Client: PLG, INC Calculation Number: 93C1793.2-02

Title: IPEEE FRAGILITY EVALUATION FOR BEAVER VALLEY UNIT 2 DEVELOPMENT OF BEAVER VALLEY UNIT 2 HCLPFs FOR FLAT BOTTOM TANKS

Project: IPEEE FRAGILITY EVALUATION FOR BEAVER VALLEY, UNIT 2

Method: SEE SHEET 1&2 OF 32

Acceptance Criteria: N/A

Remarks:

Verification Method ☒ Design Review Method ☐ Alternate Calculation ☐ Qualification Test ☐ Other ☐ No Verification Necessary

Results:

REVISIONS

Revision No.	0		
Description	Original Issue		
Total Pages (Cumulative)	32		
By/Date	/ 1-23-97		
Checked/Date	PRW 1-23-97		
Approved/Date	PRW 1-23-97		

S&A
Stevenson and Associates

CALCULATION
COVER
SHEET

FIGURE 2.8

CONTRACT NO.
93C1793 (B)

9811190213 981112
PDR ADOCK 05000412
P PDR

CLIENT PLG/DUQUESNE LIGHT JOB No. 93C1783.2 SHEET 1 OF 32

SUBJECT IPEEE FRAGILITY EVALUATION FOR BEAVER VALLEY UNIT 2

DEVELOPMENT OF BEAVER VALLEY UNIT 2 HCLPFS FOR FLAT BOTTOM TANKS

REVISIONS 0 SHS 1/23/97
PRJ 1-23-97

I, INTRODUCTION

THIS CALCULATION DOCUMENTS THE DEVELOPMENT OF FRAGILITIES FOR FLAT BOTTOM TANKS. THE TANK EVALUATIONS INCLUDED A WALKDOWN, REVIEW OF DRAWINGS, DOCUMENTATION AND HCLPF CALCULATIONS. IN GENERAL THE TANKS WERE JUDGED DURING THE WALKDOWN TO BE AS OR MORE SEISMICALLY RESISTANT AS THE UNIT 1 TANKS. THE FOLLOWING TANKS WERE EVALUATED IN THIS CALCULATION:

2WTD-TK23	DEMINERALIZED WATER STORAGE TANK, DIA=48' HT=48'
2FWE-TK-210	PRIMARY PLANT - DEMINERALIZED WATER STORAGE TANK, DIA.=30' HT=30'
2WTD-TK211	TURBINE PLANT DEMINERALIZED WATER STORAGE TANK, DIA.=30' HT=30'
2CHS-TK21A & B	BORIC ACID TANKS, DIA=13'-6" HT=13'-11"
2QSS-TK21	RWST, DIA=50', HT=62'

THIS CALCULATION INCLUDES A DETAILED EVALUATION OF THE ANCHORAGE CAPACITY AND ANCHORAGE TO TANK CAPACITY FOR TANK 2WTD-TK23. THIS WAS JUDGED TO HAVE THE MOST VULNERABLE CHAIR DETAIL. THE CALCULATION INDICATES THAT THE CHAIR, CONNECTION TO THE TANK AND ANCHORAGE EMBEDMENT ARE SUFFICIENT TO DEVELOP THE FULL YIELD STRENGTH OF THE ANCHORAGE.

S&A
Stevenson and Associates
A Structural-Mechanical Consulting Engineering Firm

CLIENT PLG/DUQUESNE LIGHT JOB No. 93C17B3.2 SHEET 2 OF 32
SUBJECT IPEEE FRAGILITY EVALUATION FOR BEAVER VALLEY UNIT 2
DEVELOPMENT OF BEAVER VALLEY UNIT 2 HCLPFs FOR FLAT BOTTOM TANKS

REVISIONS
0 JBS 1/23/97
PRW 1-23-97

THE ANCHORAGE EVALUATION IS FOLLOWED BY A DETAILED HCLPF CALCULATION FOR THE TANK. THE ANCHORGE DETAILS FOR THE OTHER TANKS WERE JUDGED ADEQUATE BASED ON COMPARISON TO THE WORST CASE CALCULATION FOR 2WTD-TK23. THE HCLPF CALCULATIONS FOR THE OTHER TANKS USING STEVENSON & ASSOC. COMPUTER PROGRAM TANKV.

THE INPUT SPECTRA FOR THE GROUND SUPPORTED TANKS IS THE UNIFORM HAZARD GROUND SPECTRA FOR THE BEAVER VALLEY SITE. THESE TANKS INCLUDE 2WTD-TK23, 2FWE-TK-210, 2WTD-TK211 AND 2QSS-TK21. THE INPUT SPECTRA FOR THE BORIC ACID TANKS 2CHS-TK21A & TK21B IS THE AXLB UHS IN-STRUCTURE RESPONSE SPECTRA AT ELEVATION 735'.

PROGRAM TANKV CALCULATES A HCLPF FOR TANKS USING THE METHODOLOGY DEVELOPED BY R.P. KENNEDY IN NUREG/CR NP-6041

S&A
Stevenson and Associates
A Structural-Mechanical Consulting Engineering Firm

CLIENT PLG/DUQUESNE LIGHT JOB No. 93C1783.2 SHEET 3 OF 32
SUBJECT IPEEE FRAGILITY EVALUATION
FOR BEAVER VALLEY UNIT 2

2WTD - TK23 - PRIMARY PLANT
DEMINERALIZED WATER STORAGE TANK

REVISIONS
0 DDS 1/15/97
PRW 1-23-97

II. 2WTD - TK23

A. INTRODUCTION

THE DEMINERALIZED WATER STORAGE TANK IS 48' IN DIAMETER AND 48' IN HEIGHT. IT WAS CHOSEN FOR A DETAILED HCLPF EVALUATION DUE TO THE RELATIVE LIGHT ANCHORAGE AND OVERALL SIZE.

THE CALCULATION INCLUDES A DETAILED EVALUATION OF THE ANCHORAGE CAPACITY. INCLUDED IS A CALCULATION OF THE CHAIR CAPACITY. THE REMAINING CALCULATION INCLUDES A HCLPF CALCULATION USING STEVENSON & ASSOCIATES PROGRAM TANKU.

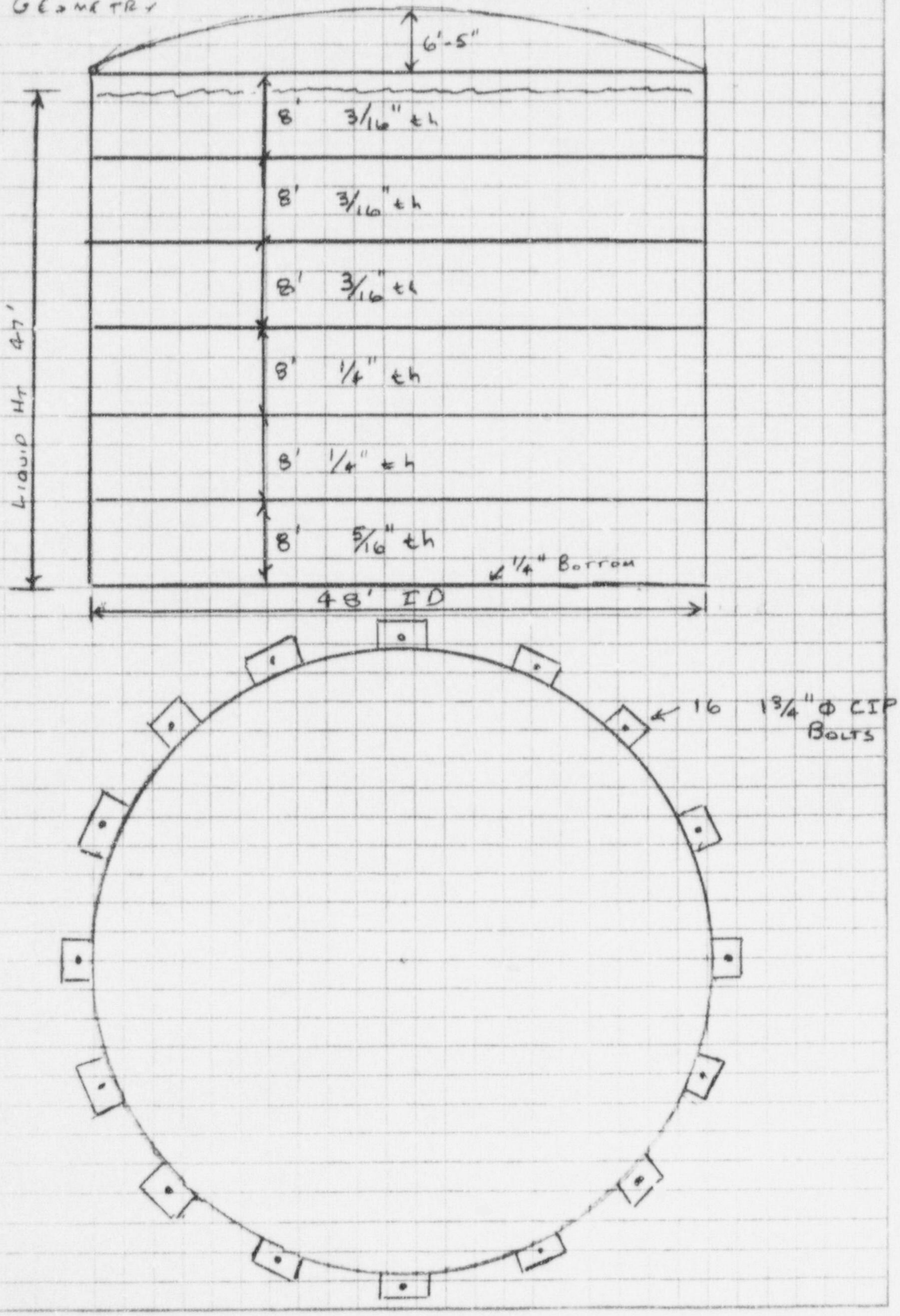
CLIENT PLG / DUQUESNE LIGHT JOB No. 93C1783.2 SHEET 4 OF 32

SUBJECT IPEEE FRAGILITY EVALUATION
FOR BEAVER VALLEY UNIT 2

2WTD-TK23
DEMINERALIZED WATER STORAGE TANK

REVISIONS
0 DJS 1/15/97
PRW 1-23-97

B. TANK GEOMETRY



CALC. # 93C1783.2-02

Stevenson and Associates
A Structural-Mechanical Consulting Engineering Firm

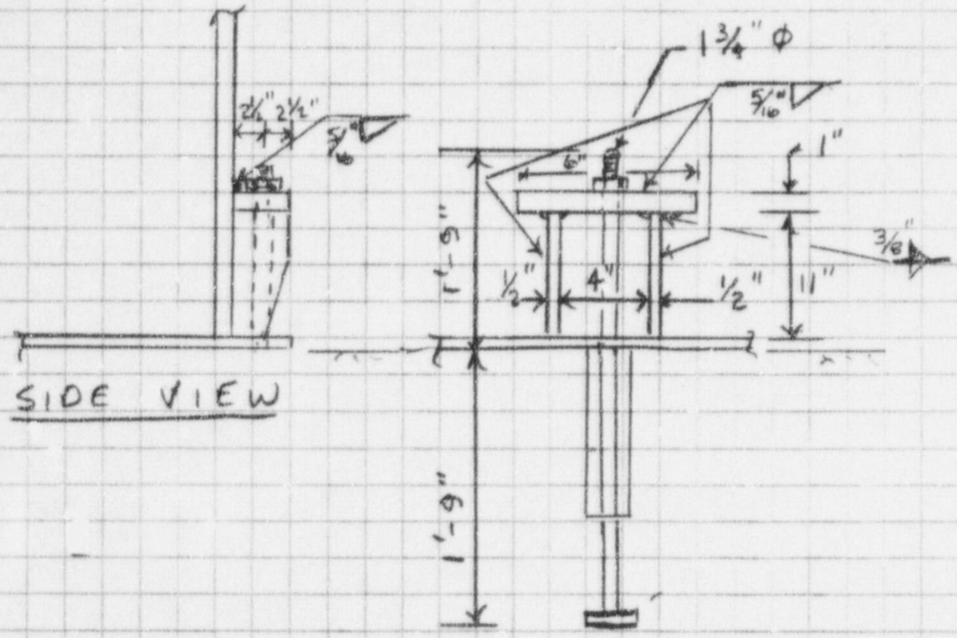
CLIENT PLG/Duquesne Light JOB No. 93C1783.2 SHEET 5 OF 32

SUBJECT IPEEE Fragility Evaluation
For Beaver Valley Unit 2

2WTD - TK23
Demineralized Water Storage Tank

REVISIONS	
0	JHS 1/15/97 PRW 1-23-97

C. CHAIR DETAILS



SIDE VIEW

FRONT VIEW

D. ANCHORAGE STRENGTH

1. BOLT STRENGTH

WILL CONSERVATIVELY USE .9 OF YIELD STRENGH

FOR BOLT. ~ $.9 \times 36^{ksi} = 32.4^{ksi}$

BOLT STRENGTH = $2.4053^{in^2} \cdot 32.4^{ksi} = 77.9^{k}$

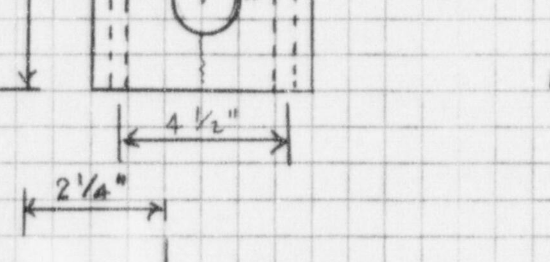
CHECK EMBEDMENT ~ $21'' > 10 \cdot (1.75) = 17.5''$ OK

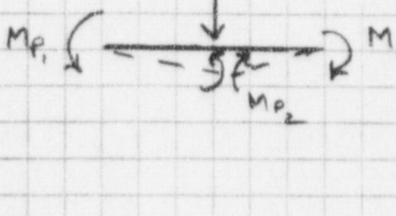
MEETS SQUG GIP CRITERIA > 10 · DIA

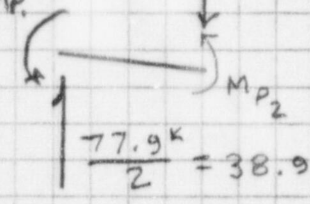
CHECK TOP CHAIR PLATE

WILL CONSERVATIVELY ASSUME FAILURE OCCURS WHEN PLASTIC HINGE IS FORMED @ CENTER OF 1" CHAIR PLATE AND @ ½" GUSSET PLATES

2. BOLT CHAIR CAPACITY - SIMPLIFIED APPROACH







$\frac{77.9^K}{2} = 38.95^K = P/2$

$\Sigma M_2 = 0 \Rightarrow P/2 \cdot (2.25") - M_{P_1} - M_{P_2} = 0$

$M_{P_1} = \frac{b d^2}{4} \cdot .9 \cdot (36^{ksi}) = \frac{5(.5)^2}{4} \cdot .9 \cdot (36) = 10.125^{k-in}$

$\uparrow$ Φ FACTOR

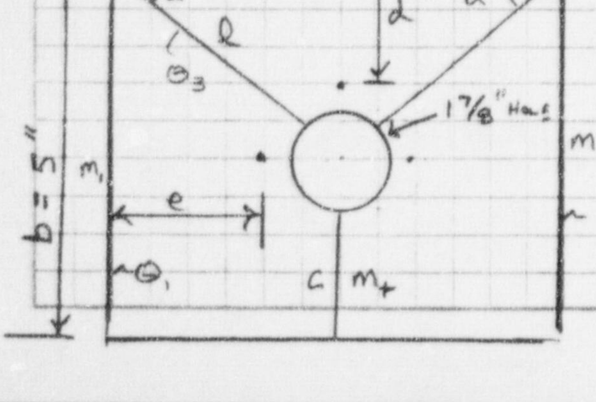
$M_{P_2} = \frac{(5 - 1.875) \cdot 1^2}{4} \cdot .9 \cdot (36^{ksi}) = 25.313^{k-in}$

$P/2 \cdot (2.25)" = M_{P_1} + M_{P_2} = 10.125^{k-in} + 25.313^{k-in}$

$\Rightarrow P_{max} = 31.5^K < 77.9^K$ ∴ CHAIR MAY GOVERN CAPACITY

3. BOLT CHAIR CAPACITY - USING YIELD LINE EVALUATION

DERIVATION OF YIELD LINE CHAIR FORMULA



d IS THE MEASUREMENT TO WHERE THE NUT IMPARTS LOAD TO THE PLATE.

$d = 2.5" - .9375" - .2188" = 1.3437"$

(.9375" — 1/2 HOLE; .2188" — 1/2 DIST FROM HOLE TO EDGE OF NUT)

$e = 2.0" - .9375" - .2188" = .8437"$

FROM VIRTUAL WORK EQUILIBRIUM:

$$2m_1 b \cdot \Theta_1 + m_2 a \Theta_2 + 2m_+ c \Theta_1 + 2m_+ l \Theta_3 = P\begin{Bmatrix}\delta_d \\ \text{or} \\ \delta_e\end{Bmatrix}$$

$$\delta_e = \Theta_1 \cdot e \qquad \delta_d = \Theta_2 \cdot d$$

$$\Theta_1 \cdot \cos\alpha = \Theta_2 \sin\alpha \Rightarrow \Theta_2 = \Theta_1 (\cot\alpha)$$

$$\Theta_3 = \Theta_{31} + \Theta_{32}, \quad \Theta_{32} = \Theta_2 \cos\alpha \qquad \Theta_{31} = \Theta_1 \sin\alpha$$

$$\Theta_3 = \Theta_1 \sin\alpha + \Theta_2 \cos\alpha$$

$$\Theta_3 = \Theta_1 \sin\alpha + \Theta_1 \frac{\cos^2\alpha}{\sin\alpha} \Rightarrow \Theta_3 \sin\alpha = \Theta_1 (\overset{1}{\cancel{\sin^2\alpha + \cos^2\alpha}})$$

$$\Theta_3 = \frac{\Theta_1}{\sin\alpha}$$

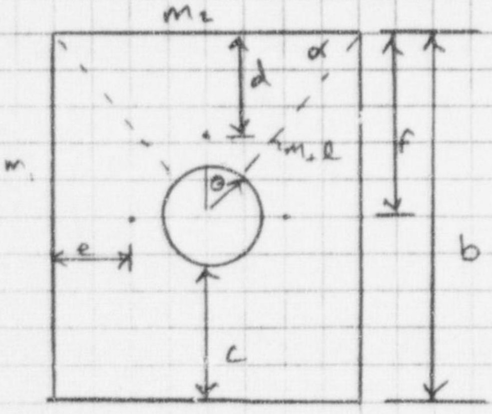
SUBSTITUTE IN EQUILIBRIUM EQN.

$$2m_1 b \cancel{\Theta_1} + m_2 a \cancel{\Theta_1}(\cot\alpha) + 2m_+ c \cancel{\Theta_1} + 2m_+ \frac{l \cancel{\Theta_1}}{\sin\alpha}$$

$$= P \cancel{\Theta_1} e \text{ or } P \cancel{\Theta_1} \cot\alpha \cdot d$$

WHICHEVER IS LESS

WILL ASSUME $\sigma_y = 36$ KSI low STRENGTH



$a = 4''$, $b = 5''$

$R_B = .9375''$ $\quad C = 1.5625''$

$f = 2.5''$, $e = .8437''$, $d = 1.3437''$

$$l \sin\alpha + R_B \cos\Theta = f = 2.5'' \Rightarrow$$

$$x = l \sin\alpha = 2.5'' - .9375'' \cos\Theta$$

$$l \cos\alpha + R_B \sin\Theta = \frac{a}{2} = 2'' \Rightarrow y = l\cos\alpha = 2'' - .9375'' \sin\Theta$$

$$l = \sqrt{x^2 + y^2} \qquad \sin\alpha = \frac{x}{l}$$

CLIENT PLG / DUQUESNE LIGHT JOB No. 93C1783.2 SHEET 8 OF 36

SUBJECT IPEEE FRAGILITY EVALUATION
FOR BEAVER VALLEY UNIT 2

2WTD - TK23
DEMINERALIZED WATER STORAGE TANK

REVISIONS
0 HJS 1/15/97
GRW 1-28-97

m_1 ~ GOVERNED BY CHAIR SUPPORT GUSSET THICKNESS)

$$= \overset{\leftarrow \Phi \text{ FACTOR}}{.9} \cdot \left[\frac{(36^{ksi}) \cdot (.5^2)}{4} \right] = 2.025 \ {}^{K-IN}/_{IN.}$$

m_+ ~ IS IN CHAIR PLATE

$$= .9 \cdot \left[\frac{36^{ksi} \cdot (1^2)}{4} \right] = 8.1 \ {}^{K-IN}/_{IN}$$

m_2 ~ GOVERNED BY TOP OF TANK WALL (WHERE WELD IS)

$$= .9 \cdot \left[\frac{36^{ksi} \cdot (.3125)^2}{4} \right] = .791 \ {}^{K-IN}/_{IN}$$

TRIAL Θ	x	y	L	$\sin\alpha$	$\cot\alpha$	M	D	P
0	1.5625	2"	2.538	0.64	1.2006	113.6	.8437	134.6
45°	1.837	1.337	2.272	0.8085	0.7278	93.4	.8437	110.7
60°	2.03125	1.1881	2.353	0.8632	0.5849	91.6	.7859	116.6
50°	1.8974	1.2818	2.290	0.82863	0.6756	92.47	.8437	109.6
55°	1.9623	1.2320	2.317	0.84691	0.62784	91.9	.8436	108.9 ← GOVERNS
53°	1.9358	1.2513	2.305	0.83983	0.64639	92.1	.8437	109.2
56°	1.9758	1.2228	2.324	0.85033	0.61888	91.8	.8316	110.4
54°	1.9490	1.2415	2.311	0.84341	0.63702	92.0	.8437	109.0

$$M \text{ FOR } 0° = 2 \cdot (2.025^K)(5) + .791\,(4'')(1.2006) + 2(8.1)(1.5625) + 2(8.1)\frac{2.538}{0.64} = 113.6$$

D = .8437 OR 1.6132
↖ GOVERNS (SMALLER)

$$M \text{ FOR } 45° = 2(2.025)(5) + .791\,(4)(.7278) + 2(8.1)(1.5625) + 2(8.1)\frac{2.272}{.8035} = 93.4$$

D = .8437 OR .9779
↖ GOVERNS

$$M \text{ FOR } 60° = 2(2.025)(5) + .791\,(4)(.5849) + 2(8.1)(1.5625) + 2(8.1)\frac{2.353}{.8632} = 91.6$$

D = .8437 OR .7859 ← GOVERNS

CALC. 93[illegible]783.2-02

S&A
Stevenson and Associates
A Structural-Mechanical Consulting Engineering Firm

CLIENT PLG/Duquesne Light JOB No. 9361783.2 SHEET 9 OF 32
SUBJECT IPEEE Fragility Evaluation
For Beaver Valley Unit 2

2WTD-TK23
Demineralized Water Storage Tank

REVISIONS
0 DDS 1/15/97
ORL 1-23-97

$$M \text{ for } 50° = 2(2.025)(5) + .791(4)(.6756) + 2(8.1)(1.5625) + 2(8.1)\frac{2.290}{.82863} = 92.47 \quad D = .8437 \text{ or } .9078$$

↑ Governs

$$M \text{ for } 55° = 2(2.025)(5) + .791(4)(.62784) + 2(8.1)(1.5625) + 2(8.1)\frac{2.317}{.84691} = 91.9 \quad D = .8437 \text{ or } .8436$$

↙ Govern

$$M \text{ for } 53° = 2(2.025)(5) + .791(4)(.64639) + 2(8.1)(1.5625) + 2(8.1)\frac{2.305}{.83983} = 92.1 \quad D = .8437 \text{ or } .8685$$

↙ Governs

$$M \text{ for } 56° = 2(2.025)(5) + .791(4)(.61888) + 2(8.1)(1.5625) + 2(8.1)\frac{2.324}{.85033} = 91.8 \quad D = .8437 \text{ or } .8316$$

↙ Governs

$$M \text{ for } 54° = 2(2.025)(5) + .791(4)(.63702) + 2(8.1)(1.5625) + 2(8.1)\frac{2.311}{0.84341} = 92.0 \quad D = .8437 \text{ or } .8560$$

↙ Governs

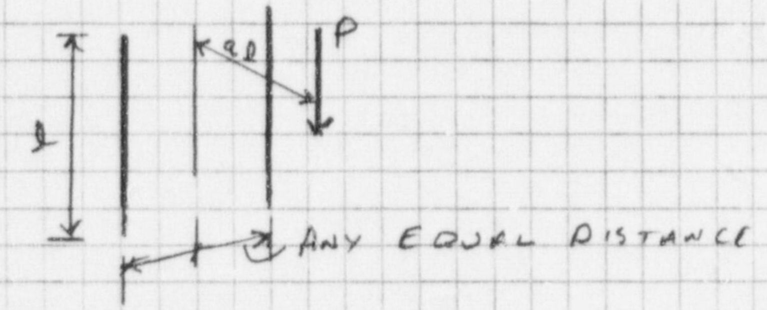
Limiting Chair Load = $108.9^K > 77.9^K$ ∴ Chair capable of restraining bolt yield load.

4. Check Weld to Tank Connection

In order to determine if the weld to tank is sufficiently strong to transfer the full bolt load to the tank wall - Table XIX of Section 4 (Pg 4-76) of the AISC Eighth Edition of the "Manual of Steel Construction" will be used.

THE TABLE INCLUDES COEFFICIENTS FOR CALCULATING AN ALLOWABLE LOAD, BASE ON THE GEOMETRY OF THE WELD PATTERN AND THE ECCENTRIC LOAD.

FROM THE TABLE:



SPECIAL CASE WHERE k = 0

WILL CONSERVATIVELY NEGLECT THE TOP WELD OF THE CHAIR PLATE TO THE TANK WALL.

$P = C C_1 D \ell$

$\ell = 11''$

$a\ell = 2.5'' \Rightarrow a = 2.5/11 = .2273$

$D = 5$ (for $5/16''$ WELD)

$C_1 = 0.857$ FOR E60 ELECTRODES

$C = 1.32$ (INTERPOLATED FROM TABLE FOR $k = 0$; $a = .2273$)

$P = 1.32(.857)\,5\,(11) = 62.2^k$ FOR NORMAL ALLOWABLES

LOAD FOR HCLPF $= 62.2^k \cdot (1.7) = 105.8^k > 77.9^k$ OK

5 ANCHORAGE CONCLUSION

ALLOWABLE ANCHORAGE LOAD IS LIMITED BY BOLT YIELD AND IS TAKEN AS 77.9^k FOR THE TANK HCLPF EVALUATION.

CLIENT PLG/Duquesne Light JOB No. 9361783.2 SHEET 11 OF 32

SUBJECT IPEEE Fragility Evaluation
For Beaver Valley Unit 2

2WTD- TK23
Demineralized Water Storage Tank

REVISIONS
0 GGS 1/17/97
PRW 1-23-97

E. Tank HCLPF Calculation

A tank HCLPF calculation was performed with TANKV for the tank geometry shown on page 12.

F. 2WTD - TK23 - DEMINERALIZED WATER STORAGE TANK
TANKV EVALUATION

TANK RADIUS = 24'
HT OF LIQUID = 47'
HT OF TANK SHELL = 48'
HT OF TANK ROOF = 2.0'
AVE THICK. OF TANK SHELL = .2292"
THICK OF TANK ROOF = .3125"
THICKNESS @ TANK BOTTOM = .3125"
THICKNESS OF TANK BOTTOM = .25"

ANCHORAGE ~ 16 $1\frac{3}{4}$" A307 ANCHOR BOLTS EVENLY SPACED

HT OF BOLT CHAIR = 12"

DEPTH OF BOLT = 17"
IN CONCRETE

BOLT CIRCLE DIAMETER = 49'-5 5/8"

HCLPF CALCULATIONS ON SUBSEQUENT PAGES 13 & 14

CALC. # 93C1783.2-02 SHT. 13 of 32

```
***************************************************
*              T A N K V  1.0a                    *
*    SEISMIC RESPONSE AND CAPACITY ANALYSIS       *
*    OF VERTICAL CYLINDRICAL LIQUID STORAGE       *
*               FLAT-BOTTOM TANKS                 *

*     prepared by Stevenson and Associates        *
*             Cleveland, OH, 1995                 *
*              i n p u t   d a t a                *
***************************************************

 Title of the Problem : 2WTD-TK23
 Input Data Number    : 1
 Input Data For Response Analysis
 -------------------------------
 Units Used           : American
 Foundation-Tank Interaction Included
 (Y or N)?                                  : N
 Capacity Analysis Required (Y or N)?       : Y
 Tank Material Type                         : carbon steel
 Young's Modulus of the Tank Material       : 29500.000 (ksi)
 Poisson's Ratio                            : 0.300
 Weight Density of the Tank Material        : 490.000 (lb/ft/ft/ft)
 Tank Liquid Type                           : water, demiwater
 Weight Density of the Liquid               : 62.400 (lb/ft/ft/ft)
 Radius of the Tank Shell                   : 24.000 (ft)
 Height of Liquid in the Tank               : 47.000 (ft)
 Height of the Tank Shell                   : 48.000 (ft)
 Height of the Tank Roof Dome               : 2.000 (ft)
 Average Thickness of the Tank Shell        : 0.229 (in)
 Equivalent Thickness of the Tank Roof (L)  : 0.313 (in)
 Thickness of the Tank Bottom (L)           : 0.250 (in)

 Response Spectrum Type                     : user defined
 Zero Period Acceleration                   : 0.000 (g)
 Vertical to Horizontal ZPA Ratio           : 0.000
 Response Spectral Accelerations at the Tank Base
 ------------------------------------------------
  fre (Hz)           sah (g)            sav (g)
 ------------------------------------------------
  1.000              0.008              0.005
  2.500              0.051              0.034
  5.000              0.119              0.079
 10.000              0.151              0.101
 25.000              0.151              0.101
 ------------------------------------------------
 Maximum Horizontal Response Spectral Acceleration
 (for typical sloshing frequencies about 0.5 Hz
 and for sloshing damping about 0.5 perc.)      : 0.010 (g)
 Uncertainity of Natural Frequencies (perc.)    : 20.000

 Input Data For Capacity Analysis
 -------------------------------
 Tank is Anchored (Y or N)?               : Y
 Type of Anchorage                        : standard
 Tank Material Specification              : SA-285(A)
```

```
 Minimum Yield Stress of the Tank
 Shell Material                              : 24.000 (ksi)
 Basic Allowable Stress
 of the Tank Shell Material                  : 11.200 (ksi)
 Thickness of the Tank Shell Near
 the Tank Bottom                             : 0.313 (in)
 Number of Anchor Bolts (uniformly
 distributed around the tank periphery)      :  16
 Anchor Bolt Material (Steel) Specification : SA-307
 Young's Modulus of Anchor Bolts             : 29500.000 (ksi)
 Nominal - Yield Tensile Stress Bolt
 Capacity of Anchor Bolts                    : 33.000 (ksi)
 Nominal Diameter of Anchor Bolts            : 1.750 (in)
 Height of Anchor Bolt Chairs                : 12.000 (in)
 Effective Depth of Anchor Bolts
 (below the tank bottom)                     : 17.000 (in)
 Guaranteed Pretension of Anchor Bolts       : 0.000 (kip)
 Reduction Factor of Anchor Bolt Tensile Capacity
 (used when the bolt chair capacity and/or the bolt
 pullout capacity are smaller than the bolt tensile
 capacity and when a brittle failure mode will occur
 rather than a ductile bolt break)           : 1.000
 Freeboard Height (above the maximum
 liquid level)                       : 1.800 (ft)
 Strength Reduction Factor
 (to estimate code-based capacities): 1.000
```

Calc. # 93C1783.2-02 Sht 14 of 32

```
***************************************************
*                 T A N K V  1.0a                 *
*    SEISMIC RESPONSE AND CAPACITY ANALYSIS       *
*    OF VERTICAL CYLINDRICAL LIQUID STORAGE       *
*               FLAT BOTTOM TANKS                 *

*      prepared by Stevenson and Associates       *
*               Cleveland, OH, 1995               *
*              o u t p u t   d a t a              *
***************************************************

 Title of the Problem : 2WTD-TK23
 Output Data Number   : 1
 Units Used           : American

 Recapitulation of Weights
 -------------------------
 Total Weight of the Tank Roof      : 27.709 (kip)
 Total Weight of the Tank Shell     : 67.743 (kip)
 Total Weight of the Tank Bottom    : 18.473 (kip)
 Total Weight of the Tank Liquid    : 5307.054 (kip)

 Natural Frequencies of the Tank-Liquid System
 ---------------------------------------------
 Fundamental Horizontal Natural Frequency
 of the Tank-Liquid System
 (foundation-tank interaction neglected)       : 4.310 (Hz)
 Fundamental Vertical Natural Frequency
 of the Tank-Liquid System
 (foundation-tank interaction neglected)       : 3.411 (Hz)
 Fundamental Sloshing Frequency                : 0.250 (Hz)

 Response Spectral Acceleretions for Calculated Frequencies
 ----------------------------------------------------------
 Spectral Acceleration of Horizontal Impulsive
 Mode Response       : 0.120 (g)
 Spectral Acceleration of Vertical
 Mode Response       : 0.063 (g)
 Spectral Acceleration of Sloshing
 Mode Response       : 0.010 (g)

 Horizontal Impulsive Mode Response
 ----------------------------------
 Impulsive Mode Base Shear          : 509.471 (kip)
 Impulsive Mode Base Moment         : 9615.961 (kip-ft)
 Impulsive Mode Hydrodynamic Pressure
 (maximum value at the tank bottom) : 0.907 (psi)

 Horizontal Convective (Sloshing) Mode Response
 ----------------------------------------------
 Convective Mode Base Shear                : 12.447 (kip)
 Convective Mode Base Moment               : 421.974 (kip-ft)
 Convective Mode Hydrodynamic Pressure
 (maximum value near the liquid surface) : 0.087 (psi)
 Theoretical Sloshing Height               : 0.202 (ft)

 Vertical Mode Response
```

```
 ----------------------
 Vertical Response Mode Liquid Pressure
 (maximum value at the tank bottom)      : 1.021 (psi)

 Combined Response
 -----------------
 Combined Seismic Base Shear             : 509.623 (kip)
 Combined Seismic Base Moment            : 9625.216 (kip-ft)
 Static Liquid Pressure
 (maximum value at the tank bottom)      : 20.367 (psi)
 Total Seismic Liquid Pressure
 (maximum value at the tank bottom)      : 1.366 (psi)
 Additional Overturning Base Moment (due to
 seismic liquid pressure at the tank bottom
 which loads the tank foundation only,
 not the tank shell and its anchor bolts): 2135.050 (kip-ft)

 Compressive Buckling Capacity of the Tank Shell,
 Liquid Hold-Down Forces
 ------------------------------------------------
 Compressive Buckling Capacity Stress
 of the Tank Shell                         : 4.360 (ksi)
 Basic Value of the Liquid Hold-Down Force : 0.126 (kip/in)
 First Derivation of the Liquid Hold-Down Force
 (with respect to the uplift displacement) : 0.265 (kip/in/in)

 Nominal & Reduced (Code-Based) Overturning Moment
 Tank Capacities
 -------------------------------------------------
 Nominal Overturning Moment Tank Capacity  : 27342.920 (kip-ft)
 Maximum Uplift (L)                        : 0.183 (in)

 fi = 1.0, no reduction required to estimate code-based capacity

 Nominal & Reduced (Code-Based) Sliding Shear Tank Capacities
 ------------------------------------------------------------
 Nominal Sliding Shear Tank Capacity       : 4105.271 (kip)

 fi = 1.0, no reduction required to estimate code-based capacity

 Other Capacity Checks
 ---------------------
 Nominal Liquid Capacity Pressure          : 24.306 (psi)

 fi = 1.0, no reduction required to estimate code-based capacity

 Seismic Margins
 ---------------
 Seismic Margin Overturning Moment Tank Capacity : 0.429 (g)
 Seismic Margin Sliding Shear Tank Capacity      : 1.216 (g)
 Seismic Margin Liquid Pressure Tank Capacity    : 0.523 (g)


 end of solution, bye
```

CALC. # 93C1783.2-02

S&A
Stevenson and Associates
A Structural-Mechanical Consulting Engineering Firm

CLIENT PLG/DUQUESNE LIGHT JOB No. 93C1783.2 SHEET 15 OF 32

SUBJECT IPEEE FRAGILITY EVALUATION FOR BEAVER VALLEY UNIT 2

2FWE-TK210
PRIMARY PLANT DEMINERALIZED WATER TANK

REVISIONS
0 BJS 1/12/97
DRW 1-23-97

III. 2FWE - TK210 - PRIMARY PLANT DEMINERALIZED WATER TANK

TANK RADIUS = 15'
HT OF LIQUID = 29'
HT OF TANK SHELL = 30'
HT OF TANK ROOF = 2'
AVR. THICK. OF TANK SHELL = .3125"
THICK. OF TANK ROOF = .3125"
THICK. OF TANK BOTTOM = .3125'
THICK. OF TANK BOTTOM = .375"

ANCHORAGE 16 ~ 1 3/4" φ A307 ANCHOR BOLTS EVENLY SPACED

HT. OF BOLT CHAIR = 13.5"

DEPTH OF BOLT IN CONCRETE = 19"

BOLT CIRCLE DIAMETER = 30'-5 5/8"

MATERIAL CARBON STEEL SA-285 GR. A

HCLPF CALC. ON SUBSEQUENT PAGES 16 & 17

```
**************************************************
*                 T A N K V  1.0a                *
*     SEISMIC RESPONSE AND CAPACITY ANALYSIS     *
*     OF VERTICAL CYLINDRICAL LIQUID STORAGE     *
*                FLAT-BOTTOM TANKS               *

*      prepared by Stevenson and Associates      *
*              Cleveland, OH, 1995               *
*                i n p u t   d a t a             *
**************************************************

 Title of the Problem : 2FWE-TK210
 Input Data Number    : 1
 Input Data For Response Analysis
 -------------------------------
 Units Used           : American
 Foundation-Tank Interaction Included
 (Y or N)?                                 : n
 Capacity Analysis Required (Y or N)?      : y
 Tank Material Type                        : carbon steel
 Young's Modulus of the Tank Material      : 29500.000 (ksi)
 Poisson's Ratio                           : 0.300
 Weight Density of the Tank Material       : 490.000 (lb/ft/ft/ft)
 Tank Liquid Type                          : water, demiwater
 Weight Density of the Liquid              : 62.400 (lb/ft/ft/ft)
 Radius of the Tank Shell                  : 15.000 (ft)
 Height of Liquid in the Tank              : 29.000 (ft)
 Height of the Tank Shell                  : 30.000 (ft)
 Height of the Tank Roof Dome              : 2.000 (ft)
 Average Thickness of the Tank Shell       : 0.313 (in)
 Equivalent Thickness of the Tank Roof (L) : 0.313 (in)
 Thickness of the Tank Bottom (L)          : 0.375 (in)

 Response Spectrum Type                    : user defined
 Zero Period Acceleration                  : 0.000 (g)
 Vertical to Horizontal ZPA Ratio          : 0.000
 Response Spectral Accelerations at the Tank Base
 -----------------------------------------------
  fre (Hz)          sah (g)             sav (g)
 -----------------------------------------------
   1.000             0.008               0.005
   2.500             0.051               0.034
   5.000             0.119               0.079
  10.000             0.151               0.101
  25.000             0.151               0.101
 -----------------------------------------------
 Maximum Horizontal Response Spectral Acceleration
 (for typical sloshing frequencies about 0.5 Hz
 and for sloshing damping about 0.5 perc.)      : 0.010 (g)
 Uncertainity of Natural Frequencies (perc.)    : 20.000

 Input Data For Capacity Analysis
 -------------------------------
 Tank is Anchored (Y or N)?           : y
 Type of Anchorage                    : standard
 Tank Material Specification          : SA-285(A)
```

```
 Minimum Yield Stress of the Tank
 Shell Material                             : 24.000 (ksi)
 Basic Allowable Stress
 of the Tank Shell Material                 : 11.200 (ksi)
 Thickness of the Tank Shell Near
 the Tank Bottom                            : 0.313 (in)
 Number of Anchor Bolts (uniformly
 distributed around the tank periphery)      :  16
 Anchor Bolt Material (Steel) Specification : SA-307
 Young's Modulus of Anchor Bolts             : 29500.000 (ksi)
 Nominal - Yield Tensile Stress Bolt
 Capacity of Anchor Bolts                    : 33.000 (ksi)
 Nominal Diameter of Anchor Bolts            : 1.750 (in)
 Height of Anchor Bolt Chairs                : 13.500 (in)
 Effective Depth of Anchor Bolts
 (below the tank bottom)                     : 19.000 (in)
 Guaranteed Pretension of Anchor Bolts       : 0.000 (kip)
 Reduction Factor of Anchor Bolt Tensile Capacity
 (used when the bolt chair capacity and/or the bolt
 pullout capacity are smaller than the bolt tensile
 capacity and when a brittle failure mode will occur
 rather than a ductile bolt break)           : 1.000
 Freeboard Height (above the maximum
 liquid level)                       : 1.800 (ft)
 Strength Reduction Factor
 (to estimate code-based capacities): 1.000
```

CALC. # 93C1783.02-02 SHT. 17 OF 32

```
****************************************************
*               T A N K V  1.0a                    *
*    SEISMIC RESPONSE AND CAPACITY ANALYSIS        *
*    OF VERTICAL CYLINDRICAL LIQUID STORAGE        *
*              FLAT BOTTOM TANKS                   *

*     prepared by Stevenson and Associates         *
*           Cleveland, OH, 1995                    *
*            o u t p u t   d a t a                 *
****************************************************

 Title of the Problem : 2FWE-TK210
 Output Data Number   : 1
 Units Used           : American

 Recapitulation of Weights
 ------------------------
 Total Weight of the Tank Roof       : 10.824 (kip)
 Total Weight of the Tank Shell      : 36.079 (kip)
 Total Weight of the Tank Bottom     : 10.824 (kip)
 Total Weight of the Tank Liquid     : 1279.127 (kip)

 Natural Frequencies of the Tank-Liquid System
 ---------------------------------------------
 Fundamental Horizontal Natural Frequency
 of the Tank-Liquid System
 (foundation-tank interaction neglected)       : 10.020 (Hz)
 Fundamental Vertical Natural Frequency
 of the Tank-Liquid System
 (foundation-tank interaction neglected)       : 8.194 (Hz)
 Fundamental Sloshing Frequency                : 0.316 (Hz)

 Response Spectral Acceleretions for Calculated Frequencies
 ----------------------------------------------------------
 Spectral Acceleration of Horizontal Impulsive
 Mode Response       : 0.151 (g)
 Spectral Acceleration of Vertical
 Mode Response       : 0.100 (g)
 Spectral Acceleration of Sloshing
 Mode Response       : 0.010 (g)

 Horizontal Impulsive Mode Response
 ---------------------------------
 Impulsive Mode Base Shear           : 158.407 (kip)
 Impulsive Mode Base Moment          : 1833.365 (kip-ft)
 Impulsive Mode Hydrodynamic Pressure
 (maximum value at the tank bottom) : 0.708 (psi)

 Horizontal Convective (Sloshing) Mode Response
 ---------------------------------------------
 Convective Mode Base Shear              : 3.038 (kip)
 Convective Mode Base Moment             : 63.236 (kip-ft)
 Convective Mode Hydrodynamic Pressure
 (maximum value near the liquid surface) : 0.055 (psi)
 Theoretical Sloshing Height             : 0.126 (ft)

 Vertical Mode Response
```

```
 ----------------------
 Vertical Response Mode Liquid Pressure
 (maximum value at the tank bottom)      : 1.008 (psi)

 Combined Response
 ----------------
 Combined Seismic Base Shear             : 158.436 (kip)
 Combined Seismic Base Moment            : 1834.456 (kip-ft)
 Static Liquid Pressure
 (maximum value at the tank bottom)      : 12.567 (psi)
 Total Seismic Liquid Pressure
 (maximum value at the tank bottom)      : 1.232 (psi)
 Additional Overturning Base Moment (due to
 seismic liquid pressure at the tank bottom
 which loads the tank foundation only,
 not the tank shell and its anchor bolts): 470.109 (kip-ft)

 Compressive Buckling Capacity of the Tank Shell,
 Liquid Hold-Down Forces
 ----------------------------------------------
 Compressive Buckling Capacity Stress
 of the Tank Shell                         : 14.015 (ksi)
 Basic Value of the Liquid Hold-Down Force : 0.104 (kip/in)
 First Derivation of the Liquid Hold-Down Force
 (with respect to the uplift displacement) : 0.166 (kip/in/in)

 Nominal & Reduced (Code-Based) Overturning Moment
 Tank Capacities
 ------------------------------------------------
 Nominal Overturning Moment Tank Capacity  : 19799.273 (kip-ft)
 Maximum Uplift (L)                        : 0.250 (in)

 fi = 1.0, no reduction required to estimate code-based capacity

 Nominal & Reduced (Code-Based) Sliding Shear Tank Capacities
 -----------------------------------------------------------
 Nominal Sliding Shear Tank Capacity       : 1506.077 (kip)

 fi = 1.0, no reduction required to estimate code-based capacity

 Other Capacity Checks
 --------------------
 Nominal Liquid Capacity Pressure          : 38.889 (psi)

 fi = 1.0, no reduction required to estimate code-based capacity

 Seismic Margins
 ---------------
 Seismic Margin Overturning Moment Tank Capacity : 1.630 (g)
 Seismic Margin Sliding Shear Tank Capacity      : 1.435 (g)
 Seismic Margin Liquid Pressure Tank Capacity    : 3.873 (g)


 end of solution, bye
```

S&A
Stevenson and Associates
A Structural-Mechanical Consulting Engineering Firm

CLIENT PLG/DUQUESNE LIGHT JOB No. 93C1783.2 SHEET 18 OF 32
SUBJECT IPEEE FRAGILITY EVALUATION
FOR BEAVER VALLEY UNIT 2

2WTD-TK-211 - TURBINE PLANT
DEMINERALIZED WATER STORAGE TANK

REVISIONS
0 DJS 1/22/97
PRW 1-22-97

IV. 2WTD-TK-211 TURBINE PLANT DEMINERALIZED WATER STORAGE TANK

TANK RADIUS = 15'
HT OF LIQUID = 29'
HT OF TANK SHELL = 30'
HT OF TANK ROOF = 2'
AVE. THICK. OF TANK SHELL = .3125"
THICK. OF TANK ROOF = .3125"
THICK. @ TANK BOTTOM = .3125"
THICK. OF TANK BOTTOM = .375"

ANCHORAGE 8 ~ $1\frac{3}{4}$" Ø A307 ANCHOR BOLTS EVENLY SPACED

HT. OF BOLT CHAIR = 13.5"

DEPTH OF BOLT IN CONCRETE = 19"

BOLT CIRCLE DIAMETER = 30'-$5\frac{5}{8}$"

MATERIAL CARBON STEEL SA-285 GR A

HCLPF CALCULATIONS ON SUBSEQUENT PAGES 19 & 20

CALC. # 97C17B3.2-02 SHT. 19 of 32

```
****************************************************
*                  T A N K V  1.0a                 *
*     SEISMIC RESPONSE AND CAPACITY ANALYSIS       *
*     OF VERTICAL CYLINDRICAL LIQUID STORAGE       *
*               FLAT-BOTTOM TANKS                  *

*      prepared by Stevenson and Associates        *
*               Cleveland, OH, 1995                *
*                i n p u t   d a t a               *
****************************************************

 Title of the Problem : 2WTD-TK-211
 Input Data Number    : 1
 Input Data For Response Analysis
 ---------------------------------
 Units Used           : American
 Foundation-Tank Interaction Included
 (Y or N)?                                : n
 Capacity Analysis Required (Y or N)?     : y
 Tank Material Type                       : carbon steel
 Young's Modulus of the Tank Material     : 29500.000 (ksi)
 Poisson's Ratio                          : 0.300
 Weight Density of the Tank Material      : 490.000 (lb/ft/ft/ft)
 Tank Liquid Type                         : water, demiwater
 Weight Density of the Liquid             : 62.400 (lb/ft/ft/ft)
 Radius of the Tank Shell                 : 15.000 (ft)
 Height of Liquid in the Tank             : 29.000 (ft)
 Height of the Tank Shell                 : 30.000 (ft)
 Height of the Tank Roof Dome             : 2.000 (ft)
 Average Thickness of the Tank Shell      : 0.313 (in)
 Equivalent Thickness of the Tank Roof (L) : 0.313 (in)
 Thickness of the Tank Bottom (L)         : 0.375 (in)

 Response Spectrum Type                   : user defined
 Zero Period Acceleration                 : 0.000 (g)
 Vertical to Horizontal ZPA Ratio         : 0.000
 Response Spectral Accelerations at the Tank Base
 ------------------------------------------------
  fre (Hz)          sah (g)            sav (g)
 ------------------------------------------------
  1.000             0.008              0.005
  2.500             0.051              0.034
  5.000             0.119              0.079
 10.000             0.151              0.101
 25.000             0.151              0.101
 ------------------------------------------------
 Maximum Horizontal Response Spectral Acceleration
 (for typical sloshing frequencies about 0.5 Hz
 and for sloshing damping about 0.5 perc.)     : 0.010 (g)
 Uncertainity of Natural Frequencies (perc.)   : 20.000

 Input Data For Capacity Analysis
 --------------------------------
 Tank is Anchored (Y or N)?             : y
 Type of Anchorage                      : standard
 Tank Material Specification            : SA-285(A)
```

```
Minimum Yield Stress of the Tank
Shell Material                             : 24.000 (ksi)
Basic Allowable Stress
of the Tank Shell Material                 : 11.200 (ksi)
Thickness of the Tank Shell Near
the Tank Bottom                            : 0.313 (in)
Number of Anchor Bolts (uniformly
distributed around the tank periphery)     :   8
Anchor Bolt Material (Steel) Specification : SA-307
Young's Modulus of Anchor Bolts            : 29500.000 (ksi)
Nominal - Yield Tensile Stress Bolt
Capacity of Anchor Bolts                   : 33.000 (ksi)
Nominal Diameter of Anchor Bolts           : 1.750 (in)
Height of Anchor Bolt Chairs               : 13.500 (in)
Effective Depth of Anchor Bolts
(below the tank bottom)                    : 19.000 (in)
Guaranteed Pretension of Anchor Bolts      : 0.000 (kip)
Reduction Factor of Anchor Bolt Tensile Capacity
(used when the bolt chair capacity and/or the bolt
pullout capacity are smaller than the bolt tensile
capacity and when a brittle failure mode will occur
rather than a ductile bolt break)          : 1.000
Freeboard Height (above the maximum
liquid level)                       : 1.800 (ft)
Strength Reduction Factor
(to estimate code-based capacities): 1.000
```

CALC. # 93C17B3.2-02 Sh. 20 of 32

```
***************************************************
*             T A N K V  1.0a                     *
*    SEISMIC RESPONSE AND CAPACITY ANALYSIS       *
*   OF VERTICAL CYLINDRICAL LIQUID STORAGE        *
*             FLAT BOTTOM TANKS                   *

*     prepared by Stevenson and Associates        *
*            Cleveland, OH, 1995                  *
*            o u t p u t   d a t a                *
***************************************************

 Title of the Problem : 2WTD-TK-211
 Output Data Number   : 1
 Units Used           : American

 Recapitulation of Weights
 -------------------------
 Total Weight of the Tank Roof      : 10.824 (kip)
 Total Weight of the Tank Shell     : 36.079 (kip)
 Total Weight of the Tank Bottom    : 10.824 (kip)
 Total Weight of the Tank Liquid    : 1279.127 (kip)

 Natural Frequencies of the Tank-Liquid System
 ---------------------------------------------
 Fundamental Horizontal Natural Frequency
 of the Tank-Liquid System
 (foundation-tank interaction neglected)      : 10.020 (Hz)
 Fundamental Vertical Natural Frequency
 of the Tank-Liquid System
 (foundation-tank interaction neglected)      : 8.194 (Hz)
 Fundamental Sloshing Frequency               : 0.316 (Hz)

 Response Spectral Acceleretions for Calculated Frequencies
 ----------------------------------------------------------
 Spectral Acceleration of Horizontal Impulsive
 Mode Response       : 0.151 (g)
 Spectral Acceleration of Vertical
 Mode Response       : 0.100 (g)
 Spectral Acceleration of Sloshing
 Mode Response       : 0.010 (g)

 Horizontal Impulsive Mode Response
 ----------------------------------
 Impulsive Mode Base Shear          : 158.407 (kip)
 Impulsive Mode Base Moment         : 1833.365 (kip-ft)
 Impulsive Mode Hydrodynamic Pressure
 (maximum value at the tank bottom) : 0.708 (psi)

 Horizontal Convective (Sloshing) Mode Response
 ----------------------------------------------
 Convective Mode Base Shear                  : 3.038 (kip)
 Convective Mode Base Moment                 : 63.236 (kip-ft)
 Convective Mode Hydrodynamic Pressure
 (maximum value near the liquid surface) : 0.055 (psi)
 Theoretical Sloshing Height                 : 0.126 (ft)

 Vertical Mode Response
```

```
 ----------------------
 Vertical Response Mode Liquid Pressure
 (maximum value at the tank bottom)      : 1.008 (psi)

 Combined Response
 -----------------
 Combined Seismic Base Shear             : 158.436 (kip)
 Combined Seismic Base Moment            : 1834.456 (kip-ft)
 Static Liquid Pressure
 (maximum value at the tank bottom)      : 12.567 (psi)
 Total Seismic Liquid Pressure
 (maximum value at the tank bottom)      : 1.232 (psi)
 Additional Overturning Base Moment (due to
 seismic liquid pressure at the tank bottom
 which loads the tank foundation only,
 not the tank shell and its anchor bolts): 470.109 (kip-ft)

 Compressive Buckling Capacity of the Tank Shell,
 Liquid Hold-Down Forces
 ------------------------------------------------
 Compressive Buckling Capacity Stress
 of the Tank Shell                          : 14.015 (ksi)
 Basic Value of the Liquid Hold-Down Force : 0.104 (kip/in)
 First Derivation of the Liquid Hold-Down Force
 (with respect to the uplift displacement) : 0.170 (kip/in/in)

 Nominal & Reduced (Code-Based) Overturning Moment
 Tank Capacities
 ------------------------------------------------
 Nominal Overturning Moment Tank Capacity  : 11815.024 (kip-ft)
 Maximum Uplift (L)                         : 0.250 (in)

 fi = 1.0, no reduction required to estimate code-based capacity

 Nominal & Reduced (Code-Based) Sliding Shear Tank Capacities
 ------------------------------------------------------------
 Nominal Sliding Shear Tank Capacity       : 1231.460 (kip)

 fi = 1.0, no reduction required to estimate code-based capacity

 Other Capacity Checks
 ---------------------
 Nominal Liquid Capacity Pressure          : 38.889 (psi)

 fi = 1.0, no reduction required to estimate code-based capacity

 Seismic Margins
 ---------------
 Seismic Margin Overturning Moment Tank Capacity : 0.973 (g)
 Seismic Margin Sliding Shear Tank Capacity      : 1.174 (g)
 Seismic Margin Liquid Pressure Tank Capacity    : 3.873 (g)


 end of solution, bye
```

CALC. # 9341793.2 - 02

S&A
Stevenson and Associates
A Structural-Mechanical Consulting Engineering Firm

CLIENT PLG/DUQUESNE LIGHT JOB No. 9341793.2 SHEET 21 OF 32

SUBJECT IPEEE FRAGILITY EVALUATION FOR BEAVER VALLEY UNIT 2

2CHS-TK21A & B
BORIC ACID TANKS

REVISIONS
0 DDS 1/21/97
PRW 1-23-97

V. TANKS 2CHS-TK21A & B - BORIC ACID TANKS

TANK RADIUS = 6.75'
HT OF LIQUID = 13.583'
HT OF TANK SHELL = 13.917'
HT OF TANK ROOF = .334'
AVE. THICK. OF TANK SHELL = .1875"
THICK. OF TANK ROOF = .3175"
THICK @ TANK BOTTOM = .1875"
THICKNESS OF TANK BOTTOM = .25"

ANCHORAGE 6 - 1¾" ϕ A307 ANCHOR BOLTS EVENLY SPACED

HT. OF BOLT CHAIR = 12"

DEPTH OF BOLT IN CONCRETE = 19"

BOLT CIRCLE DIAMETER = 13'-11⅝"

LOCATION OF TANKS - AXLB EL. 735'

CONVERSION OF HORIZONTAL SPECTRUM TO UHS 5% DAMPED HORIZONTAL SPECTRUM ON PAGES 22 TO 24.

CONVERSION OF VERTICAL SPECTRUM TO UHS 5% DAMPED VERTICAL SPECTRUM ON PAGES 25 TO 27.

HCLPF CALCULATION ON PAGES 28 & 29.

```
AUXI04E2.uh2

Beaver Valley Unit 2, Auxiliary Bldg., Horizontal, Elevation 734.5 ft
SSE: Equip.Damp.= 0.01, ZPGA=0.125g / UHS: Equip.Damp.=0.05, ZPGA=0.151g

  DMP. RS =    .100E-01 DMP RS-PSD =    .500E-01
  DURATION =    12.0      PROB. =    .150      MFREQ.=  .000E+00
  NP.     FREQ.          RS.     RS-PSD.        PSD

     1    .250          .429          .692E-01     .165E-01
     2    .350          .429          .692E-01     .544E-02
     3    .450          .429          .692E-01     .325E-02
     4    .550          .429          .692E-01     .211E-02
     5    .650          .429          .692E-01     .149E-02
     6    .750          .429          .69?E-01     .110E-02
     7    .850          .429          .692E-01     .842E-03
     8    .950          .429          .692E-01     .644E-03
     9    1.05          .441          .692E-01     .532E-03
    10    1.15          .482          .765E-01     .542E-03
    11    1.25          .555          .130         .632E-03
    12    1.35          .663          .186         .435E-03
    13    1.45          1.19          .362         .398E-02
    14    1.55          1.19          .356         .268E-02
    15    1.65          1.19          .336         .231E-02
    16    1.75          1.19          .313         .193E-02
    17    1.85          1.19          .286         .148E-02
    18    1.95          1.19          .262         .585E-03
    19    2.05          1.46          .296         .110E-03
    20    2.15          3.54          .610         .206E-01
    21    2.25          3.54          .610         .127E-01
    22    2.35          3.82          .610         .161E-01
    23    2.45          3.82          .610         .137E-01
    24    2.55          3.82          .610         .130E-01
    25    2.67          3.82          .672         .106E-01
    26    2.82          3.82          .672         .990E-02
    27    2.98          3.82          .672         .915E-02
    28    3.13          3.82          .672         .853E-02
    29    3.28          3.82          .672         .798E-02
    30    3.43          3.82          .672         .920E-02
    31    3.58          1.27          .290         .171E-05
    32    3.73          1.27          .330         .753E-04
    33    3.88          1.27          .374         .215E-03
    34    4.03          1.27          .395         .300E-03
    35    4.18          1.27          .414         .338E-03
    36    4.33          1.27          .433         .353E-03
    37    4.48          1.27          .431         .357E-03
    38    4.63          1.27          .424         .356E-03
    39    4.78          1.27          .381         .351E-03
    40    4.93          1.27          .381         .348E-03
    41    5.10          1.27          .381         .315E-03
    42    5.30          1.27          .381         .312E-03
    43    5.50          1.26          .381         .293E-03
    44    5.70          1.23          .381         .261E-03
    45    5.90          1.21          .381         .303E-03
    46    6.10          .582          .381         .559E-06
```

–	47	6.30	.540	.381	.110E-05
–	48	6.50	.518	.177	.115E-05
	49	6.70	.499	.177	.101E-05
	50	6.90	.482	.177	.817E-06
	51	7.10	.467	.177	.632E-06
	52	7.30	.452	.177	.477E-06
	53	7.50	.437	.177	.355E-06
	54	7.70	.428	.176	.297E-06
	55	7.90	.420	.176	.250E-06
	56	8.10	.412	.176	.209E-06
	57	8.32	.404	.176	.168E-06
	58	8.57	.395	.176	.133E-06
	59	8.82	.386	.176	.105E-06
	60	9.07	.378	.176	.834E-07
	61	9.32	.371	.176	.659E-07
	62	9.57	.366	.176	.573E-07
	63	9.82	.362	.176	.502E-07
–	64	10.1	.358	.176	.439E-07
–	65	10.3	.353	.185	.375E-07
	66	10.6	.349	.185	.320E-07
	67	10.9	.344	.185	.274E-07
	68	11.2	.340	.185	.234E-07
	69	11.5	.336	.185	.201E-07
	70	11.8	.332	.185	.172E-07
	71	12.1	.329	.185	.148E-07
	72	12.4	.328	.185	.141E-07
	73	12.7	.327	.185	.138E-07
	74	13.0	.327	.185	.135E-07
	75	13.4	.327	.185	.132E-07
–	76	13.7	.326	.185	.128E-07
–	77	14.0	.326	.190	.125E-07
	78	14.2	.326	.195	.122E-07
	79	14.6	.326	.199	.119E-07
	80	14.9	.325	.203	.115E-07
	81	15.3	.325	.205	.110E-07
	82	15.8	.326	.202	.109E-07
	83	16.3	.326	.199	.106E-07
	84	16.7	.326	.197	.103E-07
	85	17.3	.326	.193	.101E-07
	86	17.7	.326	.189	.977E-08
	87	18.3	.326	.185	.949E-08
	88	18.8	.326	.181	.922E-08
	89	19.2	.326	.179	.896E-08
	90	19.8	.326	.178	.871E-08
	91	20.3	.326	.177	.844E-08
–	92	21.0	.326	.175	.737E-08
	93	22.0	.326	.172	.701E-08
–	94	23.0	.326	.170	.668E-08
	95	24.0	.326	.168	.638E-08
–	96	25.0	.319	.163	.463E-08
	97	26.0	.319	.161	.437E-08
–	98	27.0	.318	.160	.411E-08
	99	28.0	.318	.159	.387E-08
	100	29.0	.317	.158	.365E-08
	101	30.0	.317	.157	.345E-08

```
 102   31.0        .317       .157        .329E-08
 103   32.0        .317       .156        .316E-08
-104   33.0        .317       .155        .296E-08
 105   36.0        .317       .155        .156E-08
 106   41.0        .317       .155        .137E-08
 107   46.0        .317       .155        .121E-08
 108   51.0        .317       .155        .107E-08
 109   56.0        .317       .155        .964E-09
 110   61.0        .317       .155        .869E-09
 111   66.0        .316       .155        .789E-09
 112   71.0        .316       .155        .720E-09
 113   76.0        .316       .155        .660E-09
 114   81.0        .316       .155        .608E-09
 115   86.0        .316       .155        .564E-09
 116   91.0        .316       .155        .537E-09
```

CALC. #93C1783.2-02 SHT. 25 OF 32

```
AUXI04V2.uh2

Beaver Valley Unit 2, Auxiliary Bldg., Vertical, Elevation 734.5 ft
SSE: Equip.Damp.= 0.01, ZPGA=0.125g / UHS: Equip.Damp.=0.05, ZPGA=0.151g

  DMP. RS =    .100E-01 DMP RS-PSD =    .500E-01
  DURATION =    12.0      PROB. =    .150     MFREQ.=  .000E+00
  NP.      FREQ.          RS.      RS-PSD.       PSD

     1     .250          .377          .631E-01     .127E-01
     2     .350          .377          .631E-01     .421E-02
     3     .450          .377          .631E-01     .252E-02
     4     .550          .377          .631E-01     .164E-02
     5     .650          .377          .631E-01     .116E-02
     6     .750          .377          .631E-01     .862E-03
     7     .850          .377          .631E-01     .666E-03
     8     .950          .377          .631E-01     .526E-03
     9     1.05          .377          .631E-01     .376E-03
    10     1.15          .448          .711E-01     .632E-03
    11     1.25          .448          .105         .460E-03
    12     1.35          .448          .126         .253E-03
    13     1.45          .646          .197         .104E-02
    14     1.55          .646          .194         .655E-03
    15     1.65          .741          .210         .988E-03
    16     1.75          .741          .196         .558E-03
    17     1.85          .987          .238         .166E-02
    18     1.95          .987          .218         .122E-02
    19     2.05          .987          .200         .109E-02
    20     2.15          .987          .462         .953E-03
    21     2.25          .987          .462         .819E-03
    22     2.35          .987          .462         .622E-03
    23     2.45          1.05          .462         .548E-03
    24     2.55          1.22          .462         .663E-03
    25     2.67          1.46          .734         .106E-03
    26     2.82          3.92          .734         .136E-01
    27     2.98          3.92          .734         .100E-01
    28     3.13          3.92          .734         .921E-02
    29     3.28          3.92          .734         .846E-02
    30     3.43          3.92          .734         .785E-02
    31     3.58          3.92          .891         .733E-02
    32     3.73          3.92          1.02         .688E-02
    33     3.88          3.92          1.15         .648E-02
    34     4.03          3.92          1.22         .614E-02
    35     4.18          3.92          1.27         .584E-02
    36     4.33          3.92          1.33         .561E-02
    37     4.48          3.89          1.32         .589E-02
    38     4.63          3.28          1.09         .369E-02
    39     4.78          1.56          .910         .196E-04
    40     4.93          1.56          .910         .222E-03
    41     5.10          1.56          .910         .363E-03
    42     5.30          1.56          .910         .424E-03
    43     5.50          1.56          .910         .454E-03
    44     5.70          1.51          .910         .491E-03
    45     5.90          .685          .910         .576E-06
    46     6.10          .685          .910         .358E-05
```

47	6.30	.685	.910	.678E-05
48	6.50	.685	.238	.954E-05
49	6.70	.685	.238	.119E-04
50	6.90	.685	.238	.138E-04
51	7.10	.685	.238	.153E-04
52	7.30	.685	.238	.167E-04
53	7.50	.685	.238	.180E-04
54	7.70	.685	.224	.215E-04
55	7.90	.573	.224	.410E-05
56	8.10	.444	.224	.243E-06
57	8.32	.433	.224	.238E-06
58	8.57	.421	.224	.200E-06
59	8.82	.410	.224	.162E-06
60	9.07	.399	.224	.129E-06
61	9.32	.389	.224	.102E-06
62	9.57	.380	.224	.800E-07
63	9.82	.371	.224	.627E-07
64	10.1	.362	.224	.490E-07
65	10.3	.353	.175	.370E-07
66	10.6	.344	.175	.276E-07
67	10.9	.335	.175	.206E-07
68	11.2	.327	.175	.154E-07
69	11.5	.319	.175	.115E-07
70	11.8	.312	.175	.866E-08
71	12.1	.304	.175	.652E-08
72	12.4	.298	.175	.491E-08
73	12.7	.293	.175	.404E-08
74	13.0	.293	.175	.407E-08
75	13.4	.293	.175	.408E-08
76	13.7	.293	.175	.408E-08
77	14.0	.293	.171	.407E-08
78	14.2	.292	.175	.405E-08
79	14.6	.292	.178	.403E-08
80	14.9	.292	.182	.400E-08
81	15.3	.292	.184	.385E-08
82	15.8	.292	.181	.379E-08
83	16.3	.292	.178	.373E-08
84	16.7	.292	.176	.366E-08
85	17.3	.292	.172	.358E-08
86	17.7	.291	.169	.351E-08
87	18.3	.291	.165	.343E-08
88	18.8	.291	.162	.335E-08
89	19.2	.291	.160	.327E-08
90	19.8	.291	.159	.315E-08
91	20.3	.290	.157	.303E-08
92	21.0	.290	.155	.265E-08
93	22.0	.289	.153	.248E-08
94	23.0	.288	.150	.232E-08
95	24.0	.288	.148	.217E-08
96	25.0	.287	.146	.203E-08
97	26.0	.286	.145	.191E-08
98	27.0	.286	.144	.179E-08
99	28.0	.285	.143	.168E-08
100	29.0	.285	.142	.158E-08
101	30.0	.284	.141	.149E-08

102	31.0	.284	.140	.140E-08
103	32.0	.283	.139	.133E-08
104	33.0	.283	.139	.123E-08
105	36.0	.282	.139	.655E-09
106	41.0	.280	.139	.545E-09
107	46.0	.280	.139	.482E-09
108	51.0	.279	.139	.430E-09
109	56.0	.279	.139	.386E-09
110	61.0	.279	.139	.349E-09
111	66.0	.279	.139	.316E-09
112	71.0	.279	.139	.289E-09
113	76.0	.279	.139	.265E-09
114	81.0	.278	.139	.244E-09
115	86.0	.278	.139	.226E-09
116	91.0	.278	.139	.214E-09

CALC. # 93C1783.2-02 SHT. 28 of 32

```
********************************************************
*                    T A N K V  1.0a                   *
*     SEISMIC RESPONSE AND CAPACITY ANALYSIS           *
*     OF VERTICAL CYLINDRICAL LIQUID STORAGE           *
*                 FLAT-BOTTOM TANKS                    *

*       prepared by Stevenson and Associates           *
*                Cleveland, OH, 1995                   *
*                  i n p u t   d a t a                 *
********************************************************

 Title of the Problem : 2CHS-TK21A&B
 Input Data Number     : 1
 Input Data For Response Analysis
 --------------------------------
 Units Used            : American
 Foundation-Tank Interaction Included
 (Y or N)?                                  : n
 Capacity Analysis Required (Y or N)?       : y
 Tank Material Type                         : carbon steel
 Young's Modulus of the Tank Material       : 29500.000 (ksi)
 Poisson's Ratio                            : 0.300
 Weight Density of the Tank Material        : 490.000 (lb/ft/ft/ft)
 Tank Liquid Type                           : water, demiwater
 Weight Density of the Liquid               : 62.400 (lb/ft/ft/ft)
 Radius of the Tank Shell                   : 6.750 (ft)
 Height of Liquid in the Tank               : 13.583 (ft)
 Height of the Tank Shell                   : 13.917 (ft)
 Height of the Tank Roof Dome               : 0.334 (ft)
 Average Thickness of the Tank Shell        : 0.188 (in)
 Equivalent Thickness of the Tank Roof (L)  : 0.317 (in)
 Thickness of the Tank Bottom (L)           : 0.250 (in)

 Response Spectrum Type                     : user defined
 Zero Period Acceleration                   : 0.000 (g)
 Vertical to Horizontal ZPA Ratio           : 0.000
 Response Spectral Accelerations at the Tank Base
 ----------------------------------------------------
  fre (Hz)            sah (g)              sav (g)
 ----------------------------------------------------
  2.050               0.296                0.200
  2.150               0.610                0.462
  2.550               0.610                0.462
  2.670               0.672                0.734
  3.580               0.290                0.891
  4.330               0.433                1.330
  4.630               0.424                1.090
  4.780               0.381                0.910
  6.300               0.381                0.910
  6.500               0.177                0.238
 10.100               0.176                0.224
 10.300               0.185                0.175
 13.700               0.185                0.175
 14.000               0.190                0.171
 21.000               0.175                0.155
 23.000               0.170                0.150
 25.000               0.163                0.146
 27.000               0.160                0.144
 33.000               0.155                0.139
 36.000               0.155                0.139
 ----------------------------------------------------
 Maximum Horizontal Response Spectral Acceleration
 (for typical sloshing frequencies about 0.5 Hz
 and for sloshing damping about 0.5 perc.)      : 0.069 (g)
 Uncertainity of Natural Frequencies (perc.)    : 20.000

 Input Data For Capacity Analysis
 --------------------------------
 Tank is Anchored (Y or N)?                  : y
 Type of Anchorage                           : standard
 Tank Material Specification                 : SA-285(A)
 Minimum Yield Stress of the Tank
 Shell Material                              : 24.000 (ksi)
 Basic Allowable Stress
 of the Tank Shell Material                  : 11.200 (ksi)
 Thickness of the Tank Shell Near
 the Tank Bottom                             : 0.188 (in)
 Number of Anchor Bolts (uniformly
 distributed around the tank periphery)     :   6
 Anchor Bolt Material (Steel) Specification : SA-307
 Young's Modulus of Anchor Bolts                : 29500.000 (ksi)
 Nominal - Yield Tensile Stress Bolt
 Capacity of Anchor Bolts                       : 33.000 (ksi)
 Nominal Diameter of Anchor Bolts               : 1.750 (in)
 Height of Anchor Bolt Chairs                   : 12.000 (in)
 Effective Depth of Anchor Bolts
 (below the tank bottom)                        : 19.000 (in)
 Guaranteed Pretension of Anchor Bolts      : 0.000 (kip)
 Reduction Factor of Anchor Bolt Tensile Capacity
 (used when the bolt chair capacity and/or the bolt
 pullout capacity are smaller than the bolt tensile
 capacity and when a brittle failure mode will occur
 rather than a ductile bolt break)          : 1.000
 Freeboard Height (above the maximum
 liquid level)                        : 0.450 (ft)
 Strength Reduction Factor
 (to estimate code-based capacities): 1.000
```

```
**************************************************
*              T A N K V  1.0a                   *
*    SEISMIC RESPONSE AND CAPACITY ANALYSIS      *
*    OF VERTICAL CYLINDRICAL LIQUID STORAGE      *
*             FLAT BOTTOM TANKS                  *

*     prepared by Stevenson and Associates       *
*           Cleveland, OH, 1995                  *
*             o u t p u t   d a t a              *
**************************************************

 Title of the Problem : 2CHS-TK21A&B
 Output Data Number   : 1
 Units Used           : American

 Recapitulation of Weights
 -------------------------
 Total Weight of the Tank Roof      : 2.227 (kip)
 Total Weight of the Tank Shell     : 4.519 (kip)
 Total Weight of the Tank Bottom    : 1.461 (kip)
 Total Weight of the Tank Liquid    : 121.321 (kip)

 Natural Frequencies of the Tank-Liquid System
 ---------------------------------------------
 Fundamental Horizontal Natural Frequency
 of the Tank-Liquid System
 (foundation-tank interaction neglected)      : 23.860 (Hz)
 Fundamental Vertical Natural Frequency
 of the Tank-Liquid System
 (foundation-tank interaction neglected)      : 19.817 (Hz)
 Fundamental Sloshing Frequency               : 0.471 (Hz)

Response Spectral Acceleretions for Calculated Frequencies
----------------------------------------------------------
Spectral Acceleration of Horizontal Impulsive
Mode Response       : 0.179 (g)
Spectral Acceleration of Vertical
Mode Response       : 0.167 (g)
Spectral Acceleration of Sloshing
Mode Response       : 0.069 (g)

Horizontal Impulsive Mode Response
----------------------------------
Impulsive Mode Base Shear          : 18.501 (kip)
Impulsive Mode Base Moment         : 99.820 (kip-ft)
Impulsive Mode Hydrodynamic Pressure
(maximum value at the tank bottom) : 0.386 (psi)

Horizontal Convective (Sloshing) Mode Response
----------------------------------------------
Convective Mode Base Shear                  : 1.911 (kip)
Convective Mode Base Moment                 : 18.921 (kip-ft)
Convective Mode Hydrodynamic Pressure
(maximum value near the liquid surface) : 0.169 (psi)
Theoretical Sloshing Height                 : 0.391 (ft)

Vertical Mode Response
```

```
----------------------
Vertical Response Mode Liquid Pressure
(maximum value at the tank bottom)      : 0.785 (psi)

Combined Response
-----------------
Combined Seismic Base Shear             : 18.600 (kip)
Combined Seismic Base Moment            : 101.597 (kip-ft)
Static Liquid Pressure
(maximum value at the tank bottom)      : 5.886 (psi)
Total Seismic Liquid Pressure
(maximum value at the tank bottom)      : 0.875 (psi)
Additional Overturning Base Moment (due to
seismic liquid pressure at the tank bottom
which loads the tank foundation only,
not the tank shell and its anchor bolts): 30.431 (kip-ft)

Compressive Buckling Capacity of the Tank Shell,
Liquid Hold-Down Forces
-----------------------------------------------
Compressive Buckling Capacity Stress
of the Tank Shell                         : 16.959 (ksi)
Basic Value of the Liquid Hold-Down Force : 0.039 (kip/in)
First Derivation of the Liquid Hold-Down Force
(with respect to the uplift displacement) : 0.081 (kip/in/in)

Nominal & Reduced (Code-Based) Overturning Moment
Tank Capacities
-----------------------------------------------
Nominal Overturning Moment Tank Capacity  : 2953.613 (kip-ft)
Maximum Uplift (L)                        : 0.250 (in)

fi = 1.0, no reduction required to estimate code-based capacity

Nominal & Reduced (Code-Based) Sliding Shear Tank Capacities
------------------------------------------------------------
Nominal Sliding Shear Tank Capacity       : 294.048 (kip)

fi = 1.0, no reduction required to estimate code-based capacity

Other Capacity Checks
---------------------
Nominal Liquid Capacity Pressure          : 51.852 (psi)

fi = 1.0, no reduction required to estimate code-based capacity

Seismic Margins
---------------
Seismic Margin Overturning Moment Tank Capacity : 4.506 (g)
Seismic Margin Sliding Shear Tank Capacity      : 2.450 (g)
Seismic Margin Liquid Pressure Tank Capacity    : 9.772 (g)


end of solution, bye
```

CLIENT PLG/Duquesne Light JOB No. 9321783.2 SHEET 30 OF 32

SUBJECT IPEEE Fragility for Beaver Valley Unit 2

2QSS-TK21
RWST

REVISIONS
0 BJS 1/21/97
PRW 1-23-97

2QSS-TK21 RWST

Tank Radius = 25'
Ht of Liquid = 61'
Ht of Tank Shell = 62'
Ht of Tank Roof = 2'
Ave. Thick. of Tank Shell = .3542" (Estimate)
Thick. of Tank Roof = .3438"
Thick @ Tank Bottom = .5625"
Thickness of Tank Bottom = .75"

Anchorage 51 - 2½" Φ A307 Anchor Bolts Evenly Spaced

Ht. of Bolt Chair = 20"

Depth of Bolt in Concrete = 48"

Bolt Circle Diameter 50'-7¾"

HCLPF Calculation on Pages 30 & 31

```
**************************************************
*                TANKV 1.0a                      *
*   SEISMIC RESPONSE AND CAPACITY ANALYSIS       *
*   OF VERTICAL CYLINDRICAL LIQUID STORAGE       *
*             FLAT-BOTTOM TANKS                  *

*    prepared by Stevenson and Associates        *
*            Cleveland, OH, 1995                 *
*               input data                       *
**************************************************

 Title of the Problem : 2QSS-TK21
 Input Data Number    : 1
 Input Data For Response Analysis
 --------------------------------
 Units Used              : American
 Foundation-Tank Interaction Included
 (Y or N)?                              : n
 Capacity Analysis Required (Y or N)?   : y
 Tank Material Type                     : carbon steel
 Young's Modulus of the Tank Material   : 29500.000 (ksi)
 Poisson's Ratio                        : 0.300
 Weight Density of the Tank Material    : 490.000 (lb/ft/ft/ft)
 Tank Liquid Type                       : water, demiwater
 Weight Density of the Liquid           : 62.400 (lb/ft/ft/ft)
 Radius of the Tank Shell               : 25.000 (ft)
 Height of Liquid in the Tank           : 61.000 (ft)
 Height of the Tank Shell               : 62.000 (ft)
 Height of the Tank Roof Dome           : 2.000 (ft)
 Average Thickness of the Tank Shell    : 0.354 (in)
 Equivalent Thickness of the Tank Roof (L)  : 0.344 (in)
 Thickness of the Tank Bottom (L)       : 0.750 (in)

 Response Spectrum Type                 : user defined
 Zero Period Acceleration               : 0.000 (g)
 Vertical to Horizontal ZPA Ratio       : 0.000
 Response Spectral Accelerations at the Tank Base
 ----------------------------------------------
  fre (Hz)          sah (g)            sav (g)
 ----------------------------------------------
  1.000             0.008              0.005
  2.500             0.051              0.034
  5.000             0.119              0.079
 10.000             0.151              0.101
 25.000             0.151              0.101
 ----------------------------------------------
 Maximum Horizontal Response Spectral Acceleration
 (for typical sloshing frequencies about 0.5 Hz
 and for sloshing damping about 0.5 perc.)      : 0.010 (g)
 Uncertainity of Natural Frequencies (perc.)    : 20.000

 Input Data For Capacity Analysis
 --------------------------------
 Tank is Anchored (Y or N)?          : y
 Type of Anchorage                   : standard
 Tank Material Specification         : SA-285(A)
```

```
Minimum Yield Stress of the Tank
Shell Material                             : 24.000 (ksi)
Basic Allowable Stress
of the Tank Shell Material                 : 11.200 (ksi)
Thickness of the Tank Shell Near
the Tank Bottom                            : 0.563 (in)
Number of Anchor Bolts (uniformly
distributed around the tank periphery)     :  51
Anchor Bolt Material (Steel) Specification : SA-307
Young's Modulus of Anchor Bolts            : 29500.000 (ksi)
Nominal - Yield Tensile Stress Bolt
Capacity of Anchor Bolts                   : 33.000 (ksi)
Nominal Diameter of Anchor Bolts           : 2.500 (in)
Height of Anchor Bolt Chairs               : 20.000 (in)
Effective Depth of Anchor Bolts
(below the tank bottom)                    : 48.000 (in)
Guaranteed Pretension of Anchor Bolts      : 0.000 (kip)
Reduction Factor of Anchor Bolt Tensile Capacity
(used when the bolt chair capacity and/or the bolt
pullout capacity are smaller than the bolt tensile
capacity and when a brittle failure mode will occur
rather than a ductile bolt break)          : 1.000
Freeboard Height (above the maximum
liquid level)                          : 1.800 (ft)
Strength Reduction Factor
(to estimate code-based capacities): 1.000
```

CALC. # 93C1783.2-02 SHT 32 of 32

```
**************************************************
*              T A N K V  1.0a                   *
*    SEISMIC RESPONSE AND CAPACITY ANALYSIS      *
*   OF VERTICAL CYLINDRICAL LIQUID STORAGE       *
*              FLAT BOTTOM TANKS                 *

*     prepared by Stevenson and Associates       *
*            Cleveland, OH, 1995                 *
*            o u t p u t   d a t a               *
**************************************************

 Title of the Problem : 2QSS-TK21
 Output Data Number   : 1
 Units Used           : American

 Recapitulation of Weights
 -------------------------

 Total Weight of the Tank Roof      : 33.077 (kip)
 Total Weight of the Tank Shell     : 140.856 (kip)
 Total Weight of the Tank Bottom    : 60.132 (kip)
 Total Weight of the Tank Liquid    : 7473.826 (kip)

 Natural Frequencies of the Tank-Liquid System
 ---------------------------------------------

 Fundamental Horizontal Natural Frequency
 of the Tank-Liquid System
 (foundation-tank interaction neglected)       : 3.962 (Hz)
 Fundamental Vertical Natural Frequency
 of the Tank-Liquid System
 (foundation-tank interaction neglected)       : 2.905 (Hz)
 Fundamental Sloshing Frequency                : 0.245 (Hz)

 Response Spectral Accelerations for Calculated Frequencies
 ----------------------------------------------------------

 Spectral Acceleration of Horizontal Impulsive
 Mode Response        : 0.112 (g)
 Spectral Acceleration of Vertical
 Mode Response        : 0.052 (g)
 Spectral Acceleration of Sloshing
 Mode Response        : 0.010 (g)

 Horizontal Impulsive Mode Response
 ----------------------------------

 Impulsive Mode Base Shear           : 716.055 (kip)
 Impulsive Mode Base Moment          : 18293.824 (kip-ft)
 Impulsive Mode Hydrodynamic Pressure
 (maximum value at the tank bottom) : 0.977 (psi)

 Horizontal Convective (Sloshing) Mode Response
 ----------------------------------------------

 Convective Mode Base Shear                  : 14.086 (kip)
 Convective Mode Base Moment                 : 667.307 (kip-ft)
 Convective Mode Hydrodynamic Pressure
 (maximum value near the liquid surface) : 0.091 (psi)
 Theoretical Sloshing Height                 : 0.210 (ft)

 Vertical Mode Response
```

```
 ----------------------

 Vertical Response Mode Liquid Pressure
 (maximum value at the tank bottom)        : 1.094 (psi)

 Combined Response
 -----------------

 Combined Seismic Base Shear               : 716.194 (kip)
 Combined Seismic Base Moment              : 18305.990 (kip-ft)
 Static Liquid Pressure
 (maximum value at the tank bottom)        : 26.433 (psi)
 Total Seismic Liquid Pressure
 (maximum value at the tank bottom)        : 1.467 (psi)
 Additional Overturning Base Moment (due to
 seismic liquid pressure at the tank bottom
 which loads the tank foundation only,
 not the tank shell and its anchor bolts): 2592.387 (kip-ft)

 Compressive Buckling Capacity of the Tank Shell,
 Liquid Hold-Down Forces
 ------------------------------------------------

 Compressive Buckling Capacity Stress
 of the Tank Shell                           : 10.236 (ksi)
 Basic Value of the Liquid Hold-Down Force : 0.309 (kip/in)
 First Derivation of the Liquid Hold-Down Force
 (with respect to the uplift displacement) : 0.455 (kip/in/in)

 Nominal & Reduced (Code-Based) Overturning Moment
 Tank Capacities
 -------------------------------------------------

 Nominal Overturning Moment Tank Capacity  : 143557.094 (kip-ft)
 Maximum Uplift (L)                          : 0.250 (in)

 fi = 1.0, no reduction required to estimate code-based capacity

 Nominal & Reduced (Code-Based) Sliding Shear Tank Capacities
 ------------------------------------------------------------

 Nominal Sliding Shear Tank Capacity         : 7661.079 (kip)

 fi = 1.0, no reduction required to estimate code-based capacity

 Other Capacity Checks
 ---------------------

 Nominal Liquid Capacity Pressure            : 42.000 (psi)

 fi = 1.0, no reduction required to estimate code-based capacity

 Seismic Margins
 ---------------

 Seismic Margin Overturning Moment Tank Capacity : 1.184 (g)
 Seismic Margin Sliding Shear Tank Capacity      : 1.615 (g)
 Seismic Margin Liquid Pressure Tank Capacity    : 1.923 (g)


 end of solution, bye
```

ATTACHMENT E

Fragility Calculations for BVPS-2 Buildings