CALCULATION COVER SHEET

* Calculation Preparation, Review and Approval Form PED-QP-3.1 Form Page No. 1 of 2 Calculation Cover Sheet * Short Term Calc: ☐ YES ☒ NO	CALCULATION NUMBER ○ FC06313 QA Category: ☒ CQE ☐ LIMITED CQE ☐ FIRE PRO. ☐ NON CQE ○ FILE NO. PED DEPARTMENT 357	Calc. Page No. 1 *TOTAL PAGES 37 + 2 Att. (9 pg)

CALCULATION TITLE USI A-46 / IPEEE, OUTLIER RESOLUTION AND DETAILED HCLPF for TANKS AC-1C & AC-1D	VENDOR CALC. NO. 94C2857-C-002 ☐ MR NO. ☒ ENGR. ANALYSIS EA-FC-93-085 ☐ DBD NO. ☐ ECN NO. ☐ OTHER

* APPROVALS - SIGNATURE & DATE					CONFIRMATION *REQUIRED (✓)	
PREPARER(S)/DATE(S)	REVIEWER(S)/DATE(S)	INDEPENDENT REVIEWER(S)/DATE(S)	*REV. NO.	SUPERSEDES *CALC. NO.	YES	NO
A. Karavoussianis 10/21/94	T. Tseng 10/31/94	[signature] 10/31/94	0	N/A		✓

* EXTERNAL ORGANIZATION DISTRIBUTION

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* SEE INSTRUCTIONS ON REVERSE SIDE
○ COMPLETED BY DOCUMENT CONTROL

PED-QP-3.25 REV. 2

CALCULATION COVER SHEET

Calculation Preparation, Review and Approval Form PED-QP-3.1 Form Page No. 2 of 2 Calculation Cover Sheet	CALCULATION NUMBER FCφ6313	Calc. Page No. 2 of 37
	FACILITY/SYSTEM	
	KEYWORD ○	

CALCULATIONS USED AS INPUT IN THE ANALYSIS		EQUIPMENT TAGS		
CALC./REV. NO.	DEPT. NO. ○	SYSTEM	ADDED	DEPT. NO.
FCφ1496, Rev. 0			AC-1C	
FCφ1682, Rev. 0			AC-10	
FCφ2483, Rev. 0				
FCφ1φ12, Rev. 2				
FCφ6323, Rev. 0 SIA, 93C2777-C-001, Rev. 0	357			

CALCULATION PREPARATION, REVIEW AND APPROVAL FORM PED—QP—3.2 Form Page No. 1 of 1 PRODUCTION ENGINEERING DIVISION CALCULATION REVISION SHEET	CALCULATION NO. FC Ø 6313

REV. NO.	DESCRIPTION / REASON FOR CHANGE
0	ORIGINAL ISSUE

REV.1

Calc Preparation, Review and Approval PED-QP-3.5 Page 1 of 2 Reviewer's Checklist-Calculations	CALCULATION NUMBER FC Ø6313

		YES	NO	N/A
1.	Is Calculation Cover Sheet attached and completed, as required, to the calculation?	✓		
2.	Is the calculation objective stated? Was this achieved?	✓		
3.	Are inputs correctly selected and incorporated into the analysis?	✓		
4.	Have inputs and/or assumptions which require confirmation at a later data, been identified on the Calculation Cover Sheet and in the calculation body?			✓
5.	Are the applicable codes, standards, regulatory requirements, and other references including issue and addenda identified such that they are traceable to source document?	✓		
6.	Was an appropriate calculation method used? Was the basic theory appropriate?	✓		
7.	Have assumptions been noted and justified?	✓		
8.	Are the calculations free of arithmetic errors?	✓		
9.	Is the calculation consistent with the design basis requirements?	✓		
10.	Is the conclusion stated?	✓		
11.	Is the calculation legible and suitable for microfilming?	✓		

Calc Preparation, Review and Approval PED-QP-3.5 Page 2 of 2 Reviewer's Checklist-Calculations	CALCULATION NUMBER FC 06313

	YES	NO	N/A
12. Are all blocks on the Calculation Cover Sheet addressed correctly?	✓		
13. Have Forms PED-QP-3.2, 3, 4 and 5 been used and correctly completed?	✓ *		
14. If the calculation has been prepared to supersede another calculation, has all the valid information been transferred in the new calculation?			✓
15. If the calculation determines that an existing or preexisting condition may be outside the design basis of the plant, are the results of a reportability evaluation performed in accordance with PED-QP-19 attached?			✓

REVIEWER COMMENTS:

* S&A calculation sheets were used

T. Tseng — Reviewer

10/31/94 — Date

Calc Preparation, Review and Approval PED-QP-3.7 Page 1 of 1 Independent Reviewer's Checklist - Calculations	CALCULATION NUMBER FC 06313

		YES	NO	N/A
1.	Are the calculation methods accurate and appropriate?	✓		
2.	Are input data sufficiently detailed?	✓		
3.	Are the calculation assumptions reasonable?	✓		
4.	Has the basis for engineering judgement been included in the calculation, when used?	✓		
5.	Is the calculation documented sufficiently such that the analysis is understandable to someone competent in the discipline without recourse to the Preparer?	✓		
6.	Have the design interface requirements been satisfied?	✓		
7.	Are the results reasonable and do they resolve the calculation objective?	✓		
8.	If an alternate calculation was used to verify the adequacy of the analysis, is it attached to the calculation?			✓
9.	If qualification testing was used to verify the adequacy of the analysis, has it been documented using a retrievable source, or attached to the calculation?			✓
10.	Are calculations involving Technical Specification values and associated margins of safety identified?			✓

INDEPENDENT REVIEWER COMMENTS:

Thomas J. Gray 10/31/94
Independent Reviewer Date

Client: Omaha Public Power District   Calculation No. 94C2857-C-002

Title: USI A-46 / IPEEE, Outlier Resolution and Detailed HCLPF for Tanks AC-1C & AC-1D

Project: OPPD, Fort Calhoun Station

Method: Conventional Engineering Hand Calculations.

Acceptance Criteria: "A Methodology for Assessment of Nuclear Power Plant Seismic Margin" EPRI NP-6041, Revision 1, August 1991

Remarks:

REVISIONS

No.	Description	By	Date	Chk.	Date	App.	Date
0	Initial Issue	A. K.	10/31/94	TMT	10/31/94	10/31/94	[signature]

Stevenson & Associates

CALCULATION COVER SHEET

FIGURE 1.3

CONTRACT NO.

94C2857

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Objective

The anchorage for the Component Cooling Heat Exchangers, AC-1C and AC-1D, were outliers according to the GIP (ref. 1) screening guidelines. The first objective of this calculation is to resolve the tank's A-46 outlier issue, by means of conventional engineering calculations.

Also, the Seismic Review Team (SRT) performed an on site inspection of the tanks and judged that the $HCLPF_{84}$ is governed by the tank's supporting system. Hence, this calculation will document a detailed anchorage $HCLPF_{84}$ for the tank and propose a possible solution to attain a 0.3G HCLPF, if necessary.

Analytical Approach

Since, both tanks, AC-1C and AC-1D, are identical and the nozzle loads for AC-1D are slightly larger, the anchorage of tank AC-1D will be analyzed. Hence, the anchorage of tank AC-1C will be enveloped by this calculation.

The tank $HCLPF_{84}$ will be calculated by computing the factor required to scale the seismic loads to the upper limit of the anchorage capacity. Then, this factor will be multiplied by the design basis earthquake peak ground acceleration (i.e. 0.17G), thus yielding the tank's $HCLPF_{84}$.

The spectral accelerations used in the both the outlier resolution and $HCLPF_{84}$ analysis are as computed in reference 5. Also, the concrete used for anchorage has a minimum 28 day compressive capacity of 4000 psi according to reference 6.

References

1. "Generic Implementation Procedure for Seismic Verification of Nuclear Plant Equipment", Revision 2, 6/28/91.

2. "Seismic Verification of Nuclear Plant Equipment Anchorage (Revision 1), Vol. 4: Guidelines on Tanks and Heat Exchangers", EPRI NP-5228-SL, June 1991.

3. "ACI Building Code", ACI-318-63.

4. "Component Cooling System Heat Exchanger", The Whitlock Mfg. Co., Dwg. L-26132-2, OPPD file #018675.

5. "IPEEE and A-46 Seismic Review FRS", Stevenson and Associates (S&A), Calculation Number 93C2777-C-001, Revision 0, Initial Issue.

6. "Design Compressive Strength of Concrete at Ft. Calhoun", R. E. Lewis of OPPD, September 16, 1993, S&A ref. 93C2777-LRC0-047.

7. "As Built Saddle Details for AC-1C & AC-1D", received from Sam Pande of OPPD via fax from P. K. Agrawal of S&L, 12/1/93, S&A ref. 94C2857-LRC0-007.

8. "Auxiliary Building Equip. Supports, Outline 8 Reinforcement Sheet 3", Omaha Public Power District, Dwg. # 11405-S-70.

9. "Theory and Analysis of Plates", Dr. Rudolph Szilard, Prentice - Hall Inc., 1974.

10. "Manual of Steel Construction, Allowable Stress Design", 9th Edition American Institute of Steel Construction Inc., 1989.

11. "Seismic Verification of Nuclear Plant Equipment Anchorage (Revision 1), Vol. 1: Development of Anchorage Guidelines", EPRI NP-5228-SL, June 1991.

12. "CQE Piping Isometrics, Seismic Sub. System #AC-215A", D-4208 Sh. 4 of 9, S&A ref. 93C2857-DC-038.

13. "Equipment Nozzle Load Summary Sheet", OPPD Calc. FC01496, Commonwealth Assoc. Filing Code 010-ACS-10-025, S&A ref. 93C2857-DC-038a.

14. "CQE Piping Isometrics, Seismic Sub. System #AC-326A", D-4220 Sh. 5&6 of 6, S&A ref. 93C2857-DC-039 & 039a.

15. "Equipment Nozzle Load Summary Sheet", OPPD Calc. FC01682, Commonwealth Assoc. Filing Code 010-ACS-10-018, S&A ref. 93C2857-DC-039a.

16. "CQE Piping Isometrics, Seismic Sub. System #RW-111A", D-4250 Sh. 1&2 of 2, S&A ref. 93C2857-DC-041 & 041a.

17. "Calc - Stress Analysis For Subsystem RW-111A", OPPD Calc. FC01012 Rev. 1A, S&A ref. 93C2857-DC-041c.

18. "CQE Piping Isometrics, Seismic Sub. System #RW-231A", D-4251 Sh. 2,3&5 of 5, S&A ref. 93C2857-DC-040, 040a & 040b.

19. "Equipment Nozzle Load Summary Sheet", OPPD Calc. FC02483, Commonwealth Assoc. Filing Code 010-RW-10-003, S&A ref. 93C2857-DC-040c.

20. "Building Code Requirements for Reinforced Concrete", ACI 319-89, American Concrete Institute, Revised 1992.

Sensitivity Analysis of Results

The calculation that follows resolved the A-46 outlier issue and attained a $HCLPF_{84}$ of 0.22G. The sensitivity analysis will examine the various factors of conservatism in the calculation and the possible effect these factors will have on the result. The two main factors which will be considered are the applied loads and support allowables.

There are two type of loads which were considered, nozzle loads and inertial loads. Since, the load were summed by the SRSS method, the nozzle load only make up 10% of the total applied load. Hence, if the nozzle load were corrected the impact on the result would be minimal, therefore, not worth looking into.

The inertial loads are derived from the heat exchanger's weight and spectral acceleration. Since, the equipment is a heat exchanger it is probably constantly full, therefore, the wet weight provided by the manufacturer is pretty accurate. As for the spectral acceleration, since, the acceleration is a function of the fundamental frequency and tank's frequency is within the rigid range, therefore, a refined frequency calculation will not have a significant impact on the results.

Since, there is no significant conservatism in the applied loads, consider the other factor, the calculated support allowables. The limiting factors in the support system are concrete for tension and anchor bolts for shear. The tension allowable may be increase by about 40% (an additional 12D for embedment) according to the British Code, if the 90° hook is considered (ref. 11). This 40% increase in the tension allowable will increase "x" to 1.35 (page 27 of this calculation) and give the tank a $HCLPF_{84}$ of 0.23, hence, it is no significant increase.

The shear allowable is governed by the steel bolt, therefore, it can not be significantly increased. Hence, it is safe to conclude that there is no significant conservatism, in this calculation, that will have a measurable impact on the results.

Summary

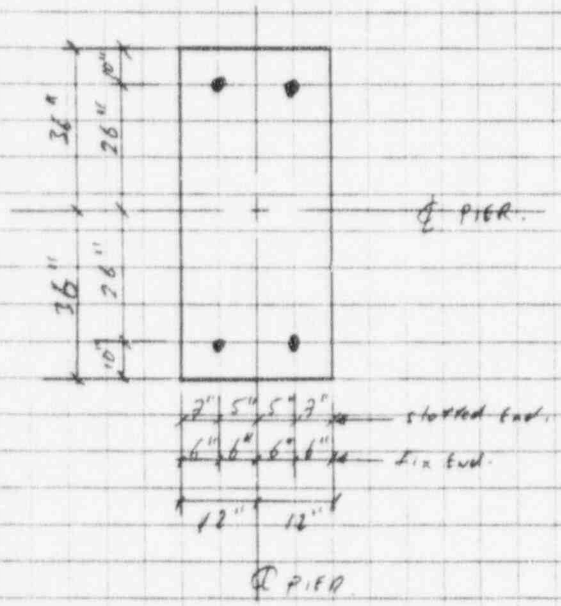
As stated in the Sensitivity Analysis of Result, the calculation that follows resolved the A-46 outlier issue and attained a $HCLPF_{84}$ of 0.22G for tanks AC-1C and AC-1D. Also, the sensitivity analysis showed that there is no significant conservatism, in the calculation, that would impact the results. This calculation proposes a possible modification to the fixed end saddle of tanks AC-1C and AC-1D, which will provide both tanks with an anchorage $HCLPF_{84}$ of at least 0.3G. (see page 37 of this calculation).

REF	
(1) SECT. 7	GIP : Input Data.
	TANK: $D = 5$ ft.
(4)	$L = 32$ ft.
	$t = 1$ in.
	$W_{ef} = 89853$ lbs
	$\gamma_h = 89853 / (\pi (5/2)^2 \times 32) = 143$ lbs/ft³
	$H_{cg} = 3.43$ ft.
	SADDLES: $S = 20.0$ ft.
	$h = 12.0$ in
	$G = 11.5 \times 10^6$ psi
	$E = 29 \times 10^6$ psi
	$NS = 2$.
(7)	BASE PLATE: $t_b = 0.5$ in
	$f_y = 36000$ psi
	$t_w = 5/8$ in $= 0.625$ in
	$e_s =$ N/A
	BOLTS: $NL = 2$
	$NB = 2$
	$d = 1$ in
	$D' = 4.33$ ft
(6)	CONCRETE $f_c' = 4000$ psi

REF

STEP 2 ANCHOR BOLT ALLOWABLES ; P_{all} & V_{all}

(8) BOLTS ARE 1"φ - 90° J-BOLTS



- REDUCTION PARAMETERS FOR EDGE DISTANCE IN SHEAR AND PULLOUT WILL USE THE FIXXED END (6"), BECAUSE THE SLOTTED END IS IN THE DIRECTION OF THE SLOTTED HOLE, HENCE NO SHEAR CAPACITY.

(1) App. C — FOR 1" J-BOLTS: ACCORDING TO GIP

P_{nom} = 26.69 kips (Pullout)

V_{nom} = 13.35 kips (shear)

L_{min} = 54.5 in (Embedment)

S_{min} = 3 in (spacing)

E_{min} = 8.75 in (Edge Distance)

EMBEDMENT CHECK:

(8) EMBEDMENT, L = (2'-9") − (5 ½") (total length; projection)

L = 27.5 in > 16 D = 16"

CONSIDER THE 1" J-BOLTS AS PLAIN REBAR, TOP BAR.

(3) Ch. 18 — ALLOWABLE BOND STRESS = ½ ($\frac{6.7\sqrt{4000}}{1}$) = 212 psi < 250 psi

∴ $P_{all} = \pi D L (212) = \pi(1)(27.5)(212)$ = 18.3 kips.

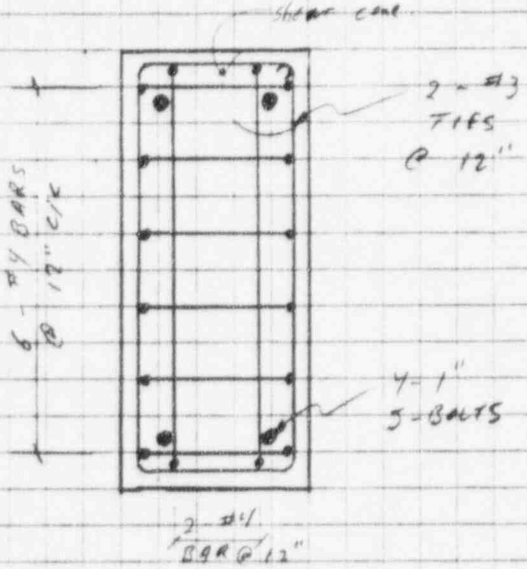
REF

(1) App. C — SPACING CHECK: $S = 2 \times 5 = 10\,in > S_{min} = 3\,in \therefore O.K.$

EDGE DISTANCE CHECK $E_1 = 6'' < E_{min} = 8.75\,in$

$E_2 = 10'' >$ " " $\therefore O.K.$

(8) CONSIDER THE REINFORCED PIER.



$V_{cone} = 2\phi\sqrt{f_c'}\ \pi(8.75\,D)^2$

$= 25.9$ KIPS

(11) p. 2-85 — $V'_{cone} = 2\phi\sqrt{f_c'}\ \pi(E_1)^2$

$= 12.2$ KIPS

$V_s = A_v f_y$

$A_v = A_{\#3} + A_{\#4} = .11 + .20 = .31$

(6) $\therefore V_s = .31(40) = 12.4$ KIPS.

(11) p. 2-85 — $\therefore\ V'_{all} = \dfrac{V'_{cone} + V_s}{1.8}$

$V'_{all} = \dfrac{12.2 + 12.4}{1.8} = 13.68 > V_{nom}$

ALLOWABLES

$P_{all} = 18.3$ KIPS

$V_{all} = 13.35$ KIPS

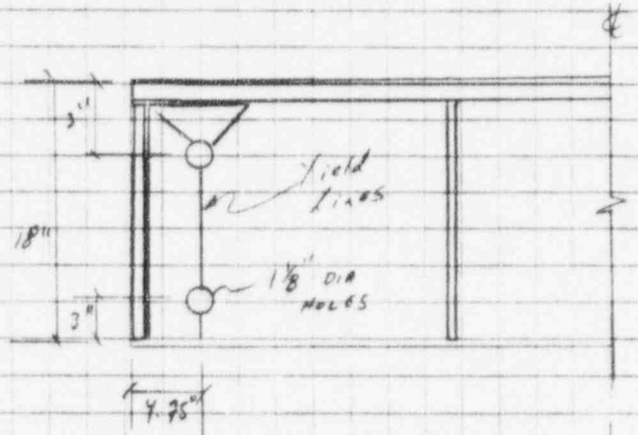
(11) p. 2-93 — SHEAR - TENSION INTERACTION

SINCE, THE FAILURE MODE IN SHEAR IS DUE TO STEEL AND TENSION IS DUE TO CONCRETE. CONSERVATIVELY USE THE CONCRETE FAILURE INTERACTION.

$$\left(\frac{P}{P_{all}}\right)^{5/3} + \left(\frac{V}{V_{all}}\right)^{5/3} \le 1$$

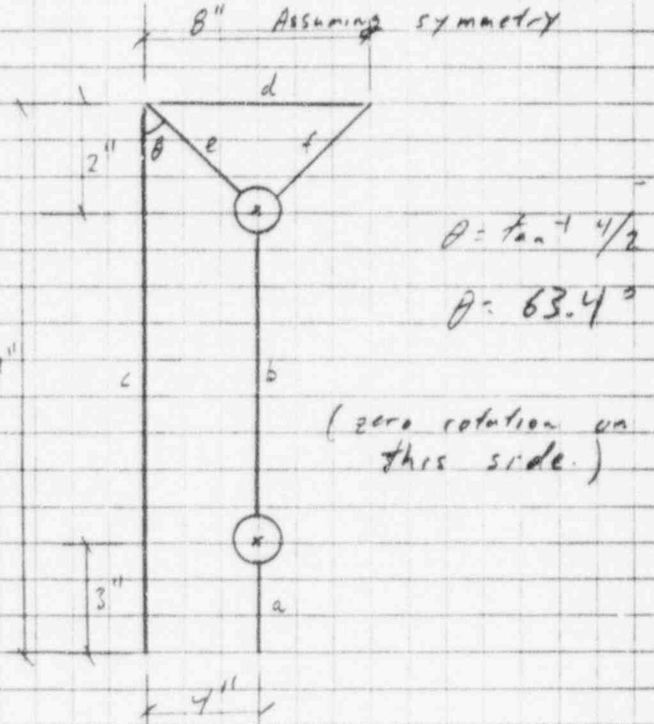
REF (9) ch. 7

CHECK BASE PLATE CAPACITY BY USING YIELD LINE ANALYSIS.
BASE PLATE IS 1/2" THICK



YIELD LINES:

(6 lines)



$\theta = \tan^{-1} 4/2$

$\theta = 63.4°$

(zero rotation on this side.)

line lengths; $l_a = 3 - 1.125/2 = 2.44"$

$l_b = 17 - 2 - 3 - 1.125 = 10.87"$

$l_c = 17"$

$l_d = 8"$

$l_e = l_f = [4 - (1.125/2) \sin 63.4°] / \sin(63.4°) = 3.91"$

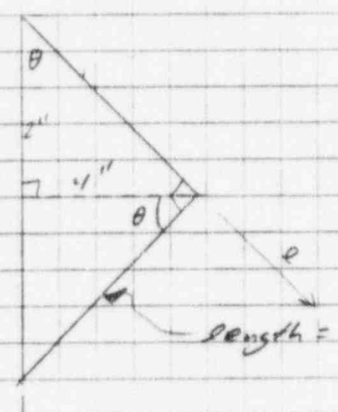
Consider a unit deflection δ'' @ the bolt holes.

Rotation about the lines:

$\beta_a = \beta_b = \beta_c = \delta/4 = 0.25\delta \ in^{-1}$

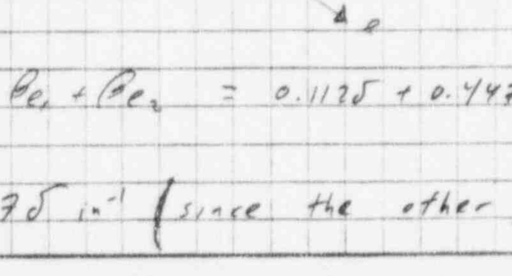
$\beta_d = \delta/2 = 0.5\delta \ in^{-1}$

β_e: ROTATION DUE TO PLATE BOUNDED BY LINES a, b, e & c



$\beta_{e_1} = \delta/8.93'' = 0.112\delta \ in^{-1}$

ROTATION DUE TO PLATE BOUNDED BY LINES e, d & f



$\beta_{e_2} = \delta/2.24'' = 0.447\delta \ in^{-1}$

$\beta_e = \beta_{e_1} + \beta_{e_2} = 0.112\delta + 0.447\delta = 0.559\delta \ in^{-1}$

$\beta_f = \beta_{e_2} = 0.447\delta \ in^{-1}$ (since the other plate has zero rotation)

REF

ENERGY EQUILIBRIUM;

$W_e = W_i$; work done by external forces equals to work done by internal ones.

THE UNIT PLASTIC MOMENT CAPACITY in [kip·in/in]

$M_u = Z\,F_y$

$= \frac{bh^2}{4} F_y = \frac{.5^2}{4}(36) = 2.25$ kip·in/in

$\delta \cdot P_u = M_u [l_a\theta_a + l_b\theta_b + l_c\theta_c + l_d\theta_d + l_e\theta_e + l_f\theta_f]$

$\delta \cdot P_u = M_u [(0.25\delta)(2.44 + 10.87 + 17) + (0.5\delta)(8) + (0.559 + 0.447)\delta(3.91)]$

$P_u = 2.25\,(15.51) = 34.9$ kips

∴ ALLOWABLE LOADING CONSISTANT w/ ASME $P_a = .9(34.9) = 31.4$ kips.

CHECK WELD CAPACITY FOR A UNIT LENGTH OF

(7) A 5/8" WELD

$M_w = (.75)(5/8)(0.707)(1.7)(.3)(60)$

$M_w = 10.1$ kip·in/in $> M_u = 2.25$

∴ O.K.

CHECK PUNCHING SHEAR:

$P_p = f_v\,\pi\,(d_e + t)\,t$ (spreading load @ 45°)

$d_e = 1.5"$ assuming a HEX NUT FOR 1" bolt. F=1.5°

(CONSERVATIVE) $P_p = 0.4(36) \cdot \pi\,(1.5 + .5)(.5)$

$P_p = 45.2$ kips $> P_u = 34.9$ kips ∴ o.k.

ALSO $P_a = 31.4$ kips $> P_{ALL} = 18.3$ kips ∴ THE BASE PLATE DOES NOT GOVERN.

REF

TANK FREQUENCY IN THE TRANSVERSE (W→E) AND VERTICAL DIRECTION.

(2) p.3-9

$$f_T = \frac{5.6}{2\pi}\left[\frac{E I g}{\bar{q} S^4}\right]^{0.5}$$

$E = 29 \times 10^6$ psi $= 4.18 \times 10^9$

$g = 32.2$ ft/s²

$$\bar{q} = \frac{\pi D^2}{4}\gamma_L = \frac{\pi (5)^2}{4}(143) = 2808 \text{ lbs/ft.}$$

$$I = \frac{\pi D^3 t}{8} = \frac{\pi (5)^3 \times \frac{1}{12}}{8} = 4.09 \text{ ft}^4$$

$$f_T = \frac{5.6}{2\pi}\left(\frac{4.18\times10^9 \times 4.09 \times 32.2}{2808 \times (20)^4}\right)^{0.5} = \underline{31.2 \text{ Hz}}$$

TANK FREQUENCY IN LONGITUDINAL (N→S) DIRECTION

(1) p7-55

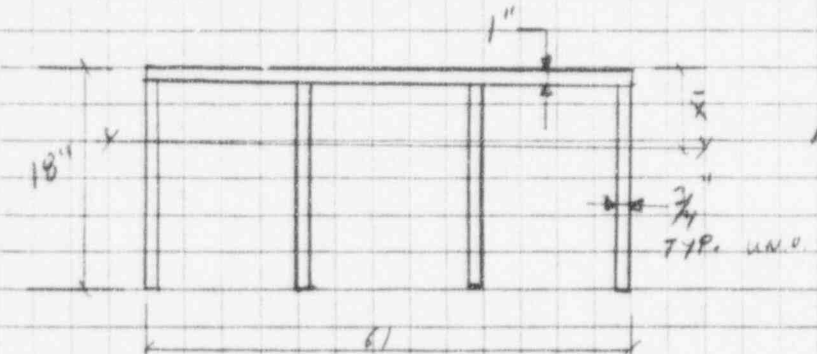
$$f_L = \frac{1}{2\pi}\sqrt{\frac{k_s g}{W_{tt}}}$$

$$A = (61\times1) + 4(3/4)(17) = 112 \text{ in}^2$$

$$k_s = \frac{1}{\frac{h^3}{3EI_{YY}} + \frac{h}{A_s G}}$$

$$\bar{X} = \frac{61\times1\times.5 + 4(3/4)(17)(9.5)}{112}$$

$\therefore \bar{X} = 4.6$ in



$$A_s = 4(3/4)(17) = 51 \text{ in}^2$$

$$I_{YY} = \frac{61\times1^3}{12} + 61\times1\times4.1^2 + 4\left[\frac{.75\times17^3}{12} + (.75)(17)(4.9)^2\right] = 3480 \text{ in}^4$$

(ref)

$$k_s = \frac{1}{\dfrac{12^3}{3\times 29\times10^6\times 3480} + \dfrac{12}{51\times 11.5\times10^6}} = 38.2\times10^6\ \#/in$$

$$g = 32.2\ ft/s^2 = 386\ in/s^2$$

$$f_L = \frac{1}{2\pi}\sqrt{\frac{38.2\times10^6\times 386}{89853}} = 64.5\ Hz$$

SINCE BOTH FREQUENCIES ARE IN THE RIGID RANGE OF THE SPECTRA, USE THE 5% DAMPED CURVES FOR BETTER ACCURACY.

SPECTRAL ACCELERATION: @ EL. 989 of the AUXILIARY BUILDING

(5) A-46; TRANSVERSE : $\alpha_{WE} = 0.32G$ (α_Y)

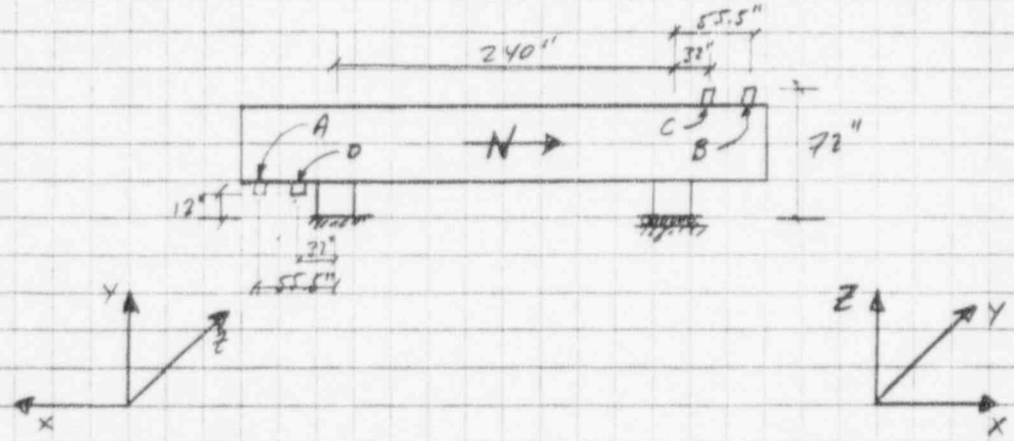
LONGITUDINAL: $\alpha_{NS} = 0.34G$ (α_X)

VERTICAL : $\alpha_V = 0.22G$ (α_Z)

NOZZLE LOADS

(4)

(12)→(19)



GLOBAL PIPING NOZZLE LOAD COORDINATE SYSTEM

ANALYSIS COORDINATE SYSTEM

REF.

(12)→(19)

OPERATING & THERMAL LOADS for AC-1D (FIXED END) units; lbs + lbs·in

NOZZLE	PIPE LOAD DIR.	PIPE LOAD MAG.	LOAD ON BASE PLATE Fx	Fy	Fz	Mx	My	Mz
A	Fx	284	-284		-7		-1700	
	Fy	-741			-912			
	Fz	121		121		-1452		
	Mx	-9984				+9984		
	My	-3960		17		-198		
	Mz	-15888			-66			
B	Fx	2384	-2384		-360		-85800	
	Fy	-28			6			
	My	386		2		-119		
	Mz	3584			15			
C	Fx	-260	260		78		18720	
	Fy	336			-45			
	My	7308		-30		2192		
	Mz	-4416			-18			
D	Fx	-562	562		14		3372	
	Fy	893			1012			
	Fz	1449		1449		-17388		
	Mx	12900				-12900		
	My	3696		-15		180		
	Mz	-24324			-101			
TOTALS			-1846	1544	-384	-19701	-65408	0

REF

(17→19)

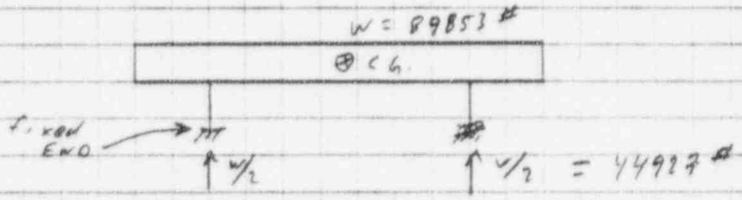
DBE LOADS for AC-1D (FIXED END) UNITS; lbs & lbs·in

NOZZLE	PIPE LOAD		LOAD ON BASE PLATE					
	DIR	MAG.	Fx	Fy	Fz	Mx	My	Mz
A	Fx	420	-420		-11		-2520	
	Fy	729			898			
	Fz	581		581		-6972		
	Mx	15732				-15732		
	My	-9000		38		-450		
	Mz	-7752			-32			
B	Fx	899	-899		-135		-32364	
	Fy	-1424			329			
	My	-55501		231		-16650		
	Mz	77160			322			
C	Fx	589	-589		-88		-21204	
	Fy	-249			33			
	My	-19896		83		-5969		
	Mz	17256			72			
D	Fx	993	-993		-25		-5958	
	Fy	1237			1402			
	Fz	951		951		-11412		
	Mx	25524				-25524		
	My	-21552		90		-1078		
	Mz	-35928			-150			
SRSS			-1522	1145	1744	-37310	-39230	0

REF

CALCULATE THE LOAD PER BOLT DUE TO DEAD LOAD, PIPING NOZZLE OPERATING LOADS AND THERMAL LOADS.

DEAD LOAD:



∴ LOADS ON THE FIXED END (NOZZLE + DEAD LOAD)

$F_x = -1846$ #

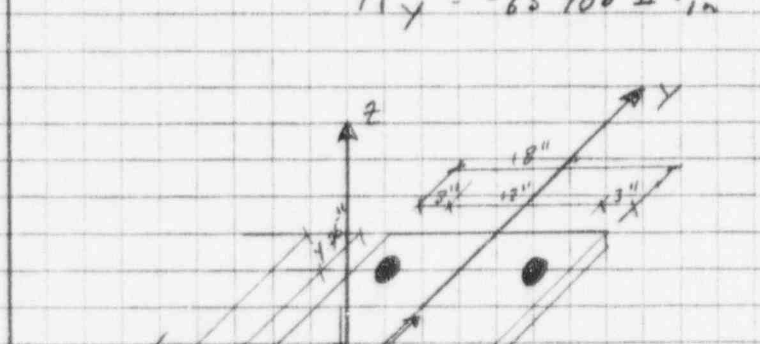
$F_y = 1544$ #

$F_z = -384 - 44927 = -45311$ #

$M_x = -19701$ #·in

$M_y = -65408$ #·in

(4)



(SADDLE AND STIFFENER PLATE ARE NOT SHOWN)

$P_{DL} = \frac{-45311}{4} + (\frac{1}{2})\frac{19701}{56.75} + (\frac{1}{4})\frac{65408}{16}$

$= -8974$ #

∴ SAY -9.0 kips (compression)

$V_{DL} = \frac{1}{4}\sqrt{1876^2 + 1544^2}$

$V_{DL} = 602$

∴ SAY 0.6 KIPS

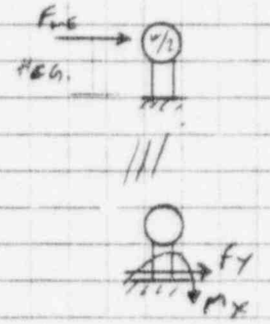
REF

∴ THE DEAD LOADS ON THE CRITICAL BOLT ARE;

$P_{DL} = -9.0$ kips

$V_{DL} = 0.6$ kips

CALCULATE LOADS ON THE BASE PLATE DUE TO SEISMIC ACCELERATION IN THE WEST-EAST (Y) DIRECTION.



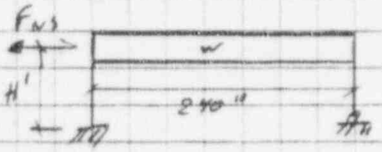
$F_{WE} = \frac{W}{2} \alpha_{WE} = \frac{1}{2}(89853)(0.32) = 14376$ #

$H_{EQ} = 3.43$ ft $= 41.2''$

$F_Y = 14376$ #

$M_X = -592300$ #·in

CALCULATE LOADS ON THE BASE PLATE DUE TO SEISMIC ACCELERATION IN THE NORTH-SOUTH (X) DIRECTION.



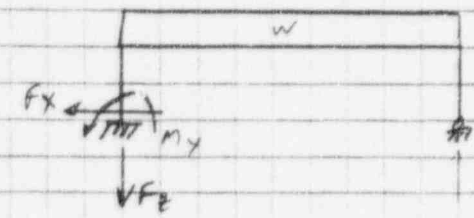
$F_{NS} = W \cdot \alpha_{NS} = 89853(0.34) = 30550$ #

SINCE, THE HX IS EXTREMELY RIGID LONGITUDINALLY, THE FORCE WILL BE EVENLY DISTRIBUTED ON THE WELD BETWEEN THE HX AND ITS SADDLE.

$Y' = \frac{2R}{\pi} = \frac{2(30)}{\pi} = 19.1''$

$H' = 42'' - 19.1 = 22.9''$

REF

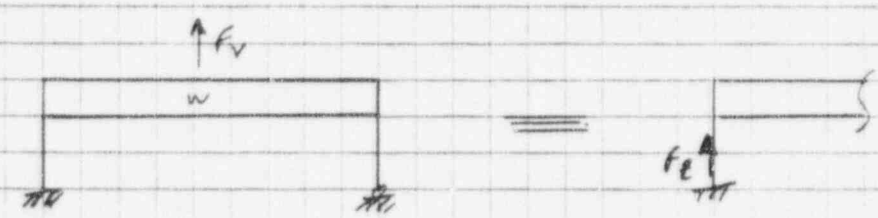


$F_x = -30550$ #

$M_y = -(30550)\frac{22.9}{2} = -349800$ #-in

$F_z = -\frac{349800}{240} = -1460$ #

CALCULATE LOADS ON THE BASE PLATE DUE TO SEISMIC ACCELERATION IN THE VERTICAL (Z) DIRECTION



$F_v = W \cdot a_v = 89853\,(0.22) = 19768$ #

$F_z = F_v/2 = \frac{19768}{2} = 9884$ #

SUMARY OF LOADS ON THE FIXED END BASE PLATE.

LOAD	Fx	Fy	Fz	Mx	My
INERTIAL SEISMIC	-30550	14376	9884 -1460	-592300	-349800
PIPING SEISMIC	-1522	1145	1741	-37310	-39230
SRSS	-30590	14420	9930	-593500	-352000

FORCE in "lbs"

MOMENT in "lbs-in"

REF

LOAD ON CRITICAL BOLT;

TENSION: due to F_z ; $P_{F_z} = \frac{9930}{4} = 2483$ lbs

due to M_x ; $P_{mx} = \frac{1}{2}\left(\frac{593500}{56.75}\right) = 5229$ lbs

due to M_y ; $P_{my} = \frac{1}{2}\left(\frac{352000}{15}\right) = 11733$ lbs

SRSS , $P_{LL} = 13084$ lbs $= 13.1$ kips

SHEAR $V_{LL} = \frac{1}{4}\sqrt{(30590)^2 + (14420)^2}$

$V_{LL} = 8455$ lbs $= 8.46$ Kips

SHEAR - TENSION INTERACTION:

$P = P_{LL} + P_{DL} = 13.1 - 9.0 = 4.1$ kips

$V = V_{LL} + V_{DL} = 8.46 + 0.6 = 9.06$ kips

$$\left(\frac{4.1}{18.3}\right)^{5/3} + \left(\frac{9.06}{13.35}\right)^{5/3} = 0.61 < 1.0 \therefore o.k$$

∴ THE TANK ANCHORAGE IS O.K. FOR A-46.

Ref

CHECK IF THE TANK MEETS A 0.3G HCLPF.

COMPARISON OF SPECTRAL ACCELERATIONS @ EL. 989 of the AUXILIARY BUILDING.

Ref	DIRECTION	A-46 (SSE)	SME	RATIO SME/SSE
(5)	α_{WE}	0.32 G	0.57 G	1.78
	α_{NS}	0.34 G	0.60 G	1.76
	α_V	0.22 G	0.38 G	1.72

*NOTE: THE SME CONSISTING OF THE SPECTRAL ACCELERATION DUE TO A 0.3G PGA

∴ USE A RATIO OF 1.78 ON THE LIVE LOADS.

∴ $P = 1.78(13.1) - 9.0 = 14.3$ kips

$V = 1.78(8.46) + 0.6 = 15.7$ kip $> V_{ALL} = 13.35$ kips

∴ TANK HCLPF IS NOT 0.3G.

CALCULATE TANK HCLPF

$$\left(\frac{x(13.1) - 9}{18.3}\right)^{5/3} + \left(\frac{x(8.46) + 0.6}{13.35}\right)^{5/3} \leq 1.0$$

BY TRIAL & ERROR $x = 1.27$

∴ HCLPF $= 1.27(.17) = \underline{0.22}$

REF

CHECK SADDLE STRESSES

(4) & (7) SADDLE WEAK AXIS : $I_{WE} = 3480\ in^4$

$S_{WE} = 3480/(18-4.6) = 260\ in^3$

Shear AREA ; $A_{WS} = 4(18)(.75) = 54\ in^2$

STRONG AXIS :

$I_{NS} = \frac{1\times61^3}{12} + 4\left(\frac{17\times(.75)^3}{12}\right) + 17(.75)(2)(30.5^2+10.5^2)$

$= 45450\ in^4$

$S_{NS} = 45450/30.5 = 1490\ in^3$

Shear Area ; $A_{WE} = 1\times61 = 61\ in^2$

(10) Ch. 5 SECT. E SECT. F ALLOWABLES: 1.7 x AISC ALLOWABLES for 36ksi STEEL EXPECT FOR DEAD LOADS.

SHEAR ; $F_{V_D} = .4\times36 = 14.4\ ksi$ (DEAD)

$F_{V_L} = 1.7(14.4) = 24.5\ ksi$

BENDING ; $F_{b_D} = .6\times F_y = 21.6\ ksi$ (DEAD)

$F_{b_L} = 1.7(21.6) = 36.7\ ksi$

REF

SEISMIC LOAD IN THE DIRECTION: W-E

(5) $F_{WE} = \alpha_{WE}(W/2) = 45000 \times 0.32 = 14{,}400\ lbs = 14.4\ kip$

$M_{NS} = \alpha_{W}(W/2) H_{CG} = 14400 \times 41.2 = 593 \times 10^3\ lbs \cdot in$
$= 593\ kip \cdot in.$

SEISMIC LOAD IN THE DIRECTION: N-S

$F_{NS} = \alpha_{NS} W = 0.34(90000) = 30.6\ kips$

$F_V = \frac{3 \alpha_{NS} W H_{CG}}{4L} = 3(30.6)(41.2)/(4 \times 240) = 4\ kips$

$M_{WE} = \alpha_{NS} \cdot W \cdot H_{CG}/4 = 30.6 \times 41.2/4 = 315\ kip \cdot in$

SEISMIC LOAD IN THE DIRECTION: VERTICAL

$F_V = \alpha_V (W/2) = 0.22(45000) = 9.9\ kips$

CHECK COMPRESSIVE SADDLE STRESS

DEAD LOAD ; 45 kips (w/2)

SEISMIC N-S ; 4 kips

SEISMIC VERTICAL ; 9.9 kips

Piping OPER. & THER. LOADS ; 0.4 kips ($F_z = -384\ lbs$)

Piping. SSE LOADS ; 1.7 kips ($F_z = \pm 1744\ lbs$)

TOTAL 61.0 kips

$\therefore$ STRESS $f_c = \frac{61.0}{112} = 0.54$ ksi $\Rightarrow$ LOW $\therefore$ O.K by INSPECTION.

REF

CHECK SHEAR:

THE SHEAR CHECK WILL BE DONE INDEPENDENTLY IN EACH DIRECTION.

W-E DIRECTION: SEISMIC W-E : 14.4 KIPS

Piping OPER & THER; 1.5 KIPS (FY)

Piping DBE ; 1.1 KIPS (FY)

TOTAL 17.0 KIPS

STRESS f_{WE} = 17.0 / 61 = 0.28 KSI << 14.4 KSI (DEAD)

∴ O.K.

N-S DIRECTION: SEISMIC N-S : 30.6 KIPS

Piping OPER & THER; 1.8 (FX)

Piping DBE ; 1.5 (FX)

TOTAL 33.9 KIPS

STRESS f_{NS} = 33.9 / 54 = 0.63 KSI << 14.4 KSI (DEAD)

∴ O.K.

CHECK BENDING:

BENDING AND AXIAL WILL NOT BE COMBINED, BECAUSE THE AXIAL STRESS WERE SHOWN TO BE NEGLIGIBLE ON THE PREVIOUS PAGE.

CLIENT 94C2857	JOB No. C-002	SHEET 31	OF 37

SUBJECT: A-46 OUTLIER RESOLUTION AND DETAILED HCLPF FOR TANKS AC-1C & AC-1D

REVISIONS: 0 — A.K. 10/31/94, THT 10/31/94

Stevenson and Associates
A Structural-Mechanical Consulting Engineering Firm

REF

DIRECTION N-S : (LOAD)

SEISMIC: 315 kip·in (M_{WE})

OPER & THER PIPING; 65.4 kip·in (M_Y)

DBE PIPING; 39.2 kip·in (M_Y)

TOTAL: 419.6 kip·in

STRESS $f_{b_{NS}}$ = 419.6/260 = 1.6 ksi (LOW)

DIRECTION W-E : (LOAD)

SEISMIC; 593 kip·in (M_{NS})

OPER & THER. PIPING; 19.7 kip·in (M_X)

DBE PIPING; 37.3 kip·in (M_X)

TOTAL: 650.0 kip·in

STRESS $f_{b_{WE}}$ = 650.0/1490 = 0.4 ksi (LOW)

SINCE THE BENDING STRESS IN BOTH DIRECTIONS ARE LOW, THE SADDLES ARE O.K BY INSPECTION

ALSO, BECAUSE OF THE SADDLE'S EXTREMLY LOW STRESSES, THE SADDLE CAN BE SCREENED OUT AT BETTER THAN 0.5G HCLPF.

∴ THE TANK HCLPF REMAINS AT 0.22G

REF.

PROPOSED POSSIBLE MODIFICATION TO ATTAIN AT LEAST A 0.3G HCLPF.

CONSIDER A MODIFICATION THAT WILL REMOVE THE LONGITUDINAL (N-S or X-AXIS) SHEAR FROM THE BOLTS.

∴ NEW SHEAR LOAD PER BOLT.

ASSUME THE SHEAR DEAD LOAD REMAINS

$V_{DL} = 0.6$ kips

@ DBE $V_{EL} = \frac{1}{4}(14420) = 3605$ lbs. $= 3.6$ kips

FOR 0.3G HCLPF

$P = 14.3$ kips (ON CRITICAL BOLT)

$V = 1.78(3.6) + 0.6 = 7.0$ kips.

∴ SHEAR - TENSION INTERACTION

$$\left(\frac{14.3}{18.3}\right)^{5/3} + \left(\frac{7}{13.35}\right)^{5/3} = 1.0 \quad \therefore \text{o.k.}$$

∴ THIS TYPE OF MODIFICATION WILL PROVIDE THE TANKS WITH AT LEAST A 0.3G HCLPF.

Stevenson and Associates

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CLIENT 94C2857 JOB No. C-002 SHEET 33 OF 37

SUBJECT

A-46 OUTLIER RESOLUTION AND DETAILED HCLPF FOR TANKS AC-1C & AC-1D

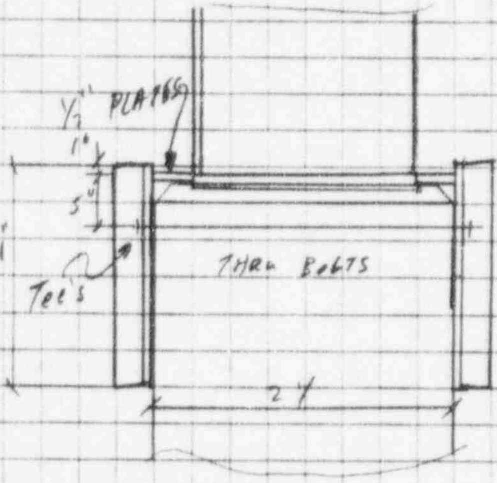
REVISIONS: 0 — R.K. 10/21/94; TMT 10/21/94

REF.

MINIMUM MODIFICATION SHEAR LOAD

$$V_m = 1.78\ (30590) = 54450\ \text{lbs}$$

(20) SECT. 9.3, 10.15, 11.3



CONCRETE BEARING STRENGTH

$\phi\,(0.85\ f_c'\ A)$

where $\phi = 0.7$

$A = 10 \times 3 = 30\ in^2$

$\therefore\ 0.7(0.85)(4000)(30) = 71400\#$

$> 54450\#\quad \therefore\ o.k.$

SHEAR : $V_c = \phi\, 2\sqrt{f_c'}\ b_w\ d.\quad ;\quad \phi = 0.85$

$$b_w = \frac{10 + 2(24)}{2} = 29$$

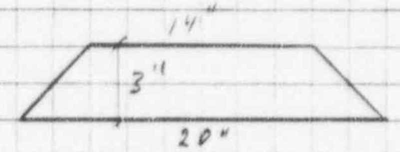
$\therefore\ V_c = (.85)2\sqrt{4000}\ (29)(24) = 88038\# > 54450$

$\therefore$ o.k.

$\therefore$ CONCRETE IS O.K.

STEEL

½ THK PLATE in compression



$\frac{KL}{r}$; $K = 1.0$ $L = 3''$ $r = \sqrt{I/A}$

$I = \frac{14 \times .5^2}{12} = 0.1458\ in^4$ $A = 14 \times .5 = 7\ in^2$

$\therefore\ r = \sqrt{\frac{.1458}{7}} = 0.144\ in$

$\frac{KL}{r} = \frac{1 \times 3}{.144} = 21$

REF

(10) chapt. 3

ALLOWABLE STRESS, $F_a = 20.5\ ksi$

$F_c = \frac{54.45}{7} = 7.8\ ksi < F_a = 20.5\ ksi$ ∴ o.k.

REQUIRED FILLET WELD

$A = 14'' \times 0.707 \times t = 9.9\ t$

ALLOWABLES STRESS: $F_w = 1.7 \times 0.3 \times 60 = 30.6\ ksi$

$F_w = \frac{F}{A}$ ∴ $A = \frac{F}{F_w}$

$9.9t = \frac{54.45}{30.6}$ ∴ $t = 0.180''$

∴ USE a $\frac{1}{4}''$ fillet weld.

DESIGN TEE SECTION

$M_{max} = 54.45 \times 5 = 272.3\ kip \cdot in$

ALLOWABLE BENDING STRESS: $F_b = 0.9 F_y = 32.4\ ksi$

∴ $S_{req} = \frac{272.3}{32.4} = 8.40\ in^3$

ALLOWABLE SHEAR STRESS = $F_v = 1.7 \times .4 \times F_y = 24.5\ ksi$

∴ $A_{s\,req} = \frac{54.45}{24.5} = 2.22\ in^2$

∴ USE WT 7 x 60

$S_{xx} = 8.67$
$A_s = 4.27$

SUBJECT A-46 OUTLIER RESOLUTION AND DETAILED HCLPF FOR TANKS AC-1C & AC-1D

REVISIONS 0 A.K. 10/21/94 JMT 10/31/94

Stevenson and Associates
A Structural-Mechanical Consulting Engineering Firm

REF

LOCAL WEB YIELDING

CHAP. 5 SECT. K

$$\frac{R}{t_w(N+2.5k)} \le 0.66F_y = 23.8\text{ksi}$$

R = 54.45 kips

t_w = 0.592

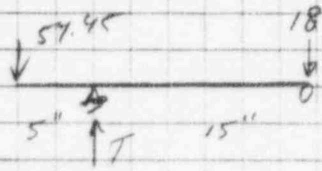
N = 0.5 + 2 × 0.94 = 2.38"

k = 1 5/8" = 1.625"

$$\frac{54.45}{0.592(2.38+2.5(1.625))} = 14.3 \text{ ksi} < 23.8\text{ksi}$$

∴ O.K.

CALCULATE THRU BOLTS



$$T = \frac{20(54.45)}{15} = 72.6 \text{ kips}$$

TRY 2-7/8" - A325 BOLT $F_T = 2(1.7 \times 26.5) = 90.1$ kips

∴ O.K

∴ USE 2-7/8"-A-325 THRU BOLTS.

CHECK PUNCHING SHEAR IN TEE FLANGE

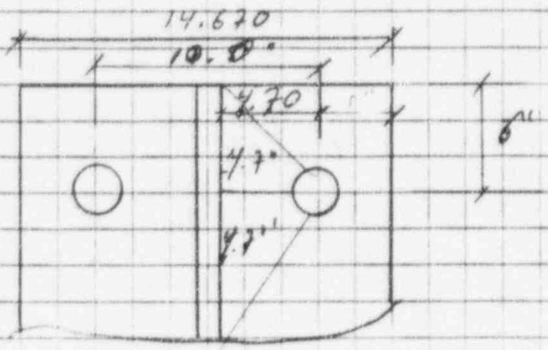
SHEAR AREA = (1 7/16) π (0.940) = 4.25 in²

TENSION PER BOLT = 72.6/2 = 36.3 kips

STRESS = 36.3/4.25 = 8.54 ksi < F_v = 24.5 ksi ∴ O.K

REF

CHECK BENDING OF FLANGE



$b = 9.4''$, $t = 0.94''$

$\therefore S = \frac{b\,t^2}{6} = 1.38\ in^3$

$M = \frac{36.3\ kip \times 4.70''}{4} = 42.7\ kip\cdot in.$

$STRESS = 42.7 / 1.38 = 30.8\ ksi < .9F_y = 32.4\ ksi$

$\therefore$ O.K.

NOTE: - FIRST ASSEMBLE THE WT7x60 AND TIGHTEN THE THRU-BOLTS.

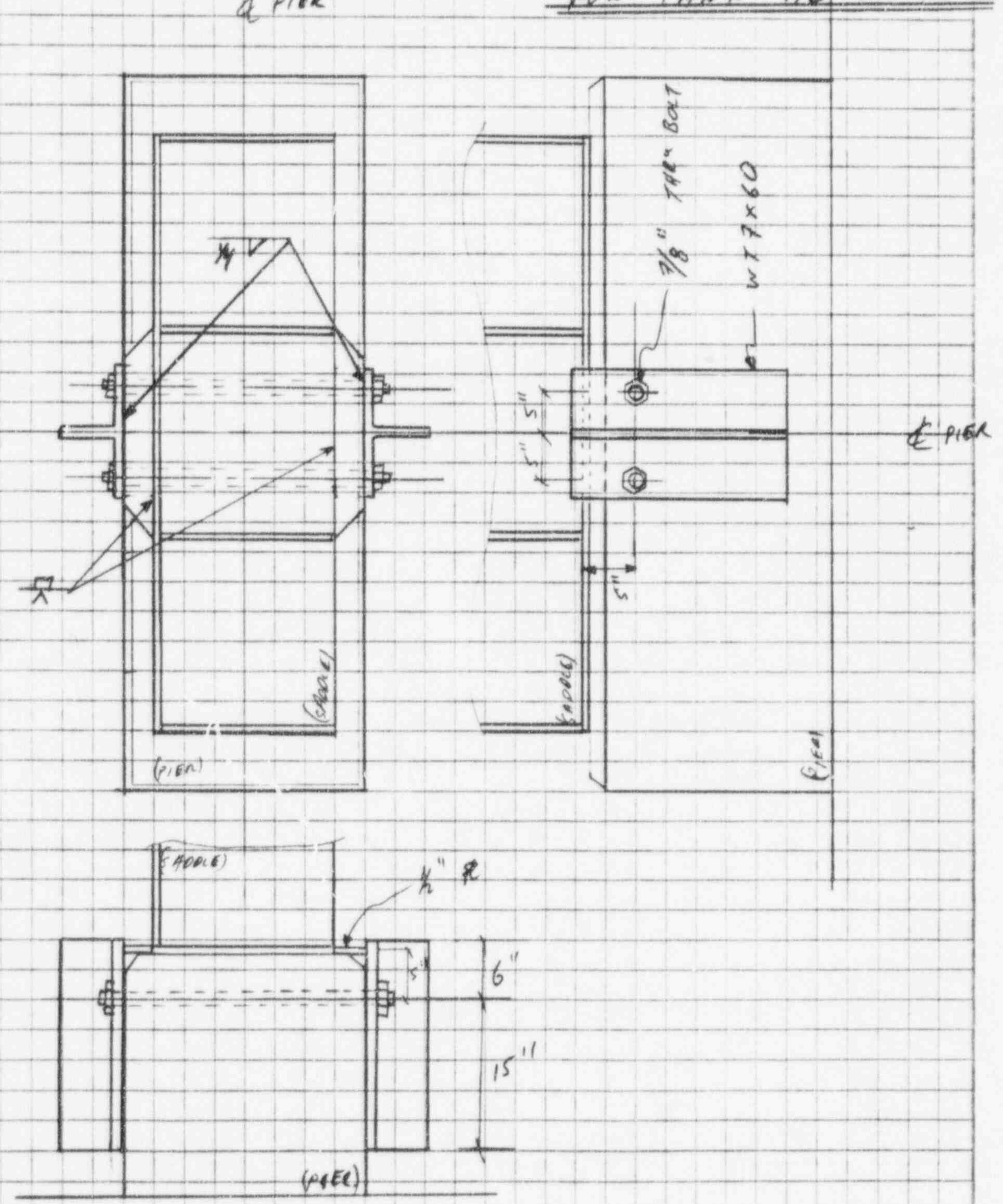
- THEN FABRICATE AND WELD THE 1/2" PLATES.

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

CLIENT	94C2857
JOB No.	C002
SHEET	37 OF 37
SUBJECT	A-46 OUTLIER RESOLUTION AND DETAILED HCLPF FOR TANKS AC-1C & AC-1D
REVISIONS	0 — A.K. 10/21/94, TMT 10/31/94

PROPOSED MODIFICATION SKETCH

FOR TANK AC-1C & AC-1D



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PRODUCTION ENGINEERING DIVISION
Omaha Public Power District
P. O. Box 399 Fort Calhoun, Nebraska 68023
(402) 533-7390

FAX COVER SHEET

Date: 9-16-93

To: PAUL KARAVOUSSINIS, S&A

Telephone: FAX 617-933-4428

From: RANDY LEWIS, OPPD

Telephone: 402-533-6508

COMMENTS: ______

Number of Pages to Follow: 6

Date: September 16, 1993
Author: R. E. Lewis, P.E.

Subject: Design Compressive Strength of Concrete at Ft. Calhoun

References:

1) Design Basis Document Containment, SDB-CONT-501, Rev. 5

2) Design Basis Document Auxiliary Building, SDB-AUX-502, Rev. 5

As identified in the attached excerpts from Ref. 1 & 2, the normal weight concrete (designated as Class B), used throughout Containment and the Auxiliary Building, was required to have a minimum 28 day compressive strength of 4000 psi. Nearly all concrete anchorages are developed in this concrete.

Heavy weight concrete (designated as Class C), used for some shielding walls, was required to have a minimum 28 day compressive strength of 3000 psi. Some anchorage may be installed in this concrete.

Class A concrete, used in the Containment shell, was required to have a minimum 28 day compressive strength of 5000 psi. Only a few anchors are installed in this concrete.

Concrete floors are generally covered by a 2" topping of light weight concrete, sloped toward floor drains, having a tested average 28 day strength of over 4000 psi.

OMAHA PUBLIC POWER DISTRICT

FT. CALHOUN STATION

DESIGN BASIS DOCUMENT
CONTAINMENT

DOCUMENT NUMBER
SDBD-CONT-501

Revision 5

February 1993

CQE

4.0 DESIGN REQUIREMENTS

4.1 SYSTEM DESIGN REQUIREMENTS

4.1.1 System General Design Requirements

4.1.1.1 Layout Requirements

The containment structure layout must include provisions to permit access to system components for maintenance, repair, refueling, and operation.

Openings in the interior concrete walls and floors must be provided and grating used where possible, without reducing the necessary shielding, to allow depressurization of all compartments in order to minimize differential pressure across the walls and floors due to a Design Basis Accident (DBA) (Ref. 1.2, Supplement 2, Question 10.1).

4.1.1.2 Environmental Conditions

The containment structure, including access openings and penetrations, and any necessary containment heat removal systems shall be designed so that the containment structure can accommodate without exceeding the design leakage rate the pressures and temperatures resulting from the largest credible energy release following a loss-of-coolant accident (LOCA), including a considerable margin for effects from metal-water or other chemical reactions that could occur as a consequence of failure of emergency core cooling systems (Ref. 2.1, Criterion 49).

4.1.1.3 Material Requirements

The requirements for structural materials used in the design of the containment structure are specified below. These requirements must be used when evaluating the effects of modifications on the existing containment structure.

- Concrete

Concrete used in the containment structure is of three classifications, Class A, Class B, and Class C.

<u>Class A Concrete</u> - must be used in the containment structure shell which comprises the cylindrical wall, spherical dome, and the portion of the foundation mat beneath the containment structure. Class A concrete must have a minimum 28 day compressive strength of 5,000 psi (Ref. 5.1, Page H2-4).

Class B Concrete - must be used for structures within the containment structure and the access gallery beneath the containment foundation mat. Class B concrete must have a minimum 28 day compressive strength of 4,000 psi (Ref. 5.1. Page H2-4).

Class C Concrete - must be used in localized portions of the containment structure where special shielding provisions are required. Class C concrete must have a minimum 28 day compressive strength of 3,000 psi and a density of not less than 225 pounds per cubic foot (Ref. 5.1, Page H2-10) For locations of type C concrete see PLDBD-NU-63, Personnel Protection.

- Reinforcing Steel

  Reinforcing steel in the portion of the mat beneath the containment structure shall conform to ASTM A432 with a minimum yield strength of 60,000 psi.

  Reinforcing steel in the balance of the structure must be intermediate grade deformed bars conforming to ASTM A15 with a minimum yield strength of 40,000 psi (Ref. 5.1, Page H3-1).

- Welding of Reinforcing Steel

  Mechanical butt splices (other than lapped) must be provided by means of the Cadweld process employing "T" series connectors designed to develop the specified tensile strength of the reinforcing steel. No individual splice shall have less than 125 percent of the minimum yield strength of the bar being spliced (Ref. 5.1. Pages H3-1 and H3-2).

- Structural Steel Members

  Structural steel shapes and plates must conform to ASTM A36 with a minimum yield strength of 36,000 psi (Ref. 5.1, Page H7-2).

- Welding of Structural Steel

  The welding of structural steel must be in compliance with AISC "Specification for Design, Fabrication and Erection of Structural Steel Buildings" and AWS D1.0-40, "Standard Code for Arc and Gas Welding in Building Construction (Ref. 5.1, Page H7-2).

OMAHA PUBLIC POWER DISTRICT

FT. CALHOUN STATION

DESIGN BASIS DOCUMENT
AUXILIARY BUILDING

DOCUMENT NUMBER
SDBD-AUX-502

Revision 5
SEPTEMBER 1993
CQE

4.1.1.3 Material Requirements

The requirements for structural materials used in the original design of the auxiliary building are specified below.

These requirements must be used when evaluating the effects of modifications on the existing auxiliary building structure.

Concrete

Normal weight concrete (designated as class B) must have a 28 day compressive strength of 4000 psi. Heavy concrete (designated as class C) must have a 28 day compressive strength of 3000 psi and a density of 225 pcf (Ref. 5.1, Section "Concrete").

Welding of Structural Steel

The welding of structural steel must be in compliance with AWS D1.0-40, Standard Code for Arc and Gas Welding in Building Construction (Ref. 5.1, Section "Structural Steel").

Welding of Reinforcing Steel

Mechanical buttsplices (other than lapped) must be provided by means of the Cadweld process employing "T" series connectors designed to develop the specified tensile strength of the reinforcing steel. No individual splice shall have less than 125 percent of the minimum yield strength of the bar being spliced (Ref. 5.1, Section "Reinforcing Steel").

Reinforcing Steel

Reinforcing steel in the auxiliary building mat and superstructure must be intermediate grade deformed bars with a minimum yield strength of 40,000 psi (Ref. 5.1, Section "Reinforcing Steel").

Structural Steel Members

Structural steel shapes and plates must have a minimum yield strength of 36,000 psi (Ref. 5.1, Section "Structural Steel").

Structural Steel Bolting

All field connections must be made with high-strength steel bolts in friction type connections (Ref. 5.1, Section "Structural Steel" 6.02).

Spent Fuel Pool Liner

The spent fuel pool liner material must be compatible with the requirements of SDBD-AC-SFP-102, Spent Fuel Storage and Fuel Pool Cooling.

94C2857-LRCO-007

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ATTACHMENT #2

TELECOPY COVER SHEET

SARGENT & LUNDY

Please Print in Black Ink Only

Date: 12/1/93

To: Paul K

Company Name: S&A

From: P.K. Agrawal

Project No.: 9233-00

Work Group No.:

Payroll No.:

Telecopy No.: 617-933-4428

City: State:

Ext.: Loc.:

Cover Sheet Plus Page(s)

Our Telecopier Number is 312-269-2179 (23E10)
312-269-2757 (23rd floor)
312-269-3680 (26th floor)

COMMENTS: Paul, I am faxing this info to you. I will also send a hard copy in overnight mail today. Any questions on this, pl call Sam directly. Thanks,

PK

94C2857 LRCO-

Received from Sam Pande 12/1/93

AC-1C

AC-1D