ATTACHMENT 4 TO AEP:NRC:1082K

Donald C. Cook Nuclear Plant
Individual Plant Examination
for External Events

Seismic Fragility Calculations

AEP-94-839

Westinghouse Electric Corporation
Energy Systems
Nuclear Technology Division
Box 355
Pittsburgh Pennsylvania 15230-0355

RLH 11/14/94

Mr. R. Bennett
Nuclear Safety Section
American Electric Power Service Corporation
One Riverside Plaza
Columbus, OH 43216-6631

November 10, 1994
NTD-NSRLA-OPL-94-394

Ref: 1) AEP-94-760, 8/19/94
AEP-94-785, 9/23/94
AEP-94-789, 10/3/94

AMERICAN ELECTRIC POWER SERVICE CORPORATION
DONALD C. COOK UNITS 1/2
<u>Transmittal of Fragility Calculation</u>

Dear Mr. Bennett:

In response to a request by AEPSC, transmitted herein are the calculations associated with the revised fragility data for the eleven components identified by AEPSC. Results from these analyses were previously transmitted to AEPSC via References 1 to 3.

These calculations can be transmitted to the NRC, and can be considered to be non-proprietary in the same manner as the previously calculations (1991 vintage) which have been audited by the NRC. Reference is made in the new calculations to the original calculations for purposes of design data and stress margin levels. For the purposes of the NRC review of the current analysis effort, the older calculations should not be needed by the NRC unless they so request.

Calculations are also included from Paul C. Rizzo Associates documenting their work done in support of the analyses performed to respond to NRC inquiries. These calculations can also be considered non-proprietary.

If additional effort is required by Westinghouse to assist AEPSC in preparation of the revised IPEEE submittal to the NRC, or to respond to NRC requests for additional information and clarification, it is requested that AEPSC authorize Westinghouse to proceed as soon as possible so that this new effort can be properly scheduled.

If you have any questions or comments, please call Robin Lapides (412/374-5683) or me.

Very truly yours,

R. S. Lapides /fcr

Keith F. Matthews
Senior Sales Engineer
Power Systems Field Sales

RSL/bbp

Attachments

AEPSC839/NSRLA394L

DC-N-6280.3

(w/o attachments)

cc:	J. Kingseed	- AEPSC	E. Lewis	- AEPSC
	D. Malin	- AEPSC	T. Georgantis	- AEPSC
	S. Brewer	- AEPSC	R. Lapides	- W
	M. Wilken	- AEPSC		

Paul C. Rizzo Associates, Inc.
CONSULTANTS

November 2, 1994

Project No. 93-1326

Dr. William S. LaPay
Westinghouse Electric Corporation
Energy Center West 410C
Post Office Box 355
Pittsburgh, PA 15230-0355

D.C. COOK IPEE

Dear Dr. LaPay:

Enclosed herewith is a copy of the following calculations generated by Paul C. Rizzo Associates in support of the D.C. Cook IPEEE submittal:

- Estimation of median seismic response factors related to soils-structure interaction effects;
- Assessment of soil liquefaction potential at the intake structure; and
- Assessment of potential seismic displacement of embankment slope at RWST.

If you have any questions please call me.

Sincerely,
Paul C. Rizzo Associates

Nishikant R. Vaidya
Principal - Structural Engineering

NRV/dha
Enclosure

18-1326/94

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NEWARK, DE COLUMBUS, OH MT. PLEASANT, SC COVINGTON, KY

Paul C. Rizzo Associates, Inc.
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By EB Date ~~10-21-94~~ Subject D.C Cook ~~Sheet No. 1~~ of 9
Chkd. By NRJ Date 11-24-94 Median Seismic Response Proj. No. 93-1326
Factors

Purpose: to estimate median seismic response factors, A_m, of the structures of the Cook Plant and log standard deviations representing randomness (β_r) and uncertainties (β_u)

References (1) "Simplified Seismic Probabilistic Risk Assessment: Procedures and Limitations", NUREG/CR-4331, L.C Shieh, J.J. Johnson, J.E. Wells, J.C. Chen, and P.D. Smith, prepared for the NRC, by LLNL.

(2) "Plant arrangement"

(3) "Existing soil profiles"

Stratigraphy

From ref (3) the finished grade at the plant is at elevation 608'. The subsurface consists of a layer of about 15' of fill underlain by a layer of very dense slightly cemented sand between elevations of approximately 591' to 556' (thickness ~ 35'). Below this layer, there is a hard to very stiff clay layer down to about elevation 504'. (approximately 50' thick). The structures are founded on the dense sand layer. Below the clay layer the soil is very compact till consisting of silt, sands and coarser material.

Containment Building

The foundation mat of this building is about 140' in diameter. The bottom of the mat is at approximately elev. 574'. The soil unit weight is ≈ 2,880 kip/ft³ (used in design evaluation).

$$V_s = \sqrt{\frac{G}{\rho}} \quad , \quad \text{for } \gamma = 100 \text{ k/ft}^3, \; g = 32.2 \text{ ft/sec}^2$$

$$V_s = \sqrt{\frac{2880 \times 32.2}{0.1}} = 947 \text{ say } 1000 \text{ ft/sec.}$$

embedment (average) ≈ 31'

$$\frac{E}{R} \doteq \frac{31'}{(140/2)} \simeq 0.45$$

The design did considered SSI (soil structure interaction) with damping ratio of 5%; additionally considered that the control motions was at the foundation elevation.

To calculate factors use Tables of Chapter 8 of Ref (1). Tables in Ref (1) are a function of type of building, $\frac{E}{R}$, thickness of soil layer at the top, and ratio of shear wave velocities (V_s soil / V_s rock)

We have a soil layer of about 608-504 = 104 feet from grade. Enter Tables with 110 ft soil layer, $V_s$soil / $V_s$rock = 1000/5000, and E/R = 0.46

Table 8.3 →. to account for location of control motion in

Forces (in building) F = 1.26

Table 8.13 → same effect in floor response spectra, as a function of different frequencies we find.

0-6 Hz	1.26	use average 1.25
6-12 Hz	1.31	
12-20 Hz	1.16	
ZPA	1.29	

SSI damping does not have a significant effect on seismic forces in the building (i.e. in relative deformations); use:

$F = 1.00$, $\beta_u = 0.0$

The effects are important in total displacements, i.e, on floor response spectra. For equipment, therefore:

Table 8.14 →

1.91	for 0-6 Hz	for 30% SSI actual but 5% SSS used in analysis (actual is 25% more than 5%)
2.05	for 6-12 Hz	
2.04	for 12-20 Hz	
2.51	for ZPA	
2.13	average	

For SSI damping of 20% (i.e. 15% above 5%) use

$$F = 1.00 + (2.13 - 1.00)\frac{15}{25} \doteq 1.67$$

Composite factor:

Building: $1.26 \times 1.00 = 1.26$

Equipment: $1.25 \times 1.67 = 2.09$

<u>Variability</u>: See page 8-10 of Ref (1)

Random uncertainty for structure best-estimate response: $\beta_R = 0.28$

For equipment in building with fundamental frequency not near SSI frequency $\beta_r = 0.28$.

For modeling uncertainty, for both structure and equipment mounted in structure with fundamental frequencies not near SSI frequencies, the total uncertainty is

$$\beta_u = 0.27$$

∴ Uncertainties in control motion (time history) is cited to be 0.15 in page 8-11 of ref.(1). In the structure this accounts for the total uncertainty ∴

$$\beta_u = 0.15$$

In equipment, where a damping factor ≠ 1 was use the above total applies the uncertainty due to SSI damping is measured by

$$\beta_u = \sqrt{0.27^2 - 0.15^2} = 0.22$$

In summary

	Building	Equipment
Control motion	0.15	0.15
SSI damping	0.00	0.22
combined	0.15	0.27

Auxiliary Building

radius of foundation mat ≈ 138' (equivalent) = R
average embedment E = 34'

$$\frac{E}{R} = \frac{34}{138} = 0.25$$

Use tables in Ref (1) for shear wall structures, with Vsoil = 1000 ft/second, and soil layer depth = 110'.

The design assumed fixed base to calculate seismic forces in the building. Therefore, Table 8 6 applies

These table, for a 110' layer provides the following:

E/R	Vs	"Factor in Forces		
0	2000	1.23	1.31	averages correspond to rock Vs of 9,000 f/sec.
0	1000	1.39		
0.35	2000	1.60	1.75	
0.35	1000	1.90		

1000 is the V_s of the soil, but 2000/9000 is closer to 1000/5000. Interpolation on the averages (for E/R = 0.25) gives:

$$F = 1.31 \times \frac{0.10}{0.35} + 1.75 \times \frac{0.25}{0.35} = 1.6$$

Use the combined uncertainty of $\beta_u = 0.27$.

The 1.60 factor already includes SSI damping,

which is equivalent to say $F_{SSID} = 1$, $\beta_{uD} = 0.0$

A SSI analysis was performed for calculating floor response spectra for equipment evaluation, including SSI damping of 20% of critical.

The control motion was applied at the foundation elevation and wave incoherence was ignored.

Table 8.13 applies (in ref. 1). for $V_s = 1000$ ft/sec, using E/R = 0.35 (only value in Table)

$F = 1.34$ from 0-6 Hz
$F = 1.32$ " 6-12 Hz
$F = 1.22$ " 12-20 Hz

use average: 1.30.

When total uncertainty is considered, $\beta_u = 0.27$. If this is assigned equally to SSI embedment and damping, each contribution will be

$$\beta_u = \sqrt{\frac{0.27^2}{2}} = .191 \text{ use } 0.20$$

PUMP/SCREEN HOUSE STRUCTURE

The Pump/Screenhouse is a substantially embedded concrete shear wall structure with an above-grade metal building enclosing the Pumphouse. The structure is 210'x108' in plan. Its foundation is about 40'-0 below grade (which is @ El. 590'-0)

Embedment Ratio $E/R = 40/85 = 0.40$
Assuming a simplified soil profile of 110ft soil layer on Bedrock, with characteristic $V_s = 1000$ ft/sec.

Assuming that the design seismic analysis (i.e. the analysis on which the design is based) included the effect of SSI,

The factor F_{SSIB} associated with embedment and resulting wave scattering, $F_{SSIM} = 1.37$ (Ref. Table 8.7, Case Comparison 1/13 of NUREG/CR-4331)

Modeling uncertainty, $\beta_u = 0.27$ (Ref. NUREG/CR-4331)

Refueling Water Storage Tank

Tank Diameter = 48'
Liquid Height = 372"

Wt. of Liquid Contained in Tank = $(\pi \times 24^2) \times \frac{372}{12} \times 62.4\ \#/ft^3$

= 3500 kips.

Fundamental frequency = 5.51 Hz (Refer S&A Calculations)
Equivalent Stiffness:

$$5.51 = \frac{1}{2\pi}\sqrt{\frac{K}{(3500/32.2)}}$$

$$K = 130{,}147\ k/ft.$$

Soil-structure Interaction frequency of the foundation mass:

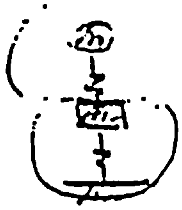
$$K_H = \frac{32(1-\nu)GR}{7-8\nu}, \qquad G = \rho V_s^2 = \frac{110}{32.2} \times (1000)^2 = 3.42\times10^3\ k/ft$$

$\nu = 0.4$
$R = 24'$-0

$$= \frac{32(1-0.4)\times3.42\times10^3\times24}{7-8\times0.4} = 414{,}720\ k/ft.$$

Assume a mat foundation 3'-0 thick x 50' ϕ
Wt. of Fdn. = $150\ \#/ft^3 \times 3.0 \times \frac{(50)^2 \times \pi}{4}$ = 883 kips

Frequency of Fdn mass = $\frac{1}{2\pi}\sqrt{\frac{414{,}720}{883/32.2}}$ = 19.6 Hz



Tank, m = 3500, f_1 = 5.5 Hz

Fdn, m = 883, f_2 = 19.6

Conclusion: Fixed Base Assumption for Tank is OK., R_{SSI} = 1.0

Purpose: To evaluate the potential for soil liquefaction at the foundation of the intake crib detail and the circulating water intake piping.

References:

1) "Foundation Investigations for the DC Cook NPP" by A&L Casagrande, August 1968

2) Dwg 12-5965, "Plant Arrangement, Sections "N-N", "P-P", "Q-Q" and "R-R", Units 1 & 2"

3) "Existing Soil Profiles", Dwg provided by client, section FF

4) "Ground Motions and Soil Liquefaction During Earthquakes", by Seed & Idriss, EERI Monograph, 1982

5) EPRI, "A Methodology for Assessment of NPP Seismic Margin (Rev. 1)" Final Report No NP-6041-SL, August 1991

6) LLNL, "Seismic Hazard Characterization of 69 NPP sites East of the Rocky Mountains," NUREG/CR-5220, 1989

Method. The procedure of Seed and Idriss (ref 4) will be used to assess liquefaction potential. This procedure is recommended for NPP Seismic Margin assessments by the EPRI (ref. 5)

Input. The main input in the Seed + Idriss method is the number of standard penetration blowcounts in the subject soil. No boring logs exist at the location of the intake crib. The stratigraphy in nearby boring logs will be "extrapolated" as shown in the following page.

The elevation of the crib foundation (see page 4 of these calcs) is about 548'. The bottom of the pipes are below 545'.

From the stratigraphy, these elevations are either in the very dense sand layer or in the hard to very stiff silty clay. The sand might liquefy and will be evaluated.

Paul C. Rizzo Associates, Inc.
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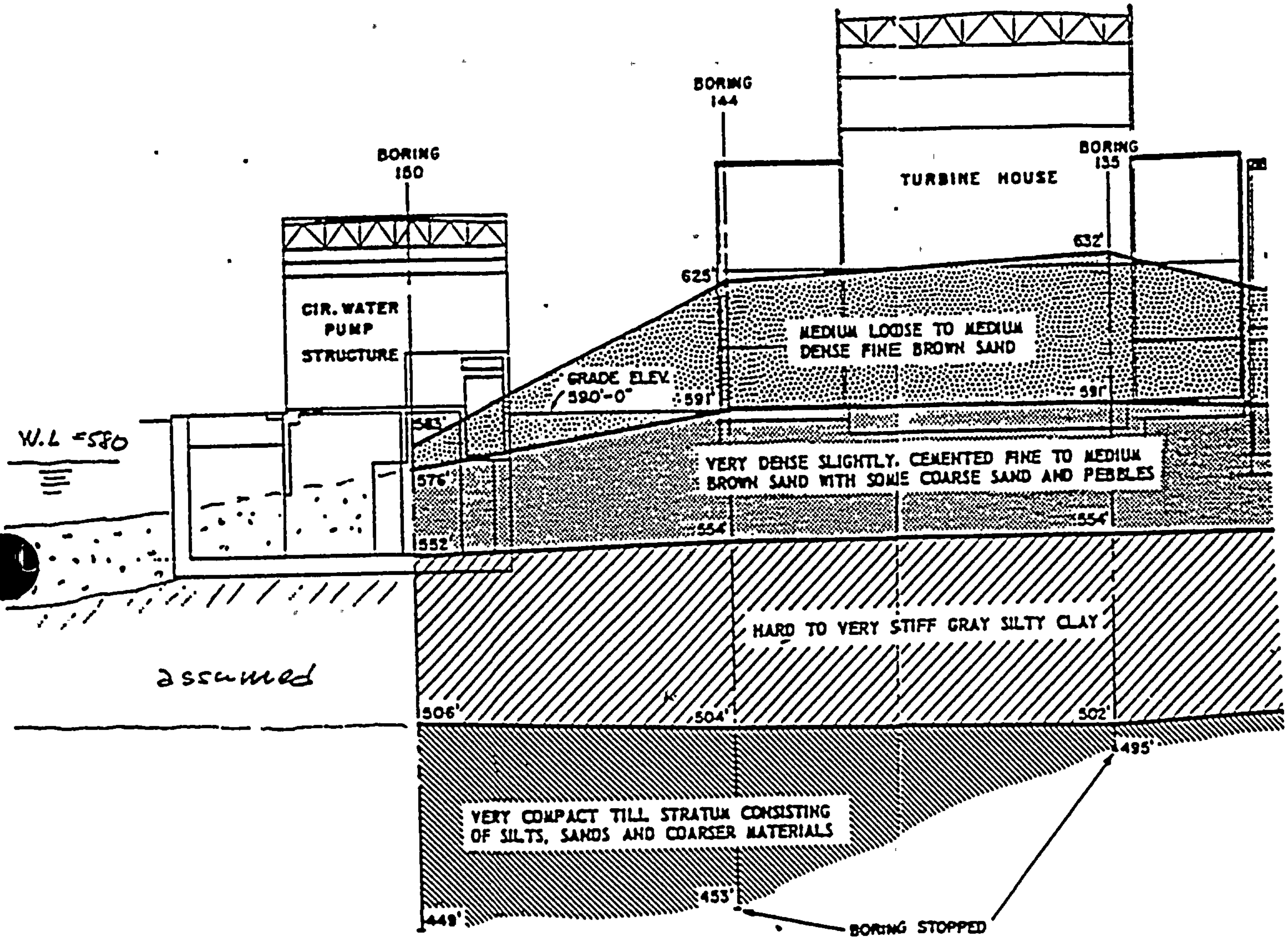
By FCB Date 10/6/94 Subject D. C. Cook Sheet No. 3 of 16
Chkd. By [illegible] Date 10-24-94 Evaluation of soil liquefaction Proj. No. 93-1326



NOTES:
1. BOTTOM ELEVATIONS INDICATE THE ELEVATION AT WHICH BORINGS WERE TERMINATED. TILL STRATUM EXTENDS TO GREATER DEPTH.
2. ALL STRUCTURES WITH FOUNDATION GRADES ABOVE THE ELEVATION OF VERY DENSE SAND STRATUM WILL BE PLACED ON COMPACTED FILL.

From Ref. 3.

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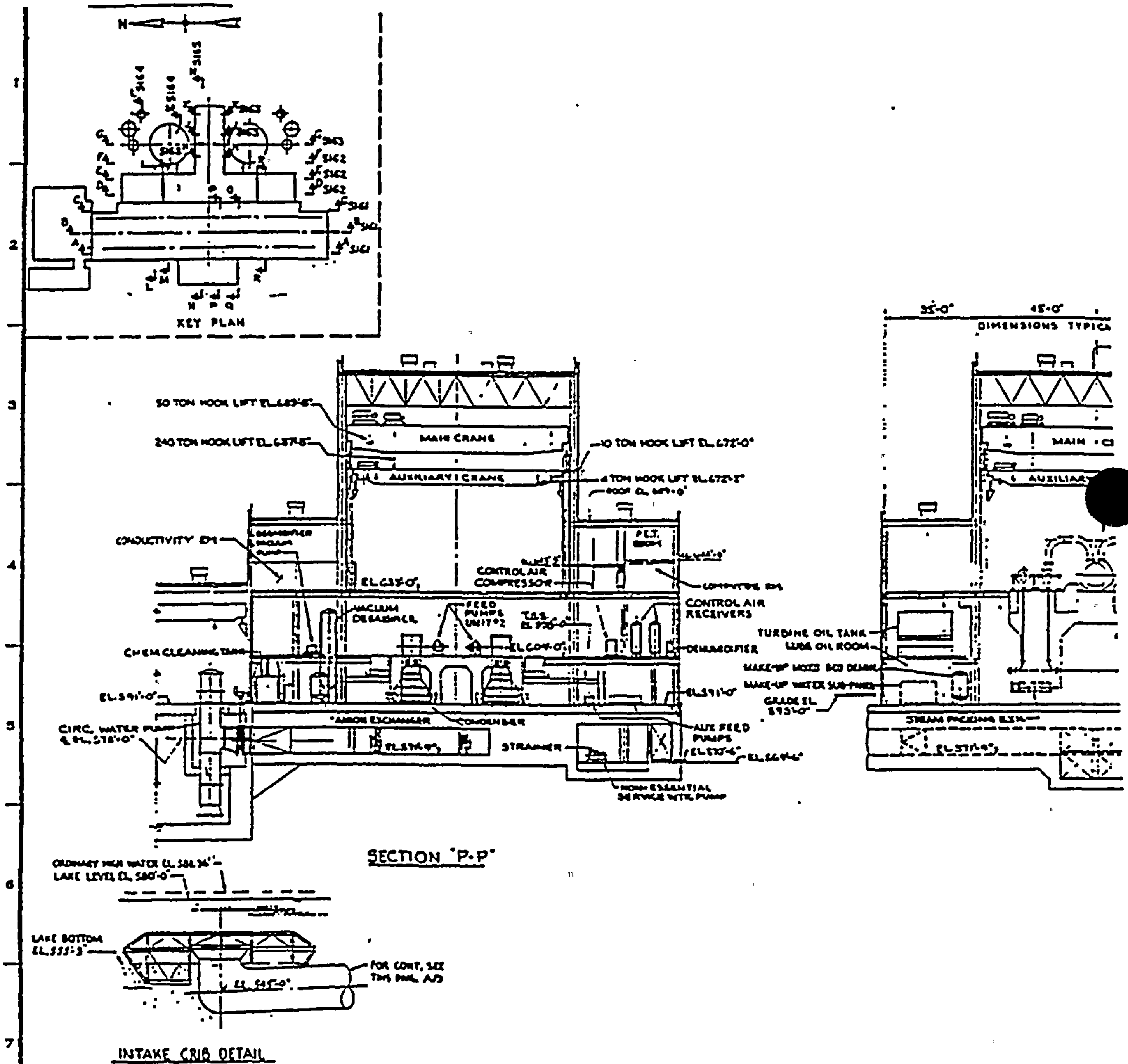
By EB Date 10/6/96 Subject D. C Cook Sheet No. 4 of 16
Chkd. By NRW Date 10-24-96 Evaluation of soil liquefaction Proj. No. 93-1326

From ref 2



The properties of the sand will be taken from ref 1. In the following page we have reproduced the blowcounts presented in such a reference. In addition, in Table 8.4-13 of the same reference we found that the dry unit weight is:

$$\gamma_d \doteq 100 \text{ lb/ft}^3$$

Because the sand is underwater, we need the saturated weight. We will consider $\gamma_s = 115 \text{ lb/ft}^3$

The Seed & Idriss procedure requires the determination of

$$\frac{\tau_{av}}{\sigma_o'} = \text{average cyclic stress ratio.}$$

Following ref 4, a_{max} = peak ground acceleration

$$(\tau_{max})_r = \frac{\gamma h}{g} a_{max}$$, define $A = \frac{a_{max}}{g}$, then

$$(\tau_{max})_r = \gamma h A$$

$$(\tau_{max})_d = (\tau_{max})_r \, r_d$$; for a superficial layer $r_d \approx 1.0$

Paul C. Rizzo Associates, Inc.
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By EB Date 10/6/94 Subject D. C. Cook Sheet No. 6 of 16
Chkd. By [illegible] Date 10-24-94 Evaluation of Soil Liquefaction Proj. No. 93-1324

From ref 1

For borings B 118 & B 118-A

From Table 8.4.1 (sheet 2) Ground Elevation is 631.3 ft.

TABLE 8.4-16 - COMPARISON OF STANDARD PENETRATION RESISTANCE MEASURED AT SAME LOCATION WITH DIFFERENT BORING EQUIPMENT

At Elevation {594' / 592'} is the compact dense sand layer

Flight Auger Raymond Boring No. 118		"Original" Raymond Boring No. 118A		Rotary Equipment Sprague & Henwood Boring No. 118B		Hollow-Stem Flight Auger AEP Boring No. 118X	
Depth - ft	N	Depth - ft	N	Depth - ft	N	Depth - ft	N
3.5-5	11	3.5-5	4	3.5-5	13	5-6.5	8
8.5-10	11	8.5-10	6	8.5-10	26	10-11.5	7
13.5-15	10	13.5-15	9	13.5-15	43	15-16.5	12
18.5-20	10	18.5-20	9	18.5-20	41	20-21.5	10
23.5-25	15	23.5-25	13	23.5-25	57	25-26.5	10
28.5-30	16	28.5-30	18	28.5-30	57	30-31.5	12
33.5-35	29	33.5-35	15	33.5-35	61	35-36.5	13
38.5-40	56	38.5-40	32	38.5-40	251	40-41.5	40
43.5-45	135	43.5-45	164	43.5-45	298	45-46.5	127
48.5-50	536	48.5-50	138	49.5-49.9	417/0.4'	50-51.5	202
53.5-55	256	53.5-55	133	53.5-55	528	55-56.5	165
58.5-60	282	58.5-60	281			60-61.5	147
63.5-65	114	63.5-65	130	65-66.5	545	65-66.5	105
68.5-70	81	69.5-71	82	68.5-70	403	70-71.5	17*
72.5-74	239	72.5-74	36			75-76.5	154
78.5-80	38	78.5-80	23			80-81.5	20
83.5-85	21	83.5-85	23				
88.5-90	21	88.5-90	21			90-91.5	26
93.5-95	35	93.5-95	25				
98.5-100	37	98.5-100	30			100-101.5	38
103.5-105	32						
108.5-110	56					110-111.5	46
113.5-115	146						
118.5-120	47					120-121.5	37
123.5-125	42						
128.5-130	711					130-131.5	123
133.5-135	R					135-136.5	167

dense sand layer

631.3' − 592. = depth 39.3'

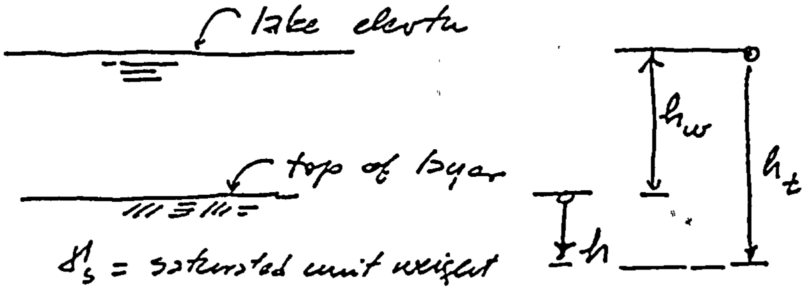
631.3' − 558.0 = 73.3'

top & bottom of dense sand layer

*Sample contained 4" peat layer.

and $\tau_{av} = 0.65(\tau_{max})_d = 0.65\,\gamma_s h A$

For an underwater layer we have:



γ_s = saturated unit weight

σ_o = total overburden pressure $= \gamma_w h_w + \gamma_s h$ where γ_w = unit weight of water

σ_o' = effective overburden pressure

$$\sigma_o' = \sigma_o - \gamma_w h_t$$

$$= (\gamma_w h_w + \gamma_s h) - \gamma_w h_t = \gamma_w h_w + \gamma_s h - \gamma_w (h_w + h)$$

$$\sigma_o' = (\gamma_s - \gamma_w) h$$

(same as when the water table is at the top of layer)

Finally

$$\frac{\tau_{av}}{\sigma_o'} = \frac{0.65\,\gamma_s h A}{(\gamma_s - \gamma_w) h}$$

$$\frac{\tau_{av}}{\sigma_o'} = 0.65\,\frac{\gamma_s}{\gamma_s - \gamma_w}\,A$$

The Seed and Idriss method provides the plot shown on page 9 of these calcs to evaluate liquefaction potential. In addition to $\frac{\tau_{av}}{\sigma_0'}$, the normalized number of blowcounts $(N_1)_{60}$ is needed to enter in such a plot. This number is given by (page C-3 of ref. 5)

$$(N_1)_{60} = N\left(\frac{ER}{60}\right) C_N C_Z C_S$$

where:

ER = energy ratio = 60 (safety hammer)
= 45 (donut hammer) ← USE

C_Z = correction factor for length of drive rods
= 0.75 if length < 10' ← USE
= 1.00 " " > 10'

C_S = correction factor for use of a liner in the sampler
= 1.0 (split spoon w/liner) ← USE
= 1.1 (no liner, depth < 10')
= 1.2 (no liner " > 10')

Conservative values have been taken for ER, C_Z & C_S, obtaining:

$$(N_1)_{60} = N\left(\frac{45}{60}\right) C_N \times 0.75 \times 1.0 = 0.5625\, C_N N$$

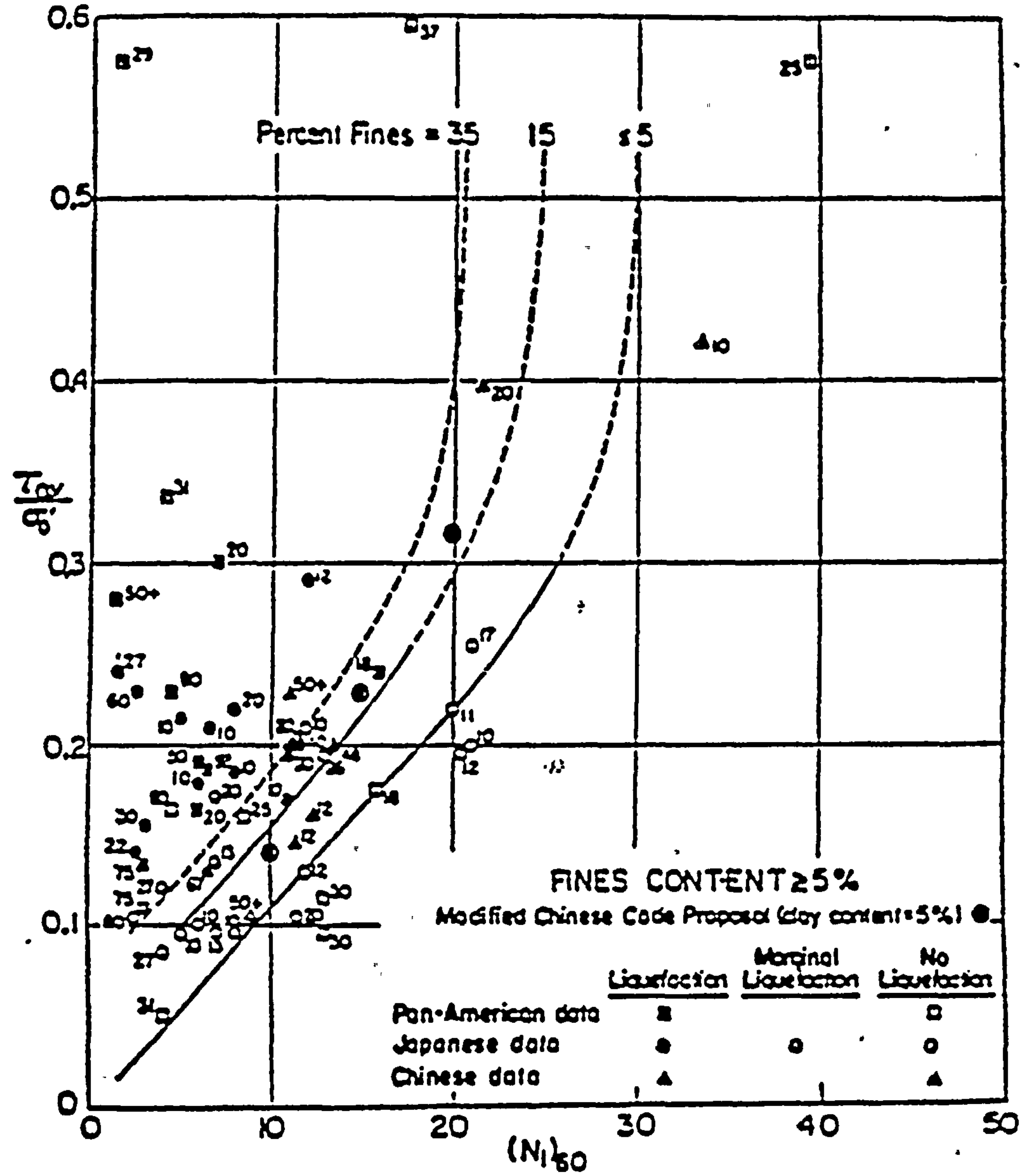


Figure C-9. Relationships between stress ratios causing liquefaction and SPT values for silty sands. Source: (8).

of ref 5

C_n is a function of the overburden pressure (transforms to a normalized pressure of 2 ksf = 1 ton/sf). C_n is given in the plot of page 11. In our case, page 4-7 of ref 1 reports that relative density of the compact sand is mostly between 85 to 100%. We will use, therefore, the curve corresponding to D_r = 60 to 80%.

To facilitate the calculations, we have approximated C_n by a quadratic curve passing by the three following points

σ'_o	C_N	$C_N = a + b\sigma'_o + c\sigma'^2_o$
4	0.75	$0.75 = a + 4b + 16c$
7	0.53	$0.53 = a + 7b + 49c$
10	0.46	$0.46 = a + 10b + 100c$

The formula at the end of page 8, and the calculations of a, b, c as well as of C_n and σ'_o have been introduced into a spreadsheet for the boring logs of page 6. Printouts of the spreadsheet for each boring log are provided in pages 12 to 15. —

Paul C. Rizzo Associates, Inc.
CONSULTANTS

By EB Date 10/10/94 Subject D. Cook Sheet No. 11 of 16
Chkd. By NEW Date 10-24-94 Evaluation of soil liquefaction Proj. No. 93-1326

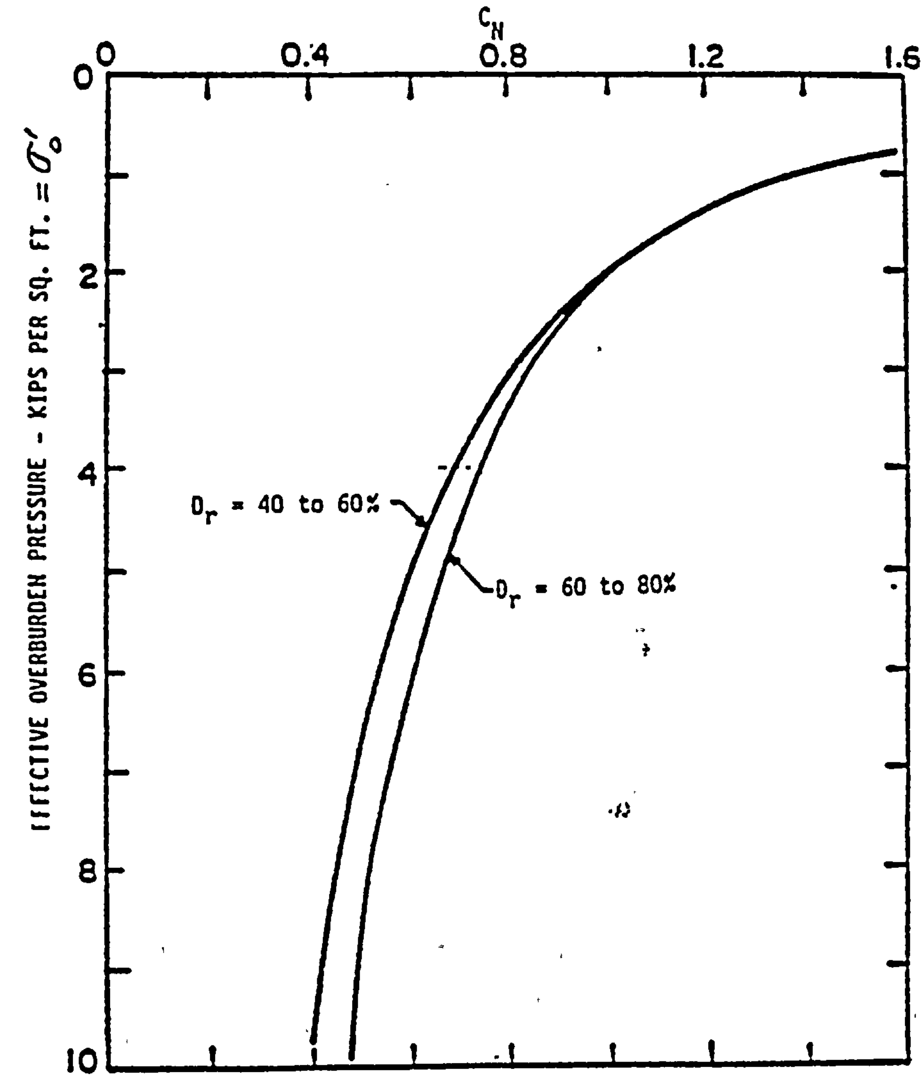


Figure C-8. Correction Factor, C_N, for SPT Values, Source: (15)

From ref. 5

D.C. Cook

By EB 10/6/94 D. C. COOK NPP Proj. No. 93-1326

NEQ 10/24/94

Calculation of N1-60 for very dense sand
Boring No. 118

equation for Cn

	1	4	16	0.75	
	1	7	49	0.53	
	1	10	100	0.46	
	3.889	-4.444	1.556	1.277	a
Inverse	-0.944	1.556	-0.611	-0.165	b
	0.056	-0.111	0.056	0.008	c

gamma-d = 100 lbs/ft^3
gamma-s = 115 lbs/ft^3
gamma-w = 62.4 lbs/ft^3
Boring 118 elevation = 631.3 ft
top of compacted sand = 594 ft
depth of loose sand = 37.3 ft
water table elevation = 590 ft

N	depth (ft)	loose sd weight (ksf)	comp snd sat wght (ksf)	groundwt buoyance height (ft)	groundwt buoyance pressure (ksf)	effectv overburdn pressure (ksf)	Cn	(N1)60
56	39.25	3.73	0.22	0.00	0.00	3.95	0.75	24
135	44.25	3.73	0.80	2.95	0.18	4.35	0.72	54
536	49.25	3.73	1.37	7.95	0.50	4.61	0.69	209
256	54.25	3.73	1.95	12.95	0.81	4.87	0.67	97
282	59.25	3.73	2.52	17.95	1.12	5.13	0.65	103
114	64.25	3.73	3.10	22.95	1.43	5.40	0.63	40
81	69.25	3.73	3.67	27.95	1.74	5.66	0.61	28
							average=>	79

D.C. Cook

By EB 10/6/94 D. C. COOK NPP Proj. No. 93-1326

Calculation of N1-60 for very dense sand
"Original" Boring No. 118A

NRW 10/24/94

equation for Cn

	1	4	16	0.75	
	1	7	49	0.53	
	1	10	100	0.46	
	3.889	-4.444	1.556	1.277	a
Inverse	-0.944	1.556	-0.611	-0.165	b
	0.056	-0.111	0.056	0.008	c

gamma-d = 100 lbs/ft^3
gamma-s = 115 lbs/ft^3
gamma-w = 62.4 lbs/ft^3
Boring 118 elevation = 631.3 ft
top of compacted sand = 594 ft
depth of loose sand = 37.3 ft
water table elevation = 590 ft

N	depth (ft)	loose sd weight (ksf)	comp snd sat wght (ksf)	groundwt buoyance height (ft)	groundwt buoyance pressure (ksf)	effectv overburdn pressure (ksf)	Cn	(N1)60
32	39.25	3.73	0.22	0.00	0.00	3.95	0.75	14
164	44.25	3.73	0.80	2.95	0.18	4.35	0.72	66
138	49.25	3.73	1.37	7.95	0.50	4.61	0.69	54
133	54.25	3.73	1.95	12.95	0.81	4.87	0.67	50
281	59.25	3.73	2.52	17.95	1.12	5.13	0.65	103
130	64.25	3.73	3.10	22.95	1.43	5.40	0.63	46
82	70.25	3.73	3.79	28.95	1.81	5.71	0.61	28
							average=>	51

D. C. Cook

By EB 10/6/94 D. C. COOK NPP Proj. No.

Calculation of N1-60 for very dense sand
Boring No. 118B

NKW 10/24/94

equation for Cn

1	4	.16	0.75
1	7	49	0.53
1	10	100	0.46

	3.889	-4.444	1.556	1.277	a
Inverse	-0.944	1.556	-0.611	-0.165	b
	0.056	-0.111	0.056	0.008	c

gamma-d = 100 lbs/ft^3
gamma-s = 115 lbs/ft^3
gamma-w = 62.4 lbs/ft^3
Boring 118 elevation = 631.3 ft
top of compacted sand = 594 ft
depth of loose sand = 37.3 ft
water table elevation = 590 ft

N	depth (ft)	loose sd weight (ksf)	comp snd sat wght (ksf)	groundwt buoyance height (ft)	groundwt buoyance pressure (ksf)	effectv overburdn pressure (ksf)	Cn	(N1)60
251	39.25	3.73	0.22	0.00	0.00	3.95	0.75	107
298	44.25	3.73	0.80	2.95	0.18	4.35	0.72	120
1043	49.70	3.73	1.43	8.40	0.52	4.63	0.69	405
528	54.25	3.73	1.95	12.95	0.81	4.87	0.67	199
545	65.75	3.73	3.27	24.45	1.53	5.48	0.62	191
403	69.25	3.73	3.67	27.95	1.74	5.66	0.61	138
							average=>	193

DC Cook

File: N1-60X.PRN
Saved 10-11-94 at 11:29:25 am — Evaluation of soil liquefaction 15

16

By EB 10/6/94 D. C. COOK NPP Pr

Calculation of N1-60 for very dense sand
Boring No. 118X

equation for Cn

	1	4	16	0.75	
	1	7	49	0.53	
	1	10	100	0.46	
	3.889	-4.444	1.556	1.277	a
Inverse	-0.944	1.556	-0.611	-0.165	b
	0.056	-0.111	0.056	0.008	c

gamma-d = 100 lbs/ft^3
gamma-s = 115 lbs/ft^3
gamma-w = 62.4 lbs/ft^3
Boring 118 elevation = 631.3 ft
top of compacted sand = 594 ft
depth of loose sand = 37.3 ft
water table elevation = 590 ft

N	depth (ft)	loose sd weight (ksf)	comp snd sat wght (ksf)	groundwt buoyance height (ft)	groundwt buoyance pressure (ksf)	effect overbur pressur (ksf	1)60
40	40.75	3.73	0.40	0.00	0.00	4.1	17
127	45.75	3.73	0.97	4.45	0.28	4.4	51
202	50.75	3.73	1.55	9.45	0.59	4.6	78
165	55.75	3.73	2.12	14.45	0.90	4.9	62
147	60.75	3.73	2.70	19.45	1.21	5.2	53
105	65.75	3.73	3.27	24.45	1.53	5.4	37
							49

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By EB Date 10/7/94 Subject D. C. Cook Sheet No. 16 of 16
Chkd. By NRJ Date 10-24-94 Evaluation of soil liquefaction Proj. No. 93-1326

CONCLUSSION.

Average $(N_1)_{60}$ values for the compact sand layer are about 50 or more. Examining Figure C-9 of Refs. (on page 9 of these calcs) we conclude that liquefaction does not constitute a problem, regardless of the value of $\frac{\tau_{av}}{\sigma_0'}$ (i.e., of the pga).

Paul C. Rizzo Associates, Inc.
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By EB Date [illegible] Subject D. C. Cook Sheet No. 1 of 8
Chkd. By NEV Date 10-24-94 Slope seismic displacements Proj. No. 93-1326

Purpose

To estimate potential displacements of the slope in the visitor center area of the Cook plant

References:

1). Plot Plan, Track and Road Layout, SH2
Dwg N: 12-3011-26 Dated 7/1/63

2) Plot Plan, Grading & Drainage Sections
SH 2
Dwg N: 12-3013-8 Dated 7/1/63

3) Makdisi, F. I and Seed, H. B, "Simplified Procedure for Estimating Dam and Embankment Earthquake-Induced Deformations," ASCE Journal of the Geotech. Eng. Division, Vol 104 GT7, July 1978, pp. 849-867.

4) "Foundation Investigation for the D.C Cook NPP" by A & L. Casagrande, August 1968

5) Richart, F.E., Hall, J.R. & Woods, R.D., "Vibrations of Soils and Foundations," Prentice Hall, 1970

6) H. Y Fang, "Foundation Engineering Handbook," Van Nostrand Reinhold, 1991.

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By EB Date 10/6/94 Subject D.C. Cook Sheet No. 8
Chkd. By NRH Date 10-24-94 Slope seismic displacement Proj. No. 93-1326

7) EPRI, "A Methodology for Assessment of NPP Seismic Margin (Rev.1)", Final Report EPRI NP-6041-SL, August 1991

8) NAVFAC, "Design Manual 7.02, Foundations and Earth Structures," Sep 1986

9) D.C Cook FSAR, "Site Environmental Study" by Dames & Moore, 1967

10) "Seismic Hazard Characterization of 69 NPP Sites East of the Rocky Mountains" NUREG/CR-5220, 19

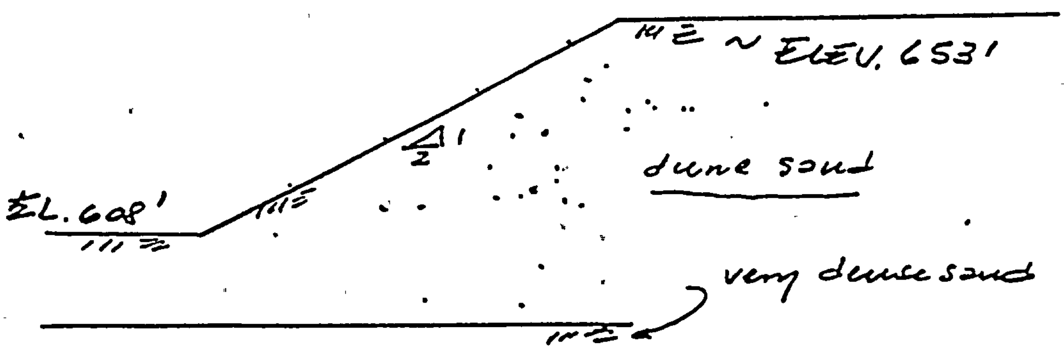
Method

Geometrical and materials data will be obtained from refs 1, 2, 4 & 9.

The procedure of ref. 3, will be followed to estimate displacements. Such a procedure is recommended in Table 7-3 of ref 7.

Geometry

From ref. 2, section H-H (CONT.), the slope under study has the following approx dimensions.



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By EB Date 10/6/94 Subject [illegible] Sheet No. 3 of 8
Chkd. By NRJ Date 10-24-94 Slope seismic displacements Proj. No. 93-1326

Estimation of seismic coefficient causing a safety factor F = 1 on a slope (to calculate k_{max}, ref 3)

From: "Foundation Eng. Handbook" pp 400
by H. S. Fang, Van Nostrand Reinhold, 1991 (ref 6)

Formula 10.27, pp

$$F = \frac{\frac{c'}{\gamma H} + \frac{(1-r_u)\tan\phi'}{N_f}}{\frac{1}{N_s} + \frac{C_s}{N_e}}$$

(assumes constant acceleration in the soil mass)

We have c' = effective cohesion = 0 (sand)

$r_u = \frac{\text{pore water pressure}}{\text{overburden pressure}} = 0$ (dry sand)

H = height of slope ≅ 45'

ϕ' = angle of internal friction ~ 33°

$\tan\phi' \doteq 0.65$
(from ref. 8, pp. 7.2-39, Table 1)

Conservatively use $\tan\phi' = 0.6$

To calculate N_f, N_s & N_e use charts of page 401 of ref. 6. The parameter γ to enter in these charts is calculated graphically in the following page.

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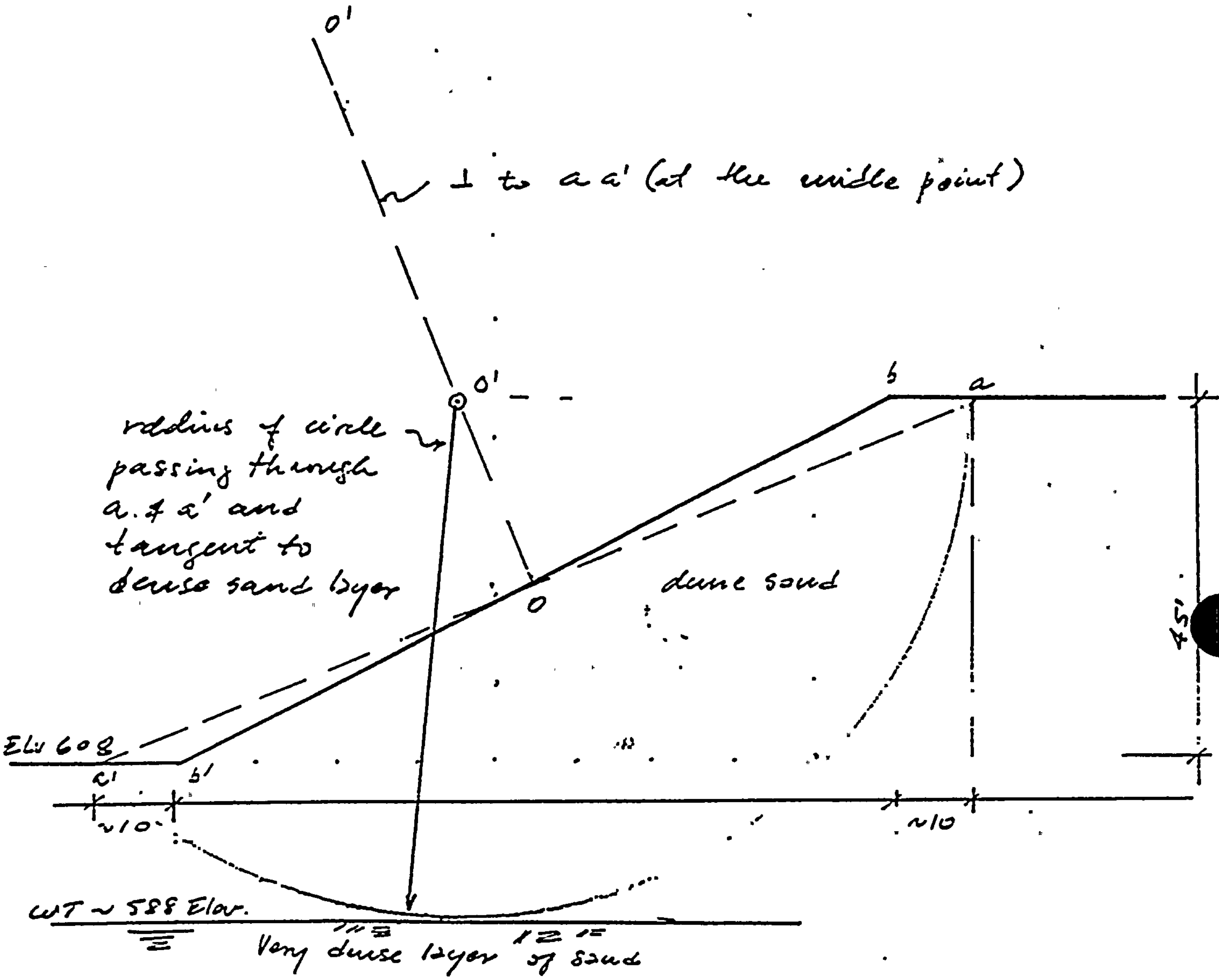
CONSULTANTS

By EB Date 10/6/94 Subject D C Cook Sheet No. 4 of 8
Chkd. By NZV Date 10.24.94 Slope seismic displacement Proj. No. 93-1326



Y' = 0 (o' is at the same elevation of b and a)

From plots on page 401 of ref 6, we have:

For $Y = 0$ $\quad N_e = 3.5$
$S = 2$ $\quad N_f = 2.3$
$N_s = 6.7$

$$\therefore \quad F = \frac{\frac{\tan\phi'}{N_f}}{\frac{1}{N_s} + \frac{c_s}{N_e}} = \frac{\frac{0.6}{2.3}}{\frac{1}{6.7} + \frac{c_s}{3.5}} = \frac{0.6 \times 3.5 \times 6.7}{(3.5 + 6.7c_s)2.3}$$

$$F = \frac{14.07}{8.05 + 15.41c_s}$$

for $F = 1$, $\quad 15.41c_s = 14.07 - 8.05$

$$c_s \doteq 0.40.$$

Therefore:

$$k_y \doteq 0.40\,g$$

To enter in the plots of ref 3, we need to estimate the average max. accelerations, k_{max}, of the slope, as well as its first natural period, T_o.

In addition, the magnitude of the earthquake causing the deformations is required. For D.C. Cook, the LLNL seismic hazard analysis (ref 10, Vol 4, p. 88) indicates that events of $M_b \leq 6.75$ control the hazard. However, conservatively we will use the curve correspon-

due to M = 7.5.

To estimate the slope period, consider a soil layer of height equal to the height of the slope. Then, using Richart, Hall & Wood pp 231 (ref 5) we have:

$$T_o = \frac{4H}{V_s} \quad , H = 45'$$

From D & M page I3-6 (ref 9) we obtain:

V_c of Dune sand = 1,600 ft/sec

Ref. 5 → pp.

$$\left(\frac{V_p}{V_s}\right)^2 = \frac{2-2\nu}{1-2\nu} = \frac{2-0.6}{1-0.6} = \frac{1.4}{0.4} \quad , \text{assuming } \nu = 0.3$$

$$V_s = \sqrt{\frac{0.4}{1.4}} \cdot V_p = 640 \frac{ft}{sec} \quad \text{for } G = G_{max}$$

$$T_o = \frac{4 \times 45}{640} = 0.28 \text{ sec.}$$

however for large accelerations

$\frac{G}{G_{max}}$ could be as low as 0.1

T_o could increase to $\frac{0.28}{\sqrt{0.1}} = 0.89$ sec.

Conservatively use $T_o = 1.0$ sec.

Paul C. Rizzo Associates, Inc.
CONSULTANTS

By EG3 Date 10/7/94 Subject D.C. Cook Sheet No. 37 of 58
Chkd. By NBU Date 10-24-94 Slope seismic displacements Proj. No. 93-1326

Plot from ref. 3

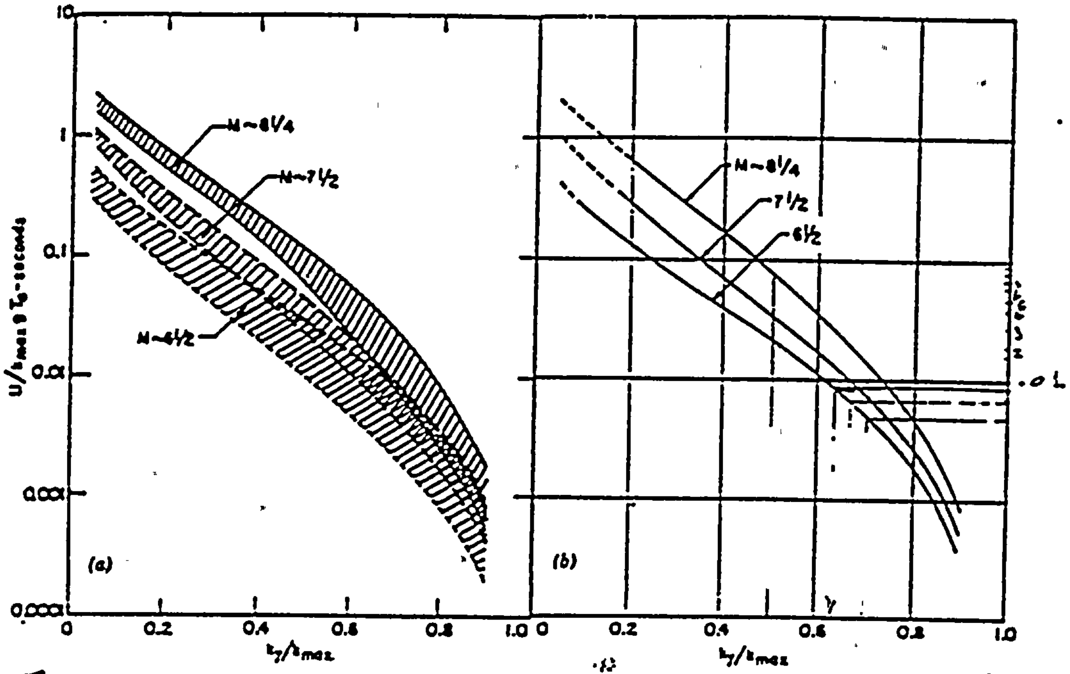


FIGURE 11.a. FIGURE 11.b ← in ref 3

.—Variation of Yield Acceleration with: (a) Normalized Permanent Displace- –Summary of All Data; and (b) Average Normalized Displacement.

Let the pga at the site vary between 0.2g and 1.2g. Some amplification is possible for the average in the dune sand layer. However, in agreement with the calculation of k_y and because we have adopted already conservative assumptions in other concepts, we will consider k_{max} = pga

Entering to the M = 7.5 curve in Figure 11b with the ratio $\frac{k_y}{k_{max}}$ we can read $u = \frac{U}{k_{max} g T_0}$ seconds. Then U is calculated as:

$$U = u\, k_{max}\, g\, T_0 .$$

In our case: $g = 32.2\ ft/sec^2$ & $T_0 = 1\ sec$; therefore

$$U = u\,(sec)\, k_{max} \times 32.2 \frac{ft}{sec^2} \times 1\ sec = 32.2\, k_{max}\, u \ (in\ ft)$$

(note that u has units of seconds

k_{max} (g')	$\frac{k_y}{k_{max}}$	u (sec)	U (ft)
0.5	0.80	0.003	0.05
0.6	0.67	0.007	0.14
0.7	0.57	0.015	0.34
0.8	0.50	0.033	0.85
0.9	0.44	0.055	1.59
1.0	0.40	0.070	2.25
1.1	0.36	0.090	3.19
1.2	0.33	0.100	3.86

WESTINGHOUSE ELECTRIC CORP.
NUCLEAR TECHNOLOGY DIVISION

DONALD C. COOK NUCLEAR POWER PLANTS SEISMIC FRAGILITY ANALYSIS CALCULATIONS

CALCULATIONS CSE-08-94-0040, CSE-08-94-0042, AND CSE-09-94-0046 AND ATTACHMENTS

AUGUST AND SEPTEMBER 1994

Signatures of Author, Verifier, and Approver are provided on each individual calculation cover sheet.

WESTINGHOUSE CALCULATION SHEET

TITLE DONALD C. COOK NUCLEAR PLANTS SEISMIC FRAGILITY ANALYSIS			PAGE 1 OF 19
PROJECT AEP	AUTHOR A J Hartman DATE 8-19-94	CHK'D BY ——— DATE	VERIFIED BY [signature] DATE 8/19/94
S.O. ATOP-4708E	CALC. NO. CSE-08-94-0040	FILE NO. AEP-947I	GROUP MSE-CSE

PURPOSE: To regenerate fragility data for four components following the approach used by Diablo Canyon, Ref. 3, in response to a request by AEP. This information is required for the effort to demonstrate that the conservative fragility parameters given in Reference 20 have not masked any dominant contributors or effected ranking for the D. C. Cook seismic IPEEE PRA evaluation.

SCOPE: The four components reviewed are:

1. Masonry wall around EDG Diesel Fuel Day Tank
2. 4 KV switchgear anchorage
3. CCW HX supports including cracks identified during the A46 walkdown
4. Auxiliary Building

METHODS: The previous fragility calculation for each component is reviewed and values are redetermined in consideration of the methodology described in Ref. 3, Sections 4 and 5, as appropriate. Median factors used in the determination of the acceleration capacity are based on variability of measured yield or ultimate strengths, reserve margins due to ductility, conservatism in the design basis spectra in comparison to the uniform hazard spectra, modelling variability based on analytical estimation of system frequency, and modelling uncertainties with respect to soil/structure interaction.

The floor median spectral capacity is first determined, and then the corresponding free field value is determined using a scaling factor.
Previous calculations are reviewed for application of as-built information.

ASSUMPTIONS:

1. Design parameters used in the previous calculations are correct. Further specific assumptions are cited in the following calculations.

2. Failure modes of previous analysis are valid.

REV. NO.	REV. DATE	AUTHOR DATE	CHK'D BY DATE	VERIFIED BY DATE

WESTINGHOUSE CALCULATION SHEET

TITLE DONALD C. COOK NUCLEAR PLANTS SEISMIC FRAGILITY ANALYSIS			PAGE 2 OF 19
PROJECT AEP	AUTHOR [signature] DATE 8-19-94	CHK'D BY DATE	VERIFIED BY [signature] DATE 8/19/94
S.O. ATOP-4708E	CALC. NO. CSE-08-94-0040	FILE NO. AEP-947I	GROUP MSE-CSE

APPLICABILITY: Use of values is limited for use in the Probabilistic Risk Assessment Evaluations

RESULTS:

Comparison of the fragility data are as follows, (old data from Ref. 20):

COMPONENT	REVISED VALUES				OLD VALUES			
	HCLPF	A_m	βr	βu	HCLPF	A_m	βr	βu
Masonry Wall	0.26g	0.66g	0.28	0.27	0.25g	0.27g	0.05	0.0
4 KV Switchgear Anchorage	0.58g	1.77g	0.31	0.37	0.55g	0.66g	0.10	0.0
CCW HX Supports	0.46g	1.07g	0.28	0.23	0.45g	0.54g	0.10	0.0
Auxiliary Building	0.32g	0.85g	0.31	0.29	0.30g	0.38g	0.13	0.0

CONCLUSION: No significant difference has been found between the regenerated HCLPF values and those previously reported.

OPEN ITEMS: None

REV. NO.	REV. DATE	AUTHOR DATE	CHK'D BY DATE	VERIFIED BY DATE

WESTINGHOUSE CALCULATION SHEET

TITLE DONALD C. COOK NUCLEAR PLANTS SEISMIC FRAGILITY ANALYSIS			PAGE 2 OF 19
PROJECT AEP	AUTHOR G J Hartman DATE 8-19-94	CHK'D BY DATE	VERIFIED BY DATE 8/19/94
S.O. AOTP-4708E	CALC. NO. CSE-06-94-0018	FILE NO. AEP-947I	GROUP MSE-CSE

REFERENCE

1. Calc AEP-025, "Auxiliary Bldg Equipment Fragility," dated 12-05-91.

2. CALC AEP-032, "Seismic Margin for 600V and 4KV Switchgears," Dated 10-14-91.

3. Report No. 1643.02, "Seismic Fragilities of Civil Structures and Equipment Components at the Diablo Canyon Power Plant," September 1988.

4. ASME Conference- Pressure Vessel and Piping Technology Conference-A Decade of Progress, L. Greimann and F. Fanous,"Reliability of Containments Under Over Pressure," 1985.

5. EQE Engineering Consultants, 52077.01-R-002, Rev. 0, "Walkdown of Auxiliary Building in Support of Cook Nuclear Plant IPEEE, Units 1 and 2," 2 Volumes, January 1992.

6. AEP Calculation DC-D-30535-193, "Structural Design Section Calculations for Auxiliary Building Steel Structure Part of Steam Generator Replacement Program," 12/8/86.

7. Calculation AEP-50, "LLNL UNS Equipment Fragility Data," 11/20/91.

8. Calculation AEP-49, "Fragility Data - LLNL UNS Spectra Shape

9. Rizzo Associates Project Letter for Project No. 93-1326, "Seismic Hazard Analysis, Donald C. Cook Nuclear Plant, Bridgman, Mich.," 08/17/94.

10. Report from Rizzo Associates 89-654, "Effects of ground Spectral Shape on Plant Response," Revision 1,Feb. 1992.

11. AEP Letter AEP-1955, "Seismic Design of Equipment Located Auxiliary Building," Dated February 5, 1971.

12. Calculation AEP-029, "Seismic Margin, for various Masonry Walls, dated 10-91.

13. Rogers,G.L., "Introduction to the Dynamics of Framed Structures," John Wiley and Sons, 1959, Figure 5.8.

REV. NO.	REV. DATE	AUTHOR	DATE	CHK'D BY	DATE	VERIFIED BY	DATE

TITLE DONALD C. COOK NUCLEAR PLANTS SEISMIC FRAGILITY ANALYSIS			PAGE 4 OF 19
PROJECT AEP	AUTHOR A J Hartman DATE 8-19-94	CHK'D BY — DATE	VERIFIED BY [signature] DATE 8/19/94
S.O. ATOP-4708E	CALC. NO. CSE-08-94-0040	FILE NO. AEP-947I	GROUP MSE-CSE

REFERENCES cont.

14. DURO-O-WAL Catalog, "4 Unit Masonry Ties and Reinforcement," G/C 1979

15. Calculation AEP-036, "Seismic Margin for Various Components - CCW HX," Rev. 0, dated 12-91.

16. R.S. Orr, Proposed Addition to: "Commentary on Code Requirements for Nuclear Safety Related Concrete Structures (ACI 349-76)," ACI Committee 349.

17. ASME Boiler and Pressure Vessel Code, Section III, Division 1, Subsection NF, and Appendix F, 1989 Edition.

18. Calculation No. CSE-08-94-0042, "Additional Margins for the CCW Heat Exchanger Supports," Rev. 0, Aug. 1994.

19. Not Used.

20. "Seismic Fragility Assessment, Donald C. Cook Nuclear Plants," Rev. 1, March 1993.

21. Not Used.

REV. NO.	REV. DATE	AUTHOR DATE	CHK'D BY DATE	VERIFIED BY DATE

WESTINGHOUSE CALCULATION SHEET

TITLE DONALD C. COOK NUCLEAR PLANTS SEISMIC FRAGILITY ANALYSIS			PAGE 5 OF 19
PROJECT AEP	AUTHOR [signature] DATE 8-19-94	CHK'D BY — DATE	VERIFIED BY [signature] DATE 8/19/94
S.O. AOTP-4708E	CALC. NO. CSE-06-94-0018	FILE NO. AEP-947I	GROUP MSE-CSE

4KV SWITCHGEAR FRAGILITY ESTIMATE

As noted in Section 4.49 of Reference 1, the 4KV switchgear is mounted on the 609' level of the AEP Auxiliary Building. The equipment assembly has a frequency between 5 and 10 Hz. The applicable spectral acceleration at 5Hz and 5% damping for the 609' level is 0.42g with a floor ZPA of 0.22g. The corresponding free field ZPA acceleration is 0.2g. The analysis tabulated below defines the spectral HCLPF value at the mounting location of the switchgear. Now the HCLPF values reported in Reference 1 correspond to the plant free field ZPA values. Since the floor level is above the Auxiliary Building base, the HCLPF value must be lowered: the spectral values must be scaled to represent the free field ZPA value. This factor is developed in two stages: first the spectral value is scaled to be representative of the floor ZPA; and second, the floor ZPA is scaled to be representative of the free field acceleration. This factor is given for the switchgear mounting as (0.22/0.42)*(0.2/0.22), and is equal to 0.48. This factor is deterministic since two other parameters ,spectral effects and modeling effects, already take into account the variability of the earthquake and building dynamic characteristics.

FRAGILITY PARAMETERS

MARGIN	F median	β_R	β_U	β_C	Reference/(NOTES)
SPECTRA	1.4	0.28	0	0.28	AEP-050 & RIZZO(4)
MATERIAL	1.09	0	0.12	0.12	Ref. 4, (1)
DUCTILITY	1.77	0.14	0.11	0.18	WELD Duc (2)
MODELING	1.0	0	0.27	0.27	(3)
SSI	1.3	0	0.20	0.20	RIZZO (4)
Resultant	3.51	0.31	0.37	0.47	median values

Values above are applicable to switchgear at the 609' level

The floor median spectral acceleration capacity = seismic design capacity (Ref. 2) times median margin factor = 1.05*3.51 = 3.69g

REV. NO.	REV. DATE	AUTHOR DATE	CHK'D BY DATE	VERIFIED BY DATE

WESTINGHOUSE CALCULATION SHEET

TITLE DONALD C. COOK NUCLEAR PLANTS SEISMIC FRAGILITY ANALYSIS			PAGE 6 OF 19
PROJECT AEP	AUTHOR R J Hartman DATE 8-19-94	CHK'D BY DATE	VERIFIED BY DATE 8/19/94
S.O. ATOP-4708E	CALC. NO. CSE-08-94-0040	FILE NO. AEP-947I	GROUP MSE-CSE

4KV SWITCHGEAR cont.

The HCLPF floor value is

$$HCLPF(floor) = 3.69*e(-1.65*(0.31 + 0.37) = 1.20g$$

The free field median spectral acceleration capacity

$$= 3.69 * 0.48 = 1.77g$$

For free field , the HCLPF value is

$$HCLPF(free\ field) = 0.48* HCLPF(floor) = 0.48*1.20 = 0.58g$$

NOTES

1. The yield strengths of steel materials vary randomly; Table 1 (Steel Yield Strength Characteristics) of Reference 4 shows the mean and coefficient of variability (COV) for various steels. The COV is defined as the ratio of the standard deviation divided by the mean value. After reviewing the data on Table 1 of Reference 4 it was determined that reasonable values for these parameters, mean and standard deviation, are 1.1 and 0.11 respectively The material is defined in terms of the mean value and has been converted to median value using a relationship described in Equation 2.4 of Reference 1.

$$F' = 1.1*e(-0.11^2/2) = 1.09$$

2. Sheets 393 through 395 of Appendix C of Reference 5 describe the mounting details used on this equipment. The corners of the cabinet are plug welded to shim plates which are fillet welded together and to the floor. Because of the joint conditions, it is felt that gross deformability of the connection is limited. For the purpose of this evaluation, it is assumed that the connection median ductility is 2.0. From the data reported in Section 4.49 of Reference 1, it is clear that the equipment is flexible and damping has an effect on the response; a value of 5% is considered to be reasonable. TABLE 5-1 of Reference 3 is used to define the ductility margin factors used in the fragility analysis.

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TITLE DONALD C. COOK NUCLEAR PLANTS SEISMIC FRAGILITY ANALYSIS			PAGE 7 OF 19
PROJECT AEP	AUTHOR [signature] DATE 8-19-94	CHK'D BY ——— DATE	VERIFIED BY [signature] DATE 8/19/94
S.O. ATOP-4708E	CALC. NO. CSE-08-94-0040	FILE NO. AEP-947I	GROUP MSE-CSE

4KV SWITCHGEAR cont.
NOTES cont.

3. The variability in modeling lies primarily in the ability of the analytical model to estimate system frequencies. For this evaluation the median factor is taken equal to 1 since the models are adequate. This evaluation follows the approach set forth in Reference 3 and is used to define variability. In this approach equation 4-33 of Reference 3 is used to estimate β_u; the value for modeling can be calculated as follows:

   β_u = ln(spectral acceler. at 85% exceedence probability frequency/spectra acceleration at median frequency).

   The estimated median frequency was taken as 5 Hz; the system frequency has been defined in Section 4.49 of Reference 1. The 85% exceedence frequency has been calculated following the suggestion given on page 4-52 of Reference 3. The 85% exceedence frequency, f_β is given by

   $$5 * e^{-0.25} = 3.9 \text{ Hz}$$

   Using the floor response given in Reference 2 and 5% damping, we have

   $$f = 5 \text{ HZ} \quad RRS = 0.42g$$
   $$f_\beta = 3.9 \text{ Hz} \quad RRS = 0.55g$$

   and $\beta_u = \ln(0.55/0.42) = 0.27$

4. The β values used were provided by RIZZO Associates, Reference 9

REV. NO.	REV. DATE	AUTHOR	DATE	CHK'D BY	DATE	VERIFIED BY	DATE

WESTINGHOUSE CALCULATION SHEET

TITLE DONALD C. COOK NUCLEAR PLANTS SEISMIC FRAGILITY ANALYSIS			PAGE 8 OF 19
PROJECT AEP	AUTHOR A. Hartman DATE 8-19-94	CHK'D BY — DATE	VERIFIED BY [signature] DATE 8/19/94
S.O. ATOP-4708E	CALC. NO. CSE-08-94-0040	FILE NO. AEP-9471	GROUP MSE-CSE

FRAGILITY ESTIMATE FOR THE AUXILIARY BUILDING

A review of the calculations given in Reference 6 indicates that the steel columns supporting the crane girders in the auxiliary Building control the fragility value and were designed on the basis of the actual material strengths reported in the mill certifications, ie, the measured yield strengths of the A-36 steel used, varied between 36 ksi and 50 ksi. According to the calculation, Reference 6, a concrete wall is attached to one of the column flanges which supplies some lateral resistance to weak axis bending of the crane girder columns. This report also indicates that under seismic design conditions some of the peak calculated steel stresses exceed 80% of the design allowable stress.

For this reason, it was concluded that the critical members used in the design of the Auxiliary Building would be the steel columns supporting the crane rails.

Because the steel yield strengths used were mill certified, there is only minimal reserve material strength reserve above that used in the design. The median margin factor for the material was taken as 1 with zero variance.

FRAGILITY PARAMETERS

MARGIN	F median	β_R	β_U	β_C	Reference/(NOTES)
SPECTRA	1.50	0.28	0	0.28	AEP-049 & RIZZO(4)
MATERIAL	1.0	0	0	0.	(1)
DUCTILITY	1.77	0.14	0.10	0.17	(2)
MODELING	1.0	0	0.	0.	(3)
SSI	1.6	0	0.27	0.27	RIZZO (4)
Resultant	4.25	0.31	0.29	0.42	median values

Values above are applicable to Auxiliary Building steel columns

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FRAGILITY ESTIMATE FOR THE AUXILIARY BUILDING cont.

The auxiliary building was designed (Ref. 6) based on a median ZPA acceleration design capacity requirement of 0.2g. The ZPA capacity = seismic design capacity required times the median margin factor = 0.20*4.25 = 0.85g

The ZPA HCLPF value is

$$HCLPF(ZPA) = 0.85*e(-1.65*(0.31 + 0.29)) = 0.32g$$

NOTES

1. As noted above, the yield strengths of the column materials used in the strength analysis were based on mill cert. tensile strengths of the individual steel columns; thus it is concluded that a deterministic median strength factor equal to 1 is appropriate.

2. References 10 and 11 describe the seismic response characteristics of the auxiliary building. It is clear from the auxiliary building floor spectra given in Reference 11 that the Auxiliary Building has a fundamental frequency between 2 Hz and 3.3 Hz For the purpose of this evaluation, it is assumed that the steel median ductility was 2.0. Since the structure is flexible, damping also has an effect on the column response; a value of 5% was considered to be reasonable. TABLE 5-1 of Reference 3 was used to define the ductility factors used in this analysis.

3. The variability in modeling lies primarily in the ability of the analytical model to estimate system frequencies. For this evaluation the median factor was taken equal to 1. This evaluation follows the approach set forth in Reference 3. In this approach equation 4-33 of Reference 3 is used to estimate β_u; the value for modeling can be calculated as follows:

   β_u = ln(spectral acceler. at 85% exceedence probability frequency/spectra acceleration at median frequency).

The estimated median building frequency was taken as 2.5 Hz. The 85% exceedence frequency has been calculated following the suggestion given on page 4-52 of Reference 3. The 85% exceedence frequency, $f_{\beta,}$ is given by

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FRAGILITY ESTIMATE FOR THE AUXILIARY BUILDING cont.

NOTE 3 cont.

$$2.5 * e^{-0.25} = 1.95 \text{ Hz}$$

Reviewing the floor response spectra given in Reference 11 for 5% damping, it is clear that there is no significant change in the spectral value in this frequency range. Indeed a frequency shift outside this range will result in a drop in the spectral level. From this it is clear that β_u can be set equal to

$$\beta_u = 0.0$$

4. The β values used were provided by RIZZO Associates, Reference 9.

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DIESEL GENERATOR DIESEL FUEL DAY TANK MASONRY WALL

INTRODUCTION

The fuel day tank is located in the diesel generator room at the 591' level. It is enclosed by a masonry block wall which has been stiffened by the presence of an angle bolted to the inside face of the wall. The concern exists (Section 4.40 of Ref. 1) that the wall could fail during a seismic event and damage the day tank. Reference 12 contains details related to the seismic design of the wall. The wall consists of a 13' wall parallel to the tank's long axis integral with 6 foot side walls at each end. The wall was assembled using DUR-O-WAL reinforcement placed at a sixteen inch spacing. The wall is not supported at the top edge by the ceiling. The bending frequency of the wall acting as a horizontal one way beam with fixed ends is 11 Hz. A wall stiffener beam consisting of one 5" angle is bolted to the inside of the masonry wall (Ref. 5 Appendix C page 301). Since the stiffener is located only on one wall face, it can develop only a limited amount of moment resistance at the wall base where it is connected to floor slab.

Since the tank level is above the Auxiliary Building base, the HCLPF value must be lowered: the spectral values must be scaled to represent the free field ZPA value. This factor is done in two stages: first the spectral value is scaled to be representative of the floor ZPA; and second, the floor ZPA is scaled to be representative of the free field acceleration. This factor (based on 2% spectral damping) is (0.22/0.29)*(0.2/0.22), and is equal to 0.69. This factor is treated as deterministic since two other parameters, spectral effects and modeling effects, already take into account the variability of the earthquake and building dynamic characteristics.

BASIC WALL STRENGTH

The stiffener is bolted to the wall at the top and bottom and breaks up the wall into two panels (5'x10.16' and the other 5'x3.17'). Since the angle connection to the floor has limited moment capacity, this restraint will not be considered in this evaluation. Since the wall continues around the tank sides, these corners will provide additional bending restraint to the long wall. This strength reserve factor had not previously been considered in Reference 12.

To reduce the conservatism reported in References 1 and 12, the wall has been reanalyzed. For the purpose of the present evaluation, it is assumed that the wall can be modeled as a one way slab fixed at each end. Assume a one foot wide section of masonry wall spans the full distance of 13.33'. Use the cross sectional properties given in Appendix A of Reference 12 to estimate the bending frequency of the wall acting as a one way slab. The beam frequency is calculated using the following equation (Ref. 13).

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DIESEL GENERATOR DIESEL FUEL DAY TANK MASONRY WALL cont.
BASIC WALL STRENGTH cont.

$f = 3.56*\sqrt{[EI/(mL^4)]} = 11.2$ Hz, where $E = 1.195*10^6$ psi, and

$I = 76.8$ in^4
$L = 13.33*12 = 159.96$ in
$m = W/g = 5.5/386 = 0.0142$ lb-sec^2/in^2

Since no spectra is available for the 591' level, this analysis will make conservative use of the spectral curve for the 609' level. It is assumed that the applicable spectral damping is 2% and the required spectral acceleration is 0.29g

The ultimate strength of the DUR-O-WAL masonry is given in Reference 12 & 14. For an 8 inch wall constructed using #9 wire spaced at 16 inches, the ultimate resisting moment is 5694 in-lbs per foot of wall height (TABLE 15 of Ref. 14).

Considering a 12" height of wall with fixed ends, the maximum moment is

$$M = \alpha*W*L^2/12 = \alpha*5.5*159.96^2/12 = \alpha*11727 \text{ in-lb/ ft. of wall height}$$

where α defines the design g level used.
α = design seismic capacity = 5694/11727 = 0.49g

FRAGILITY PARAMETERS

MARGIN	F median	β_R	β_U	β_C	Reference/(NOTES)
SPECTRA	1.3	0.28	0	0.28	AEP-050 & RIZZO(4)
MATERIAL	1.09	0	0.13	0.13	Ref. 4, (1)
DUCTILITY	1.054	0.02	0.01	0.02	(2)
MODELING	1.0	0	0.13	0.13	(3)
SSI	1.3	0	0.20	0.20	RIZZO (4)
Resultant	1.94	0.28	0.27	0.39	median values

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SAME INFORMATION AS WESTINGHOUSE FORM 33213H

WESTINGHOUSE CALCULATION SHEET

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DIESEL GENERATOR DIESEL FUEL DAY TANK MASONRY WALL cont.
FRAGILITY PARAMETERS cont.

Values above are applicable to masonry wall at 591' level

The floor median spectral acceleration capacity = seismic design capacity times median margin factor = 0.49g*1.94 = 0.95g

The HCLPF floor value is

$$HCLPF(floor) = 0.95g*e(-1.65*(0.28 + 0.27)) = 0.38g$$

The free field median spectral acceleration capacity
= 0.95g * 0.69 = 0.66g

For free field , the HCLPF value is

$$HCLPF(free\ field) = 0.69* HCLPF(floor) = 0.69*0.38 = 0.26g$$

NOTES

1. For the DUR-O- WAL material, the nominal yield strength is 70000 psi (Attachment B of References 12 and 14). For this case the controlling factor is steel yield. Now Table 1 (Steel Yield Strength Characteristics) of Reference 4 shows the mean and coefficient of variability (COV) for various steels. The COV is defined as the ratio of the standard deviation divided by the mean value. After reviewing the data on Table 1 of Reference 4 it was determined that reasonable values for these parameters , mean and standard deviation (for a high strength material), are 1.1 and 0.13 respectively. The material is defined in terms of the mean value and has been converted to median value using a relationship described in Equation 2.4 of Reference 1

$$F' = 1.1*e(-0.13^2/2) = 1.09$$

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DIESEL GENERATOR DIESEL FUEL DAY TANK MASONRY WALL cont.
NOTES cont.

2. The main source of ductility in the masonry wall during bending arises from the ductility of the DUR-O-WAL steel and its bond to the masonry. For the purpose of this evaluation, it is assumed that the connection median ductility is 1.5. Due to the high calculated frequency for the wall, it is assumed that damping effects will not effect ductility. TABLE 5-1 of Reference 3 is used to define the ductility margin factors used in the fragility analysis.

3. The variability in modeling lies primarily in the ability of the analytical model to estimate system frequencies. For this evaluation the median factor is taken equal to 1 since the models are adequate. This evaluation follows the approach set forth in Reference 3 and is used to define variability. In this approach equation 4-33 of Reference 3 is used to estimate β_u; the value for modeling can be calculated as follows:

   β_u = ln(spectral acceler. at 85% exceedence probability frequency/spectra acceleration at median frequency).

   The estimated median frequency was taken as 11 Hz; the system frequency has been defined in Section 4.40 of Reference 1. The 85% exceedence frequency has been calculate following the suggestion given on page 4-52 of Reference 3. The 85% exceedence frequency, f_β is given by

   $$11 * e^{-0.25} = 8.6 \text{ Hz}$$

   Using the floor response given in Reference 2 and 2% damping, we have

   f = 11 HZ RRS = 0.29g
   f_β = 8.6 Hz RRS = 0.33g

   and $\beta_u = \ln(0.33/0.29) = 0.13$

4. The β values used were provided by RIZZO Associates, Reference 9

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CCW HEAT EXCHANGER SUPPORTS

Anchorage

The heat exchanger is mounted on a pedestal at each end, on the 609' floor elevation of the auxiliary building. One pedestal has additional anchorage and the equipment is considered fixed, while the second end is free to slide to accommodate thermal growth. The heat exchanger is anchored by 2 J-Bolts on each pedestal, embedded into the floor concrete below the pedestal. The J-Bolt has an embedment length of 24", before the bend, while the pedestal is 7" high, so the bend lies 17" below the concrete floor surface. The equipment is welded to two saddle supports made up of angles which rest on a 1-1/2" thick layer of grout, which caps the pedestal top. The pedestal concrete edge distance is a minimum of 6".

Cracks have been found in a plane between the concrete and grout interface and on a number of vertical planes passing through the pedestals at each end. The pedestals were designed to provide for free axial thermal growth of the heat exchanger; one end was designed to be fixed while the other end could slide axially. The cracks found are inconsistent with the expected pedestal deformation under the design condition loads. The cracking condition must have occurred due to normal deadweight and the tank heat up condition, since no seismic loading for which the pedestals were designed has yet occurred. With the deadweight load of 40 kips at each support point and μ ranging from 0.3 to 0.7 for steel on concrete, a frictional shear load of 28 kips can be induced in the concrete before sliding, while resisting the thermal growth of the tank. This load should be sufficient to crack the bond between surfaces. As a result it is concluded that the cracking was produced by thermal heat up.

Thermal loads are self equilibrating and thus need not be additive to the design loads under the Faulted Condition; the presence of the thermal axial loads indicates that the sliding support was not free to slide. Finally, the presence of the vertical cracks will not effect the development of bending resistance, and the presence of the horizontal crack at the grout/pedestal interface is considered in this evaluation.

The strength of the interface between grout and concrete is maintained by the frictional resistance. The resisting frictional force is equal to the deadweight or normal force at the support times the coefficient of friction. Using $\mu = 0.6$ from Section 11.7.4 of ACI-349, the $V_n = 0.6(40)$, but must not exceed $0.2f_c'A_c$ per Section 11.7.5 of ACI-349, using A_c equal to the concrete area under the saddle. The resulting shear capacity is the MIN[24, 157.5] or 24 kips.

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CCW HEAT EXCHANGER SUPPORTS cont.
Spectral Floor Acceleration Capacity

Consider additional margins based on Ref. 18.
Reference 15 applies a prying factor of two in the determination of the seismic design capacity based on anchor bolt tensile strength, for a median spectral floor acceleration capacity of 0.45g. This factor is conservative since the weight of the heat exchanger will aid in reducing the lifting of the plate and therefore prying. A computer model of the base plate (saddle base) was developed with the stiffener plates represented. Loads were determined based on the seismic design capacity of Reference 15. The anchor in tension has a pullout load of 10.13 kips, per Ref. 18. The ultimate load will be used as the steel capacity. The steel capacity will be considered to control over the concrete for tension since the J-Bolt is deeply embedded. The capacity of the steel, F_t, is S_uA_t or 26.8 kips, where A_t = 0.462 in.^{2}, S_u = 58 ksi. A factor of safety of 26.8/10.13 = 2.65 is obtained.

Shear-Tension interaction should also be considered. The concrete shear capacity for the free edge distance is $(1.1)2(f_c')^{1/2}\pi\, m^2$, from ACI-349 Appendix B, Section B.5.1.2 and Commentary, where m is the edge distance, f_c' is the concrete compressive strength, and m is the distance to the free edge. A minimum edge distance of 6" is applied and the strength is 14.7 kips per anchor bolt.

The ultimate shear strength for the anchor bolt steel is $0.42S_u$ per the ASME Code, Appendix F, Section F-1335.2. The capacity, F_v, is $0.42S_uA_s$ or 14.64 kips, where A_s = 0.601 in.^{2}, considering the bolts to act in combination with load redistribution, the factor of safety for 0.45g loading is (2x14.64)/18 = 1.63. The nominal bolt area is used since the bolt shear strength must be developed at the grout/pedestal interface, since the grout relies on frictional strength. Drawing 12-3285-23 shows the thread ending at the grout/pedestal interface.

Consider parabolic shear/tension interaction similar to the ASME Code, NF-3324.6:

$$(1/2.65)^2+(1/1.63)^2 \leq 1.0 = 0.520$$

Obtaining a similar relationship in terms of variable A_H :

$$[(62.3A_H - 13.33)0.689/F_t]^2 + [80A_H /2F_v]^2 = 1.0$$

a iterative solution of 0.587g is obtained, where A_H is the horizontal g value and the vertical g is assumed to be 2/3 A_H.

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SAME INFORMATION AS WESTINGHOUSE FORM 55213H

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CCW HEAT EXCHANGER SUPPORTS cont.
Spectral Floor Acceleration Capacity cont.

Scale Factor

The median free field spectral acceleration capacity equals the median floor spectral acceleration capacity times a scale factor. The heat exchanger is mounted at the 609' level of the AEP auxiliary building, per Ref. 1, page 27. The applicable frequency for the support is 33 Hz. and 2% damping is applied per Ref. 15 page 4. The nominal seismic spectral acceleration at the equipment frequency is 0.22g, equivalent to the floor ZPA since the support frequency resides in the rigid range. The corresponding free field ZPA is 0.2g. The scale factor is 0.22/0.22 * 0.2/0.22 = 0.91

FRAGILITY PARAMETERS

MARGIN	F median	β_R	β_U	β_C	Reference/(NOTES)
SPECTRA	1.2	0.28	0	0.28	(1)
DUCTILITY(2)	1.0	0	0	0	(3)
MATERIAL	1.28	0	0.123	0.123	(4)
MODELING	1.0	0	0	0	(5)
SSI	1.3	0	0.20	0.20	(6)
Resultant	2.0	0.28	0.23	0.37	median values

Values above are applicable to the heat exchanger anchorage at the 609' level

The floor median spectral acceleration capacity = seismic design capacity times median margin factor = 0.587*2.0 = 1.17g

The HCLPF floor value is

HCLPF(floor) = 1.17*e(-1.65*(0.28 + 0.23)) = 0.50g

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CCW HEAT EXCHANGER SUPPORTS cont.

FRAGILITY PARAMETERS cont.

The free field median spectral acceleration capacity

$= 1.17 * 0.91 = 1.07g$

For free field , the HCLPF value is

HCLPF(free field) $= 0.91*$ HCLPF(floor) $= 0.91*0.50 = 0.46g$

NOTES

1. UHS factor from Westinghouse Calc. No. AEP-050, Ref. 7. Adjustment to reflect the conservatism of the DC Cook FSAR SSE ground Design Spectra w.r.t the LLNL UHS 10,000 year median spectral shape. βr was provided in Ref. 9, by Rizzo Associates.

2. Inelastic Energy Absorption Factor for the critical element, the anchor bolts. See Note 3.

3. From Westinghouse Calc. # AEP-036, Ref. 15, the tensile capacity of the 7/8" diameter J-Bolt controls, over the concrete capacity indicating a ductile mode of failure. A reasonable conclusion despite the cracking of the pedestal, since the J-Bolt is embedded in the concrete floor, and the shear capacity is not degraded by the cracks in the pedestal. However, brittle failure must be considered as described in Section 5.1.1.1 of the Ref. 3. Considering the system ductility, the inelastic energy absorption associated with the anchor bolts is small. Since the supported equipment is massive, the equipment will typically be stressed below the yield point, while the bolts are stressed at a level well above the yield point. The amount of inelastic energy absorption derived from the bolts is therefore minimal. Since the failure is considered brittle, a factor of 1.0 is applied.

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CCW HEAT EXCHANGER SUPPORTS cont.

NOTES cont.

4. Similar random strength material factors are found for the concrete and the steel. Ref. 3, Section 4.1.1.1, page 4-8, provides an average value for strength increase due to aging and batch strength. Table 4-1 provides values for fc = 3000 psi, but not for 3500 psi, per Ref. 15. As a result, the value for 3000 psi will be used. Note that on page 4-10 of Ref. 3, it is stated that the strength may increase for the rate of loading at seismic response frequency, however the increase factor is cancelled by the in-place strength reduction factor. This in-place strength reduction factor is based on the difference in strength between in place concrete and the test cylinder concrete.

$$F\ med. = 1.29*e(-(0.123^2)/2) = 1.28$$

For the steel, a mean factor of 1.189 can be found in Table 1 of Ref. 4, with a COV of 0.0871. A median value of 1.18 is obtained, and a dynamic increase factor of 1.1 can be applied per Ref. 16, resulting in a median value of 1.3. The concrete controls.

5. Variability in modelling based on analytical model frequency estimates is not applicable since the pedestal and heat exchanger is rigid.

6. From Ref. 9.

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COVER 1

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***                             ***
***    MESPLAT ON THE SUN 4     ***
***        VERSION 2.1          ***
***         02/25/91            ***
***                             ***
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8/19/94
2 COVER PGS + 12 OUTPUT

CASE NUMBER: 1

VERIFIED BY T.U 8/23/94

```
ACCOUNT
PLATE  6.0 37.5 0.44 0.0
TITLE D.C. COOK CCW HEAT EXCNGR ANCHORAGE FORCE END STIFF EDGE
OPTION 40 3.0 2.0 Y Y Y .280E+08 .280E+08
BOLT  3.000  5.500 1 0.0
BOLT  3.000 32.000 1 0.0
PROP 1 0.875 27.0 0.0
REGION 1  1.62 7.00 0.00 0.00 0.0 1 0
LOAD 1 0.0 -9000 -33400 0.0 0.0 0.0
REGION 2 1.62 18.75 0.00 0.00 0.0 1 0
LOAD 2 0.0 0.0 -9300 0.0 0.0 0.0
REGION 3 1.62 30.5 0.00 0.00 0.0 1 0
LOAD 3 0.0 -9000 14700 0.0 0.0 0.0
STIFF 0.0 0.0 0.0 37.5 6.0 0.4375
STIFF 0.0 7.0 6.0 7.0 6.0 0.4375
STIFF 0.0 18.75 6.0 18.75 6.0 0.4375
STIFF 0.0 30.5 6.0 30.5 6.0 0.4375
MC1,2=          0 ,    1250000
START BPCOM NX1 =       4 AND NY1 =      15
XX LINE LIST
   0.000000   1.620000   3.810000   6.000000
YY LINE LIST
   0.000000   2.333333   4.666667   7.000000   9.937500  12.875000  15.812500
  18.750000  21.687500  24.625000  27.562500  30.500000  32.833333  35.166667
  37.500000
START PHASE 0
START PHASE 1 - LOOP =      0 NEQ =    504 NRE =      0
MEMORY =    225000 WORDS
NCOL IS    504 FOR BLOCK NUMBER       1
START PHASE 2 HERE
NCOL IS    504 FOR BLOCK NUMBER       1
CALLING LDGEN
START SOLUTION PHASE
NBLOCK= 1 LBLOCK=    56155 NCM=   224555
ITERATION       1
NUMBER OF NON-CONVERGED GAPS IS      48
ITERATION       2
NUMBER OF NON-CONVERGED GAPS IS      34
ITERATION       3
NUMBER OF NON-CONVERGED GAPS IS      16
ITERATION       4
NUMBER OF NON-CONVERGED GAPS IS      25
ITERATION       5
NUMBER OF NON-CONVERGED GAPS IS      12
ITERATION       6
NUMBER OF NON-CONVERGED GAPS IS      12
ITERATION       7
NUMBER OF NON-CONVERGED GAPS IS      13
ITERATION       8
NUMBER OF NON-CONVERGED GAPS IS       8
```

COVER2

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ITERATION       9
NUMBER OF NON-CONVERGED GAPS IS       2
ITERATION      10
NUMBER OF NON-CONVERGED GAPS IS       1
ITERATION      11
NUMBER OF NON-CONVERGED GAPS IS       0
BPOUT
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WESPLAT ON THE SUN 4 VERSION 2.1 02/25/91
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TITLE: D.C. COOK CCW HEAT EXCNGR ANCHORAGE FORCE END STIFF EDGE

ELEMENT STRESSES AT FINAL ITERATION

LOCATION(IN)		STRESSES(PSI)							
X	Y	SIGX	SIGY	SIGXY	SIG1	SIG2	SIGE	SMAX	
0.810	1.167	-468.0	762.3	893.5	1231.9	-937.6	1884.6	2169.5	TOP
0.810	1.167	-438.0	881.6	812.1	1268.2	-824.5	1825.9	2092.8	MIDDLE
0.810	1.167	-407.9	1001.0	730.8	1311.6	-718.5	1783.0	2030.1	BOTTOM
2.715	1.167	-779.8	327.7	-163.1	351.3	-803.4	1025.2	1154.6	TOP
2.715	1.167	-762.1	356.0	-170.6	381.5	-787.5	1032.5	1169.0	MIDDLE
2.715	1.167	-744.3	384.3	-178.0	411.8	-771.7	1040.6	1183.5	BOTTOM
4.905	1.167	-295.1	-186.7	-396.7	159.5	-641.2	734.1	800.7	TOP
4.905	1.167	-299.7	-206.4	-413.2	162.8	-668.9	763.5	831.7	MIDDLE
4.905	1.167	-304.3	-226.1	-429.8	166.4	-696.8	793.2	863.2	BOTTOM
0.810	3.500	74.3	2055.8	1237.3	2650.2	-520.0	2944.8	3170.2	TOP
0.810	3.500	343.1	2154.0	923.6	2542.0	-44.8	2564.7	2586.8	MIDDLE
0.810	3.500	611.9	2252.3	609.8	2454.2	410.0	2277.0	2454.2	BOTTOM
2.715	3.500	314.8	1554.3	161.0	1574.9	294.3	1450.3	1574.9	TOP
2.715	3.500	392.6	1440.6	111.1	1452.3	381.0	1304.2	1452.3	MIDDLE
2.715	3.500	470.4	1326.9	61.1	1331.2	466.0	1170.0	1331.2	BOTTOM
4.905	3.500	90.4	-664.2	-751.6	554.1	-1127.8	1484.6	1681.9	TOP
4.905	3.500	12.8	-773.3	-777.5	491.0	-1251.4	1556.1	1742.4	MIDDLE
4.905	3.500	-64.7	-882.4	-803.4	427.8	-1375.0	1631.5	1802.8	BOTTOM
0.810	5.833	-674.5	406.9	265.3	468.5	-736.1	1051.8	1204.6	TOP
0.810	5.833	238.7	1504.6	-5.5	1504.7	238.7	1400.6	1504.7	MIDDLE
0.810	5.833	1151.9	2602.3	-276.4	2653.2	1101.0	2308.8	2653.2	BOTTOM
2.715	5.833	-930.1	-3144.7	1716.4	5.2	-4080.0	4082.6	4085.2	TOP
2.715	5.833	-17.7	-2089.2	1458.6	735.5	-2842.4	3272.7	3577.8	MIDDLE
2.715	5.833	894.8	-1033.8	1200.7	1470.5	-1609.4	2668.2	3079.9	BOTTOM
4.905	5.833	2.4	-3313.8	-694.8	142.0	-3453.5	3526.7	3595.6	TOP
4.905	5.833	-36.0	-2813.5	-784.7	170.4	-3019.9	3108.6	3190.2	MIDDLE
4.905	5.833	-74.4	-2313.1	-874.7	226.8	-2614.3	2734.8	2841.2	BOTTOM
0.810	8.469	-305.0	5261.0	448.2	5296.9	-340.9	5475.3	5637.8	TOP
0.810	8.469	595.3	6448.3	-136.9	6451.5	592.1	6176.8	6451.5	MIDDLE
0.810	8.469	1495.7	7635.6	-722.1	7719.4	1411.9	7119.3	7719.4	BOTTOM
2.715	8.469	-440.8	857.2	1677.3	2006.7	-1590.4	3122.1	3597.0	TOP
2.715	8.469	581.8	1717.6	1352.1	2616.2	-316.8	2788.1	2933.0	MIDDLE
2.715	8.469	1604.5	2578.0	1026.8	3227.6	954.9	2871.8	3227.6	BOTTOM
4.905	8.469	139.8	-3970.5	215.1	151.0	-3981.8	4059.4	4132.8	TOP
4.905	8.469	61.6	-3987.3	-324.7	87.5	-4013.2	4057.6	4100.7	MIDDLE
4.905	8.469	-16.6	-4004.1	-864.5	162.8	-4183.5	4267.2	4346.3	BOTTOM
0.810	11.406	-819.4	5360.9	1187.3	5581.2	-1039.7	6167.1	6620.8	TOP
0.810	11.406	-285.9	5891.9	411.8	5919.2	-313.2	6081.9	6232.5	MIDDLE
0.810	11.406	247.6	6422.9	-363.7	6444.2	226.3	6334.1	6444.2	BOTTOM

TITLE: D.C. COOK CCW HEAT EXCNGR ANCHORAGE FORCE END STIFF EDGE

ELEMENT STRESSES AT FINAL ITERATION

LOCATION(IN)					STRESSES(PSI)				
X	Y	SIGX	SIGY	SIGXY	SIG1	SIG2	SIGE	SMAX	
2.715	11.406	-734.1	1451.8	1299.5	2056.9	-1339.1	2962.8	3396.0	TOP
2.715	11.406	-130.0	1777.3	437.8	1873.0	-225.7	1995.4	2098.7	MIDDLE
2.715	11.406	474.1	2102.8	-423.9	2206.5	370.4	2046.6	2206.5	BOTTOM
4.905	11.406	-139.3	-3521.3	938.3	103.6	-3764.2	3817.1	3867.9	TOP
4.905	11.406	127.7	-3325.2	224.4	142.2	-3339.8	3413.1	3482.0	MIDDLE
4.905	11.406	394.7	-3129.1	-489.6	461.4	-3195.9	3449.8	3657.3	BOTTOM
0.810	14.344	-667.1	5525.3	1838.9	6030.2	-1172.0	6693.6	7202.2	TOP
0.810	14.344	-21.9	6111.6	571.2	6164.3	-74.7	6202.0	6239.0	MIDDLE
0.810	14.344	623.2	6697.9	-696.5	6776.7	544.4	6521.6	6776.7	BOTTOM
2.715	14.344	-892.4	1596.5	1344.2	2183.8	-1479.8	3192.3	3663.7	TOP
2.715	14.344	19.8	1976.7	357.1	2039.8	-43.3	2061.8	2083.2	MIDDLE
2.715	14.344	932.0	2356.9	-630.0	2595.5	693.5	2327.6	2595.5	BOTTOM
4.905	14.344	-401.3	-2816.8	1140.4	52.0	-3270.1	3296.5	3322.2	TOP
4.905	14.344	-9.8	-2921.6	161.4	-0.8	-2930.5	2930.1	2930.5	MIDDLE
4.905	14.344	381.8	-3026.3	-817.6	567.7	-3212.3	3530.6	3780.0	BOTTOM
0.810	17.281	-611.5	4641.4	941.6	4805.1	-775.2	5235.9	5580.3	TOP
0.810	17.281	635.3	6289.9	102.1	6291.8	633.4	6000.2	6291.8	MIDDLE
0.810	17.281	1882.1	7938.4	-737.3	8026.9	1793.6	7297.3	8026.9	BOTTOM
2.715	17.281	-1442.0	-391.0	1735.2	896.5	-2729.5	3271.2	3626.0	TOP
2.715	17.281	601.4	1966.5	461.0	2107.6	460.3	1919.4	2107.6	MIDDLE
2.715	17.281	2644.8	4324.1	-813.1	4653.3	2315.6	4029.9	4653.3	BOTTOM
4.905	17.281	-367.5	-4503.6	1462.2	97.2	-4968.3	5017.6	5065.6	TOP
4.905	17.281	146.6	-2423.3	410.4	210.5	-2487.2	2598.9	2697.8	MIDDLE
4.905	17.281	660.6	-343.0	-641.5	973.3	-655.6	1419.6	1628.9	BOTTOM
0.810	20.219	-582.4	3552.8	849.1	3720.4	-750.0	4146.5	4470.3	TOP
0.810	20.219	674.6	5201.1	39.2	5201.5	674.2	4899.3	5201.5	MIDDLE
0.810	20.219	1931.6	6849.5	-770.7	6967.4	1813.6	6260.8	6967.4	BOTTOM
2.715	20.219	-942.0	173.8	1296.6	1027.4	-1795.6	2474.8	2823.1	TOP
2.715	20.219	616.2	1772.2	541.9	1986.5	401.9	1819.2	1986.5	MIDDLE
2.715	20.219	2174.4	3370.6	-212.7	3407.3	2137.7	2982.6	3407.3	BOTTOM
4.905	20.219	230.4	-2671.3	1411.1	803.4	-3244.4	3711.9	4047.8	TOP
4.905	20.219	139.1	-1702.3	325.6	195.0	-1758.2	1863.4	1953.2	MIDDLE
4.905	20.219	47.9	-733.4	-759.9	511.7	-1197.2	1519.1	1708.9	BOTTOM
0.810	23.156	-909.6	2606.4	298.7	2631.6	-934.8	3203.0	3566.4	TOP
0.810	23.156	-50.2	2853.6	-397.5	2907.0	-103.6	2960.2	3010.6	MIDDLE
0.810	23.156	809.3	3100.7	-1093.7	3539.0	371.0	3368.8	3539.0	BOTTOM
2.715	23.156	-341.3	953.2	1639.1	2068.3	-1456.4	3067.7	3524.7	TOP
2.715	23.156	90.3	1214.3	649.9	1511.5	-206.8	1624.8	1718.3	MIDDLE
2.715	23.156	522.0	1475.3	-339.4	1583.9	413.5	1422.9	1583.9	BOTTOM
4.905	23.156	138.1	-887.5	1818.2	1514.4	-2263.9	3293.5	3778.3	TOP
4.905	23.156	78.5	-824.7	606.3	382.9	-1129.1	1361.6	1512.1	MIDDLE
4.905	23.156	18.9	-761.9	-605.5	349.0	-1092.0	1302.0	1440.9	BOTTOM

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TITLE: D.C. COOK CCW HEAT EXCNGR ANCHORAGE FORCE END STIFF EDGE

ELEMENT STRESSES AT FINAL ITERATION

LOCATION(IN)					STRESSES(PSI)				
X	Y	SIGX	SIGY	SIGXY	SIG1	SIG2	SIGE	SMAX	
0.810	26.094	-1674.2	-1022.7	708.1	-569.1	-2127.9	1908.1	2127.9	TOP
0.810	26.094	200.1	498.3	-537.9	907.4	-209.0	1027.9	1116.4	MIDDLE
0.810	26.094	2074.4	2019.4	-1783.9	3831.0	262.8	3706.5	3831.0	BOTTOM
2.715	26.094	1638.2	1166.9	2575.6	3988.9	-1183.8	4694.2	5172.7	TOP
2.715	26.094	106.3	252.6	653.8	837.3	-478.4	1153.5	1315.8	MIDDLE
2.715	26.094	-1425.7	-661.7	-1268.0	280.6	-2368.0	2520.0	2648.6	BOTTOM
4.905	26.094	531.1	2732.4	2901.4	4734.9	-1471.4	5617.0	6206.3	TOP
4.905	26.094	-112.9	238.8	680.8	766.1	-640.2	1219.6	1406.4	MIDDLE
4.905	26.094	-756.9	-2254.8	-1539.7	206.3	-3218.1	3326.0	3424.4	BOTTOM
0.810	29.031	2344.6	4186.0	3960.7	7331.6	-801.0	7763.2	8132.7	TOP
0.810	29.031	-541.1	-2362.5	-1197.5	52.7	-2956.3	2982.9	3008.9	MIDDLE
0.810	29.031	-3426.8	-8911.0	-6355.7	753.1	-13090.9	13483.3	13844.1	BOTTOM
2.715	29.031	2229.5	8648.3	4642.4	11082.6	-204.8	11186.4	11287.5	TOP
2.715	29.031	-524.6	-939.3	1400.2	683.5	-2147.4	2558.6	2830.9	MIDDLE
2.715	29.031	-3278.7	-10526.8	-1842.0	-2837.4	-10968.1	9860.4	10968.1	BOTTOM
4.905	29.031	2911.4	9284.8	327.8	9301.6	2894.6	8244.6	9301.6	TOP
4.905	29.031	-22.3	1522.1	252.0	1562.2	-62.4	1594.3	1624.6	MIDDLE
4.905	29.031	-2956.0	-6240.5	176.3	-2946.5	-6250.0	5415.6	6250.0	BOTTOM
0.810	31.667	6191.2	-916.2	2425.9	6940.3	-1665.3	7905.6	8605.5	TOP
0.810	31.667	72.6	1410.5	-1073.5	2006.4	-523.3	2312.9	2529.7	MIDDLE
0.810	31.667	-6046.0	3737.3	-4572.8	5541.8	-7850.6	11655.5	13392.4	BOTTOM
2.715	31.667	-16820.2	-11001.6	3771.9	-9147.3	-18674.4	16173.7	18674.4	TOP
2.715	31.667	174.7	2863.1	1293.8	3384.6	-346.9	3570.7	3731.4	MIDDLE
2.715	31.667	17169.5	16727.7	-1184.3	18153.3	15743.9	17076.5	18153.3	BOTTOM
4.905	31.667	-2306.2	-6205.0	1346.3	-1886.5	-6624.7	5911.7	6624.7	TOP
4.905	31.667	31.2	1094.1	-246.9	1148.6	-23.3	1160.5	1171.9	MIDDLE
4.905	31.667	2368.7	8393.1	-1840.1	8910.7	1851.1	8144.5	8910.7	BOTTOM
0.810	34.000	4899.4	-1583.2	298.3	4913.1	-1596.9	5876.6	6510.0	TOP
0.810	34.000	-56.2	-50.4	7.0	-45.8	-60.9	54.9	60.9	MIDDLE
0.810	34.000	-5011.9	1482.3	-284.4	1494.7	-5024.3	5915.0	6519.0	BOTTOM
2.715	34.000	-18868.9	-11555.6	2016.3	-11036.5	-19388.0	16844.0	19388.0	TOP
2.715	34.000	-282.9	-396.8	190.4	-141.1	-538.6	483.8	538.6	MIDDLE
2.715	34.000	18303.0	10761.9	-1635.5	18642.4	10422.4	16182.3	18642.4	BOTTOM
4.905	34.000	-6298.0	-8247.3	4848.8	-2326.9	-12218.4	11237.2	12218.4	TOP
4.905	34.000	-21.0	107.1	-239.8	291.2	-205.1	432.0	496.3	MIDDLE
4.905	34.000	6256.0	8461.4	-5328.3	12799.9	1917.5	11957.1	12799.9	BOTTOM
0.810	36.333	679.8	1192.6	-403.1	1413.9	458.4	1249.5	1413.9	TOP
0.810	36.333	1.3	-45.3	280.6	259.6	-303.5	488.2	563.1	MIDDLE
0.810	36.333	-677.1	-1283.1	964.3	30.7	-1990.9	2006.5	2021.6	BOTTOM
2.715	36.333	-6140.9	-544.7	182.3	-538.7	-6146.8	5895.9	6146.8	TOP
2.715	36.333	171.2	-126.4	63.3	184.2	-139.3	281.0	323.5	MIDDLE
2.715	36.333	6483.4	291.9	-55.6	6483.9	291.4	6343.2	6483.9	BOTTOM

WESPLAT ON THE SUN 4   VERSION 2.1 02/25/91
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TITLE: D.C. COOK CCW HEAT EXCNGR ANCHORAGE FORCE END STIFF EDGE

ELEMENT STRESSES AT FINAL ITERATION

LOCATION(IN)		STRESSES(PSI)							
X	Y	SIGX	SIGY	SIGXY	SIG1	SIG2	SIGE	SMAX	
4.905	36.333	-4661.1	-1090.9	·2321.7	52.6	-5804.6	5831.1	5857.3	TOP
4.905	36.333	92.9	26.9	-105.3	170.3	-50.5	200.3	220.7	MIDDLE
4.905	36.333	4846.9	1144.6	-2532.3	6132.5	-141.0	6204.2	6273.5	BOTTOM

TITLE: D.C. COOK CCW HEAT EXCNGR ANCHORAGE FORCE END STIFF EDGE

PLATE WIDTH . . . . 6.000 INCHES
PLATE LENGTH. . . . . 37.500 INCHES
PLATE THICKNESS . . . . 0.440 INCHES
PLATE MODULUS . . . . 28.0E+06 PSI
BOLT MODULUS. . . . . 28.0E+06 PSI

NUMBER OF ITERATIONS 11

NUMBER OF ELEMENTS IN X DIRECTION . 3
NUMBER OF ELEMENTS IN Y DIRECTION . 14
NUMBER OF BOLTS 2
NUMBER OF LOAD POINTS 3

BOLT LOCATIONS, PROPERTIES, AND LOADS

LOCATION X (IN)	LOCATION Y (IN)	DIAMETER (IN)	LENGTH IN INCHES OR STIFFNESS IN LBS/IN	SHEAR STIFFNESS (LBS/IN)	PRELOAD (LBS)	BOLT LOADS AXIAL (LBS)	BOLT LOADS SHEAR (LBS)
3.000	5.500	0.875	27.000	0.49E+07	0.	0.	10688.
3.000	32.000	0.875	27.000	0.49E+07	0.	10198.	7413.

MAXIMUM PLATE STRESSES AND LOCATIONS

LOCATION X (IN)	LOCATION Y (IN)	Z	STRESSES (PSI) PRINCIPAL SIGMA(1)	PRINCIPAL SIGMA(2)	EFFECTIVE SIGMA(E)
2.715	31.667	BOTTOM	18153.	15744.	17077. *
2.715	34.000	TOP	-11036.	-19388. *	16844.

TITLE: D.C. COOK CCW HEAT EXCNGR ANCHORAGE FORCE END STIFF EDGE

MAXIMUM PLATE STRESS INTENSITIES AND LOCATIONS

LOCATION X (IN)	LOCATION Y (IN)	Z	STRESS INTENSITIES (PSI) (Note 1) Sgie	STRESS INTENSITIES (PSI) (Note 2) Smax
2.715	34.000	TOP	16844.	----------
0.810	14.344	MIDDLE	6202.	----------
2.715	31.667	BOTTOM	17077.	----------
2.715	34.000	TOP	----------	19388.
0.810	8.469	MIDDLE	----------	6452.
2.715	34.000	BOTTOM	----------	18642.

Note 1: Maximum distortion energy theory
Note 2: ASME NF maximum shear stress theory

ATTACHMENT LOCATIONS AND PROPERTIES

ATTACHMENT NUMBER	CENTER LOCATION X (IN)	CENTER LOCATION Y (IN)	DIMENSIONS X(IN)	DIMENSIONS Y(IN)	ANGLE DEG.	SHAPE	LINK
1	1.620	7.000	0.000	0.000	0.0	RECTANGLE	1
2	1.620	18.750	0.000	0.000	0.0	RECTANGLE	2
3	1.620	30.500	0.000	0.000	0.0	RECTANGLE	3

TITLE: D.C. COOK CCW HEAT EXCNGR ANCHORAGE FORCE END STIFF EDGE

PLATE LOADS AT ATTACHMENT CENTERS

CENTER LOCATION X (IN)	CENTER LOCATION Y (IN)	FORCES (LBS) FX	FY	FZ	MOMENTS (IN-LBS) MX	MY	MZ
1.620	7.000	0	-9000	-33400	0	0	0
1.620	18.750	0	0	-9300	0	0	0
1.620	30.500	0	-9000	14700	0	0	0

PLATE DISPLACEMENTS AND ROTATIONS AT ATTACHMENT CENTERS

CENTER LOCATION X (IN)	CENTER LOCATION Y (IN)	DISPLACEMENTS (IN) DX	DY	DZ	ROTATIONS (RAD) RX	RY	RZ
1.620	7.000	-0.0011	-0.0037	0.0000	0.0003	0.0003	0.0008
1.620	18.750	-0.0048	-0.0017	0.0096	0.0017	0.0026	-0.0001
1.620	30.500	-0.0006	-0.0014	0.0335	-0.0012	0.0071	-0.0004

STIFFNER LOCATIONS AND PROPERTIES

STIFFNER NUMBER	START LOCATION X (IN)	START LOCATION Y (IN)	END LOCATION X (IN)	END LOCATION Y (IN)	HEIGHT (IN)	THICKNESS (IN)
1	0.000	0.000	0.000	37.500	6.000	0.4375
2	0.000	7.000	6.000	7.000	6.000	0.4375
3	0.000	18.750	6.000	18.750	6.000	0.4375
4	0.000	30.500	6.000	30.500	6.000	0.4375

TITLE: D.C. COOK CCW HEAT EXCNGR ANCHORAGE FORCE END STIFF EDGE

DISPLACEMENT VECTOR AT FINAL ITERATION

NODE	LOCATION (IN)		DISPLACEMENT (IN)			ROTATIONS (RAD)		
	X	Y	DX	DY	DZ	RX	RY	RZ
1	0.000	0.000	5.59E-03	-5.46E-03	-4.11E-07	-1.88E-05	-4.09E-05	1.04E-03
2	1.620	0.000	5.54E-03	-3.66E-03	3.96E-05	-1.63E-05	-2.02E-05	9.65E-04
3	3.810	0.000	5.44E-03	-1.47E-03	8.95E-05	-1.11E-05	-2.38E-05	9.25E-04
4	6.000	0.000	5.41E-03	6.55E-04	1.45E-04	-1.56E-05	-2.55E-05	9.11E-04
5	0.000	2.333	3.18E-03	-5.36E-03	-1.59E-07	4.66E-05	1.28E-07	1.02E-03
6	1.620	2.333	3.16E-03	-3.60E-03	2.03E-05	1.93E-06	-1.76E-05	9.48E-04
7	3.810	2.333	3.12E-03	-1.44E-03	6.15E-05	-1.19E-05	-2.06E-05	9.10E-04
8	6.000	2.333	3.11E-03	6.07E-04	1.01E-04	-2.87E-05	-1.98E-05	8.96E-04
9	0.000	4.667	8.79E-04	-5.16E-03	1.99E-04	1.24E-04	1.69E-04	9.53E-04
10	1.620	4.667	8.72E-04	-3.46E-03	-4.25E-09	-6.23E-05	6.10E-05	8.96E-04
11	3.810	4.667	9.06E-04	-1.35E-03	-9.07E-09	-5.15E-05	-1.55E-05	8.76E-04
12	6.000	4.667	9.48E-04	3.90E-04	-9.04E-10	-5.41E-05	1.56E-05	8.46E-04
13	0.000	7.000	-1.09E-03	-4.71E-03	7.84E-04	4.10E-04	4.80E-04	6.60E-04
14	1.620	7.000	-1.11E-03	-3.67E-03	-2.71E-06	2.76E-04	2.81E-04	8.07E-04
15	3.810	7.000	-1.04E-03	-1.50E-03	1.67E-05	2.02E-04	-6.62E-05	9.08E-04
16	6.000	7.000	-9.61E-04	6.53E-05	-1.71E-07	7.97E-05	3.67E-05	6.57E-04
17	0.000	9.938	-2.86E-03	-4.00E-03	2.75E-03	8.62E-04	6.53E-04	5.30E-04
18	1.620	9.938	-3.00E-03	-3.06E-03	1.74E-03	6.99E-04	5.66E-04	5.61E-04
19	3.810	9.938	-3.05E-03	-1.78E-03	7.29E-04	3.07E-04	3.69E-04	5.76E-04
20	6.000	9.938	-2.94E-03	-4.95E-04	-2.07E-09	-1.88E-05	3.19E-04	5.64E-[illegible]
21	0.000	12.875	-4.16E-03	-3.20E-03	5.60E-03	1.13E-03	1.14E-03	3.16E-[illegible]
22	1.620	12.875	-4.26E-03	-2.61E-03	3.84E-03	7.81E-04	1.03E-03	3.33E-04
23	3.810	12.875	-4.31E-03	-1.85E-03	1.76E-03	3.63E-04	8.67E-04	3.43E-04
24	6.000	12.875	-4.25E-03	-1.13E-03	-1.02E-09	3.56E-05	7.70E-04	3.46E-04
25	0.000	15.812	-4.73E-03	-2.38E-03	9.41E-03	1.41E-03	1.95E-03	9.98E-05
26	1.620	15.812	-4.85E-03	-2.15E-03	6.34E-03	8.76E-04	1.81E-03	1.11E-04
27	3.810	15.812	-4.89E-03	-1.89E-03	2.79E-03	3.69E-04	1.41E-03	1.24E-04
28	6.000	15.812	-4.81E-03	-1.69E-03	-1.92E-08	-1.82E-04	1.20E-03	1.36E-04
29	0.000	18.750	-4.76E-03	-1.52E-03	1.42E-02	1.84E-03	2.86E-03	-1.16E-04
30	1.620	18.750	-4.79E-03	-1.73E-03	9.57E-03	1.66E-03	2.60E-03	-1.16E-04
31	3.810	18.750	-4.75E-03	-1.94E-03	4.83E-03	1.25E-03	2.06E-03	-1.16E-04
32	6.000	18.750	-4.69E-03	-2.17E-03	-2.34E-07	7.74E-04	2.34E-03	-1.67E-06
33	0.000	21.688	-4.02E-03	-8.12E-04	2.08E-02	2.46E-03	3.22E-03	-3.37E-04
34	1.620	21.688	-4.09E-03	-1.38E-03	1.57E-02	2.25E-03	3.08E-03	-2.39E-04
35	3.810	21.688	-4.12E-03	-1.95E-03	9.24E-03	1.74E-03	2.86E-03	-1.92E-04
36	6.000	21.688	-4.08E-03	-2.52E-03	3.02E-03	1.24E-03	2.85E-03	-1.70E-04
37	0.000	24.625	-2.98E-03	-4.42E-04	2.81E-02	2.46E-03	3.80E-03	-3.77E-04
38	1.620	24.625	-3.01E-03	-1.15E-03	2.22E-02	2.24E-03	3.53E-03	-3.03E-04
39	3.810	24.625	-3.03E-03	-1.93E-03	1.46E-02	1.87E-03	3.50E-03	-2.56E-04
40	6.000	24.625	-3.02E-03	-2.72E-03	6.82E-03	1.18E-03	3.56E-03	-2.39E-04
41	0.000	27.562	-1.84E-03	-3.78E-04	3.58E-02	3.09E-03	4.46E-03	-4.12E-04
42	1.620	27.562	-1.80E-03	-1.13E-03	2.91E-02	2.53E-03	3.99E-03	-3.36E-04
43	3.810	27.562	-1.78E-03	-1.92E-03	1.95E-02	1.15E-03	4.91E-03	-2.75E-04

TITLE: D.C. COOK CCW HEAT EXCNGR ANCHORAGE FORCE END STIFF EDGE

DISPLACEMENT VECTOR AT FINAL ITERATION

NODE	LOCATION (IN)		DISPLACEMENT (IN)			ROTATIONS (RAD)		
	X	Y	DX	DY	DZ	RX	RY	RZ
44	6.000	27.562	-1.82E-03	-2.68E-03	8.68E-03	-2.90E-04	4.77E-03	-2.52E-04
45	0.000	30.500	-6.20E-04	-5.19E-04	4.34E-02	1.36E-03	6.16E-03	-4.85E-04
46	1.620	30.500	-6.39E-04	-1.45E-03	3.35E-02	-1.16E-03	7.12E-03	-3.90E-04
47	3.810	30.500	-6.99E-04	-1.76E-03	1.80E-02	-3.51E-03	6.10E-03	-2.15E-04
48	6.000	30.500	-7.31E-04	-2.51E-03	3.76E-03	-2.19E-03	6.67E-03	-2.04E-04
49	0.000	32.833	1.27E-04	-6.50E-04	4.86E-02	2.14E-03	1.01E-02	-2.69E-04
50	1.620	32.833	1.06E-04	-1.08E-03	2.96E-02	1.21E-03	1.27E-02	-2.97E-04
51	3.810	32.833	5.83E-05	-1.65E-03	8.98E-03	7.54E-04	4.63E-03	-2.69E-04
52	6.000	32.833	4.43E-05	-2.44E-03	-6.11E-08	-1.46E-03	3.96E-03	-2.54E-04
53	0.000	35.167	7.30E-04	-6.55E-04	5.40E-02	2.52E-03	1.07E-02	-2.42E-04
54	1.620	35.167	7.47E-04	-1.08E-03	3.59E-02	3.12E-03	1.09E-02	-2.89E-04
55	3.810	35.167	7.68E-04	-1.70E-03	1.47E-02	3.08E-03	8.20E-03	-2.84E-04
56	6.000	35.167	7.74E-04	-2.37E-03	-3.65E-08	1.12E-03	6.19E-03	-2.78E-04
57	0.000	37.500	1.44E-03	-6.47E-04	5.95E-02	2.25E-03	1.05E-02	-4.58E-04
58	1.620	37.500	1.43E-03	-1.10E-03	4.24E-02	2.60E-03	1.04E-02	-3.25E-04
59	3.810	37.500	1.44E-03	-1.72E-03	2.11E-02	2.47E-03	8.77E-03	-2.93E-04
60	6.000	37.500	1.44E-03	-2.35E-03	3.39E-03	1.49E-03	7.63E-03	-2.85E-04

TITLE: D.C. COOK CCW HEAT EXCNGR ANCHORAGE FORCE END STIFF EDGE

CONCRETE REACTION AT EACH NODE

NODE	LOCATION (IN) X	Y	REACTION (LBS)
1	0.000	0.000	-4110.7
2	1.620	0.000	0.0
3	3.810	0.000	0.0
4	6.000	0.000	0.0
5	0.000	2.333	-1585.5
6	1.620	2.333	0.0
7	3.810	2.333	0.0
8	6.000	2.333	0.0
9	0.000	4.667	0.0
10	1.620	4.667	-42.5
11	3.810	4.667	-90.7
12	6.000	4.667	-9.0
13	0.000	7.000	0.0
14	1.620	7.000	-27052.3
15	3.810	7.000	0.0
16	6.000	7.000	-1709.1
17	0.000	9.938	0.0
18	1.620	9.938	0.0
19	3.810	9.938	0.0
20	6.000	9.938	-20.7
21	0.000	12.875	0.0
22	1.620	12.875	0.0
23	3.810	12.875	0.0
24	6.000	12.875	-10.2
25	0.000	15.812	0.0
26	1.620	15.812	0.0
27	3.810	15.812	0.0
28	6.000	15.812	-191.7
29	0.000	18.750	0.0
30	1.620	18.750	0.0
31	3.810	18.750	0.0
32	6.000	18.750	-2338.2
33	0.000	21.688	0.0
34	1.620	21.688	0.0
35	3.810	21.688	0.0
36	6.000	21.688	0.0
37	0.000	24.625	0.0
38	1.620	24.625	0.0
39	3.810	24.625	0.0
40	6.000	24.625	0.0
41	0.000	27.562	0.0
42	1.620	27.562	0.0
43	3.810	27.562	0.0

TITLE: D.C. COOK CCW HEAT EXCNGR ANCHORAGE FORCE END STIFF EDGE

CONCRETE REACTION AT EACH NODE

NODE	LOCATION (IN) X	Y	REACTION (LBS)
44	6.000	27.562	0.0
45	0.000	30.500	0.0
46	1.620	30.500	0.0
47	3.810	30.500	0.0
48	6.000	30.500	0.0
49	0.000	32.833	0.0
50	1.620	32.833	0.0
51	3.810	32.833	0.0
52	6.000	32.833	-611.0
53	0.000	35.167	0.0
54	1.620	35.167	0.0
55	3.810	35.167	0.0
56	6.000	35.167	-365.4
57	0.000	37.500	0.0
58	1.620	37.500	0.0
59	3.810	37.500	0.0
60	6.000	37.500	0.0

TITLE: D.C. COOK CCW HEAT EXCNGR ANCHORAGE FORCE END STIFF EDGE

TRANSLATIONAL EQUILIBRIUM CHECK

DIRECTION	X	Y	Z
APPLIED FORCE	0.00000E+00	-0.18000E+05	-0.28000E+05
REACTION	-0.16462E-09	-0.18000E+05	-0.27940E+05
DIFFERENCE	0.16462E-09	-0.17099E-09	-0.60493E+02

0 --- WARNING, THE DIFFERENCE BETWEEN APPLIED FORCE AND REACTION IS GREATER THAN
END OF RUN

WESTINGHOUSE ELECTRIC CORP.

CALCULATION CSE-08-94-0042

ATTACHMENT

REFERENCE 10

Equip Id: 2-HE-15E   Train: 2   Equip Class: 21

Drawing No.: 2-5135A   2-5113

Function: CCW

System: COMPONENT COOLING WATER

Equip Desc: EAST COMPONENT COOLING WATER HEAT EXCHANGER

Building: AUXILIARY   Room: 609 HALLWAY

Elev: 609   Sort: S,_   Notes:

Normal State: Desired State: Power Req'd: N

Support System Drawing:

Req'd Support Comp:

Safety Related Status: NUCLEAR SR   Min/Opt: MIN

Alias No: Power Train: NA

Comp Served: EAST COMPONENT COOLING WATER HEAT EXCHANGER

MFR: M.L.W. INDUSTRIES

Model:

Panel:

Elem. Drawing: NOT APPL

Wiring Drawing: NOT APPL

Power Source: NOT APPL

Walkdown: F   Relay Eval: N

Comp Type: HE

Iso Drawing: 2-CCW-41, 2-CCW-42

Location: 30 FEET EAST OF THE #2 MONITOR TANK

Cook Nuclear Plant

SQUG Pre-Walkdown Anchor Inspection Summary Sheet

Component No. - 2-~~4~~E-15E Class 21

SQUG Discrepancy

Any particular area the Seismic Review Team should pay extra attention to?
Yes ✓ No ___ (If yes, check items that apply.)

	Remarks
Anchor Type	
Anchor Diameter	
Anchor Spacing	
Anchor Number	
Anchor Embedment ✓	
Anchor Edge Distance ✓	
Anchor Gap ✓	
Anchor Thread Engagement	
Anchor Grip	
Anchor Angularity	
Concrete Crack ✓	

Others (describe briefly)

Design Basis Discrepancy

If there is concern for Design Basis Discrepancy, circle the applicable item and explain.

1. Hardware Maintenance Type Discrepancy
2. Drawing Update Type Discrepancy
3. Significant Operability/Design Basis Discrepancy
4. Others

Condition:

NONE

Actions Taken:

NONE

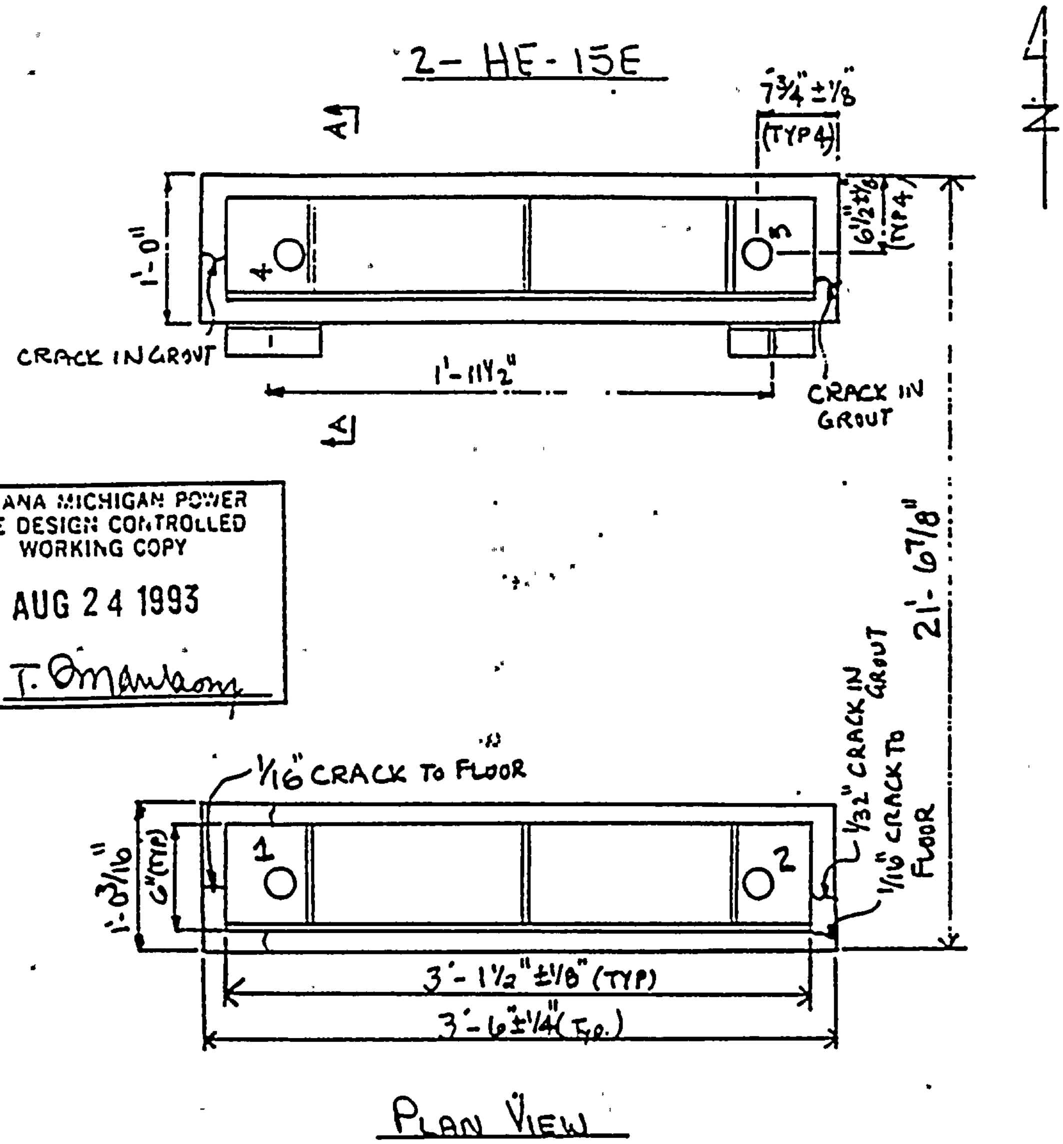
Prepared By T-Smantany Date 8-24-93

ANCHOR INSPECTION DATA SHEET

2	AUX. EL.609'-0"	NORTH SOUTH HALLWAY
Unit #	Bldg.	Location

12-3285-23, 12-3288-4	2-HE-15E
Installation dwg. / Rev.	Equipment No.

Anchorage Arrangement Sketch



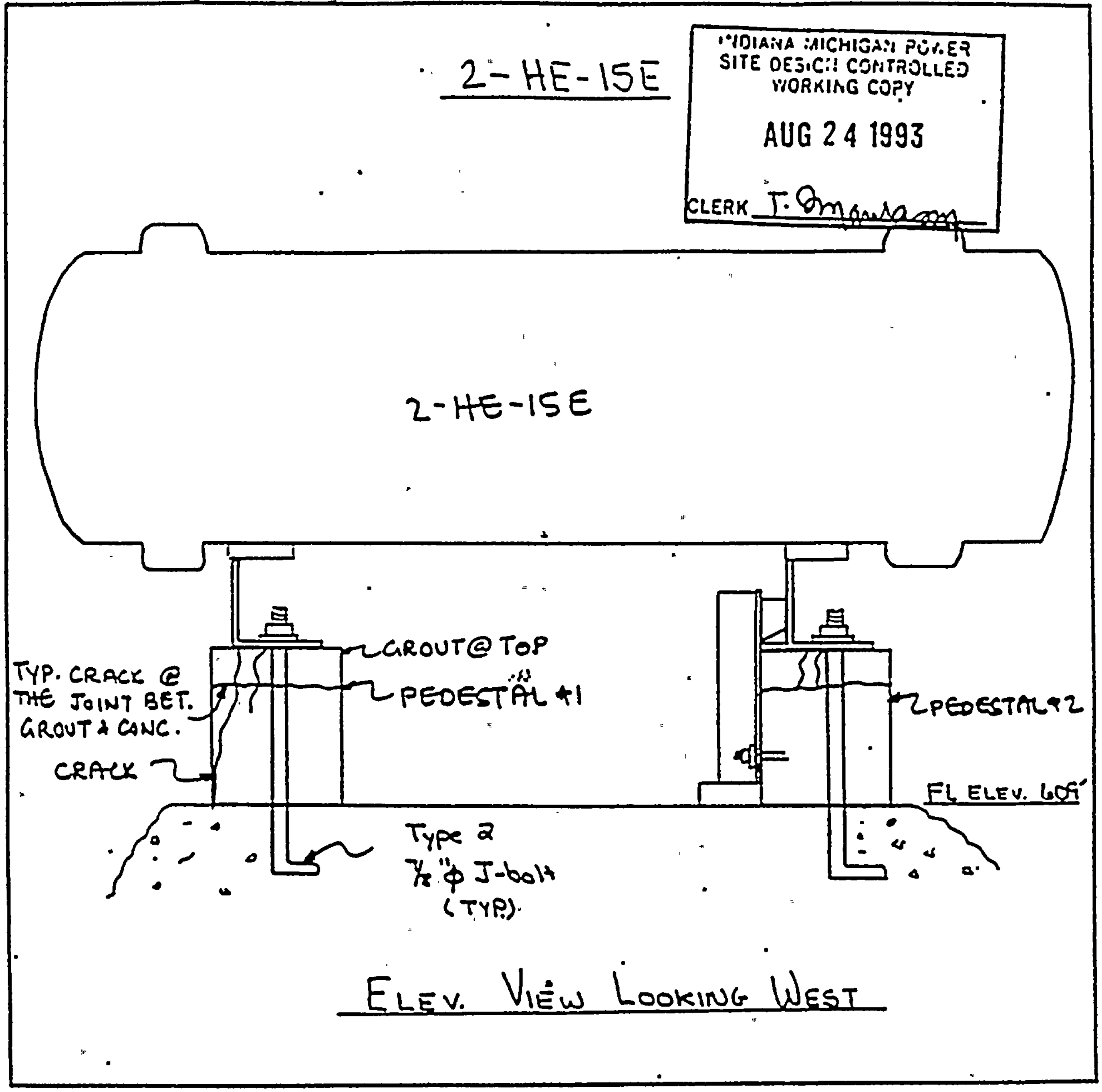
Drawn by:	T. Omanbam	Date:	4-23-93
Verified by:	(signature) Qual./Cert. Inspector	Date:	6-1-93
Reviewed by:	T. Omanbam Construction Anchor Review Engineer	Date:	8-24-93

ANCHOR INSPECTION DATA SHEET

2	AUX EL 609'-0"	NORTH SOUTH HALLWAY
Unit #	Bldg.	Location

12-3285-23, 12-3288-4	2-HE-15E
Installation dwg. / Rev.	Equipment No.

Anchorage Arrangement Sketch



Drawn by: T. Omanson Date: 4-23-93

Verified by: [signature] Date: 6-1-93
Qual./Cert. Inspector

Reviewed by: T. Omanson Date: 8-24-93
Construction Anchor Review Engineer

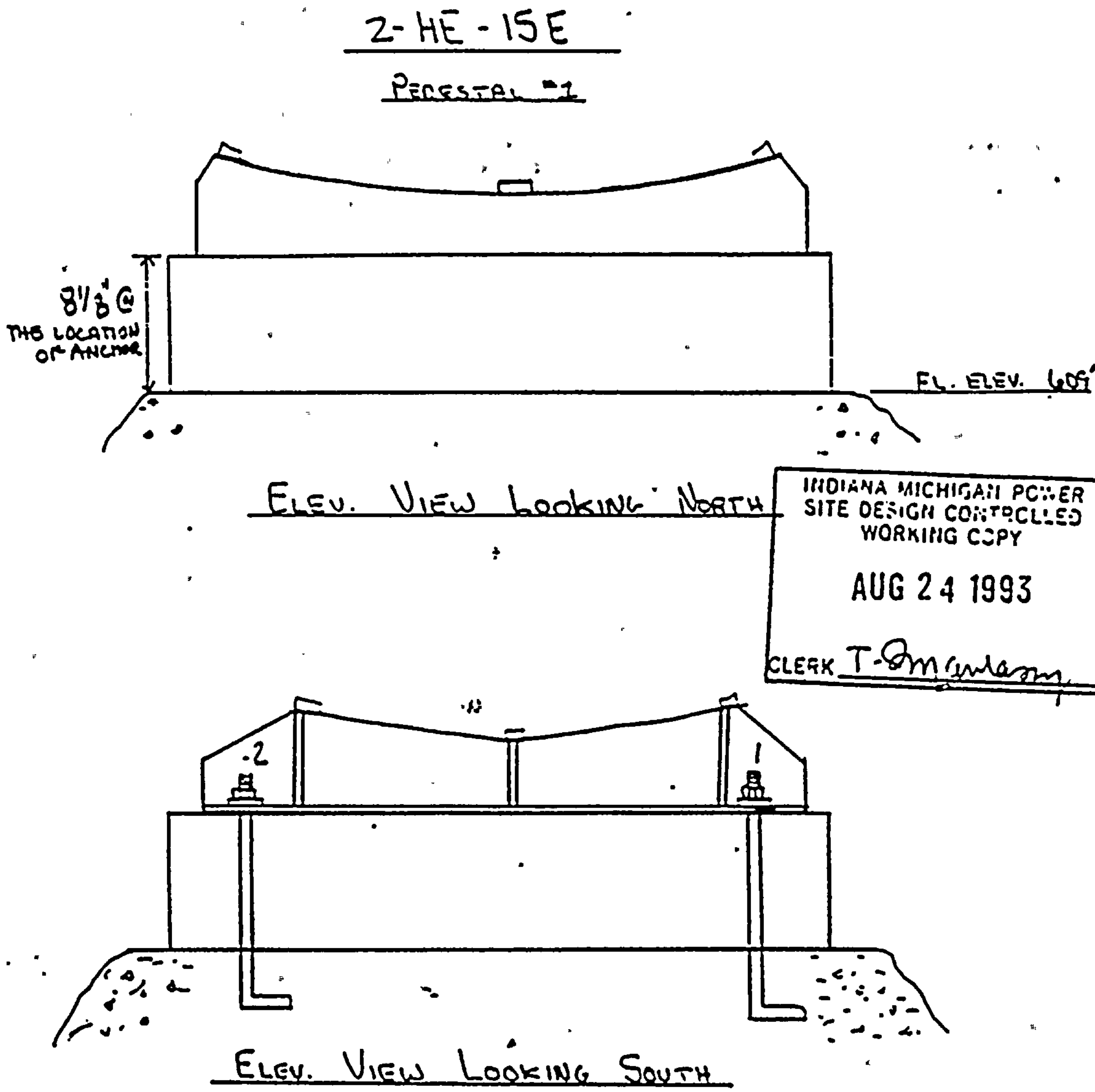
ATTACHMENT NO. 1

ANCHOR INSPECTION DATA SHEET

2	AUX EL. 609'-5"	NORTH SOUTH HALLWA
Unit #	Bldg.	Location

12-3285-23, 12-3288-4	2-HE-15E
Installation dwg. / Rev.	Equipment No.

Anchorage Arrangement Sketch



Drawn by:	T. Omarlasm	Date:	4-23-93
Verified by:	RWhalen Qual./Cert. Inspector	Date:	6-1-93
Reviewed by:	T. Omarlasm Construction Anchor Review Engineer	Date:	8-24-93

ANCHOR INSPECTION DATA SHEET

~~Equipment No.~~: 2-HE-15E ~~Dwg No.~~: 12-3288-4

Anchor type: J BOLT Dia: 7/8"φ Dwg No.:

Tightness established by: ☐ "Snug Fit" ☐ Torque

Torque Wrench No.: NA Cal. Due Date:

Tightness verified? ☐ Yes ☒ No NA Construction ARE Date:

Equipment base flexible? ☐ Yes ☒ No T. Omanhenn Construction ARE Date: 4-23-93

PHYSICAL CHARACTERISTICS

Bolt ID	1	2	3	4					Comments
Gaps	*	0	0	0					
Anchor length	2'-6 3/4"	2'-6 3/4"	2'-6 3/4"	2'-6 3/4"					FROM DWG 12-3073B-2
Protruding length	4 3/4"	4 15/16"	~~3 3/4~~ 5"	~~3 7/8~~ 4 4/4" 3 7/8					TOLERANCE ±3/8". SEE BELOW
Embedment	2'-2"	2'-1 13/16"	~~2'-3"~~ 2'-1 3/4	2'-2 7/8					
Bolt grip	3 3/8"	3 9/16"	2 1/2"	2 9/16"					TOLERANCE ±3". SEE NOTE BELOW
Concrete condition	CRACK	CRACK	CRACK	CRACK	N	A			SEE SKETCH
Edge distance	6"	6"	6"	6"					TOLERANCE ±1/2"
Anchor spacing	2'-2 1/2"	2'-2 1/2"	2'-2 1/2"	2'-2 1/2"					TOLERANCE ±1/4"
Anchor angularity	0	0	0	0					
Thread engagement	OK	OK	OK	OK					

Comments: * 1/16" GAP BETWEEN NUT & WASHER, 1/16" GAP BETWEEN WASHER & STEEL. ALL ANCHORS HAVE A WASHER. PROTRUDING LENGTH & BOLT GRIP ARE MEASURED FROM THE JOINT OF GROUT & CONCRETE PAD. DEPTH OF GROUT VARIES FROM 1 3/4" TO 3". HENCE PROTRUDING LENGTH & BOLT GRIP CANNOT BE MEASURED ACCURATELY. EDGE DISTANCE IS APPLICABLE ONLY TO THE PEDESTAL.

Verified by: [signature] Qual./Cert. Inspector Date: 4-27-93

Reviewed by: T. Omanhenn Construction ARE Date: 8-24-93

INDIANA MICHIGAN POWER
SITE DESIGN CONTROLLED
WORKING COPY
AUG 24 1993
CLERK T. Omanhenn

ANCHOR INSPECTION DATA SHEET

Equipment No.: 2-HE-15E Dwg No.: 12-3288

Anchor type: WEDGE ANCHOR Dia: 1"Φ Dwg No.: 12-3073A, 12-3073B

Tightness established by: ☐ "Snug Fit" ☒ Torque

Torque Wrench No.: CPM 511 Cal. Due Date: 4 Sept. 93

Tightness verified? ☒ Yes ☐ No S. Thakkar, Construction ARE Date: 4-23-93

Equipment base flexible? ☐ Yes ☒ No T. Smarlang, Construction ARE Date: 4-23-93

PHYSICAL CHARACTERISTICS

Bolt ID	5	6	7	8					Comments
Gaps	0	0	0	0					
Anchor length	7 3/4"	9"	9"	9"					
Protruding length	2 1/2"	2"	1 15/16"	1 7/8"					
Embedment	5 1/4"	7"	7 1/16"	7 1/8"					
Bolt grip	13/16"	7/8	13/16"	7/8"	N		A		
Concrete condition	CRACK	CRACK	CRACK	CRACK					
Edge distance	4 3/16"	4 3/16"	4"	4"					To TOP OF GROUT
	1 3/4"	1 3/4"	2"	2"					To TOP OF CONCR.
Anchor spacing	5 3/8"	5 3/8"	5 5/16"	5 5/16"					
Anchor angularity	0	0	0	0					
Thread engagement	OK	OK	OK	OK					

Comments:

Tightness Verified by: B. [signature] 6-1-93 / Dims. [signature] Date: 6-1-93
Qual./Cert. Inspector

Reviewed by: T. Smarlang, Construction ARE Date: 8-24-93

INDIANA MICHIGAN POWER
SITE DESIGN CONTROLLED
WORKING COPY
AUG 24 1993
CLERK

ANCHOR INSPECTION DATA SHEET

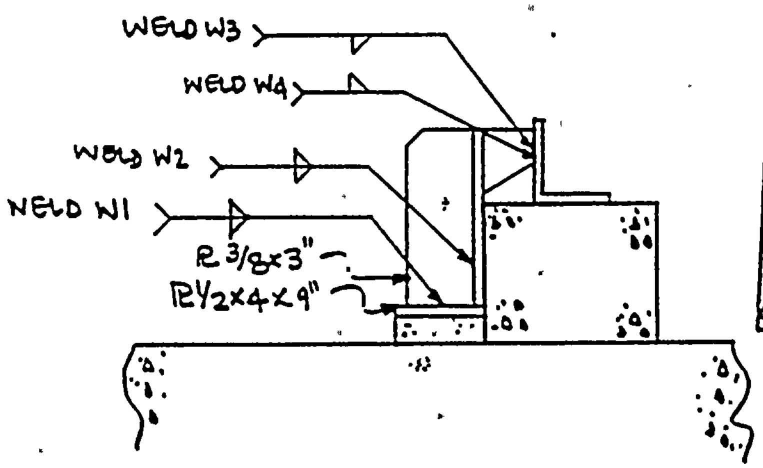
Equipment No.: ~~1-HE-13E~~ 15 E (initialed 6-1-93) Dwg No.: 12-3238-4

Embedded Steel Dwg. No.: NA

PHYSICAL CHARACTERISTICS

Weld ID	W1	W2	W3	W4				
Type	1	1	1	1	NA			
Size	3/16	3/16	-	1/4				
Length	5"	28"	5"	5"				
Cracks	Yes No (NO circled)	Yes No (NO circled)	Yes No	Yes No (NO circled)	Yes No	Yes No	Yes No	Yes No
Lack of Penetration	Yes No (NO circled)	Yes No (NO circled)	Yes No	Yes No (NO circled)	Yes No	Yes No	Yes No	Yes No
Porosity	Yes No (NO circled)	Yes No (NO circled)	Yes No	Yes No (NO circled)	Yes No	Yes No	Yes No	Yes No

Weld Type Codes
1 = Fillet
2 = Plug/Slot
3 = Groove



SECT. 'A-A'

INDIANA MICHIGAN POWER
SITE DESIGN CONTROLLED
WORKING COPY
AUG 24 1993
CLERK T. Omanlam

WELD W3 - TOO MUCH SLAG. CANNOT VERIFY ANYTHING EXCEPT THE LENGTH

Equipment base flexible: ☐ Yes ☒ No T. Omanlam Construction Are Date: 4-23-93

Reviewed by: T. Omanlam Construction Anchor Review Engineer Date: 8-24-93

Verified by: [signature] Qual./Cert. Inpsector Date: 6-1-93

S & A DEPARTMENT
CONTROLLED DOCUMENT
COPY NO. 3-1

12 SHP 5050 NDE.008
ATTACHMENT NO. 1

ULTRASONIC TEST REPORT

JOB ORDER NO.: N/A REPORT DATE: 4-13 93 REQUEST NO. N/A

IDENTIFICATION

Unit Two
Component 2-HE-15E
Item Anchors
Material C/S
Other Sqing

TECHNIQUE

Test Unit/ S/N KBUSK-7S CQC-405
Freq./Diameter 5mhz .250"
Reference Standard QC-8
Couplant/Batch No. Ultragel II 5838

TEST DATA/REMARKS

Anchors 1 thru 4
A back reflection indicating anchor bolt length was not obtained during this exam. This would be indicative of a J-bolt type Anchor.

* Anchors 5, 6, 7, 8

Anchor	Length
5	7 3/4"
6	9"
7	9"
8	9"

PERFORMED BY: [signature] LEVEL: II DATE: 4-13-93
REVIEWED BY: Stephen R. Vaz[signature] LEVEL: II DATE: 4/14/93

FORM NO. 12 SHP 5050 NDE.008-1

AEP
INDIANA MICHIGAN POWER

Date February 25, 1992

Subject SQUG Bolting UT Examinations - J-Bolts

From J.F. Steinhauser

To J. Wisniewski

Ultrasonic examinations were performed on mock J-bolts in an attempt to accurately determine their length. Due to the geometry of the J-bolts results were inconclusive. The bend at the bottom of the bolts did not provide an adequate response for measurement and in most cases reflected the majority of the sound beam towards the opposite end of the bolt not the entry surface.

I do not recommend the use of ultrasonics for length/ embedment determination on this type of bolting.

J.F. Steinhauser

c: G.A. Tollas
E.A. Morse
J.L. Winckel
File

COMPONENT: 2-HE-15E

COMPONENT TYPE: HEAT EXCHANGER

PLANT SYSTEM: COMPONENT COOLING WATER

FUNCTIONAL NAME: EAST COMPONENT COOLING WATER HEAT EXCHANGER

UNIT: 2

BUILDING: AUXILIARY

FLOOR ELEVATION: 609

ROOM: 609 HALLWAY

FEG:
216.01 "E" CCW (EAST CCW PUMP AND HEAT EXCHANGER)

OTHER LOCATION INFORMATION:
30 FEET EAST OF THE #2 MONITOR TANK

FLOW DIAGRAM: 2-5135A 2-5113

ELEM. DIAGRAM: NOT APPL

ELEC. ONE-LINE DIAGRAM: NOT APPL

CABLE SCHEDULE: NOT APPL

WIRING DRAWING: NOT APPL

PIPING DRAWING: 12-5502B 12-5486B 12-5486C

INSTRUMENT DRAWING: NOT APPL

ISOMETRIC DRAWING: 2-CCW-41 2-CCW-42

MANUFACTURER: M.L.W. INDUSTRIES

COMPONENT SERIAL NUMBER: 9860Q

UNVALIDATED COMPONENT INFORMATION:
MATERIAL SPECIFIC #SA285CFBQ, MAXIMUM WORKING PRESSURE SHELL 150 PSI AT 200'F, MAXIMUM WORKING PRESSURE TUBES 150 PSI AT 200'F, ORDER #31603-1B

VICS NUMBER: 00700

NPRDS REPORTABILITY: YES

NPRDS COMPONENT: HEAT EXCHANGERS

NPRDS SYSTEM: COMPONENT COOLING WATER SYSTEM

COGNIZANT SECTION: HEAT EXCHANGERS, PUMPS & TURBINES SECTION

COMPONENT: 2-HE-15E (CONTINUED)

SAFETY RELATED **

SAFETY RELATED STATUS: NUCLEAR SAFETY RELATED

PROCUREMENT GRADE:
NUCLEAR SERVICE QUALITY PURCHASED FROM A QUALIFIED SUPPLIER

NORMAL OPER. PROCEDURE NUMBER: 2-OHP 4021.016.003 12-OHP 4021.019.001

ABNORMAL AND EMERGENCY
OPERATING PROCEDURE NUMBER: 2-OHP 4022.016.002 2-OHP 4022.016.003
2-OHP 4023.016.001 2-OHP 4023.019.001 2-OHP 4023.001.001
12-OHP 4023.001.012

SURVEILLANCE PROCEDURE NUMBER: 2-THP 4030.STP.241 2-OHP 4030.STP.020E
2-OHP 4030.STP.022E 2-OHP 4030.STP.020W 2-EHP 4030.STP.248

TEST PROCEDURE NUMBER: 2-OHP 5070.ISI.033 12-MHI 2293
12-THP6040.PER.002-CCW 12-IHP 6030.IMP.059

APPLICABLE TECHNICAL SPECIFICATIONS: (NUMBERS/MODES)
3.7.3.1 1,2,3,4

SHOWN ON SLIDE NUMBER: 2A609-331 2A609-3403

ERIFIER NAME: BROWN M S DATE: 05/15/86 TIME: 09:13:30

OMPONENT M & E DATA

M & E NUMBER	DESCRIPTION	LOCN	UM	ON HAND
09-995560	GASKET MK HE-015 FLEXITALLIC 47-9/10X46-1/2 W/3/8 IN WIDE CL RIB 1/2 IN R F/COMPONENT		EA	
09-995561	GASKET MK HE-015 FLEXITALLIC 51-13/16X50-3/4 D-J ARMCO F/COMPONENT COOLING HEAT EXCHANGER		EA	
09-995562	GASKET MK HE-015 FLEXITALLIC 51-13/16X50-3/4 W/3/8 IN WIDECL RIB 1/2 IN R F/COMPONENT		EA	

** END OF REPORT **

WESTINGHOUSE CALCULATION SHEET

TITLE			PAGE 1 OF 6
DONALD C. COOK NUCLEAR POWER PLANTS SEISMIC FRAGILITY ANALYSIS - CCW Heat Exchanger Anchorage			
PROJECT AEP	AUTHOR [signature] DATE 8/19/94	CHK'D. BY — DATE	VERIFIED BY [signature] DATE 8/23/94
S.O. AOTP-4708E	CALC. NO. CSE-08-94-0042	FILE NO. AEP-947I	GROUP M&SE-CSE

PURPOSE: To determine if additional seismic margin exists for the CCW Heat Exchanger Anchorage.

SCOPE: The J-Bolts for the support on either end.

ASSUMPTIONS:

1. All J-Bolt anchors are assumed active in shear. This assumption results from the fact that cracks are found in both pedestals at the grout and concrete interface, and vertical cracks also exist in the pedestal. These cracks are represenataive of thermal growth as discussed in Ref. 2.

2. The vertical seismic excitation is 2/3 of the horizontal. - Conservative.

3. Anchors are A307 or A36.

4. The J-Bolts are so deeply embedded, the the steel capacity controls for tension.

METHOD: Ref. 4 considered a prying factor ot 2.0, use WEPLAT to model the the saddle plate and bolts to determine if the prying factor is less. Consdier both shear and tension, applying a parbolic interaction equation similar to that used in the ASME Code, Ref. 3, NF-3324.6. The ultimate strength is applied for tension, while 0.42Su is applied for shear per the ASME Code, Appendix F, Section F-1335.2. The failure values are applied to remove conservatisms for the fragility analysis.

COMPUTER CODE: Finite element analysis of base plates is provided using WESPLAT. WESPLAT can be used for the analysis of any rectangular plate attached by anchors to a rigid foundation. The code is non-linear, using gaps to model the uplift of the plate from the concrete. The plate elements are linear eleastic.
The code is verified and maintained under configuration control on the SUN/OS Workstation, per Ref. ~~28~~ (REF. 8 RJC 8/19/94). Verification documentation is maintained in the SMACC/WESPLAT file, located in the NTD central file.
This code is selected since it is appropraite for the problem, configuration controlled, and an in-house code.

APPLICABILITY: This evaluation is applicable for ~~fargility~~ fragility analysis only.

RESULTS: The revised g level is: 0.587 g

CONCLUSION: The prying factor of 2.0 is conservative, but the increase in the seismic capacity is offset by consideration of the tension and shear interaction.

OPEN ITEMS: NONE

REV. NO.	REV. DATE	AUTHOR DATE	CHK'D. BY DATE	VERIFIED BY DATE

TITLE DONALD C. COOK NUCLEAR POWER PLANTS SEISMIC FRAGILITY ANALYSIS - CCW Heat Exchanger Anchorage			PAGE 2 OF 6
PROJECT AEP	AUTHOR / DATE [signature] 8/19/94	CHK'D. BY — DATE	VERIFIED BY T.H. B. DATE 8/23/94
S.O. AOTP-4708E	CALC. NO. CSE-08-94-0042	FILE NO. AEP-947I	GROUP M&SE-CSE

REFERENCES:

1. Report No. 1643.02, "Seismic Fragilities of Civil Structures and Equipment Components at the Diablo Canyon Power Plant," NTS Engineering, September 1988, Long Beach CA, QA Report No. 34001.01-R014, Rev. 0.

2. Westinghouse Calc. No. MSE-CSE-08-94-0040, Rev. 0, 08/19/94.

3. ASME Code, Section III, Division 1, Appendix F and Subsection NF, 1989 Edition.

4. Westinghouse Elec. Corp. Calc. # AEP-036, "Seismic Margin for Various Components - CCW HX," for the Donald C. Cook Nuclear Power Plants, Rev. 0, Oct. 1991.

5. DeWolf, J.T., Ricker, D.T., "Column Base Plates," AISC, Steel Design Guide Series, 2nd Printing, 1991.

6. Westinghouse Elec. Corp. Calc. # AEP-025, "Aux. Building Equipment Fragility," for the Donald C. Cook Nuclear Power Plants, Rev. 0, Dec. 1991.

7. ASCE Nuclear Structures and Materials Committee, "State of the Art Report on Steel Embedments," June 1984.

8. Westinghouse Elec. Corp. Letter FDRT-SSD-003, "WESPLAT on the SUN 4," Dated 01/14/91.

9. MLW Industries Drawing No. 850L-240600, Rev. A, 10/17/72.

10. Cook Nuclear Plant SQUG Walkdown Package for 2-HE-15E, Aug. 1993.

11. Screening Eval. Worksheet for 1- and 2-HE-15E, 03/13/91.

12. WESPLAT RUN "D.C. Cook CCW Heat Excngr Anchorage Force End Stiff Edge," Version 2.1, 02/25/01, Run Date 08/16/94, 10:10:02.

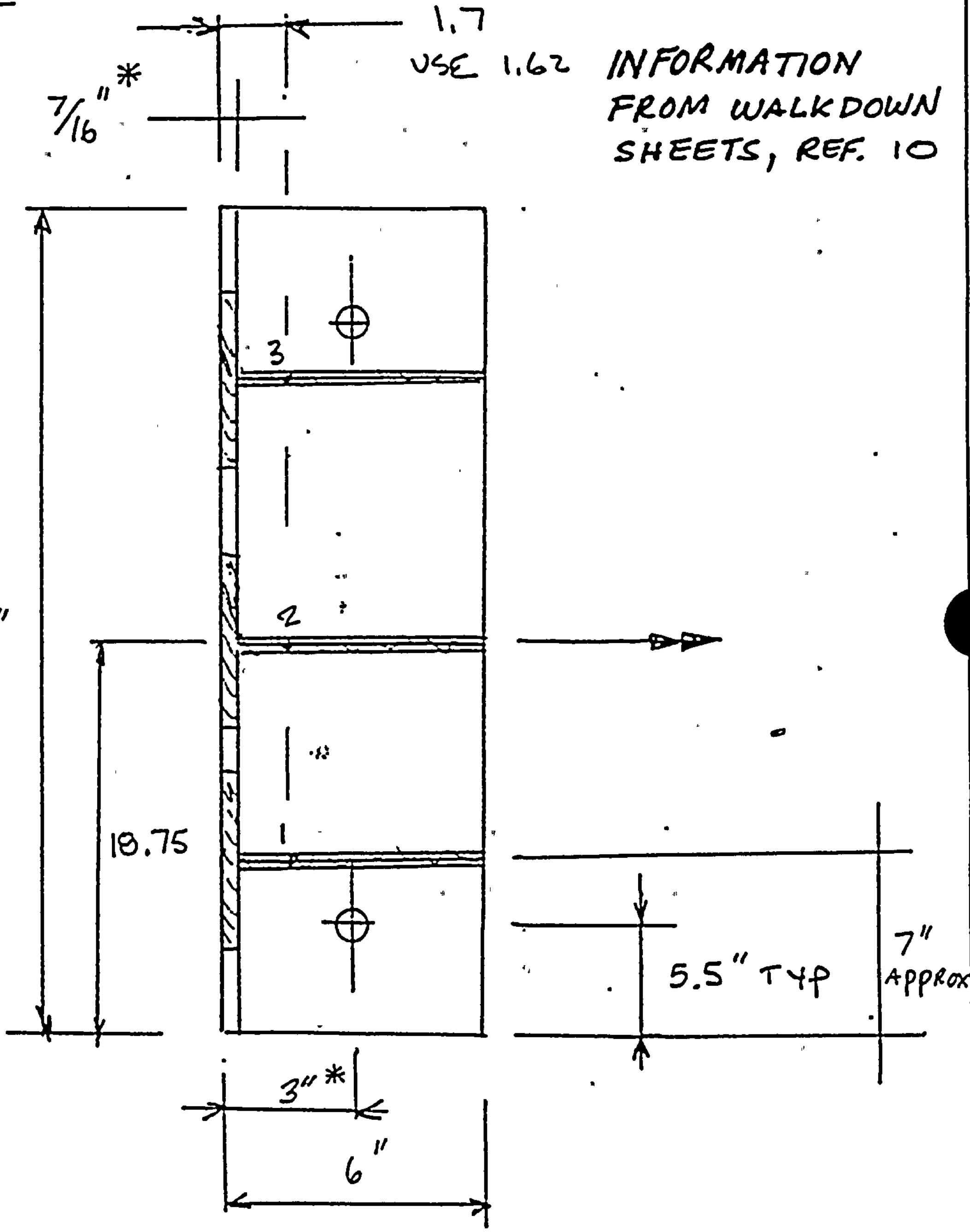
13. WESPLAT RUN "D.C. Cook CCW Heat Excngr Anchorage Force End Stiff Edge," Version 2.1, 02/25/01, Run Date 08/16/94, 13:20:12.

REV. NO.	REV.DATE	AUTHOR DATE	CHK'D. BY DATE	VERIFIED BY DATE

WESTINGHOUSE CALCULATION SHEET

TITLE D.C. COOK			PAGE 3 OF 6
PROJECT AEP	AUTHOR [signature] DATE 8/19/94	CHK'D. BY DATE ——	VERIFIED BY T.H.B. DATE 8/23/94
S.O. AOTP-4b/8E	CALC. NO. CSE-08-94-0042	FILE NO. AEP 947I	GROUP MSE CSE

WESPLAT MODEL

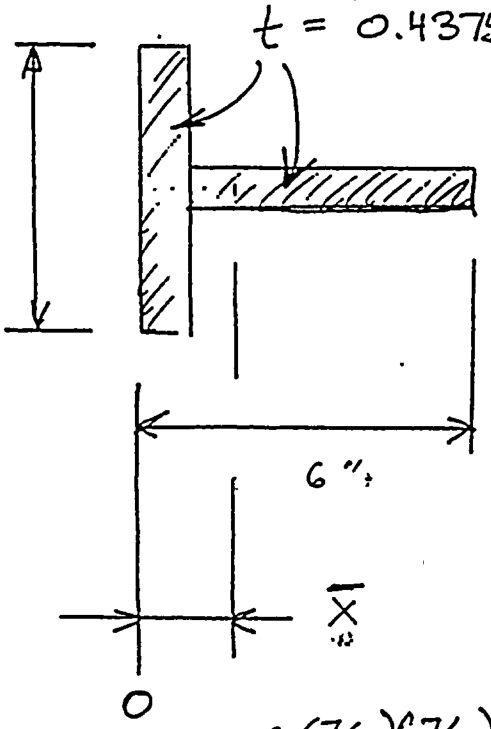


* BASED ON PHOTOGRAPH

REV. NO.	REV. DATE	AUTHOR DATE	CHK'D. BY DATE	VERIFIED BY DATE

TITLE DG-COOK			PAGE 4 OF 6
PROJECT AEP	AUTHOR [signature] DATE 8/19/94	CHK'D. BY ——— DATE	VERIFIED BY [signature] DATE 8/23/94
S.O. AOTP 4708E	CALC. NO. CSE-08-94-0042	FILE NO. AEP 947I	GROUP MSE CSE

APPLY THE LOAD @ THE C.G. OF THE T SECTION REPRESENTING LONGITUDINAL & LATERAL STIFFENERS - AS A RESULT OF LATERAL STIFFENING EFFECT OF TANK



$$\bar{X} = \frac{6(7/16)(7/32) + (6-7/16)(7/16)\left(\frac{6-7/16}{2}+7/16\right)}{6(7/16)+(6-7/16)(7/16)}$$

$$= 1.662"$$

1.62 IS USED IN THE MODEL
DIFFERENCE IS INSIGNIFICANT

REV. NO.	REV. DATE	AUTHOR DATE	CHK'D. BY DATE	VERIFIED BY DATE

WESTINGHOUSE CALCULATION SHEET

TITLE			PAGE
DC -COOK-- =			5 OF 6
PROJECT AEP	AUTHOR [signature] DATE 8/19/94	CHK'D. BY —— DATE	VERIFIED BY T.H. [signature] DATE 8/23/94
S.O. AOTP 4705E	CALC. NO. CSE-08-94-0042	FILE NO. AEP 947I	GROUP MSE-CSE

LOADS @ NODES 1, 2, 3 (LOAD POINTS)

$a_H = 0.45$

$M_{OT} = 0.45(80)(31.375)/2 = 564.8$ K-IN
DIVIDE BY 2 FOR 2 PEDESTALS

$F_V = -40 + \frac{2}{3}\,0.45(80)/2 = -28$

$F_H = 0.45(80)/2 = 18$ KIPS

BREAK MOMENT INTO COUPLE

NODE 1 $\quad F_V = -\frac{28}{3} - \frac{565}{23.5} = -33.4$

$F_H = 18/3 = 6$ kips

NODE 2 $\quad F_V = \frac{-28}{3} = -9.3$

$F_H = 6$ KIPS

NODE 3 $\quad F_V = \frac{-28}{3} + \frac{565}{23.5} = 14.7$ K

$F_H = 6$ kips

$\pm F_V \cong \pm F_{Z_{WESPLAT}}$

$+ F_H \cong - F_{Y_{WESPLAT}}$

REV. NO.	REV. DATE	AUTHOR DATE	CHK'D. BY DATE	VERIFIED BY DATE

TITLE: DONALD C. COOK NUCLEAR POWER PLANTS SEISMIC FRAGILITY ANALYSIS - CCW Heat Exchanger Anchorage			PAGE 6 OF 6
PROJECT: AEP	AUTHOR / DATE: 9/1994	CHK'D. BY / DATE:	VERIFIED BY / DATE: T.W. BQ 8/25/94
S.O.: AOTP-4708E	CALC. NO.: CSE-08-94-0042	FILE NO.: AEP-947I	GROUP: M&SE-CSE

DETERMINATION OF THE SPECTRAL FLOOR CAPACITY

Determine the maximum g value to satisfy the parabolic interaction equation based on WESPLAT results, (REF 12 & 13) REF 12 IS APPLIED

The overturning moment per pedestal is from M(ot) = 80(Ah)(31.375)/2, from Ref. 4.

The resisting vertical load per pedestal is Fvt = -40 + (2/3)40Ah.

The resulting pullout load at node 3 of the WESPLAT model is P = M(ot)/(37.5-14) + Fvt/3.

Assuming a linear relationship between the bolt tensile load and the pullout load at * node 3, the bolt load factor is 10.13/14.7, so the bolt load would be 10.13P/14.7.

The ultimate tensile force, Ft, is SuAt

The shear load per two bolts is V = 80Ah/2.

The ultimate shear load, Fv = 2(0.42)SuAs for two bolts.

So the parbolic shear/tension interaction in terms of Ah is:

[(62.3Ah - 13.33)0.689/Ft]^2 + [80Ah/2Fv]^2 < or = 1.0
or
[0.689P/Ft]^2 + [V/Fv]^2 < or = 1.0

Consider steel only.
Allow Ft = 26.8 kips where At = 0.462 sq. in.
Allow. Fv = (use min.)
Concrete 29.412 = 1.1(2)(fc')^0.5(PI)m^2times 2
Steel 29.281 kips where As = 0.601 sq. in.

Ah	P	10.13P/14.7	V	Int. Eq.	
0.450	14.7	10.1	18.0	0.521	
0.500	17.8	12.3	20.0	0.676	
0.510	18.4	12.7	20.4	0.710	
0.550	20.9	14.4	22.0	0.854	
0.555	21.2	14.6	22.2	0.873	
0.587	23.2	16.0	23.5	1.000	Use 0.587
0.600	24.0	16.6	24.0	1.054	
0.700	30.3	20.9	28.0	1.521	
0.800	36.5	25.2	32.0	2.076	
0.900	42.7	29.4	36.0	2.719	

* as long as there is not a significant change in bolt tension.

REV. NO.	REV. DATE	AUTHOR	DATE	CHK'D. BY	DATE	VERIFIED BY	DATE

WESTINGHOUSE ELECTRIC CORP.

CALCULATION CSE-08-94-0042

ATTACHMENT

WESPLAT RUN "D.C. Cook CCW Heat Excngr Anchorage Force End Stiff Edge," Version 2.1, 02/25/01, Run Date 08/16/94, 10:10:02.

1 COVER

```
***************************************
***                                 ***
***       WESPLAT ON THE SUN 4      ***
***           VERSION 2.1           ***
***            02/25/91             ***
***                                 ***
***************************************
```

R [signature] 2 COVER PGS + 12 OUTPUT

```
CASE NUMBER:   1

ACCOUNT
PLATE  6.0 37.5 0.44 0.0
TITLE D.C. COOK CCW HEAT EXCNGR ANCHORAGE FORCE END STIFF EDGE
OPTION 40 3.0 2.0 Y Y Y .280E+08 .280E+08
BOLT  3.000  5.500 1 0.0
BOLT  3.000 32.000 1 0.0
PROP 1 0.875 27.0 0.0
REGION 1  1.62 7.00 0.00 0.00 0.0 1 0
LOAD 1 0.0 -6000 -33400 0.0 0.0 0.0
REGION 2 1.62 18.75 0.00 0.00 0.0 1 0
LOAD 2 0.0 -6000 -9300 0.0 0.0 0.0
REGION 3 1.62 30.5 0.00 0.00 0.0 1 0
LOAD 3 0.0 -6000 14700 0.0 0.0 0.0
STIFF 0.0 0.0 0.0 37.5 6.0 0.4375
STIFF 0.0 7.0 6.0 7.0 6.0 0.4375
STIFF 0.0 18.75 6.0 18.75 6.0 0.4375
STIFF 0.0 30.5 6.0 30.5 6.0 0.4375
MC1,2=            0 ,     1250000
START BPCOM NX1 =       4 AND NY1 =      15
XX LINE LIST
   0.000000    1.620000    3.810000    6.000000
YY LINE LIST
   0.000000    2.333333    4.666667    7.000000    9.937500   12.875000   15.812500
  18.750000   21.687500   24.625000   27.562500   30.500000   32.833333   35.166667
  37.500000
START PHASE 0
START PHASE 1 - LOOP =      0 NEQ =    504 NRE =      0
MEMORY =    225000 WORDS
NCOL IS     504 FOR BLOCK NUMBER       1
START PHASE 2 HERE
NCOL IS     504 FOR BLOCK NUMBER       1
CALLING LDGEN
START SOLUTION PHASE
NBLOCK= 1 LBLOCK=    56155 NCM=   224555
ITERATION       1
NUMBER OF NON-CONVERGED GAPS IS     48
ITERATION       2
NUMBER OF NON-CONVERGED GAPS IS     30
ITERATION       3
NUMBER OF NON-CONVERGED GAPS IS     21
ITERATION       4
NUMBER OF NON-CONVERGED GAPS IS     25
ITERATION       5
NUMBER OF NON-CONVERGED GAPS IS     15
ITERATION       6
NUMBER OF NON-CONVERGED GAPS IS      7
ITERATION       7
NUMBER OF NON-CONVERGED GAPS IS     12
ITERATION       8
NUMBER OF NON-CONVERGED GAPS IS      5
```

VERIFIED BY T. H. B[signature] 8/23/94

```
ITERATION        9
NUMBER OF NON-CONVERGED GAPS IS       9
ITERATION       10
NUMBER OF NON-CONVERGED GAPS IS      10
ITERATION       11
NUMBER OF NON-CONVERGED GAPS IS       7
ITERATION       12
NUMBER OF NON-CONVERGED GAPS IS       6
ITERATION       13
NUMBER OF NON-CONVERGED GAPS IS       3
ITERATION       14
NUMBER OF NON-CONVERGED GAPS IS       2
ITERATION       15
NUMBER OF NON-CONVERGED GAPS IS       1
ITERATION       16
NUMBER OF NON-CONVERGED GAPS IS       0
BPOUT
```

2 cover

TITLE: D.C. COOK CCW HEAT EXCNGR ANCHORAGE FORCE END STIFF EDGE

ELEMENT STRESSES AT FINAL ITERATION

LOCATION(IN)					STRESSES(PSI)				
X	Y	SIGX	SIGY	SIGXY	SIG1	SIG2	SIGE	SMAX	
0.810	1.167	-514.9	774.8	926.1	1258.5	-998.5	1958.9	2257.0	TOP
0.810	1.167	-459.2	910.3	846.0	1314.0	-862.9	1898.6	2176.8	MIDDLE
0.810	1.167	-403.5	1045.8	765.9	1375.6	-733.3	1854.3	2108.9	BOTTOM
2.715	1.167	-842.8	338.9	-169.9	362.8	-866.7	1094.2	1229.5	TOP
2.715	1.167	-814.6	371.8	-173.4	396.6	-839.4	1093.0	1236.0	MIDDLE
2.715	1.167	-786.4	404.6	-176.9	430.3	-812.1	1092.8	1242.4	BOTTOM
4.905	1.167	-322.8	-194.2	-418.7	165.1	-682.1	777.9	847.2	TOP
4.905	1.167	-325.6	-214.7	-434.6	167.9	-708.3	805.5	876.2	MIDDLE
4.905	1.167	-328.5	-235.2	-450.5	171.0	-734.8	833.5	905.7	BOTTOM
0.810	3.500	-74.2	2139.5	1400.3	2817.6	-752.3	3259.5	3569.9	TOP
0.810	3.500	216.7	2239.0	1082.2	2709.0	-253.2	2844.0	2962.2	MIDDLE
0.810	3.500	507.7	2338.5	764.1	2615.6	230.6	2508.2	2615.6	BOTTOM
2.715	3.500	187.6	1683.6	118.1	1692.8	178.3	1611.1	1692.8	TOP
2.715	3.500	275.2	1562.4	68.2	1566.0	271.6	1449.4	1566.0	MIDDLE
2.715	3.500	362.8	1441.1	18.2	1441.4	362.5	1298.7	1441.4	BOTTOM
4.905	3.500	104.7	-718.6	-830.1	619.6	-1233.5	1633.9	1853.1	TOP
4.905	3.500	22.7	-835.8	-855.1	550.2	-1363.4	1706.4	1913.6	MIDDLE
4.905	3.500	-59.3	-953.1	-880.1	480.9	-1493.3	1783.0	1974.1	BOTTOM
0.810	5.833	-680.4	758.8	715.1	1053.7	-975.2	1757.5	2028.9	TOP
0.810	5.833	263.7	1885.2	467.2	2010.2	138.7	1944.6	2010.2	MIDDLE
0.810	5.833	1207.7	3011.7	219.4	3038.0	1181.4	2652.6	3038.0	BOTTOM
2.715	5.833	-912.3	-2778.5	1406.8	-157.3	-3533.6	3457.6	3533.6	TOP
2.715	5.833	35.7	-1690.8	1125.0	590.5	-2245.6	2591.8	2836.1	MIDDLE
2.715	5.833	983.8	-603.0	843.2	1348.2	-967.4	2014.4	2315.6	BOTTOM
4.905	5.833	11.4	-3562.5	-724.8	152.8	-3703.9	3782.6	3856.7	TOP
4.905	5.833	-37.7	-3074.7	-812.4	166.0	-3278.4	3364.5	3444.4	MIDDLE
4.905	5.833	-86.7	-2587.0	-900.0	203.6	-2877.2	2984.2	3080.8	BOTTOM
0.810	8.469	-365.6	4021.3	851.9	4180.9	-525.2	4466.7	4706.1	TOP
0.810	8.469	540.0	5181.3	298.9	5200.4	520.8	4960.6	5200.4	MIDDLE
0.810	8.469	1445.6	6341.3	-254.1	6354.4	1432.4	5773.1	6354.4	BOTTOM
2.715	8.469	-519.3	-243.5	1385.4	1010.8	-1773.6	2441.4	2784.4	TOP
2.715	8.469	518.2	603.5	1046.0	1607.7	-486.0	1897.9	2093.7	MIDDLE
2.715	8.469	1555.6	1450.5	706.6	2211.6	794.5	1940.4	2211.6	BOTTOM
4.905	8.469	121.0	-4299.9	192.4	129.3	-4308.2	4374.3	4437.5	TOP
4.905	8.469	42.2	-4310.8	-347.0	69.6	-4338.3	4373.5	4407.9	MIDDLE
4.905	8.469	-36.6	-4321.8	-886.3	139.4	-4497.9	4569.2	4637.3	BOTTOM
0.810	11.406	-680.5	4393.2	1245.7	4682.6	-969.8	5235.3	5652.4	TOP
0.810	11.406	-182.6	4869.4	498.5	4918.1	-231.3	5037.7	5149.4	MIDDLE
0.810	11.406	315.4	5345.5	-248.6	5357.7	303.1	5212.8	5357.7	BOTTOM

TITLE: D.C. COOK CCW HEAT EXCNGR ANCHORAGE FORCE END STIFF EDGE

ELEMENT STRESSES AT FINAL ITERATION

LOCATION(IN) X	Y	SIGX	SIGY	SIGXY	STRESSES(PSI) SIG1	SIG2	SIGE	SMAX	
2.715	11.406	-583.9	647.9	1270.9	1444.3	-1380.3	2446.4	2824.6	TOP
2.715	11.406	8.0	939.8	423.1	1103.2	-155.4	1188.6	1258.7	MIDDLE
2.715	11.406	599.9	1231.7	-424.8	1445.2	386.4	1295.9	1445.2	BOTTOM
4.905	11.406	-109.7	-4018.2	876.6	77.9	-4205.8	4245.3	4283.7	TOP
4.905	11.406	155.3	-3834.6	172.9	162.7	-3842.1	3925.9	4004.8	MIDDLE
4.905	11.406	420.2	-3651.0	-530.9	488.3	-3719.1	3985.7	4207.4	BOTTOM
0.810	14.344	-421.6	4532.1	1634.6	5022.9	-912.3	5535.7	5935.2	TOP
0.810	14.344	189.0	5075.9	397.3	5107.9	156.9	5031.3	5107.9	MIDDLE
0.810	14.344	799.5	5619.6	-839.9	5761.8	657.4	5462.8	5761.8	BOTTOM
2.715	14.344	-639.6	729.2	1332.5	1542.8	-1453.2	2595.0	2996.0	TOP
2.715	14.344	246.5	1079.1	377.9	1225.0	100.5	1178.0	1225.0	MIDDLE
2.715	14.344	1132.5	1429.0	-576.7	1876.2	685.3	1644.4	1876.2	BOTTOM
4.905	14.344	-387.8	-3293.3	1222.8	58.3	-3739.5	3769.0	3797.8	TOP
4.905	14.344	-2.4	-3404.7	273.6	19.4	-3426.6	3436.3	3446.0	MIDDLE
4.905	14.344	382.9	-3516.2	-675.7	496.7	-3629.9	3902.1	4126.6	BOTTOM
0.810	17.281	-673.3	3151.8	115.6	3155.3	-676.7	3542.4	3832.0	TOP
0.810	17.281	554.9	4744.8	-749.3	4874.8	424.9	4676.8	4874.8	MIDDLE
0.810	17.281	1783.0	6337.8	-1614.3	6851.9	1268.9	6313.9	6851.9	BOTTOM
2.715	17.281	-1512.8	-1761.7	2259.9	626.1	-3900.6	4248.4	4526.7	TOP
2.715	17.281	495.1	522.9	1060.4	1569.5	-551.5	1906.0	2121.0	MIDDLE
2.715	17.281	2502.9	2807.5	-139.2	2861.5	2448.9	2679.1	2861.5	BOTTOM
4.905	17.281	-369.1	-4583.1	1475.9	96.4	-5048.5	5097.4	5144.9	TOP
4.905	17.281	133.4	-2538.9	458.0	209.7	-2615.2	2726.1	2824.9	MIDDLE
4.905	17.281	635.8	-494.7	-559.9	866.2	-725.1	1379.9	1591.3	BOTTOM
0.810	20.219	-514.3	5147.1	28.7	5147.2	-514.4	5422.8	5661.6	TOP
0.810	20.219	761.2	6859.9	-811.4	6966.0	655.1	6662.6	6966.0	MIDDLE
0.810	20.219	2036.7	8572.7	-1651.4	8966.2	1643.2	8268.0	8966.2	BOTTOM
2.715	20.219	-858.5	1585.8	1828.5	2562.9	-1835.7	3826.6	4398.6	TOP
2.715	20.219	724.8	3252.5	1140.4	3691.0	286.3	3556.5	3691.0	MIDDLE
2.715	20.219	2308.0	4919.3	452.3	4995.4	2231.9	4334.3	4995.4	BOTTOM
4.905	20.219	238.4	-2623.1	1434.7	833.8	-3218.5	3706.5	4052.3	TOP
4.905	20.219	149.7	-1637.8	372.7	224.3	-1712.4	1834.9	1936.8	MIDDLE
4.905	20.219	61.1	-652.5	-689.2	480.4	-1071.8	1376.4	1552.2	BOTTOM
0.810	23.156	-1152.2	3696.0	102.4	3698.2	-1154.3	4390.7	4852.5	TOP
0.810	23.156	-262.0	4002.3	-571.7	4077.6	-337.3	4256.3	4414.9	MIDDLE
0.810	23.156	628.2	4308.5	-1245.8	4690.5	246.1	4572.4	4690.5	BOTTOM
2.715	23.156	-589.5	1834.6	1635.1	2657.9	-1412.8	3579.9	4070.7	TOP
2.715	23.156	-136.6	2149.1	670.9	2331.5	-319.0	2506.3	2650.5	MIDDLE
2.715	23.156	316.3	2463.7	-293.3	2503.0	277.0	2376.7	2503.0	BOTTOM
4.905	23.156	126.2	-505.8	1905.4	1741.6	-2121.2	3350.6	3862.8	TOP
4.905	23.156	71.7	-392.9	718.2	594.2	-915.4	1317.2	1509.6	MIDDLE
4.905	23.156	17.2	-280.0	-469.0	360.5	-623.4	862.2	983.9	BOTTOM

WESPLAT ON THE SUN 4 VERSION 2.1 02/25/91
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TITLE: D.C. COOK CCW HEAT EXCNGR ANCHORAGE FORCE END STIFF EDGE

ELEMENT STRESSES AT FINAL ITERATION

LOCATION(IN)		STRESSES(PSI)							
X	Y	SIGX	SIGY	SIGXY	SIG1	SIG2	SIGE	SMAX	
0.810	26.094	-1809.9	53.7	773.4	332.9	-2089.0	2273.8	2421.9	TOP
0.810	26.094	96.5	1633.9	-451.3	1756.6	-26.2	1769.9	1782.8	MIDDLE
0.810	26.094	2002.8	3214.2	-1676.0	4390.6	826.4	4041.3	4390.6	BOTTOM
2.715	26.094	1477.3	1990.0	2539.0	4285.5	-818.2	4747.8	5103.7	TOP
2.715	26.094	-29.9	1127.4	638.6	1410.5	-313.0	1590.3	1723.5	MIDDLE
2.715	26.094	-1537.1	264.9	-1261.8	914.4	-2186.6	2759.8	3101.0	BOTTOM
4.905	26.094	499.3	3147.3	2825.8	4943.9	-1297.3	5704.3	6241.2	TOP
4.905	26.094	-139.4	696.7	629.6	1034.4	-477.1	1338.2	1511.4	MIDDLE
4.905	26.094	-778.0	-1754.0	-1566.7	374.9	-2906.9	3111.3	3281.8	BOTTOM
0.810	29.031	2377.9	5478.5	4338.3	8535.2	-678.8	8894.1	9214.0	TOP
0.810	29.031	-473.6	-983.1	-770.9	83.6	-1540.3	1583.8	1623.9	MIDDLE
0.810	29.031	-3325.2	-7444.8	-5880.2	845.6	-11615.5	12060.5	12461.1	BOTTOM
2.715	29.031	2295.1	9727.1	4358.1	11738.4	283.9	11599.0	11738.4	TOP
2.715	29.031	-449.8	205.4	1095.0	1020.7	-1265.1	1983.4	2285.8	MIDDLE
2.715	29.031	-3194.8	-9316.3	-2168.2	-2504.7	-10006.4	9018.8	10006.4	BOTTOM
4.905	29.031	2923.2	9584.6	339.8	9601.9	2905.9	8528.7	9601.9	TOP
4.905	29.031	-0.9	1797.0	236.0	1827.5	-31.3	1843.4	1858.8	MIDDLE
4.905	29.031	-2925.0	-5990.6	132.3	-2919.3	-5996.3	5193.6	5996.3	BOTTOM
0.810	31.667	6169.1	-1171.6	2875.8	7161.5	-2164.1	8453.9	9325.6	TOP
0.810	31.667	59.8	1126.5	-612.1	1405.1	-218.7	1526.3	1623.8	MIDDLE
0.810	31.667	-6049.5	3424.7	-4100.1	4952.7	-7577.5	10930.5	12530.1	BOTTOM
2.715	31.667	-16682.1	-11230.0	3510.2	-9511.7	-18400.4	15938.3	18400.4	TOP
2.715	31.667	132.4	2490.5	961.8	2833.0	-210.1	2943.7	3043.2	MIDDLE
2.715	31.667	16946.8	16211.1	-1586.6	18207.7	14950.2	16817.3	18207.7	BOTTOM
4.905	31.667	-2251.1	-5882.5	1401.0	-1773.5	-6360.2	5684.8	6360.2	TOP
4.905	31.667	34.8	1318.5	-267.2	1371.9	-18.6	1381.3	1390.5	MIDDLE
4.905	31.667	2320.8	8519.5	-1935.3	9074.1	1766.2	8332.6	9074.1	BOTTOM
0.810	34.000	5063.5	-1591.3	474.4	5097.1	-1624.9	6074.8	6722.1	TOP
0.810	34.000	70.9	-71.7	142.9	159.3	-160.1	276.6	319.3	MIDDLE
0.810	34.000	-4921.8	1448.0	-188.6	1453.6	-4927.4	5792.6	6380.9	BOTTOM
2.715	34.000	-18558.2	-11604.7	2016.1	-11062.4	-19100.5	16610.5	19100.5	TOP
2.715	34.000	-162.2	-489.8	151.7	-102.7	-549.3	505.8	549.3	MIDDLE
2.715	34.000	18233.8	10625.1	-1712.7	18601.6	10257.3	16137.8	18601.6	BOTTOM
4.905	34.000	-6243.2	-8265.4	4804.9	-2344.2	-12164.4	11178.2	12164.4	TOP
4.905	34.000	-29.8	152.6	-305.3	380.0	-257.2	555.2	637.2	MIDDLE
4.905	34.000	6183.6	8570.6	-5415.4	12922.4	1831.7	12110.9	12922.4	BOTTOM
0.810	36.333	785.0	1193.5	-351.7	1396.0	582.5	1214.5	1396.0	TOP
0.810	36.333	13.3	-46.5	296.1	281.0	-314.2	515.7	595.2	MIDDLE
0.810	36.333	-758.5	-1286.5	943.9	-42.3	-2002.6	1981.8	2002.6	BOTTOM
2.715	36.333	-6003.0	-563.0	211.2	-554.8	-6011.2	5753.9	6011.2	TOP
2.715	36.333	209.0	-135.1	65.9	221.2	-147.3	321.2	368.5	MIDDLE
2.715	36.333	6421.1	292.7	-79.4	6422.1	291.7	6281.3	6422.1	BOTTOM

WESPLAT ON THE SUN 4   VERSION 2.1 02/25/91
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TITLE: D.C. COOK CCW HEAT EXCNGR ANCHORAGE FORCE END STIFF EDGE

ELEMENT STRESSES AT FINAL ITERATION

LOCATION(IN)		STRESSES(PSI)							
X	Y	SIGX	SIGY	SIGXY	SIG1	SIG2	SIGE	SMAX	
4.905	36.333	-4586.8	-1111.3	2303.6	36.5	-5734.5	5752.8	5771.0	TOP
4.905	36.333	113.8	30.7	-118.8	198.1	-53.6	229.6	251.7	MIDDLE
4.905	36.333	4814.4	1172.6	-2541.1	6119.6	-132.6	6187.0	6252.3	BOTTOM

TITLE: D.C. COOK CCW HEAT EXCNGR ANCHORAGE FORCE END STIFF EDGE

PLATE WIDTH . . . . 6.000 INCHES
PLATE LENGTH. . . . . 37.500 INCHES
PLATE THICKNESS . . . . 0.440 INCHES
PLATE MODULUS . . . . 28.0E+06 PSI
BOLT MODULUS. . . . . 28.0E+06 PSI

NUMBER OF ITERATIONS 16

NUMBER OF ELEMENTS IN X DIRECTION . 3
NUMBER OF ELEMENTS IN Y DIRECTION . 14
NUMBER OF BOLTS 2
NUMBER OF LOAD POINTS 3

BOLT LOCATIONS, PROPERTIES, AND LOADS

LOCATION X (IN)	LOCATION Y (IN)	DIAMETER (IN)	LENGTH IN INCHES OR STIFFNESS IN LBS/IN.	SHEAR STIFFNESS (LBS/IN)	PRELOAD (LBS)	BOLT LOADS AXIAL (LBS)	BOLT LOADS SHEAR (LBS)
3.000	5.500	0.875	27.000	0.49E+07	0.	0.	10713.
3.000	32.000	0.875	27.000	0.49E+07	0.	10130.	7388.

MAXIMUM PLATE STRESSES AND LOCATIONS

LOCATION X (IN)	LOCATION Y (IN)	Z	STRESSES (PSI) PRINCIPAL SIGMA(1)	PRINCIPAL SIGMA(2)	EFFECTIVE SIGMA(E)
2.715	31.667	BOTTOM	18208.	14950.	16817. *
2.715	34.000	TOP	-11062.	-19100. *	16610.

TITLE: D.C. COOK CCW HEAT EXCNGR ANCHORAGE FORCE END STIFF EDGE

MAXIMUM PLATE STRESS INTENSITIES AND LOCATIONS

LOCATION X (IN)	Y (IN)	Z	STRESS INTENSITIES (PSI) (Note 1) Sgie	(Note 2) Smax
2.715	34.000	TOP	16610.	----------
0.810	20.219	MIDDLE	6663.	----------
2.715	31.667	BOTTOM	16817.	----------
2.715	34.000	TOP	----------	19100.
0.810	20.219	MIDDLE	----------	6966.
2.715	34.000	BOTTOM	----------	18602.

Note 1: Maximum distortion energy theory
Note 2: ASME NF maximum shear stress theory

ATTACHMENT LOCATIONS AND PROPERTIES

ATTACHMENT NUMBER	CENTER LOCATION X (IN)	Y (IN)	DIMENSIONS X(IN)	Y(IN)	ANGLE DEG.	SHAPE	LINK
1	1.620	7.000	0.000	0.000	0.0	RECTANGLE	1
2	1.620	18.750	0.000	0.000	0.0	RECTANGLE	2
3	1.620	30.500	0.000	0.000	0.0	RECTANGLE	3

TITLE: D.C. COOK CCW HEAT EXCNGR ANCHORAGE FORCE END STIFF EDGE

PLATE LOADS AT ATTACHMENT CENTERS

CENTER LOCATION X (IN)	CENTER LOCATION Y (IN)	FORCES (LBS) FX	FY	FZ	MOMENTS (IN-LBS) MX	MY	MZ
1.620	7.000	0	-6000	-33400	0	0	0
1.620	18.750	0	-6000	-9300	0	0	0
1.620	30.500	0	-6000	14700	0	0	0

PLATE DISPLACEMENTS AND ROTATIONS AT ATTACHMENT CENTERS

CENTER LOCATION X (IN)	CENTER LOCATION Y (IN)	DISPLACEMENTS (IN) DX	DY	DZ	ROTATIONS (RAD) RX	RY	RZ
1.620	7.000	-0.0011	-0.0036	0.0000	0.0003	0.0003	0.0008
1.620	18.750	-0.0049	-0.0023	0.0093	0.0016	0.0026	-0.0001
1.620	30.500	-0.0007	-0.0013	0.0331	-0.0011	0.0070	-0.0004

STIFFNER LOCATIONS AND PROPERTIES

STIFFNER NUMBER	START LOCATION X (IN)	START LOCATION Y (IN)	END LOCATION X (IN)	END LOCATION Y (IN)	HEIGHT (IN)	THICKNESS (IN)
1	0.000	0.000	0.000	37.500	6.000	0.4375
2	0.000	7.000	6.000	7.000	6.000	0.4375
3	0.000	18.750	6.000	18.750	6.000	0.4375
4	0.000	30.500	6.000	30.500	6.000	0.4375

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TITLE: D.C. COOK CCW HEAT EXCNGR ANCHORAGE FORCE END STIFF EDGE

DISPLACEMENT VECTOR AT FINAL ITERATION

NODE	LOCATION (IN)		DISPLACEMENT (IN)			ROTATIONS (RAD)		
	X	Y	DX	DY	DZ	RX	RY	RZ
1	0.000	0.000	5.52E-03	-5.45E-03	-4.25E-07	-1.99E-05	-3.16E-05	1.03E-03
2	1.620	0.000	5.47E-03	-3.67E-03	2.71E-05	-1.39E-05	-1.50E-05	9.46E-04
3	3.810	0.000	5.37E-03	-1.50E-03	7.13E-05	-6.56E-06	-2.30E-05	9.02E-04
4	6.000	0.000	5.33E-03	5.90E-04	1.27E-04	-1.07E-05	-2.59E-05	8.88E-04
5	0.000	2.333	3.15E-03	-5.35E-03	-1.57E-07	5.06E-05	8.64E-06	9.99E-04
6	1.620	2.333	3.12E-03	-3.60E-03	1.37E-05	5.55E-06	-1.58E-05	9.27E-04
7	3.810	2.333	3.07E-03	-1.47E-03	5.36E-05	-7.52E-06	-2.09E-05	8.87E-04
8	6.000	2.333	3.06E-03	5.40E-04	9.34E-05	-2.46E-05	-2.03E-05	8.72E-04
9	0.000	4.667	8.92E-04	-5.14E-03	2.15E-04	1.29E-04	1.79E-04	9.28E-04
10	1.620	4.667	8.69E-04	-3.44E-03	-4.32E-09	-6.37E-05	6.63E-05	8.78E-04
11	3.810	4.667	8.84E-04	-1.38E-03	-9.46E-09	-5.00E-05	-1.68E-05	8.48E-04
12	6.000	4.667	9.34E-04	3.06E-04	-8.59E-10	-5.23E-05	1.59E-05	8.19E-04
13	0.000	7.000	-1.07E-03	-4.72E-03	8.11E-04	4.09E-04	4.96E-04	7.08E-04
14	1.620	7.000	-1.09E-03	-3.56E-03	-2.68E-06	2.95E-04	2.91E-04	8.25E-04
15	3.810	7.000	-1.02E-03	-1.55E-03	1.69E-05	2.00E-04	-6.84E-05	8.34E-04
16	6.000	7.000	-9.27E-04	-3.66E-05	-1.76E-07	7.85E-05	3.78E-05	6.59E-04
17	0.000	9.938	-2.86E-03	-4.09E-03	2.77E-03	8.54E-04	6.59E-04	5.15E-04
18	1.620	9.938	-2.96E-03	-3.14E-03	1.76E-03	6.98E-04	5.72E-04	5.56E-04
19	3.810	9.938	-2.98E-03	-1.87E-03	7.35E-04	3.08E-04	3.74E-04	5.65E-04
20	6.000	9.938	-2.86E-03	-6.22E-04	-2.02E-09	-1.76E-05	3.21E-04	5.54E-0[illegible]
21	0.000	12.875	-4.13E-03	-3.40E-03	5.57E-03	1.10E-03	1.12E-03	3.26E-[illegible]
22	1.620	12.875	-4.22E-03	-2.80E-03	3.83E-03	7.60E-04	1.03E-03	3.44E-[illegible]
23	3.810	12.875	-4.24E-03	-2.02E-03	1.75E-03	3.55E-04	8.65E-04	3.56E-04
24	6.000	12.875	-4.16E-03	-1.29E-03	-8.72E-10	3.50E-05	7.68E-04	3.59E-04
25	0.000	15.812	-4.79E-03	-2.69E-03	9.26E-03	1.36E-03	1.92E-03	1.41E-04
26	1.620	15.812	-4.86E-03	-2.46E-03	6.24E-03	8.42E-04	1.78E-03	1.36E-04
27	3.810	15.812	-4.84E-03	-2.15E-03	2.75E-03	3.53E-04	1.39E-03	1.62E-04
28	6.000	15.812	-4.77E-03	-1.87E-03	-1.87E-08	-1.80E-04	1.19E-03	1.71E-04
29	0.000	18.750	-4.82E-03	-1.87E-03	1.39E-02	1.80E-03	2.81E-03	-2.14E-04
30	1.620	18.750	-4.85E-03	-2.31E-03	9.34E-03	1.58E-03	2.55E-03	-1.48E-04
31	3.810	18.750	-4.81E-03	-2.21E-03	4.71E-03	1.22E-03	2.01E-03	2.78E-05
32	6.000	18.750	-4.75E-03	-2.35E-03	-2.34E-07	7.58E-04	2.29E-03	-8.58E-06
33	0.000	21.688	-4.08E-03	-1.11E-03	2.04E-02	2.42E-03	3.15E-03	-3.01E-04
34	1.620	21.688	-4.20E-03	-1.68E-03	1.54E-02	2.22E-03	3.01E-03	-2.18E-04
35	3.810	21.688	-4.28E-03	-2.21E-03	9.04E-03	1.72E-03	2.79E-03	-1.58E-04
36	6.000	21.688	-4.24E-03	-2.71E-03	2.98E-03	1.23E-03	2.78E-03	-1.39E-04
37	0.000	24.625	-3.10E-03	-6.13E-04	2.76E-02	2.45E-03	3.72E-03	-3.75E-04
38	1.620	24.625	-3.15E-03	-1.32E-03	2.18E-02	2.23E-03	3.44E-03	-2.99E-04
39	3.810	24.625	-3.20E-03	-2.11E-03	1.44E-02	1.87E-03	3.41E-03	-2.51E-04
40	6.000	24.625	-3.20E-03	-2.89E-03	6.78E-03	1.19E-03	3.48E-03	-2.34E-04
41	0.000	27.562	-1.92E-03	-4.19E-04	3.52E-02	3.10E-03	4.37E-03	-4.38E-04
42	1.620	27.562	-1.91E-03	-1.18E-03	2.87E-02	2.55E-03	3.89E-03	-3.54E-04
43	3.810	27.562	-1.93E-03	-2.01E-03	1.93E-02	1.17E-03	4.81E-03	-2.98E-04

TITLE: D.C. COOK CCW HEAT EXCNGR ANCHORAGE FORCE END STIFF EDGE

DISPLACEMENT VECTOR AT FINAL ITERATION

NODE	LOCATION (IN)		DISPLACEMENT (IN)			ROTATIONS (RAD)		
	X	Y	DX	DY	DZ	RX	RY	RZ
44	6.000	27.562	-1.97E-03	-2.83E-03	8.71E-03	-2.57E-04	4.67E-03	-2.73E-04
45	0.000	30.500	-6.63E-04	-4.71E-04	4.29E-02	1.40E-03	6.05E-03	-4.53E-04
46	1.620	30.500	-6.88E-04	-1.31E-03	3.31E-02	-1.10E-03	7.01E-03	-3.90E-04
47	3.810	30.500	-7.55E-04	-1.82E-03	1.79E-02	-3.48E-03	6.01E-03	-3.05E-04
48	6.000	30.500	-7.91E-04	-2.65E-03	3.87E-03	-2.20E-03	6.57E-03	-2.14E-04
49	0.000	32.833	1.31E-04	-5.64E-04	4.82E-02	2.19E-03	1.00E-02	-3.13E-04
50	1.620	32.833	1.24E-04	-1.03E-03	2.94E-02	1.24E-03	1.26E-02	-3.33E-04
51	3.810	32.833	9.44E-05	-1.69E-03	8.95E-03	7.52E-04	4.60E-03	-3.15E-04
52	6.000	32.833	7.40E-05	-2.57E-03	-5.85E-08	-1.49E-03	3.95E-03	-2.97E-04
53	0.000	35.167	8.32E-04	-5.62E-04	5.37E-02	2.57E-03	1.06E-02	-2.80E-04
54	1.620	35.167	8.50E-04	-1.05E-03	3.57E-02	3.14E-03	1.08E-02	-3.29E-04
55	3.810	35.167	8.77E-04	-1.74E-03	1.47E-02	3.09E-03	8.16E-03	-3.26E-04
56	6.000	35.167	8.86E-04	-2.48E-03	-3.61E-08	1.14E-03	6.19E-03	-3.21E-04
57	0.000	37.500	1.63E-03	-5.53E-04	5.93E-02	2.30E-03	1.04E-02	-4.95E-04
58	1.620	37.500	1.61E-03	-1.06E-03	4.24E-02	2.64E-03	1.04E-02	-3.65E-04
59	3.810	37.500	1.62E-03	-1.76E-03	2.11E-02	2.50E-03	8.74E-03	-3.34E-04
60	6.000	37.500	1.63E-03	-2.47E-03	3.45E-03	1.52E-03	7.61E-03	-3.27E-04

TITLE: D.C. COOK CCW HEAT EXCNGR ANCHORAGE FORCE END STIFF EDGE

CONCRETE REACTION AT EACH NODE

NODE	LOCATION (IN) X	Y	REACTION (LBS)
1	0.000	0.000	-4253.8
2	1.620	0.000	0.0
3	3.810	0.000	0.0
4	6.000	0.000	0.0
5	0.000	2.333	-1566.4
6	1.620	2.333	0.0
7	3.810	2.333	0.0
8	6.000	2.333	0.0
9	0.000	4.667	0.0
10	1.620	4.667	-43.2
11	3.810	4.667	-94.6
12	6.000	4.667	-8.6
13	0.000	7.000	0.0
14	1.620	7.000	-26832.2
15	3.810	7.000	0.0
16	6.000	7.000	-1762.7
17	0.000	9.938	0.0
18	1.620	9.938	0.0
19	3.810	9.938	0.0
20	6.000	9.938	-20.2
21	0.000	12.875	0.0
22	1.620	12.875	0.0
23	3.810	12.875	0.0
24	6.000	12.875	-8.7
25	0.000	15.812	0.0
26	1.620	15.812	0.0
27	3.810	15.812	0.0
28	6.000	15.812	-187.4
29	0.000	18.750	0.0
30	1.620	18.750	0.0
31	3.810	18.750	0.0
32	6.000	18.750	-2343.2
33	0.000	21.688	0.0
34	1.620	21.688	0.0
35	3.810	21.688	0.0
36	6.000	21.688	0.0
37	0.000	24.625	0.0
38	1.620	24.625	0.0
39	3.810	24.625	0.0
40	6.000	24.625	0.0
41	0.000	27.562	0.0
42	1.620	27.562	0.0
43	3.810	27.562	0.0

TITLE: D.C. COOK CCW HEAT EXCNGR ANCHORAGE FORCE END STIFF EDGE

CONCRETE REACTION AT EACH NODE

NODE	LOCATION (IN) X	Y	REACTION (LBS)
44	6.000	27.562	0.0
45	0.000	30.500	0.0
46	1.620	30.500	0.0
47	3.810	30.500	0.0
48	6.000	30.500	0.0
49	0.000	32.833	0.0
50	1.620	32.833	0.0
51	3.810	32.833	0.0
52	6.000	32.833	-584.9
53	0.000	35.167	0.0
54	1.620	35.167	0.0
55	3.810	35.167	0.0
56	6.000	35.167	-361.5
57	0.000	37.500	0.0
58	1.620	37.500	0.0
59	3.810	37.500	0.0
60	6.000	37.500	0.0

TITLE: D.C. COOK CCW HEAT EXCNGR ANCHORAGE FORCE END STIFF EDGE

TRANSLATIONAL EQUILIBRIUM CHECK

DIRECTION	X	Y	Z
APPLIED FORCE	0.00000E+00	-0.18000E+05	-0.28000E+05
REACTION	-0.13642E-09	-0.18000E+05	-0.27938E+05
DIFFERENCE	0.13642E-09	-0.15280E-09	-0.62148E+02

0 --- WARNING, THE DIFFERENCE BETWEEN APPLIED FORCE AND REACTION IS GREATER THAN
END OF RUN

WESTINGHOUSE ELECTRIC CORP.

CALCULATION CSE-08-94-0042

ATTACHMENT

WESPLAT RUN "D.C. Cook CCW Heat Excngr Anchorage Force End Stiff Edge," Version 2.1, 02/25/01, Run Date 08/16/94, 13:20:12.

TITLE	DONALD C. COOK NUCLEAR POWER PLANTS SEISMIC FRAGILITY ANALYSIS		PAGE 1 OF 29
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S.O. AOTP-4708J	CALC. NO. CSE-09-94-0046	FILE NO. AEP-947I	GROUP M&SE-CSE

PURPOSE: To obtain fragility data for plant components following the approach used by Diablo Canyon, Ref. 3, in response to a request by AEP following NRC comments. This information is required for the effort to demonstrate that the conservative fragility parameters given in Reference 8 have not masked any dominant contributors or effected ranking for the D. C. Cook seismic IPEEE PRA evaluation.

SCOPE: The components reviewed are:

Part 1 and 2 have separate reference indexes.

1.	Refueling Water Storage Tank	Part 1
2.	Auxiliary Piping Supports	" "
3.	Screen House (Base Slab)	" "
4.	Essential Service Water Pump	Part 2
5.	4KV - 600V Transformer (Surrounded by Masonry Wall)	" "
6.	Motor Control Centers	" "
7.	PORV's	" "

METHODS: The previous fragility calculation for each component is reviewed and fragility parameters are developed following the methodology described in Ref. 3, Sections 4 and 5, as appropriate. Median factors used in the determination of the acceleration capacity are based on variability of measured yield or ultimate strengths, reserve margins due to ductility, conservatism in the design basis spectra in comparison to the uniform hazard spectra, modelling variability based on analytical estimation of system frequency and loading, and modelling uncertainties with respect to soil/structure interaction.

The floor median spectral capacity is first determined, and then the corresponding free field value is obtained using a scaling factor.

ASSUMPTIONS:

1. Design parameters used in the previous calculations are correct. Further specific assumptions are cited in the following calculations.

2. Failure modes of previous analysis are valid.

APPLICABILITY: Use of values is limited for use in the Probabilistic Risk Assessment Evaluations

RESULTS: See page 2.

CONCLUSION: No significant difference has been found between the HCLPF values calculated following Reference 3 methods and those previously reported.

OPEN ITEMS: None

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WESTINGHOUSE CALCULATION SHEET

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AEP EQUIPMENT FRAGILITY DATA SUMMARY FOR ALL COMPONENTS EVALUATED

COMPONENT	Am (g)	Ac (g)	Br	Bu	
1. Refueling Water Storage Tank	0.95	0.40	0.31	0.21	
2. Auxiliary Piping Supports	0.81	0.31	0.31	0.28	
3. Screen House (Base Slab)	1.06	0.35	0.31	0.35	
4. Essential Service Water Pump	1.13	0.45	0.31	0.25	
5. 4KV - 600V Transformer (Wall)	0.79	0.33	0.28	0.25	
6. Motor Control Centers	0.64	0.22	0.34	0.30	
7. PORV's Item 1	1.29	0.31	0.26	0.60	
Item 2	1.68	0.47	0.20	0.57	

Am = Median Free Field Spectral Acceleration Cap. (g)
Ac = Free Field HCLPF Value (g)

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WESTINGHOUSE CALCULATION SHEET

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AEP EQUIPMENT FRAGILITY - PART 1

1. Refueling Water Storage Tank
2. Auxiliary Piping Supports
3. Screen House (Base Slab)

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SAME INFORMATION AS WESTINGHOUSE FORM 55213H

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Fragility Data Summary Table, HCLPF Calculation

Item: Refueling Water Storage Tank (Overturning), Item 52, per Ref.1

Design/Analysis Reserve Margin Factors	Median Factor of Safety	Br	Bu	Bc	Notes
Spectra	1.100	0.280	0.000	0.280	[1]
Ductility	1.800	0.140	0.100	0.172	[2]
Material - Mean	1.158	0.000	0.092	0.092	[3]
- Median	1.153				
Modelling	1.000	0.000	0.158	0.158	[4]
Soil/Structure Interaction	1.000	0.000	0.000	0.000	[5]
Dynamic Increase Factor	1.100				[3]
Resultant [6]	2.51	0.31	0.21	0.38	
Median Free Field Spectral Acceleration Cap. (g) [7]	0.95				
Free Field HCLPF Value (g)	0.40				

Notes:

[1] UHS factor from Westinghouse Calc. No. AEP-050. Adjustment to reflect the conservatism of the DC Cook FSAR SSE ground Design Spectra w.r.t the LLNL UHS 10,000 year median spectral shape. A factor of 1.0 is provided, but review of the spectra comparison plot provided in Ref. 3 for Calc. # AEP-049, indicates that the factor is conservative and a value of 1.1 can be determined. 3.1/2.7 for 6Hz. Br was provided in Ref. 9, by Rizzo Associates.

[2] Inelastic Energy Absorption Factor for the critical item, the restraining steel straps. Unlike anchor bolts, where a brittle mode of failure would be projected per page 5-7 of Ref. 3, the straps will provide a ductile mode of failure. This is a result of the flexible nature of the straps which have a two foot length exposed above the concrete. Using the methodology of Section 4.1.2.3, and a median ductility factor of 2.0, at 5% damping, and 6Hz. frequency, AEP-026, the factor based on values provided in Table 5.1, for the amplified acceleration region, on page 5-117 of Ref.3 is approximately 1.8, with Br = 0.14 and Bu = 0.1.

[3] For the steel, a mean factor of 1.158 can be found in Table 1 of Ref. 4, with a COV of 0.0923. A median value of 1.151 is obtained, and a dynamic increase factor of 1.1 can be applied per Ref. 5, resulting in a median value of 1.2661.

Table 1 provides the mean value and the COV. The log normal standard deviation equals [SQRT(ln(COV^2 + 1)] per eq. 3.3.35, page 266, of Ref. 12. The median value is 1.158e(-0.092^2)/2) = 1.151.

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Fragility Data Summary Table, HCLPF Calculation

Item: Refueling Water Storage Tank (Overturning), Item 52, per Ref.1 cont.

Notes:

[4] Variablity in modelling based on analytical model frequency estimates, Bu, is determined based on the different ground spectral "g" values obtained in Ref. 2 and Ref. 6. Each reference determined an individual impulse mode natural frequency and then determined the corresponding ground spectral acceleration. Employing equation 4-33 from Ref. 3, Bu = ln(0.363/0.31) = 0.158. Ref. 2 determined that the frequency was 6.13 Hz, with "g" value of 0.31, while Ref. 6 has 4.68 Hz. and 0.363 g, page b14.

Other factors derived in Section 4.1.3.1, Ref. 3, based on the complexity of structures are not employed for this simple structure.

[5] Rizzo, Ref. 13.

[6] Resultant equals the product of the median values.

[7] The median free field spectral acceleration capacity is obtained by dividing the seismic design capacity by the required design ground spectral acceleration, times the ground ZPA value, times the resultant median margin g from page Ref. 2, page 5. This value equals maximum capacity from Ref. 2 The required design ground spectral acceleration, based on the tank impulse frequency and coefficient of damping is 0.31g, from the same reference. The ground ZPA value is 0.2g. Conservatism in the stress limit is removed by dividing by 0.9; a stress limit of 0.9Sy is applied for the straps on page 16 of Ref. 2. The seismic design capacity divided by the required design ground spectral acceleration, times the ground ZPA value, divided by 0.9 = 1.55(0.34g)(0.2g)/[(0.31g)(0.9)] =
0.3778 g.

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Fragility Data Summary Table, HCLPF Calculation

Item: Auxiliary Piping Supports [8]

Design/Analysis Reserve Margin Factors	Median Factor of Safety	Br	Bu	Bc	Notes
Spectra	1.300	0.280	0.000	0.280	[1]
Ductility	1.460	0.140	0.100	0.172	[2]
Material - Mean	1.158	0.000	0.092	0.092	[3]
- Median	1.153				
Modelling	1.300	0.000	0.131	0.131	[4]
Soil/Structure Interaction	1.300	0.000	0.200	0.200	[5]
Dynamic Increase Factor & Margin to Stress Limit	1.100				[9]
Resultant [6]	4.07	0.31	0.28	0.42	
Median Free Field Spectral Acceleration Capacity (g) [7]	0.81				
Floor HCLPF Value (g)	0.31				

Notes:

[1] UHS factor from Westinghouse Calc. No. AEP-049. Adjustment to reflect the conservatism of the DC Cook FSAR SSE ground Design Spectra w.r.t the LLNL UHS 10,000 year median spectral shape. A factor of 1.3 is provided on page 3. Br is provided in Ref. 9.

[2] The inelastic Energy Absorption Factor is determined considering the combined ductility of the piping and support system. Assuming a buckling failure mode for the support, a hysteretic effect will be considered, resulting from the directional behavior for this mode of failure. Using the methodology of Section 4.1.2.3, Ref. 3, and a median ductility factor of 2.0 at 5% damping, the factor based on values provided in Table 5.1 on page 5-117 of Ref.3 is 1.767, with Br = 0.14 and Bu = 0.1, for the amplified acceleration region. Section 4.1.2.5 of Ref. 3 gives the formula $F\mu = 1 + CD(F\mu' - 1)$ for use in consideration of the hysteretic effect using the Riddell-Newmark approach. CD = 0.6, similar to Ref. 3, and $F\mu' = 1.767$, resulting in $F\mu = 1.46$.

[3] The material factor is based on yield strength and not the elastic modulus, although the buckling mode of failure is considered. This results from the consideration that the piping/support system will not fail with local support buckling and yielding will occur within the piping or through load redistribution. For the steel, a mean factor of 1.158 can be found in Table 1 of Ref. 4, with a COV of 0.0923. A median value of 1.151 is obtained, and a dynamic increase factor of 1.1 can be applied per Ref. 5, resulting in a median value of 1.2661. SA-36 is considered.

Table 1 provides the mean value and the COV. The log normal standard deviation equals [SQRT(ln(COV^2 + 1)] per eq. 3.3.35, page 266, of Ref. 12. The median value is 1.158e(-0.092^2)/2) = 1.151.

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Fragility Data Summary Table, HCLPF Calculation

Item: Auxiliary Piping Supports

Notes:

[4] The modelling factor is based on damping. Ref. 7 indicates that 1/2 % damping is conservatively used for analysis, where 5 % damping is appropriate, considering that the ductility factor is based on 5 % damping. A factor of 1.3 is applied as indicated in the reference.

Modelling uncertainty variability is based on damping, per Ref. 7, conservatively considering two standard deviations. Two standard deviations are conservative since per Ref. 3, page 5-25, 1.33 standard deviations has been found between 3 and 5 % damping.

[5] Rizzo, Ref. 9.

[6] Resultant equals the product of the median values.

[7] The median free filed spectral acceleration capacity is equal to the free filed seismic design capacity times the resultant median margin factor. The Median free field spectral acceleration capacity is 0.2000 g.

[8] The support may be designed to buckle at the SSE Level of 0.2g, and not at 2/3 of the critical buckling load. As a result, this will be considered as the support mode of failure. Anchors or embedments are assumed to have a margin of safety of between 2 and 3. Connections are as strong as or have more strength than structural systems subject to local buckling. The piping system as a whole will not fail when local support buckling occurs, permitting load redistribution and yielding of the system, and the consideration of ductility effects. Hysteretic effects are considered as a result of the directional behavior of the buckling mode of failure.

[9] The dynamic increase factor is not appliable for buckling failure, but is included based on the fact that the piping will not fail and the load will redistribute to other supports.

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AEP	[signature]	9/22/94	—		W. S. LaPay	9/23/94

S.O.	CALC. NO.	FILE NO.	GROUP
AOTP-4708J	CSE-09-94-0046	AEP-947I	M&SE-CSE

Fragility Data Summary Table, HCLPF Calculation

Item: Screen House - Examine the Base Slab which has the lowest previous HCLPF.

Design/Analysis Reserve Margin Factors	Median Factor of Safety	Br	Bu	Bc	Notes
Spectra	1.500	0.280	0.000	0.280	[1]
Ductility	1.460	0.140	0.100	0.172	[2]
Material - Mean	1.290	0.000	0.095	0.095	[3]
- Median	1.284				
Modelling	1.150	0.000	0.180	0.180	[4]
Soil/Structure Interaction	1.370	0.000	0.270	0.270	[5]
Resultant [6]	4.43	0.31	0.35	0.47	
Median Free Field Spectral Acceleration Capacity (g) [7]	1.06				
Floor HCLPF Value (g)	0.35				

Notes:

[1] UHS factor from Westinghouse Calc. No. AEP-049. Adjustment to reflect the conservatism of the DC Cook FSAR SSE ground Design Spectra w.r.t the LLNL UHS 10,000 year median spectral shape. A factor of 1.5 is provided on page 3. Br is provided in Ref. 9.

[2] The inelastic Energy Absorption Factor is determined considering the combined ductility of the piping and support system. To reflect ductility in reinforced concrete, hysteretic effects must be considered. Using the methodology of Section 4.1.2.3, Ref. 3, and a median ductility factor of 2.0 at 5% damping, the factor based on values provided in Table 5.1 on page 5-117 of Ref.3 is 1.767, with Br = 0.14 and Bu = 0.1, for the amplified acceleration region. Section 4.1.2.5 of Ref. 3 gives the formula $F\mu = 1 + CD(F\mu' - 1)$ for use in consideration of the hysteretic effect using the Riddell-Newmark approach. CD = 0.6, similar to Ref. 3, and $F\mu' = 1.767$, resulting in $F\mu = 1.46$.

[3] Ref. 3, Section 4.1.1.1, page 4-8, provides an average value for strength increase due to aging and batch strength. Table 4-1 provides values for fc = 3000 psi, but not for 3500 psi, per Ref. 15. As a result, the value for 3000 psi will be used. Note that on page 4-10 of Ref. 3, it is stated that the strength may increase for the rate of loading at seismic response frequency, however the increase factor is cancelled by the in-place strength reduction factor. This in-place strength reduction factor is based on the difference in strength between in place concrete and the test cylinder concrete.

Table 4-1 provides the mean value and the COV. The log normal standard deviation equals [SQRT(ln(COV^2 + 1)] per eq. 3.3.35, page 266, of Ref. 12. The median value is 1.29e(-0.095^2)/2) = 1.28

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Fragility Data Summary Table, HCLPF Calculation

Item: Screen House - Base Slab

Notes:

[4] Variablity in modelling, Bu, is based on analytical model frequency variability and determined based on methods defined in Section 4.1.3 of Ref. 3. Base slab frequencies are not determined in the calculation. Reviewing the response spectra, Ref. 9, the frequency corresponding to the peak acceleration, considering broadening, is 2.5 Hz. The frequency for one standard deviation is 2.5exp(0.25) = 3.2. The corresponding ground spectral acceleration is obtained from Ref. 10. Employing equation 4-33 from Ref. 3 to determine the variability based on model frequencies, Bu = ln(0.30/0.27) = 0.105. Considering a 5 % non-exceedance frequency of 2.5exp(1.65(0.25)) = 3.78, with a corresponding maximum g value for the frequency range of 0.315g, variability Buf = ln(0.315/0.27)/1.65 = 0.10. Considering a Bu = 0.10 for mode shape variability, the combined Bu = SRSS(0.105, 0.10) = 0.145.

Additional conservatism exits in the modelling and stress evaluation (strength). "Failure" of the base slab as defined in the evaluation performed in Ref. 11 is local shear failure under a pile. The structure is redundant and therefore load redistribution can occur. Further it has been recognized that additional capacity exists in shear walls. Similarly the base slab will also have inherent capacity. Reasonable factors to reflect these additional conservatisms are as follows:

Redundancy 1.1 with Bu = 0.05
Shear Strength 1.05 with Bu = 0.10

Therefore the combined factor is 1.15 with a Bu = SRSS(0.145, 0.05, 0.10) = 0.18.

[5] Rizzo, Ref. 13.

[6] Resultant equals the product of the median values.

[7] The median free field spectral acceleration capacity is equal to the free field seismic design capacity times the resultant median margin factor. The free field seismic design capacity is 0.2400 g from Ref. 11. This value equals maximum capacity from Ref. 11, page 20, divided by the ZPA value to determine margin. This is multiplied by the ZPA value to determine the free field seismic design capacity.

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REFERENCES:

1. Westinghouse Elec. Corp. Calc. # AEP-025, "Aux. Building Equipment Fragility," for the Donald C. Cook Nuclear Power Plants, Rev. 0, Dec. 1991.

2. Westinghouse Elec. Corp. Calc. # AEP-026, "Seismic Margin for Various Components - RWST/CWST," for the Donald C. Cook Nuclear Power Plants, Rev. 0, Nov. 1991.

3. Report No. 1643.02, "Seismic Fragilities of Civil Structures and Equipment Components at the Diablo Canyon Power Plant," NTS Engineering, September 1988, Long Beach CA, QA Report No. 34001.01-R014, Rev. 0.

4. ASME Conference- Pressure Vessel and Piping Technology Conference-A Decade of Progress, L. Greimann and F. Fanous,"Reliability of Containments Under Over Pressure," 1985

5. R.S. Orr, "Commentary on Code Requirements for Nuclear Safety Related Concrete Structures (ACI 349-85)," ACI Committee 349.

6. Stevens and Assoc.s, "Earthquake Analysis of D.C. Cook Nuclear Power Plant Refueling Water Storage Tank Subjected to Nozzle Loadings to Original and Current Design Criteria," Rev. 0, 09/12/89.

7. Westinghouse Elec. Corp. Calc. # AEP-007, "Piping Supports Fragility Analysis," for the Donald C. Cook Nuclear Power Plants, Rev. 0, Oct. 1990.

8. "Seismic Fragility Assessment, Donald C. Cook Nuclear Plants," Rev. 1, March 1993.

9. Paul C. Rizzo Assoc. Inc. Letter, "Seismic Hazard Analysis, Donald C. Cook Nuclear Plant, Bridgman Mich.," Project No. 93-1326, Dated August 12th, 1994.

9. AEP Letter No. AEP-2097, "Floor Response Curves for EL 591' of Turbine Building & Screenhouse," March 23, 1971.

10. Westinghouse Letter No. GFZ-1051, "AEP/AMP Project, Seismic Design Memo," March 9, 1971.

11. Westinghouse Elec. Corp. Calc. # AEP-019, "Screen House Fragility Analysis," for the Donald C. Cook Nuclear Power Plants, Rev. 0, Nov. 1990.

12. J.R. Benjamin, C.A. Cornell, "Probability, Statistics, and Decision for Civil Engineers," McGraw Hill, New York, NY, 1970.

13. RIZZO ASSOC MEMO, NISH VAIDYA TO N. LAPAY, PROJECT NO. 93-1326, 9/23/94, MEMO & LETTER 10/12/94,

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TITLE DONALD C. COOK NUCLEAR POWER PLANTS SEISMIC FRAGILITY ANALYSIS			PAGE 11 OF 29
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AEP EQUIPMENT FRAGILITY - PART 2

4. Essential Service Water Pump
5. 4KV - 600V Transformer (Surrounded by Masonry Wall)
6. Motor Control Centers
7. PORV's

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AEP EQUIPMENT FRAGILITY

ESSENTIAL SERVICE WATER PUMPS (ESWP)

As noted in Section 4:54 of Reference 1, the ESW pump is mounted on the 591' level of the AEP Screenhouse. According to information provided in References 2 and 3 the pump housing is also supported 27'6" below the motor support. The pump assembly has a frequency of 2.25 Hz. The applicable spectral acceleration (Ref. 4) at a frequency of 2.25 Hz and 5% damping for the 591' level is 0.82g with a floor ZPA of 0.20g. The corresponding free field ZPA acceleration is 0.20g. The analysis tabulated below defines the spectral HCLPF value at the mounting location of the pumps. Now the HCLPF values reported in Reference 1 correspond to the plant free field ZPA values. Since the floor level is above the building base, the HCLPF value must be lowered; the spectral values must be scaled to represent the free field ZPA value. This factor is calculated in two stages: in the first the spectral value is scaled to be representative of the floor ZPA; and in the second, the floor ZPA is scaled to be representative of the free field acceleration. This factor is given for the ESW pump as (0.20/0.82)*(0.2/0.20) and is equal to 0.24. This factor is deterministic since two other parameters, spectral effects and modeling effects, already take into account the variability of the earthquake and building dynamic characteristics.

MARGIN	F median	β_R	β_U	β_C	Reference/(NOTES)
SPECTRA	1.3	0.28	0	0.28	AEP-050 & RIZZO(4)
MATERIAL	1.09	0	0.11	0.11	Ref. 6, (1)
DUCTILITY	1.77	0.14	0.10	0.17	(2)
MODELING	1.0	0	0.0	0.0	(3)
SSI	1.3	0	0.20	0.20	RIZZO (4)
Resultant	3.26	0.31	0.25	0.40	median values

AEP EQUIPMENT FRAGILITY

ESSENTIAL SERVICE WATER PUMPS (ESWP)cont.

Values above are applicable to ESW pump located at the 591' level of the screen house (Ref.4)

The floor median spectral acceleration capacity = seismic design capacity (Ref. 2) times median margin factor = 1.45g*3.26 = 4.7g

The HCLPF floor value is

$$HCLPF(floor) = 4.7g*e(-1.65*(0.31 + 0.25)) = 1.87g$$

The free field median spectral acceleration capacity = 4.7g*0.24= 1.13g

For free field , the HCLPF value is

$$HCLPF(free\ field) = 0.24*HCLPF(floor) = 0.24*1.87g = 0.45g$$

NOTES

1. The yield strengths of steel materials vary randomly; Table 1 (Steel Yield Strength Characteristics) of Reference 6 shows the mean and coefficient of variability (COV) for various steels. The COV is define as the ratio of the standard deviation divided by the mean value. After reviewing the data on Table 1 of Reference 6 it was determined that reasonable values for these parameters, mean and standard deviation, are 1.1 and 0.11 respectively The material is defined in terms of the mean value and has been converted to median value using a relationship described in Equation 2.4 of Reference 1

$$F' = 1.1*e(-0.11^2/2) = 1.09$$

AEP EQUIPMENT FRAGILITY

ESSENTIAL SERVICE WATER PUMPS (ESWP) cont.

2. As noted above the pump is supported (References 2 and 3) at the bottom of upper housing and at one point near the bottom of the pump housing. A review of the analysis indicates that the pump housing sections are subject to the highest stresses and as a result the pump can be expected exhibit significant ductility For the purpose of this evaluation, it is assumed that the pump structure has a median ductility of 2.0. From the data reported in Section 4.54 of Reference 1, it is clear that the equipment is flexible and damping has an effect on the response; a value of 5% is considered to be reasonable. TABLE 5-1 of Reference 5 is used to define the ductility margin factors used in the fragility analysis.

3. The variability in modeling lies primarily in the ability of the analytical model to estimate system frequencies. For this evaluation the median factor is taken equal to 1 since the models are considered adequate. This evaluation follows the approach set forth in Reference 5 and is used to define variability. In this approach equation 4-33 of Reference 5 is used to estimate β_u; the value for modeling can be calculated as follows:

   β_u = ln(spectral acceleration. at 85% exceedence probability frequency/spectra acceleration at median frequency).

   The estimated median frequency was taken as 2.25 Hz; the system frequency has been defined in Section 4.54 of Reference 1. The 85% exceedence frequency has been calculate following the suggestion given on page 4-52 of Reference 5. The 85% exceedence frequency, f_β is given by

   $$2.25 * e^{-0.25} = 1.8 \text{ Hz}$$

AEP EQUIPMENT FRAGILITY

ESSENTIAL SERVICE WATER PUMPS (ESWP)cont.

Note 3 cont.
Reviewing the floor response spectra given in Reference 4 for 5% damping, it is clear that frequency shifts in this range can only result in lower seismic levels. From this it is clear that β_u can be set to zero

$$f = 2.25 \text{ HZ} \qquad RRS = 0.82g$$
$$f_\beta = 1.8 \text{ Hz} \qquad RRS = 0.55g$$

and $\beta_u = 0.$

4. The β_r values used were provided by RIZZO Associates, Reference 14. The median UHS factor is obtained from Reference 12: This factor reflects the conservatism of the Donald C. Cook FSAR SSE ground design spectra with respect to the LLNL UHS 10,000 year median spectral shape.

AEP EQUIPMENT FRAGILITY

4KV - 600v TRANSFORMER SURROUNDED BY MASONRY WALL

INTRODUCTION

The TRANSFORMER is located at the 609'6" level of the Auxiliary building (Ref. 8). Donald C. Cook drawing 1-4034-22 shows the location of this wall which is built up of 12" blocks and has a fire rating of 4 hours. This wall extends horizontally 12' perpendicular to a wall enclosing the room and has a height of 15.3'. The wall is designed to serve as an enclosure for the adjacent transformer. The concern exists (Section 4.51 of Ref. 1) that the wall could fail during a seismic event and prevent the transformer from performing it safety related function (Ref. 7). Reference 9 contains details related to the seismic design of the wall. The wall was assembled using DUR-O-WAL reinforcement. The bending frequency of the wall acting as a horizontal one way beam with fixed ends is 20 Hz (Ref. 9).

Since the base of the wall is above the Auxiliary Building base, the HCLPF value must be lowered: the spectral values must be scaled to represent the free field ZPA value. This factor is done in two stages: first the spectral value is scaled to be representative of the floor ZPA; and second, the floor ZPA is scaled to be representative of the free field acceleration. This factor (based on 2% spectral damping) is (0.22/0.24)*(0.2/0.22), and is equal to 0.83. This factor is treated as deterministic since two other parameters, spectral effects and modeling effects, already take into account the variability of the earthquake and building dynamic characteristics.

AEP EQUIPMENT FRAGILITY

4KV - 600v TRANSFORMER SURROUNDED BY MASONRY WALL cont.

BASIC WALL STRENGTH

Reference 9 describes the modifications made by AEP to strengthen the masonry wall next to the 4KV transformer. The change involved the addition of a WF14x30 column at the free end of the existing masonry wall. This edge serves as a support for the wall. The column is then bolted to the building structure at the floor and ceiling levels. The other vertical edge is supportedby an existing Auxiliary Building wall.

For the purpose of this evaluation, it will be conservatively assumed that the wall behaves as a horizontal beam (the DUR-O-WAL lies in a horizontal plane). Since no information is provided on the size of reinforcement used, it will be conservatively assumed that the wire is No. 9 and that the vertical spacing is 16 inches. The ultimate bending strength for the DUR-O-WAL is given in Table 15 of Reference 11 is 9053 in-lb/ft of wall height. The wall weighs 90 pcf or 90 lb/ft^2 of loaded surface. It is assumed further that the interfaces between the masonry wall and the existing wall and between the masonry wall and the steel column can transfer some edge moment thus reducing the peak beam moment value by 20 percent.

Considering a 12" height of wall with a span of 12' and partially restrained vertical edges, the maximum moment is

$$M = [\alpha*W*L^2/8]*0.8 = [\alpha*7.5*144^2/8]*0.8$$

$$= \alpha*15552 \text{ in-lb/ft}$$

where α defines the design g level used.
α = design seismic capacity = 9053/15552 = 0.58g

AEP EQUIPMENT FRAGILITY

4KV - 600v TRANSFORMER SURROUNDED BY MASONRY WALL cont.

FRAGILITY PARAMETERS

MARGIN	F median	β_R	β_U	β_C	Reference/(NOTES)
SPECTRA	1.1	0.28	0	0.28	AEP-050 & RIZZO(4)
MATERIAL	1.09	0	0.13	0.13	Ref. 6, (1)
DUCTILITY	1.05	0.02	0.01	0.02	(2)
MODELING	1.0	0	0.08	0.08	(3)
SSI	1.3	0	0.20	0.20	RIZZO (4)
Resultant	1.64	0.28	0.25	0.38	median values

Values above are applicable to masonry wall at 609'6" level
The floor median spectral acceleration capacity = seismic design capacity times median margin factor = 0.58g*1.64 = 0.95g

The HCLPF floor value is

HCLPF(floor) = 0.95g*e(-1.65*(0.28 + 0.25)) = 0.40g

The free field median spectral acceleration capacity
= 0.95g* 0.83 = 0.79g

For free field , the HCLPF value is

HCLPF(free field) = 0.83*HCLPF(floor) = 0.83*0.40g = 0.33g

AEP EQUIPMENT FRAGILITY

4KV - 600v TRANSFORMER SURROUNDED BY MASONRY WALL cont.

NOTES

1. For the DUR-O- WAL material, the nominal yield strength is 70000 psi (Attachment B of Reference 9 and Reference 11) and in this case, the controlling factor is steel yield. Now Table 1 (Steel Yield Strength Characteristics) of Reference 6 shows the mean and coefficient of variability (COV) for various steels. The COV is defined as the ratio of the standard deviation divided by the mean value. After reviewing the data on Table 1 of Reference 6 it was determined that reasonable values for these parameters , mean and standard deviation (for a high strength material), are 1.1 and 0.13 respectively. The material is defined in terms of the mean value and has been converted to median value using a relationship described in Equation 2.4 of Reference 1

$$F' = 1.1 * e(-0.13^2/2) = 1.09$$

2. The main source of ductility in the masonry wall during bending arises from the ductility of the DUR-O-WAL steel and its bond to the masonry. For the purpose of this evaluation, it is assumed that the connection median ductility is 1.5. Due to the high calculated frequency for the wall, it is assumed that damping effects will not effect ductility. TABLE 5-1 of Reference 5 is used to define the ductility margin factors used in the fragility analysis.

AEP EQUIPMENT FRAGILITY

4KV - 600v TRANSFORMER SURROUNDED BY MASONRY WALL cont.

3. The variability in modeling lies primarily in the ability of the analytical model to estimate system frequencies. For this evaluation the median factor is taken equal to 1 since the models are adequate. This evaluation follows the approach set forth in Reference 5 and is used to define variability. In this approach equation 4-33 of Reference 5 is used to estimate β_u; the value for modeling can be calculated as follows:

   β_u = ln(spectral acceleration. at 85% exceedence probability frequency/spectra acceleration at median frequency).

   The estimated median frequency was taken as 20 Hz; the system frequency has been defined in Section 4.51 of Reference 1. The 85% exceedence frequency has been calculated following the suggestion given on page 4-52 of Reference 5. The 85% exceedance frequency, f_β is given by

   $$20 * e^{-0.25} = 15.6 \text{ Hz}$$

   Using the floor response given in Reference 9 and 2% damping, we have

   f = 20 HZ   RRS = 0.24g
   f_β = 15.6Hz   RRS = 0.26g

   and β_u = ln(0.26/0.24) = 0.08

4. The β_r values used were provided by RIZZO Associates, Reference 14. The median UHS factor is obtained from Reference 12: This factor reflects the conservatism of the Donald C. Cook FSAR SSE ground design spectra with respect to the LLNL UHS 10,000 year median spectral shape.

AEP EQUIPMENT FRAGILITY

MOTOR CONTROL CENTERS

As noted in Section 4.20 of Reference 1, some of the MCC equipment mounted on the 587' Hallway and the Emergency Diesel Generator rooms in the AEP Auxiliary Building had floor mounting details which could limit the seismic load capacity of the MCC assembly to a value less than the capacity for a cabinet installed using standard mounting techniques. For some of these units the rear of the cabinet was fillet welded to a plate embedded in the floor. The connection was made by installing shim plates under the corner of the cabinet and fillet welding the rear edge of the shim to the cabinet and the front edge of the shim to the embedded steel. Because of this arrangement it was necessary for the rear corner of cabinet to lift off from the floor before the shim could develop a significant amount of resistance to the seismically induced overturning moment.

The equipment assembly has a frequency of 7.5 Hz. The applicable spectral acceleration at 7.5 Hz and 5% damping for the 587' level is 0.27g with a floor ZPA of 0.20g. The corresponding free field ZPA acceleration is 0.20g. The analysis below defines the spectral HCLPF value at the mounting location of the switchgear. Now the HCLPF values reported in Reference 1 correspond to the plant free field ZPA values. Since the floor level is above the Auxiliary Building base, the HCLPF value must be lowered; the spectral values must be scaled to represent the free field ZPA value. This factor is developed in two stages: first the spectral value is scaled to be representative of the floor ZPA; and second, the floor ZPA is scaled to be representative of the free field acceleration. This factor is given for the switchgear mounting as (0.20/0.27)*(0.2/0.2), and is equal to 0.74. This factor is deterministic since two other parameters ,spectral effects and modeling effects, already take into account the variability of the earthquake and building dynamic characteristics.

AEP EQUIPMENT FRAGILITY

MOTOR CONTROL CENTERS cont.

FRAGILITY PARAMETERS

MARGIN	F median	β_R	β_U	β_C	Reference/(NOTES)
SPECTRA	1.3	0.28	0	0.28	AEP-050 & RIZZO(4)
MATERIAL	1.16	0	0.09	0.09	Ref. 6, (1)
DUCTILITY	2.23	0.19	0.12	0.22	(2)
MODELING	1.0	0	0.17	0.17	(3)
SSI	1.3	0	0.20	0.20	RIZZO (4)
Resultant	4.37	0.34	0.30	0.42	median values

Values above are applicable to MCC units at the 587' level of the hallway and the Emergency Diesel Generator room in the Auxiliary Building.

The floor median spectral acceleration capacity = seismic design capacity (Ref. 1) times median margin factor = 0.20g*4.37 = 0.87g

The HCLPF floor value is

HCLPF(floor) = 0.87g*e(-1.65*(0.34 + 0.30)) = 0.30g

The free field median spectral acceleration capacity
= 0.87g*0.74 = 0.64g

For free field , the HCLPF value is

HCLPF(free field) = 0.74* HCLPF(floor) = 0.74*0.30g = 0.22g

AEP EQUIPMENT FRAGILITY

MOTOR CONTROL CENTERS cont.

NOTES

1. The yield strengths of steel materials vary randomly; Table 1 (Steel Yield Strength Characteristics) of Reference 6 shows the mean and coefficient of variability (COV) for various steels. For the mounting condition discussed above, the yield strength of the shim material is the significant parameter; for this evaluation the material has been assumed to be simulate to A36 material. The COV is defined as the ratio of the standard deviation divided by the mean value. After reviewing the data on Table 1 of Reference 6 it was determined that reasonable values for these parameters, mean and standard deviation, are 1.16 and 0.09 respectively The material is defined in terms of the mean value and has been converted to median value using a relationship described in Equation 2.4 of Reference 1.

$$F' = 1.16 * e(-0.09^2/2) = 1.16$$

2. Sheets 133 to 139 and 332 to 335 of Appendix C of Reference 7 describe the mounting details used on this equipment. The connection was made by installing shim plates under the rear edge of the cabinet and fillet welding the rear edge of the shim to the cabinet and the front edge of the shim to the embedded steel. Because of this arrangement, it was necessary for the rear corner of cabinet to lift off from the floor before the welded on shim could develop a significant amount of resistance to the seismically induced overturning moment. As part of this change the shim must undergo a significant amount of inelastic deformation before reaching a stable condition with the primary loading of the shim being tension. In this case ductility is not used to absorb energy but rather to permit the assembly to develop a stable equilibrium position. Since the shims are made from low strength steel, such as A36, this analysis will assume that the connection median ductility is 3 with a damping

AEP EQUIPMENT FRAGILITY

MOTOR CONTROL CENTERS cont.

Note 2 cont.

value of 5%. TABLE 5-1 of Reference 5 is used to define the ductility margin factors used in the fragility analysis..

3. The variability in modeling lies primarily in the ability of the analytical model to estimate system frequencies. For this evaluation the median factor is taken equal to 1 since the models are adequate. This evaluation follows the approach set forth in Reference 5 and is used to define variability. In this approach equation 4-33 of Reference 5 is used to estimate β_u; the value for modeling can be calculated as follows:

   β_u = ln(spectral acceleration. at 85% exceedence probability frequency/spectra acceleration at median frequency).

   The estimated median frequency was taken as 5 Hz; the system frequency has been defined in Section 4.20 of Reference 1. The 85% exceedence frequency has been calculated following the suggestion given on page 4-52 of Reference 5. The 85% exceedence frequency, f_β is given by

   $$7.5 * e^{-0.25} = 5.84 \text{ Hz}$$

   Using the floor response given in Reference 2 and 5% damping, we have

   $f = 7.5$ HZ RRS = 0.27g
   $f_\beta = 5.84$ Hz RRS = 0.32g

   and $\beta_u = \ln(0.32/0.27) = 0.17$

AEP EQUIPMENT FRAGILITY

MOTOR CONTROL CENTERS cont.

4. The β_r values used were provided by RIZZO Associates, Reference 14. The median UHS factor is obtained from Reference 12: This factor reflects the conservatism of the Donald C. Cook FSAR SSE ground design spectra with respect to the LLNL UHS 10,000 year median spectral shape.

AEP EQUIPMENT FRAGILITY

PRESSURIZER POWER OPERATED RELIEF VALVES (PORV)

The results from the walkdown of the Unit 1 and Unit 2 containments, Donald C Cook Nuclear Plant, is reported in Reference 10. Table 3.1 notes that the fragility properties of the Pressurizer Relief Block valves should be developed using generic data; the valve under consideration is motor operated (See Figure 3-4 in Reference 10). The evaluation (Ref. 17) was based on the generic data given Reference 15 for large motor operated valves. Reference 15 contains data developed for Zion plant which is of the same vintage as the Donald C. Cook plant. The NRC reviewed the data provided (Ref. 18) and felt based on past experience that these β values were overly conservative. Westinghouse then reviewed additional published generic data to ascertain if less conservative estimates for the fragility of this motor driven valve are available. Two references were identified that contained appropriate data. The results are tabulated below.

ITEM	Reference	Spectral Acceleration (g)	β_R	β_U
1	15	4.83	.26	.60
2	16	6.3	0.2	0.57

AEP EQUIPMENT FRAGILITY

PRESSURIZER POWER OPERATED RELIEF VALVES (PORV) cont.

The applicable spectral acceleration (Ref. 19) at a frequency of 5 Hz and 5% damping for the 687.5' level of the containment Building is 0.75g with a floor ZPA of 0.75g. The corresponding free field ZPA acceleration is 0.2g. The analysis tabulated below defines the spectral HCLPF value at the mounting location of the pumps. Now the HCLPF values reported in Reference 17 correspond to the plant free field ZPA values. Since the floor level is above the Containment base, the HCLPF value must be lowered: the spectral values must be scaled to represent the free field ZPA value. This factor is calculated in two stages: in the first the spectral value is scaled to be representative of the floor ZPA; and in the second, the floor ZPA is scaled to be representative of the free field acceleration. This factor is given for the ESW pump as (0.75/0.75)*(0.2/0.75), and is equal to 0.27.

Item	Spectra Capacity at floor level (g)	Spectra Capacity at Free Field (g)	HCLPF at Floor Level (g)	HCLPF at Free Field (g)
1	4.83	1.29	1.17(1.52)*	0.31(0.40)*
2	6.3	1.68	1.77 (2.30)*	0.47(0.61)*

Note: * UHS Scale factor of 1.3 for PORV given in TABLE 8.3-1 (Ref. 12) is used to estimate seismic capacity of the motor operated valve.

As can be seen, The data sets above use essential the same β values; the difference in the calculated HCLPF values is primarily due to the difference in estimated valve spectral capacity.

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REFERENCE

1. Calc AEP-025, "Auxiliary Bldg Equipment Fragility," dated 12-05-91.

2. CALC AEP-027, "Essential Service Water Pump Margin," Dated 09-10-91.

3. McDonald Engineering Report, ME 732, "Seismic-Stress Analysis of ASME Section III Case 3 Pumps - AEP Service Water Pumps," April 1980.

4. AEP Letter 2097, dated 03-23-1971, Subject: "Floor Response Curves for Elevation 591' of Turbine Building and Screen House," American Electric Power Service Company."

5. Report No. 1643.02, "Seismic Fragilities of Civil Structures and Equipment Components at the Diablo Canyon Power Plant," September 1988.

6. ASME Conference- Pressure Vessel and Piping Technology Conference-A Decade of Progress, L. Greimann and F. Fanous,"Reliability of Containments Under Over Pressure," 1985.

7. EQE Engineering Consultants, 52077.01-R-002, Rev. 0, "Walkdown of Auxiliary Building in Support of Cook Nuclear Plant IPEEE, Units 1 and 2," 2 Volumes, January 1992.

8. AEP Letter AEP-1955, "Seismic Design of Equipment Located Auxiliary Building," Dated February 5, 1971.

9. Calculation AEP-029, "Seismic Margin, for various Masonry Walls, dated 10-91.

10. EQE Engineering Consultants, 52077.01-R-001, Rev. 0, "Walkdown of Containment in Support of Cook Nuclear Plant IPEEE, Units 1 and 2," 2 Volumes, April 1992.

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REFERENCE cont.

11. DURO-O-WAL Catalog, "4 Unit Masonry Ties and Reinforcement," G/C 1979

12. Calculation AEP-50, "LLNL UHS Equipment Fragility Data," 11/20/91.

13. NOT USED

14. LETTER Rizzo Associates, "Seismic Hazard Analysis, Donald C. Cook Nuclear Plant," 08/17/94.

15. NUREG/CR-3558, "Handbook of the Nuclear Power Plant Seismic Fragilities-Seismic Margin Research Program," Appendix F.

16. NUREG/CR-3892, "A Research Program for the Seismic Qualification of Nuclear Plant Electrical and Mechanical Equipment," Vol. 1, Table 9.0-2.

17. CALC AEP-021, "System Equipment AEP,Fragility Data," Dated 01-15-91.

18. Not Used.

19. AEP Letter AEP-2265, Subject: "Donald C. Cook Nuclear Power Plant Containment -Seismic Response Curves," American Electric Power Service Company, Dated June 3, 1971.

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WESTINGHOUSE ELECTRIC CORP.

DONALD C. COOK NUCLEAR POWER PLANTS
SEISMIC FRAGILITY ANALYSIS CALCULATIONS

Supplementary References

Paul C. Rizzo Associates, Inc.
CONSULTANTS

August 17, 1994

Project No. 93-1326

Dr. William S. LaPay
Westinghouse Electric Corporation
Post Office Box 2728
Pittsburgh, PA 15230

SEISMIC HAZARD ANALYSIS
DONALD C. COOK NUCLEAR PLANT
BRIDGMAN, MICHIGAN

Dear Dr. LaPay:

As requested by Westinghouse, this letter documents Paul C. Rizzo Associates' estimates of response factors to approximate the median seismic response (A_m) of the building structures and equipment of the Donald C. Cook Plant, and the probability distribution of this response in terms log standard deviations representing randomness (β_r) and modeling uncertainties (β_u). We base these on the SSMRP results summarized in NUREG/CR-4331, and a review of the site-specific conditions. Consistent with industry practice for probabilistic risk assessment, these estimates rely to a significant extent on judgment. We suggest that limited confirmatory analyses be performed to calibrate and substantiate the recommendations.

The median response may be approximated on the basis of the design response by using response factors which account for conservatism in the design methodology. Of the several factors that lead to this conservatism, we address two factors, namely, the manner in which foundation embedment and wave incoherence was treated in the soil-structure interaction analysis, and the method used to account for soil-structure interaction radiation damping.

The random uncertainty in the response results from the earthquake to earthquake differences in ground motion which account for the peaks and valleys variability in the spectral shape. On the basis of the SSMRP analysis, we suggest that the seismic fragility estimates for structures and equipment, tied to PGAs should use a randomness variability of $\beta_r = 0.28$ over the entire frequency range of interest.

Modeling uncertainties are presented in the following paragraphs along with the structure-specific response factors which account for the subsurface conditions at the site. Briefly, the finished grade at the Plant site is 608 feet 0 inches. The site subsurface consists of about 15 feet of fill underlain by very dense slightly cemented fine to medium sand approximately 35 feet in thickness between Elevations 594 feet 0 inches and 556 feet 0 inches. This is underlain by a 50 foot layer of hard to very stiff silty clay on a very compact till stratum. Plant structures are founded on the dense sand layer.

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CONTAINMENT BUILDING

The Containment Building/Internal Structure is supported on a foundation mat about 140 feet - 0 inches in diameter. The bottom of foundation is at average Elevation of 574 feet 0 inches. The design evaluation used a soil shear modulus of 2,880 kips/ft (approximate V_s = 1,000 ft/sec) and a soil damping of 5 percent in the soil-structure interaction analysis. Additionally, the design analysis conservatively applied the control motion at the foundation elevation.

Based on the embedment ratio (embedment depth/structure radius) of about 0.45 and the likelihood that the soil-structure interaction damping could be as high as 15 to 20 percent, Table 1 presents the estimates of response factors and modeling uncertainties for the Containment Building structure and equipment.

AUXILIARY/DIESEL BUILDING

The Auxiliary/Diesel Building has an equivalent foundation radius of 138 feet and an average embedment of 34 feet. The design analysis assumed fixed base conditions in calculating the building seismic forces. However soil-structure interaction was included in a subsequent calculation to obtain floor response spectra for equipment evaluation. The soil-structure interaction analysis used a soil shear modulus of 2,880 kip/ft (approximate V_s = 1,000 ft/sec) and soil damping of 20 percent. The control motion was applied at the foundation elevation and the effects of wave incoherence were not included.

Based on an embedment ratio of 0.25, Table 2 presents the estimates of the response factors and modeling uncertainties for the Auxiliary/Diesel Building structure and equipment.

TURBINE PEDESTAL AND CIRCULATING WATER/PUMP HOUSE

It is noted that the FSAR reported the seismic dynamic analysis only for the Containment/Internal Structure and the Auxiliary/Diesel Building Structure. In the absence of specific data for the Turbine Pedestal and the Circulating Water Pump/Screen House Structures we suggest that the response factors and variabilities for the Auxiliary/Diesel Building be used for these structures as well.

We trust that the response factors and variabilities proposed above are satisfactory for use in the fragility analyses. Please call me if you have any questions.

Very truly yours,,

Paul C. Rizzo Associates

Nish Vaidya

Nishikant R. Vaidya
Principal - Structural Engineering.

NRV/EBZ/jmc
Enclosure

16-1326/94

DCR

TABLE 1

RESPONSE FACTORS AND MODELING UNCERTAINTIES(1) CONTAINMENT BUILDING/INTERNAL STRUCTURE

Parameter	Building		Equipment	
	F_a(2)	β_u	F_a(2)	β_u
SSI Embedment	1.26	0.15	1.25	0.15
SSI Damping	1.00	0.00	1.67	0.22
Composite	1.26	0.15	2.09	0.27

(1) Basis: 110-foot soil layer on bedrock, V_s = 1,000/5,000 fps, E/R = 0.46. (Ref. NUREG/CR-4331)
(2) Median Response = Design Response/F_a

TABLE 2

RESPONSE FACTORS AND MODELING UNCERTAINTIES(1) AUXILIARY/DIESEL BUILDING

Parameter	Building		Equipment	
	F_a(2)	β_u	F_a(2)	β_u
SSI Embedment	1.60	0.27	1.30	0.20
SSI Damping	1.00	0.00	1.00	0.00
Composite	1.60	0.27	1.30	0.20

(1) Basis: 110-foot soil layer on bedrock, V_s = 1,000/5,000 fps E/R = 0.25. (Ref. NUREG/CR-4331)

(2) Median Response = Design Response/F_a

MEMO

TO:	Dr. W. S. LaPay, Westinghouse	Project No. 93-1326
FROM:	Nish Vaidya, Paul C. Rizzo Associates	September 23, 1994

SEISMIC IPEEE
DONALD C. COOK NUCLEAR PLANT

In accordance with our telephone conversation this morning, our recommendations for the Seismic Response Factors and Variability associated with soil-structure interaction for the Pump/Screen House and the Refueling Water Storage Tank are as follows:

Pump/Screen House:	$R_{ssi} = 1.37$, $\beta_u = 0.27$
Refueling Water Storage Tank:	$R_{ssi} = 1.0$, $\beta_u = 0$

The basis for the above recommendations will be discussed in a letter report which will also include results of the analysis of liquefaction potential of the Pump/Screen House foundation soils. Please call me or Enrique Bazan if you have any questions.

SEE ALSO RIZZO LETTER DATED 10/12/94, ON FOLLOWING PAGE.
[signature] 10/14/94

mm1-1326/94

DCR

Paul C. Rizzo Associates, Inc.
CONSULTANTS

October 12, 1994

Project No. 93-1326

Dr William S. LaPay
Westinghouse Electric Corporation
Post Office Box 2728
Pittsburgh, PA 15230

SEISMIC HAZARD ANALYSIS
DONALD C. COOK NUCLEAR PLANT
BRIDGMAN, MICHIGAN

Dear Dr. LaPay:

This letter documents Paul C. Rizzo Associates estimates of response factors to approximate median seismic response (A_m) from the design seismic response of the Screen House and the Refueling Water Storage Tanks (RWST) structures of the Donald C. Cook Plant, as well as estimates of log standard deviation measuring randomness (β_r) and uncertainty (β_u) in such a response. We have based our estimates on the SSMRP information provided in NUREG/CR-4331. This letter also presents Paul C. Rizzo Associates assessments of the potential for soil liquefaction under the Intake Crib Structure and of permanent displacements of the embankment slopes affecting the Refueling Water Storage Tanks as a result of seismic ground motions. We have based both assessments on procedures proposed in the EPRI report "A methodology for the Assessment of Nuclear Power Plant Seismic Margin (Revision 1)."

PUMP/SCREEN HOUSE

The Pump/Screen House is a substantially embedded concrete shear wall structure with an above grade metal building enclosing the Pump House. The Pump/Screen House structure is about 210 feet by 108 feet in plan. Its foundation is approximately 40 feet below grade (which is at Elevation 580'-0"). The Response Reduction Factors for the Pump/Screen House associated with soil structure interaction are based on the assumption that the design seismic analysis included some soil-structure interaction. However, it is assumed that this analysis did not include the effects of the embedment. The soil profile is considered to be represented by a 110 foot soil layer with a characteristic shear wave velocity of 1000 feet per second overlying bedrock. The embedment ratio (embedment depth divided by the smaller plan dimension) is 0.37.

Variation of ground motion through the embedment depth and the attendant wave scattering effects are expected to result in a reduction of the seismic response calculated on the basis of the conservative assumption that the control motion is applied at the

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a response reduction factor $R_{ssi} = 1.37$ is recommended. Because the actual damping used in the design seismic analysis is not known, it is recommended that the response reduction associated with radiation damping be ignored. On the basis of the SSMRP, we estimate that the variability associated with the soil-structure interaction can be represented by $\beta_u = 0.27$.

REFUELING WATER STORAGE TANK

The Refueling Water Storage Tank is an above grade structure supported on a concrete mat. The tank is 48 feet in diameter and has a liquid height of 31 feet. A fixed base analysis reported by Stevenson and Associates resulted in a fundamental frequency of about 5.5 Hz. Consistent with the foundation compliance for a rigid base, the natural frequency of the foundation mass in the horizontal soil-structure mode is about 15 Hz. On the basis of these results, it is considered that relative to the structure, the foundation is rigid and the assumption of a fixed base for the seismic analysis is appropriate. Accordingly, we recommend that effects of soil structure interaction on the seismic response of the Refueling Water Storage tanks be ignored, i. e, that $R_{ssi} = 1.0$ and $\beta_u = 0$ be used for these tanks.

SOIL LIQUEFACTION AT THE INTAKE CRIB

The stratigraphy of the site shows three horizontal layers. The top layer is formed by medium to lose dune sand down to an elevation of approximately 590 feet. This layer was completely excavated in all areas where buildings exist. Underlying this material, there is a layer of very dense sand approximately 35 feet in thickness, reaching an elevation of about 554 feet. This layer is on top a layer of hard to very stiff clay with an a thickness of about 50 feet. No boring logs exist at the location of the Intake Crib. However, the available boring logs show that the sand layers dip down in the direction of the lakebed.

Our examination of liquefaction potential considers that it is possible that the Intake Crib is founded on the very dense sand layer. Following the procedure developed by Seed and Idriss, we have estimated average cyclic stress ratios (ratio of average seismic shear stress to effective overburden pressure) on a sand layer at the bottom of the lake for various levels of ground motion. Then, on the basis of data provided in the 1968 foundations investigations report by A. & L. Casagrande, we have determined normalized blowcounts $(N_1)_{60}$ corresponding to the very dense sand. We found that minimum average values of $(N_1)_{60}$ are of the order of 50. According to the Seed and Idriss criteria, values of $(N_1)_{60}$ of this order suggest that liquefaction will not occur in this layer, independent of the level of peak ground acceleration.

SEISMIC DISPLACEMENTS OR EMBANKMENTS SLOPE AT RWST

The Plant grading plan shows a 2:1 slope, with a height of about 45 feet above elevation 608 feet, near the Refueling Water Storage Tanks. These embankments are assumed to

comprise dune sand. Our estimation of maximum seismically induced displacements follows the methodology outlines by Makdisi and Seed. The fundamental period of the slope was estimated assuming a compressive wave velocity of 1,649 ft/second for the dune sand, as reported in the FSAR of the plant. This corresponds to a shear wave velocity of about 640 ft/second.

Permanent displacements of the slope were predicted for the critical failure surface when the peak ground acceleration (PGA) is 0.5 g or larger. The following table provides our estimates of permanent slope movement for PGA's up to 1.2g.

TABLE 1

POTENTIAL DISPLACEMENT OF EMBANKMENT SLOPE DUE TO SEISMIC GROUND MOTION

PGA (g's)	Permanent Displacement (feet)
0.5	0.05
0.6	0.14
0.7	0.34
0.8	0.85
0.9	1.59
1.0	2.25
1.1	3.19
1.2	3.86

We hope that the above information is appropriate for use. Please call me if you have any questions.

Very truly yours,
Paul C. Rizzo Associates

Nishikant R. Vaidya
Principal - Structural Engineering

NRV/EB/dha

WESTINGHOUSE ELECTRIC CORP.

CALCULATION CSE-08-94-0042

ATTACHMENT

REFERENCE 11

SCREENING EVALUATION WORK SHEET (SEWS)

2-HE-15E

Equip. ID No. 1-HE-15E Equip. Class 21 - Tanks and Heat Exchangers

Equipment Description East CCW Heat Exchanger

Location: Bldg. Aux. Floor El. 609 Room, Row/Col 44N-Unit 1, 44S Unit

Manufacturer, Model, Etc. MLW Industries

Des. Press = 150 psig. Des Temp = 200°F

SHELL CAPACITY VS DEMAND

Buckling capacity of shell of large, flat-bottom, vertical tank is equal to or greater than demand: Y N U (N/A)

Horz. HX on Saddles

ANCHOR BOLTS AND EMBEDMENT

Capacity of anchor bolts and their embedments is equal to or greater than demand: Y N U N/A

Evaluation Reqd.

CONNECTION BETWEEN ANCHOR BOLTS AND SHELL

Capacity of connections between the anchor bolts and the tank shell is equal to or greater than the demand: Y N U N/A

Include saddle/shell weld in evaluation

FLEXIBILITY OF ATTACHED PIPING

Attached piping has adequate flexibility to accommodate motion of large, flat-bottom, vertical tank: Y N U (N/A)

Horz HX is rigid

IS EQUIPMENT SEISMICALLY ADEQUATE? Y N U

Evaluation Reqd.

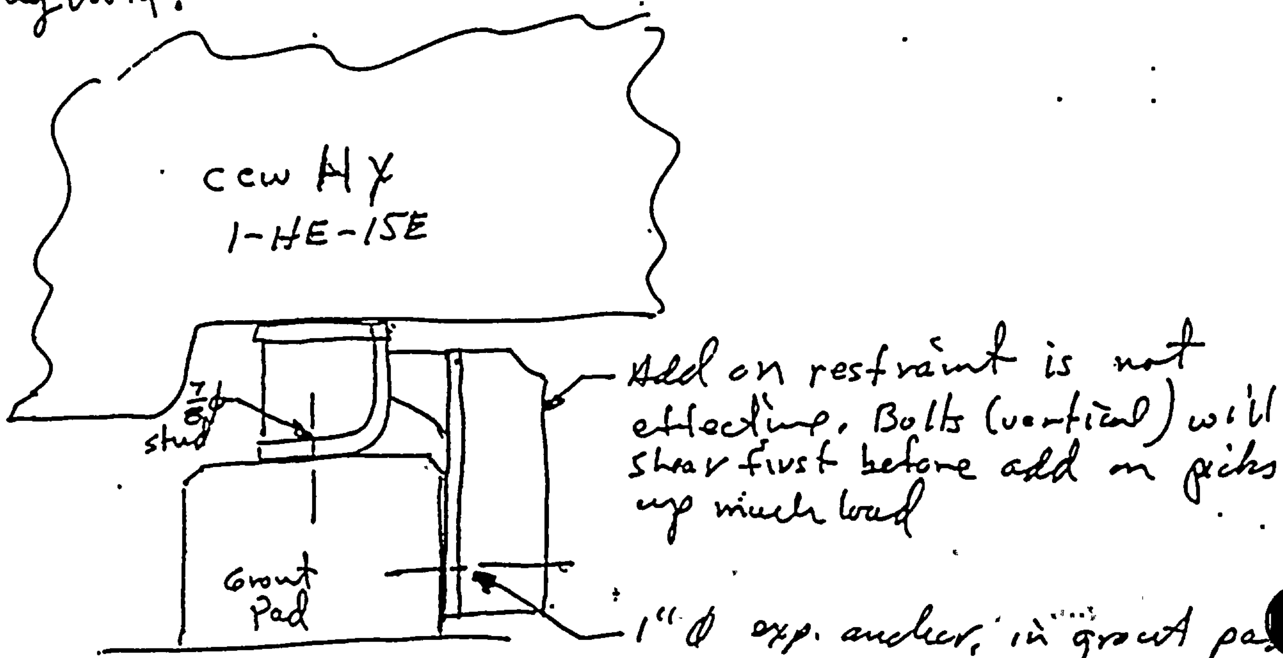
SCREENING EVALUATION WORK SHEET (SEWS)

Equip. ID No. 2-HE-15E / 1-HE-15E   Equip. Class 21 - Tanks and Heat Exchangers

Equipment Description East CCW Heat Exchanger

COMMENTS

Should review anchorage and develop plant specific fragility.



Fixed End of HX

No evidence of movement on floating end. Check drawings for slotted holes.

2-HE15E has same anchorage

Evaluated by: R D Campbell   Date: 3-13-91

A J Hartman   3-13-91

[signature]   3-13-91

SCREENING EVALUATION WORK SHEET (SEWS)

Equip. ID No. 1-HE-15W (2-HE-15W) Equip. Class 21 - Tanks and Heat Exchangers

Equipment Description West CCW Heat Exchanger

Location: Bldg. Aux. Floor El. 609 Room, Row/Col 44N-unit 1, 44S Unit 2

Manufacturer, Model, Etc. MLW Industries

SHELL CAPACITY VS DEMAND

Buckling capacity of shell of large, flat-bottom, vertical tank is equal to or greater than demand: Y N U (N/A)

HX is horizontal saddle supported.

ANCHOR BOLTS AND EMBEDMENT

Capacity of anchor bolts and their embedments is equal to or greater than demand: Y N U N/A

Evaluation Reqd.

CONNECTION BETWEEN ANCHOR BOLTS AND SHELL

Capacity of connections between the anchor bolts and the tank shell is equal to or greater than the demand: Y N U N/A

Include saddle/shell weld in evaluation

FLEXIBILITY OF ATTACHED PIPING

Attached piping has adequate flexibility to accommodate motion of large, flat-bottom, vertical tank: Y N U (N/A)

Horz. Tank is rigid

g=0.22

IS EQUIPMENT SEISMICALLY ADEQUATE? Y N U

Evaluation Req.

SCREENING EVALUATION WORK SHEET (SEWS)
2-HE-15W

Equip. ID No. 1-HE-15W Equip. Class 21 - Tanks and Heat Exchangers

Equipment Description West CCW Heat Exchanger

COMMENTS

1-HE 15W is same as 1-HE-15E

2-HE 15W does not have add on support like 1-HE15 E+W and 2 HE15E. This is governing case.

photo 1+2, of 1-HE15W
photo 3 of 2-HE15W

W should review anchorage detail and develop plant specific fragility for both cases.

Evaluated by: R D Campbell Date: 3-13-91
A. J. Hartman 3-13-91
[signature] 3-13-91

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ATTACHMENT TO AEP:NRC:1147E

DONALD C. COOK NUCLEAR PLANT

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