U.S. Nuclear Regulatory Commission
3F0897-01
Enclosure 1

ATTACHMENT C

FLORIDA POWER CORPORATION
CRYSTAL RIVER UNIT 3
DOCKET NUMBER 50-302/LICENSE NUMBER DPR-72

FPC CALCULATION S94-0011

UNRESOLVED SAFETY ISSUED A-46

Florida Power CORPORATION

INTEROFFICE CORRESPONDENCE

Nuclear Engineering (OFFICE) CZI (MAC) 5882 (PHONE)

SUBJECT: Crystal River Unit No. 3
Quality Document Transmittal - Analysis/Calculations
File: CALC

TO: Records Management - NR2A

The following analysis/calculation package is submitted as the QA Record copy:

DOCNO (FPC DOCUMENT IDENTIFICATION NUMBER)	REV	SYSTEM(S)	TOTAL PAGES TRANSMITTED
S-94-0011	0	CD, EF DH CA	126

TITLE: SEISMIC VERIFICATION OF TANKS - SQUG METHODOLOGY

KWDS (IDENTIFY KEYWORDS FOR LATER RETRIEVAL): TANK, SQUG, SEISMIC

DXREF (REFERENCES OR FILES - LIST PRIMARY FILE FIRST): SP-83-033

VEND (VENDOR NAME)	VENDOR DOCUMENT NUMBER (DXREF)	SUPERSEDED DOCUMENTS (DXREF)
G/CI	DC-5520-161.0 SE	NA
TAG		
CDT-1	CAT-5B	
EFT-2		
DHT-1		
CAT-5A		
PART NO.		

COMMENTS (USAGE RESTRICTIONS, PROPRIETARY, ETC.)

NOTE:
Use Tag number only for valid tag numbers (i.e., RCV-8, SWV-34, DCH-99), otherwise; use Part number field (i.e., CSC1459, AC1459). If more space is required, write "See Attachment" and list on separate sheet.

DESIGN ENGINEER	DATE	VERIFICATION ENGINEER	DATE	SUPERVISOR, NUCLEAR ENG.	DATE
C. Glenn Pugh	2/11/94	N/A		[signature]	2/14/94

cc: MAR Owner (If MAR Related) ☐ Yes ■ No
MAR/Project File
Mgr., Nucl. Config. Mgt.
File (CALC) -- FPES - "Original" w/attach
Mgr., S. Nucl. Eng. Serv. w/attach
GLENN PUGH w/ATTACH.

Supervisor, Nuclear Document Control w/Plant Doc. Rev. Eval. and Analysis / Calc. Summary
Plant Document Review Required ☐ Yes ■ No
A/E ☐ Yes ■ No
(If Yes, Transmit w/attach)

Rev. 3/93

RET: Life of Plant RESP: Nuclear Engineering 900 628

Florida Power Corporation

PLANT DOCUMENT REVIEW EVALUATION

DOCUMENT TYPE / NUMBER TO BE EVALUATED

S-94-0011

PART I

INSTRUCTIONS: Calculations, Document Change Notices, and Plant Equipment Equivalency Replacements have the potential to affect plant documents. The Originator of any of these documents is required to determine which, if any, plant organizations should review the subject document for impact. The Originator should use the best judgment to make this determination based on the nature of the changes. If in doubt as to whether or not a plant organization should review a particular document, it is suggested that the subject organization be contacted.

The Originator is to check the appropriate boxes below and attach to the subject package as follows:

Calculations - Insert behind Analysis/Calculation Transmittal
DCNs - Insert behind DCN page 1
PEEREs - Insert behind PEERE page 2
CIDPs - Insert behind CIDP page 1

The above referenced document must be distributed as follows:

- [x] No Review Required
- [ ] Senior Radiation Protection Engineer
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CIDPs - Distribute with Attachments
Calcs - Distribute with Transmittal Memo, Summary - **PEERE** - Distribute with Attachments - **DCNs** - Distribute with Attachments and Drawings

PART II

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REVIEWING DEPARTMENT

PLANT REVIEW IMPACT EVALUATION: The above referenced document has been reviewed and evaluated as follows:

- [ ] No Action Required
- [ ] Action Required: The below listed document(s) is affected and requires revision and/or other actions as indicated (i.e., generate a new procedure, void a procedure, etc.)

DOCUMENTS / ACTIONS

REVIEWER / DATE

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Upon completion, forward evaluation form only to Nuclear Document Control (NR2A)
* If the Supervisor or designee acts as the Originator or Reviewer, the applicable "Originator/Reviewer" block should be NA'd.

	CALCULATION	PAGE 1 OF 114
	PROJECT: FPC- Crystal River Unit 3	IDENTIFIER DC-5520-161. 05E
	SUBJECT: Seismic Verification of Tanks	CLASSIFICATION Nuclear Safety
	DISCIPLINE NAME AND NUMBER Structural/Piping 2241 & 2242	W.O. 04-5520-161

REVISION	0	1	2	3
ITEM(S) REVISED	Initial Issue			
ORIGINATOR	Samir J. Serhan S.J. Serhan			
DATE	01/19/94			
REVIEWER	G.M. Jackson			
DATE	01/19/94			
APPROVAL	Samir J. Serhan S.J. Serhan			
DATE	01/19/94			
ASSUMPTIONS/PRELIMINARY DATA	None			
PAGES REFERENCE	N/A			

THIS CALCULATION ALSO REQUIRES VERIFICATION PER DCP 2.05 (YES) NO

THE REVIEW OF THE CALCULATION INCLUDED EVALUATION AGAINST THE FOLLOWING QUESTIONS:	REMARKS See Attach. C of calculation.	REMARKS	REMARKS	REMARKS
WERE INPUTS, INCLUDING CODES, STANDARDS, AND REGULATORY REQUIREMENTS, CORRECTLY SELECTED AND APPLIED?	Yes			
ARE ASSUMPTIONS REASONABLE AND ADEQUATELY IDENTIFIED?	Yes			
HAVE APPLICABLE CONSTRUCTION AND OPERATING EXPERIENCES BEEN CONSIDERED?	N/A			
WAS AN APPROPRIATE CALCULATION METHOD USED?	Yes			
IS THE OUTPUT REASONABLE COMPARED TO INPUTS?	Yes			

GAI-525 2-92[PC]

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1. **OBJECTIVE**

The objective of this calculation is to:

- o generate 4% damped acceleration response spectrum curves for use in the tanks evaluation. The scope of this item includes the following locations:
  - Free-Field Ground
  - Auxiliary Building Elevation 119'
- o perform seismic verification of tanks by using the PSP Section 7 Methodology [Reference 4]. The scope of this item includes the following tanks:
  - Condensate Storage Tank [CDT-1]
  - Dedicated Emergency Feedwater Tank [EFT-2]
  - Borated Water Tank [DHT-1]
  - Horizontal Boric Acid Tank [CAT-5A and CAT-5B]

2. DESIGN INPUT AND REFERENCES

(1) Generic Implementation Procedure (GIP) for Seismic Verification of Nuclear Plant Equipment, Revision 2, SQUG, February 1992.

(2) G/C Calculation DC-5520-127.0SE, Revision 0, Floor Response Spectrum Generation, CR3, 1992.

(3) Computer Software: MathCAD, Version 2.5, Mathsoft Inc.

(4) Florida Power Corporation's Plant Specific Procedures (PSP) for Seismic Verification of Nuclear Plant Equipment, Revision 0.

(5) Florida Power Corporation "Environmental and Seismic Qualification Program Manual".

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3. ASSUMPTIONS

All assumptions are noted in the body of the calculation.

4. GENERATION OF 4.0% DAMPED RESPONSE SPECTRA

In this section, G/C will develop the 4% damped floor acceleration response curves for the free-field ground and Auxiliary Building Elevation 119′ for use in the tanks evaluation.

As done in Reference [2], the Power Method will be used in the generation of the 4% damped OBE acceleration response curves for the free-field ground and the Auxiliary Building Elevation 119′.

The reader is referred to Reference [2] for description of the lumped mass model of the Auxiliary Building, ground response spectra (plot and digitized values), and structural damping values.

To achieve the objective of this calculation, the 4.0% OBE curves are generated and the results shall be multiplied by a factor of 2.0 to develop the corresponding 4.0% SSE curves. Plots and tables of the generated broadened OBE acceleration response spectra are documented in the following subsections.

4.1 Ground Spectrum

The following pages document the generation of the 4.0 damped OBE ground acceleration response spectrum in the horizontal direction by using the Power Method.

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GENERATION OF 4.0% DAMPED HORIZONTAL GROUND RESPONSE SPECTRUM

Given: 3.0% and 5.0% Damped Ground Response Spectra

Required: 4.0% Damped Ground Response Spectrum

Read in the input data for the 3.0% and 5.0% damped horizontal OBE ground response spectra (see page 23 of Reference 2):

$N3 = 15$ [Number of Data Pairs for the 3.0% Spectrum]

Frequency (Hz)	Acceleration (g)
$F3_0 = 0.25$	$A3_0 = 0.03$
$F3_1 = 0.5$	$A3_1 = 0.05$
$F3_2 = 1.0$	$A3_2 = 0.1$
$F3_3 = 1.22$	$A3_3 = 0.124$
$F3_4 = 1.43$	$A3_4 = 0.123$
$F3_5 = 1.667$	$A3_5 = 0.12$
$F3_6 = 2.0$	$A3_6 = 0.114$
$F3_7 = 2.5$	$A3_7 = 0.109$
$F3_8 = 3.33$	$A3_8 = 0.105$
$F3_9 = 5.0$	$A3_9 = 0.097$
$F3_{10} = 7.14$	$A3_{10} = 0.082$
$F3_{11} = 10.0$	$A3_{11} = 0.068$
$F3_{12} = 16.67$	$A3_{12} = 0.059$
$F3_{13} = 50$	$A3_{13} = 0.052$
$F3_{14} = 100$	$A3_{14} = 0.05$

$N5 := 16$ [Number of Data Pairs for the 5.0% Spectrum]

Frequency (Hz)	Acceleration (g)
$F5_0 := 0.25$	$A5_0 := 0.02$
$F5_1 := 0.5$	$A5_1 := 0.04$
$F5_2 := 1.0$	$A5_2 := 0.082$
$F5_3 := 1.11$	$A5_3 := 0.092$
$F5_4 := 1.22$	$A5_4 := 0.099$
$F5_5 := 1.43$	$A5_5 := 0.1$
$F5_6 := 1.667$	$A5_6 := 0.097$
$F5_7 := 2.0$	$A5_7 := 0.092$
$F5_8 := 2.5$	$A5_8 := 0.087$
$F5_9 := 3.33$	$A5_9 := 0.08$
$F5_{10} := 5.0$	$A5_{10} := 0.07$
$F5_{11} := 7.14$	$A5_{11} := 0.061$
$F5_{12} := 10.0$	$A5_{12} := 0.056$
$F5_{13} := 16.67$	$A5_{13} := 0.0525$
$F5_{14} := 50.0$	$A5_{14} := 0.051$
$F5_{15} := 100.0$	$A5_{15} := 0.05$

$I3 := 0 .. (N3 - 1)$

$I5 := 0 .. (N5 - 1)$

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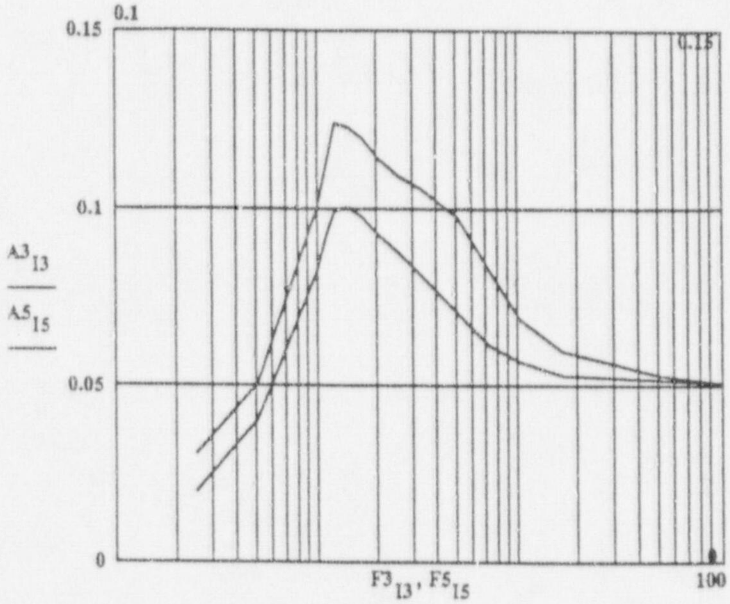
Acceleration (g)



Frequency (Hz)

Figure OBE Ground Response Spectra for 3.0% and 5.0% Equipment Damping. Horizontal Direction.

F3 and F5 do not have the same frequency spacing and, consequently, their frequency and acceleration values do not match one-to-one. Therefore, linear interpolation is performed to obtain acceleration values (A3final and A5final) at 250 selected frequencies (F).

$$J := 1 .. 250$$

$$F_J := 0.2 \cdot J$$ [Selected Frequencies]

$$A3final_J := linterp\left(F3, A3, F_J\right)$$

$$A5final_J := linterp\left(F5, A5, F_J\right)$$

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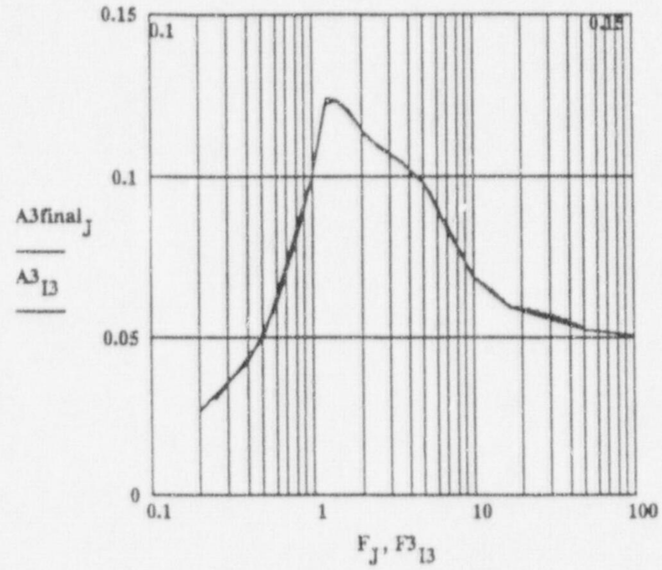
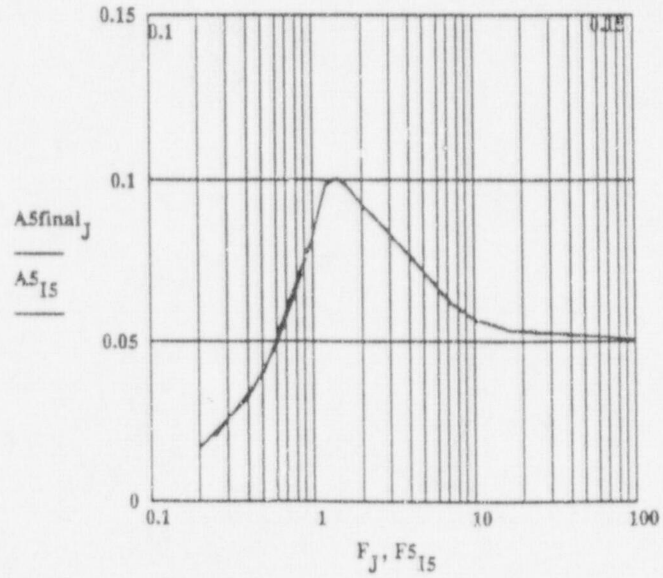
Acceleration
(g)



Frequency (Hz)

Figure Comparison of Original 3.0% Ground Spectrum and Interpolated 3.0% Ground Spectrum.

Acceleration
(g)



Frequency (Hz)

Figure Comparison of Original 3.0% Ground Spectrum and Interpolated 3.0% Ground Spectrum.

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Using the Power Method described in Calculation DC-5520-127.0SE, the 4.0% damped ground spectrum is derived as follows:

$\beta 1 := 3$ $\beta 2 := 5$ $\beta 3 := 4$

$$n := \frac{\ln\left[\frac{\beta 3}{\beta 1}\right]}{\ln\left[\frac{\beta 2}{\beta 1}\right]} \qquad n = 0.563$$

$$A4final_J := \left[A3final_J\right]^{(1-n)} \cdot \left[A5final_J\right]^{n}$$

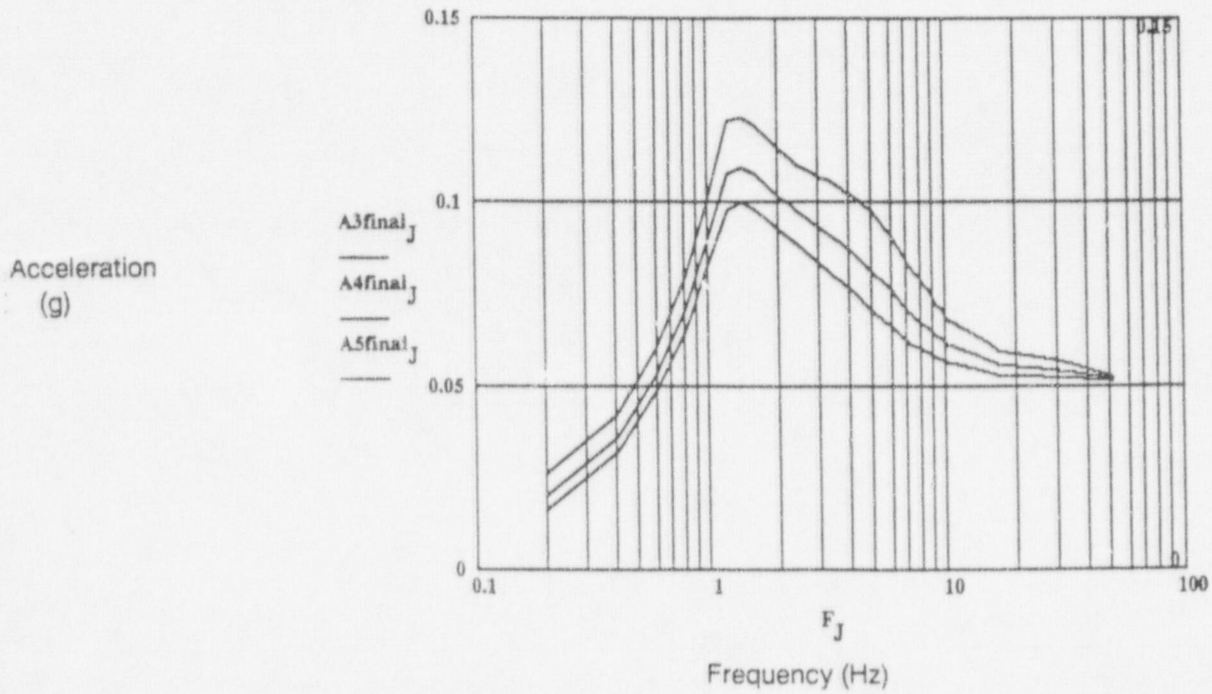

Figure OBE Ground Response Spectra for 3.0%, 4.0%, and 5.0% equipment damping.
Horizontal Direction.

Listing of the 4.0% Damped Horizontal OBE Ground Spectrum

$J := 1..35$

Frequency (Hz) F_J	Acceleration (g) $A4final_J$
0.2	0.02
0.4	0.036
0.6	0.053
0.8	0.071
1	0.089
1.2	0.108
1.4	0.109
1.6	0.107
1.8	0.104
2	0.101
2.2	0.099
2.4	0.097
2.6	0.095
2.8	0.094
3	0.092
3.2	0.091
3.4	0.09
3.6	0.089
3.8	0.087
4	0.086
4.2	0.085
4.4	0.084
4.6	0.083
4.8	0.082
5	0.081
5.2	0.08
5.4	0.079
5.6	0.078
5.8	0.076
6	0.075
6.2	0.074
6.4	0.073
6.6	0.072
6.8	0.071
7	0.07

Listing of the 4.5% Damped Horizontal OBE Ground Spectrum

$J := 36 .. 70$

Frequency (Hz) F_J	Acceleration (g) $A4final_J$
7.2	0.069
7.4	0.069
7.6	0.068
7.8	0.067
8	0.067
8.2	0.066
8.4	0.066
8.6	0.065
8.8	0.065
9	0.064
9.2	0.063
9.4	0.063
9.6	0.062
9.8	0.062
10	0.061
10.2	0.061
10.4	0.061
10.6	0.06
10.8	0.06
11	0.06
11.2	0.06
11.4	0.06
11.6	0.06
11.8	0.059
12	0.059
12.2	0.059
12.4	0.059
12.6	0.059
12.8	0.059
13	0.058
13.2	0.058
13.4	0.058
13.6	0.058
13.8	0.058
14	0.058

Listing of the 4.0% Damped Horizontal OBE Ground Spectrum

$J := 71 .. 105$

Frequency (Hz) F_J	Acceleration (g) $A4final_J$
14.2	0.057
14.4	0.057
14.6	0.057
14.8	0.057
15	0.057
15.2	0.057
15.4	0.056
15.6	0.056
15.8	0.056
16	0.056
16.2	0.056
16.4	0.055
16.6	0.055
16.8	0.055
17	0.055
17.2	0.055
17.4	0.055
17.6	0.055
17.8	0.055
18	0.055
18.2	0.055
18.4	0.055
18.6	0.055
18.8	0.055
19	0.055
19.2	0.055
19.4	0.055
19.6	0.055
19.8	0.055
20	0.055
20.2	0.055
20.4	0.055
20.6	0.055
20.8	0.055
21	0.055

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Listing of the 4.0% Damped Horizontal OBE Ground Spectrum

J := 106 .. 140

Frequency (Hz) F_J	Acceleration (g) $A4final_J$
21.2	0.055
21.4	0.055
21.6	0.055
21.8	0.055
22	0.055
22.2	0.055
22.4	0.055
22.6	0.055
22.8	0.055
23	0.055
23.2	0.055
23.4	0.054
23.6	0.054
23.8	0.054
24	0.054
24.2	0.054
24.4	0.054
24.6	0.054
24.8	0.054
25	0.054
25.2	0.054
25.4	0.054
25.6	0.054
25.8	0.054
26	0.054
26.2	0.054
26.4	0.054
26.6	0.054
26.8	0.054
27	0.054
27.2	0.054
27.4	0.054
27.6	0.054
27.8	0.054
28	0.054

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Listing of the 4.0% Damped Horizontal OBE Ground Spectrum

J := 141 .. 175

Frequency (Hz) F_J	Acceleration (g) $A4final_J$
28.2	0.054
28.4	0.054
28.6	0.054
28.8	0.054
29	0.054
29.2	0.054
29.4	0.054
29.6	0.054
29.8	0.054
30	0.054
30.2	0.054
30.4	0.054
30.6	0.054
30.8	0.054
31	0.054
31.2	0.054
31.4	0.054
31.6	0.054
31.8	0.054
32	0.054
32.2	0.053
32.4	0.053
32.6	0.053
32.8	0.053
33	0.053
33.2	0.053
33.4	0.053
33.6	0.053
33.8	0.053
34	0.053
34.2	0.053
34.4	0.053
34.6	0.053
34.8	0.053
35	0.053

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Listing of the 4.0% Damped Horizontal OBE Ground Spectrum

$J := 176 .. 210$

Frequency (Hz) F_J	Acceleration (g) $A4final_J$
35.2	0.053
35.4	0.053
35.6	0.053
35.8	0.053
36	0.053
36.2	0.053
36.4	0.053
36.6	0.053
36.8	0.053
37	0.053
37.2	0.053
37.4	0.053
37.6	0.053
37.8	0.053
38	0.053
38.2	0.053
38.4	0.053
38.6	0.053
38.8	0.053
39	0.053
39.2	0.053
39.4	0.053
39.6	0.053
39.8	0.053
40	0.053
40.2	0.053
40.4	0.053
40.6	0.053
40.8	0.052
41	0.052
41.2	0.052
41.4	0.052
41.6	0.052
41.8	0.052
42	0.052

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$J := 211 .. 250$

Frequency (Hz) F_J	Acceleration (g) $A4final_J$
42.2	0.052
42.4	0.052
42.6	0.052
42.8	0.052
43	0.052
43.2	0.052
43.4	0.052
43.6	0.052
43.8	0.052
44	0.052
44.2	0.052
44.4	0.052
44.6	0.052
44.8	0.052
45	0.052
45.2	0.052
45.4	0.052
45.6	0.052
45.8	0.052
46	0.052
46.2	0.052
46.4	0.052
46.6	0.052
46.8	0.052
47	0.052
47.2	0.052
47.4	0.052
47.6	0.052
47.8	0.052
48	0.052
48.2	0.052
48.4	0.052
48.6	0.052
48.8	0.052
49	0.052
49.2	0.052
49.4	0.052
49.6	0.051
49.8	0.051
50	0.051

4.2 Auxiliary Building Elevation 119'

The following pages document the generation of the 4.0 damped OBE floor acceleration response spectrum for the Auxiliary Building Elevation 119' in the horizontal direction by using the Power Method.

GENERATION OF 4.0% DAMPED HORIZONTAL RESPONSE SPECTRUM FOR AUXILIARY BUILDING ELEVATION 119'

Given: 0.5% and 1.0% Damped Floor Response Spectra (Reference 5)

Required: 4.0% Damped Floor Response Spectrum

Read in the input data for the 0.5% and 1.0% damped horizontal OBE floor response spectra:

$N = 76$ [Number of Data Points]

Frequency (Hz)	0.5% Damped Acceleration (g)	1.0% Damped Acceleration (g)
$F_1 = 0.5$	$A05_1 = 0.04$	$A1_1 = 0.04$
$F_2 = 0.6$	$A05_2 = 0.048$	$A1_2 = 0.048$
$F_3 = 0.7$	$A05_3 = 0.064$	$A1_3 = 0.064$
$F_4 = 0.8$	$A05_4 = 0.088$	$A1_4 = 0.088$
$F_5 = 0.9$	$A05_5 = 0.114$	$A1_5 = 0.114$
$F_6 = 1.0$	$A05_6 = 0.15$	$A1_6 = 0.15$
$F_7 = 1.1$	$A05_7 = 0.175$	$A1_7 = 0.16$
$F_8 = 1.2$	$A05_8 = 0.19$	$A1_8 = 0.184$
$F_9 = 1.3$	$A05_9 = 0.2$	$A1_9 = 0.184$
$F_{10} = 1.4$	$A05_{10} = 0.2$	$A1_{10} = 0.165$
$F_{11} = 1.5$	$A05_{11} = 0.2$	$A1_{11} = 0.16$
$F_{12} = 1.6$	$A05_{12} = 0.2$	$A1_{12} = 0.16$
$F_{13} = 1.7$	$A05_{13} = 0.2$	$A1_{13} = 0.16$
$F_{14} = 1.8$	$A05_{14} = 0.2$	$A1_{14} = 0.155$
$F_{15} = 1.9$	$A05_{15} = 0.2$	$A1_{15} = 0.15$
$F_{16} = 2.0$	$A05_{16} = 0.2$	$A1_{16} = 0.148$
$F_{17} = 2.1$	$A05_{17} = 0.2$	$A1_{17} = 0.145$

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Frequency (Hz)	0.5% Damped Acceleration (g)	1.0% Damped Acceleration (g)
$F_{18} = 2.2$	$A05_{18} = 0.2$	$A1_{18} = 0.142$
$F_{19} = 2.3$	$A05_{19} = 0.2$	$A1_{19} = 0.141$
$F_{20} = 2.4$	$A05_{20} = 0.2$	$A1_{20} = 0.14$
$F_{21} = 2.5$	$A05_{21} = 0.2$	$A1_{21} = 0.14$
$F_{22} = 2.6$	$A05_{22} = 0.2$	$A1_{22} = 0.141$
$F_{23} = 2.7$	$A05_{23} = 0.2$	$A1_{23} = 0.143$
$F_{24} = 2.8$	$A05_{24} = 0.2$	$A1_{24} = 0.145$
$F_{25} = 2.9$	$A05_{25} = 0.2$	$A1_{25} = 0.146$
$F_{26} = 3.0$	$A05_{26} = 0.2$	$A1_{26} = 0.148$
$F_{27} = 3.15$	$A05_{27} = 0.2$	$A1_{27} = 0.15$
$F_{28} = 3.3$	$A05_{28} = 0.2$	$A1_{28} = 0.151$
$F_{29} = 3.45$	$A05_{29} = 0.2$	$A1_{29} = 0.151$
$F_{30} = 3.6$	$A05_{30} = 0.2$	$A1_{30} = 0.151$
$F_{31} = 3.8$	$A05_{31} = 0.2$	$A1_{31} = 0.148$
$F_{32} = 4.0$	$A05_{32} = 0.2$	$A1_{32} = 0.145$
$F_{33} = 4.2$	$A05_{33} = 0.2$	$A1_{33} = 0.144$
$F_{34} = 4.4$	$A05_{34} = 0.2$	$A1_{34} = 0.145$
$F_{35} = 4.6$	$A05_{35} = 0.2$	$A1_{35} = 0.148$
$F_{36} = 4.8$	$A05_{36} = 0.2$	$A1_{36} = 0.15$
$F_{37} = 5.0$	$A05_{37} = 0.2$	$A1_{37} = 0.145$
$F_{38} = 5.25$	$A05_{38} = 0.2$	$A1_{38} = 0.141$
$F_{39} = 5.5$	$A05_{39} = 0.2$	$A1_{39} = 0.15$
$F_{40} = 5.75$	$A05_{40} = 0.2$	$A1_{40} = 0.153$

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Frequency (Hz)	0.5% Damped Acceleration (g)	1.0% Damped Acceleration (g)
F_{41} = 6.0	$A05_{41}$ = 0.2	$A1_{41}$ = 0.155
F_{42} = 6.25	$A05_{42}$ = 0.2	$A1_{42}$ = 0.16
F_{43} = 6.5	$A05_{43}$ = 0.2	$A1_{43}$ = 0.172
F_{44} = 6.75	$A05_{44}$ = 0.2	$A1_{44}$ = 0.175
F_{45} = 7.0	$A05_{45}$ = 0.2	$A1_{45}$ = 0.19
F_{46} = 7.25	$A05_{46}$ = 0.2	$A1_{46}$ = 0.193
F_{47} = 7.5	$A05_{47}$ = 0.21	$A1_{47}$ = 0.20
F_{48} = 7.75	$A05_{48}$ = 0.22	$A1_{48}$ = 0.21
F_{49} = 8.0	$A05_{49}$ = 0.23	$A1_{49}$ = 0.22
F_{50} = 8.5	$A05_{50}$ = 0.25	$A1_{50}$ = 0.24
F_{51} = 9.0	$A05_{51}$ = 0.29	$A1_{51}$ = 0.28
F_{52} = 9.5	$A05_{52}$ = 0.32	$A1_{52}$ = 0.304
F_{53} = 10.0	$A05_{53}$ = 0.343	$A1_{53}$ = 0.326
F_{54} = 10.5	$A05_{54}$ = 0.375	$A1_{54}$ = 0.356
F_{55} = 11.0	$A05_{55}$ = 0.405	$A1_{55}$ = 0.385
F_{56} = 11.5	$A05_{56}$ = 0.41	$A1_{56}$ = 0.39
F_{57} = 12.0	$A05_{57}$ = 0.47	$A1_{57}$ = 0.415
F_{58} = 12.5	$A05_{58}$ = 0.54	$A1_{58}$ = 0.418
F_{59} = 13.0	$A05_{59}$ = 0.54	$A1_{59}$ = 0.418
F_{60} = 13.5	$A05_{60}$ = 0.54	$A1_{60}$ = 0.415
F_{61} = 14.0	$A05_{61}$ = 0.54	$A1_{61}$ = 0.41
F_{62} = 14.5	$A05_{62}$ = 0.54	$A1_{62}$ = 0.408
F_{63} = 15.0	$A05_{63}$ = 0.48	$A1_{63}$ = 0.38

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Frequency (Hz)	0.5% Damped Acceleration (g)	1.0% Damped Acceleration (g)
$F_{64} = 16.0$	$A05_{64} = 0.34$	$A1_{64} = 0.33$
$F_{65} = 17.0$	$A05_{65} = 0.28$	$A1_{65} = 0.28$
$F_{66} = 18.0$	$A05_{66} = 0.24$	$A1_{66} = 0.24$
$F_{67} = 20.0$	$A05_{67} = 0.16$	$A1_{67} = 0.16$
$F_{68} = 22.0$	$A05_{68} = 0.12$	$A1_{68} = 0.12$
$F_{69} = 25.0$	$A05_{69} = 0.11$	$A1_{69} = 0.08$
$F_{70} = 28.0$	$A05_{70} = 0.14$	$A1_{70} = 0.075$
$F_{71} = 31.0$	$A05_{71} = 0.22$	$A1_{71} = 0.065$
$F_{72} = 34.0$	$A05_{72} = 0.18$	$A1_{72} = 0.06$
$F_{73} = 36.0$	$A05_{73} = 0.12$	$A1_{73} = 0.06$
$F_{74} = 40.0$	$A05_{74} = 0.09$	$A1_{74} = 0.055$
$F_{75} = 45.0$	$A05_{75} = 0.07$	$A1_{75} = 0.05$
$F_{76} = 50.0$	$A05_{76} = 0.06$	$A1_{76} = 0.04$

$Ncount = 1 .. N$

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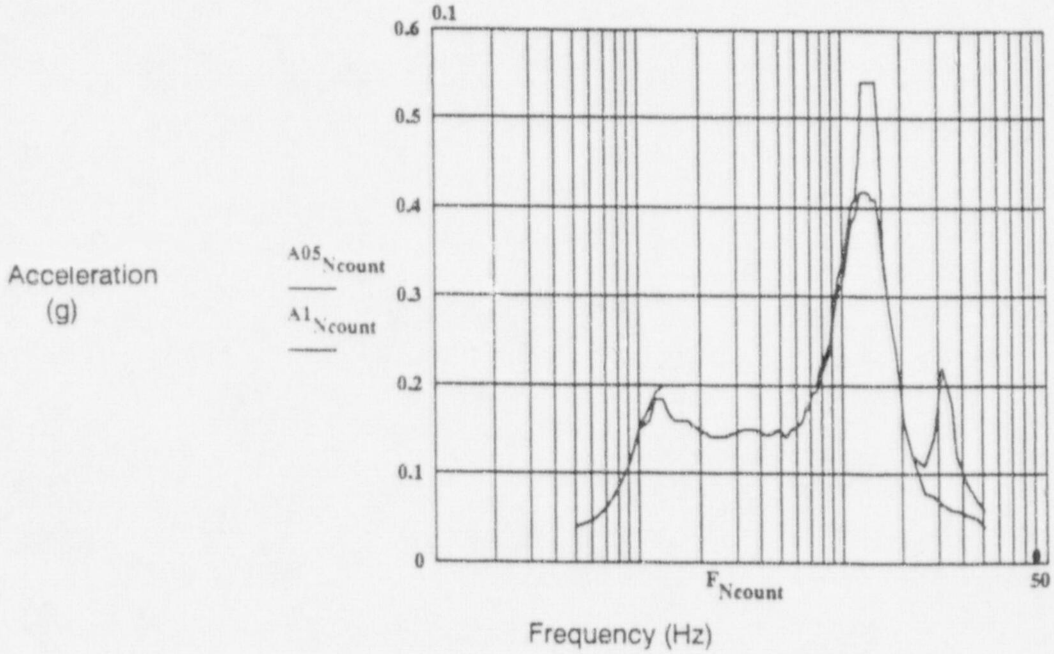

Figure OBE Response Spectra for 0.5% and 1.0% Equipment Damping. Auxiliary Building Elevation 119' for Horizontal Direction.

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Using the Power Method described in Calculation DC-5520-127.0SE, the 4.0% damped floor spectrum is derived as follows:

$\beta 1 := 0.5 \qquad \beta 2 := 1.0 \qquad \beta 3 := 4.0$

$$n := \frac{\ln\left[\frac{\beta 3}{\beta 1}\right]}{\ln\left[\frac{\beta 2}{\beta 1}\right]} \qquad n = 3$$

$$A4_{Ncount} := \left[A05_{Ncount}\right]^{(1-n)} \cdot \left[A1_{Ncount}\right]^{n}$$

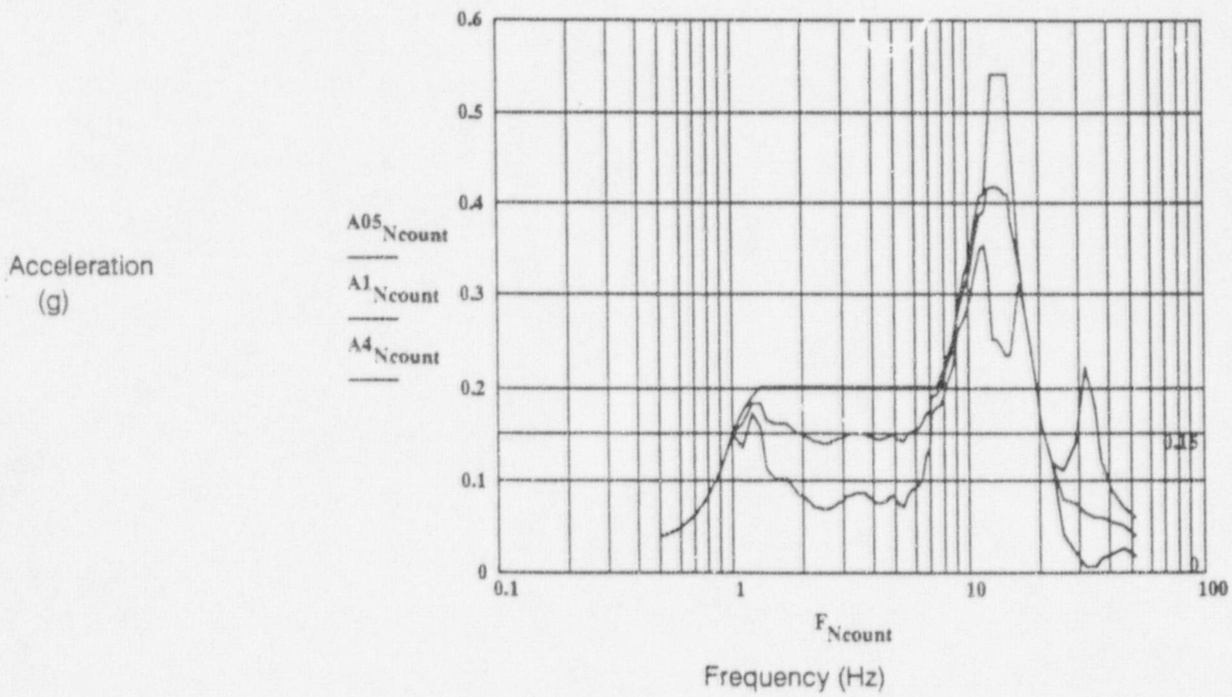

Figure OBE Ground Response Spectra for 0.5%, 1.0%, and 4.0% Damping in the Horizontal Direction.

Listing of the 4.0% Damped Horizontal OBE Floor Spectrum

$J = 1..35$

Frequency (Hz) F_J	Acceleration (g) $A4_J$
0.5	0.04
0.6	0.048
0.7	0.064
0.8	0.088
0.9	0.114
1	0.15
1.1	0.134
1.2	0.173
1.3	0.156
1.4	0.112
1.5	0.102
1.6	0.102
1.7	0.102
1.8	0.093
1.9	0.084
2	0.081
2.1	0.076
2.2	0.072
2.3	0.07
2.4	0.069
2.5	0.069
2.6	0.07
2.7	0.073
2.8	0.076
2.9	0.078
3	0.081
3.15	0.084
3.3	0.086
3.45	0.086
3.6	0.086
3.8	0.081
4	0.076
4.2	0.075
4.4	0.076
4.6	0.081

$J := 36..76$

Frequency (Hz) F_J	Acceleration (g) $A4_J$
4.8	0.084
5	0.076
5.25	0.07
5.5	0.084
5.75	0.09
6	0.093
6.25	0.102
6.5	0.127
6.75	0.134
7	0.171
7.25	0.18
7.5	0.181
7.75	0.191
8	0.201
8.5	0.221
9	0.261
9.5	0.274
10	0.294
10.5	0.321
11	0.348
11.5	0.353
12	0.324
12.5	0.25
13	0.25
13.5	0.245
14	0.236
14.5	0.233
15	0.238
16	0.311
17	0.28
18	0.24
20	0.16
22	0.12
25	0.042
28	0.022
31	0.006
34	0.007
36	0.015
40	0.021
45	0.026
50	0.018

5. CONDENSATE STORAGE TANK

The following pages document the seismic verification of the Condensate Storage Tank by using the PSP Section 7 Methodology [Reference 4].

FPC- Crystal River Unit 3

USI A-46 Project

Tanks Evaluation

Tank: Condensate Storage Tank [CDT-1]

Originator: Samir J. Serhan 06/25/1993

Reviewer: Gary M. Jackson

Program Name: TANKv1

Dr. Samir J. Serhan
Gilbert/Commonwealth,Inc.
April 5, 1993

SEISMIC VERIFICATION OF VERTICAL TANKS

Scope:

This seismic verification procedure is applicable to tanks with the following characteristics:

(a) Large cylinderical tanks,

(b) Axis of symmetry is vertical,

(c) Flat bottom,

(d) Anchored to concrete pads or building floor,

(e) Tank material is carbon steel (ASTM A36 or A283 Grade C), stainless steel (ASTM A240 Type 304), aluminum (various alloys), or better material,

(f) Anchor bolts are evenly spaced around tank circumference within + or - 5 degrees,

(g) Anchor bolts are cast-in-place or J-bolts (ASTM A36 or A307, A325),

(h) Fluid in tank is water or similar material, and

(i) Dimensions for tank shell, anchorage, and content should fall within the following range of parameters:

[See the following page]

Nominal Radius (R):	60" to 420"
Height of Tank Shell (Hp):	120" to 960"
Maximum Height of Fluid (H):	120" to 960"
Minimum Thickness of Tank Shell in the lowest 10% of Hp (ts):	0.1875" to 1.0"
Effective Thickness of Tank Shell [(tav+tmin)/2] (tef):	0.1875" to 1.0"
Diameter of Anchor Bolt (d):	0.5" to 2.0"
Number of anchor bolts (N):	8 or more
Ratio of Thickness of Wall ts to Radius of Tank (ts/R):	0.001 to 0.01
Ratio of Thickness of Wall tef to Radius of Tank (tef/R):	0.001 to 0.01
Ratio of Maximum Height of Fluid to Radius of Tank (H/R):	1.0 to 5.0

Evaluation Process:

Per the PSP Section 7 [4], the seismic verification for vertical tanks consists of the following 23 steps:

* STEP 1 INPUT DATA to be provided by the user

Tank Shell:

R = 192 in [Nominal Radius of Tank.

Hp = 420 in [Height of Tank Shell]

tmin = 0.25 in [Minimum Shell Thickness]

ts = 0.25 in [Minimum Shell Thickness in lowest 10% Hp]

n = 5 [Variation of Shell Thickness Along Height]

h_1 = 84 in t_1 = 0.25 in

h_2 = 84 in t_2 = 0.25 in

h_3 = 84 in t_3 = 0.25 in

h_4 = 84 in t_4 = 0.25 in

h_5 = 84 in t_5 = 0.25 in

(Step 1 Continued)

σ_ψ = 30000 psi [Yield Stress of Tank Shell Material]

hc = 8.5 in [Height of Chair]

Es = $29 \cdot 10^6$ psi [Young's Modulus of Tank Shell Material]

Tank Foundation:

Vs = 1500 ft/sec [Shear Wave Velocity of Supporting Soil]

Tank Content:

Γ_ϕ = 0.0361 lbf/in^3 [Weight Density of Fluid in Tank]

H = 390 in [Maximum Height of Fluid]

hf = 30 in [Freeboard Height]

Tank Anchorage Bolts:

N = 24 [Number of Anchor Bolts]

d = 1.25 in [Diameter of Anchor Bolt]

hb = 47 in [Effective Length of Anchor Bolt]

Eb = 30000000 psi [Young's Modulus of Anchor Bolt]

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STEP 2 Ratios:

$\mathrm{HoverR} = \frac{H}{R}$ $\mathrm{HoverR} = 2.031$

$\mathrm{tsoverR} = \frac{ts}{R}$ $\mathrm{tsoverR} = 0.001$

$i = 1..n$

$\mathrm{tav} = \frac{\sum_i \left[t_i \cdot h_i \right]}{Hp}$ $\mathrm{tav} = 0.25$ in

$\mathrm{tef} = \frac{\mathrm{tav} + \mathrm{tmin}}{2}$ $\mathrm{tef} = 0.25$ in

$\mathrm{tefoverR} = \frac{\mathrm{tef}}{R}$ $\mathrm{tefoverR} = 0.001$

$\mathrm{Ab} = \frac{\pi \cdot d^2}{4}$ $\mathrm{Ab} = 1.227$ in^2

$\mathrm{tp} = \left[\frac{N \cdot Ab}{2 \cdot \pi \cdot R} \right] \cdot \left[\frac{Eb}{Es} \right]$ $\mathrm{tp} = 0.025$ in

$\mathrm{cp} = \left[\frac{tp}{ts} \right] \cdot \left[\frac{hc}{hb} \right]$ $\mathrm{cp} = 0.018$

$W = \pi \cdot R^2 \cdot H \cdot \Gamma\phi$ $W = 1.631 \cdot 10^6$ lbf

* Note to User:

Before proceeding to Step 2, confirm that the values listed and ratios calculated in Step 1 are within the applicable range of parameters documented in the scope of this seismic verification procedure.

STEP 3 Fluid-Structure Modal Frequency (Impulsive Frequency)

* Note to User:

Using the following parameters, enter Table 7-3 of the PSP Section 7 and obtain Ff in Hz:

$R = 192$ in

$tefoverR = 0.001$

$HoverR = 2.031$

The following answer is provided by the user:

$Ff = 7.5$ Hz [This frequency is for carbon steel tanks containing water]

For tanks made of stainless steel or aluminum :

$$Ff = Ff \cdot \sqrt{\frac{0.0361}{\Gamma\phi}} \cdot \sqrt{\frac{Es}{30 \cdot 10^6}}$$

$Ff = 7.374$ Hz

The Condensate Storage Tank is made of carbon steel, therefore

$Ff = 7.5$ Hz

STEP 4 Spectral Acceleration for Impulsive Frequency

* Note to User:

Using the 4% damped maximum horizontal ground or floor (whichever is applicable) acceleration response spectrum, determine the maximum spectral acceleration Saf over the frequency range 0.8 Ff < F < 1.2 Ff.

For tanks with concrete pads founded on ground with a shear wave velocity less than 3500 ft/sec, the following is suggested in lieu of conducting soil/structure interaction analysis:

If Ff is less than the peak frequency of the maximum horizontal ground acceleration response spectrum, ignore soil/structure interaction effects.

Otherwise, use the peak spectral acceleration for Saf.

The following answer is provided by the user:

Saf = 0.137 g (From page 14 @ 7.5 Hz, Saf = 2 x 0.0685)

STEP 5 Base Shear Load

* Note to User:

Using the following parameters, enter Figure 7-3 of the PSP Section 7 and obtain the base shear load coefficient Qp:

HoverR = 2.031

tefoverR = 0.001

The following answer is provided by the user:

Qp = 0.725

Therefore, the shear load at the base of the tank is equal to:

$Q = Qp \cdot W \cdot Saf$ $Q = 1.62 \cdot 10^5$ lbf

STEP 6 Base Overturning Moment

* Note to User:

Using the following parameters, enter Figure 7-4 of the PSP Section 7 and obtain the base overturning moment coefficient Mp:

$HoverR = 2.031$

$tefoverR = 0.001$

The following answer is provided by the user:

$Mp = 0.368$

Therefore, the overturning moment at the base of the tank is equal to:

$M = Mp \cdot W \cdot H \cdot Saf$ $\quad M = 3.206 \cdot 10^{7}$ in-lbf

STEP 7 Bolt Tensile Load Capacity

* Note to User:

Using Appendix C of the GIP [Reference 1] , obtain anchor bolt tensile capacity Pu in lbf.

The following answer is provided by the user:

The Condensate Storage Tank is anchored to its foundation by 24 1.25" ϕ cast-in-place J bolts with 90-degree hooks. The minimum bend radius is 4ϕ, and the minimum straight extension of the hook is also 4ϕ. The corresponding values for the Condensate Storage Tank are 0.8ϕ and 1.8ϕ, respectively. As a conservative assumption, the length of the hook will not be included in the embedment length. The actual embedment length provided for the anchor bolt is

$L = 39.25$ in

From Table C.4-1 of the GIP, $Lmin = 68.125$ in

(Step 7 Continued)

Sinc Lmin > L > or = 16d, the reduction factor for embedment is calculated as:

$$Rembed = \frac{(L + 8 \cdot d)}{62.5 \cdot d} \qquad Rembed = 0.63$$

The pullout and shear capacity given in Table C.4-1 of the GIP are based on f'c of 3500 psi. Therefore, the reduction factor for f'c of 3000 psi is calculated as:

$$Rconc = \sqrt{\frac{3000}{3500}} \qquad Rconc = 0.926$$

Using Table C.4-1 of the GIP, the pullout capacity and shear capacity of a 1.25" ϕ anchor are:

$Pnom = 41720$ lbf

$Vnom = 20860$ lbf

Applying reduction factors

$$Pu = Pnom \cdot Rembed \cdot Rconc \qquad Pu = 2.435 \cdot 10^4 \text{ lbs}$$

The allowable bolt stress is:

$$Fb = \frac{Pu}{Ab} \qquad Fb = 1.984 \cdot 10^4 \text{ psi}$$

STEP 8 Top Plate of Anchor Bolt Chair

The dimensions f and c represent the length along the vertical stiffeners and thickness of the top plate, respectively. The dimension g represents the distance between the inner surfaces of the vertical stiffener plates.

* The following dimensions f, c and g are provided by the user:

$f = \frac{6 - d}{2}$ $f = 2.375$ in

$c = 0.5$ in

$g = 3$ in

The maximum bending stress in the top plate is calculated as:

$$\sigma = \frac{(0.375 \cdot g - 0.22 \cdot d) \cdot Pu}{f \cdot c^2}$$

$\sigma = 3.486 \cdot 10^4$ psi < $fy = 3.6 \cdot 10^4$

If the above relation is OK, there is no load reduction factor to be applied on the anchor bolt allowable tensile stress Fb. Otherwise, multiply Fb by the following reduction factor:

$$Rchair = \left[\frac{fy}{\sigma} \right]$$

$Rchair = 1.033$ (Do not use if > 1.0)

STEP 9 Tank Shell Stress

* For the calculation of the tank shell stress, the following dimensions should be provided by the user:

$a = 5$ in [Width of chair top plate parallel to shell]

$e = 3$ in [Eccentricity of anchor bolt with respect to shell outside surface]

$tb = 0.25$ in [Thickness of base plate of tank]

$h = 8.75$ in [Height of chair]

The maximum bending stress σ in the tank shell is:

$$Z = \frac{1.0}{\left[\frac{0.177 \cdot a \cdot tb}{\sqrt{R \cdot ts}} \cdot \left[\left(\frac{tb}{ts}\right)^2\right] + 1.0\right]}$$

$$\sigma = \left(\frac{Pu \cdot e}{ts^2}\right) \cdot \left[\frac{1.32 \cdot Z}{\left(\frac{1.43 \cdot a \cdot h^2}{R \cdot ts}\right) + \left(4 \cdot a \cdot h^2\right)^{0.333}} + \frac{0.031}{\sqrt{R \cdot ts}}\right]$$

$\sigma = 7.051 \cdot 10^4$ psi < $\sigma\psi = 3 \cdot 10^4$ psi

If the above relation is OK, there is no load reduction factor to be applied on the anchor bolt allowable tensile stress Fb. Otherwise, multiply Fb by the following reduction factor:

$Rshell = \left(\frac{\sigma\psi}{\sigma}\right)$ $Rshell = 0.425$ (Do not use if > 1.0)

$Fr = Fb \cdot Rshell$ $Fr = 8.442 \cdot 10^3$ psi

STEP 10 Vertical Stiffener Plates
----

* The following dimensions are provided by the user:

$k = 3.75$ in [Average width of chair vertical stiffener plate]

$j = 0.5$ in [Thickness of chair vertical stiffener plate]

* The user should check that the following four relations are satisfied:

$\frac{k}{j} = 7.5 \quad < \quad \frac{95}{\sqrt{\frac{fy}{1000}}} = 15.833$

$j = 0.5 \quad > \quad 0.04 \cdot (h - c) = 0.33$ in

$j = 0.5 \quad > \quad 0.5$ in (marginal, OK)

$\frac{Pu}{2 \cdot k \cdot j} = 6.493 \cdot 10^3 \quad < \quad 21000$ psi

If one or more of the above relations are not satisfied, consult applicable codes and standards for an appropriate reduction factor or consider the tank as an outlier.

STEP 11 Chair-to-Tank Shell Weld

The required load per inch for the weld between the chair and tank shell is:

$$Ww = Pu \cdot \sqrt{\left[\frac{1}{a+2\cdot h}\right]^2 + \left[\frac{e}{a\cdot h+0.667\cdot h^2}\right]^2}$$

* The user should provide thickness of leg of weld and check that the following relation is satisfied:

$tw = 0.25$ in

$Ww = 1.328\cdot 10^3$ < or = $\frac{30600\cdot tw}{\sqrt{2}} = 5.409\cdot 10^3$

If the above relations are not satisfied, consult applicable codes and standards for an appropriate reduction factor or consider the tank as an outlier.

STEP 12 Fluid Pressure for Elephant-Foot Buckling

* Using the following parameters, enter Figure 7-7 of the PSP Section 7 and obtain the fluid pressure coefficient Pep for elephant-foot buckling:

$Saf = 0.137$ g

$HoverR = 2.031$

The following answer is provided by the user:

$Pep = 2.2$

Based on the value of Pep, the fluid pressure at the base of the tank for elephant-foot buckling is:

$Pe = Pep \cdot \Gamma\phi \cdot R$

$Pe = 15.249$ psi

STEP 13 Elephant-Foot Buckling Stress Capacity Factor

* Using the following parameters, enter Figure 7-8 of the PSP Section 7 and obtain the fluid pressure coefficient Pep for elephant-foot buckling:

$Pe = 15.249$

$tsoverR = 0.001$

The following answer is provided by the user for tanks made of Carbon Steel:

$\sigma\pi\varepsilon = 11.8$ ksi

$\sigma\pi\varepsilon = \sigma\pi\varepsilon \cdot 1000$ $\qquad \sigma\pi\varepsilon = 1.18 \cdot 10^4$ psi

For tanks made of stainless steel or aluminum, the following procedure applies:

$$S1 = \frac{R}{400 \cdot ts}$$

$$S2 = \frac{S1 + \left[\frac{\sigma\psi}{36000}\right]}{S1 + 1}$$

$$\sigma\pi\varepsilon = \frac{0.6 \cdot Es}{\frac{R}{ts}} \cdot \left[1 - \left[\frac{Pe \cdot R}{\sigma\psi \cdot ts}\right]^2\right] \cdot \left[1 - \left[\frac{1}{1.12 + S1^{1.5}}\right]\right] \cdot S2$$

$\sigma\pi\varepsilon = 1.332 \cdot 10^4$ psi

For the Condensate Storage Tank, $\sigma\pi\varepsilon = 1.18 \cdot 10^4$ psi

STEP 14 Fluid Pressure for Diamond-Shape Buckling

* Using the following parameters, enter Figure 7-9 of the PSP Section 7 and obtain the pressure coefficient Pep for diamond-shape buckling:

Saf = 0.137 g

HoverR = 2.031

The following answer is provided by the user:

Pdp = 2.1

Based on the value of Pdp, the fluid pressure at the base of the tank for diamond-shape buckling is:

$$Pd = Pdp \cdot \Gamma\phi \cdot R$$

Pd = 14.556 psi

STEP 15 Diamond-Shape Buckling Stress Capacity Factor

* Using the following parameters, enter Figure 7-10 of the PSP Section 7 and obtain the stress capacity factor σpd for diamond-shape buckling:

$Pd = 14.556$ psi

$tsoverR = 0.001$

The following answer is provided by the user:

$\sigma\pi\delta = 12.2$ ksi

$\sigma\pi\delta = \sigma\pi\delta \cdot 1000$ $\sigma\pi\delta = 1.22 \cdot 10^4$ psi

This value of σpd is for carbon steel. For tanks made of stainless steel or aluminum, the following procedure is applied:

* Using the following parameter, enter Figure 7-11 of the PSP Section 7, obtain δΓ, and calculate σpd:

$\frac{Pd}{Es} \cdot \left[\frac{R}{ts}\right]^2 = 0.296$ $\delta\Gamma = 0.12$ [Figure 7-11]

$\phi = \frac{1}{16} \cdot \sqrt{\frac{R}{ts}}$ $\Gamma = 1 - 0.73 \cdot \left[1 - \exp(-\phi)\right]$

$\sigma\pi\delta = \left[0.6 \cdot \Gamma + \delta\Gamma\right] \cdot \left[\frac{Es}{\frac{R}{ts}}\right]$ $\sigma\pi\delta = 1.357 \cdot 10^4$ psi

For Condensate Storage Tank, $\sigma\pi\delta = 1.22 \cdot 10^4$ psi

STEP 16 Allowable Buckling Stress

The allowable buckling stress σc is calculated as 72% of the lower value of σpe or σpd.

$jjj := 0..1$

$\sigma\pi_0 := \sigma\pi\varepsilon$ $\quad\sigma\pi_0 = 1.18 \cdot 10^4$ psi

$\sigma\pi_1 := \sigma\pi\delta$ $\quad\sigma\pi_1 = 1.22 \cdot 10^4$ psi

$\sigma\chi := 0.72 \cdot \min(\sigma\pi)$

$\sigma\chi = 8.496 \cdot 10^3$ psi

STEP 17 Overturning Capacity of Tank

Ductile Failure:

Ductile failure modes are

Anchor bolt stretching (Step 7)

Chair top plate bending (Step 8)

Tank shell bending (Step 9)

Using the following parameters, enter Figure 7-12 of the PSP Section 7, and obtain the base overturning moment coefficient Mcapp:

$$cp = 0.018$$

$$\frac{\sigma\chi}{Fr} \cdot \frac{hc}{hb} = 0.182$$

$$Mcapp = 0.06$$ [Figure 7-12]

The base overturning moment is:

$$McapDUCT = Mcapp \cdot (2 \cdot Fr) \cdot \left[R^2 \cdot ts \right] \cdot \left[\frac{hb}{hc} \right]$$

$$McapDUCT = 5.163 \cdot 10^7 \quad \text{in-lbf}$$

STEP 17 Continued

Brittle Failure:

Brittle failure modes are

Concrete cone failure (Step 7)

Chair stiffener plate shear or buckling failure (Step 10)

Chair-to-tank wall weld shear failure (Step 11)

Using the following parameters, enter Table 7-4 of the PSP Section 7, and obtain the base overturning moment coefficient Mcapp:

$$cp = 0.018$$

$$Mcapp = 0.04094 \quad \text{[Table 7-4]}$$

The base overturning moment is:

[User Note: Use the smaller value of Fb or FR from Steps 7, 8, 9, 10, or 11]

$$McapBRIT = Mcapp \cdot (2 \cdot Fr) \cdot \left[R^2 \cdot ts \right] \cdot \left[\frac{hb}{hc} \right]$$

$$McapBRIT = 3.523 \cdot 10^7 \quad \text{in-lbf}$$

STEP 18 Capacit vs. Demand for Base Overturning Moment

* If the expected failure mode is ductile, the user should select the McapDUCT for use as Mcap. However, if the expected failure mode is brittle, the user should select the lower of McapDUCT and McapBRIT for use as Mcap.

For the Condensate Storage Tank, the expected failure mode is brittle (not enough embedment length). Therefore,

$$Mcap = McapBRIT$$

$$Mcap = 3.523 \cdot 10^{7} \quad \text{in-lbf}$$

The base overturning moment demand is determined from Step 6 and it is equal to:

$$M = 3.206 \cdot 10^{7} \quad \text{in-lbf}$$

* The user should check that the following relation is satisfied:

$$Mcap = 3.523 \cdot 10^{7} \quad > \text{ or } = \quad M = 3.206 \cdot 10^{7}$$

[OK, marginal]

If the above relation is not satisfied, consider the tank as an outlier.

STEP 19 Base Shear Load Capacity

The base shear load capacity is determined as:

$$Qcap = 0.55 \cdot (1 - 0.218 \cdot Saf) \cdot W$$

$$Qcap = 8.7 \cdot 10^5 \quad \text{lbf}$$

STEP 20 Capacity vs. Demand for Base Shear

* The user should check that the following relation is satisfied:

$$Qcap = 8.7 \cdot 10^5 \quad > \text{or} = \quad Q = 1.62 \cdot 10^5 \quad \text{OK}$$

If the above relation is not satisfied, consider the tank as an outlier.

STEP 21 Slosh Height

$G = 386.4$ in/sec/sec [Acceleration of Gravity]

The sloshing mode frequency is:

$$Fs = \frac{1}{2\cdot\pi}\cdot\sqrt{\frac{1.84\cdot G}{R}\cdot\tanh\left(\frac{1.84\cdot H}{R}\right)}$$

$Fs = 0.306$ Hz

* Note to User:

Using the 1/2% damped maximum horizontal ground or floor (whichever is applicable) acceleration response spectrum, determine the spectral acceleration Sas at frequency = Fs.

$Sas = 0.13$ g (OBE Acc. from Fig. 24 of Reference 5 @ 0.31 Hz times 2)

The slosh height is:

$hs = 0.837\cdot R\cdot Sas$ $hs = 20.892$ in

STEP 22 Freeboard Clearance vs. Slosh Height

* The user should check that the following relation is satisfied:

$hf = 30$ > or = $hs = 20.892$ [OK]

If the above relation is not satisfied, consider the tank as an outlier.

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CONCLUSION: Tank under evaluation is acceptable per PSP Section 7 seismic verification procedure.

6. **DEDICATED EMERGENCY FEEDWATER TANK**

The following pages document the seismic verification of the Dedicated Emergency Feedwater Tank by using the PSP Section 7 Methodology [Reference 4].

FPC- Crystal River Unit 3

USI A-46 Project

Tanks Evaluation

Tank: Dedicated Emergency Feedwater Tank [EFT-2]

Originator: Samir J. Serhan 10/08/1993

Reviewer: Gary M. Jackson

Program Name: TANKv3

Dr. Samir J. Serhan
Gilbert/Commonwealth, Inc.
April 5, 1993

SEISMIC VERIFICATION OF VERTICAL TANKS

Scope:

This seismic verification procedure is applicable to tanks with the following characteristics:

(a) Large cylinderical tanks,

(b) Axis of symmetry is vertical,

(c) Flat bottom,

(d) Anchored to concrete pads or building floor,

(e) Tank material is carbon steel (ASTM A36 or A283 Grade C), stainless steel (ASTM A240 Type 304), aluminum (various alloys), or better material,

(f) Anchor bolts are evenly spaced around tank circumference within + or - 5 degrees,

(g) Anchor bolts are cast-in-place or J-bolts (ASTM A36 or A307, A325),

(h) Fluid in tank is water or similar material, and

(i) Dimensions for tank shell, anchorage, and content should fall within the following range of parameters:

[See the following page]

Nominal Radius (R):	60" to 420"
Height of Tank Shell (Hp):	120" to 960"
Maximum Height of Fluid (H):	120" to 960"
Minimum Thickness of Tank Shell in the lowest 10% of Hp (ts):	0.1875" to 1.0"
Effective Thickness of Tank Shell [(tav+tmin)/2] (tef):	0.1875" to 1.0"
Diameter of Anchor Bolt (d):	0.5" to 2.0"
Number of anchor bolts (N):	8 or more
Ratio of Thickness of Wall ts to Radius of Tank (ts/R):	0.001 to 0.01
Ratio of Thickness of Wall tef to Radius of Tank (tef/R):	0.001 to 0.01
Ratio of Maximum Height of Fluid to Radius of Tank (H/R):	1.0 to 5.0

Evaluation Process:

Per the PSP Section 7 [4], the seismic verification for vertical tanks consists of the following 23 steps:

* STEP 1   INPUT DATA to be provided by the user

Tank Shell:

R = 167.81 in [Nominal Radius of Tank]

Hp = 480 in [Height of Tank Shell]

$tmin$ = 0.1875 in [Minimum Shell Thickness]

ts = 0.375 in [Minimum Shell Thickness in lowest 10% Hp]

n = 5 [Variation of Shell Thickness Along Height]

h_1 = 96 in t_1 = 0.375 in

h_2 = 96 in t_2 = 0.3125 in

h_3 = 96 in t_3 = 0.25 in

h_4 = 96 in t_4 = 0.1875 in

h_5 = 96 in t_5 = 0.1875 in

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(Step 1 Continued)

$\sigma\psi = 30000$ psi [Yield Stress of Tank Shell Material]

$hc = 8.0$ in [Height of Chair]

$Es = 29 \cdot 10^{6}$ psi [Young's Modulus of Tank Shell Material]

Tank Foundation:

$Vs = 1500$ ft/sec [Shear Wave Velocity of Supporting Soil]

Tank Content:

$\Gamma\phi = 0.0361$ lbf/in^3 [Weight Density of Fluid in Tank]

$H = 465$ in [Maximum Height of Fluid]

$hf = 15$ in [Freeboard Height]

Tank Anchorage Bolts:

$N = 36$ [Number of Anchor Bolts]

$d = 1.375$ in [Diameter of Anchor Bolt]

[Diameter of anchor bolt is reduced from 1.5" to 1.375" to obtain the allowable capacities from GIP Table C.3-1]

$hb = 46$ in [Effective Length of Anchor Bolt]

$Eb = 30000000$ psi [Young's Modulus of Anchor Bolt]

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STEP 2 Ratios:

$HoverR := \frac{H}{R}$ $\quad HoverR = 2.771$

$tsoverR := \frac{ts}{R}$ $\quad tsoverR = 0.002$

$i := 1..n$

$tav := \frac{\sum_i \left[t_i \cdot h_i \right]}{Hp}$ $\quad tav = 0.263$ in

$tef := \frac{tav + tmin}{2}$ $\quad tef = 0.225$ in

$tefoverR := \frac{tef}{R}$ $\quad tefoverR = 0.001$

$Ab := \frac{\pi \cdot d^2}{4}$ $\quad Ab = 1.485$ in^2

$tp := \left[\frac{N \cdot Ab}{2 \cdot \pi \cdot R} \right] \cdot \left[\frac{Eb}{Es} \right]$ $\quad tp = 0.052$ in

$cp := \left[\frac{tp}{ts} \right] \cdot \left[\frac{hc}{hb} \right]$ $\quad cp = 0.024$

$W := \pi \cdot R^2 \cdot H \cdot \Gamma\phi$ $\quad W = 1.485 \cdot 10^6$ lbf

* Note to User:

Before proceeding to Step 2, confirm that the values listed and ratios calculated in Step 1 are within the applicable range of parameters documented in the scope of this seismic verification procedure.

Answer: Yes [Diameter of anchor bolt is reduced to 1.375" to obtain allowable capacities from Table C.3-1 of the ~~PSP~~ GIP] SJS 1-18-94

STEP 3 Fluid-Structure Modal Frequency (Impulsive Frequency)

* Note to User:

Using the following parameters, enter Table 7-3 of the PSP Section 7 and obtain Ff in Hz:

$R = 167.81$ in

$tefoverR = 0.001$

$HoverR = 2.771$

The following answer is provided by the user:

$Ff = 5.74$ Hz [This frequency is for carbon steel tanks containing water]

For tanks made of stainless steel or aluminum :

$$Ff = Ff \cdot \sqrt{\frac{0.0361}{\Gamma\phi}} \cdot \sqrt{\frac{Es}{30 \cdot 10^6}} \qquad Ff = 5.644 \text{ Hz}$$

The Emergency Feedwater Tank is made of carbon steel, therefore

$Ff = 5.74$ Hz

STEP 4 Spectral Acceleration for Impulsive Frequency

* Note to User:

Using the 4% damped maximum horizontal ground or floor (whichever is applicable) acceleration response spectrum, determine the maximum spectral acceleration Saf over the frequency range 0.8 Ff < F < 1.2 Ff.

For tanks with concrete pads founded on ground with a shear wave velocity less than 3500 ft/sec, the following is suggested in lieu of conducting soil/structure interaction analysis:

If Ff is less than the peak frequency of the maximum horizontal ground acceleration response spectrum, ignore soil/structure interaction effects.

Otherwise, use the peak spectral acceleration for Saf.

The following answer is provided by the user:

$Saf = 0.699$ g (Figure EFW07 of Reference 5)

STEP 5 Base Shear Load

* Note to User:

Using the following parameters, enter Figure 7-3 of the PSP Section 7 and obtain the base shear load coefficient Qp:

$HoverR = 2.771$

$tefoverR = 0.001$

The following answer is provided by the user:

$Qp = 0.735$

Therefore, the shear load at the base of the tank is equal to:

$Q = Qp \cdot W \cdot Saf$ $Q = 7.63 \cdot 10^{5}$ lbf

STEP 6 Base Overturning Moment

* Note to User:

Using the following parameters, enter Figure 7-4 of the PSP Section 7 and obtain the base overturning moment coefficient Mp:

HoverR = 2.771

tefoverR = 0.001

The following answer is provided by the user:

Mp = 0.393

Therefore, the overturning moment at the base of the tank is equal to:

$M = Mp \cdot W \cdot H \cdot Saf$ $\quad M = 1.897 \cdot 10^{8}$ in-lbf

STEP 7 Bolt Tensile Load Capacity

* Note to User:

Using Appendix C of the GIP [Reference 1], obtain anchor bolt tensile capacity Pu in lbf.

The following answer is provided by the user:

The EFT-2 Tank is anchored to its foundation by 36 1.375" ϕ cast-in-place bolts with end plate. The actual embedment length provided for the anchor bolt is

$L = 39.0$ in

From Table C.3-1 of the GIP, **Lmin** = 13.75 in

(Step 7 Continued)

Sinc Lmin < L , the reduction factor for embedment is calculated as:

$$Rembed := 1.0$$

The pullout and shear capacity given in Table C.3-1 of the GIP [Reference 1] are based on f'c of 3500 psi. Therefore, the reduction factor for f'c of 3000 psi is calculated as:

$$Rconc := \sqrt{\frac{3000}{3500}} \qquad Rconc = 0.926$$

Using Table C.3-1 of the GIP [Reference 1], the pullout capacity and shear capacity of a 1.375" ϕ anchor are:

$$Pnom := 50400 \quad lbf$$

$$Vnom := 25250 \quad lbf$$

Applying reduction factors

$$Pu := Pnom \cdot Rembed \cdot Rconc \qquad Pu = 4.666 \cdot 10^{4} \quad lbs$$

The allowable bolt stress is:

$$Fb := \frac{Pu}{Ab} \qquad Fb = 3.142 \cdot 10^{4} \quad psi$$

STEP 8 Top Plate of Anchor Bolt Chair

The dimensions f and c represent the length along the vertical stiffeners and thickness of the top plate, respectively. The dimension g represents the distance between the inner surfaces of the vertical stiffener plates.

* The following dimensions f, c and g are provided by the user:

$$f = \frac{8 - d}{2} \qquad f = 3.313 \text{ in}$$

$$c = 1.0 \text{ in}$$

$$g = 3.25 \text{ in}$$

The maximum bending stress in the top plate is calculated as:

$$\sigma = \frac{(0.375 \cdot g - 0.22 \cdot d) \cdot Pu}{f \cdot c^2}$$

$$\sigma = 1.291 \cdot 10^4 \text{ psi} \quad < \quad fy = 3.6 \cdot 10^4$$

If the above relation is OK, there is no load reduction factor to be applied on the anchor bolt allowable tensile stress Fb. Otherwise, multiply Fb by the following reduction factor:

$$Rchair = \left[\frac{fy}{\sigma}\right]$$

$$Rchair = 2.789$$ (Do not use if > 1.0)

* Answer by User:

$$Rchair = 1.0$$

$$\sigma = \sigma \cdot Rchair \qquad \sigma = 1.291 \cdot 10^4 \text{ psi}$$

STEP 9 Tank Shell Stress

* For the calculation of the tank shell stress, the following dimensions should be provided by the user:

$a = 8$ in [Width of chair top plate parallel to shell]

$e = 5.0$ in [Eccentricity of anchor bolt with respect to shell outside surface]

$tb = 0.25$ in [Thickness of base plate of tank]

$h = 8$ in [Height of chair]

The maximum bending stress σ in the tank shell is:

$$Z = \frac{1.0}{\left[\frac{0.177 \cdot a \cdot tb}{\sqrt{R \cdot ts}} \cdot \left[\left(\frac{tb}{ts}\right)^2\right] + 1.0\right]}$$

$$\sigma = \left[\frac{Pu \cdot e}{ts^2}\right] \cdot \left[\frac{1.32 \cdot Z}{\left[\frac{1.43 \cdot a \cdot h^2}{R \cdot ts} + \left[\left(4 \cdot a \cdot h^2\right)^{0.333}\right]\right]} + \frac{0.031}{\sqrt{R \cdot ts}}\right]$$

$\sigma = 9.485 \cdot 10^4$ psi < $\sigma\psi = 3 \cdot 10^4$ psi

If the above relation is OK, there is no load reduction factor to be applied on the anchor bolt allowable tensile stress Fb. Otherwise, multiply Fb by the following reduction factor:

$Rshell = \left[\frac{\sigma\psi}{\sigma}\right]$ $Rshell = 0.316$ (Do not use if > 1.0)

* Answer by User:

$Fr = Fb \cdot Rshell$ $Fr = 9.939 \cdot 10^3$ psi

STEP 10 Vertical Stiffener Plates

* The following dimensions are provided by the user:

$k = 5.0$ in [Average width of chair vertical stiffener plate]

$j = 0.5$ in [Thickness of chair vertical stiffener plate]

* The user should check that the following four relations are satisfied:

$$\frac{k}{j} = 10 \quad < \quad \frac{95}{\sqrt{\frac{fy}{1000}}} = 15.833$$

$$j = 0.5 \quad > \quad 0.04 \cdot (h - c) = 0.28 \text{ in}$$

$$j = 0.5 \quad > \quad 0.5 \text{ in} \quad \text{(marginal, OK)}$$

$$\frac{Pu}{2 \cdot k \cdot j} = 9.332 \cdot 10^3 \quad < \quad 21000 \text{ psi}$$

If one or more of the above relations are not satisfied, consult applicable codes and standards for an appropriate reduction factor or consider the tank as an outlier.

STEP 11 Chair-to-Tank Shell Weld

The required load per inch for the weld between the chair and tank shell is:

$$Ww = Pu \cdot \sqrt{\left[\frac{1}{a+2\cdot h}\right]^2 + \left[\frac{e}{a\cdot h + 0.667\cdot h^2}\right]^2}$$

* The user should provide thickness of leg of weld and check that the following relation is satisfied:

$$tw = 0.25 \quad \text{in}$$

$$Ww = 2.926\cdot 10^3 \quad < \text{or} = \quad \frac{30600\cdot tw}{\sqrt{2}} = 5.409\cdot 10^3$$

If the above relations are not satisfied, consult applicable codes and standards for an appropriate reduction factor or consider the tank as an outlier.

STEP 12 Fluid Pressure for Elephant-Foot Buckling

* Using the following parameters, enter Figure 7-7 of the PSP Section 7 and obtain the fluid pressure coefficient Pep for elephant-foot buckling:

Saf = 0.699 g

HoverR = 2.771

The following answer is provided by the user:

Pep = 3.95

Based on the value of Pep, the fluid pressure at the base of the tank for elephant-foot buckling is:

$$Pe = Pep \cdot \Gamma\phi \cdot R$$

Pe = 23.929 psi

STEP 13 Elephant-Foot Buckling Stress Capacity Factor

* Using the following parameters, enter Figure 7-8 of the PSP Section 7 and obtain the fluid pressure coefficient Pep for elephant-foot buckling:

$$Pe = 23.929$$

$$tsoverR = 0.002$$

The following answer is provided by the user:

$$\sigma\pi\varepsilon := 19.0 \quad ksi$$

$$\sigma\pi\varepsilon := \sigma\pi\varepsilon \cdot 1000 \qquad \sigma\pi\varepsilon = 1.9\cdot 10^{4} \quad psi$$

For tanks made of stainless steel or aluminum,

$$S1 := \frac{R}{400\cdot ts}$$

$$S2 := \frac{S1 + \left[\frac{\sigma\psi}{36000}\right]}{S1 + 1}$$

$$\sigma\pi\varepsilon := \frac{0.6\cdot Es}{\frac{R}{ts}}\cdot\left[1 - \left[\frac{Pe\cdot R}{\sigma\psi\cdot ts}\right]^{2}\right]\cdot\left[1 - \left[\frac{1}{1.12 + S1^{1.5}}\right]\right]\cdot S2$$

$$\sigma\pi\varepsilon = 1.769\cdot 10^{4} \quad psi$$

For Emergency Feedwater Tank, $\sigma\pi\varepsilon := 1.9\cdot 10^{4}$ psi

Engineering Instruction No. 2

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STEP 14 Fluid Pressure for Diamond-Shape Buckling

* Using the following parameters, enter Figure 7-9 of the PSP Section 7 and obtain the pressure coefficient Pep for diamond-shape buckling:

Saf = 0.699 g

HoverR = 2.771

The following answer is provided by the user:

Pdp = 3.1

Based on the value of Pdp, the fluid pressure at the base of the tank for diamond-shape buckling is:

$Pd = Pdp \cdot \Gamma\phi \cdot R$

$Pd = 18.78$ psi

STEP 15 Diamond-Shape Buckling Stress Capacity Factor

* Using the following parameters, enter Figure 7-10 of the PSP Section 7 and obtain the stress capacity factor σpd for diamond-shape buckling:

$Pd = 18.78$ psi

$tsoverR = 0.002$

The following answer is provided by the user:

$\sigma\pi\delta = 23.0$ ksi

$\sigma\pi\delta = \sigma\pi\delta \cdot 1000$ $\qquad \sigma\pi\delta = 2.3 \cdot 10^{4}$ psi

This value of σpd is for carbon steel. For tanks made of stainless steel or aluminum, the following procedure is applied:

* Using the following parameter, enter Figure 7-11 of the GIP Section 7, obtain $\delta\Gamma$, and calculate σpd:

$$\frac{Pd}{Es} \cdot \left[\frac{R}{ts} \right]^{2} = 0.13 \qquad \delta\Gamma = 0.09$$ [Figure 7-11]

$$\phi = \frac{1}{16} \cdot \sqrt{\frac{R}{ts}} \qquad \Gamma = 1 - 0.73 \cdot \left[1 - \exp(-\phi) \right]$$

$$\sigma\pi\delta = \left[0.6 \cdot \Gamma + \delta\Gamma \right] \cdot \left[\frac{Es}{\frac{R}{ts}} \right] \qquad \sigma\pi\delta = 2.39 \cdot 10^{4} \text{ psi}$$

For Emergency Feedwater Tank, $\sigma\pi\delta = 2.3 \cdot 10^{4}$ psi

STEP 16 Allowable Buckling Stress

The allowable buckling stress σc is calculated as 72% of the lower value of σpe or σpd.

$jjj := 0..1$

$\sigma\pi_0 := \sigma\pi\varepsilon \qquad \sigma\pi_0 = 1.9\cdot 10^4$ psi

$\sigma\pi_1 := \sigma\pi\delta \qquad \sigma\pi_1 = 2.3\cdot 10^4$ psi

$\sigma\chi := 0.72\cdot \min(\sigma\pi)$

$\sigma\chi = 1.368\cdot 10^4$ psi

STEP 17 Overturning Capacity of Tank

Ductile Failure:

Ductile failure modes are

Anchor bolt stretching (Step 7)

Chair top plate bending (Step 8)

Tank shell bending (Step 9)

Using the following parameters, enter Figure 7-12 of the PSP Section 7, and obtain the base overturning moment coefficient Mcapp:

$$cp = 0.024$$

$$\frac{\sigma\chi}{Fr} \cdot \frac{hc}{hb} = 0.239$$

$$Mcapp = 0.07$$ [Figure 7-12]

The base overturning moment is:

$$McapDUCT = Mcapp \cdot (2 \cdot Fr) \cdot \left[R^2 \cdot ts \right] \cdot \left[\frac{hb}{hc} \right]$$

$$McapDUCT = 8.449 \cdot 10^7$$ in-lbf

STEP 17 Continued

Brittle Failure:

Brittle failure modes are

Concrete cone failure (Step 7)

Chair stiffener plate shear or buckling failure (Step 10)

Chair-to-tank wall weld shear failure (Step 11)

Using the following parameters, enter Table 7-4 of the PSP Section 7, and obtain the base overturning moment coefficient Mcapp:

$$cp = 0.024$$

$$Mcapp = 0.056$$ [Table 7-4]

The base overturning moment is:

$$McapBRIT = Mcapp \cdot (2 \cdot Fr) \cdot \left[R^2 \cdot ts\right] \cdot \left[\frac{hb}{hc}\right]$$

$$McapBRIT = 6.759 \cdot 10^7$$ in-lbf

STEP 18 Capacit vs. Demand for Base Overturning Moment

* If the expected failure mode is ductile, the user should select the McapDUCT for use as Mcap. However, if the expected failure mode is brittle, the user should select the lower of McapDUCT and McapBRIT for use as Mcap.

For the Emergency Feedwater Tank, the expected failure mode is ductile (Step 9). Therefore,

Mcap = McapDUCT

VERIFIER COMMENT: WALL BENDING → STEP 9 OK

$$Mcap = 8.449 \cdot 10^{7} \text{ in-lbf}$$

The base overturning moment demand is determined from Step 6 and it is equal to:

$$M = 1.897 \cdot 10^{8} \text{ in-lbf}$$

* The user should check that the following relation is satisfied:

$$Mcap = 8.449 \cdot 10^{7} \quad > \text{ or } = \quad M = 1.897 \cdot 10^{8} \quad [NG]$$

STEP 19 Base Shear Load Capacity

The base shear load capacity is determined as:

$$Qcap = 0.55 \cdot (1 - 0.218 \cdot Saf) \cdot W$$

$$Qcap = 6.923 \cdot 10^5 \quad lbf$$

STEP 20 Capacity vs. Demand for Base Shear

* The user should check that the following relation is satisfied:

$Qcap = 6.923 \cdot 10^5$ > or = $Q = 7.63 \cdot 10^5$ [NG]

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	DATE	01/18/94			

STEP 21 Slosh Height

$G = 386.4$ in/sec/sec [Acceleration of Gravity]

The sloshing mode frequency is:

$$Fs = \frac{1}{2 \cdot \pi} \cdot \sqrt{\frac{1.84 \cdot G}{R} \cdot \tanh\left[\frac{1.84 \cdot H}{R}\right]} \qquad Fs = 0.328 \quad \text{Hz}$$

* Note to User:

Using the 1/2% damped maximum horizontal ground or floor (whichever is applicable) acceleration response spectrum, determine the spectral acceleration Sas at frequency = Fs.

$Sas = 0.1$ g (estimated from Figure EFW07 of Reference 5)

The slosh height is:

$$hs = 0.837 \cdot R \cdot Sas \qquad hs = 14.046 \quad \text{in}$$

STEP 22 Freeboard Clearance vs. Slosh Height

* The user should check that the following relation is satisfied:

$hf = 15$ > or = $hs = 14.046$ OK

CONCLUSION: Tank under evaluation is an outlier per PSP Section 7 seismic verification procedure due to base shear and overturning moment.

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7. **BORATED WATER TANK**

The following pages document the seismic verification of the Borated Water Tank by using the PSP Section 7 Methodology [Reference 4].

FPC- Crystal River Unit 3

USI A-46 Project

Tanks Evaluation

Tank: Borated Water Tank [DHT]

Originator: Samir J. Serhan 10/08/1993

Reviewer: Gary M. Jackson

Program Name: TANKv2

Dr. Samir J. Serhan
Gilbert/Commonwealth,Inc.
April 5, 1993

SEISMIC VERIFICATION OF VERTICAL TANKS

Scope:

This seismic verification procedure is applicable to tanks with the following characteristics:

(a) Large cylinderical tanks,

(b) Axis of symmetry is vertical,

(c) Flat bottom,

(d) Anchored to concrete pads or building floor,

(e) Tank material is carbon steel (ASTM A36 or A283 Grade C), stainless steel (ASTM A240 Type 304), aluminum (various alloys), or better material,

(f) Anchor bolts are evenly spaced around tank circumference within + or - 5 degrees,

(g) Anchor bolts are cast-in-place or J-bolts (ASTM A36 or A307, A325),

(h) Fluid in tank is water or similar material, and

(i) Dimensions for tank shell, anchorage, and content should fall within the following range of parameters:

[See the following page]

Nominal Radius (R):	60" to 420"
Height of Tank Shell (Hp):	120" to 960"
Maximum Height of Fluid (H):	120" to 960"
Minimum Thickness of Tank Shell in the lowest 10% of Hp (ts):	0.1875" to 1.0"
Effective Thickness of Tank Shell [(tav+tmin)/2] (tef):	0.1875" to 1.0"
Diameter of Anchor Bolt (d):	0.5" to 2.0"
Number of anchor bolts (N):	8 or more
Ratio of Thickness of Wall ts to Radius of Tank (ts/R):	0.001 to 0.01
Ratio of Thickness of Wall tef to Radius of Tank (tef/R):	0.001 to 0.01
Ratio of Maximum Height of Fluid to Radius of Tank (H/R):	1.0 to 5.0

Evaluation Process:

Per the PSP Section 7 [4], the seismic verification for vertical tanks consists of the following 23 steps:

* STEP 1 INPUT DATA to be provided by the user

Tank Shell:

R = 240.21 in [Nominal Radius of Tank]

Hp = 564 in [Height of Tank Shell]

tmin = 0.25 in [Minimum Shell Thickness]

ts = 0.421 in [Minimum Shell Thickness in lowest 10% Hp]

n = 5 [Variation of Shell Thickness Along Height]

h_1 = 94 in t_1 = 0.421 in

h_2 = 94 in t_2 = 0.3683 in

h_3 = 94 in t_3 = 0.3158 in

h_4 = 94 in t_4 = 0.2634 in

h_5 = 188 in t_5 = 0.25 in

(Step 1 Continued)

$\sigma\psi$ = 30000 psi [Yield Stress of Tank Shell Material]

hc = 27.75 in [Height of Chair]

Es = $29 \cdot 10^6$ psi [Young's Modulus of Tank Shell Material]

Tank Foundation:

Vs = 5000 ft/sec [Shear Wave Velocity of Supporting Soil]

[Tank is supported on concrete floor, Auxiliary Bldg. Elev. 119']

Tank Content:

$\Gamma\phi$ = 0.0361 lbf/in^3 [Weight Density of Fluid in Tank]

H = 573.6 in [Maximum Height of Fluid]

hf = 0 in [Freeboard Height]

Tank Anchorage Bolts:

N = 32 [Number of Anchor Bolts]

d = 1.375 in [Diameter of Anchor Bolt]

[Diameter of anchor bolt is reduced from 2.5" to 1.375" to satisfy the applicable range of parameters and to obtain the allowable capacities from GIP Table C.4-1] [SEE VERIFIER COMMENT *]

hb = 120.75 in [Effective Length of Anchor Bolt]

Eb = 30000000 psi [Young's Modulus of Anchor Bolt]

* THIS IS CONSERVATIVE.

STEP 2 Ratios:

$HoverR := \frac{H}{R}$ $HoverR = 2.388$

$tsoverR := \frac{ts}{R}$ $tsoverR = 0.002$

$i := 1..n$

$tav := \frac{\sum_i \left[t_i \cdot h_i \right]}{Hp}$ $tav = 0.311$ in

$tef := \frac{tav + tmin}{2}$ $tef = 0.281$ in

$tefoverR := \frac{tef}{R}$ $tefoverR = 0.001$

$Ab := \frac{\pi \cdot d^2}{4}$ $Ab = 1.485$ in^2

$tp := \left[\frac{N \cdot Ab}{2 \cdot \pi \cdot R}\right] \cdot \left[\frac{Eb}{Es}\right]$ $tp = 0.033$ in

$cp := \left[\frac{tp}{ts}\right] \cdot \left[\frac{hc}{hb}\right]$ $cp = 0.018$

$W := \pi \cdot R^2 \cdot H \cdot \Gamma\phi$ $W = 3.754 \cdot 10^6$ lbf

* Note to User:

Before proceeding to Step 2, confirm that the values listed and ratios calculated in Step 1 are within the applicable range of parameters documented in the scope of this seismic verification procedure.

Answer: Yes [Diameter of anchor bolt is reduced to 1.375" to satisfy the applicable range of parameters and to obtain allowable capacities from Table C.4-1]

STEP 3 Fluid-Structure Modal Frequency (Impulsive Frequency)

* Note to User:

Using the following parameters, enter Table 7-3 of the PSP Section 7 and obtain Ff in Hz:

$R = 240.21$ in

$tefoverR = 0.001$

$HoverR = 2.388$

The following answer is provided by the user:

$Ff = 4.8$ Hz [This frequency is for carbon steel tanks containing water]

For tanks made of stainless steel or aluminum :

$$Ff = Ff \cdot \sqrt{\frac{0.0361}{\Gamma\phi}} \cdot \sqrt{\frac{Es}{30 \cdot 10^6}} \qquad Ff = 4.719 \text{ Hz}$$

The Borated Water Tank is made of stainless steel, therefore

$Ff = 4.719$ Hz

STEP 4 Spectral Acceleration for Impulsive Frequency

* Note to User:

Using the 4% damped maximum horizontal ground or floor (whichever is applicable) acceleration response spectrum, determine the maximum spectral acceleration Saf over the frequency range 0.8 Ff < F < 1.2 Ff.

For tanks with concrete pads founded on ground with a shear wave velocity less than 3500 ft/sec, the following is suggested in lieu of conducting soil/structure interaction analysis:

If Ff is less than the peak frequency of the maximum horizontal ground acceleration response spectrum, ignore soil/structure interaction effects.

Otherwise, use the peak spectral acceleration for Saf.

The following answer is provided by the user:

Saf = 0.18 g (page 28: 2 x 0.09)

STEP 5 Base Shear Load

* Note to User:

Using the following parameters, enter Figure 7-3 of the PSP Section 7 and obtain the base shear load coefficient Qp:

HoverR = 2.388

tefoverR = 0.001

The following answer is provided by the user:

Qp = 0.733

Therefore, the shear load at the base of the tank is equal to:

$Q = Qp \cdot W \cdot Saf$ $Q = 4.953 \cdot 10^5$ lbf

STEP 6 Base Overturning Moment

* Note to User:

Using the following parameters, enter Figure 7-4 of the PSP Section 7 and obtain the base overturning moment coefficient Mp:

HoverR = 2.388

tefoverR = 0.001

The following answer is provided by the user:

Mp = 0.382

Therefore, the overturning moment at the base of the tank is equal to:

$M = Mp \cdot W \cdot H \cdot Saf \qquad M = 1.48 \cdot 10^8$ in-lbf

STEP 7 Bolt Tensile Load Capacity

* Note to User:

Using Appendix C of the GIP, obtain anchor bolt tensile capacity Pu in lbf.

The following answer is provided by the user:

The Borated Water Tank is anchored to its foundation by 32 2.0" ϕ cast-in-place J bolts with 90-degree hooks. The minimum bend radius is 4ϕ, and the minimum straight extension of the hook is also 4ϕ. The corresponding values for the Borated Water Tank are 0.5ϕ* and 3ϕ, respectively. As a conservative assumption, the length of the hook will not be included in the embedment length. The actual embedment length provided for the anchor bolt is

$L = 92.75$ in

From Table C.4-1 of the GIP, $Lmin = 75.0$ in

(Step 7 Continued)

Sinc Lmin < L , the reduction factor for embedment is calculated as:

$$\text{Rembed} := 1.0$$

The pullout and shear capacity given in Table C.4-1 of the GIP are based on f'c of 3500 psi. Therefore, the reduction factor for f'c of 3000 psi is calculated as:

$$\text{Rconc} := \sqrt{\frac{3000}{3500}} \qquad \text{Rconc} = 0.926$$

Using Table C.4-1 of the GIP, the pullout capacity and shear capacity of a 1.375" ɸ anchor are:

$$\text{Pnom} := 50400 \quad \text{lbf}$$

$$\text{Vnom} := 25250 \quad \text{lbf}$$

Applying reduction factors

$$\text{Pu} := \text{Pnom} \cdot \text{Rembed} \cdot \text{Rconc} \qquad \text{Pu} = 4.666 \cdot 10^{4} \quad \text{lbs}$$

The allowable bolt stress is:

$$\text{Fb} := \frac{\text{Pu}}{\text{Ab}} \qquad \text{Fb} = 3.142 \cdot 10^{4} \quad \text{psi}$$

STEP 8 Top Plate of Anchor Bolt Chair

The dimensions f and c represent the length along the vertical stiffeners and thickness of the top plate, respectively. The dimension g represents the distance between the inner surfaces of the vertical stiffener plates.

* The following dimensions f, c and g are provided by the user:

$f := \frac{7.5 - d}{2}$ $f = 3.063$ in

$c := 1.5$ in

$g := 3$ in

The maximum bending stress in the top plate is calculated as:

$$\sigma := \frac{(0.375 \cdot g - 0.22 \cdot d) \cdot Pu}{f \cdot c^2}$$

$\sigma = 5.57 \cdot 10^3$ psi < $fy := 3.6 \cdot 10^4$

If the above relation is OK, there is no load reduction factor to be applied on the anchor bolt allowable tensile stress Fb. Otherwise, multiply Fb by the following reduction factor:

$$Rchair := \left[\frac{fy}{\sigma}\right]$$

$Rchair = 6.464$ (Do not use if > 1.0)

* Answer by User:

$Rchair := 1.0$

$\sigma := \sigma \cdot Rchair$ $\sigma = 5.57 \cdot 10^3$ psi

STEP 9   Tank Shell Stress

* For the calculation of the tank shell stress, the following dimensions should be provided by the user:

$a := 5$ in   [Width of chair top plate parallel to shell]

$e := 3.56$ in   [Eccentricity of anchor bolt with respect to shell outside surface]

$tb := 0.25$ in   [Thickness of base plate of tank]

$h := 28.5$ in   [Height of chair]

The maximum bending stress σ in the tank shell is:

$$Z := \frac{1.0}{\left[\frac{0.177 \cdot a \cdot tb}{\sqrt{R \cdot ts}} \cdot \left[\left[\frac{tb}{ts}\right]^2\right] + 1.0\right]}$$

$$\sigma := \left[\frac{Pu \cdot e}{ts^2}\right] \cdot \left[\frac{1.32 \cdot Z}{\left[\frac{1.43 \cdot a \cdot h^2}{R \cdot ts}\right] + \left[\left[4 \cdot a \cdot h^2\right]^{0.333}\right]} + \frac{0.031}{\sqrt{R \cdot ts}}\right]$$

$\sigma = 1.774 \cdot 10^4$ psi   < $\sigma\psi = 3 \cdot 10^4$ psi

If the above relation is OK, there is no load reduction factor to be applied on the anchor bolt allowable tensile stress Fb. Otherwise, multiply Fb by the following reduction factor:

$Rshell := \left[\frac{\sigma\psi}{\sigma}\right]$ $Rshell = 1.691$ (Do not use if > 1.0)

* Answer by User:

$Rshell := 1.0$

$Fr := Fb \cdot Rshell$ $Fr = 3.142 \cdot 10^4$ psi

STEP 10 Vertical Stiffener Plates

* The following dimensions are provided by the user:

$k = 5.25$ in [Average width of chair vertical stiffener plate]

$j = 1.0$ in [Thickness of chair vertical stiffener plate]

* The user should check that the following four relations are satisfied:

$\frac{k}{j} = 5.25 \quad < \quad \frac{95}{\sqrt{\frac{fy}{1000}}} = 15.833$

$j = 1 \quad > \quad 0.04 \cdot (h - c) = 1.08$ in (marginal, OK)

$j = 1 \quad > \quad 0.5$ in

$\frac{Pu}{2 \cdot k \cdot j} = 4.444 \cdot 10^3 \quad < \quad 21000$ psi

If one or more of the above relations are not satisfied, consult applicable codes and standards for an appropriate reduction factor or consider the tank as an outlier.

STEP 11 Chair-to-Tank Shell Weld

The required load per inch for the weld between the chair and tank shell is:

$$Ww = Pu \cdot \sqrt{\left[\frac{1}{a+2 \cdot h}\right]^2 + \left[\frac{e}{a \cdot h + 0.667 \cdot h^2}\right]^2}$$

* The user should provide thickness of leg of weld and check that the following relation is satisfied:

$tw = 0.25$ in

$Ww = 790.786$ < or = $\frac{30600 \cdot tw}{\sqrt{2}} = 5.409 \cdot 10^3$

If the above relations are not satisfied, consult applicable codes and standards for an appropriate reduction factor or consider the tank as an outlier.

STEP 12 Fluid Pressure for Elephant-Foot Buckling

* Using the following parameters, enter Figure 7-7 of the PSP Section 7 and obtain the fluid pressure coefficient Pep for elephant-foot buckling:

$Saf = 0.18$ g

$HoverR = 2.388$

The following answer is provided by the user:

$Pep = 2.7$

Based on the value of Pep, the fluid pressure at the base of the tank for elephant-foot buckling is:

$Pe = Pep \cdot \Gamma\phi \cdot R$

$Pe = 23.413$ psi

STEP 13 Elephant-Foot Buckling Stress Capacity Factor

* Using the following parameters, enter Figure 7-8 of the PSP Section 7 and obtain the fluid pressure coefficient Pep for elephant-foot buckling:

$Pe = 23.413$

$tsoverR = 0.002$

The following answer is provided by the user for tanks made of Carbon Steel:

$\sigma_{\pi\epsilon} := 19$ ksi

$\sigma_{\pi\epsilon} := \sigma_{\pi\epsilon} \cdot 1000$ $\qquad \sigma_{\pi\epsilon} = 1.9 \cdot 10^{4}$ psi

For tanks made of stainless steel or aluminum, the following procedure applies:

$$S1 := \frac{R}{400 \cdot ts}$$

$$S2 := \frac{S1 + \left[\frac{\sigma\psi}{36000}\right]}{S1 + 1}$$

$$\sigma_{\pi\epsilon} := \frac{0.6 \cdot Es}{\frac{R}{ts}} \cdot \left[1 - \left[\frac{Pe \cdot R}{\sigma\psi \cdot ts}\right]^{2}\right] \cdot \left[1 - \left[\frac{1}{1.12 + S1^{1.5}}\right]\right] \cdot S2$$

$\sigma_{\pi\epsilon} = 1.471 \cdot 10^{4}$ psi

For the Borated Water Tank, $\sigma_{\pi\epsilon} = 1.471 \cdot 10^{4}$ psi

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STEP 14 Fluid Pressure for Diamond-Shape Buckling

* Using the following parameters, enter Figure 7-9 of the PSP Section 7 and obtain the pressure coefficient Pep for diamond-shape buckling:

$Saf = 0.18$ g

$HoverR = 2.388$

The following answer is provided by the user:

$Pdp = 2.5$

Based on the value of Pdp, the fluid pressure at the base of the tank for diamond-shape buckling is:

$Pd = Pdp \cdot \Gamma\phi \cdot R$

$Pd = 21.679$ psi

STEP 15 Diamond-Shape Buckling Stress Capacity Factor

* Using the following parameters, enter Figure 7-10 of the PSP Section 7 and obtain the stress capacity factor σpd for diamond-shape buckling:

$Pd = 21.679$ psi

$tsoverR = 0.002$

The following answer is provided by the user:

$\sigma\pi\delta = 23.5$ ksi

$\sigma\pi\delta = \sigma\pi\delta \cdot 1000$ $\quad$ $\sigma\pi\delta = 2.35 \cdot 10^4$ psi

This value of σpd is for carbon steel. For tanks made of stainless steel or aluminum, the following procedure is applied:

* Using the following parameter, enter Figure 7-11 of the PSP Section 7, obtain $\delta\Gamma$, and calculate σpd:

$\frac{Pd}{Es} \cdot \left[\frac{R}{ts} \right]^2 = 0.243$ $\quad$ $\delta\Gamma = 0.09$ [Figure 7-11]

$\phi = \frac{1}{16} \cdot \sqrt{\frac{R}{ts}}$ $\quad$ $\Gamma = 1 - 0.73 \cdot [1 - \exp(-\phi)]$

$\sigma\pi\delta = [0.6 \cdot \Gamma + \delta\Gamma] \cdot \left[\frac{Es}{\frac{R}{ts}} \right]$ $\quad$ $\sigma\pi\delta = 1.781 \cdot 10^4$ psi

For the Borated Water Tank, $\sigma\pi\delta = 1.781 \cdot 10^4$ psi

STEP 16 Allowable Buckling Stress

The allowable buckling stress σc is calculated as 72% of the lower value of σpe or σpd.

$jjj := 0..1$

$\sigma\pi_0 := \sigma\pi\varepsilon$ $\qquad \sigma\pi_0 = 1.471 \cdot 10^4$ psi

$\sigma\pi_1 := \sigma\pi\delta$ $\qquad \sigma\pi_1 = 1.781 \cdot 10^4$ psi

$\sigma\chi := 0.72 \cdot \min(\sigma\pi)$

$\sigma\chi = 1.059 \cdot 10^4$ psi

STEP 17 Overturning Capacity of Tank

Ductile Failure:

Ductile failure modes are

Anchor bolt stretching (Step 7)

Chair top plate bending (Step 8)

Tank shell bending (Step 9)

Using the following parameters, enter Figure 7-12 of the PSP Section 7, and obtain the base overturning moment coefficient Mcapp:

$$cp = 0.018$$

$$\frac{\sigma\chi}{Fr} \cdot \frac{hc}{hb} = 0.077$$

$$Mcapp = 0.08$$ [Figure 7-12]

The base overturning moment is:

[User Note: Use the smaller value of Fb or FR from Steps 7, 8, 9, 10, or 11]

$$McapDUCT = Mcapp \cdot (2 \cdot Fr) \cdot \left[R^2 \cdot ts \right] \cdot \left[\frac{hb}{hc} \right]$$

$$McapDUCT = 5.315 \cdot 10^8$$ in-lbf

STEP 17 Continued

Brittle Failure:

Brittle failure modes are

Concrete cone failure (Step 7)

Chair stiffener plate shear or buckling failure (Step 10)

Chair-to-tank wall weld shear failure (Step 11)

Using the following parameters, enter Table 7-4 of the PSP Section 7, and obtain the base overturning moment coefficient Mcapp:

$$cp = 0.018$$

$$Mcapp = 0.041 \qquad \text{[Table 7-4]}$$

The base overturning moment is:

$$McapBRIT = Mcapp \cdot (2 \cdot Fr) \cdot \left[R^2 \cdot ts \right] \cdot \left[\frac{hb}{hc} \right]$$

$$McapBRIT = 2.724 \cdot 10^8 \quad \text{in-lbf}$$

STEP 18 Capacit vs. Demand for Base Overturning Moment

* If the expected failure mode is ductile, the user should select the McapDUCT for use as Mcap. However, if the expected failure mode is brittle, the user should select the lower of McapDUCT and McapBRIT for use as Mcap.

For the Borated Water Tank, the expected failure mode is brittle (90-degree hook does not meet requirements). Therefore,

$$\mathbf{Mcap} = \mathbf{McapBRIT}$$

$$\mathbf{Mcap} = 2.724 \cdot 10^{8} \quad \text{in-lbf}$$

The base overturning moment demand is determined from Step 6 and it is equal to:

$$\mathbf{M} = 1.48 \cdot 10^{8} \quad \text{in-lbf}$$

* The user should check that the following relation is satisfied:

$$\mathbf{Mcap} = 2.724 \cdot 10^{8} \quad > \text{ or } = \quad \mathbf{M} = 1.48 \cdot 10^{8} \quad [\text{OK}]$$

STEP 19 Base Shear Load Capacity

The base shear load capacity is determined as:

$$Qcap = 0.55 \cdot (1 - 0.218 \cdot Saf) \cdot W$$

$$Qcap = 1.983 \cdot 10^{6} \quad lbf$$

STEP 20 Capacity vs. Demand for Base Shear

* The user should check that the following relation is satisfied:

$Qcap = 1.983 \cdot 10^{6}$ > or = $Q = 4.953 \cdot 10^{5}$ OK

STEP 21 Slosh Height

$G = 386.4$ in/sec/sec [Acceleration of Gravity]

The sloshing mode frequency is:

$$Fs = \frac{1}{2\cdot\pi}\cdot\sqrt{\frac{1.84\cdot G}{R}\cdot\tanh\left[\frac{1.84\cdot H}{R}\right]} \qquad Fs = 0.274 \quad \text{Hz}$$

* Note to User:

Using the 1/2% damped maximum horizontal ground or floor (whichever is applicable) acceleration response spectrum, determine the spectral acceleration Sas at frequency = Fs.

$Sas = 0.08$ g (page 21 @ 0.5 Hz: 2 x 0.04)

The slosh height is:

$hs = 0.837\cdot R\cdot Sas$ $hs = 16.084$ in

STEP 22 Freeboard Clearance vs. Slosh Height

* The user should check that the following relation is satisfied:

$hf = 0$ > or = $hs = 16.084$ NG

If the above relation is not satisfied, consider the tank as an outlier.

Borated Water Tank is an outlier

CONCLUSION: Tank under evaluation is an outlier per PSP Section 7 seismic verification procedure.

Conditions: The type of concrete anchorage is assumed to consist of J bolts. Should be confirmed later.

8. **HORIZONTAL BORIC ACID TANK**

The following pages document the seismic verification of the Horizontal Boric Acid Tank by using the PSP Section 7 Methodology [Reference 4].

FPC- Crystal River Unit 3

USI A-46 Project

Tanks Evaluation

Tank: Horizontal Boric Acid Tank [CAT-5A and CAT-5B]

Originator: Samir J. Serhan 10/08/1993

Reviewer: Gary M. Jackson

Program Name: TANKh1

Dr. Samir J. Serhan
Gilbert/Commonwealth,Inc.
May 10, 1993

SEISMIC VERIFICATION OF HORIZONTAL TANKS AND HEAT EXCHANGERS

Scope:

This seismic verification procedure is applicable to tanks with the following characteristics:

(a) cylinderical tanks and heat exchangers,

(b) curved bottom supported by saddle plates,

(c) anchored to a stiff foundation,

(d) all base plates under the saddles have slotted holes in the longitudinal direction except for the one under the saddle at one end,

(e) tank and saddles are made of steel,

(f) saddles are uniformly spaced,

(g) tank overhanging at both ends (each) should be less than half of the uniform spacing between saddles, and

(h) dimensions for tank shell, anchorage, and content should fall within the following range of parameters:

[See the following page]

Diameter of Tank (D):	1' to 14'
Length of Tank (L):	4' to 60'
Height of Center-of-Gravity of Tank and Fluid above floor (Hcg):	1' to 12'
Number of Saddles (NS):	2 to 6
Spacing between Support Saddles (S):	3' to 20'
Number of Bolting Locations per Saddle (NL):	2 to 3
Number of Anchor Bolts per Bolting Location (NB):	1 to 2
Distance between Extreme Anchor Bolts in Base Plate of Saddle (Dprime):	1' to 12'
Ratio of Tank C.G. Height to Saddle Spacing (Hcg/S):	0.1 to 2.0
Ratio of Tank C.G. Height to Distance between Extreme Anchor Bolts (Hcg/Dprime):	0.5 to 2.0

Weight Density:

Horizontal Tanks (GAMMAt):	60 to 75 lb/ft^3
Horizontal Heat Exchangers (GAMMAh):	130 to 180 lb/ft^3

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Evaluation Process:

Per the PSP Section 7 [Reference 4], the seismic verification for horizontal tanks and heat exchangers consists of the following 11 steps:

* STEP 1 INPUT DATA to be provided by the user

Tank:

D = 9 ft [Diameter of Tank]

L = 17.08 ft [Length of Tank]

t = 0.25 in [Thickness of Tank Shell]

Wtf = 73000 lb [Weight of Tank plus Fluid]

GAMMAt = 61.16 lb/ft^3 [Weight Density of Tank]

GAMMAh = 0 lb/ft^3 [Weight Density of Heat Exchanger]

Hcg = 5.28 ft [C.G. of Tank and Fluid above Floor]

Saddles:

S = 9.92 ft [Spacing between Support Saddles]

h = 12 in [Height of Saddle Plate from bottom of Tank to Base Plate]

G = 11153846 psi [Shear Modulus of Saddle Plate and Stiffener Material]

E = 29000000 psi [Elastic Modulus of Saddle Plate and Stiffener Material]

NS = 2 [Number of Saddles]

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Base Plate:

tb = 0.75	in	[Thickness of Base Plate under Saddle]
fy = 30000	psi	[Minimum Specified Yield Strength of Saddle Base Plate]
tw = 0.25	in	[Thickness of Leg of Weld between Saddle and Base Plate]
es = 2.7	in	[Eccentricity from Anchor Bolt Centerline to Vertical Saddle Plate]

Bolts:

NL = 2		[Number of Bolt Locations on each Saddle]
NB = 2		[Number of Anchor Bolts at each Bolt Location]
d = 1.0	in	[Diameter of Anchor Bolt]
Dprime = 102	in	[Distance between Extreme Anchor Bolts in Base Plate of Saddle]

* Note to User:

Before proceeding to Step 2, confirm that the values listed and ratios calculated in Step 1 are within the applicable range of parameters documented in the scope of this seismic verification procedure.

Answer: Yes

STEP 2   Anchor Bolt Allowable Loads

Per Section 4.4 and Appendix C of the GIP [Reference 1], the following values are determined for the anchor bolt allowables:

$\text{Puprime} := 2670$ lbs   [Anchor Bolt Allowable Tension]

$\text{Vuprime} := 13350$ lbs   [Anchor Bolt Allowable Shear]

Reduction factor for concrete strength,

$\text{RFconc} := \sqrt{\left[\frac{3000}{3500}\right]}$ $\text{RFconc} = 0.926$

$\text{Puprime} := \text{Puprime} \cdot \text{RFconc}$ $\text{Puprime} = 2.472 \cdot 10^{3}$ lbs

$\text{Vuprime} := \text{Vuprime} \cdot \text{RFconc}$ $\text{Vuprime} = 1.236 \cdot 10^{4}$ lbs

STEP 3   Base Plate Bending Strength Reduction Factor

The base plate bending strength reduction factor is equal to the ratio of the base plate yield strength over the maximum bending stress:

$\text{RB} := \frac{\left[\text{fy} \cdot \text{tb}^{2}\right]}{(3 \cdot \text{Puprime})}$ $\text{RB} = 2.276$

STEP 4   Base Plate Weld Strength Reduction Factor

The base plate weld strength reduction factor is equal to the ratio of the weld allowable strength (30600 psi) over the weld stress:

$\text{RW} := \frac{\left[2 \cdot \left[\sqrt{2}\right] \cdot \text{tw} \cdot \text{es} \cdot 30600\right]}{\text{Puprime}}$ $\text{RW} = 23.634$

STEP 5 Anchorage Allowable Loads

The tension allowable anchorage load is:

$$Rsmaller := if(RW > RB, RB, RW)$$

$$Rsmaller = 2.276$$

$$Pu := Puprime \cdot Rsmaller \qquad Pu = 5.625 \cdot 10^3 \text{ lb}$$

The shear allowable anchorage load is:

$$Vu := Vuprime \qquad Vu = 1.236 \cdot 10^4 \text{ lb}$$

STEP 6 Ratios

Calculate the following items:

$$\alpha := \frac{Pu}{Vu}$$

$$Wb := \frac{Wtf}{(NS \cdot NL \cdot NB)}$$

$$F1 := \sqrt{\left[\left[NS^2\right] + 1\right]}$$

$$F2 := \sqrt{\left[NL^2 \cdot \left[\frac{Hcg}{Dprime}\right]^2 + \left[\frac{Hcg}{S}\right]^2 \cdot \left[\frac{NS^2}{(NS - 1)^2}\right]\right]}$$

STEP 7 Acceleration Capacity of Tank Anchorage

$\lambda 1 := \left[\frac{Vu}{Wb}\right] \cdot \left[\frac{1}{F1}\right]$ $\lambda 1 = 0.606$ g

$\lambda 2 := \frac{\left[\frac{Vu}{Wb} + \frac{0.7}{\alpha}\right]}{\left[\left[\frac{0.7}{\alpha}\right] \cdot F2 + F1\right]}$ $\lambda 2 = 0.745$ g

Pick smaller of the above two values,

$\lambda := \mathbf{if}(\lambda 1 > \lambda 2, \lambda 2, \lambda 1)$ $\lambda = 0.606$ g

STEP 8 Tank Stiffness in Transverse and Vertical Directions

* Note to User:

Using the following parameters, enter Figure 7-14 (Tanks) or Figure 7-15 (Heat Ecchangers) of the PSP Section 7 and obtain the maximum saddle spacing for rigid transverse and vertical response:

$\frac{D}{12} = 0.75$ ft (D = 9' from page 105)

$t = 0.25$ in

The following answer is provided by the user:

$Sc := 19.3$ ft or $Sc \cdot 12 = 231.6$ in

If Sc > or = S ======> Tank is Rigid

If Sc < S ======> Tank is Flexible

* Note to User:

The following answer is provided by the user:

"Tank is _Rigid_ in the Transverse and Vertical Directions"

STEP 9 Tank Stiffness in Longitudinal Direction

The longitudinal stiffness of the end unslotted saddle is determind by assuming a fixed end at the tank and a pinned end at the base plate.

* Note to User:

Calculate the moment of inertia (Iyy) and area (As) of the saddle plate and its stiffeners at a cross section just below the bottom of the cylindrical tank. The following answer is provided by the user:

$As := 79$ in^2

$Iyy := 115$ in^4

$g := 386$ in/sec^2

$$ks := \frac{1}{\left[\frac{h^3}{(3 \cdot E \cdot Iyy)} + \frac{h}{(As \cdot G)}\right]} \qquad ks = 5.367 \cdot 10^6 \text{ lb/in}$$

$$Flong := \frac{1}{[2 \cdot \pi]} \cdot \sqrt{\frac{(ks \cdot g)}{Wtf}} \qquad Flong = 26.811 \text{ Hz}$$

If Flong > or = 30 ======> Tank is Rigid

If Flong < 30 ======> Tank is Flexible

* Note to User:

The following answer is provided by the user:

"Tank is ___Flexible___ in the Longitudinal Direction"

STEP 10 Seismic Demand Acceleration

* Note to User:

Using the 4% damped maximum horizontal ground or floor (whichever is applicable) acceleration response spectrum, determine the spectral acceleration demand:

If Sc > or = S

and

If Flong > or = 30

The following answer is provided by the user:

Sa = 0.044 g [Page 28 @ 28 Hz: 2 x 0.022]

Otherwise,

The following answer is provided by the user:

Sa = 0.71 g [Page 28 @ 11.5 Hz: 2 x 0.353]

* Note to User:

The following answer is provided by the user:

Sa = 0.044 g [Demand: since Flong = 26.81 Hz]

Knowing that: $\lambda = 0.606$ g [Capacity]

If Capacity is > Demand ======> Tank Anchorage is Okay

If Capacity is < Demand ======> Tank Anchorage is No Good

* Note to User:

The following answer is provided by the user:

"Tank Anchorage is ___Okay___"

STEP 11 Saddle Stresses

Note to User:

The end unslotted saddle snould resist the longitudinal seismic shear load causing weak-axis berdir.g. In addition, all saddles should resist the vertical seismic and dead loads, and the overturning moment from transverse seismic loads.

The combined compression and bending stresses in the saddles should be evaluated according to the AISC Manual with the 1.7 increase factor on the allowable stresses (SSE Loading).

The Seismic Review Team will evaluate the saddle stresses during the official A-46 in-plant walkdowns.

CONCLUSION: Tank under evaluation is acceptable per PSP Section 7 seismic verification procedure.

Conditions: The Seismic Review Team will evaluate Step 11 during the A-46 in-plant walkdowns.

---

9. CONCLUSIONS

Plots and tables of the generated 4.0% damped OBE acceleration response spectra are documented in Section 4 for the free-field ground and the Auxiliary Building Elevation 119'.

Seismic verification of four tanks is performed in Sections 5 through 8 by using the PSP Section 7 Methodology [Reference 4]. The verification results are:

- <u>Condensate Storage Tank [CDT-1]</u>

  Result: Tank is acceptable

- <u>Dedicated Emergency Feedwater Tank [EFT-2]</u>

  Result: Tank is an outlier

  Reasons: Base shear and overturning moment exceed allowable values.

- <u>Borated Water Tank [DHT-1]</u>

  Result: tank is an outlier

  Reasons: Freeboard clearance is not acceptable

  Conditions: Concrete anchorage is assumed to consist of J Bolts

- <u>Horizontal Boric Acid Tank [CAT-5A and CAT-5B]</u>

  Result: tanks are acceptable

  Conditions: Seismic Review Team will evaluate Step 11 during the A-46 in-plant walkdowns.

CALCULATION	SUBJECT FPC - Crystal River Unit 3 Seismic Verification of Tanks		IDENTIFIER DC-5520-161.0SE		PAGE A0 OF 4 PAGES
	REV.	0	1	2	3
	MICROFILMED				
	ORIGINATOR	S.J. Serhan			WO.
	DATE	01/18/94			

ATTACHMENT A G/C DESIGN INFORMATION TRANSMITTAL

POWER AND INDUSTRIAL SYSTEMS DIVISION – READING

DESIGN INFORMATION TRANSMITTAL

A. REQUEST

TO: J.K. BEIL (RESPONDENT'S FULL NAME) LOCATION: ______

FROM: G.M. JACKSON (REQUESTER'S FULL NAME) LOCATION: ______

DATE: 5/21/93 RESPONSE REQUESTED BY: 5/24/93 (DATE)

SUBJECT: WATER LEVELS, ETC. FOR TANKS => CDT-1, DHT-1, EFT-2, CAT-5A/-5B, AND DFT-3A/-3B

REQUEST THE FOLLOWING FOR EACH TANK:

a) weight density of fluid in tank

b) Height of fluid @ the maximum level to which the tank will be filled.

c) Height of freeboard above fluid ~~level~~ surface @ the maximum level to which the tank will be filled (GMJ 5-21-93)

ATTACHMENT: YES ___ NO X SIGNATURE G.M. Jackson

cc:

B. NOTE: IF INFORMATION FORWARDED BELOW IS NOT A RESPONSE TO A DOCUMENTED REQUEST, STATE "N/A" IN BLANKS ABOVE.

RESPONSE

TO: G.M. JACKSON LOCATION: ______

FROM: J.K. BEIL (RESPONDENT'S FULL NAME) DATE: 5-24-93

SEE ATTACHED SHEETS (2).

STATUS OF INFORMATION: PRELIMINARY ___ FINAL X

SOURCE(S): SEE ATTACHED SHEETS

ATTACHMENT: YES X NO ___ SIGNATURE J.K. Beil

cc: E.B. Toll

SUMMARY OF TANK DATA

The following is in response to your DIT dated May 21, 1993. All of the information has been referenced or assumed with engineering judgement. The data has not been verified.

When a level range is given as maximum or minimum, the level may fall somewhere between the two points during operation. The maximum and minimum levels may not be achieved during operation due to procedural/operational intervention or operator action due to alarms.

The height of freeboard is not given since levels above tank bottom are given and the freeboard height can be calculated from that point.

<u>CDT-1</u>

Maximum Height = 151'-6" el. (390" above inside tank bottom)
[This height is based on the CDV-113 interlock from Ref. 1]

Minimum Height = 123'10¼" el. (58" above inside tank bottom)
[Based on NPSH and Vortexing from Ref. 2]

Weight Density of Fluid = 62.305 lbm/ft^3 (70 °F) to 61.376 lbm/ft^3 (140 °F)
[Refs. 3 and 4]

<u>DHT-1</u>

Maximum Height = 47.8' above tank bottom (Ref. 5, p. 20 for maximum inventory)

Minimum Height = 119'-10" el. (8" above tank bottom)
[Based on min. usable volume from Ref. 6]

Weight Density of Fluid = 62.426 lbm/ft^3 (40 °F) to 61.996 lbm/ft^3 (100 °F)
[Based on water and from Refs. 5, p. 20 and 4]

<u>EFT-2</u>

Maximum Height = 38'-9" above tank bottom
[Based on the Hi-Alarm point from Ref. 7]

Minimum Height = 121'-7" el. (3'-1" above tank bottom)
[Based on min. usable volume from Ref. 8]

Weight Density of Fluid = Assumed the same as for CDT-1

<u>DFT-3A/3B</u>

Maximum Height = 31" above tank bottom
[Based on DFP-1A/1B auto stop point and Ref. 9]

Minimum Height = 5 13/16" above tank bottom
[Based on level at 2nd seat of foot valve and Ref. 9]

Weight Density of Fluid = 60.84 lbm/ft^3
[Based on Fuel Oil No. 6 at 100 °F and Refs. 4 and 10]

CAT-5A/5B

Maximum Height = 95" above tank bottom
[Based on the Hi-Level Alarm and Ref. 11]

Minimum Height = 30" above tank bottom
[Based on the Lo-Level Alarm and Ref. 11]

Weight Density of Fluid = 61.16 lbm/ft^3 (152 °F) to 60.94 lbm/ft^3 (164 °F)
[Based on water as a fluid since the saturation of boric acid is approximately 7% and Refs. 12 and 13]

REFERENCES

1. FPC IDS CD-58-LS, Rev. 9

2. G/CI Calculation DC-5520-124-01.00-ME, Rev. 0

3. FPC Spec. SP-5745, Addendum C, 6/16/70

4. Crane 410, 1981

5. FPC EDBD for Decay Heat Removal, Rev. 3

6. G/CI Calculation DC-5520-124-03.00-ME, Rev. 0

7. FPC EDBD for Emergency Feedwater/Emergency Feedwater Initiation and Control, TC No. 230, sheet 4 of 5

8. G/CI Calculation EFC-0428-5503-022-001, Rev. 2

9. FPC Calculation M-91-1032, Rev. 1

10. FPC RO-2891, Rev. 14

11. IDS CA-11-LS, Rev. 6 and CA-13-LS, Rev. 7

12. Keenan and Keyes Thermodynamic Properties of Steam, 1936

13. FPC IDS CA-12-TS1, Rev. 2

CALCULATION	SUBJECT FPC - Crystal River Unit 3 Seismic Verification of Tanks			IDENTIFIER DC-5520-161.0SE	PAGE A0 OF 2 PAGES
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	MICROFILMED				
	ORIGINATOR	S.J. Serhan			WO.
	DATE	01/18/94			

ATTACHMENT B FPC TELECOPY
DEDICATED EMERGENCY FEEDWATER TANK

P.1 #2

TELECOPY
FLORIDA POWER CORPORATION
GENERAL OFFICE COMPLEX
ST. PETERSBURG, FLORIDA

DATE 10/7/93

TO/COMPANY GARY JACKSON / GCI

FROM GLENN PUGH / FPC

TELECOPY NUMBER

ADDITIONAL PAGES OF TELECOPY 1

FPC telecopy # (813) 866-4984
If you have any problems in receipt of this telecopy, please notify telecopy operator at (813) 866-4494.

FOR FPC (Nuclear) USE ONLY: DISTRIBUTE & SEND BY MAIL ☐ DISCARD ☐ HOLD FOR PICK-UP ☒

CALL WHEN SENT ☐ MAIL TO RECIPIENT ☐

NOTES:

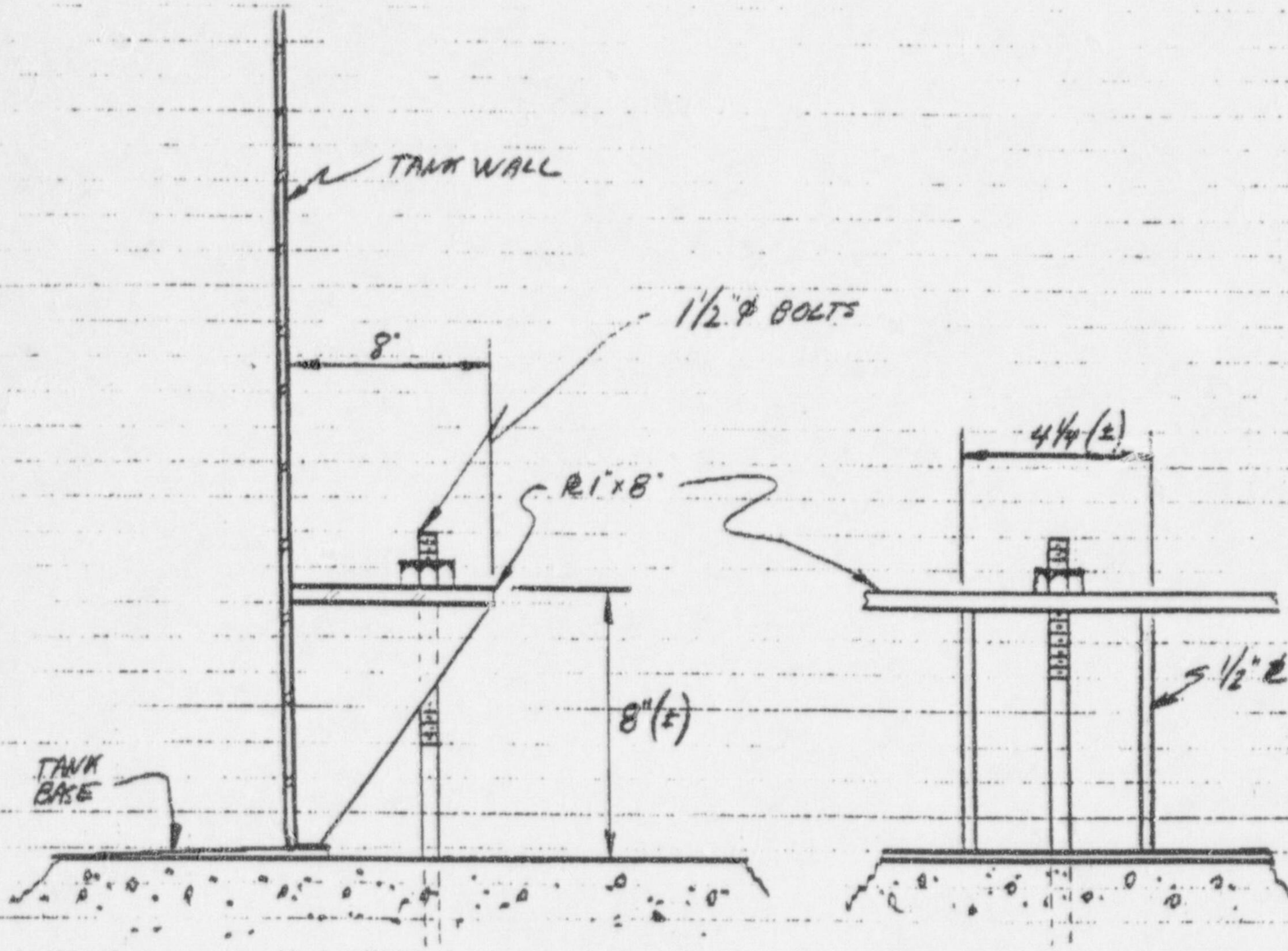
GARY,

ATTACHED IS THE ANCHOR BOLT DETAIL FOR THE EFW TANK.

HOPE IT HELPS

Glenn

DC-5520-161... p. 2 of 2



CALCULATION	SUBJECT FPC - Crystal River Unit 3 Seismic Verification of Tanks			IDENTIFIER DC-5520-161.0SE	PAGE A0 OF
	REV. 0	1	2	3	
	MICROFILMED				PAGES
	ORIGINATOR S.J. Serhan				WO.
	DATE 01/18/94				

ATTACHMENT C DESIGN VERIFICATION RECORD

DCP 2.05

DESIGN VERIFICATION RECORD

PAGE A1 OF 2

PROJECT: Crystal River Unit 3

SUBJECT: FPC- Crystal River # 3- Seismic Verification of Tanks

IDENTIFIER: DC-5520-161 .0SE

DISCIPLINE NAME AND NUMBER: Structural/Piping 2241 & 2242

W.O. 04-5520-161

A

Samir J. Serhan — ORIGINATOR

Samir J. Serhan — PROJECT ENGINEER

THIS DOCUMENT CONTAINS PRELIMINARY DATA/ASSUMPTIONS:

NO ✓ YES ______ PAGE(S) ______

A COMPUTER PROGRAM WAS:

✓ NOT USED ______ USED

PROGRAM SYSTEM NAME	REV.	VALIDATED & USED WITHIN LIMITS OF VERIFICATION	MUST BE VERIFIED TOGETHER WITH CALC.
(1)			
(2)			
(3)			

VERIFICATION PACKAGE (IDENTIFY EACH ITEM)

DOCUMENTS TO BE VERIFIED	REV.		REV.
(1) Calculation # DC-5520-161.0SE	0	(4)	
(2)		(5)	
(3)		(6)	

SUPPORTING DOCUMENTS	REV.		REV.
(1) See Page 4		(6)	
(2)		(7)	
(3)		(8)	
(4)		(9)	

Samir J. Serhan — ORIGINATOR'S SIGNATURE

1/19/94 — DATE

B

NO VERIFICATION REQUIRED PER DCP 2.05:

REASON: ______

VERIFICATION REQUIRED (CHECK METHOD(S)):

DESIGN REVIEW ✓ ALTERNATE CALCULATION ______ QUALIFICATION TESTING ______

IDENTIFICATION OF VERIFIER/~~VERIFICATION TEAM~~ Gary M. Jackson

Samir J. Serhan — PROJECT ENGINEER'S SIGNATURE

1/19/94 — DATE

W.O. 0' 5520-161	IDENTIFIER: DC-5520-161.0SE
	PAGE A2 OF 2

C | CONCURRENCE WITH SELECTION OF VERIFIER(S):

[signature]
DISCIPLINE CHIEF ENGINEER'S SIGNATURE

1/19/94
DATE

D | EXTENT OF VERIFICATION:

COMPUTER PROGRAM USE (IF APPLICABLE):

(1)______________________ PROGRAM NAME(S)

PROGRAM IS VALIDATED PER DCP 1.40 AND HAS BEEN USED WITHIN THE ESTABLISHED LIMITS OF VERIFICATION AS SHOWN ON THE PROGRAM VERIFICATION RECORDS. A COPY OF THE DVR HAS BEEN SENT TO THE MANAGER OF ENGINEERING SERVICES.

(2)______________________ PROGRAM NAME(S)

PROGRAM IS NOT VALIDATED OR NOT USED WITHIN THE LIMITS OF VERIFICATION. THE PROGRAM IS VERIFIED TOGETHER WITH THIS CALCULATION AS DESCRIBED BELOW.

Detailed Review of Calculation # DC-5520-161.0SE Revision 0 per DCP 2.05.

RESULTS OF VERIFICATION:

Reviewer thoroughly reviewed the analytical procedure utilized, results obtained, and conclusions.

Reviewer concurs with the findings of this calculation.

Calculation # DC-5520-161.0SE Revision 0 is complete and acceptable.

ATTESTATION:

THIS DESIGN VERIFICATION WAS PERFORMED IN ACCORDANCE WITH DCP 2.05.

[signature]
VERIFIER'S SIGNATURE

1/19/94
DATE

E | COMPLETION OF VERIFICATION AND APPROVAL:

[signature]
PROJECT ENGINEER'S SIGNATURE

1/19/94
DATE

ENCLOSURE 2

FLORIDA POWER CORPORATION
CRYSTAL RIVER UNIT 3
DOCKET NUMBER 50-302/LICENSE NUMBER DPR-72

USI A-46 OUTLIER RESOLUTION SCHEDULE AND STATUS

UNRESOLVED SAFETY ISSUED A-46

CRYSTAL RIVER UNIT 3

USI A -46 OUTLIER RESOLUTION SCHEDULE AND STATUS

UNRESOLVED SAFETY ISSUE (USI) A-46, GENERIC LETTER 87-02

A list that identified and described 111 outliers was included with the RAI response provided by FPC to the NRC in letter, 3F0397-28, dated March 27, 1997.

At the request of the NRC staff, FPC has prepared an action plan for resolving these USI A-46 outliers. This action plan commits FPC to resolve a number of outliers prior to restart scheduled for December 1997. The methodology used to select which outliers would be resolved prior to restart and which outliers will be worked later is outlined below.

There are one hundred eleven (111) outlying components identified by tag numbers on the outlier list. The detailed list showing the current status of each outlier is provided here in Enclosure 2. These 111 outliers are categorized as either Restart or Post-Restart. The categorizing of outliers was based on their association with plant systems that were assessed for readiness in accordance with the methodology of the CR-3 System Readiness Review Plan. This plan was submitted to the NRC by FPC letters, 3F0397-19, dated March 27, 1997, and, 3F0397-36, dated March 31, 1997. The System Readiness Review Plan was implemented for 105 plant systems using a graded approach methodology. Each of the systems were classified into one of three levels. The level classification was determined by a safety significance process relying on three aspects. The first aspect utilized a fission product barrier approach to comply with 10 CFR 50, Appendix A II. The second aspect relied on an analytical approach which took into consideration several system specific factors such as, PSA model importance, Maintenance Rule risk significance, Improved Technical Specification safety significance, and Safety Classification. The third aspect considered previous assessment results and findings, number of modifications performed on the system, and other opportunities for configuration changes. Based on these aspects, the systems are classified as Level 1, Level 2, and Level 3. As a result, the outlying components have been categorized and tabulated as follows.

Restart: Out of the 111 outliers, FPC will resolve 70 outliers by restart in December 1997. This number consists of the following:

19 Safety related components in System Readiness Level 1 systems.
38 Safety related components (and some non-safety related components considered important to start-up activities), in System Readiness Level 2 systems. And, safety related components in System Readiness Level 3 systems.
10 Components in systems of various system readiness levels solely in need of maintenance to resolve.
3 Components (including the Control Room Ceiling that will be resolved as part of the Control Room noise abatement modification, MAR 97-03-04-01).

Post-Restart: The remaining 41 outliers will be completed based on a work-off curve that will be developed prior to restart. All outliers are required to be resolved before December 2000. This number is consists of the following:

24 Non-safety related components in System Readiness Level 2 systems.
17 Non-safety related components in System Readiness Level 3 systems.

ID Number	Tag Number	Description	Restart Outlier	Work Priority Category	Disposition Status	Disposition Document	Comments
1	DFT-3A	DIESEL GENERATOR FUEL OIL DAY TANK A	Y	1	To be determined (TBD)		Programmatic Solutions to assist in resolving outlier
2	DFT-3B	DIESEL GENERATOR FUEL OIL DAY TANK B	Y	1	To be determined		Programmatic Solutions to assist in resolving outlier
3	DHT-1	BORATED WATER STORAGE TANK	Y	1	95%	Revise SEWS and Revised Calculation yet to be done	Acceptable as is
4	EFT-2	EMERGENCY FEEDWATER TANK	Y	1	To be determined		Programmatic Solutions to assist in resolving outlier
5	EGCP-2A	EMERGENCY DIESEL GEN A ELECTRICAL EQUIPMENT CABINET	Y	1	To be determined		Programmatic Solutions to assist in resolving outlier
6	EGCP-2B	EMERGENCY DIESEL GEN B ELECTRICAL EQUIPMENT CABINET	Y	1	To be determined		Programmatic Solutions to assist in resolving outlier
7	EGDG-1B	DIESEL GENERATOR B	Y	1	To be determined		Programmatic Solutions to assist in resolving outlier
8	ESCP-4A	ENGINEERED SAFEGUARDS ACTUATION RELAY CABINET 4A	Y	1	50%	Verbal agreement with Ops.	Operations is taking lead to have storage cabinet and tool boxes moved to less vital area.
9	ESCP-4B	ENGINEERED SAFEGUARDS ACTUATION RELAY CABINET 4B	Y	1	50%	Verbal agreement with Ops.	Operations is taking lead to have storage cabinet and tool boxes moved to less vital area.
10	ESCP-4C	ENGINEERED SAFEGUARDS ACTUATION RELAY CABINET 4C	Y	1	50%	Verbal agreement with Ops.	Operations is taking lead to have storage cabinet and tool boxes moved to less vital area.
11	ESCP-4D	ENGINEERED SAFEGUARDS ACTUATION RELAY CABINET 4D	Y	1	50%	Verbal agreement with Ops.	Operations is taking lead to have storage cabinet and tool boxes moved to less vital area.
12	ESCP-5A	ENGINEERED SAFEGUARDS ACTUATION RELAY CABINET 5A	Y	1	0%	Work Request(WR) No. (LATER)	WR to be written to fix lower door latch
13	MUP-1A	MAKE-UP AND PURIFICATION PUMP 3A	Y	1	100%	WR# NU0344791	Walkdown on 6/23/97 showed that a U-Bolt was inplace. WR to be voided. No outlier present now.
14	MUV-051	LET-DOWN FLOW CONTROL VALVE	Y	1	To be determined	WR# (LATER)	Work Request to be written to resolve
15	MUV-200	LETDOWN ISOLATION VALVE TO DEMINERALIZER MUDM-1A	Y	1	To be determined		Programmatic Solutions to assist in resolving outlier
16	MUXS-1	4160V ISOLATION SWITCH	Y	1	100%	WR# NU0344312	Work Request written to inspect further
17	RCV-10	PRESSURIZER POWER OPERATED RELIEF VALVE	Y	1	70%	Analysis/Calculation 001	Seismic Demand issue
18	RCV-11	PRESSURIZER BLOCK VALVE	Y	1	70%	Analysis/Calculation 001	Seismic Demand issue

ID Number	Tag Number	Description	Restart Outlier	Work Priority Category	Disposition Status	Disposition Document	Comments
19	RR2B	ENGINEERED SAFEGUARD AUXILIARY RELAY RACK RR2B	Y	1	100%	WR# NU0344784	Work complete in field. Field has fixed latch, replaced missing screws
20	ACDP-68-T	ES DISTRIBUTION PANEL 3AB TRANSFORMER	Y	2	To be determined		
21	AH-196-POS1	AHD-1 CONTROL	Y	2	To be determined	WR# (LATER)	Programmatic Solutions to assist in resolving outlier
22	AH-196-POS3	AHD-3 CONTROL	Y	2	To be determined	WR# (LATER)	Work Request to be written
23	AH-967-SV	AHD-1 & AHD-1D CONTROL	Y	2	To be determined		Programmatic Solutions to assist in resolving outlier
24	AHD-01D	CONTROL COMPLEX MAKE-UP AIR	Y	2	To be determined		Programmatic Solutions to assist in resolving outlier
25	DCP-1B	DECAY HEAT CLOSED CYCLE COOLING PUMP B	Y	2	To be determined		This is a problem with a pipe hanger. This may be rolled into the effort being done to resolve generic piping issues.
26	DPBA-1A	250/125V BATTERY A	Y	2	To be determined		Programmatic Solutions to assist in resolving outlier
27	DPBA-1B	250/125V BATTERY B	Y	2	To be determined		Programmatic Solutions to assist in resolving outlier
28	DRRD-2-1	CRD DC BREAKER CABINET UNIT 1 & 2	Y	2	20%	WR# NU0344316	WR written to inspect further - on Hold pending operations permission to access cabinet
29	DRRD-2-2	CRD DC BREAKER CABINET UNIT 3 & 4	Y	2	20%	WR# NU0344316	WR written to inspect further - on Hold pending operations permission to access cabinet
30	DRRD-2-3	CRD DC BREAKER CABINET TRIP RESET	Y	2	20%	WR# NU0344316	WR written to inspect further - on Hold pending operations permission to access cabinet
31	MSV-411	MAIN STEAM LINE A-2 ISOLATION VALVE	Y	2	To be determined		Programmatic Solutions to assist in resolving outlier
32	MTSW-2C	4160V ES 3A (NORTH)	Y	2	To be determined		Programmatic Solutions to assist in resolving outlier
33	MTSW-2E	4160V ES 3B (NORTH)	Y	2	20%	WR# NU0344313	WR written to inspect further - on Hold pending operations permission to access cabinet
34	MTSW-2F	4160V ES 3B (SOUTH)	Y	2	20%	WR# NU0344313	WR written to inspect further - on Hold pending operations permission to access cabinet
35	MTSW-3F	480V ES BUS 3A	Y	2	To be determined		Programmatic Solutions to assist in resolving outlier
36	MTSW-3F-T	4160/480V ES BUS 3A TRANSFORMER	Y	2	To be determined		Programmatic Solutions to assist in resolving outlier

ID Number	Tag Number	Description	Restart Outlier	Work Priority Category	Disposition Status	Disposition Document	Comments
37	MTSW-3G	480V ES BUS 3B	Y	2	To be determined		Programmatic Solutions to assist in resolving outlier
38	MTSW-3G-T	4160/480V ES BUS 3B TRANSFORMER	Y	2	To be determined		Programmatic Solutions to assist in resolving outlier
39	NI-1-A3	PROPORTIONAL COUNTER ASSEMBLY	Y	2	To be determined		
40	NI-2-B3	PROPORTIONAL COUNTER ASSEMBLY	Y	2	To be determined		
41	NI-3-C3	COMPENSATED ION CHAMBER/ASSEMBLY	Y	2	To be determined		
42	NI-4-D3	COMPENSATED ION CHAMBER/ASSEMBLY	Y	2	To be determined		
43	RSA	REMOTE SHUTDOWN RELAY CABINET A	Y	2	To be determined		
44	RSA-1	REMOTE SHUTDOWN RELAY CABINET A-1	Y	2	To be determined		
45	RWP-2A	NUCLEAR SERVICE SEA WATER PUMP 3A	Y	2	60%	Analysis/Calculation 004	Calculation to verify long pump shaft
46	RWP-2B	NUCLEAR SERVICE SEA WATER PUMP 3B	Y	2	60%	Analysis/Calculation 004	Calculation to verify long pump shaft
47	RWP-3A	DECAY HEAT SERVICE SEA WATER PUMP 3A	Y	2	60%	Analysis/Calculation 004	Calculation to verify long pump shaft
48	RWP-3B	DECAY HEAT SERVICE SEA WATER PUMP 3B	Y	2	60%	Analysis/Calculation 004	Calculation to verify long pump shaft
49	SWP-1A	EMERGENCY NUCLEAR SERVICE CCC PUMP 3A	Y	2	100%	WR# NU0344310	WR written to inspect further. Follow-up inspections found the SWP's to be acceptable
50	SWP-1B	EMERGENCY NUCLEAR SERVICE CCC PUMP 3B	Y	2	100%	WR# NU0344796	WR written to inspect further. Follow-up inspections found the SWP's to be acceptable
51	SWP-1C	NORMAL NUCLEAR SERVICE CLOSED CYCLE COOLING PUMP	Y	2	100%	WR# NU0344311	WR written to inspect further. Follow-up inspections found the SWP's to be acceptable
52	SWV-354-SV1	SWV-354 CONTROL	Y	2	To be determined		
53	SWV-354-SV2	SWV-354 CONTROL	Y	2	To be determined		
54	VBIT-1A	DUAL INPUT INVERTER 3A	Y	2	To be determined		

ID Number	Tag Number	Description	Restart Outlier	Work Priority Category	Disposition Status	Disposition Document	Comments
55	WDT-1A	WASTE GAS DECAY TANK 1A	Y	2	95%	Closed based on inspection of tapes and photos	Revise SEWS yet to be done
56	WDT-1B	WASTE GAS DECAY TANK 1B	Y	2	95%	Closed based on inspection of tapes and photos	Revise SEWS yet to be done
57	WDT-1C	WASTE GAS DECAY TANK 1C	Y	2	95%	Closed based on inspection of tapes and photos	Revise SEWS yet to be done
58	AH-196-POS2	AHD-2 CONTROL	Y	3	10%	TBD	Walkdown to determine WR scope
59	ATCP-1	ANTICIPATED TRANSIENT WITHOUT SCRAM LOGIC CABINET	Y	3	100%	WR# NU0344792	WR completed. Outlier complete with missing bolts now installed.
60	CAP-1B	BORIC ACID PUMP B	Y	3	100%	WR# NU0344793	WR# NU0344793 returned with work being completed. Field installed missing bolts. Dated 6/24/97
61	IAP-1A	INSTRUMENT AIR COMPRESSOR A	Y	3	10%	TBD	Walkdown to determine WR scope
62	NI&P-D2	NI&P SYSTEM SUBASSEMBLY D CABINET 2	Y	3	10%	TBD	Walkdown to determine WR scope
63	VBXS-1B	VITAL BUS TRANSFER SWITCH B	Y	3	10%	WR# NU0344786	WR written to resolve outlier. Waiting for field work to complete.
64	VBXS-1C	VITAL BUS TRANSFER SWITCH C	Y	3	10%	WR# NU0344787	WR written to resolve outlier. Waiting for field work to complete.
65	VBXS-1D	VITAL BUS TRANSFER SWITCH D	Y	3	10%	WR# NU0344788	WR written to resolve outlier. Waiting for field work to complete.
66	VBXS-3B	EFIC VITAL BUS TRANSFER SWITCH B	Y	3	10%	WR# NU0344789	WR written to resolve outlier. Waiting for field work to complete.
67	VBXS-3D	EFIC VITAL BUS TRANSFER SWITCH D	Y	3	10%	WR# NU0344790	WR written to resolve outlier. Waiting for field work to complete.
68	AHF-17A	CONTROL COMPLEX NORMAL SUPPLY FAN A	Y	4	80%	PEERE 1512	Fixing as part of CC Noise Abatement project. PEERE 1512 issued to replaced isolator. Waiting for field work to be completed.
69	AHF-17B	CONTROL COMPLEX NORMAL SUPPLY FAN B	Y	4	80%	PEERE 1512	Fixing as part of CC Noise Abatement project. PEERE 1512 issued to replaced isolator. Waiting for field work to be completed.
70	CEILING	CONTROL ROOM CEILING	Y	4	20%	MAR 97-03-04-01	Fixing as part of CC Noise Abatement project.
71	AHP-01A	CONTROL COMPLEX HVAC AIR COMPRESSOR A	N	5	To be determined		

ID Number	Tag Number	Description	Restart Outlier	Work Priority Category	Disposition Status	Disposition Document	Comments
72	AHP-01B	CONTROL COMPLEX HVAC AIR COMPRESSOR B	N	5	To be determined		
73	AHP-01C	CONTROL COMPLEX HVAC AIR COMPRESSOR	N	5	To be determined		
74	AHP-01D	CONTROL COMPLEX HVAC AIR COMPRESSOR D	N	5	To be determined		
75	DPBA-1C	250/125V BATTERY C	N	5	90%	Analysis/Calculation 003	Masonry wall failure due to seimic event is not a concern, acceptable as is.
76	DPBC-1G	BATTERY CHARGER G	N	5	90%	Analysis/Calculation 003	Masonry wall failure due to seimic event is not a concern, acceptable as is.
77	DPBC-1H	BATTERY CHARGER H	N	5	90%	Analysis/Calculation 003	Masonry wall failure due to seimic event is not a concern, acceptable as is.
78	DPBC-1I	BATTERY CHARGER I	N	5	90%	Analysis/Calculation 003	Masonry wall failure due to seimic event is not a concern, acceptable as is.
79	DPDP-1C	250/125V DC MAIN PANEL 3C	N	5	90%	Analysis/Calculation 003	Masonry wall failure due to seimic event is not a concern, acceptable as is.
80	DPDS-1C	BATTERY 3C DISCONNECT SWITCH	N	5	90%	Analysis/Calculation 003	Masonry wall failure due to seimic event is not a concern, acceptable as is.
81	DPXS-1C	DPBC-I INPUT POWER TRANSFER SWITCH	N	5	To be determined		
82	MTMC-09	480V PRESSURIZER HEATER MCC 3B	N	5	To be determined		
83	MTMC-12	480V TURBINE MCC 3A	N	5	To be determined		
84	MTSW-3A	480V TURBINE AUXILIARY BUS A	N	5	To be determined		
85	MTSW-3C	480V REACTOR AUXILIARY BUS A	N	5	To be determined		
86	MTSW-3D	480V REACTOR AUXILIARY BUS B	N	5	To be determined		
87	MTSW-3J	480V PLANT AUXILIARY BUS	N	5	95%	Revise SEWS	Acceptable as is
88	MTSW-3J-T	4160/480V PLANT AUXILIARY BUS TRANSFORMER	N	5	To be determined		
89	RWP-1	NORMAL NUCLEAR SERVICES SEA WATER PUMP MOTOR COOLER	N	5	60%	Analysis/Calculation 004	STAAD Analysis of long pump shaft

ID Number	Tag Number	Description	Restart Outlier	Work Priority Category	Disposition Status	Disposition Document	Comments
90	SF-9-FIT	SPENT FUEL COOLANT FLOW TRANSMITTER	N	5	To be determined		
91	WDT-3A	RC BLEED TANK 3A	N	5	To be determined		
92	WDT-3B	RC BLEED TANK 3B	N	5	To be determined		
93	WD[illegible]3C	RC BLEED TANK 3C	N	5	To be determined		
94	WDT	REACTOR COOLANT DRAIN TANK	N	5	To be determined		
95	CDHE-[illegible]	MAIN CONDENSER A	N	6	To be determined		
96	CDH[illegible]4B	MAIN CONDENSER B	N	6	To be determined		
97	ER1	EVENTS RECORDER CABINET 1	N	6	To be determined		
98	ER2	EVENTS RECORDER CABINET 2	N	6	To be determined		
99	ER3	EVENTS RECORDER CABINET 3	N	6	To be determined		
100	ER4	EVENTS RECORDER CABINET 4	N	6	To be determined		
101	ER5	EVENTS RECORDER CABINET 5	N	6	To be determined		
102	ER6	EVENTS RECORDER CABINET 6	N	6	To be determined		
103	ER7	EVENTS RECORDER CABINET 7	N	6	To be determined		
104	ER8	EVENTS RECORDER CABINET 8	N	6	To be determined		
105	ICS-5	INTEGRATED CONTROL SYSTEM CABINET 5	N	6	To be determined		
106	NGT-XX	ADV BACKUP NITROGEN SUPPLY TANKS (10)	N	6	To be determined		
107	NNI-5	AUXILIARY CONTROL SYSTEM CABINET 5	N	6	To be determined		

ID Number	Tag Number	Description	Restart Outlier	Work Priority Category	Disposition Status	Disposition Document	Comments
108	NNI-6	AUXILIARY CONTROL SYSTEM CABINET 6	N	6	To be determined		
109	PORV/TEMP	PORV & TEMPERATURE SATURATION CABINET	N	6	To be determined		
110	RFL MPLXR	RFL MULTIPLEXER FOR 500 KV SWITCHYARD	N	6	To be determined		
111	TPC	TRANSMITTER POWER SUPPLY CABINETS A & B	N	6	To be determined		

Work Priority Categories:

Restart Categories:

1 = System Readiness Level 1 systems - safety related.
2 = System Readiness Level 2 systems - safety related,
System Readiness Level 2 systems - Non-safety related but considered important to startup, and
System Readiness Level 3 systems - safety related.
3 = Various System Readiness Levels, requiring minor maintenance only.
4 = Control Room noise abatement modification (PEERE 1512 and MAR 97-03-04-01).

Post-Restart Categories:

5 = System Readiness Level 2 systems - non-safety related.
6 = System Readiness Level 3 systems - non-safety related.