NMC
Committed to Nuclear Excellence

Monticello Nuclear Generating Plant
Operated by Nuclear Management Company, LLC

January 2, 2007

L-MT-06-087
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 Seismic 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.

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 (PaR) 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) during a teleconference with the NMC requested additional information pertaining to the seismic design of the fuel storage rack. Enclosure 1 provides the response to this request. Enclosure 2 provides a copy of a calculation performed by Stevenson & Associates on behalf of NMC to independently determine the natural frequencies of the PaR 8x8 fuel storage rack.

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 02, 2007.

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

Enclosures: (2)

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

ENCLOSURE 1

SEISMIC RAI RESPONSE

Background

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

On September 7, 2006, (Reference 3) 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) during a teleconference with the NMC requested additional information (RAI) pertaining to the seismic design of the fuel storage rack. The RAIs are shown in bold and the NMC responses are provided immediately thereafter in standard type.

NRC Request for Additional Information

NMC provided results of seismic analyses performed in 1977 for the following spent fuel storage rack configurations: 8x10, 8x11, 9x12, and 10x11 cells, using an Iowa plant site response spectrum. NMC utilized the above analyses to qualify the PaR (8x8) spent fuel storage rack at Monticello plant.

The NRC staff reviewed the NMC submittals and has the following comments:

(1) The frequency ranges at which the maximum spectral acceleration amplitude appears differ significantly between Iowa, Monticello response spectra and that from an artificial time history, as tabulated below (based on Figure AA and BB of Enclosure 1 of the 9/7/06 submittal):

Specification Site	Frequency Corresponding to Maximum Horizontal Spectral Acceleration	Frequency Corresponding to Maximum Vertical Spectral Acceleration
Iowa	3.6 - 4.5 Hz	3.3 - 6.2 Hz
Monticello	1.6 - 2.6 Hz	3.3 - 4.3 Hz
Artificial Time History	4.5 - 5.5 Hz	3.3 - 4.3 Hz

The Figure AA and BB and the above table indicate that the two response spectra (Iowa and Monticello sites) are significantly different, especially for the horizontal component of the ground motion. More important, contrary to the assertion made by NMC (Section 3.0 (3) of Enclosure 1 to the 9/7/06 letter), the time history spectrum used in the seismic response analysis does

not envelop the specific spectrum (Monticello plant site) as required by RG 1.60.

The site design response spectrum for the fuel storage racks analysis at the MNGP was generated in compliance with the requirements of Regulatory Guide 1.60, "Design Response Spectra for Seismic Design of Nuclear Power Plants," Revision 1, dated December 1973. This site design response spectrum was used to generate the horizontal and vertical floor response spectra at the spent fuel pool elevation. These are the MNGP response spectra shown on Figures AA and BB.

While it is true that both the vertical and horizontal artificial time history response spectrums shown on Figures AA and BB do not envelope the MNGP floor response spectrum over the entire frequency range, the fundamental frequencies used in the PaR analysis are 14.0 Hz vertical and 8.0 Hz horizontal. In the range of fundamental frequencies for the PaR 8x8 fuel storage rack (23 Hz vertical, 9 Hz horizontal, Enclosure 2) to zero period (∞ Hz) the artificial time history response spectrum does bound the MNGP response spectrum by a wide margin. Thus the seismic loading used in the 1977 PaR Systems Report will bound loads from a seismic evaluation using the MNGP response spectrum.

It should be noted that the MNGP does not have a 6 percent damping response spectra. The 5 percent MNGP response spectra is plotted on Figures AA and BB to compare to the artificial time history response spectrum which was for a 6 percent damping. A 6 percent damping response spectra for the MNGP would be lower than the 5 percent shown.

(2) The submittals are lacking structural and seismic analyses for the proposed 8x8 spent fuel storage rack. The seismic analysis results provided by NMC were all for the existing fuel rack configurations at a different plant site, and those rack configurations do not envelop the proposed rack configuration. In addition, only two components (1 horizontal and 1 vertical) of ground motion were considered in the seismic analyses; this is not in compliance with the guidelines of RG 1.60.

The 1977 PaR Systems Report provided structural and seismic analyses for the various fuel storage rack sizes listed therein, which encompasses the 8x8 fuel storage rack to be installed at the MNGP in the event of a full-core offload was required. Although the PaR Systems Report did not specifically analyze all sizes and configurations of the fuel storage racks qualified in the report, the analyses performed on the fuel storage rack configurations bound the fuel storage racks listed within the report. Two response spectrums were generated, a horizontal and a vertical. The last paragraph on page 9 in Section 5.3 of the PaR Systems Report indicates that an equal load set was applied in an orthogonal plane and that the results were combined using the square-root-sum-of-the-squares (SRSS) method. This substantiates that the load and stress results are based on 3 components of seismic motion, two simultaneous horizontal directions combined with the vertical direction.

During a teleconference with the NRC staff on December 8, 2006, the staff indicated that the PaR Systems Report (Reference 1) did not clearly identify that the frequencies for the evaluated fuel storage racks enveloped the 8x8 fuel storage rack proposed to be used, if necessary, at the MNGP. To resolve this issue, NMC directed Stevenson & Associates to perform a calculation to independently determine the natural frequencies of the PaR Systems 8x8 fuel storage rack. Enclosure 2 provides a copy of this calculation. The results of this calculation confirm the statements made by NMC in our September 7, 2006, RAI response (Reference 3). A summary of the analysis is presented below.

The simplified 2-dimensional dynamic model presented in the PaR Systems qualification report was recreated and validated by comparing the results to a SAP2000 computer program (Reference 4) run using the same fuel storage rack model (8x11) as given in the 1977 PaR Systems Report. The results for the recreated model indicate a horizontal first mode frequency of 8.2 Hz and a vertical frequency 17.2 Hz. These results are within three (3) percent of the PaR Systems Report values, thus validating that this modeling technique is capable of adequately capturing the dynamic properties of the PaR 8x8 fuel storage rack.

The PaR 8x8 fuel storage rack was then modeled by amending the input properties of the SAP2000 model. The properties were computed following the same methodology presented in the 1977 PaR Systems Report. The 8x8 fuel storage rack model yielded the following results: a first mode horizontal natural frequency of 9.0 Hz and a vertical frequency of 23.0 Hz. Since these values are bounded by (are higher than) the PaR Systems Report values and the response spectra used by PaR bounds the MNGP spectra for the frequency ranges of interest, these results confirm that the PaR Systems Report is conservative for the 8x8 fuel storage rack, that is proposed for use at the MNGP in the event that an emergency full-core offload is necessary.

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. CSI, SAP2000, Integrated Software for Structural Analysis and Design, Version 10.0.2.

ENCLOSURE 2

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

BY

STEVENSON & ASSOCIATES

Engineering Change

Company Name :	Nuclear Management Company, LLC	Print Date: 01/02/2007
EC Number :	0000009757 000	
Status/Date :	MODIFIED 01/02/2007	
Facility :	MT MONTICELLO	
Type/Sub-type:	DOC	Page: 1

EC Title: CA-06-114, EVALUATION OF THE 8X8 SPENT FUEL RACK TO DETERMINE THE NATURAL FREQUENCIES

Mod Nbr : KW1: KW2: KW3: KW4: KW5:

Master EC :	N	Work Group :		Temporary :	N
Outage :	N	Alert Group:	E-ME/CS DE	Aprd Reqd Date:	12/29/2006
WO Required :	N	Image Addr :		Exp Insvc Date:	
Adv Wk Appvd:	N	Alt Ref. :		Expires On :	
Auto-Advance:	N	Priority :		Auto-Asbuild :	N
Caveat Outst:		Department :		Discipline :	
Resp Engr :	DENNIS	A ZERCHER			
Location :					

Units

Fac	Unit	Description
MT	1	UNIT 1

Systems

Fac	System	Description
MT	STR	Structures & Buildings

Engineering Change

Print Date: 01/02/2007

NMC Committed to Nuclear Excellence

Page: 1

EC Number	:	0000009757 000
Status/Date	:	MODIFIED 01/02/2007
Facility	:	MT
Type/Sub-type	:	DOC

EC Title: CA-06-114, EVALUATION OF THE 8X8 SPENT FUEL RACK TO DETERMINE THE NATURAL FREQUENCIES

Mod Nbr : KW1: KW2: KW3: KW4: KW5:

Master EC :	N	Work Group :		Temporary :	N
Outage :	N	Alert Group:	E-ME/CS DE	Aprd Reqd Date:	12/29/2006
WO Required :	N	Image Addr :		Exp Insvc Date:	
Adv Wk Appvd:	N	Alt Ref. :		Expires On :	
Auto-Advance:	N	Priority :		Auto-Asbuild :	N
Caveat Outst:		Department :		Discipline :	
Resp Engr :	DENNIS A ZERCHER				
Location :					

Milestone	Date	PassPort	Name		Req By
APPROVED BY	12/28/2006	N104322	OHOTTO	JOSHUA	APPROVED
Vendor acceptance performed by site personnel.					
CLOSE					CLOSED
DSGN VERIFY	12/27/2006	ZRCD01	ZERCHER	DENNIS	
This is a vendor (Stevenson & Associates) calculation. See the calcualtion for the desgin verification completed by Stevenson & Associates.					
PREPARED (DOC)	12/27/2006	ZRCD01	ZERCHER	DENNIS	H/APPR

Engineering Change

EC Number : 0000009757 000
Facility : MT
Type/Sub-type: DOC

Print Date: 01/02/2007

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Attributes

Attribute Sub-category: DOC

Attribute Name	Value	PassPort	Date
SCRN NO	SCR-06-0575	ZRCD01	12/27/2006

Engineering Change

EC Number : 0000009757 000
Facility : MT
Type/Sub-type: DOC

Print Date: 01/02/2007

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Topic : REVIEWER COMMENTS
From Panel : TIME100

Last Updated By :
Last Updated Date:
Text Status :

Engineering Change

EC Number	:	0000009757 000
Facility	:	MT
Type/Sub-type:		DOC

Print Date: 01/02/2007

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Topic	:	JUSTIFICATION	**Last Updated By**	:	ZRCD01
From Panel	:	TIME100	**Last Updated Date**	:	12/27/2006
			Text Status	:	UNLOCKED

See attached calcualtion for details of the evaluation of the spnt fuel storage rack natural frequencies.

Engineering Change

EC Number : 0000009757 000
Facility : MT
Type/Sub-type: DOC

Print Date: 01/02/2007

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Topic : DESCRIPTION
From Panel : TIME100

Last Updated By : ZRCD01
Last Updated Date: 12/27/2006
Text Status : UNLOCKED

The purpose of this calcualtion is to determine the natural frequencies of the PaR 8X8 spent fuel storage rack.

QF-0549 (FP-E-CAL-01), Rev. 1

NMC	**Calculation Signature Sheet**

Document Information

NMC Calculation (Doc) No: CA-06-114	Revision: 0
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: 9757	☒ Vendor Calc
Vendor Name or Code:Stevenson & Associates	Vendor Doc No: 06Q4646-C-001
Description of Revision:Initial	
Prepared by: BY VENDOR	Date:
Reviewed by: DENNIS ZERCHER / [signature]	Date: 12-21-2006
Type of Review: ☐ Design Verification ☐ Tech Review ☒ Vendor Acceptance	
Method Used (For DV Only): ☐ Review ☐ Alternate Calc ☐ Test	
Approved by: Josh Ohotto / [signature]	Date: 12-21-2006

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

Add additional lines if needed.

MONTICELLO NUCLEAR GENERATING PLANT		3494
TITLE:	**CALCULATION COVER SHEET**	Revision 17
		Page 1 of 1

Title *Evaluation of the 8X8 spent fuel storage rack to determine the natural frequencies* CA- *06* - *114* Rev. *0*

10 CFR50.59 Screening or Evaluation No: *SCR-06-0575*

Associated Reference(s): *EC 9757*

Does this calculation:	YES	NO	Calc No(s), Rev(s), Add(s)
Supercede another calculation?	☐	☒	
Augment (credited by) another calculation?	☐	☒	
Affect the Fire Protection Program per Form 3765?	☐	☒	If Yes, attach Form 3765
Affect piping or supports?	☐	☒	If Yes, attach Form 3544
Affect IST Program Valve or Pump Reference Values, and/or Acceptance Criteria?	☐	☒	If Yes, inform IST Coordinator and provide copy of calculation

What systems are affected?

DBD Section (if any): B.02.01

Topic Code (See Form 3805): FPC

Structure Code (See Form 3805): STR

Other Comments:

Prepared by: Dennis Zeachon [signature] Date: 12-21-2006
Print/Signature

M/cah

QF-0547 (FP-E-MOD-11) Rev. 0

NMC Committed to Nuclear Excellence Fleet Modification Process	**External Design Document Suitability Review Checklist**

External Design Document Being Reviewed:calculation

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

Number: CA-06-114 Rev: 0 Date: 12/21/06

This design document was received from:

Organization Name: Stevenson & Associates PO or DIA Reference: Located in EC 9757

The purpose of the suitability review is to ensure that a calculation, analysis or other design document provided by an External Design Organization complies with the conditions of the purchase order and/or Design Interface Agreement (DIA) and is appropriate for its intended use. The suitability review does not serve as an independent verification. Independent verification of the design document supplied by the External Design Organization should be evident in the document, if required.

The reviewer should use the criteria below as a guide to assess the overall quality, completeness and usefulness of the design document. The reviewer is not required to check calculations in detail.

REVIEW		**Check**
1.	Design inputs correspond to those that were transmitted to the External Design Organization.	☒
2.	Assumptions are described and reasonable.	☒
3.	Applicable codes, standards and regulations are identified and met.	☐ N/A
4.	Applicable construction and operating experience is considered.	☐ N/A
5.	Applicable structure(s), system(s), and component(s) are listed.	☒
6.	Formulae and equations are documented. Unusual symbols are defined.	☒
7.	Acceptance criteria are identified, adequate and satisfied.	☒
8.	Results are reasonable compared to inputs.	☒
9.	Source documents are referenced.	☒
10.	The document is appropriate for its intended use.	☒
11.	The document complies with the terms of the Purchase Order and/or DIA.	☒
12.	Inputs, assumptions, outputs, etc. which could affect plant operation are enforced by adequate procedural controls. List any affected procedures.	☒
13.	Plant impact has been identified and either implemented or controlled. (e.g., For piping analyses, the piping and support database is updated or a tracking item has been initiated.)	☒

Completed by: [signature] Date: 12-21-2006

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Fleet Modification Process

Design Review Comment Form

Sheet ___ of ___

DOCUMENT NUMBER/ TITLE:
CA-06-114/ Evaluation of the 8X8 spent fuel storage rack to determine the natural frequencies

REVISION: ______0___ DATE: 12-21-06

ITEM #	REVIEWER'S COMMENTS	PREPARER'S RESOLUTION	REVIEWER'S DISPOSITION
1.	None		

Reviewer: [signature] Date: 12-21-06	Preparer: by Vendor Date:

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		
Description	Original Issue		
Total Pages (Cumulative)	12		
By/Date	Sung-June Kim / 12/18/06		
Checked/Date	Violeta Medina Andres / 12/18/06		
Approved/Date	Walter Djordjevic / 12/18/06		

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

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Table of Figures

1. Objective

The existing 8x8 spent fuel storage rack was obtained from Duane Arnold which procured the rack from PAR Systems in 1977 with a qualification. The seismic evaluation portion of the referenced report evaluates an 8x12, 9x12, 8x11 and 10x11 rack configuration, 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 a qualification. The simplified 2D dynamic model presented in the PAR Systems qualification report [1], was recreated and validated by comparing the results of a current run using the same rack model (8x11 fuel rack) 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 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. A vertical diaphragm 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
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 the 8x11 fuel rack was chosen for comparison since it was determined to have the lowest 1st horizontal frequency mode of all 4 fuel rack configurations.

5. DESIGN INPUTS

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

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

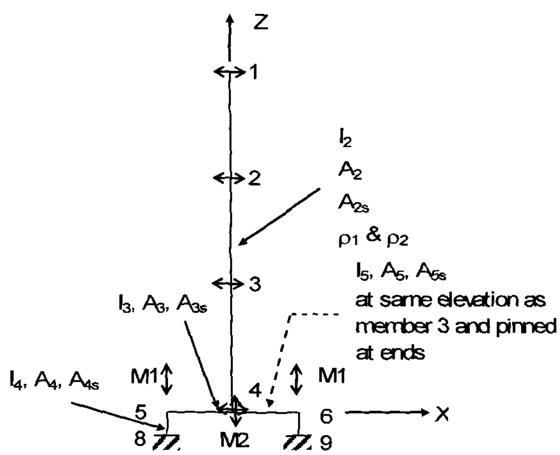

Figure 1: Single Rack Attached Fuel Model (Fig. 2 [1])

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
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.

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 Validation

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 SAP200 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).

Thus, the SAP2000 model is validated. It is concluded that the SAP2000 model is capable of capturing the dynamic properties of the 8x8 rack.

6.2 8x8 Rack Model

6.2.1 Properties and Inputs

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

Module 8x8 fuel rack

<u>Properties</u>

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 [2]	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	I_{eff} =	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 I_{eff} 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

6.2.2 Joint Coordinates

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

6.2.3 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 64 745 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

6.2.4 Modal Analysis

The results of the SAP2000 model for the 8x8 rack is presented in the following. 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.

Mode	Frequency	Description
1	9.0	1st horizontal mode
2	23.0	"Casting Bottom" vertical mode
3	36.3	2nd horizontal mode
4	65.9	3rd horizontal mode

7. CONCLUSION

The simplified 2D dynamic model presented in PAR Systems qualification report [1], was recreated in SAP2000. Comparison of the results of a current run using the same rack model (8x11 fuel rack) as given in the aforementioned report [1] showed that the models matched well; the 1st horizontal mode is above 8 Hz, and the "*Casting Bottom*" vertical mode only differentiates from the hand computed frequency by 3% (see Sect. 6.1.4).

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 frequency and the "*Casting Bottom*" vertical mode are found to be at 9.0 Hz and 23 Hz, respectively.

The artificial vertical and horizontal time history response spectrum at 6% damping compared to Iowa Spec. M-303 response spectrum overlaid with the MNGP time history response spectrum at 5% damping is presented in Attachment A. 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 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 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) **Attachment A** **Time History Response Spectrum Comparison**	Sheet A1 of 12 Date: 12/11/2006 Revision: 0 By: SJK Check: VMA

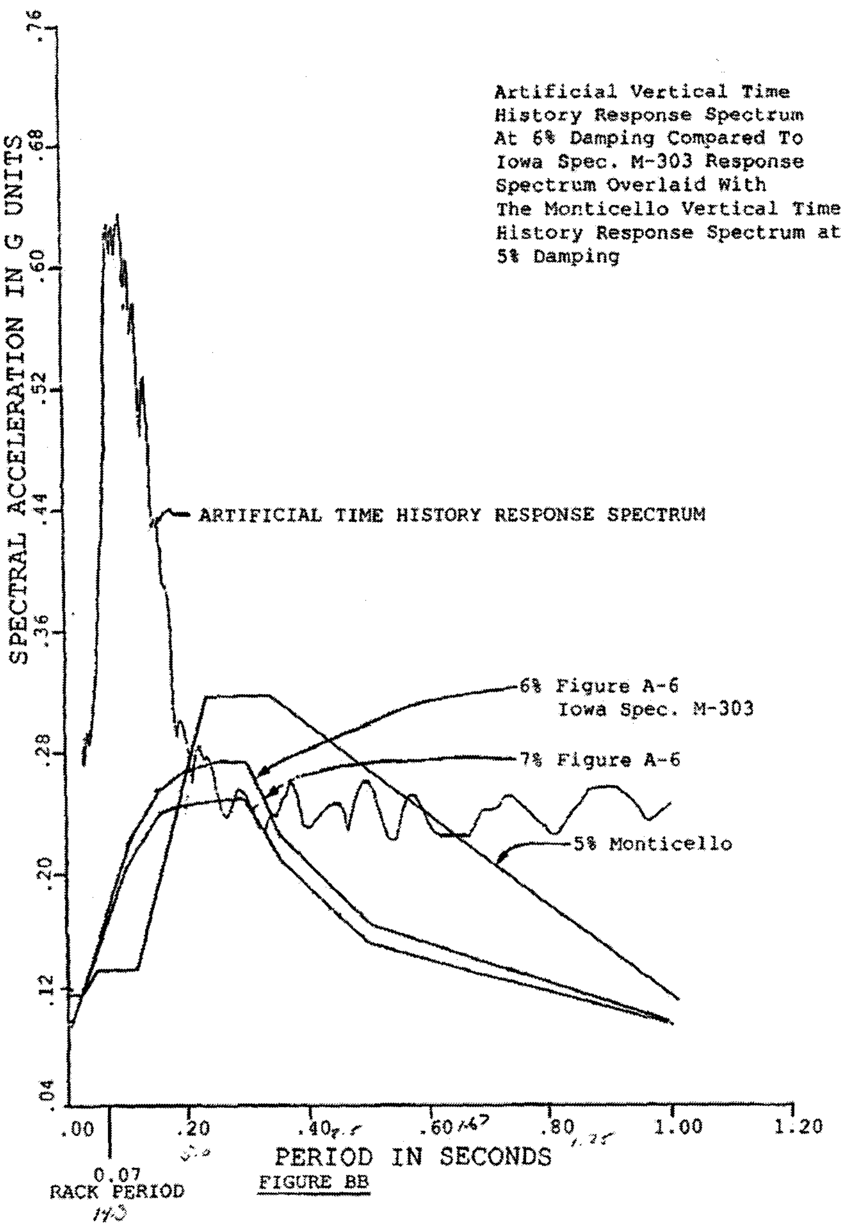

FIGURE BB

Attachment A

Time History Response Spectrum Comparison

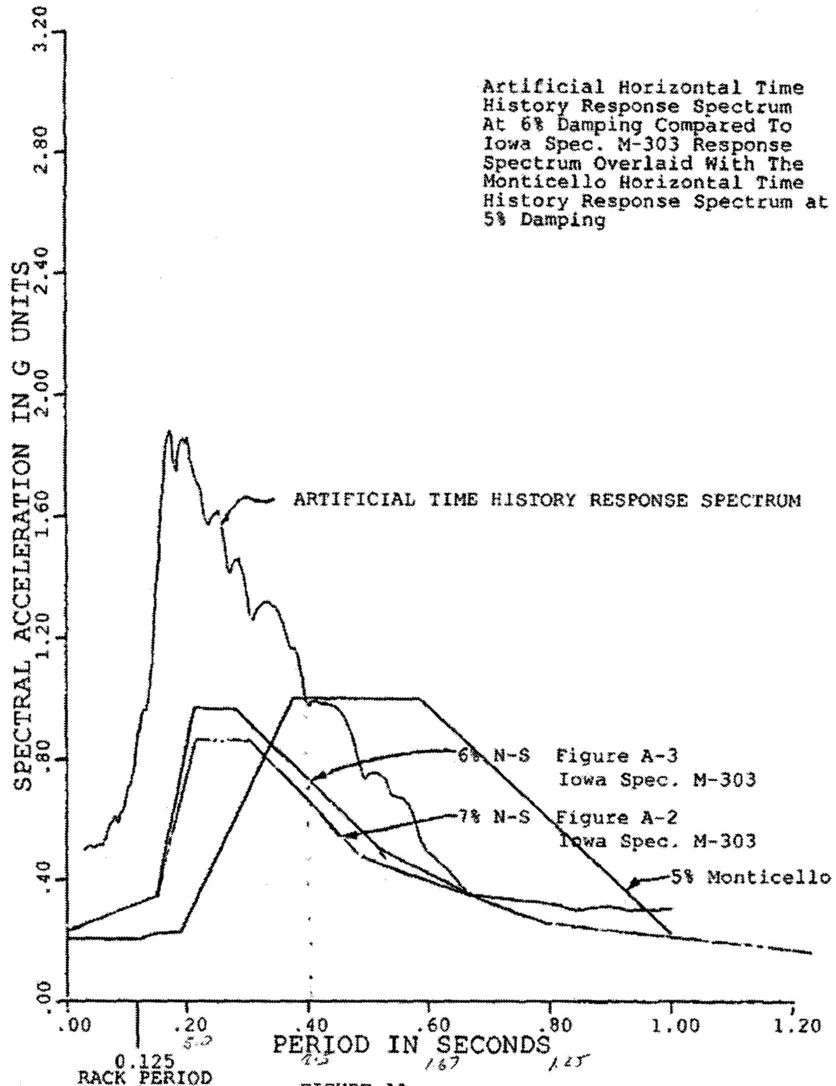

FIGURE AA