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Monticello Nuclear Generating Plant
Operated by Nuclear Management Company, LLC

January 29, 2007

L-MT-07-008
10 CFR 50.90

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555

Monticello Nuclear Generating Plant
Docket 50-263
License No. DPR-22

Response to Request for Additional Information for a License Amendment Request for Contingent Installation of a Temporary Fuel Storage Rack in the Spent Fuel Pool (TAC No. MD0302)

References:
1) NMC letter to U.S. NRC, "License Amendment Request for Contingent Installation of a Temporary Spent Fuel Storage Rack," (L-MT-06-013), dated March 7, 2006.

2) NMC letter to U.S. NRC, "Supplement to a License Amendment Request for Contingent Installation of a Temporary Fuel Storage Rack in the Spent Fuel Pool (TAC No. MD0302)," (L-MT-06-044), dated May 30, 2006.

3) NMC letter to U.S. NRC, "Response to Request for Additional Information for a License Amendment Request for Contingent Installation of a Temporary Fuel Storage Rack in the Spent Fuel Pool (TAC No. MD0302)," (L-MT-06-058), dated September 7, 2006.

4) NMC letter to U.S. NRC, "Response to Request for Additional Seismic Information for a License Amendment Request for Contingent Installation of a Temporary Fuel Storage Rack in the Spent Fuel Pool (TAC No. MD0302)," (L-MT-06-087), dated January 2, 2007.

On March 7, 2006, as supplemented on May 30, 2006, the Nuclear Management Company, LLC (NMC) submitted a license amendment request for the Monticello Nuclear Generating Plant (References 1 and 2) to revise the licensing basis to allow temporary installation of a Programmed and Remote Systems Corporation 8x8 (64 cell) high-density fuel storage rack in the spent fuel pool to maintain full core off-load capability.

On September 7, 2006, (Reference 3) the NMC provided additional information on the structural, seismic and thermal hydraulic design of the proposed temporary high-density fuel storage rack. On December 8, 2006, the U.S. Nuclear Regulatory Commission (NRC) requested additional information (RAI) on the seismic design of the fuel storage rack during a teleconference. A response to this RAI on January 2, 2007, (Reference 4) provided an independent calculation performed by Stevenson & Associates on behalf of NMC entitled, "Evaluation of the 8X8 Spent Fuel Storage Rack to Determine the Natural Frequencies," which confirmed the natural frequency of the PaR 8x8 fuel storage rack and the validity of the simplified PaR models. During teleconferences on January 5, 2007, and January 22, 2007 the NRC requested clarification for several items and additional information concerning this calculation. Enclosure 1 provides Revision 2 to this calculation, which addresses these requests.

This letter makes no new commitments or changes to any existing commitments.

I declare under penalty of perjury that the foregoing is true and correct.

Executed on January 29, 2007.

John T. Conway

John T. Conway
Site Vice President, Monticello Nuclear Generating Plant
Nuclear Management Company, LLC

Enclosure: (1)

cc: Administrator, Region III, USNRC
Project Manager, Monticello, USNRC
Resident Inspector, Monticello, USNRC
Minnesota Department of Commerce

ENCLOSURE 1

REVISED EVALUATION OF THE 8X8 SPENT FUEL STORAGE RACK TO DETERMINE THE NATURAL FREQUENCIES

BY

STEVENSON & ASSOCIATES

REVISION 2

NMC

Calculation Signature Sheet

Document Information

NMC Calculation (Doc) No: CA-06-114	Revision: 2
Title:Evaluation of the 8X8 spent fuel storage rack to determine the natural frequencies	
Facility: ☒ MT ☐ PB ☐ PI ☐ PL ☐ HU/FT	Unit: ☒ 1 ☐ 2
Safety Class: ☒ SR ☐ Aug Q ☐ Non SR	
Special Codes: ☐ Safeguards ☐ Proprietary	
Calc Type (PassPort DOC-DESC-CODE): (if applicable, Palisades only)	

NOTE:	Print **and** sign name in signature blocks, as required.

Major Revisions

EC Number: 10036	☒ Vendor Calc
Vendor Name or Code:Stevenson & Associates	Vendor Doc No: 06Q4646-C-001 rev 2
Description of Revision:Added clarification on p7 & 9	
Prepared by: VENDOR	Date:
Reviewed by: DENNIS ZERCHER / [signature]	Date: 1-26-2007
Type of Review: ☐ Design Verification ☐ Tech Review ☒ Vendor Acceptance	
Method Used (For DV Only): ☐ Review ☐ Alternate Calc ☐ Test	
Approved by: Todd Hurrle / [signature]	Date: 1-26-07

Minor Revisions

EC No:	☐ Vendor Calc:
Minor Rev. No:	
Description of Change:	
Pages Affected:	
Prepared by:	Date:
Reviewed by:	Date:
Type of Review: ☐ Design Verification ☐ Tech Review ☐ Vendor Acceptance	
Method Used (For DV Only): ☐ Review ☐ Alternate Calc ☐ Test	
Approved by:	Date:

NMC	**Calculation Signature Sheet**

(continued on next page)

NMC	Calculation Signature Sheet

EC No:	☐ Vendor Calc:
Minor Rev. No:	
Description of Change:	
Pages Affected:	
Prepared by:	Date:
Reviewed by:	Date:
Type of Review: ☐ Design Verification ☐ Tech Review ☐ Vendor Acceptance	
Method Used (For DV Only): ☐ Review ☐ Alternate Calc ☐ Test	
Approved by:	Date:

EC No:	☐ Vendor Calc:
Minor Rev. No:	
Description of Change:	
Pages Affected:	
Prepared by:	Date:
Reviewed by:	Date:
Type of Review: ☐ Design Verification ☐ Tech Review ☐ Vendor Acceptance	
Method Used (For DV Only): ☐ Review ☐ Alternate Calc ☐ Test	
Approved by:	Date:

EC No:	☐ Vendor Calc:
Minor Rev. No:	
Description of Change:	
Pages Affected:	
Prepared by:	Date:
Reviewed by:	Date:
Type of Review: ☐ Design Verification ☐ Tech Review ☐ Vendor Acceptance	
Method Used (For DV Only): ☐ Review ☐ Alternate Calc ☐ Test	
Approved by:	Date:

NMC	Calculation Signature Sheet

NOTE:	This table is used for data entry into the PassPort Controlled Documents Module, reference tables. If the calculation references and inputs are all listed in the calculation directly, then only the inputs and outputs need to be listed here. If the calculation invokes this form for the list of references and inputs, then list them all here. Only the input and output references need to be entered in PassPort.

Associated Document References:

#	Document Name	Document Number	Doc Revision	Control Doc and Doc Type (i.e. in Pass-Port) :	Type (input, output, general ref):
1	Fuel Storage System Design Report	none	3	☐	input
2				☐	
3				☐	
4				☐	
5				☐	
6				☐	
7				☐	
8				☐	
9				☐	
10				☐	
11				☐	
12				☐	
13				☐	
14				☐	

Add additional lines if needed.

NMC	**Calculation Signature Sheet**

Associated Equipment or System References:

#	Facility	Unit	System	Equipment Type	Equipment Number
1	Monticello	1	FPC	Spent fuel storage rack	
2					
3					
4					
5					
6					
7					
8					
9					
10					

Add additional lines if needed.

Superseded Calculations

Facility	Calc Document Number	Title
mt	CA 06-114 rev 1	Evaluation of the 8X8 spent fuel storage rack to determine the natural frequencies

Add additional lines if needed.

Client:	Monticello Nuclear Generating Plant (MNGP)	Calculation No.	06Q4646-C-001
Title:	Evaluation of the 8X8 spent fuel storage rack to determine the natural frequencies		

Project: Evaluation of the 8X8 spent fuel storage rack to determine the natural frequencies

Method: Explained within

Acceptance Criteria: Explained within

Remarks:

Verification Method ☒ Design Review Method ☐ Alternate Calculation ☐ Qualification Test ☐ Other ☐ No Verification Necessary

Results: See body of calculation

Computer Programs Used	Program Name	Version/Revision	Release Date	QA Verified
	SAP2000	10.0.2	March 1. 2006	Yes

REVISIONS

Revision No.	0	1	2
Description	Original Issue	Included 10x10 rack model	Modified pg 7 & 9
Total Pages (Cumulative)	12	15	15
By/Date	Sung-June Kim / ~~12/18/06~~	Sung-June Kim / 1/10/07	Sung-June Kim 1/22/07
Checked/Date	Violeta Medina Andres / 12/18/06	Tsiming Tseng / 1/10/07	Tsiming Tseng 1/22/07
Approved/Date	Walter Djordjevic / 12/18/06	Walter Djordjevic / 1/10/07	Walter Djordjevic 1/22/07

S&A Stevenson & Associates	CALCULATION COVER SHEET FIGURE 2.9	CONTRACT NO. **06Q4646**

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1. Objective

The existing 8x8 spent fuel storage rack was obtained from Duane Arnold which procured the rack from PAR Systems in 1977 with seismic qualification. The seismic evaluation portion of the referenced report evaluates 8x12, 9x12, 8x11 and 10x11 rack configurations, and determines the lateral and vertical fundamental frequencies to be 8 Hz and 14 Hz.

The objective of this calculation is to determine the natural frequency of the 8x8 spent fuel storage rack and show that the dynamic characteristics of the 8x8 fuel rack are within the range of the PAR Systems qualification.

2. Executive Summary

The objective of this calculation is to determine the natural frequency of the 8x8 spent fuel storage rack, which was obtained from Duane Arnold which procured the rack from PAR Systems in 1977 with seismic qualification. The simplified 2D dynamic model presented in the PAR Systems qualification report [1], was recreated and validated by comparing the results of current runs using the same rack models (8x11 and 10x10 fuel racks) as given in the aforementioned report [1].

The 8x8 fuel rack was then modeled by amending the input properties of the SAP2000 model. The properties were computed following the same methodology presented in referenced report [1]. The 1st horizontal natural frequency is found to be at 9.0 Hz. The "*Casting Bottom*" vertical mode is approximately 23 Hz.

Comparison between the Iowa Spec. M-303 response spectrum and the MNGP time history response spectrum at 5% damping shows that the Iowa Spec. M-303 envelopes the MNGP response spectrum both vertically and horizontally in frequency ranges that are approximately higher than 5 Hz and 2.5 Hz, respectively. Since the 8x8 fuel rack natural frequency lies within this range, it can be concluded that the Iowa Spec. M-303 loads shall always be larger than MNGP. Thus, the original qualification report [1] should insure the seismic qualification of the 8x8 fuel rack configuration as well.

3. References

1. PAR Systems Report Sect. 5.3., "Model Description, Formulation and Assumptions for the Seismic Analysis of BWR Spent Fuel Racks at DAEC, JAF and Peach Bottom", Rev. 3, March 27,1978
2. Roark's Formulas for Stress and Strain, Warren C. Young, 6th Edition, McGraw-Hill International Editions, 1989
3. CSI, SAP2000, Integrated Software for Structural Analysis and Design, Version 10.0.2.

4. METHODOLOGY

The rack structure is a large rectangular tube enveloped by the side panels with no structural stiffness added for either the poison cans or fuel assemblies. Dynamic analysis of a detailed SAP IV model have determined a lower bound horizontal frequency for the 4 fuel rack configurations to be approximately at 8 Hz with a vertical diaphragm fundamental frequency of the bottom casting to be at 14 Hz [1].

A simplified ANSYS model (see Fig. 2 of [1]), consisting of a cantilever beam extending the height of the racks, attached to a horizontal beam at the base bottom casting elevation with leg beams connecting the ends of this member to the floor, show that the fundamental frequencies of this idealized system agree quite closely with the detailed model. Thus, this simplified model will be used to determine the natural frequency of the 8x8 rack.

The methodology consists of the steps outlined below. The detailed calculations, organized according to these steps, are provided in Sect. 6. The coordinate system used in the calculations follows the right hand rule, where the XY plane = floor plane and Z = Vertical.

1. Recreate and match the dynamic characteristics of the simplified dynamic ANSYS model (Fig. 2 of [1]) with the new SAP2000 model
2. Model a 8x8 fuel rack by amending the properties of the SAP2000 model; follow the same procedures presented in [1] for consistency
3. Perform a modal analysis in order to obtain the natural frequencies of the 8x8 fuel rack

Note that two fuel rack configurations, 8x11 and 10x10, were chosen for comparison of the simplified model to the detailed model for the following reasons:

- The 8x11 fuel rack was determined to have the lowest 1st horizontal frequency mode of all 4 fuel rack configurations.
- The 10x10 fuel rack was chosen because it matches the configuration of the detailed 10x10 SAPIV model shown in Figure 1 of the PaR report [Ref. 1].

5. GENERAL DESIGN INPUTS FOR COMPUTER MODELS

Metal Plate Properties [1]

Young's Modulus:	E = 10300 ksi
Shear Modulus:	G = 3800 ksi

Cavity Loads [1]

Dry Module Mass	136 lbf	Wet Module Weight	78 lbf
Dry Fuel & Channel Mass	745 lbf	Wet Fuel & Channel	672 lbf
Entrapped Water Mass	181 lbf		
Total Horizontal Mass	1062 lbf/cavity	Total Wet Wt.	750 lbf/cavity

6. CALCULATION

The simplified models for an 8x11, 10x10 and 8x8 are constructed based on the data provided in Reference [1]. In this section, a modal analysis is performed for each of the simplified models and compared to the detailed model reported frequency results

6.1 SAP2000 Model – 8x11 Fuel Rack

6.1.1 Properties and Input

First recreate the original 8x11 fuel rack model in SAP2000. The following properties are presented in Reference [1].

Module size = 8 x 11
Rack height = 167 in
No. Cavity = 88
M2 = 32780 lbf
M1 = 22374 lbf
Xl = 23.2 in
I2 = 66520 in^4
A2 = 126 in^2
A2s = 63 in^2
I3 = 388000 in^4
A3 = 167 in^2
A3s = 167 in^2 (use total area, [1])
I4 = 280 in^4
A4 = 38 in^2
A4s = 19 in^2
I5 = 211 in^4
A5 = 153 in^2
A5s = 76.5 in^2

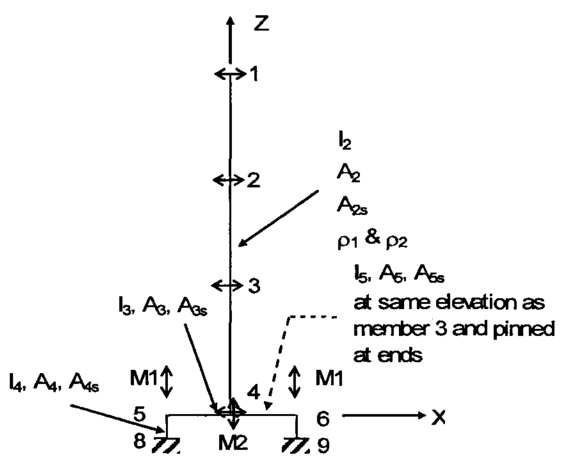

Figure 1: Single Rack Attached Fuel Model (Fig. 2 [1])

Total weight of Section 2 is recomputed accordingly (include weight of Sect. 1),

Total weight for Sect. 1 W1 = 65560 lbf [1]
Total weight for Sect. 2 W2 = 27896 lbf [1]

Total weight Ws = 93456 lbf = W1 + W2

6.1.2 Joint Coordinates

Joint ID	X (in)	Y (in)	Z (in)
1	0	0	167
2	0	0	111.33
3	0	0	55.67
4	0	0	0
5	-23.2	0	0
6	23.2	0	0
7	-23.2	1	0
8	-23.2	0	-10
9	23.2	0	-10

Joint ID	X (in)	Y (in)	Z (in)
10	23.2	1	0
11	0	1	0

Per Reference 1, Section 5, which represents the vertical diaphragm of the "bottom casting", is located at the same elevation as Section 3 but is not attached to it. However, SAP2000 does not allow two different nodes to be assigned at the same location, therefore Section 5 is offset 1" in the Y – direction. Joints 5 & 7 and 6 & 10 are assigned *rigid body* constraints.

It is noted that nodes 2 & 3 are equally spaced between nodes 1 & 4 in order to have a more uniform distribution, which gives a better representation of the model. This minor adjustment is carried throughout this calculation.

6.1.3 Distributed Mass

Concentrated fuel, racks and water mass at nodes 1 and 4 in X-direction only = 40.33 lbf-s^2/in = Ws / g / 6

Concentrated fuel, racks and water mass at nodes 2 and 3 in X-direction only = 80.66 lbf-s^2/in = Ws / g / 3

Concentrated fuel mass at node 11 In Z-direction only = 84.9 lbf-s^2/in = M2 / g

Concentrated masses at nodes 5 and 6 In Z-direction only = 57.9 lbf-s^2/in = M1 / g

6.1.4 Model Results and Comparisons

The results of the SAP2000 model for the 8x11 rack is presented in the following. The 1st and 2nd horizontal natural frequencies are given at 8.2 Hz and 33.7 Hz, respectively. The "Casting Bottom" vertical mode is approximately 17.2 Hz.

Mode	Frequency	Description
1	8.2	1st horizontal mode
2	17.2	"Casting Bottom" vertical mode
3	33.7	2nd horizontal mode
4	61.4	3rd horizontal mode

Reference [1] determined the lower bound for the fuel rack configurations to be approximately 8 Hz. The results of the SAP2000 model validates the reports statement. Also, the vertical diaphragm frequency of the bottom casting was computed to be at 17.7 Hz [1] (for the 8x11 fuel rack), which is also close to the recreated model 17.2 Hz (~ 3% difference).

6.2 SAP2000 Model – 10 x 10 Fuel Rack

6.2.1 Properties and Input

The following properties are calculated based on information presented in Reference [1] for the 6-5/8" cell size.

Module 10x10 fuel rack

Properties				
elastic modulus	E =	10300000	psi	given
# of cavities in X direction	Nx =	10		given
# of cavities in Y direction	Ny =	10		given
center to center distance between fuel channels	c.c =	6.625	in	for types similar to those in IOWA
outside length of fuel channel	lout =	5.494	in	given
inside length of fuel channel	lin =	5.273	in	given
rack height	L =	167	in	given
weight / cavity	Wt/cavity	745	lbf	given
area of fuel channel	A =	2.38	in^2	= lout^2 - lin^2
moment of inertia of channel	I =	11.50	in^4	= (lout^4 - lin^4) / 12
shear area	As =	1.19	in2	= A / 2
Module Section Properties				
total # of cavities	N =	100		= Nx x Ny
distance between supports	X1 =	29.8	in	= (Nx - 1) x c.c / 2
Section 2				
rack depth	b =	66.3	in	= Ny x c.c.
rack width	h =	66.3	in	= Nx x c.c.
area	A2 =	132.5	in^2	= (2/2) x b + (2/2) x h
moment of inertia	I2 =	100254	in^4	= h^3/12 + b x (h/2 + 0.75)^2
shear area	A2s =	66	in^2	= A2 / 2
Section 3				
moment of inertia	I3 =	388000	in^4	given
area	A3 =	167	in^2	given
Section 4				
moment of inertia	I4 =	280	in^4	given
area	A4 =	38	in^2	given
shear area	A4s =	19	in^2	= A4 / 2
Section 5				
design area	Ad =	9	in^2	given
mid span deflection [1]	Δ =	0.055	in	= 1.36 x (10^-5) x Nx x Ny x (Nx - 1)^2 x (Ny - 1)^2 / ((Nx - 1)^2 + (Ny - 1)^2)
moment of inertia	Ieff =	362	in^4	= 5 x Wt/cavity x Nx x Ny x (Nx - 1)^3 x c.c^3 / (384 x E x D)
frequency of bottom casting	fw =	15.007	Hz	= π / (2 x (Nx - 1) x c.c.) x sqrt(E x Ieff x g / (N x Wt/cavity x (Nx - 1) x c.c.))

area	A5 =	162	in^2	= ((Nx - 1) + (Ny - 1)) x Ad
shear area	A5s =	81	in^2	= A5 / 2

6.2.2 Joint Coordinates

Joint ID	X (in)	Y (in)	Z (in)
1	0	0	167
2	0	0	111.33
3	0	0	55.67
4	0	0	0
5	-29.8	0	0
6	29.8	0	0
7	-29.8	1	0
8	-29.8	0	-10
9	29.8	0	-10
10	29.8	1	0
11	0	1	0

6.2.3 Distributed Mass

Total weight for Sect. 1 W1 = 74500 lbf = N x 745 lbf
Total weight for Sect. 2 W2 = 31700 lbf = N x (181 lbf + 136 lbf)

Total weight Ws = 106200 lbf = W1 + W2

Concentrated fuel, racks and water mass at nodes 1 and 4 in X-direction only = 45.9 lbf-s^2/in = Ws / g / 6

Concentrated fuel, racks and water mass at nodes 2 and 3 in X-direction only = 91.7 lbf-s^2/in = Ws / g / 3

Concentrated fuel mass at node 11 In Z-direction only, M2 = 37250 lbf = ½ x 100 x 745 lbf
m2 = 96.5 lbf-s^2/in = M2 / g

Concentrated masses at nodes 5 and 6 In Z-direction only M1 = 25425 lbf = ½ x 100 x 136 lbf + ¼ x 100 x 745 lbf
m1 = 65.9 lbf-s^2/in = M1 / g

6.2.4 Model Results and Comparisons

The results of the SAP2000 model for the 10x10 rack are presented below The simplified model frequencies are 8.9 Hz for the fundamental horizontal mode, 14.5 Hz for the vertical diaphragm mode and 34.2 Hz for the 2nd horizontal mode. The simplified model's fundamental horizontal frequency is within about 10% of that of the detailed model and the fundamental vertical frequency is within about 3%.

Mode	Frequency	Description
1	8.9	1st horizontal mode
2	14.5	"Casting Bottom" vertical mode
3	34.2	2nd horizontal mode

6.3 SAP 2000 Model - 8x8 Rack Model

6.3.1 Properties and Inputs

The methodology in computing the following properties closely follows that presented in Reference [1]. This will ensure consistency between the models.

Module 8x8 fuel rack

Properties				
elastic modulus	E =	10300000	psi	given
# of cavities in X direction	Nx =	8		given
# of cavities in Y direction	Ny =	8		given
center to center distance between fuel channels	c.c =	6.625	in	for types similar to those in IOWA
outside length of fuel channel	lout =	5.494	in	given
inside length of fuel channel	lin =	5.273	in	given
rack height	L =	167	in	given
weight / cavity	Wt/cavity	745	lbf	given
area of fuel channel	A =	2.38	in^2	= lout^2 - lin^2
moment of inertia of channel	I =	11.50	in^4	= (lout^4 - lin^4) / 12
shear area	As =	1.19	in2	= A / 2
Module Section Properties				
total # of cavities	N =	64		= Nx x Ny
distance between supports	X1 =	23.2	in	= (Nx - 1) x c.c / 2
Section 2				
rack depth	b =	53.0	in	= Ny x c.c.
rack width	h =	53.0	in	= Nx x c.c.
area	A2 =	106.0	in^2	= (2/2) x b + (2/2) x h
moment of inertia	I2 =	51762	in^4	= h^3/12 + b x (h/2 + 0.75)^2
shear area	A2s =	53	in^2	= A2 / 2
Section 3				
moment of inertia	I3 =	388000	in^4	given
area	A3 =	167	in^2	given
Section 4				
moment of inertia	I4 =	280	in^4	given
area	A4 =	38	in^2	given
shear area	A4s =	19	in^2	= A4 / 2
Section 5				
design area	Ad =	9	in^2	given

mid span deflection [1]	Δ =	0.021	in	= 1.36 x (10^-5) x Nx x Ny x (Nx - 1)^2 x (Ny - 1)^2 / ((Nx - 1)^2 + (Ny - 1)^2)
moment of inertia	Ieff =	282	in^4	= 5 x Wt/cavity x Nx x Ny x (Nx - 1)^3 x c.c^3 / (384 x E x Δ)
frequency of bottom casting	fw =	24.118	Hz	= π / (2 x (Nx - 1) x c.c.) x SQRT(E x Ieff x g / (N x Wt/cavity x (Nx - 1) x c.c.))
area	A5 =	126	in^2	= ((Nx - 1) + (Ny - 1)) x Ad
shear area	A5s =	63	in^2	= A5 / 2

6.3.2 Joint Coordinates

The same coordinates are used as in the previous 8x11 model.

6.3.3 Distributed Mass

Total weight for Sect. 1	W1	= 47680 lbf	= N x 745 lbf
Total weight for Sect. 2	W2	= 20288 lbf	= N x (181 lbf + 136 lbf)
Total weight	Ws	= 67968 lbf	= W1 + W2

Concentrated fuel, racks and water mass at nodes 1 and 4 in X-direction only = 29.33 lbf-s^2/in = Ws / g / 6

Concentrated fuel, racks and water mass at nodes 2 and 3 in X-direction only = 58.65 lbf-s^2/in = Ws / g / 3

Concentrated fuel mass at node 11 In Z-direction only,	M2	= 23840 lbf	= ½ x 64 x 745 lbf
	m2	= 61.7 lbf-s^2/in	= M2 / g
Concentrated masses at nodes 5 and 6 In Z-direction only	M1	= 16272 lbf	= ½ x 64 x 136 lbf + ¼ x 64 x 745 lbf
	m1	= 42.144 lbf-s^2/in	= M1 / g

6.3.4 Model Results and Comparisons

The results of the SAP2000 model for the 8x8 rack are presented below The 1st and 2nd horizontal natural frequencies are given at 9.0 Hz and 36.3 Hz, respectively. The "Casting Bottom" vertical mode is approximately 23 Hz, which is greater than the 14 Hz mode reported for the 10x10 rack due to the overall difference in vertical mass (64 fuel cells compared to 100 fuel cells in the 10x10 rack)..

Mode	Frequency	Description
1	9.0	1st horizontal mode
2	23.0	"Casting Bottom" vertical mode
3	36.3	2nd horizontal mode

6.4 Simplified Model Validation

The 10x11 rack configuration [1] was also investigated simply for the purpose of additional model comparisons. The results of the SAP2000 simplified models for the 8x11, 10x10 and 10x11 racks, as well as the results of the 8x8 simplified rack model, are compared in Table 1 below to the frequency response data given in the PaR report [Ref. 1] for the detailed 10x10 model:

Table 1
Comparison of Simplified vs. Detailed Model Results

Rack Configuration	Fundamental Horizontal Frequency (Hz)	Fundamental Vertical Frequency (Hz)	Second Horizontal Frequency (Hz)
10x10 Detailed Model	**8**	**14**	**>28**
10x10 Simplified Model	8.9	14.5	34.2
10x11 Simplified Model	8.6	13.2	33.4
8x11 Simplified Model	8.2	17.2	33.7
8x8 Simplified Model	9	23	36.3

The results for the 10x10 simplified model compare well with the results reported for the detailed model. The fundamental horizontal and vertical frequencies are within about 10% of one another. The fundamental vertical mode is a diaphragm mode of the casting bottom. The second horizontal mode is 34.2 Hz, which is greater than 28 Hz. This difference has no effect on the load and stress evaluations of the racks since the Artificial Time History Response Spectrum used in the PaR analysis and the Monticello 5% Response Spectrum amplitudes effectively do not vary at frequencies greater than 28 Hz.

The 10x11, 8x11 and the 8x8 simplified model results also compare well thus supporting the statement made in the PaR report that the simplified model is a reasonable model for similar but different rack configuration combinations varying from 8 to 12 fuel cells on a side.

It is reasonably concluded that the SAP2000 simplified model is validated and is capable of capturing the dynamic properties of the 8x8 rack.

7. CONCLUSION

The simplified 2D dynamic model presented in PAR Systems qualification report [1], was recreated in SAP2000. Comparison of the results of current runs using the same rack models, an 8x11 and a 10x10 fuel rack, as given in the aforementioned report [1] showed that the models matched well. The conclusions drawn from the table are:

- The frequency results of the 10x10 simplified model agree very well with detailed 10x10 model results
- The 10x11, 8x11 and 8x8 rack configurations also agree well, even though they are slightly different rack configurations, which indicates that the variability of frequency results is not large even for slightly different rack configurations. This supports the PaR report conclusion that the "*simplified*" model is representative for all of the rack configurations varying from 8 to 12 fuel cells on a side.

- Since the fundamental frequencies are in good agreement for all rack configurations, the conclusion that the 8x8 rack is bounded by the results contained in the PaR report is further substantiated.

The vertical and horizontal response spectra for 6% damping of Iowa Spec. M-303 overlaid with the MNGP response spectra at 5% damping are presented in Attachment A. Note that the racks have been qualified under the 6% Iowa Spec. M-303 response spectrum curves. The comparison shows that the Iowa Spec. M-303 envelopes the MNGP response spectrum both vertically and horizontally in frequency ranges that are higher than 5 Hz and 2.5 Hz, respectively. Since the 8x8 fuel rack natural frequency is higher than 5 Hz, it can be concluded that the Iowa Spec. M-303 loads shall always be larger than MNGP. Thus, the original qualification report [1] insures the seismic suitability of the 8x8 fuel rack configuration as well.

STEVENSON & ASSOCIATES a structural-mechanical consulting engineering firm	JOB NO.: 06Q4646 Calculation: C-001 Client: Monticello Nuclear Generating Plant (MNGP)	Sheet A1 of 15 Date: 1/22/2007 Revision: 2
	Attachment A **Time History Response Spectrum Comparison**	By: SJK Check: TMT

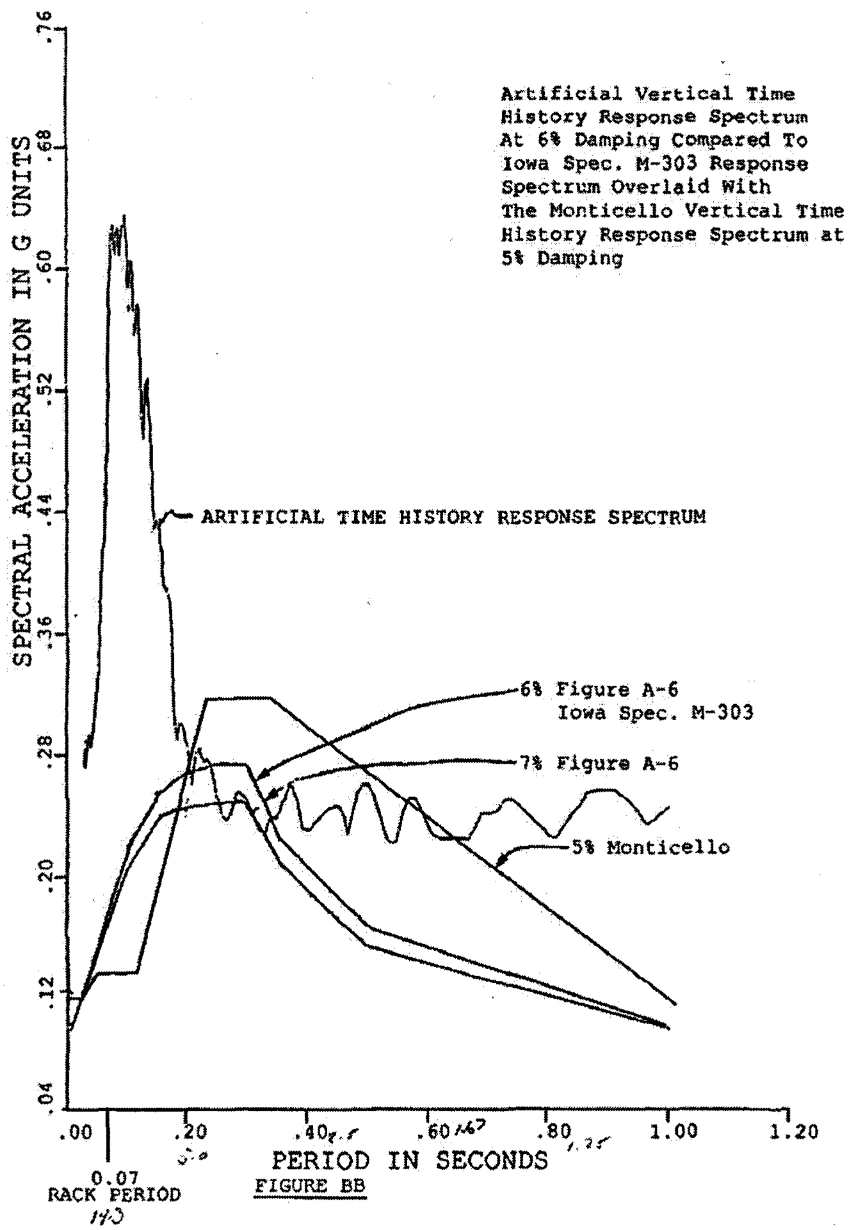

FIGURE BB

Attachment A

Time History Response Spectrum Comparison

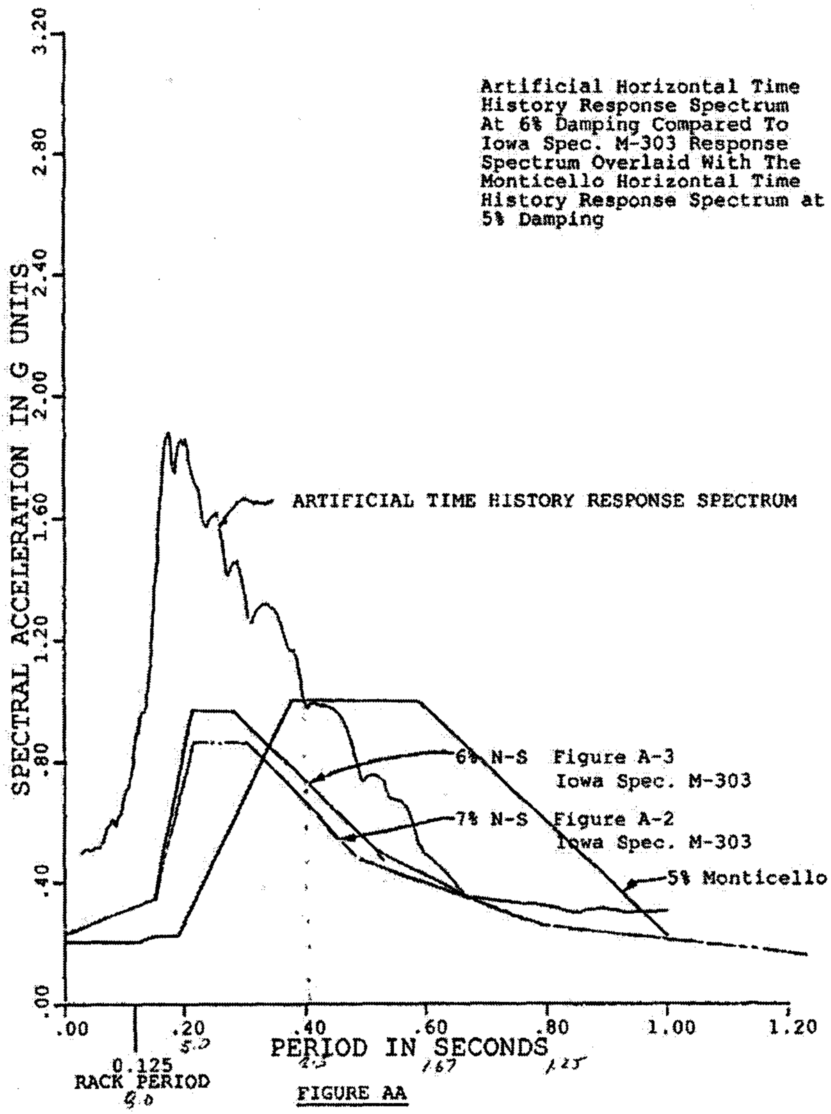

FIGURE AA