Client: Wisconsin Electric Power Company

Calculation No.: 91C2696-C015

Title: WEP Point Beach Raceway LAR#9 Fragility Analysis

Project: Point Beach A-46/IPEEE

Method: Conventional Engineering Hand Calculation

Acceptance Criteria: EPRI TR-103959, "Methodology for Developing Seismic Fragilities"

Remarks:

REVISIONS

No.	Description	By	Date	Chk.	Date	App.	Date
0	Original Issue	TMT	3/7/95	A.K	3/10/95	MD	3/13/95

S&A Stevenson and Associates

CALCULATION COVER SHEET

FIGURE 1.3

CONTRACT NO. 91C2696

Introduction

The raceway systems selected as LAR#9 in the A-46 program are outliers since they do not meet the requirements of Section 8.0 of the GIP [4]. See S&A's Cable Tray and Conduits Supports LAR Report [3].

The fragilities of the cable tray systems to be used in the seismic PRA are estimated in this calculation. From the LAR report, it is clear that these raceway systems are heavily loaded. The gravity load takes away major portion of the capacity. The raceway systems do not even pass the dead load check based on standard design basis or GIP procedures. To obtain a meaningful fragility estimate, the fragility analysis follows the median fragility approach rather than the CDFM or HCLPF approach.

Since the purpose of this calculation is to estimate the fragilities, only the critical components identified in the LAR report are evaluated.

References

1. WEPC, Facsimile Transmission, Tim Dykstra to W. Djordjevic, 2/8/1995, S&A91C2696-LRCO-134.
2. Unistrut General Engineering Catalog No. 10, 1983.
3. S&A, USI A-46 Limited Analytical Review Cable Tray and Conduit Supports, for Point Beach Nuclear Power Plant, WEPC.
4. SQUG, Generic Implementation Procedure (GIP) for Seismic Verification of Nuclear Plant Equipment, Revision 2, February 14, 1992.
5. S&A, "Point Beach SSI and IPEEE Floor Response Spectra", S&A Calculation 91C2696-C001, December, 1993.
6. Blevins, R. D., "Formulas for Natural Frequency and Mode Shape," Van Nostrand Reinhold. 1979, p. 138.
7. URS/John A. Blume & Associates, "Analytical Techniques, Models, and Seismic Evaluation of Electrical Raceway Systems," August 1983.
8. EPRI, "Seismic Verification of Nuclear Plant Equipment Anchorage (Revision 1), Volume 1: Development of Anchorage Guidelines," EPRI NP-5228-SL, Revision 1, Volume 1, Final Report, June 1991.
9. ASTM Standards, Vol 01.03, Designation A570-79, 1983.
10. ASTM Standards, Vol 01.06, Designation A446-76 (Reapproved 1981), 1983.
11. EPRI, "Methodology for Developing Seismic Fragilities," TR-103959, Final Report, June 1994.

Description of System

The LAR#9 is located in the Central Auxiliary Building Elevation 8'. The support consists of a single post cantilever P1001 with five trays on the one side and one tray on the opposite side. There is also conduits and marinite board attached to the support (see the field sketch in [1]). The Marinite board is estimated to weigh 60 lbs.

Typical support span equals 5 feet. LAR#9 is supported on the ceiling by two 3/8" and one 1/2" concrete expansion anchors.

Allowable Loads

Since a median fragility analysis is performed in this calculation, the allowable loads are the unfactored manufacturer specified loads or the material strength values.

P1000 and P1001 members

The P1000 and P1001 are of gauge 12 construction and made of either ASTM A570 Gr33 or A446 GrA material [2]. The strengths of the materials are [9, 10]

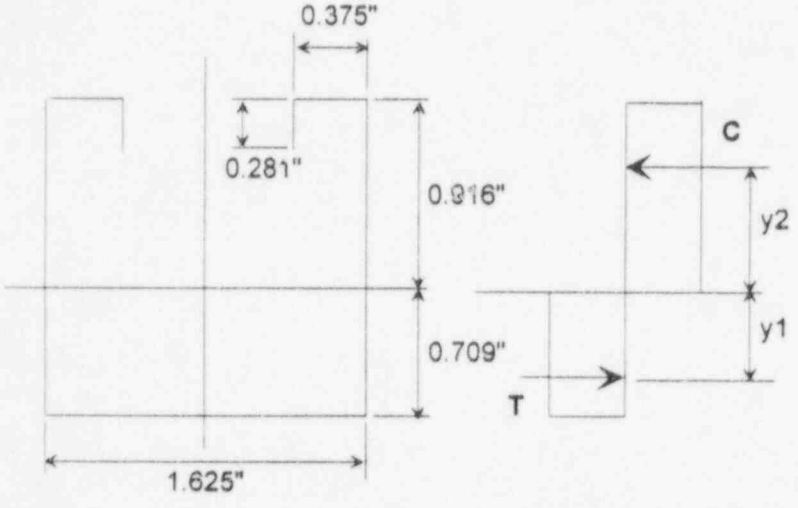
Material	Yield Point	Tensile Strength
A570 Gr33	33,000 psi	52,000 psi
A446 GrA	33,000 psi	45,000 psi

The median yield stress and the nominal yield stress for typical carbon steels A36 and A307 is reported in Table 3-9 of [11] at 36 ksi and 44 ksi respectively. Applying the same ratio, the yield point for the P1000 members is

33,000 * 44 / 36 = 40,300 psi

The plastic modulus of the sections will be determined in the following:

P1000, from [2]



y_2 = [(0.281 - 0.105) * (0.916 - (0.281 + 0.105)/ 2) + 0.375 * (0.916 - 0.105 / 2) + (0.916 - 0.105) * (0.916 -0.105) / 2] / (0.281 - 0.105 + 0.375 + 0.916 - 0.105)
= 0.573 in

y_1 = (1.625 * (0.709 - 0.105 / 2) + 2 * (0.709 - 0.105) * (0.709 - 0.105) / 2) / (1.625 + 2 * (0.709 - 0.105))
= 0.505 in

M_p = 40,300 * 0.555 * (0.573 + 0.505) / 2 = 12,100 lb-in

P1001

$$M_p = 40{,}300 * 1.11 / 2 * 0.709 * 2 = 31{,}700 \text{ lb-in}$$

P1325 clip angle connection

The capacity of the P1325 connection will be governed by either the slipping of the side bolts or the pull out of the top bolts. According to the catalog capacity [2], the resistance to slip is 1,500 lbs. per bolt, and the pull out strength is 2,000 lbs. per bolt, both with a minimum safety factor of 3. The slip capacity governs,

$$\text{Capacity P1325} = 1{,}500 * 2 * 3 = 9{,}000 \text{ lbs.}$$

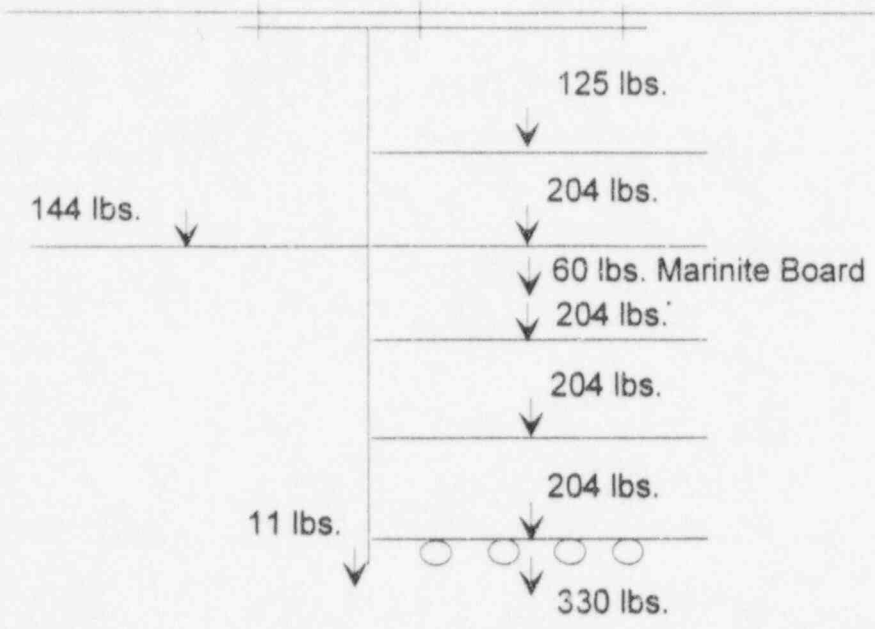
Concrete Expansion Anchors

From [4], the 1/2" expansion anchor has a nominal tension capacity of 2.29 kips. From [8], this capacity has a factor of safety of 3 against the mean capacity from testings. Even though the anchor type is unknown, no reduction of capacity is taken since a median fragility is sought. The median tension capacity for a 1/2" expansion anchor is, taking correction for the concrete strength

$$P_u = 2{,}290 * 3{,}000 / 4{,}000 * 3 = 5{,}150 \text{ lbs}$$

Tray Weight and Support Loads

The actual raceway weight is transmitted from WEPC in [1]. The weights are summarized in the table below. The other support loads, including the conduits and the risers are extracted from the previous LAR report [3]. The loads are shown in the following figure:



The total load and moment due to the gravity load on the support is summarized in the following table:

Tiers	Raceway	Weight (lb/ft)	span (ft)	Load (lb)	Offset (in)	Moment (lb-in)
1	Unknown	25	5	125	13	1,625
2	2FA01	40.76	5	204	13	2,649
3	2FB01	40.76	5	204	13	2,649
4	2FC01	40.76	5	204	13	2,649
5	2FD01	40.76	5	204	13	2,649
6	JE03	28.88	5	144	-13	-1,877
Marinite Board		60		60	13	780
Conduit 1	4 x 4"	66	5	330	13	4,290
Conduit 2	1"	2.2	5	11	-2	-22
TOTAL				1,486		15,393

Frequency Analysis

Assuming a uniformly loaded cantilever P1001 beam, 62" long, the uniform weight is

$w = 1{,}486 / 62 = 24.0$ lb/in

$$f_1 = \frac{1.875^2}{2\pi(62)^2}\sqrt{\frac{(29E6)0.93}{24/386}} = 3.0 \text{ Hz}$$

The P1325 connection between the post and the runner is of finite stiffnesss. The connection stiffness is estimated at about 300 kip-in./rad from [7]. The frequency due to joint flexibility is

$$f_2 = \frac{1}{2\pi}\sqrt{\frac{300{,}000 \times 386}{1486 \times 31^2}} = 1.43 \text{ Hz}$$

Combined frequency

$$f = 1\Big/\sqrt{\frac{1}{3.0^2} + \frac{1}{1.43^2}} = 1.30 \text{ Hz}$$

Since a median fragility is sought, no broadening nor shifting is required. The horizontal spectral acceleration obtained from the 5% damped FRS at Central Auxiliary Building Elevation 26' of the 0.4g RLE is 0.124g. Since the system frequency is low, the acceleration level of the raceway system is also anticiapted to be low, the damping is conservatively assumed to be 5%.

Due to the large eccentricity of the weight, the vertical mode is well coupled with the horizontal mode, the fundamental mode of the system is still 1.30 Hz. The spectral acceleration is interpolated from the ground spectra at 0.125g.

Frequency (Hz)	RS (g)
1.000	0.094
1.300	0.125
2.500	0.255

The moment due to the 0.4g RLE is summarized in the table below:

Tiers	Weight (lb)	Offset (in)	Moment (lb-in)
Unknown	125	12	186
2FA01	204	26	657
2FB01	204	38	960
2FC01	204	50	1,264
2FD01	204	62	1,567
JE03	144	26	466
Marinite	60	32	238
Conduit 1	330	62	2,537
Conduit 2	11	62	85
TOTAL	1,486		7,959

Vertical Member (P1001)

The median fragility for the vertical P1001 member in bending is

(31,700 - 15,393 * (1 + 0.125)) / 7,959 * 0.4 = 0.72g

The contribution from the axial load to the stress is small and is therefore neglected.

Vertical Member to Runner Connection (P1325)

The vertical load and moment due to the dead load translate to two forces acting on the two sides of the connection (3.25" apart)

$P_1 = (1{,}486 / 2 + 15{,}393 / 3.25) * (1 + 0.125) = 6{,}164$ lbs.

The seismic load further imposes

$P_1 = 7{,}959 / 3.25 = 2{,}449$ lbs.

The median fragility can be calculated by

(9,000 - 6,164) / 2,449 * 0.4 = 0.46g

Runner

Since the runner is supported very close to the anchor point, the bending of the runner will not govern.

Ceiling Anchorage

The tension demand on the center 1/2" expansion anchor is checked in the following.

$$P_D = \left(1{,}486\frac{9.5}{9.5+4.25} + \frac{15{,}393}{9.5+4.25}\right)(1+0.125) = 2{,}414 \text{ lbs}$$

$$P_S = \frac{7{,}959}{9.5+4.25} = 579 \text{ lbs}$$

Median Fragility = (5,150 - 2,414) / 579 * 0.4 = 1.89g

Conclusion

The fragility of LAR#9 is governed by the connection between the post and the runner. The median fragility is 0.46g.

CCW Heat Exchanhger

Wisconsin Electric Power Company - Point Beach Nuclear Plant **SCREENING EVALUATION WORK SHEET (SEWS)**		GIP Rev 2, Corrected, 2/14/92 Status: Yes Sheet 1 of 2
ID : 1HX-12A (Rev. 0)	Class : 21 - Tanks and Heat Exchangers	
Description : COMPONENT COOLING WATER HEAT EXCHANGER		
Building : PAB	Floor El. : 46.0000	Room, Row/Col : AREA 5
Manufacturer, Model, Etc. :		

BASIS : External analysis

1. The buckling capacity of the shell of a large, flat-bottom, vertical tank is equal to or greater than the demand.	N/A
2. The capacity of the anchor bolts and their embedments is equal to or greater than the demand.	Yes
3. The capacity of connections between the anchor bolts and the tank shell is equal to or greater than the demand.	Yes
4. Attached piping has adequate flexibility to accommodate the motion of a large, flat-bottom, vertical tank.	N/A
5. A ring-type foundation is not used to support a large, flat-bottom, vertical tank.	N/A

IS EQUIPMENT SEISMICALLY ADEQUATE? **Yes**

COMMENTS

The SRTs are M. A. Woznicki and J. D. Stevenson - 10/20/93.

REF: WEPCo. Calculation No. 86-020 Rev. 0 "New Component Cooling Water Heat Exchanger Support Design" and S&A Calculation No. 91C2696-C-007 Rev. 0 "USI A-46 / IPEEE, Equipment Fragilities for 1HX-12A, HX-12B, HX-12C and 2HX-12D".

Anchorage:
Heat Exchangers 1HX-12A, HX-12B, HX-12C and 2HX-12D are identical and located in a row next to each other. Each HX is supported on two saddles which are 18' apart. The fixed end saddle is anchored into the concrete floor by 2 - 1" grout-in-place bolts (embedment = 12"). The slotted end saddle is bolted onto a base plate by 2 - 1" bolts and the base plate is anchored into the concrete floor by 4 - 5/8" x 8.5" Hilti Kwik bolts (4.5" min. embedment).

The referenced S&A calculation perform an A-46 evaluation of the HX anchorage by scaling the HCLPF and concluded that the HX has an A-46 safety factor of at least 1.31, therefore the HX is adequately anchored.

Interaction:
This HX is in contact with a 2" pipe and 4" tube, but the HX is not expected to displace and cause failure of the parts and attached components. Therefore, the SRT judged that the interaction is not a credible hazard.

Evaluated by: John D. Stevenson Date: 10/20/93

MAW 06/14/96

Attachment: Pictures

Wisconsin Electric Power Company - Point Beach Nuclear Plant **SCREENING EVALUATION WORK SHEET (SEWS)**		GIP Rev 2, Corrected, 2/14/92 Status: Yes Sheet 2 of 2
ID : 1HX-12A (Rev. 0)	Class : 21 - Tanks and Heat Exchangers	
Description : COMPONENT COOLING WATER HEAT EXCHANGER		
Building : PAB	Floor El. : 46.0000	Room, Row/Col : AREA 5
Manufacturer, Model, Etc. :		

PICTURES

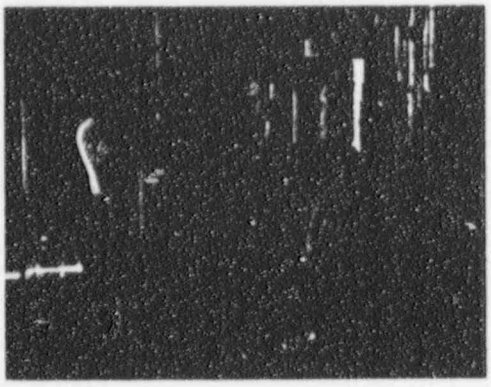


Fig.1: 1HX-12A

Fig.2: 1HX-12A - HX Anchorage

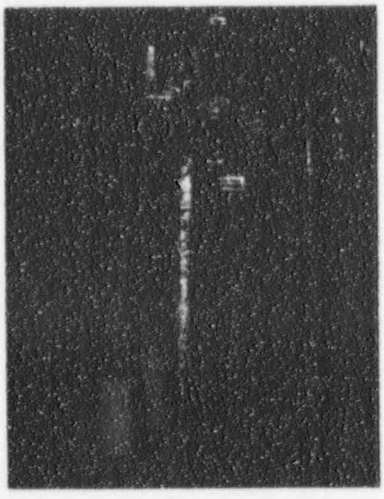


Fig.3: 1HX-12A - HX interaction w/ instrument post

Wisconsin Electric Power Company - Point Beach Nuclear Plant **SCREENING EVALUATION WORK SHEET (SEWS)**		GIP Rev 2, Corrected, 2/14/92 Status: Yes Sheet 1 of 2
ID : HX-12B (Rev. 0)	Class : 21 - Tanks and Heat Exchangers	
Description : COMPONENT COOLING WATER HEAT EXCHANGER		
Building : PAB	Floor El. : 46.0000	Room, Row/Col : AREA 5
Manufacturer, Model, Etc. :		

BASIS : External analysis

1. The buckling capacity of the shell of a large, flat-bottom, vertical tank is equal to or greater than the demand.	N/A
2. The capacity of the anchor bolts and their embedments is equal to or greater than the demand.	Yes
3. The capacity of connections between the anchor bolts and the tank shell is equal to or greater than the demand.	Yes
4. Attached piping has adequate flexibility to accommodate the motion of a large, flat-bottom, vertical tank.	N/A
5. A ring-type foundation is not used to support a large, flat-bottom, vertical tank.	N/A

IS EQUIPMENT SEISMICALLY ADEQUATE? **Yes**

COMMENTS

The SRTs are M. A. Woznicki and J. D. Stevenson - 10/20/93.

REF: WEPCo. Calculation No. 86-020 Rev. 0 "New Component Cooling Water Heat Exchanger Support Design" and S&A Calculation No. 91C2696-C-007 Rev. 0 "USI A-46 / IPEEE, Equipment Fragilities for 1HX-12A, HX-12B, HX-12C and 2HX-12D".

Anchorage:
Heat Exchangers 1HX-12A, HX-12B, HX-12C and 2HX-12D are identical and located in a row next to each other. Each HX is supported on two saddles which are 18' apart. The fixed end saddle is anchored into the concrete floor by 2 - 1" grout-in-place bolts (embedment = 12"). The slotted end saddle is bolted onto a base plate by 2 - 1" bolts and the base plate is anchored into the concrete floor by 4 - 5/8" x 8.5" Hilti Kwik bolts (4.5" min. embedment).

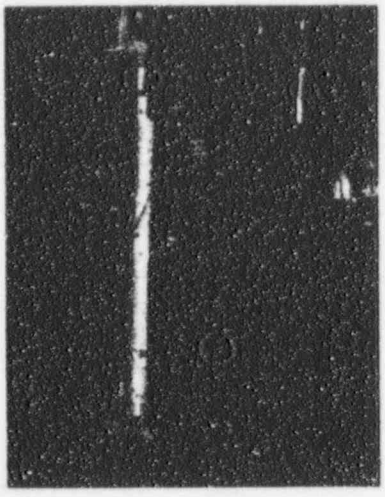
The referenced S&A calculation perform an A-46 evaluation of the HX anchorage by scaling the HCLPF and concluded that the HX has an A-46 safety factor of at least 1.31, therefore the HX is adequately anchored.

Evaluated by: John D. Stevenson MAW Date: 10/20/93 06/14/96

Attachment: Pictures

Wisconsin Electric Power Company - Point Beach Nuclear Plant **SCREENING EVALUATION WORK SHEET (SEWS)**		GIP Rev 2, Corrected, 2/14/92 Status: Yes Sheet 2 of 2
ID : HX-12B (Rev. 0)	Class : 21 - Tanks and Heat Exchangers	
Description : COMPONENT COOLING WATER HEAT EXCHANGER		
Building : PAB	Floor El. : 46.0000	Room, Row/Col : AREA 5
Manufacturer, Model, Etc. :		

PICTURES



2HX-12D - CC Heat Exchangers & Saddles (Typical)

Wisconsin Electric Power Company - Point Beach Nuclear Plant SCREENING EVALUATION WORK SHEET (SEWS)		GIP Rev 2, Corrected, 2/14/92 Status: Yes Sheet 1 of 2
ID : HX-12C (Rev. 0)	Class : 21 - Tanks and Heat Exchangers	
Description : COMPONENT COOLING WATER HEAT EXCHANGER		
Building : PAB	Floor El. : 46.0000	Room, Row/Col : AREA 5
Manufacturer, Model, Etc. :		

BASIS : External analysis

1. The buckling capacity of the shell of a large, flat-bottom, vertical tank is equal to or greater than the demand.	N/A
2. The capacity of the anchor bolts and their embedments is equal to or greater than the demand.	Yes
3. The capacity of connections between the anchor bolts and the tank shell is equal to or greater than the demand.	Yes
4. Attached piping has adequate flexibility to accommodate the motion of a large, flat-bottom, vertical tank.	N/A
5. A ring-type foundation is not used to support a large, flat-bottom, vertical tank.	N/A

IS EQUIPMENT SEISMICALLY ADEQUATE? **Yes**

COMMENTS

The SRTs are M. A. Woznicki and J. D. Stevenson - 10/20/93.

REF: WEPCo. Calculation No. 86-020 Rev. 0 "New Component Cooling Water Heat Exchanger Support Design" and S&A Calculation No. 91C2696-C-007 Rev. 0 "USI A-46 / IPEEE, Equipment Fragilities for 1HX-12A, HX-12B, HX-12C and 2HX-12D".

Anchorage:
Heat Exchangers 1HX-12A, HX-12B, HX-12C and 2HX-12D are identical and located in a row next to each other. Each HX is supported on two saddles which are 18' apart. The fixed end saddle is anchored into the concrete floor by 2 - 1" grout-in-place bolts (embedment = 12"). The slotted end saddle is bolted onto a base plate by 2 - 1" bolts and the base plate is anchored into the concrete floor by 4 - 5/8" x 8.5" Hilti Kwik bolts (4.5" min. embedment).

The referenced S&A calculation perform an A-46 evaluation of the HX anchorage by scaling the HCLPF and concluded that the HX has an A-46 safety factor of at least 1.31, therefore the HX is adequately anchored.

Evaluated by: John D. Stevenson Date: 10/20/93

MAW 06/14/96

Attachment: Pictures

Wisconsin Electric Power Company - Point Beach Nuclear Plant **SCREENING EVALUATION WORK SHEET (SEWS)**		GIP Rev 2, Corrected, 2/14/92 Status: Yes Sheet 2 of 2
ID : HX-12C (Rev. 0)	Class : 21 - Tanks and Heat Exchangers	
Description : COMPONENT COOLING WATER HEAT EXCHANGER		
Building : PAB	Floor El. : 46.0000	Room, Row/Col : AREA 5
Manufacturer, Model, Etc. :		

PICTURES

2P-12D CC Heat Exchangers & Saddles (Typical)

Wisconsin Electric Power Company - Point Beach Nuclear Plant **SCREENING EVALUATION WORK SHEET (SEWS)**		GIP Rev 2, Corrected, 2/14/92 Status: Yes Sheet 1 of 2
ID : 2HX-12D (Rev. 0)	Class : 21 - Tanks and Heat Exchangers	
Description : COMPONENT COOLING WATER HEAT EXCHANGER		
Building : PAB	Floor El. : 46.0000	Room, Row/Col : AREA 5
Manufacturer, Model, Etc. :		

BASIS : External analysis

1. The buckling capacity of the shell of a large, flat-bottom, vertical tank is equal to or greater than the demand.	N/A
2. The capacity of the anchor bolts and their embedments is equal to or greater than the demand.	Yes
3. The capacity of connections between the anchor bolts and the tank shell is equal to or greater than the demand.	Yes
4. Attached piping has adequate flexibility to accommodate the motion of a large, flat-bottom, vertical tank.	N/A
5. A ring-type foundation is not used to support a large, flat-bottom, vertical tank.	N/A

IS EQUIPMENT SEISMICALLY ADEQUATE? **Yes**

COMMENTS

The SRTs are M. A. Woznicki and J. D. Stevenson - 10/20/93.

REF: WEPCo. Calculation No. 86-020 Rev. 0 "New Component Cooling Water Heat Exchanger Support Design" and S&A Calculation No. 91C2696-C-007 Rev. 0 "USI A-46 / IPEEE, Equipment Fragilities for 1HX-12A, HX-12B, HX-12C and 2HX-12D".

Anchorage:
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The referenced S&A calculation perform an A-46 evaluation of the HX anchorage by scaling the HCLPF and concluded that the HX has an A-46 safety factor of at least 1.31, therefore the HX is adequately anchored.

Evaluated by: J. D. Stevenson Date: 10/20/93

M. A. Woznicki 06/14/96

Attachment: Pictures

Wisconsin Electric Power Company - Point Beach Nuclear Plant **SCREENING EVALUATION WORK SHEET (SEWS)**		GIP Rev 2, Corrected, 2/14/92 Status: Yes Sheet 2 of 2
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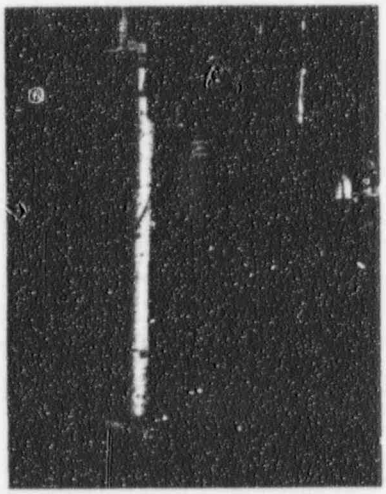
Building : PAB	Floor El. : 46.0000	Room, Row/Col : AREA 5
Manufacturer, Model, Etc. :		

PICTURES



2HX-12D - CC Heat Exchangers & Saddles (Typical)