Verified Revision ✓
Initial TJ Date 11/2/98

CALCULATION TITLE PAGE

Total Number of Pages: 16

Seismic Capacity of the RBCCW Heat Exchangers

TITLE

N/A	0	93C2799-C-018
CALCULATION #	REVISION No #	VENDOR CALCULATION NUMBER

CCR	2330A	CS	HXR
System Name	System Number	Structure	Component

NUCLEAR INDICATOR:
☒ CAT1 ☐ RWQA ☐ SBOQA
☐ FPQA ☐ ATWSQA ☐ NON-QA

Calc. Supports DCR/MMOD?
☐ Yes ☒ No → DCR/MMOD No

Calc. Supports Licensing?
☐ Yes ☒ No → Chg. Doc. Ref.

Calc. Supports Ind. Analysis?
☐ Yes ☒ No → Reference

INCORPORATES:

CCN NO:	AGAINST REV.
N/A	N/A

Affects DBS?
☐ Yes ☒ No → Reference

Executive Summary

(This NU Calculation is generated to enter the attached S&A calculation into NU's document control/tracking system, and to document the current NU technical review. This S&A calculation is part of NU's IPEEE program.)

This calculation evaluated the seismic capacity of the RBCCW Heat Exchangers (X18A, X18B & X18C). The result is a high-confidence of low probability of failure (HCLPF) capacity in terms of PGA. The HCLPF capacity of these heat exchanger is 0.29g PGA. This capacity is used in the seismic margin assessment.

Approvals (Print/Signature)		
Preparer: Apostolos Karavoussianis	A. Karavoussianis	Date: 12/20/97
Interdiscipline Reviewer: N/A	Discipline: N/A	Date: N/A
Interdiscipline Reviewer: N/A	Discipline: N/A	Date: N/A
Independent Reviewer: Nabil Juraydini	Nabil Juraydini	Date: 12/31/97
Supervisor: Steve Wainio	Steve Wainio	Date: 3/16/98

Installation Verification (Calculation accurately represents actual field conditions or does not affect plant configuration)

Preparer/Designer Engineer: NABIL JURAYDINI Nabil Juraydini Date: 12/31/97

3-13-98

3-26-98

3-27-98

9901080227 IUPP 4pgs

DCM FORM 5-1A
Rev. 06

CTP/PassPort DATABASE INPUTs

Calculation Number: _____ N/A _____ _____ Revision: N/A
(prefix) (sequence no.) (suffix)

Vendor Calculation Number/Other: 93C2799-C-018 Revision: 0

CCN # N/A QA ☒ Yes ☐ No Calc Voided: ☐ Yes ☒ No

Superseded By: N/A Supersedes Calc: N/A

Discipline (Up to 10) L, N, Q

Unit	Project Reference (EWA)	Component Id	Computer Code	Rev. No./ Level No.
02	M2-94223	X18A	N/A	N/A
		X18B		
		X18C		

PMMS CODES*

Structure	System	Component	Reference Calculation	Rev No.
~~CS~~ AB	CCR	HXR	93C2799-C-005	~~N/A~~ 1

*The codes required must be alpha codes designed for structure, system and component.

Reference Drawing	Sheet	Rev. No.
25203-29004	20	N/A
25203-11090	N/A	N/A

Comments:
None

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Calculation Review Comment and Resolution Form

(Sheet 1 of 1)

Calculation Number:	93C2799-C-018	Revision:	0	Calculation Title:	Seismic Capacity of the RBCCW Heat Exchangers
Calc. Originator:	Apostolos Karavoussianis	Reviewer (PRINT):	**Nabil Juraydini**		

This form is intended to document significant comments and their resolutions. Typographical errors and other editorial recommendations may be marked up in the calculation text and presented to the originator

Review Type ☐ **Interdiscipline** ☒ **Independent**

Reviewer (SIGN) Nabil Juraydini Date: 12/31/97

(signature signifies all comments have been resolved to your satisfaction)

Item	Page/Section	Comments	Response
1 of 1	N/A	This NU Calculation is generated to enter the attached S&A calculation into NU's document control/tracking system, and to document the current NU technical review. This S&A calculation is part of NU's IPEEE program. There are no technical or significant review comments which need to be document here. Only S&A's calculation cover sheet is numbered as page 1D (this page was not numbered by S&A), and S&A calculation's first pages is re-numbered as 1E. These changes are for page numbering purposes only.	

Client: NU Calculation No. C018

Title: Seismic Capacity of the RBCCW Heat Exchangers

Project: MP2 IPEEE

Method: See inside

Acceptance Criteria: See inside

Remarks:

REVISIONS

No.	Description	By	Date	Chk.	Date	App.	Date
0	Initial Issue 11 pp.	JDS	11/15/95	MSLi	11/16/95	GJD	11/16/95

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CALCULATION COVER SHEET

FIGURE 1.3

CONTRACT NO. 93C2799

1 Introduction & Summary

This calculation evaluates the seismic capacity of the Millstone Point Unit 2 Reactor Building Component Cooling Water Heat Exchangers, equipment IDs X18A, X18B, X18C. The result is a high-confidence of low probability of failure (HCLPF) capacity in terms of peak ground acceleration (PGA). The results are to be used in the seismic margin assessment of MP2. Refer to NP-6041 (reference 1) for a discussion of a seismic margin assessment and HCLPF.

Summary of Results

The capacity of each RBCCW Hx in terms of PGA is 0.29g. This value is a HCLPF capacity as defined in NP-6041. Capacity is controlled by anchorage shear.

2 References

1. A Methodology for Assessment of Nuclear Power Plant Seismic Margin, Electric Power Research Institute, prepared by Jack R. Benjamin and Associates, Inc., et al., August 1991. NP-6041-SL, Revision 1.
2. Generic Implementation Procedure for Seismic Verification of Nuclear Plant Equipment, Revision 2, Seismic Qualification Utility Group, February 1992.
3. NU drawings; 25203 series (individual drawings referenced by extension number in body of calculation).
4. "Code Requirements for Nuclear Safety Related Concrete Structures", ACI 349-90, American Concrete Institute.
5. "Building Code Requirements for Reinforced Concrete", ACI 318-89, American Concrete Institute.
6. "Manual of Steel Construction", 9th Edition, American Institute of Steel Construction.
7. S&A calculations for job 93C2799.
8. Seismic Verification of Nuclear Plant Equipment Anchorage (Revision 1) Volume 4, Electric Power Research Institute, prepared by URS/John Blume & Associates, June 1991. NP-5228-SL, Revision 1..
9. S&A document received 93C2799-DC-024.
10. Blevins, R., "Formulas for Natural Frequency and Mode Shape", 1979.

3 Configuration, Criteria and Assumptions

The configuration is shown in the following sheets and was obtained from referenced drawings. The evaluation is based on the guidance of NP-6041, as outlined in Section 6 of that document. Seismic demand is per S&A calculation 93C2799-C005.

Based on the IPEEE walkdown and A-46 walkdown and screening results, attached piping is well restrained [9]. Therefore no piping loads are included.

Assumptions

- Yield stress of saddle material is assumed to be 30 ksi
- Similar to other saddle plates, vertical transverse saddle plate is 3/4" thick.

4 Calculation

Capacity calculations are contained in the following pages.

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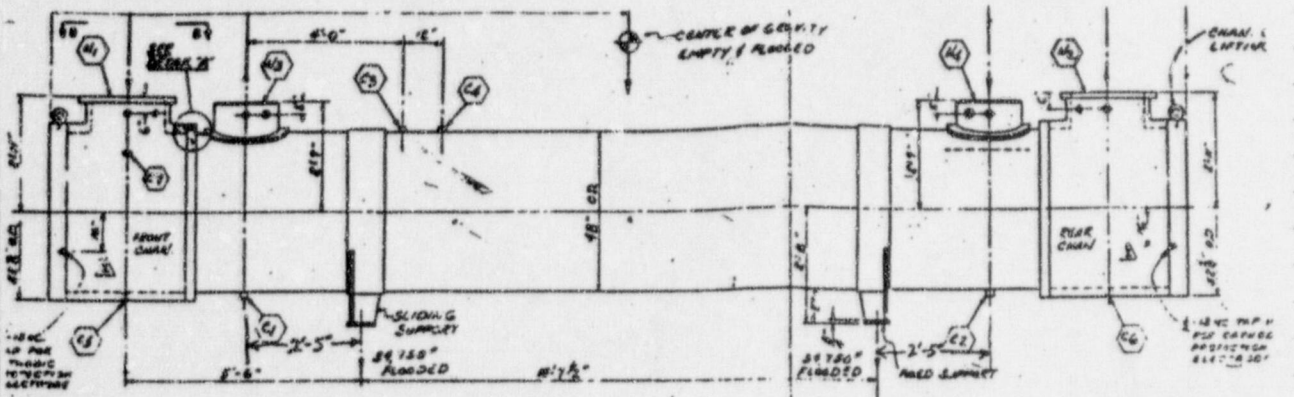
CLIENT NU JOB No. 9X2799 SHEET 3 OF

SUBJECT C018

XIBA,B,C Seismic Capacity

REVISIONS 0 JAS 11/14/95 MD: 11/16/95

Configuration



NOTES:

1. NOZZLES N1 & N2 TO HAVE (1) 3/4" FT SCRD (150) & (1) 1" FT SCRD (150) 60° APART
2. NOZZLES N3 & N4 TO HAVE (1) 3/4" S.W. COUP (150) & (1) 1" S.W. COUP (150) 60° APART
3. RATING OF NOT REQ'D COUP & S.W. COVE SHALL BE 2000#
4. CONSTRUCTED TO ASME CODE SECT. VIII DIV 1 & TEMA 'R' EXCEPT CHANNEL TO TUBESHEET & CHANNEL COVER GASKET (C-1477)
5. CHANNELS AND COVERS TO BE COATED PER SPECIFICATION SPAGE-7G.

24" 150# ANSI R.F.	CHAN. OUTLET
24" 150# ANSI R.F.	CHAN. OUTLET
20" WELD STUB	SHELL OUTLET
20" WELD STUB	SHELL INLET
1" S.W. COUP	SHELL DRAIN
"	"
3/4" S.W. COUP	SHELL VENT
"	SHELL RELIEF VALVE
1" FT SCRD	CHAN. DRAIN
"	"
1/2" FT SCRD	CHAN RELIEF VALVE
1/2" FT SCRD	PLUGGED VENT'ING
1/2 FT SCRD	PLUGGED VENT'ING

	SHELL SIDE	TUBE SIDE
DESIGN PRESS.	150# @	125#
DESIGN TEMP	250°	170°F
TEST PRESS.	192.5 psig	260#
CORR. ALLOW.	1/8"	0"

AT NO TIME SHALL TEST WATER BE BELOW 70°F. USE INHIBITED WATER.

CAPACITY: SHELL SIDE TUBE SIDE

WEIGHTS: EMPTY FLOODED CHANNEL CHANNEL COVER

DETAIL OF 24" 150# NOZZLE

DETAIL OF WELD STUBS

DETAIL "A" SHOWING CHANNEL TO TUBESHEET GASKET JOINT. TYP GASKET JOINT AT CHANNEL COVER.

BECHTEL CORP. MILLSTONE PE CUST. SPEC NO: EQUIP NO: SAI SPEC NO: EQUIPMENT #

25203-29004 Q

SHEET 2

STRUTHER

BETTIS COOLING AT 65 °

• See next sheet for modification to saddle

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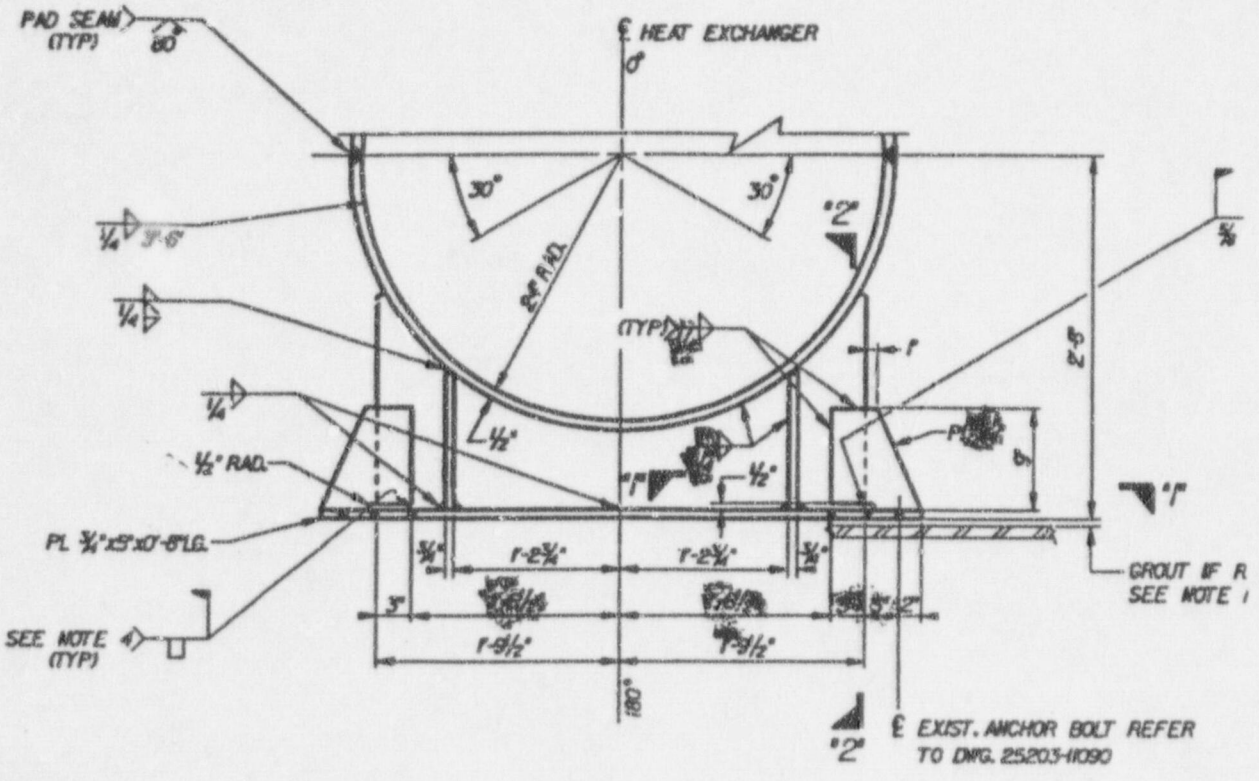
CLIENT NU JOB No. 93C2799 SHEET 4 OF

SUBJECT C018

X1BA,B,C Seismic Capacity

REVISIONS 0 11/14/95 11/15/95



FIXED END CRADLE

LOOKING WEST

[From 29004 sht 20]

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CLIENT NV JOB No. 93C2799 SHEET 5 OF

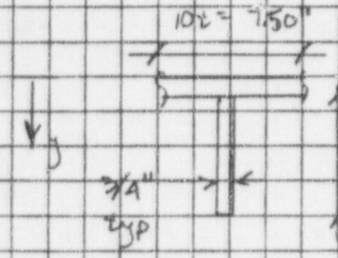
SUBJECT CAB

X18A, B, C Seismic Capacity

REVISIONS 0 JOA 11/14/95 MSJ 11/16/95

Longitudinal Frequency

Effective section @ webs



$\bar{y} = \dfrac{(3/4)[(7.5")(7/8") + (8.5")(5.0")]}{\underbrace{(3/4")(7.5" + 8.5")}_{12.\,in^2}}$

$\bar{y} = 2.832"$

$I = \dfrac{(8.5")^3(7/4")}{12} + \dfrac{(3/4")^3(7.5")}{12} + (2.457")^2(5.63\,in^2) + (2.168")^2(6.38\,in^2)$

$= 102.6\ in^4$

$A_s = (9.25")(3/4") = 6.94\ in^2$ (shear area)

Stiffness each element

$K_1 = 3EI/\ell^3 = 3[29{,}000\ ksi][102.6\ in^4]/(13.2")^3$

$= 3.881\ k/in$ where $\ell = 13.2" = 8" + 24.5"(1 - \cos\theta)$

$\theta = \sin^{-1}\left(\dfrac{15.125}{24.5}\right)$

$k_2 = \dfrac{GA}{\ell} = \dfrac{(11{,}150\ ksi)(6.94\,in^2)}{13.2"}$

$= 5{,}862\ k/in$

Net stiffness each element

$K_n = 1/(1/k_1 + 1/k_2) = 2{,}335\ k/in$

Longitudinal Frequency, 2 elements effective @ fixed saddle

$$f_L = \frac{1}{2\pi}\left(\frac{2k_L}{W}g\right)^{1/2} = \frac{1}{2\pi}\left(\frac{2(2335)(386.4)}{69.5}\right)^{1/2} \text{ Hz}$$

$$= 25.6 \text{ Hz} \pm 15\%$$

Vertical Frequency per NP-5228 Vol 4, approximate

Actual $Y = 23.88''$, insignificant; O.K. MSL

$$f_V = \frac{5.6}{2\pi}\left(\frac{EIg}{qS^4}\right)^{1/2}$$

$$I = \pi(24.25'')^3(0.50'') = 22,400 \text{ in}^4$$

$$S = 223.5 \text{ in}$$

$$q = 695 \text{ k}/(4034) = 0.172 \text{ k/in}$$

$$f_V = \frac{5.6}{2\pi}\left[\frac{(29,000)(22,400)(386.4)}{(0.172)(223.5)^4}\right]^{1/2} \text{ Hz}$$

$$= 21.6 \text{ Hz} \pm 15\%$$

Transverse Frequency

Since saddles are stiff in transverse

$$f_t \approx f_V = 21.6 \text{ Hz} \pm 15\%$$

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CLIENT NU JOB No. 9302799 SHEET 7 OF

SUBJECT C018

X18 A, B, C Seismic Capacity

REVISIONS 0 SDI 11/14/95 MD: 11/15/95

Seismic Demand

Elevation -255', demand is ground spectrum, per C005

Mode	Freq.	Damping	S_a
Long	25.6 ± 15%	4%	0.39
Vert	21.6 ± 15%	4%	2/3 (0.43) = 0.287
Trans	21.6 ± 15%	4%	0.43

4% damping judged reasonable, same as GIP

Anchorage Capacity

1" Φ cast-in-place bolts per drwg 11090, estimated embedment

$$l_e = 18" - 5" = 13"$$

Steel capacities

$$T_a = \pi (0.5")^2 (34\ ksi) = 26.7\ k$$

$$V_a = \pi (0.5")^2 (17\ ksi) = 13.35\ k$$

Check embedment per ACI-349, shear cone pullout

$$T = 4(0.65)(3000)^{1/2}\left[\pi (13")^2\right] = 75{,}600\ lb >> T_a$$

ok

Conclusion: allowables based on steel

$T_a = 26.7\ k$ $V_a = 13.35\ k$

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CLIENT NU JOB No. 9362799 SHEET 9 OF

SUBJECT COIB

X1B A,B,C Seismic Capacity

REVISIONS
0 SAS 11/14/95
MSL1 VIK/95

Capacity Vs Demand

Check 2 cases

1) 100% Long, 40% Trans, 40% Vertical

Check for tension, moment due to transverse about edge of saddles

$$M_d = (0.40)(0.43)(69.5\,k)(32.5") = 388.5\ in\text{-}k$$

Restoring moment from net vertical

$$M_R = (1 - 0.40(0.287))(69.5)(43"/2) = 1323\ k\text{-}in$$

Tension on an anchor, ignore longitudinal effect

$$T_d = (M_d - M_R)/2(40") < 0 \quad \text{No tension.}$$

Shear on anchors to fixed saddle, vector sum

$$V_d = \left(\left(\frac{0.39}{2}\right)^2 + \left(\frac{0.40(0.43)}{4}\right)^2\right)^{1/2}(69.5k) = 13.88\ K$$

HCLPF capacity

$$PGA_1 = \left(\frac{13.35\,k}{13.88\,k}\right)(0.30g) = 0.289\,g$$

2) 100% Trans, 40% Long., 40% Vertical

Following previous

$M_d = (0.43)(69.5\ k)(32.5'') = 971\ in\text{-}k$

$M_R = 1323\ in\text{-}k$

$T_d < 0$

$V_d = \left(\left(\frac{0.15g}{2}\right)^2 + \left(\frac{0.43}{4}\right)^2\right)^{1/2}(69.5\ k) = 9.23\ k < V_a$ ok

Conclusion: Case 1 controls, HCLPF capacity

$PGA_a = 0.29g$

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CLIENT NU JOB No. 9302799 SHEET 11 OF

SUBJECT CQB

XIBA, B, C Seismic Capacity

REVISIONS: SAS 11/15/95; MSL: 11/16/95

Other Checks

Check saddle bending / shear for longitudinal load

$$M = (0.39)(69.5\ k)(13.2'')/2 = 178.9\ in\text{-}k$$

$$f_b = \frac{M_y}{I} = \frac{(178.9\ in\text{-}k)(6.48'')}{102.6\ in^4} = 11.2\ ksi < 30.6\ ksi$$

← conservative since drops @ top (↓ below)

Check width / thickness for "stem type" per AISC

$$9.25/0.75 = 12.33 < 127/\sqrt{30} = 23.2 \quad \text{OK}$$

Allowable stress per AISC, bending

$$f_{ab} = 1.7(0.60)F_y = (1.7)(0.60)(30\ ksi) = 30.6\ ksi$$

Shear stress, allowable $1.7(0.40)(30\ ksi) = 20.4\ ksi$ per AISC

$$f_v = (0.38)(69.5\ k)/2(6.94\ in^2) = 1.90\ ksi < 20.4\ ksi$$

By inspection, other stresses are also ok. Note dominant anchorage load is shear.