.0. See (i) below.

i. Modeling of spent fuel pool wells and interior floor slabs and equipment therefor

The finite element model of the refueling pools (SFP;TC;CSA) consisted of shell elements and the BSAP computer program was used for the analysis. The analysis was performed for all (D.L, L.L.,Hydrostatic, Hydrodynamics, Seismic, Thermal and Tornado) Loads. Spent fuel racks and other equipment were analyzed and designed by vendor (G.E.)

3. Development of in-structure response specta

a. General procedures
FSAR: Sect. 3.7.2.5; CE 920 & CE-921

(i) Smoothing (describe specific smoothing method used)
Smoothed floor response spectra curves represent an envelope of the maximum peaks for each direction.

(ii) Peak widening
FSAR: Sect. 3.7.2.9; Min. 10 percent of peak frequency.

b. Typical results (attach figures)

See Calcs. C-H004.1 through C-H004.6 for floor response spectrum curves.

(i) Basemat spectra
See calcs. C-H004.1 through C-H004.6

(ii) Interior floors spectra (Key floors with floor elevations identified)

See calcs. C-H004.1 through C-H004.6

4. Vertical Dynamic Analysis

a. Mathematical Model - general description with sketch

Similar to FSAR: Figure 3.7-19 & 3.7-20
Calcs. No. C-H002.8

b. Development of stiffnesses, including floor stiffness, as applicable.
Floors considered rigid, their masses were taken into account as lumped masses. Mass moment of inertia for floors were computed.

c. Method of Analysis (Description of method used as well as each item considered in the analysis)
Modal response for Stress Analysis: CE-917 & CE-918
Time History for floor response spectra: CE-920 & CE-921
Soil-Structure Interaction was considered.

B. Stress Analysis

1. Shear Walls and Floors

a. Mathematical model (General description w/sketch)
FSAR: Sect. 3.8.4.1.1.1 & Figures 3.8-77 through 3.8-85

b. Method of analysis (Incorporation of torsion)
FSAR: Sect. 3.8.4.4.1 Floor :Calc. C-H021.0 through C-H029.0
Ext. Walls:Calc. C-H013.0
Int. Walls:Calc. C-H014.0, C-H016.0 & C-H017.0
Shear transferred by shear walls and distributed according to wall rigidities. Additional shear due to torsional effects is considered.

c. Load combinations
FSAR: Sect. 3.8.6.2

d. Key results
See Part II

2. Foundation mat

a. Mathematical model (Description of boundary conditions)
FSAR: Sect. 3.8.5.1.2 & Sect. 3.8.5.4.2 & Figure 3.8-77.

b. Method of analysis
The finite element model of the foundation consisted of shell elements supported on Catahoula SAP Program was used for analysis. Exterior walls considered as providing fixity around edges. Interior walls considered as stiffeners to foundation mat. All loads (D.L., L.L., Earth Pressure, Seismic, Hydrostatic) were considered for analysis. See calc. C-H011.0.

c. Load combinations
FSAR: Sect. 3.8.6.2

d. Key results (Figures, etc.)
See Part II

3. Material to protect against structure-to-structure interaction

Rodofoam II was used between Containment & Auxiliary: Turbine & Auxiliary Diesel Generator and Auxiliary, and Control and Auxiliary

a. Mechanical properties

Under seismic testing - Load transfer at 50 percent compression was 17.8 psi.

b. Additional pressure on walls

FSAR: Figure 3.7-21, 3-D Model for Auxiliary and Control Building
FSAR: Section. 3.7.2.1.1.3.2 for negligible interaction.

c. Findings and comments

4. Computer programs used in analysis

CE-650, 917, 918, 920, 931, 779, 800, 668, 309, 901

a. Assumptions and limitations

FSAR: Appendix - 3D

b. Applicability

FSAR: Appendix - 3D

c. Verification (Sensitivity study in case of numerical solutions; e.g., finite element analysis)

FSAR: Appendix - 3D

d. Load input (Include all cases)

FSAR: Appendix - 3D

e. Output (Include all cases)

FSAR: Appendix - 3D

f. Other discussions

FSAR: Appendix -3D

5. Overall stability

a. Forces and moments from seismic analysis

FSAR: Figure 3-7-38 - N – S: SSE
3-7-39 - N – S: OBE
3-7-40 - E – W: SSE
3-7-41 - E – W: OBE
3-7-42 - Vertical: SSE
3-7-43 - Vertical: OBE

b. Various cases considered

Sliding, overturning and stresses for bearing were considered: Calcs. C-H002.9

c. Bearing pressure versus bearing capacity and safety

factor against bearing failure			Ultimate Cap.	S. F.
Maximum bearing pressure)	= 17.5 KSF	(D+L)	88.0 KSF	5.0
)	= 23.0 KSF	(D+L+E)	88.0 KSF	3.8

d. Factors of safety

FSAR: Table: 3.8-1

(i) Sliding

SF = 2.38

(ii) Overturning (Vertical displacement)

SF = 7.40

6. Interaction of non-category I structures with the structure considered

No interaction considered. Adjacent non-Cat. I structure (Turbine Building) is designed to Cat. I requirements.
See FSAR: Section 3.8.4.1

a. Identification of pertinent Non-Category I structures

Turbine Building designed for Category I requirements to prevent adverse effects on Auxiliary Building

b. Consideration given to potential failure of Non-Category I systems on Category I systems

See above

c. General findings and comments

7. Design Consideration for Tornado Missiles

a. Design requirements

FSAR: Section 3.5.1.4
Section 3.5.3.1

b. Models for

(i) Local damage

Penetration perforation and spalling criteria is satisfied as per FSAR: Section 3.5.3.1

(ii) Overall response

Structural response is satisfied as per FSAR: Section 3.5.3.1 and calculation E-020.0

c. Load combinations

FSAR: Section 3.8.6.2 and BC-TOP 3A

d. Forces

FSAR: Section 3.5.3.1

e. General comments and preliminary audit findings

III. CONFORMANCE TO ACCEPTABLE CRITERIA

A. Identification of deviations, if any

Auxiliary Building was designed to ACI 318-71.
See FSAR Section 3.8.4.

B. Justification of deviations and disposition of the deviations

See FSAR Section 3.8.4.

C. General comments

Part II - AUDIT OF KEY DESIGNS

For each key deisgn area audited, the design calculations should be reviewed together with applicable drawings, sketches, etc. Also, key details and/or sections, as appropriate, in this audit report should be included.

DRAFT A, WCB3, 11

I. SPECIFIC CHECK OF KEY LOCATIONS

A. Exterior Shear Walls

1. Design requirements

FSAR: Section 3.8.4.1.1.1; Section 3.8.4.4.1; Section 3.8.4.5

2. Design loads (from general analysis)
   1. Dead Load
   2. Live Load
   3. OBE & SSE
   4. Tornado Missiles
   5. Wind and tornado (Include depressurization)
   6. Soil pressure and ground water pressure
3. Forces and moments at key sections

Calcs. C-H013.0

4. Detailed design of rebar placement at key sections

C-1334; C-1335, C-1350D and C-0204

5. General comments and preliminary audit findings

B. Interior Shear Walls

1. Design requirements

FSAR: Section 3.8.4.1.1.1; Section 3.8.4.4.1; Section 3.8.4.5

2. Design loads (from general analysis)
   1. Dead Load
   2. Live Load
   3. OBE & SSE
   4. Tornado (Depressuriztion)
   5. Thermal -(SFP & Steam tunnel)
   6. Pressure - Steam tunnel, RHR, RWCU See Calc.C-H017
3. Forces and moments at key sections

Calcs. C-H014.0
C-H016.0
C-H017.0

4. Detailed design of rebar placement at key sections

C-0204, C-1350D, C-1339 through C-1342

5. General comments and preliminary audit findings

C. Main Floors and Roofs (Elevation)

1. Design requirements

FSAR: Section 3.8.4.1.1.1; Section 3.8.4.4.1; Section 3.8.4.5

2. Design loads (from general analysis)

1. Dead Load
2. Live Load
3. OBE & SSE
4. Tornado (Depressurization included)
5. Crane and monorails
6. Tornado - Missiles
7. Thermal - SFP and Steam Tunnel
8. Pressure: Steam tunnel, RHR RWCU, etc.

See Calcs. C-H017.2

3. Forces and moments at key sections

Composite floor. Calcs. C-H011.1
See drawing C-1338 for typical reinforcement.

4. Detailed design of rebar placement at key sections

C-1338, C-0204

5. General comments and preliminary audit findings.

D. Steel Structural Bracing Systems (if any)

Not Applicable

1. Design requirements

2. Design loads

3. Forces and moments at key sections

4. General comments and preliminary audit findings

E. Foundation Mat

1. Design requirements

FSAR: Section 3.8.5 & 2

2. Design loads (from general analysis)
   1. Dead Load
   2. Live Load
   3. OBE & SSE
   4. Earth Pressure
   5. Ground water pressure
   6. Construction Load

3. Forces and moments at key sections
   Calcs. C-H011.0

4. Detailed design of rebar placement at key sections
   C-1300B, C1301, C-1302, C-1303, C-1334, C-1335

5. General comments and preliminary audit findings

F. Main Frame Concrete Column Design (Key Columns)

1. Design requirements
   FSAR: Section 3.8.4.1.1.1; Section 3.8.4.4.1; Section 3.8.4.5

2. Design loads (from general analysis)
   1. Dead Load
   2. Live Load
   3. OBE & SSE
   4. Crane and Monorail

3. Forces and moments at key sections
   Steel columns and composite columns See calc C-H030.0

4. Detailed design of rebar placement at key sections
   C-1350D, C-1355A

5. General comments and preliminary audit findings

G. Secondary Floors
   a. Steel platform @ El. 103'-0"
   b. Floor @ El. 245'-0"

1. Design requirements
   FSAR: Section-3.8.4.1.1.1; Section 3.8.4.4.1; Section 3.8.4.5

2. Design loads (from general analysis)
   1. Dead Load
   2. Live Load
   3. OBE & SSE

3. Forces and moments at key sections
   Similar to main floor - Ref. Item C on Page WCB3, 12

4. Detailed design of rebar placement at key sections
   Drawing C-1358, C-1359, C-1360
   Drawing C-1381B; C-1330

5. General comments and preliminary audit findings

H. Detailing at Floor-Wall Joints
To provide continuity for transmitting loads from slab into wall

1. Design requirements
   FSAR: Section 3.8.4.1.1.1; Section 3.8.4.4.1; Section 3.8.4.5

2. Design loads (from general analysis)
   1. Dead Load
   2. Live Load
   3. OBE & SSE
   4. Earth Pressure
   5. Ground water Pressure
   6. Wind and Tornado

3. Forces and moments at key sections
   See calc. C-H011.1

4. Detailed design of rebar placement at key sections
   C-0204, C-1334, C-1335, C-1337 through C-1342

5. General comments and preliminary audit findings

I. Dynamic Effects Applied to Floors and Walls by Machinery
Dynamic effects from machinery were considered negligible
Major pump and machinery supports are designed to meet the vendor's requirement.

1. Design requirements

2. Design loads (from general analysis)

3. Forces and moments at key sections

4. Detailed design

5. General comments and preliminary audit findings

J. Crane and Supports

1. Design of bents (columns and roof trusses)

Not Applicable

a. Design requirements

b. Design loads (from general analysis)

c. Forces and moments at key sections

d. Detailed design

e. General comments and preliminary audit findings

2. Design of girders supporting crane rails

1. Reinforced concrete corbel: Fuel cask crane - 150 ton capacity.
2. Structural steel bracket: New fuel bridge crane - 5 ton capacity.

a. Design requirements

FSAR: Section 3.8.4.1.1.1: Section 3.8.4.4.1 and Section 3.8.4.5

b. Design loads (from general analysis)

1. Dead Load
2. Live Load
3. OBE and SSE
4. Crane Load

All loads furnished by vendor

c. Forces and moments at key sections

See calcs. C-H013.0; C-H034.0; C-H035.0

d. Detailed design

C-1354-A to E, C-1381A, C-1381D, C-1382

e. General comments and preliminary audit findings

K. Design of spent fuel bridge

Fuel handling platform, purchased under Spec. 9645-M-001.0

1. Design requirements

   Spec. 9645-M-001.0

2. Design loads (from general analysis)
   1. Dead Load
   2. Live Load (includes impact)
   3. OBE and SSE

3. Forces and moments at key sections

   Calcs. not submitted by vendor (G.E.) yet.

4. Detailed design

   Calcs. not submitted by vendor (G.E.) yet.

5. General comments and preliminary audit findings

L. Fuel Pool Liner Design

Spec. C-171.0 and C-171.1
Spec. C-131.0
Fuel pool liner is designed as form for concrete wall by vendor under Spec. C-171.0. Leak chase system developed @ liner joints, and leak tightness of fuel liner is maintained.

1. Stresses and strain controls

   Governing stress: (Fresh concrete) =17,516 psi

2. Conformance to code requirements

   Liner : ASTM A240, Type 304, Hot-rolled, annealed and pickled.
   Shear studs: ASTM A108, Grades 1008 through 1020
   Bolt, screws: ASTM A320 Class B, AISI Type 304
   Welding: ASME Code - Section IX

3. Analysis procedure and results

   Analyzed and designed by vendor
   Stresses checked by Project. See calc. C-G300.0

4. Consideration of accidental drop of crane loads

   Not considered in calculation.

5. Corrosion effects (e.g., pitting) on liner integrity

   Negligible over 40 years Stainless steel liner ASTM A240 Type 304

6. preliminary findings of audit results