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 ○ FCØ6314	Calc. Page No. 1 *TOTAL PAGES 25 + 1 ATT. (7 P.)
	QA Category: ☒ CQE ☐ LIMITED CQE ☐ FIRE PRO. ☐ NON CQE ○ FILE NO. PED DEPARTMENT 357	

CALCULATION TITLE USI A-46 OUTLIER RESOLUTION FOR HEAT EXCHANGER CH-7	VENDOR CALC. NO. 94C2857-C-003 ☐ MR NO. ☒ ENGR. ANALYSIS EA-FC-93-085 ☐ DBD NO. ☐ ECN NO. ☐ OTHER

* APPROVALS - SIGNATURE & DATE

PREPARER(S)/DATE(S)	REVIEWER(S)/DATE(S)	INDEPENDENT REVIEWER(S)/DATE(S)	*REV. NO.	SUPERSEDES *CALC. NO.	CONFIRMATION *REQUIRED (✓) YES	NO
A. Kanavouncomit 11/7/94	Tsiming Tseng 12/5/94	[signature] 12-12-94	0	N/A		✓

* EXTERNAL ORGANIZATION DISTRIBUTION

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* SEE INSTRUCTIONS ON REVERSE SIDE
° COMPLETED BY DOCUMENT CONTROL

CALCULATION COVER SHEET

Calculation Preparation, Review and Approval Form PED-QP-3.1 Form Page No. 2 of 2 Calculation Cover Sheet	CALCULATION NUMBER FCΦ6314 FACILITY/SYSTEM KEYWORD ○	Calc. Page No. 2 of 25

CALCULATIONS USED AS INPUT IN THE ANALYSIS		EQUIPMENT TAGS		
CALC./REV. NO.	DEPT. NO. ○	SYSTEM	ADDED	DEPT. NO.
FC-Φ1496 Rev. 0			CH-7	
FCΦ2116 Rev. 0				
FCΦΦ997 Rev. 3		-		
FCΦ6328 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. FCØ6314

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

Calc Preparation, Review and Approval PED-QP-3.5 Page 1 of 2 Reviewer's Checklist-Calculations	CALCULATION NUMBER FC⌀6314

		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 Ø6314

		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:

Tsiming Tseng / 12-5-94

Reviewer Date

Calc Preparation, Review and Approval PED-QP-3.7 Page 1 of 1 Independent Reviewer's Checklist - Calculations	CALCULATION NUMBER FCØ6314

		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:

[signature] 12/12/94

Independent Reviewer Date

Client: Omaha Public Power District Calculation No. 94C2857-C-003

Title: USI, A-46 Outlier Resolution for Heat Exchanger CH-7

Project: OPPD, Fort Calhoun Station

Method: Conventional Engineering Hand Calculations.

Acceptance Criteria: " Generic Implementation Procedure (GIP) for Seismic Verification of Nuclear Plant Equipment ", SQUG, Revision 2A, March 1993.

Remarks:

REVISIONS

No.	Description	By	Date	Chk.	Date	App.	Date
0	Initial Issue	A. K	11/7/94	TMT	12/5/94	T. Tracy	12-12-94

S&A Stevenson & Associates	CALCULATION COVER SHEET FIGURE 1.3	CONTRACT NO. **94C2857**

Table of Contents

Objective

The anchorage for the Letdown Heat Exchanger, CH-7, is an outlier according to GIP (ref. 1) screening guidelines. The objective of this calculation is to resolve the heat exchanger's A-46 outlier issue, by means of conventional engineering calculations.

Analytical Approach

The heat exchanger is supported on two saddle. The saddles are anchored into concrete piers by 2 - 7/8 J-Bolts per saddle and one of the saddles' base plate is anchored by slotted holes in the longitudinal direction of the tank. Hence, the critical anchorage will be at the saddle with-out the slotted holes, i.e. the fixed end saddle.

The outlier will be resolved by comparing the anchorage capacity to the demand. The capacity consists of anchor bolt and saddle stress allowables. The anchor bolt allowables are subject to reduction factors due to concrete embedment, edge distance and strength.

The demand consists of nozzle loads due to operating conditions, thermal and seismic loading, in addition to the heat exchanger's seismic inertia loads. These loads will be transferred to the fixed end base plate and summed up. First, the seismic loads will be summed by using the SRSS method and, then added to the dead loads.

The spectral accelerations used to calculate the heat exchanger's seismic inertia loads in the analysis is 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, Section 1801.

4. "Letdown Heat Exchanger", Atlas Industrial Mfg. Co., Dwg. D-1843-5, OPPD file #00716.

5. "IPEEE and A-46 Seismic Review FRS", Stevenson and Associates (S&A), Calculation Number 93C2777-C-001, Revision 0, OPPD Calc. FC06323, Rev. 0.

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

7. "Auxiliary Building Foundation Plan El. 971'-0", Outline - Sheet 3", Omaha Public Power District, Dwg. # 11405-S-49.

8. "Auxiliary Building Equip. Supports, Outline 8 Reinforcement Sheet 2", Omaha Public Power District, Dwg. # 11405-S-69.

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. 5 of 9, S&A ref. 93C2857-DC-024.

13. "Equipment Nozzle Load Summary Sheet", OPPD Calc. FC01496, Commonwealth Assoc. Filing Code 010-ACS-10-025, S&A ref. 93C2857-DC-024a.

14. "CQE Piping Isometrics, Seismic Sub. System #AC-325A", D-4218 Sh. 5 of 6, S&A ref. 93C2857-DC-025.

15. "Equipment Nozzle Load Summary Sheet", OPPD Calc. FC02116, Commonwealth Assoc. Filing Code 010-ACS-10-023, S&A ref. 93C2857-DC-025a.

16. "CQE Piping Isometrics, Seismic Sub. System #CH-456A", D-4234 Sh. 3 of 3, S&A ref. 93C2857-DC-026.

17. "Calc - Stress Analysis For Subsystem CH-456A", OPPD Calc. FC00994 Rev. 3, S&A ref. 93C2857-DC-026c.

18. "Manual of Steel Construction", 6th Edition, American Institute of Steel Construction Inc., 1963.

Summary

The calculation that follows resolved the A-46 outlier issue for the Letdown Heat Exchanger, CH-7. The anchor bolt allowable was derived through the use of plain bar bond strength and shear cone capacity, including the available pier reinforcement. Then, by using a yield line analysis method, the saddle base plate capacity was found to exceed the anchor bolt tensile allowable, hence the tensile allowable is governed by the base plate.

The calculation shows the heat exchanger's fundamental frequency within the rigid range, hence, the 5% floor response spectral acceleration is used. Following the demand calculation on the critical bolt, the bilinear formulation for shear-tension interaction was used and the anchor bolt was found to be adequate.

Finally, the saddle stresses were checked and the saddle were also found adequate. Hence, the heat exchanger's anchorage meets the A-46 requirements set forth by the GIP (ref. 1) by a margin of 1.3, hence, the outlier issue is resolved.

REF

1. SECT. 7 — G/P: INPUT DATA

TANK: $D = 20'' = 1.67'$

$L = 18.9'$

4. $t = 0.375''$

$W_{t} = 6786$ lbs

$\gamma_t = 6786 / (\pi/4 \times 1.67^2 \times (18.9)) = 163.9$ pcf

$H_{CG} = 15'' = 1.25'$ (@ fixed end saddle)

SADDLES: $S = 12.0'$

$h = 5''$ (@ fixed end saddle)

$G = 11500$ ksi

$E = 29000$ ksi

$NS = 2$

BASE PLATE: $t_b = 0.5''$

18. $f_y = 33$ ksi SA-7

$t_w = 0.5''$

$e_s = 2.25''$

BOLTS: $NL = 2$

$NB = 1$

$d = 7/8''$

$D' = 16'' = 1.33'$

6. CONCRETE: $f_c' = 4000$ psi

REF

ANCHOR BOLT ALLOWABLES:

ANCHOR BOLTS : 7/8" J-BOLTS. -90°

7.
8. TOTAL BOLT LENGTH = 2'-5" = 29"

PROJECTION = 3 1/2" HOOK LENGTH = 5.75"

PIER SIZE 2'-0" × 1'-0" × 1'-6 1/2" HIGH
includes 1 1/2" GROUT

∴ EDGE DISTANCE 6" & 4"

PIER REINFORCEMENT.

3-#6 ⊓ BARS ALONG THE 2'-0" LENGTH

2-#6 ⊓ BARS ALONG THE 1'-0" LENGTH

2-#4 TIES AROUND THE PIER.

- ALL ⊓ BARS ARE EMBEDED 12" INTO THE CONCRETE FLOOR.

1. App. C 7/8" J-BOLTS $P_u' = 20.44$ kips

$V_u' = 10.22$ kips

EMBEDMENT CAPACITY:

EMBEDMENT ; $L = 29" - 3.5" = 25.5"$

CONSIDER THE 7/8" J-BOLT AS PLAIN REBAR, TOP BAR

3. ALLOWABLE BOND STRESS $= \frac{1}{2}(6.7\sqrt{4000}/7/8) = 242$ psi < 250 psi

$P_{ALL} = \pi D L (242) = \pi (7/8)(25.5)(242) = 16963$ lbs

∴ $P_{ALL} = 17.0$ kips.

REF

EDGE DISTANCE

CONSIDER THE 4" EDGE DISTANCE:

SINCE, THE PIER IS REINFORCE, ACCOUNT FOR AT LEAST ONE OF THE #6 ⊓ BOLTS AND ONE SIDE OF ONE OF THE #4 TIES TO BE ENGAGED.

11. $\therefore \quad V'_{cone} = 2\phi\sqrt{f'_c}\,\pi\,E^2$

$= 2(0.65)(\sqrt{4000})\,\pi\,(4)^2 = 4133\text{ lbs} = 4.1\text{ kips}$

$V'_s = A_v f_y$

$A_v = A_{\#4} + A_{\#6} = 0.2 + .44 = 0.64\text{ in}^2$

$V'_s = 0.64 \times 40 = 25.6\text{ kips}$

$\therefore V'_{All} = 4.1 + 25.6 = 29.7\text{ kips} > V'_u$

$\therefore$ ALLOWABLES:

$P_{All} = 17.0\text{ kips}$

$V_{All} = 10.22\text{ kips}$

CHECK BASEPLATE THICKNESS

1. Sect. 7 $R_B = \frac{f_y}{\sigma} = \frac{f_y t_b^2}{3 P_{All}} = \frac{33(.5)^2}{3(17)} = 0.162$

THIS CHECK IS TOO CONSERVATIVE, THEREFORE

9. USE THE YIELD LINE ANALYSIS TO CHECK THE BASE PLATE.

Stevenson and Associates

A Structural-Mechanical Consulting Engineering Firm

CLIENT 94C2857 JOB No. C-003 SHEET 15 OF 25

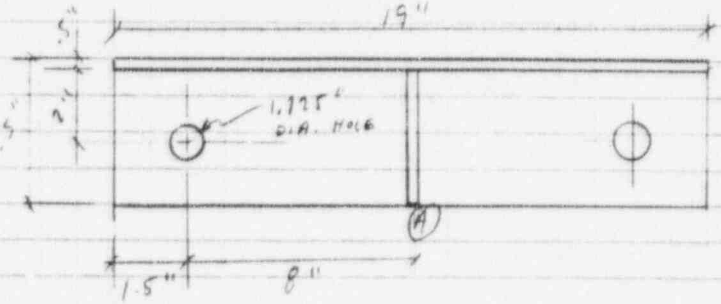
SUBJECT

A-46 Outlier Resolution for Heat Exchanger CH-7

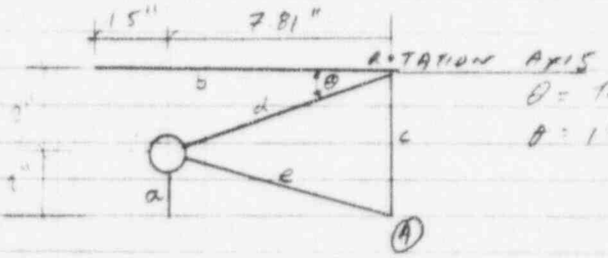
REVISIONS: 0 A.K. 11/8/94 TMT 12/5/94

REF

9. BASE PLATE:



YIELD LINES



$\theta = \tan^{-1}(2/7.81)$

$\theta = 14.36°$

line lengths: $l_a = 2.0 - 1.125/2 = 1.437"$

$l_b = 1.5 + 7.81 = 9.31"$

$l_c = 4"$

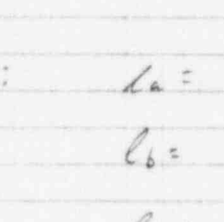
$l_e = l_d = (\sqrt{7.81^2 + 2^2}) - \frac{1.125}{2} = 7.5"$

CONSIDER A UNIT DISPLACEMENT @ (A) AND ZERO DISPLACEMENT @ BOLT.

ROTATION @ LINES: $\beta_a = \delta/7.81 = 0.128\delta$

$\beta_c = \delta/7.81 = 0.128\delta$

β_d: ROTATION DUE TO PLATE BOUNDED BY c, d & e

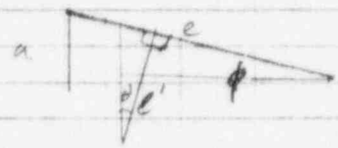


$l' = c \cos\theta = 4 \cos 14.36 = 3.875$

$\beta_d = \frac{1}{l'} = 0.258$

REF

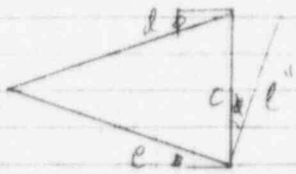
θ_{e_1} ROTATION DUE TO PLATE BOUNDED BY LINES a & E



$$l' = \frac{l_e}{\sin\phi} = \frac{7.5}{\sin\phi} = 30.2''$$

$$\theta_{e_1} = \frac{1}{30.2} = 0.033$$

θ_{e_2}: ROTATION DUE TO PLATE BOUNDE BY LINES c, d & e



$$l'' = \frac{c}{\cos\phi} = 4/\cos\phi = 4.129$$

$$\theta_{e_2} = \frac{1}{4.129} = 0.242$$

$$\theta_e = 0.242 + 0.033 = 0.275$$

9\. ENERGY EQUILIBRIUM; WORK DONE BY EXTERNAL FORCES EQUALS THE WORK DONE BY THE INTERNAL FORCES.

$$W_e = W_i$$

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

$$M_u = Z F_y = \frac{1(t_b)^2}{4}(33) = \frac{1 \times .5^2}{4}(33)$$

$$M_u = 2.06 \text{ kip in/in}$$

$$\delta \cdot P_u = M_u(l_a\theta_a + l_c\theta_c + l_d\theta_d + l_e\theta_e)$$

$$\delta \cdot P_u = (2.06)\left[(1.437)(0.128) + (4)(0.128) + 7.5(0.258 + 0.275)\right]8$$

$\therefore$ $P_u = 9.7$ kips.

ALLOWABLE LOADING CONSISTANT WITH ASME; $0.9(9.7) = 8.7$ kips

$< P_{all} = 17.0$ kips $\therefore$ THE ½" BASE PLATE WILL GOVERN.

REF

CHECK WELD STRENGTH:

1. SECT 7 $RW = \frac{30.6 \times S_i}{\sigma_y} = \frac{\sqrt{2}\, t_w\, e_s\, (30.6)}{P_{ALL}} = \frac{\sqrt{2}\,(.5)(2.25)(30.6)}{17}$

$RW = 2.86 \geq 1.0 \quad \therefore$ WELD IS O.K.

CHECK PUNCHING SHEAR

$P_p = f_v \cdot \pi\,(d_e + t_b)\, t_b$ (SPREADING LOAD @ 45°)

10 SHEET 4 $d_e = 1.44''$ ASSUMING A HEX NUT FOR 3/8" bolt. $F = 1\ 7/16''$

$P_p = 0.4(32)\,\pi\,(1.44 + 0.5)(0.5)$ (CONSERVATIVE)

$P_p = 40.2$ KIPS $>$ $P_{ALL} = 17.0$ KIPS $\therefore$ O.K.

SINCE THE BASEPLATE GOVERNS FOR UPLIFT

$\therefore$ $P_{ALL} = 8.7$ KIPS

$V_{ALL} = 10.22$ KIPS.

TANK FREQUENCY IN THE TRANSVERSE (N-E) AND VERTICAL DIRECTION

2. $f_T = \frac{5.6}{2\pi}\sqrt{\frac{E\, I\, g}{q\, S^4}}$; $E = 29\times10^6$ psi $= 4.18\times10^9$ psf

$g = 32.2$ ft/s²

$q = \frac{\pi D^2}{4}\gamma_n = \frac{\pi\,(1.67)^2}{4}(163.9) = 359$ lbs/ft

$I = \frac{\pi D^3}{8} t = \frac{\pi\,(1.67)^3}{8} \times \frac{0.375}{12} = 0.0572\ ft^4$

$f_T = \frac{5.6}{2\pi}\sqrt{\frac{4.18\times10^9\,(0.0572)\,(32.2)}{359 \times 12^4}} = 28.7\ Hz$

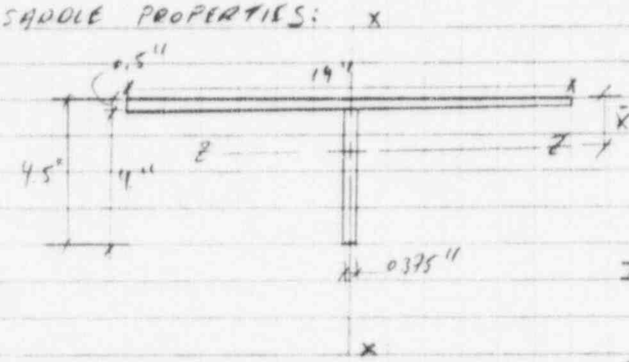
$\therefore$ 20% range is 23.0 Hz TO 34.4 Hz

REF

TANK FREQUENCY IN THE LONGITUDINAL (N-S) DIRECTION

2. $f_l = \frac{1}{2\pi}\sqrt{\frac{k_s g}{W_{ef}}}$; $g = 32.2\ ft/s^2 = 386\ in/s^2$

SADDLE PROPERTIES:

4. 

$A = (19 \times 0.5) + 4(0.375) = 11\ in^2$

$\bar{x} = \frac{(19 \times 0.5)(0.25) + 4(0.375)(2.5)}{11}$

$\bar{x} = 0.557"$

$I_{xx} = \frac{.5(19)^3}{12} + \frac{4(0.375)^3}{12} = 285.8\ in^4$ (STRONG)

$S_{xx} = \frac{285.8}{9.5} = 30.1\ in^3$

$A_{zz} = .5(19) = 9.5\ in^2$ (SHEAR)

$I_{zz} = \frac{19(0.5)^3}{12} + (0.5)(19)(0.307)^2 + \frac{0.375(4)^3}{12} + (0.375)(4)(1.943)^2$

$I_{zz} = 8.76\ in^4$ (weak axis)

$S_{zz} = \frac{8.76}{4.5 - 0.557} = 2.22\ in^3$ $A_{xx} = .375(4.5) = 1.69\ in^2$ (A_s)

BOTH ENDS FIXED WITH ONE FREE SWAY.

$k_s = \frac{1}{\frac{h^3}{12EI_{zz}} + \frac{h}{A_s G}} = \frac{1}{\frac{5^3}{12 \times 29 \times 10^6 \times 8.76} + \frac{5}{1.69 \times 11.5 \times 10^6}} = 3.35 \times 10^6\ \#/in$

2. $\therefore f_l = \frac{1}{2\pi}\sqrt{\frac{3.35 \times 10^6 (386)}{6786}} = 69.5\ Hz$

∴ 20% RANGE IS 55.6Hz → 83.4Hz

SINCE BOTH FREQUENCIES ARE > 20HZ, THE 5% DAMPING FLOOR RESPONSE SPECTRA CAN BE USED

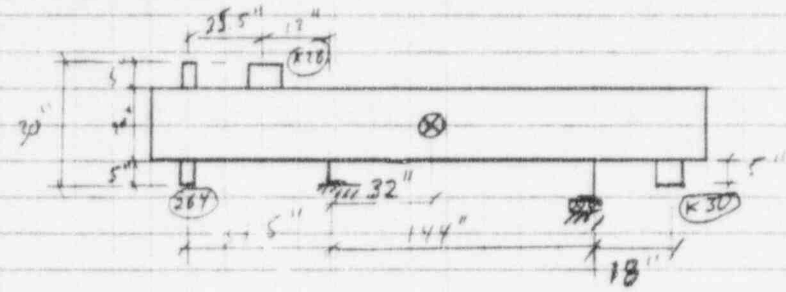
SPECTRAL ACCELERATION @ EL. 989' of the Auxiliary Building.

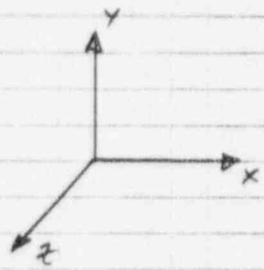
5.
TRANSVERSE :	$\alpha_{we} = 0.33\ G$	@ 23.0 Hz	(Z)
LONGITUDINAL :	$\alpha_{ns} = 0.37\ G$	@ 48.7 Hz	(X)
vertical	$\alpha_v = 0.24\ G$	@ 23.0 Hz	(Y)

REF

NOZZLE LOADS

12. TO 17.

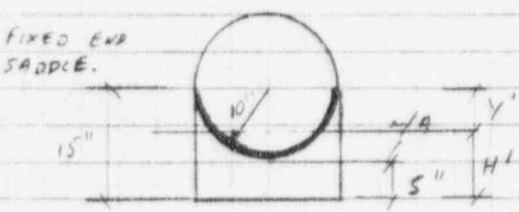




MOMENTS DUE TO LOAD APPLIED IN THE LONGITUDINAL DIRECTION:

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

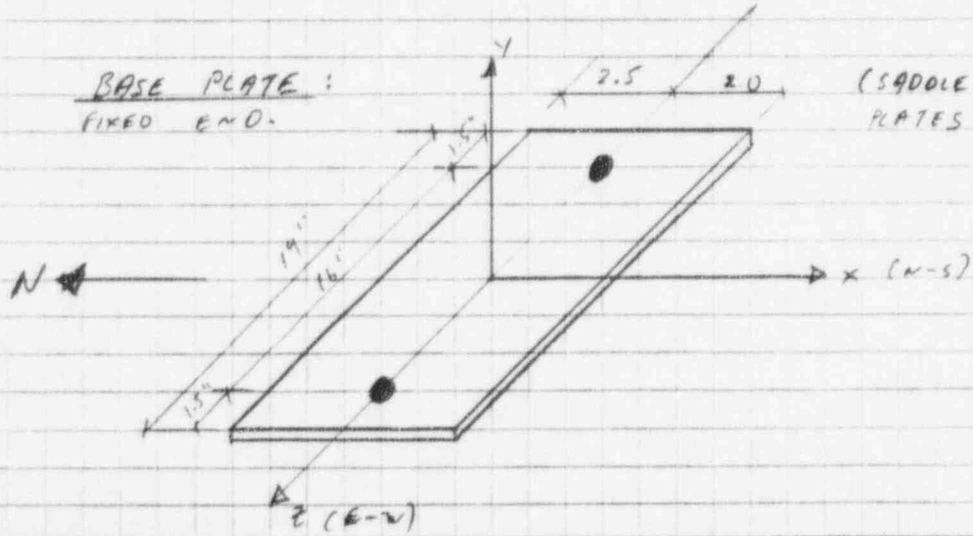
HENCE, THE MOMENT ARM OF THE LOAD IS.



$Y' = \frac{2R}{\pi} = \frac{2(10)}{\pi} = 6.4$

$H' = 15 - 6.4 = 8.6"$

BASE PLATE:
FIXED END.



(SADDLE AND STIFFENER PLATES ARE NOT SHOWN)

RBF

OPERATING & THERMAL NOZZLE LOADS FOR CH-7 (FIXED END)

UNITS; lbs & lbs·in

NOZZLE	LOAD ON NOZZLE		LOAD ON BASE PLATE				
	DIR	MAG.	Fx	Fy	Fz	Mx	Mz
264	Fx	62	62				-533
(MAX A)	FY	29		37			
	Fz	73			92		
	Mx	-1776				-1776	
(MIN A)	MY	-950			-7	-57	
	MZ	-1471		10			
K28	Fx	218	218	45			-6540
	FY	-693		-751			
	Fz	87			94	2820	
	Mx	1608				1608	
	MY	-3588			-25	-215	
	MZ	-10632		74			
K30	Fx	632	632				-5435
	FY	-298		37			
	Fz	66			-8	-69	
	MY	-15312			-106	-912	
	MZ	-26778		186			
TOTALS			912	-362	40	1399	-12508

S&A Stevenson and Associates. A Structural-Mechanical Consulting Engineering Firm	
CLIENT	94C2857
JOB No.	C-003
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REVISIONS	0: A.K. 11/7/94; TMT 12/15/94

REF

DBE NOZZLE LOADS FOR CH-7 (FIXED END)

UNITS; lbs & lbs·in

NOZZLE	LOAD ON NOZZLE DIR	LOAD ON NOZZLE MAG.	LOAD ON BASE PLATE Fx	Fy	Fz	Mx	Mz
264	FX	37	37				-318
	FY	30		38			
	FZ	32			+40		
	MX	520				520	
	MY	685			5	43	
	MZ	-794		6			
K28	FX	921	921	192			-7921
	FY	223		242			
	FZ	394			427	12805	
	MX	18360				18360	
	MY	18852			131	1127	
	MZ	-46788		325			
K30	FX	939	939				-8075
	FY	-39		5			
	FZ	-85			11	95	
	MY	19140			133	1144	
	MZ	-2700		19			
	SRSS		1316	450	468	22448	-11316

Stevenson and Associates
A Structural-Mechanical Consulting Engineering Firm

CLIENT 94C2857 JOB No. C-003 SHEET 22 OF 25

SUBJECT

A-46 Outlier Resolution for Heat Exchanger CH-7

REVISIONS	
0	A.K 11/3/94 TMT 12/5/94

Ref

CALCULATE DEAD LOAD ON BASE PLATE DUE TO WEIGHT OF HX.

∴ $F_Y = -5278$ lbs

∴ LOADS ON BASE PLATE DUE TO DEAD WEIGHT, OPERATING WEIGHT NOZZLE AND THERMAL NOZZLE LOADS

$F_X = 912$ lbs

$F_Y = -5278 - 362 = -5640$ lbs

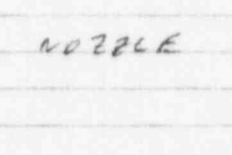
$F_Z = 40$ lbs

$M_X = 1399$ lbs·in

$M_Z = -12508$ lbs·in

CALCULATE LOADS ON BASE PLATE DUE TO SEISMIC

FORCE IN THE EAST-WEST DIRECTION (Z):
(TRANSVERSE)



$F_{EW} = 0.33\,(5278) = 1742$ lbs

$F_Z = 1742$ lbs

$M_X = 15 \times 1742 = 26130$ lbs·in

REF

FORCE IN THE NORTH-SOUTH DIRECTION (X);
(LONGITUDINAL)

$F_{NS} = 0.34\ (6786) = 2307$ lbs

$F_x = 2307$ lbs

$M_z = -2307 \times 8.6 = -19840$ lbs·in.

$F_y = 19840/144 = 138$ lbs

FORCE IN THE VERTICAL DIRECTION (Y);

$F_V = 0.24\ (5278) = 1267$ lbs

$F_y = 1267$ lbs.

SUMMARY OF SEISMIC LOADS ON BASE PLATE

LOAD	FX	FY	FZ	MX	MZ
INERTIAL SEISMIC	2307	138 ~~1267~~	1742	26130	-19840
NOZZLE SEISMIC	1316	450	468	22448	-11316
SRSS (SEISMIC)	2656	1352	1804	34448	-22840

CALCULATE BOLT SHEAR:

$V_x = (912 + 2656)/2 = 1784$ lbs

$V_z = (40 + 1804)/2 = 922$ lbs

$\therefore V = \sqrt{1784^2 + 922^2} = 2008$ lbs $= 2.0$ kips.

REF

CALCULATE BOLT PULLOUT:

DEAD LOAD: due to $F_y = \frac{-5640}{2} = -2820$ lbs

due to $M_x = 1399/(19-1.5) = 80$ lbs

due to $M_z = \left(\frac{12508}{2}\right)/2 = 3127$ lbs

$\therefore P_{DL} = 387$ lbs

SEISMIC: due to $F_y = 1352/2 = 676$ lbs

due to $M_x = 34448/17.5 = 1969$ lbs

due to $M_z: \left(\frac{22840}{2}\right) \times 1/2 = 5710$ lbs

$\therefore$ SRSS; $P_{LL} = 6078$ lbs

$\therefore P = P_{DL} + P_{LL} = 387 + 6078 = 6465$ lbs

SAY $P = 6.5$ kips

$\therefore$ SHEAR-TENSION INTERACTION USING THE BILINEAR FORMULATION

1. APP. C

$\frac{V}{V_{ALL}} = 2/10.22 = 0.20 < 0.3$

& $P/P_{ALL} = \frac{6.5}{8.7} = 0.75 < 1.0$

MARGIN $= \frac{1}{0.75} = 1.3$

$\therefore$ THE ANCHOR BOLTS ARE O.K.

REF.

2. CHECK SADDLE STRESS 1.7 × AISC ALLOWABLES EXCEPT FOR DEAD LOADS

SHEAR:

10 $F_{VD} = 0.4 \times 33 = 13.2$ ksi

SECT. E
SECT. F. $F_{VL} = 1.7 \times 13.2 = 22.4$ ksi

BENDING:

$F_{BD} = .6 \times 33 = 19.8$ ksi

$F_{BL} = 1.7 \times 19.8 = 33.7$ ksi

SHEAR:

$$f_v = \frac{V_x}{A_{xx}} + \frac{V_z}{A_{zz}} = \frac{1.784}{1.69} + \frac{0.922}{9.5}$$

(CONSERVATIVE) $f_v = 1.2$ ksi $<< 13.2$ ksi (LOW)

∴ SADDLE IS OK IN SHEAR.

BENDING.

AXIAL DL ; $P_{DL} = 2810/11 = 256$ psi (low)

LL ; $P_{LL} = 676/11 = 61$ psi (low)

Mx ; DL ; $f_{mxD} = 1.344/30.1 = 0.05$ ksi

LL ; $f_{mxL} = 34.448/30.1 = 1.14$ ksi

Mz ; DL ; $f_{mzD} = 12.508/2.22 = 5.63$ ksi

LL ; $f_{mzL} = 22.840/2.22 = 10.29$ ksi

STRESSES DUE TO AXIAL ARE VERY LOW, THEREFORE IGNORE:

$$\therefore \frac{.05 + 5.63}{19.8} + \frac{\sqrt{(1.14^2 + 10.29^2)}}{33.7} = 0.6 < 1.0 \therefore O.K.$$

MARGIN = 1/0.6 ≈ 1.7

∴ THE SADDLES ARE O.K.

FCØ6314 , 94C2857-C-003 , ATTACHMENT #1 pg. 1 of

SEP-16-1993 14:20 FROM PED NUCLEAR 7W-EP TO 916179334428 P.01

93C2777-LRCO-047

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PRODUCTION ENGINEERING DIVISION
Omaha Public Power District
P. O. Box 399 Fort Calhoun, Nebraska 68023
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FAX COVER SHEET

Date: 9-16-93

To: PAUL KARAVOUSSIANIS, 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.

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OMAHA PUBLIC POWER DISTRICT

FT. CALHOUN STATION

DESIGN BASIS DOCUMENT
CONTAINMENT

DOCUMENT NUMBER
SDBD-CONT-301

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.

  Class A Concrete - 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 "S[illegible]ication for Design, Fabrication and Erection of [illegible]ral Steel Buildings" and AWS D1.0-40, "Standard Code for [illegible]nd Gas Welding in Building Construction (Ref. 5.1. Page [illegible]).

OMAHA PUBLIC POWER DISTRICT

FT. CALHOUN STATION

DESIGN BASIS DOCUMENT
AUXILIARY BUILDING

DOCUMENT NUMBER
SDBD-AUX-502

Revision 5
SEPTEMBER 1993
CQE

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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.