ENCLOSURE 2

NEXTERA ENERGY POINT BEACH, LLC
POINT BEACH NUCLEAR PLANT, UNITS 1 AND 2

LICENSE AMENDMENT REQUEST 265
REVISION TO THE REACTOR VESSEL HEAD DROP METHODOLOGY
SUPPLEMENT 1

CN-MRCDA-08-51, REVISION 1
POINT BEACH UNITS 1 AND 2 EVALUATION OF BOTTOM MOUNTED INSTRUMENTATION (BMI) CONDUITS FOR A POSTULATED CLOSURE HEAD ASSEMBLY DROP EVENT

53 pages follow

WESTINGHOUSE ELECTRIC COMPANY LLC

Calculation Note Number	Revision	Shop Order Number	Network/Activity	Page
CN-MRCDA-08-51	1	105, 90	123167/0050	1
Project	Releasable (Y/N)	Open Items (Y/N)	Files Attached (Y/N)	Total No. Pages
Point Beach BMI Analysis	Y	N	Y	53

Title: Point Beach Units 1 and 2 Evaluation of Bottom Mounted Instrumentation (BMI) Conduits for a Postulated Closure Head Assembly Drop Event

Author Name(s)	Signature / Date	Scope
W. C. Castillo	*Electronically Approved**	Rev. 1 Changes (See Record of Revisions)

Verifier Name(s)	Signature / Date	Scope
D. P. Molitoris	*Electronically Approved**	Rev. 1 Changes (See Record of Revisions)

Manager Name	Signature / Date
A. E. Lloyd	*Electronically Approved**

Electronically approved records are authenticated in the electronic document management system. This record was final approved on Dec-16-2009. (This statement was added by the EDMS system to the quality record upon its validation.)

Westinghouse

Record of Revisions

Rev	Date	Revision Description
0	10/2/08	Original Issue
1-A	12/4/09	This calculation note was revised due to a new offer from the customer requesting additional analyses. Revision 1-A changes include: Added Appendix A, changed allowable primary membrane stress in Table 2-1 and Section 5.3, revised and added references in Section 3.0, revised Sections 1.0 and 2.0, updated Section 4.5 to use P_m designation, updated Table 6-1 to add reference, and added electronically attached file listings to Table 6-2.
1	See EDMS	This is the final version of Revision 1 of this calculation note. Revision 1-A was issued for customer comment. There were no comments that required resolution; therefore, there have been no additional revisions to the information in this calculation note.

Trademark Notes:

Table of Contents

1.0 Background and Purpose

During closure head assembly removal or reassembly, it is postulated that the polar crane fails, and the closure head assembly falls and impacts the reactor vessel (RV) concentrically. The purpose of this calculation is to qualify the bottom mounted instrumentation (BMI) conduits attached to the Point Beach Units 1 and 2 RV for a postulated closure head drop using a finite element model generated in ANSYS® (see Figure 1-1). Acceptability is based on maintaining the structural integrity of the BMI conduits such that core cooling will not be compromised and the core will remain covered.

In revision 1 of this calculation note, additional analyses were added in Appendix A to study the effect of using the large-deflection option within ANSYS and the effect of modeling BMI-to-floor contact. With the exception of a few modifications, which are discussed in detail in Appendix A, all models, acceptance criteria, methods, and assumptions remain the same as those presented in the body of this calculation note.

This calculation note was prepared according to Westinghouse Procedure NSNP 3.2.6.

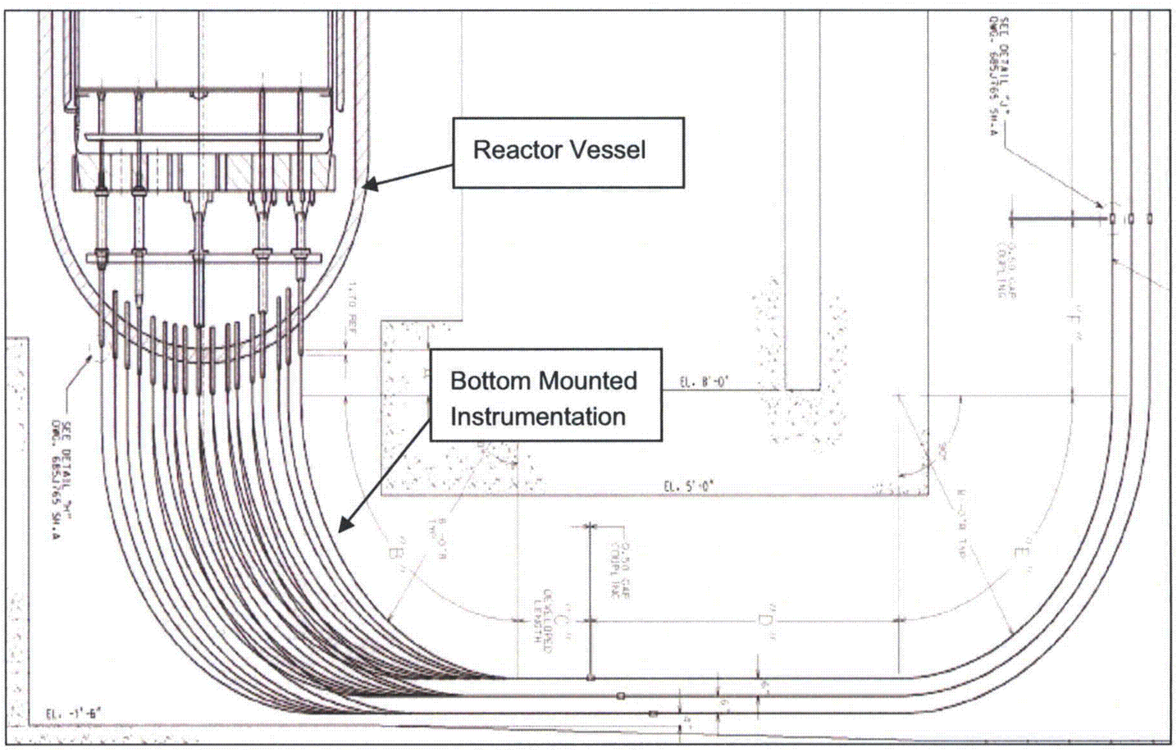

Figure 1-1: Bottom Mounted Instrumentation and Reactor Vessel

2.0 Summary of Results and Conclusions

The responses of the BMI conduits to the postulated closure head drop events defined in [7] were calculated for Point Beach Units 1 and 2 in Section 5.3. These analyses assume that the BMI conduits do not contact the floor and the large-deflection option within ANSYS is not used. The resulting stress intensities in the BMI conduits were compared to the allowable limits defined in Section 4.5. The results are summarized in Table 2-1.

The analyses presented in Appendix A consider the large-deflection option within ANSYS and floor contact. The resulting stress intensities of these analyses were also compared to the allowable limits defined in Section 4.5. The results are summarized in Tables A-1 through A-3

The maximum stresses that the BMI conduits experience were determined to be within the allowable limits. Therefore, it is concluded that the Point Beach Units 1 and 2 BMI conduits are acceptable for the postulated closure head assembly drop events defined in [7].

Table 2-1: Maximum Stress Intensity Results for BMI Conduit

Unit	BMI Conduit Number	Stress Category	Location	Time (seconds)	Stress Intensity (psi)	Allowable Stress (psi)	Margin(1) (%)
Unit 1	**32**	Membrane Stress	BMI Nozzle to BMI Conduit Interface(2)	1.2850	10,410	52,500	80.17
		Membrane plus Bending Stress	BMI Nozzle to BMI Conduit Interface(2)	1.3422	62,008	67,500	8.14
Unit 2	**32**	Membrane Stress	BMI Nozzle to BMI Conduit Interface(2)	1.2846	9,940	52,500	81.07
		Membrane plus Bending Stress	BMI Nozzle to BMI Conduit Interface(2)	1.3416	61,897	67,500	8.30
Unit 1	**29**	Membrane Stress	BMI Nozzle to BMI Conduit Interface(2)	1.285	11,430	52,500	78.23
		Membrane plus Bending Stress	BMI Nozzle to BMI Conduit Interface(2)	1.3502	61,569	67,500	8.79
Unit 2	**29**	Membrane Stress	BMI Nozzle to BMI Conduit Interface(2)	1.285	10,910	52,500	79.22
		Membrane plus Bending Stress	BMI Nozzle to BMI Conduit Interface(2)	1.3494	61,288	67,500	9.20

Notes:

1) Percent Margin = (1 – Actual Stress / Allowable Stress)·100%
2) This interface is represented in the finite element models as node 1. See Figures 4-5 and 5-1.

3.0 References

1. ASME Boiler and Pressure Vessel Code, Section II and Appendix F, 1998 Edition through 2000 Addenda.
2. Westinghouse Letter, LTR-SST-07-45, Rev. 0, "ANSYS 11.0 for HP-UX 11.23 Release Letter," November 30, 2007.
3. Sargent & Lundy Calculation, M-11165-048-1, Rev. 0, "Evaluation of Bottom-Mounted Instrument (BMI) Conduits for Postulated Reactor Vessel Displacement," May 26, 2005.
4. Sargent & Lundy Design Information Transmittal, DIT-PB-EXT-0652-00, "Time History Data from Reactor Vessel Drop Analysis," August 23, 2008.
5. Westinghouse Calculation Note, CN-RCDA-04-46, Rev. 1, "Weld Overlay – Material Properties," June 19, 2006.
6. Nuclear Energy Institute Document, NEI 08-05, Rev. 0, Industry Initiative on Control of Heavy Loads, Section on Load Drop Analyses, July 31, 2008, available under NRC ADAMS Accession Number ML082180684.
7. Sargent & Lundy Calculation, 2005-06760, Rev. 3, "Analysis of a Postulated Reactor Head Drop Onto the Reactor Vessel Flange," July 22, 2005.
8. Inman, Daniel J., "Engineering Vibration," 2nd Edition, Prentice Hall, Upper Saddle River, NJ, 2001.
9. Callister, William D. Jr., "Materials Science and Engineering an Introduction," 5th Edition, John Wiley & Sons, Inc., New York, NY, 2000.
10. Combustion Engineering Drawing, E-233-697, Rev. 3, "Instrumentation Penetration Assembly and Details Bottom Head for Westinghouse Electric Corp. 132" I.D. P.W.R."
11. Westinghouse Drawing, 685J765, Rev. 8, Sheet A, "Incore Thimble, Seal Table/Instrument Drive, Bottom Mounted Instrumentation Point Beach N.P. Units 1&2."
12. Westinghouse Drawing, 685J765, Rev. 8, Sheet B, "Incore Thimble, Seal Table/Instrument Drive, Bottom Mounted Instrumentation Point Beach N.P. Units 1&2."
13. Westinghouse Drawing, 685J765, Rev. 8, Sheet C, "Incore Thimble, Seal Table/Instrument Drive, Bottom Mounted Instrumentation Point Beach N.P. Units 1&2."
14. Point Beach Nuclear Plant Design Information Transmittal EC 12260 DIT No.1, "PBNP Drawings," May 28, 2008.
15. Point Beach Nuclear Plant Design Information Transmittal EC 12260 DIT No.2, "Sargent & Lundy calculations M-11165-048-1, Rev. 0 and 2005-06760, Rev. 3," May 28, 2008.
16. Westinghouse Letter, LTR-SST-08-61, "Software Release Letter for ANSYS 11.0 SP1 on GNU/Linux 2.6 with Service Pack 2," December 17, 2008.

References [11], [12], and [13] were transmitted to Westinghouse for use in this analysis by [14]. References [3] and [7] were transmitted to Westinghouse for use in this analysis by [15].

4.0 Calculations

4.1 LIMITS OF APPLICABILITY

This analysis is applicable to the structural evaluations of the BMI conduits for the postulated closure head assembly drop events at Point Beach Units 1 and 2, as defined by [7].

4.2 OPEN ITEMS

This calculation note contains no open items.

4.3 METHOD DISCUSSION

An evaluation of the BMI conduits for the postulated closure head assembly drop events at Point Beach Units 1 and 2, as defined in [7], will be performed using finite element models of BMI conduit numbers 32 and 29, which are highlighted in Figure 4-1. The BMI conduits for Point Beach Units 1 and 2 are identical. Therefore, only two models were required; one for conduit number 32 and one for conduit number 29. Figure 4-2 shows the finite element model of BMI conduit number 32. BMI conduit numbers 32 and 29 were analyzed because they are the conduits with the shortest and longest overall lengths, respectively. It is assumed that all of the BMI conduits experience the same time-history transient effects due to the head drop accident. Therefore, selecting the shortest and longest BMI conduits will give a bounding range of the stresses experienced by all of the BMI conduits during the head drop accident.

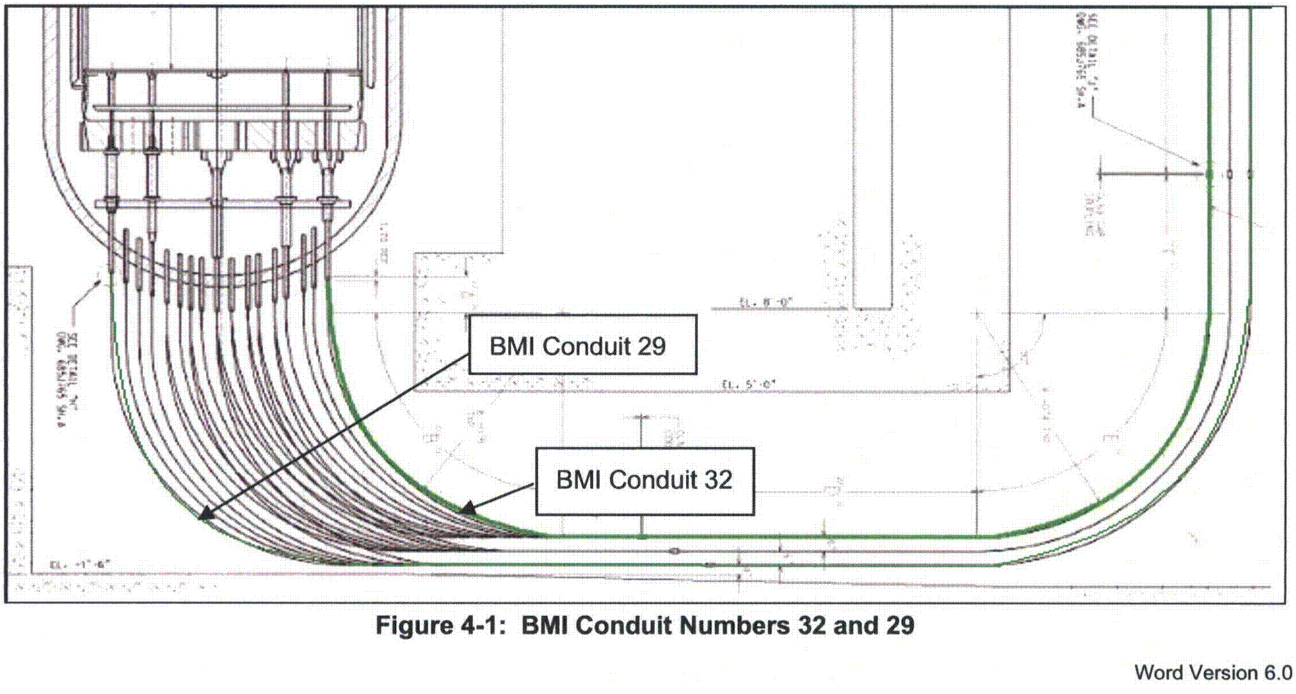

Figure 4-1: BMI Conduit Numbers 32 and 29

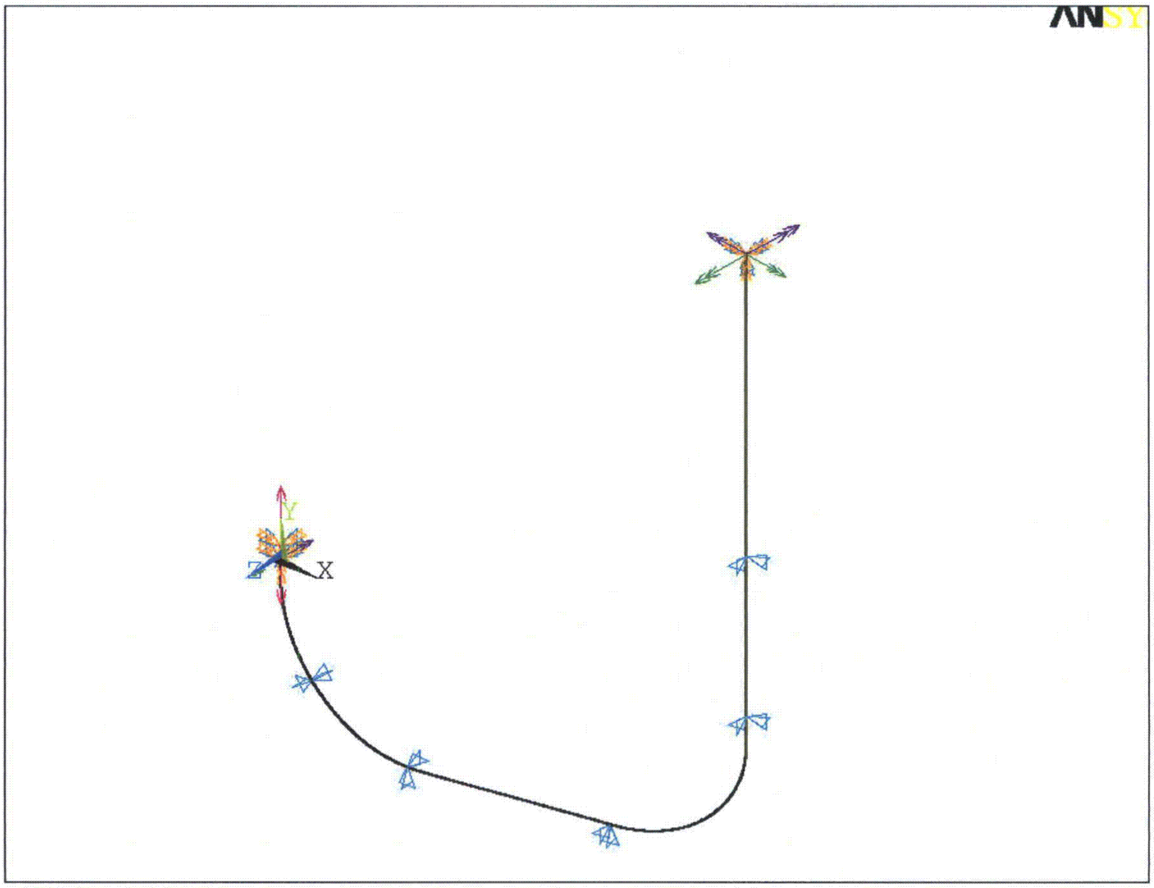

Figure 4-2: BMI Conduit Number 32 Finite Element Model

The displacement time-histories calculated in [4] and [7] for Point Beach Units 1 and 2, respectively, were applied to the BMI conduit models. The displacement time-histories were originally applied to the BMI conduit models at the RV-BMI interface; however, this resulted in incorrect applied accelerations. ANSYS determined accelerations based on the input displacement time-histories. "Noise" in the displacement time-histories caused large, unrealistic accelerations to be applied to the models, as illustrated in Figure 4-3.

A spring-mass system was added to the BMI conduit finite element models between node 10000000 (node representing the RV) and node 1 (BMI nozzle to BMI conduit interface) to filter out the high frequency noise, as illustrated in Figure 4-4. Figure 4-5 displays the spring-mass system in the finite element model between node 10000000 and node 1. The natural frequency of the spring was selected such that the high frequency noise would be eliminated without impacting the response of the conduit. A natural frequency of 100 Hz was selected for the spring-mass system. This frequency will filter out the high frequency noise without impacting the input frequency of 17.24 Hz and the BMI conduit natural frequency of 17.686 Hz. See Section 5.4 for a discussion of the input and conduit natural frequencies.

The spring stiffness was made sufficiently high to ensure that the BMI conduit would follow the input displacement time-history. A spring stiffness of 100,000,000 lb_f/in was selected. The mass of the system was calculated from the natural frequency and stiffness of the spring-mass system using Equations 4-1 through 4-3 [8]. The computed mass assigned to the spring-mass system was 253.3 $lb_f \cdot s^2$/in. The mass value is large relative to the BMI conduit mass (0.498 $lb_f \cdot s^2$/in); this minimizes feedback from the BMI conduit into the applied load. Therefore, the output response of the spring-mass system is equivalent to the input displacement time-history, as illustrated in Figures 5-5, 5-6 and 5-7. Table 4-4 contains the frequency, spring constant, and computed mass of the spring-mass system.

Based on the information above, Westinghouse believes with a high level of confidence that the spring-mass system used to filter the high frequency noise will not impact the responses of the BMI conduits to the postulated closure head drop events defined in [7].

$$\omega_n = \sqrt{\frac{K}{m}}$$ Natural Frequency [8] (rad/s) Equation 4-1

$$f = \frac{1}{2 \cdot \pi} \omega_n$$ Frequency [8] (Hz) Equation 4-2

$$m = \frac{K}{(2 \cdot \pi \cdot f)^2}$$ Mass for Spring System [8] ($lb_f \cdot s^2$/in) Equation 4-3

In Equations 4-1 through 4-3, ω_n and f_n are the natural frequency, m is the mass, and K is the stiffness.

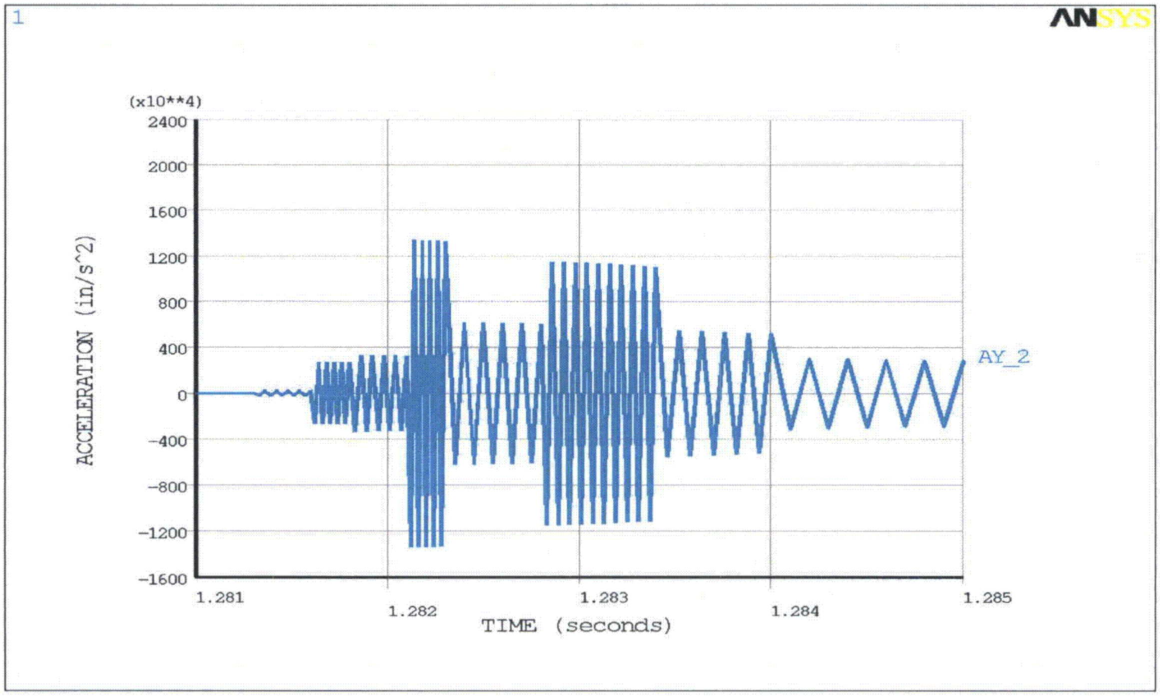

Figure 4-3: Acceleration of Node 1 before Application of Spring-Mass System

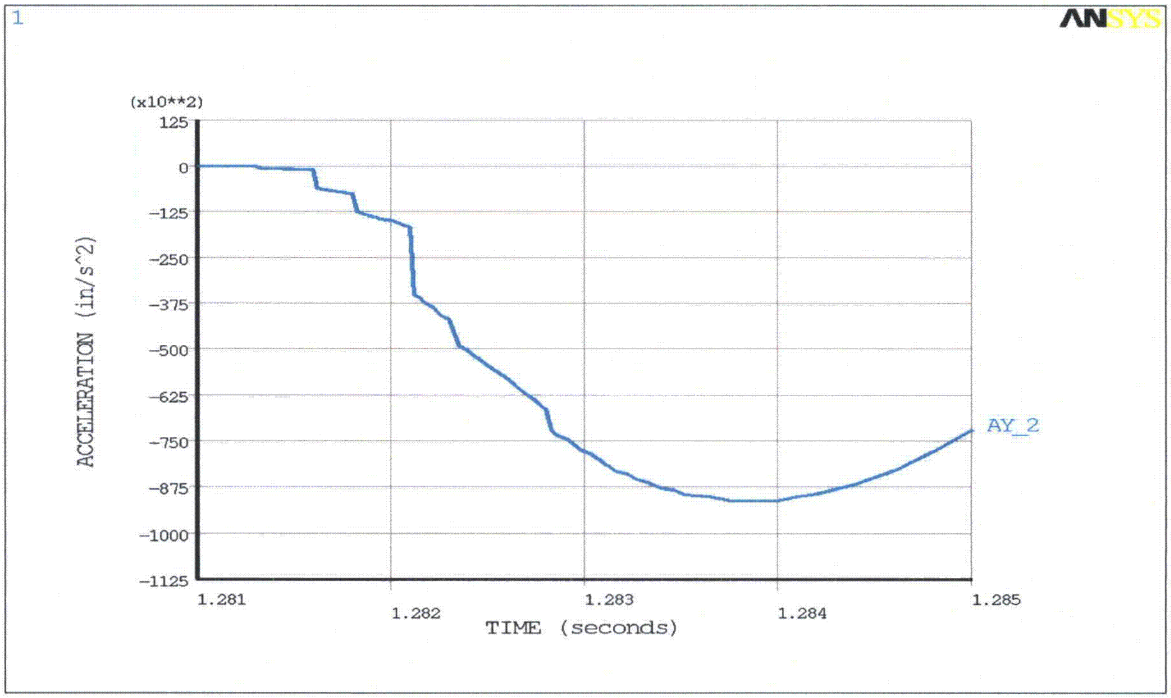

Figure 4-4: Acceleration of Node 1 after Application of Spring-Mass System

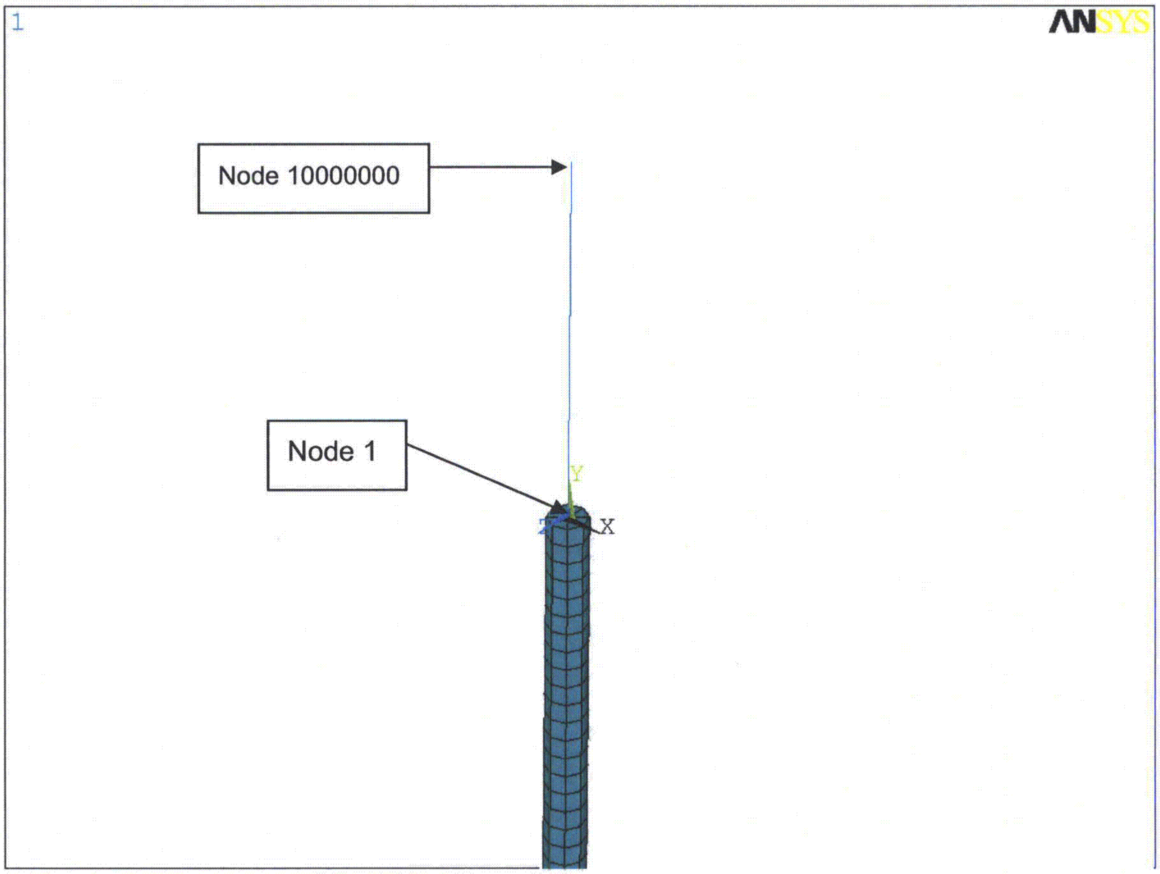

Figure 4-5: Spring-Mass System Representation

The finite element models were constrained to represent the supports described in the walk-down information [3, Attachment B]. The displacement time-histories for Point Beach Units 1 and 2 were applied through node 10000000 to the BMI nozzle location at node 1. The displacement time-histories were used to determine the responses of the BMI conduits to the postulated closure head assembly drop events defined in [7]. Then, the maximum stress intensity was calculated at each node for the entire dynamic analysis for both models using Equation 4-4. The maximum value of each model was compared to the appropriate ASME Code [1] allowable stress to determine acceptability.

$$\sigma_{\text{intensity}} = \frac{P}{A} + \sqrt{\left(\frac{M_x \cdot c}{I}\right)^2 + \left(\frac{M_z \cdot c}{I}\right)^2}$$ Stress Intensity (psi) Equation 4-4

In Equation 4-4, $\sigma_{intensity}$ is the stress intensity, P is the axial force, A is the area, M_x is the bending moment about the x-axis, M_z is the bending moment about the z-axis, c is the radius of the pipe, and I is the moment of inertia of the pipe.

Finally, static and modal analyses were performed to better understand the responses generated by the dynamic BMI conduit finite element models.

4.4 DISCUSSION OF SIGNIFICANT ASSUMPTIONS

The following significant assumptions were used to simplify the analysis and ensure conservatism:

1. The representative models used in this analysis are conservatively based on the BMI conduits with the shortest and longest overall lengths, conduit numbers 32 and 29, respectively. These conduits were selected because they provide the bounding range of stresses that the BMI conduits will experience during RV displacement.
2. Any gaps that exist between the conduit and the U-bolts were conservatively ignored for this analysis.
3. The gap between the conduit U-bolt supports and the floor was conservatively ignored. This gap allows for 1 inch to 4.5 inches of vertical deflection before vertical movement is restrained. The BMI models used in this analysis represent the U-bolt supports as being rigid in the vertical and lateral directions. Only axial translation and all rotational degrees of freedom were allowed at the U-bolt locations. The support structures were conservatively modeled as rigid boundary conditions. This will result in conservative BMI conduit loads because the support structures will absorb no energy caused by the accident.
4. A beta damping value of 5% damping at 30 Hz was included in the models in accordance with NEI 08-05 [6]. Beta damping was used to assist in eliminating high frequency noise found in the responses of the systems. The actual systems respond at approximately 17.24 Hz. Due to the linear behavior of beta damping, a damping value of approximately 2.875% will be experienced by the systems at the response frequency. This damping value will have a negligible effect on the actual response of the systems. The gaps discussed in assumptions 3 and 4 would cause structural damping in the systems. Ignoring these gaps and, therefore, eliminating this structural damping, adds conservatism to the analyses.
5. Contact between the floor and the BMI conduit was conservatively ignored for this analysis. It was assumed that allowing the BMI conduit to deflect freely, constrained only by rigid supports, as described in the third assumption, would cause the highest stresses; therefore, these stresses would be the most conservative. The effect of the force imposed on the BMI conduit by the floor was conservatively assumed to be negligible compared to the stresses at the supports.

6. The couplings along the BMI conduits were not modeled for this analysis. The fillet welds at the couplings are designed to be as strong as the BMI conduit; therefore, it was assumed that the couplings did not need to be independently analyzed.

7. The instrumentation inside the conduits was conservatively not modeled for this analysis. The instrumentation would cause a negligible increase in the strength of the conduit by absorbing some of the energy the conduit experiences in the dynamic analysis.

8. The BMI nozzle that connects the BMI conduit to the RV is not analyzed in this calculation. It was conservatively assumed that the nozzle would be much stronger than the BMI conduit. This assumption is based on a comparison of the moment of inertia, cross-sectional area, and material properties of the BMI nozzle, as referenced in [10]. The moment of inertia of the nozzle is more than 4.5 times greater than the conduit, the cross-sectional area of the nozzle is nearly twice that of the conduit, and the yield and ultimate stress of the nozzle are 5 and 15 ksi greater. The nozzles were manufactured with SB-166 steel, which has yield and ultimate strengths of 35.0 ksi and 85.0 ksi at 70°F, respectively [1].

4.5 ACCEPTANCE CRITERIA

The BMI conduits are qualified for the closure head assembly drop if the calculated maximum primary stress intensities are below the allowable ASME Code [1] limit for Level D conditions. The faulted stress intensity limits are defined in Section F-1341.2 of [1].

P_m < Greater of $0.7S_u$ and $S_y + 1/3(S_u - S_y)$ [1, F1341.2(a)] Equation 4-5

$P_m + P_b$ < $0.90S_u$ [1, F1341.2(b)] Equation 4-6

In Equations 4-5 and 4-6, P_m is the general primary membrane stress intensity, P_b is the primary bending stress intensity, S_y is the yield strength, and S_u is the ultimate strength.

4.6 INPUT

The dimensions used to model the BMI conduits can be found in [11], [12], and [13]. The dimensions were taken from BMI conduit numbers 32 and 29, which were the conduits with the shortest and longest overall lengths, respectively (as discussed in Section 4.4). The material assigned to the models was ASTM A213 Type 304 stainless steel [13]. The true stress-strain data can be seen in Table 4-1 and Figure 4-6. The true stress-strain data was constructed using ASME Code minimum values. Table 4-2 summarizes the key material properties and the associated ANSYS material number. The average values of conduit wall thickness and inner diameter given in [11] were used; see Table 4-3.

The spring-mass system discussed in Section 4.3 was given the properties found in Table 4-4. The mass found in Table 4-4 was calculated from Equation 4-3.

Table 4-1: True Stress-Strain Data for ASTM A213 Type 304[1] Stainless Steel at 70°F [5]

True Strain (in/in)	**True Stress** (ksi)
0.0000	0.0
0.0011	32.4
0.0033	36.1
0.0150	44.5064
0.0300	51.4189
0.0450	56.5363
0.0600	61.6537
0.0750	66.7710
0.0900	71.8884
0.1050	75.9161
0.1200	79.3467
0.1350	82.7773
0.1500	86.2079
0.1650	89.6385
0.1800	93.0690
0.1950	95.4012
0.2100	97.5322
0.2250	99.6633
0.2400	101.7943
0.2550	103.9253
0.2600	104.6357

Note:

1) The material referenced in [5] is an ASTM Type 304 alloy that is applicable to the material used in this analysis.

Table 4-2: ASTM A-213 Type 304 Stainless Steel Material Properties

Material	Temperature (°F)	Density(1) (lb_m/in^3)	Elastic Modulus(2) (psi)	Poisson's Ratio(3)	ANSYS Material Number	Yield Strength(4) (psi)	Ultimate Strength(4) (psi)
ASTM A-213 Type 304	70	0.289	2.8349×10^7	0.3	1	30,000	75,000

Notes:

1. From [9, Appendix B, Table B.1].
2. Calculated from data provided in [5] to match the initial slope of the stress-strain curve.
3. Common material property.
4. Ultimate strength and yield strength obtained from [1].

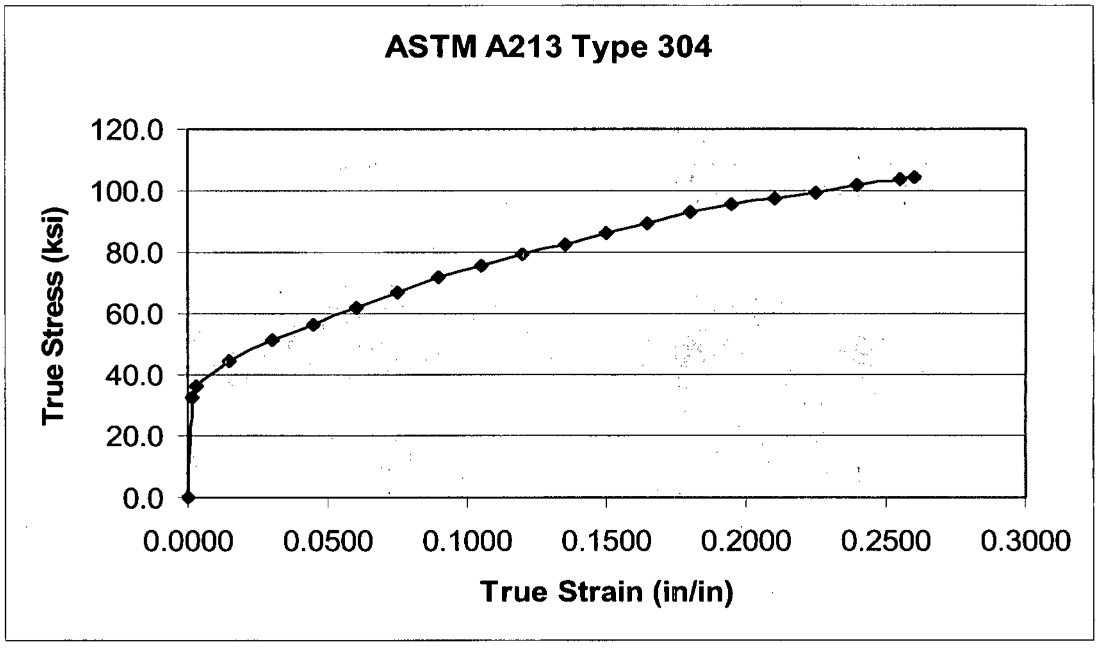

Figure 4-6: True Stress-Strain Data for ASTM A213 Type 304 Stainless Steel at 70°F

Table 4-3: BMI Conduit Average Wall Thickness and Average Inner Diameter [11]

Average Wall Thickness (in)	**Average Inner Diameter** (in)
0.3125	0.375

Table 4-4: Spring-Mass System Properties

Spring Constant (lb_f/in)	**Frequency** (Hz)	**Mass** ($lb_f.s^2$/in)
100,000,000	100	253.3

4.7 SARGENT & LUNDY HEAD DROP PARAMETERS

Sargent & Lundy performed head drop analyses in [7] for Point Beach Units 1 and 2. The head drop weight and drop height parameters from [7] for Point Beach Units 1 and 2 are reported in Table 4-5. This information included in this document for informational purposes only.

Table 4-5: Sargent & Lundy Head Drop Parameters [7]

	Unit 1	**Unit 2**
Drop Weight (lb_f)	200,000	194,000
Drop Height (ft)	26.4	26.4

5.0 Evaluations, Analysis, Detailed Calculations, and Results

5.1 MODEL DOCUMENTATION

5.1.1 Geometry

The BMI conduit finite element models were constructed using the dimensions for the BMI conduits with the shortest and longest overall lengths from [13]. Node 10000000 was added to the models, as discussed in Section 4.3. Then, the models were constrained to accurately represent the plant walk-down information [3, Attachment B]. The global coordinate system and all constraints can be seen in Figure 5-1.

The following describes the constraints and loads applied to the finite element model for BMI conduit number 32. The same methodology was used to model BMI conduit number 29.

Nodes 1 and 10000000 were constrained such that translation along the y-axis (axial direction) was allowed and all other degrees of freedom were fixed. To represent the spider support, a local coordinate system was placed at node 1122 and the x-axis was rotated 35° about the z-axis towards the y-axis. See Figure 5-2. This node was then constrained in the local x and z directions, allowing all rotational degrees of freedom and translation in the axial direction. As the conduit approaches the floor and begins to travel horizontally, the conduit is rotated 18.5° about the global y-axis. See Figure 5-3. To accurately represent the U-bolt constraints, a local coordinate system rotated 18.5° about the global y-axis was created. The y-axis represents the axial direction, the z-axis represents the vertical direction, and the x-axis represents the horizontal direction. See Figure 5-4. The U-bolt constraints were represented by constraining nodes 1423 and 49 in the local x and z directions and nodes 318 and 424 in the local x and y directions, thereby allowing all rotational degrees of freedom and translation in the axial direction. The seal table constraint was represented by fixing node 627 in all degrees of freedom. After the model was appropriately constrained, displacement time-histories were applied to node 10000000 in the y direction.

The results detailed in Section 5.0 are for BMI conduit number 32 of Point Beach Unit 2. The same methodology was used for BMI conduit number 29 of Point Beach Unit 2 and BMI conduit numbers 32 and 29 for Point Beach Unit 1. The results are displayed in Section 5.3.

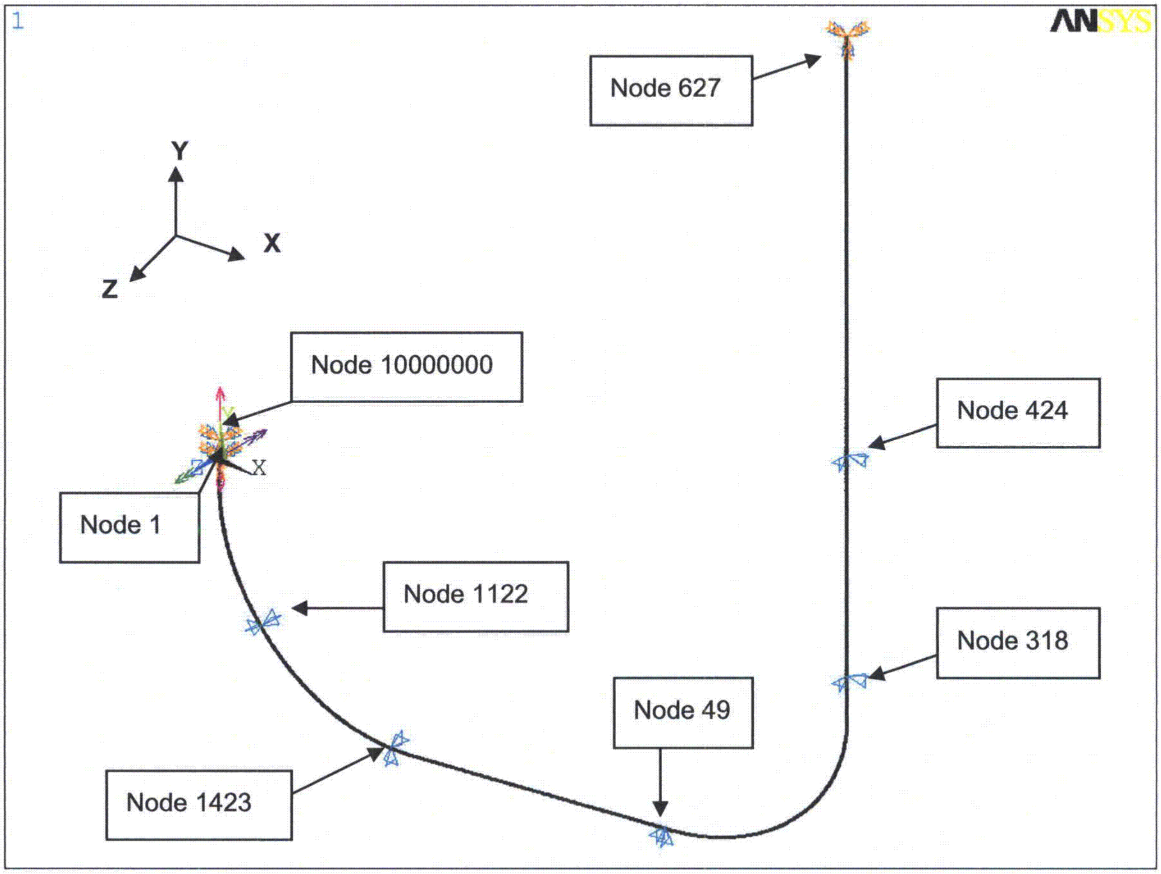

Figure 5-1: Displacement Constraints on Point Beach BMI Conduit Number 32

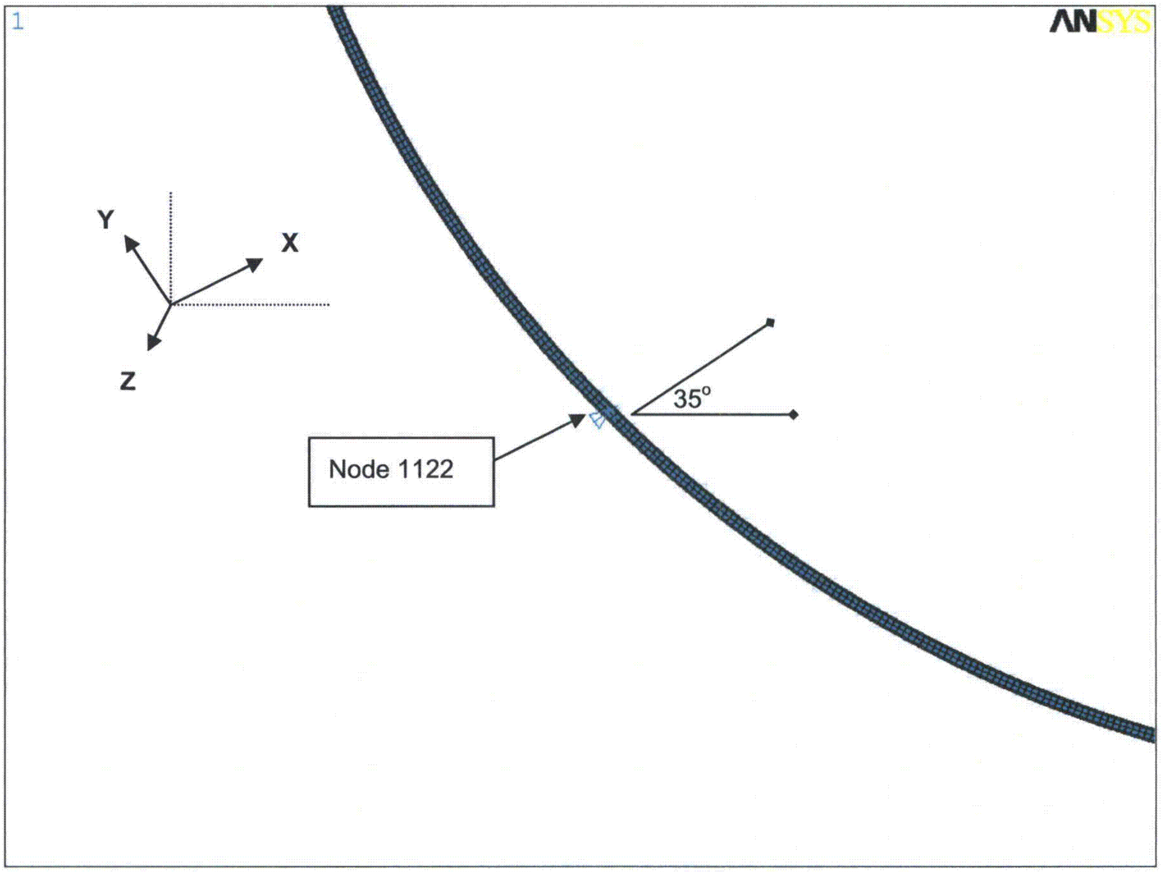

Figure 5-2: Spider Support Representation at Node 1122

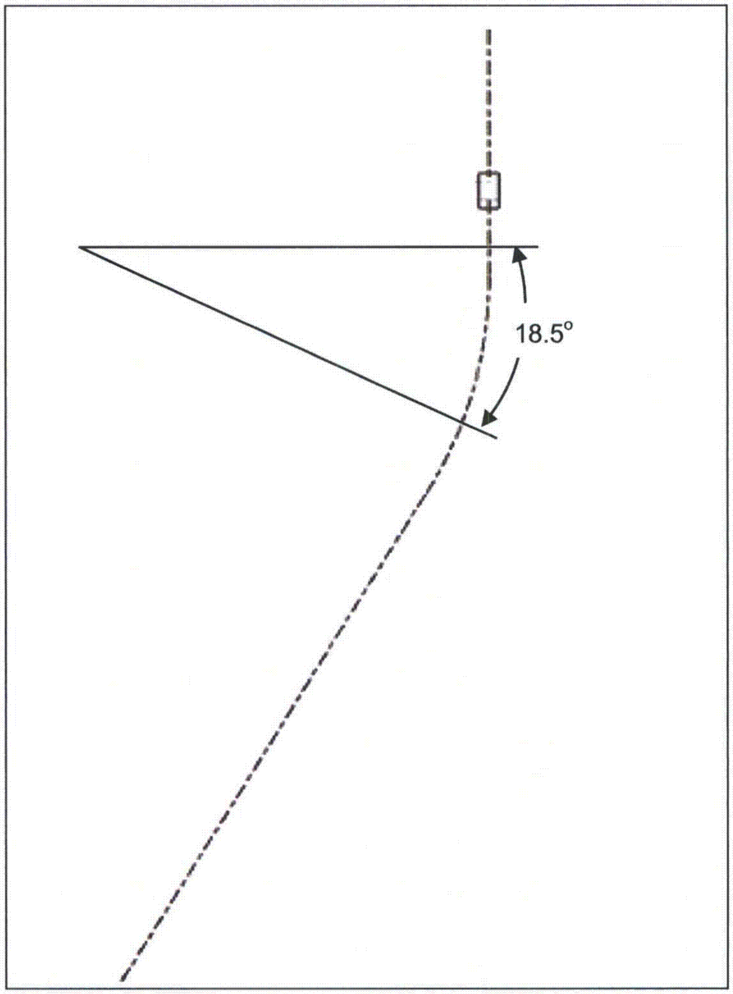

Figure 5-3: Rotation of BMI Conduit about the Global Y-Axis

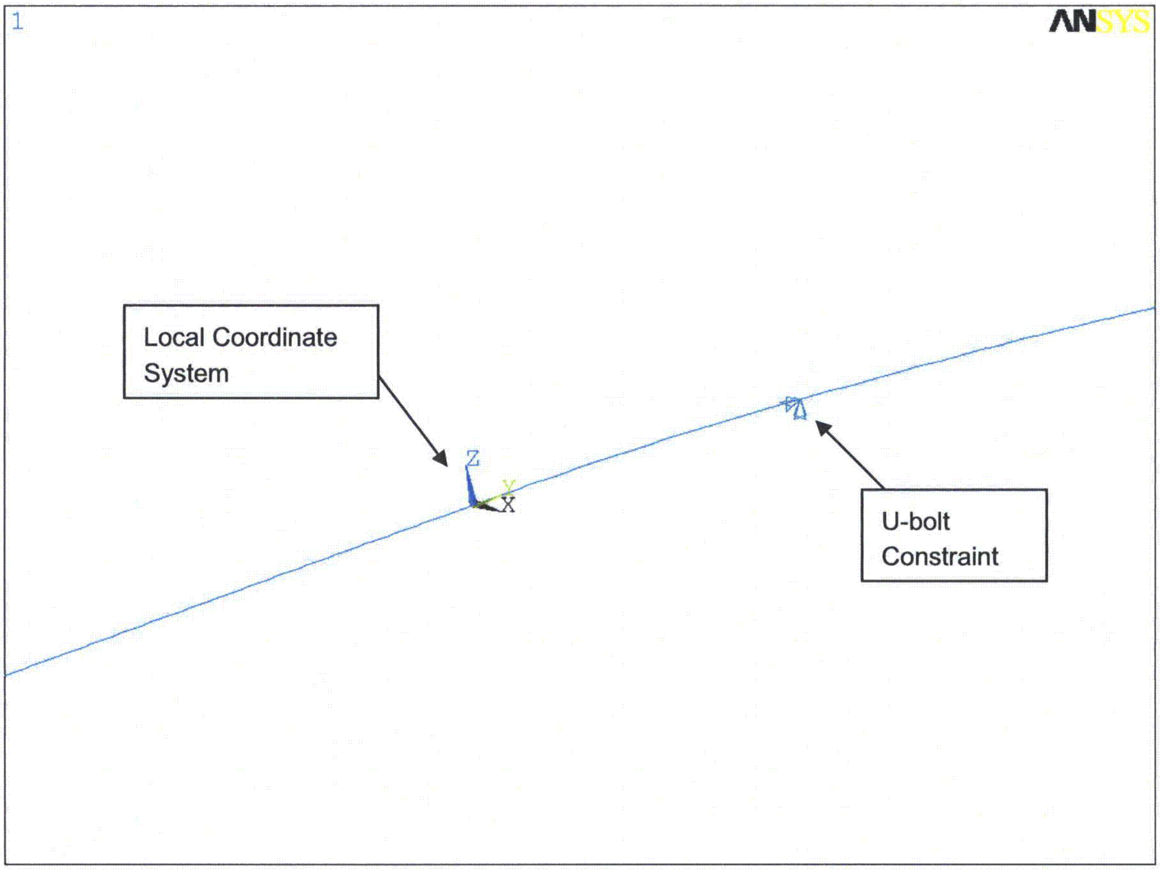

Figure 5-4: Rotated Local Coordinated System for U-bolt Constraints

5.1.2 Element Selection

The spring modeled between node 1 and node 10000000 was created using a COMBIN40 spring element. The element was given one degree of freedom in the y direction. The spring properties from Table 4-4 of Section 4.6 were applied to the spring element. The mass of 253.3 $lb_f.s^2/in$ was applied to the element at node 1. The entire BMI conduit was modeled using BEAM188 elements. This element was selected for its ability to model nonlinear material behavior. A circular tube cross-section was applied to the beam element with dimensions from Table 4-3.

5.1.3 Mesh Adequacy

The mesh for each finite element model was given a refinement of 0.5-inch divisions for the BMI conduit. A mesh adequacy study was deemed unnecessary for the finite element model because of the mesh density assigned to the model. Westinghouse believes with a high level of confidence, based on previous analyses and experience, that the mesh utilized for this analysis will accurately model the dynamic response and identify the resulting stresses present in the conduit.

Only one element was required for the spring-mass system between nodes 10000000 and 1.

5.2 ANALYSIS DOCUMENTATION

5.2.1 Macros

A post-processing macro was created to determine the maximum stress intensity and the corresponding time step for each node for the entire head drop event. This macro was necessary to determine the magnitude, location, and time of the maximum stress intensity to be compared to the allowable limits. The macro was written in APDL language, and used a “do loop” to find the maximum stress intensity and corresponding time for each node throughout the entire time-history of the dynamic analysis. The membrane and bending stresses at each node over time were calculated. Because there is bending stress about the x and z axes, the square root of the sum of squares was used to determine the total primary bending stress. Then, the primary membrane and primary bending stresses at each node for the full time-history were added together to calculate the stress intensity over time for each node. Finally, the maximum stress intensity value for each node was extracted to be compared to the allowable limits for membrane plus bending stress intensity. The maximum membrane stress was conservatively approximated and compared to the appropriate allowable limits.

5.2.2 Applied Loads

The displacement time-history from [7] was used to load the Point Beach Unit 2 BMI conduit model by applying the displacement to node 10000000, as discussed in Section 4.3. Figure 5-5 displays a plot of the displacement time-history from [7] for the Point Beach Unit 2 BMI conduit. Figures 5-6 and 5-7 display the displacements of node 10000000 and node 1, respectively, for the Point Beach Unit 2 BMI conduit. Comparing Figures 5-6 and 5-7 shows that the BMI conduit experiences the same displacement time-history as the mass node (node 10000000); therefore, it can be concluded that the spring-mass added to the system to filter out the high frequency acceleration noise does not impact the displacement time-history of the conduit.

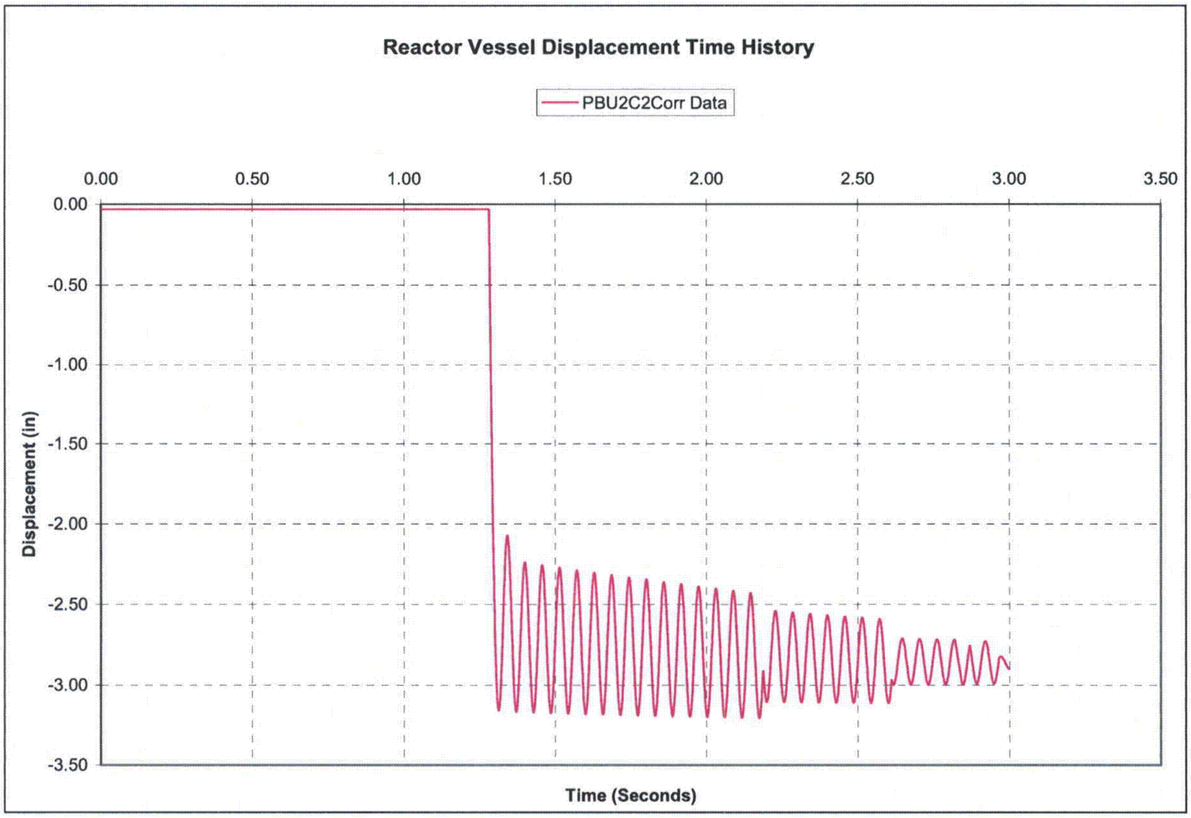

Figure 5-5: Point Beach Unit 2 Displacement Time-History Applied Load [7]

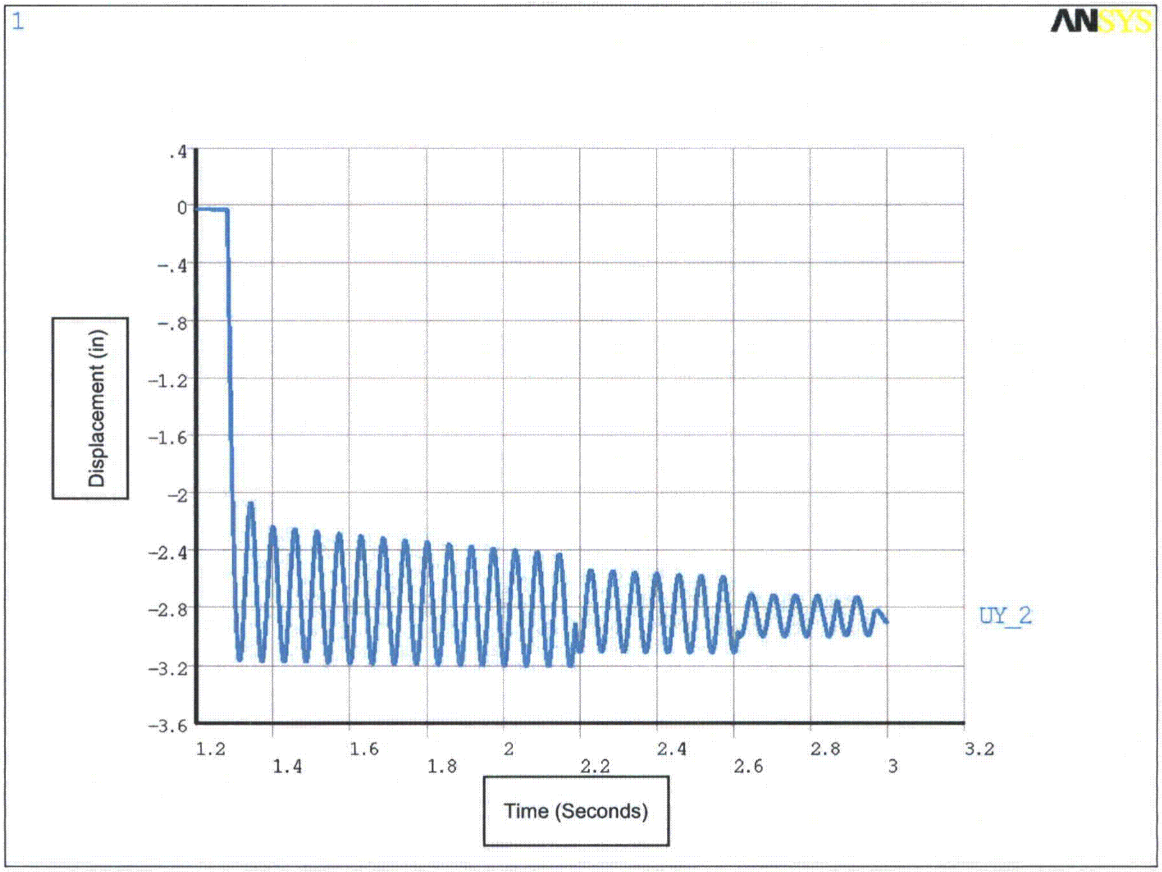

Figure 5-6: Displacement Time-History of Node 10000000 (Unit 2, Conduit 32)

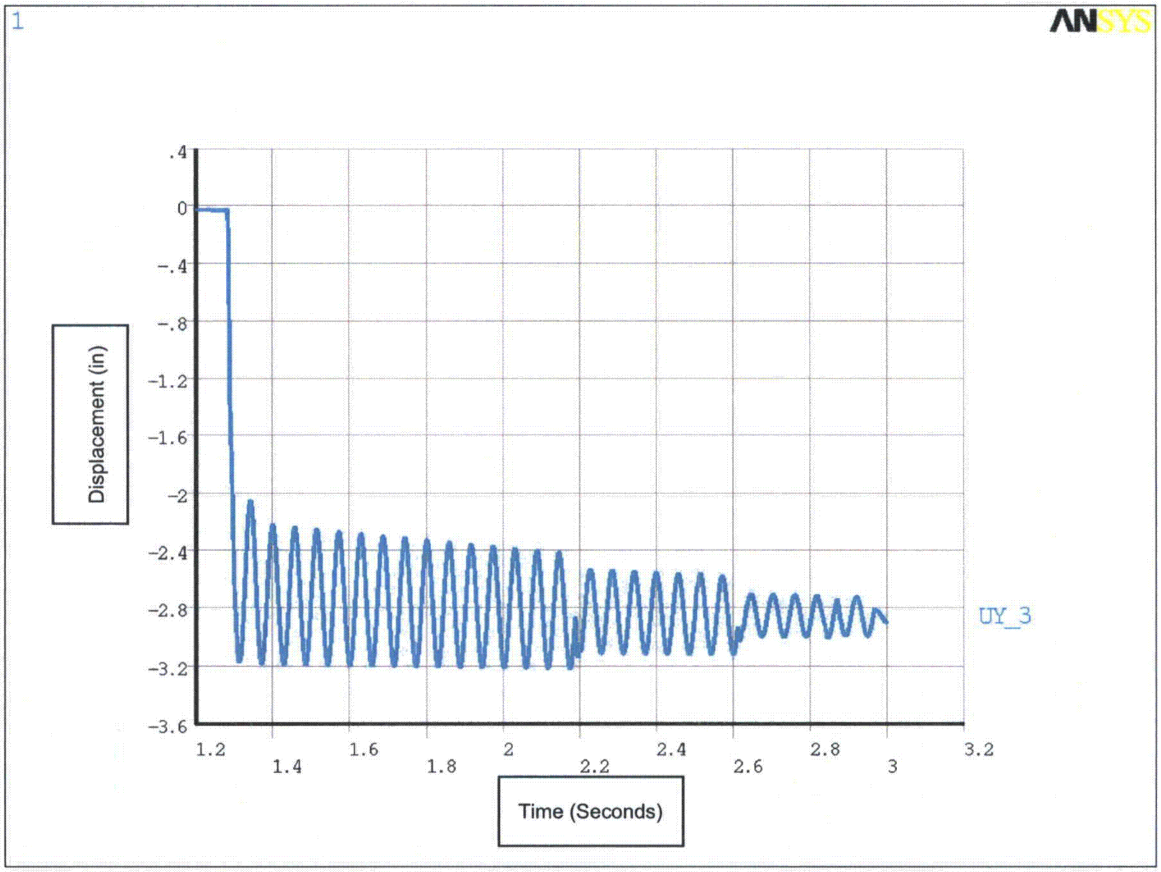

Figure 5-7: Displacement Time-History of Node 1 (Unit 2, Conduit 32)

5.3 RESULTS DOCUMENTATION

The response of the finite element model to the applied displacement time-history was compared to the acceptance criteria discussed in Section 4.5. The post-processing macro discussed in Section 5.2.1 was used to determine the maximum stress intensity over time for each node. The membrane plus bending stress intensity results are outlined in Table 5-1. Figure 5-8 shows the displacement of the BMI conduit plotted over the un-deformed shape at the time of the maximum stress intensity. Figure 5-9 shows a plot of the membrane and bending stresses at node 1. The maximum membrane stress intensity results are outlined in Table 5-2.

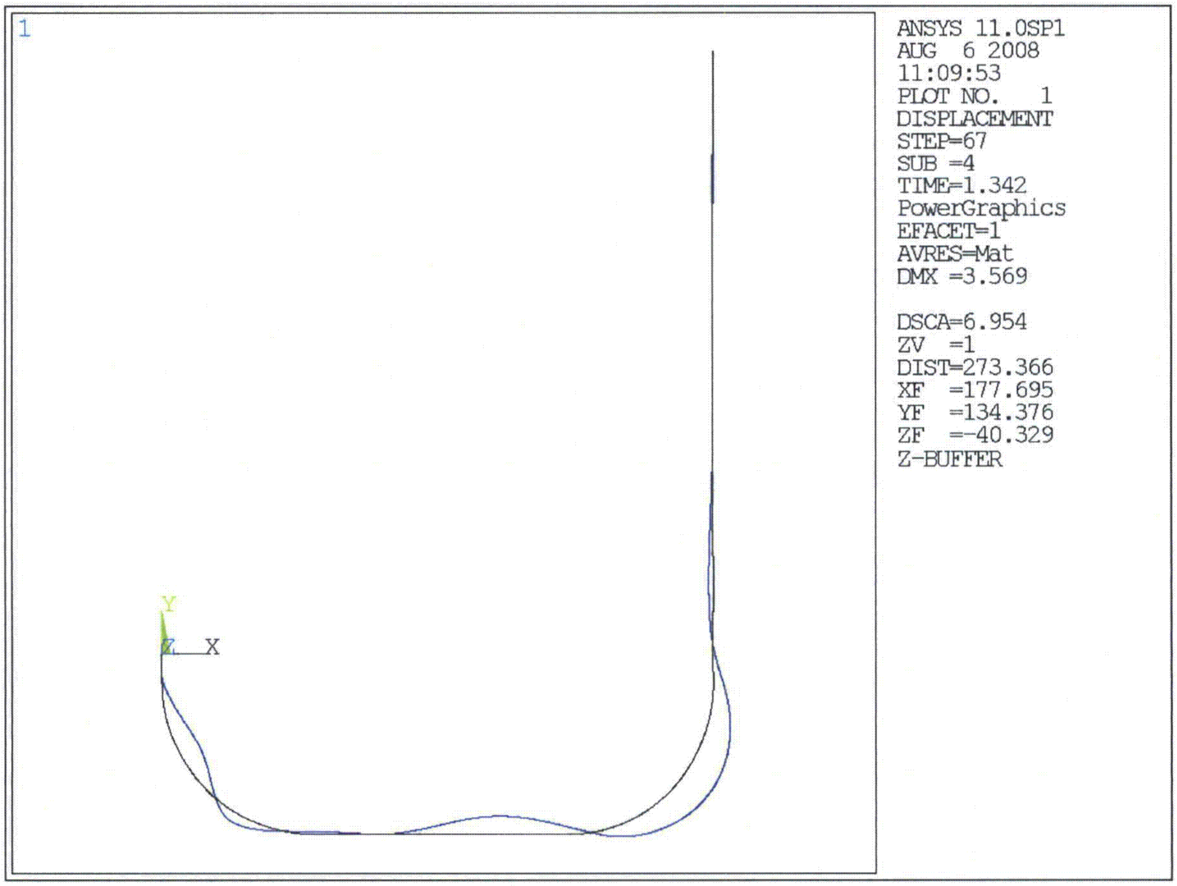

Figure 5-8: Displacement Plot of BMI Conduit at Time of Maximum Stress Intensity (Unit 2, Conduit 32)

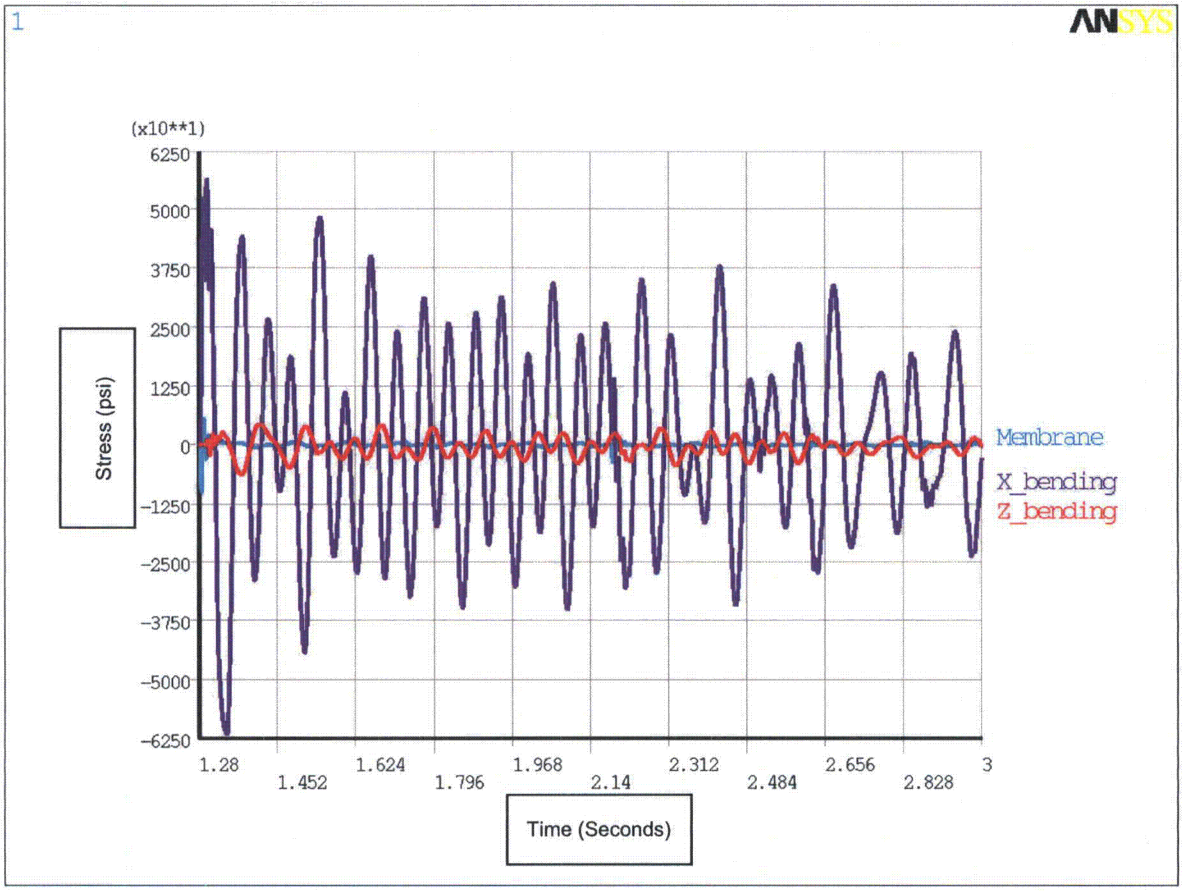

Figure 5-9: Membrane and Bending Stresses at Node 1 (Unit 2, Conduit 32)

Table 5-1: Maximum Membrane plus Bending Stress Intensity Result Summary (Unit 2, Conduit 32)

Node	Stress Intensity (psi)	Time (seconds)
1	61,897	1.3416

Table 5-2: Maximum Membrane Stress Intensity Result Summary (Unit 2, Conduit 32)

Node	Stress Intensity (psi)	Time (seconds)
1	9,940	1.2846

From Equations 4-5 and 4-6 of Section 4.5, the allowable maximum stress intensity can be calculated.

Membrane Stress Intensity:

$$\sigma_{allowable} = S_y + \frac{1}{3}(S_u - S_y) = (30000) + \frac{1}{3}(75000 - 30000) = 45000 \ psi$$

$$\sigma_{allowable} = 0.7S_u = (0.7)\cdot(75000) = 52500 \ psi$$

The greater of these two values will be used as the allowable stress intensity per the acceptance criteria defined in Section 4.5.

$$\sigma_{allowable} = 52500 \ psi$$

Membrane plus Bending Stress Intensity:

$$\sigma_{allowable} = 0.9S_u = (0.9)\cdot(75000) = 67500 \ psi$$

Comparing the maximum stress intensity from Table 5-2 to the allowable limit for primary membrane stress intensity shows that the maximum stress intensity calculated during the dynamic analysis of the Point Beach Unit 2 BMI conduit is less than the allowable limit based on the criteria outlined in [1].

$$9940 \ psi < 52500 \ psi$$

Comparing the maximum stress intensity from Table 5-1 to the allowable limit for primary membrane plus bending stress intensity shows that the maximum stress intensity calculated during the dynamic analysis of the Point Beach Unit 2 BMI conduit is less than the allowable limit based on the criteria outlined in [1].

$$61897 \ psi < 67500 \ psi$$

The percent margin for the BMI conduit is the ratio of the maximum stress intensity and the allowable stress. The percent margin for the maximum primary membrane plus bending stress intensity will be conservatively used. As discussed in Section 4.6, ASME Code minimum material properties were used in this analysis. The actual properties of the BMI conduit would be stronger, which would yield a higher margin.

$$Percent_{margin} = 1 - \frac{\sigma_{max}}{\sigma_{allowable}} = 8.30\%$$

The results of the Point Beach Unit 2 conduit number 29 analysis can be seen in Tables 5-3 and 5-4.

Table 5-3: Maximum Membrane Stress Intensity Result Summary (Unit 2, Conduit 29)

Node	Stress Intensity (psi)	Time (seconds)
1	10,910	1.2850

Table 5-4: Maximum Membrane plus Bending Stress Intensity Result Summary (Unit 2, Conduit 29)

Node	Stress Intensity (psi)	Time (seconds)
1	61,288	1.3494

The results of the Point Beach Unit 1 analyses can be seen in Tables 5-5, 5-6, 5-7, and 5-8.

Table 5-5: Maximum Membrane Stress Intensity Result Summary (Unit 1, Conduit 32)

Node	Stress Intensity (psi)	Time (seconds)
1	10,410	1.2850

Table 5-6: Maximum Membrane plus Bending Stress Intensity Result Summary (Unit 1, Conduit 32)

Node	Stress Intensity (psi)	Time (seconds)
1	62,008	1.3422

Table 5-7: Maximum Membrane Stress Intensity Result Summary (Unit 1, Conduit 29)

Node	Stress Intensity (psi)	Time (seconds)
1	11,430	1.2850

Table 5-8: Maximum Membrane plus Bending Stress Intensity Result Summary (Unit 1, Conduit 29)

Node	Stress Intensity (psi)	Time (seconds)
1	61,569	1.3502

The percent margins of BMI conduit number 32 for primary membrane plus bending stress intensity are 8.14% for Unit 1 and 8.30% for Unit 2. The percent margins of BMI conduit number 29 for primary membrane plus bending stress intensity are 8.79% for Unit 1 and 9.20% for Unit 2. Therefore, the response of the BMI conduits at Point Beach Unit 1 and Point Beach Unit 2 to the postulated closure head drop events defined in [7] results in stresses within the acceptable limits stated in [1].

5.4 RESULTS VERIFICATION

The following results verification was performed for BMI conduit number 32 of Point Beach Units 1 and 2. The results verification concludes that the dynamic analyses accurately capture the responses of the systems. Although no results verification was performed for BMI conduit number 29, Westinghouse expects, with a high degree of confidence, that the conclusion will remain the same (i.e., that the BMI model accurately captures the response of the system).

As discussed in Section 4.3, the results of the dynamic analyses were compared to the results of a static analysis. Because the maximum stress intensities of the dynamic analyses occur at a displacement of approximately 2 inches, the result of the static analysis for a displacement of 2 inches was used for comparison. These results can be seen in Table 5-9.

Table 5-9: Maximum Membrane plus Bending Stress Intensity Result Summary for Static Analysis

Displacement (in)	Stress Intensity[1] (psi)
2	5,049

Note:

1. The maximum stress intensity was conservatively computed by summing the absolute values of the maximum membrane and bending stresses.

To understand why the maximum stress intensities of the dynamic analyses were approximately 12 times greater than the stress intensity of the static analysis for both Unit 1 and Unit 2, a modal analysis was performed. The response of the systems to the displacement time-histories, [4] and [7], applied at the BMI nozzle location results in an oscillation of 17.24 Hz for both Unit 1 and Unit 2. These frequencies were computed using Equation 5-1.

$$f = \frac{1}{t}$$ Frequency (Hz) Equation 5-1

In equation 5-1, f is frequency (Hz) and t is the period (seconds). Figures 5-10 and 5-11 display the locations in the displacement time-histories where the periods and frequencies were computed.

The BMI conduit responses caused by the displacement time-histories appear to be approaching resonance frequencies. Table 5-10 summarizes the modes of the systems suspected of causing amplification in the response of the dynamic analysis. See Figure 5-12. An additional figure is provided to show the modal response of the BMI conduit model with the spring-mass system included. This figure shows that the spring-mass system does not impact the response of the conduit model. See Figure 5-13.

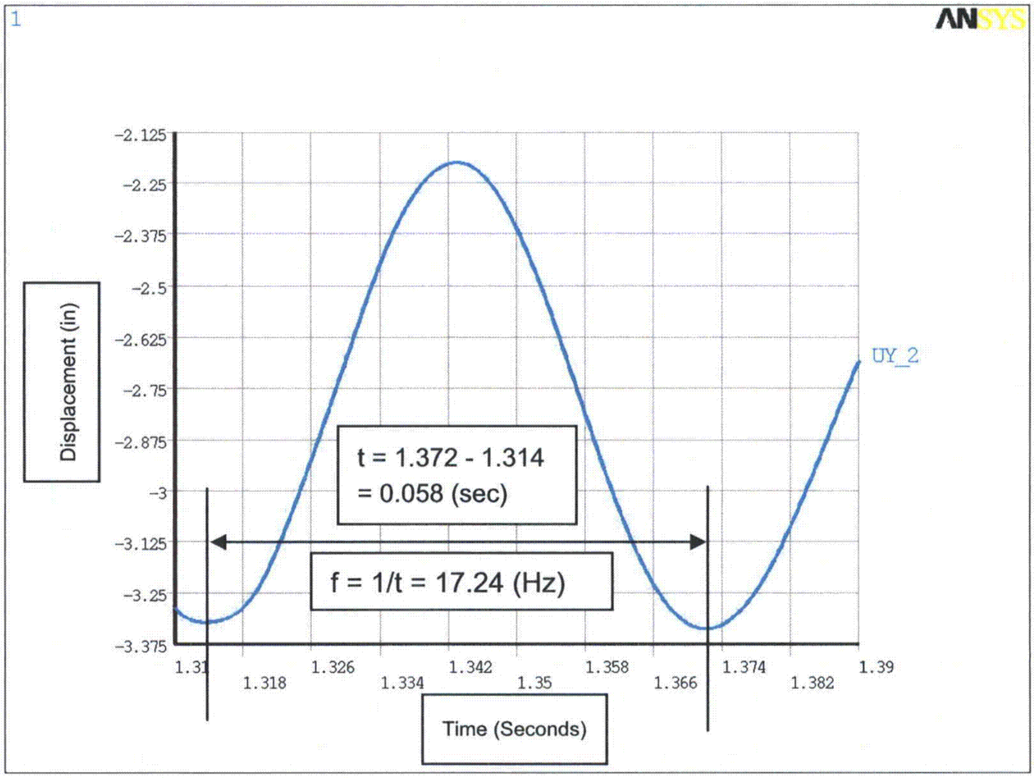

Figure 5-10: Period and Corresponding Frequency of Point Beach Unit 1 Displacement Response

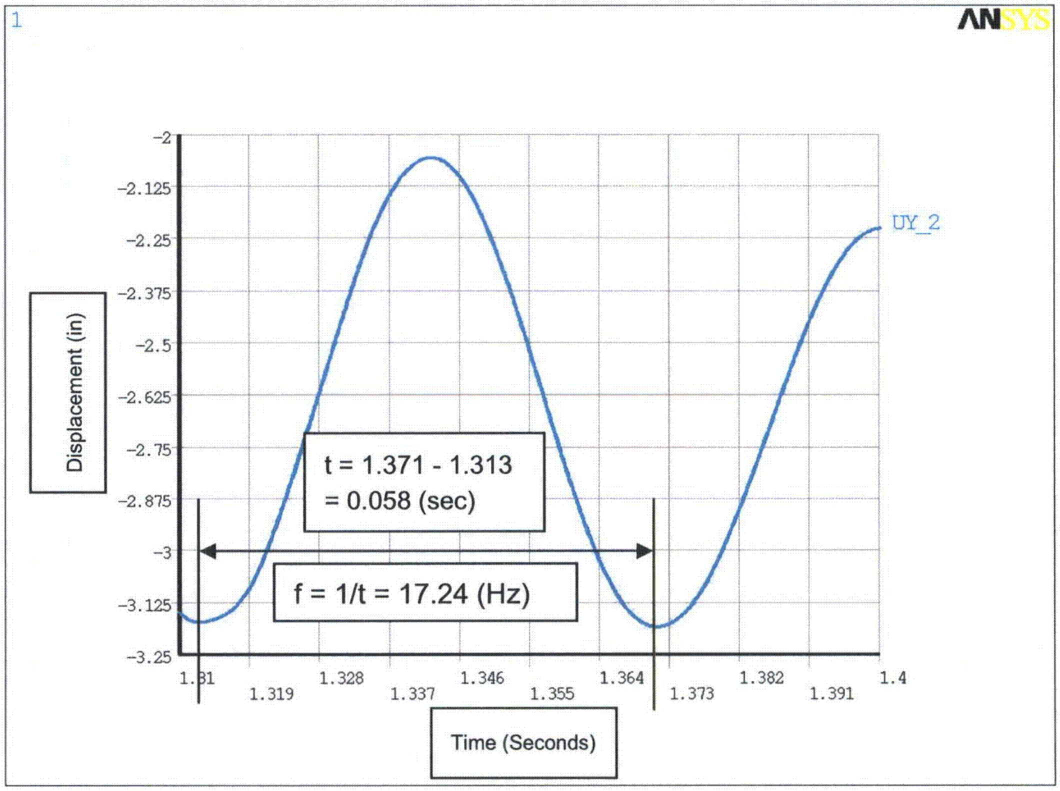

Figure 5-11: Period and Corresponding Frequency of Point Beach Unit 2 Displacement Response

Table 5-10: Modal Analysis of BMI Conduit

Unit	Mode	Frequency (Hz)
1	18	17.686
2	18	17.686

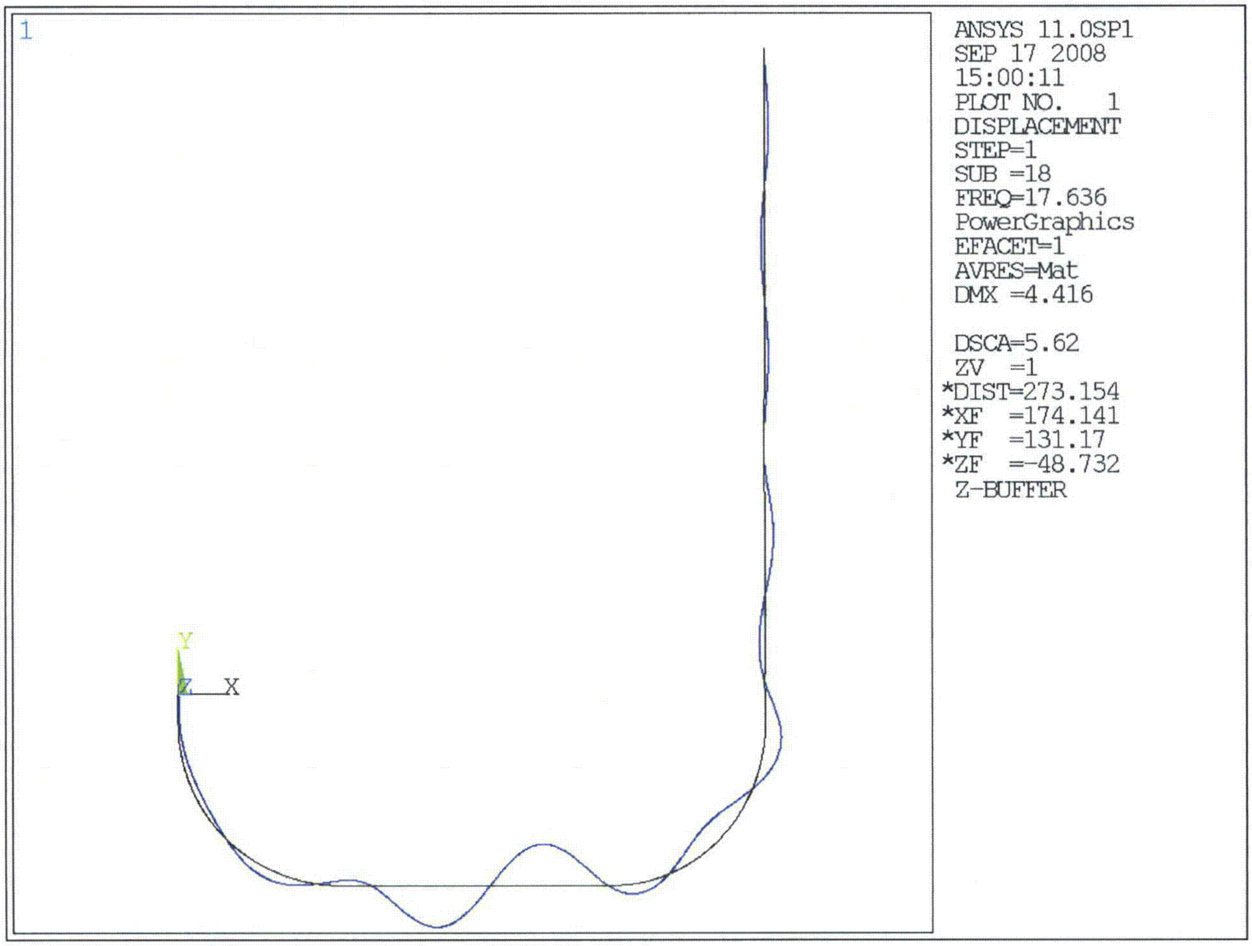

Figure 5-12: Mode Shape of the BMI Conduit Model at 17.686 Hz

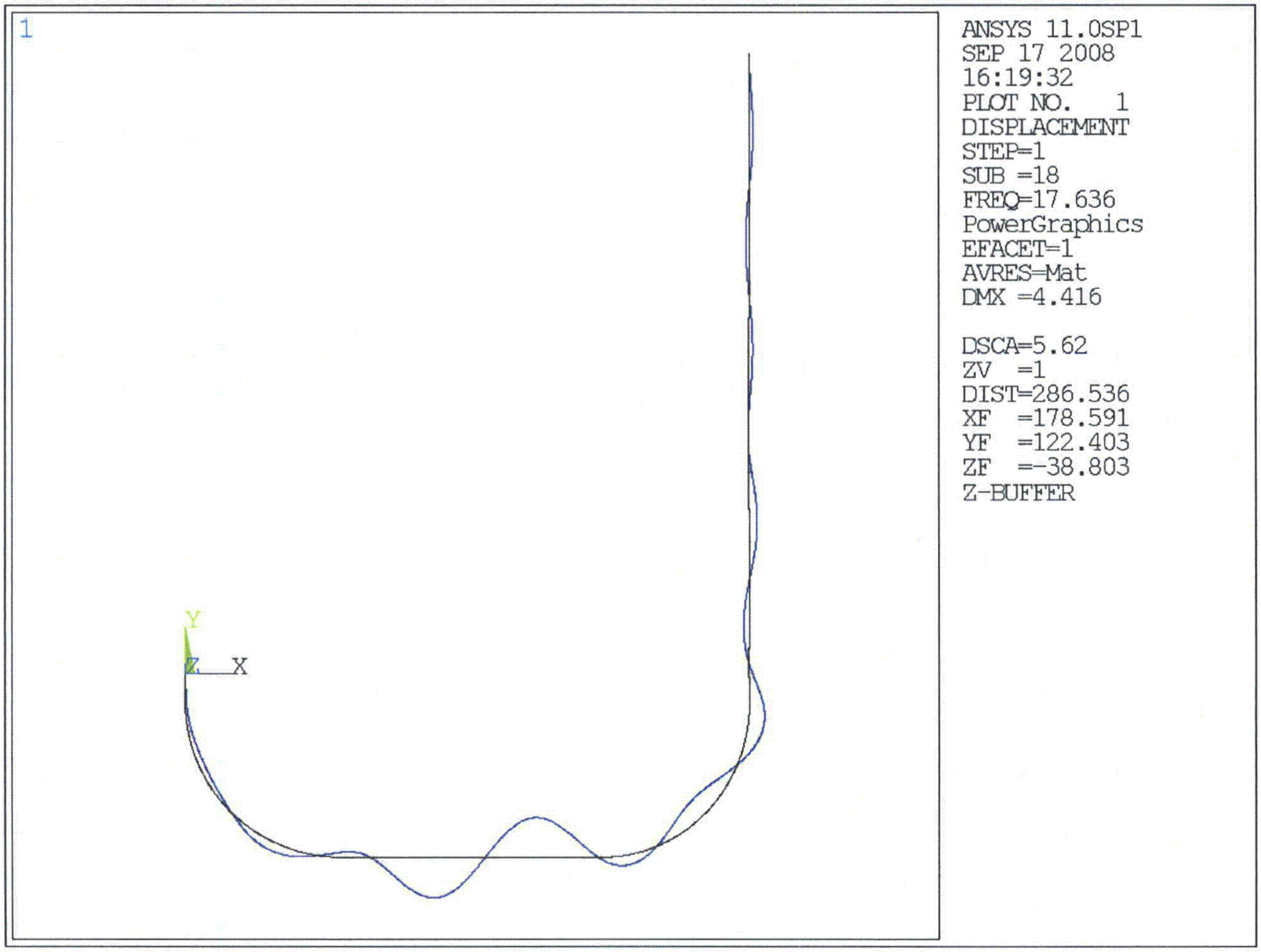

Figure 5-13: Mode Shape of the BMI Conduit Model with Spring-Mass System at 17.686 Hz

Comparing the shape of the BMI conduits responses in Figure 5-8 and Figure 5-14 to the mode shape of the systems in Figures 5-12, shows that the response of the BMI conduits to the postulated head drop events defined in [7] excites this mode causing an amplification of the response. This comparison explains why the results of the dynamic analyses are 12 times greater than the results of the static analysis.

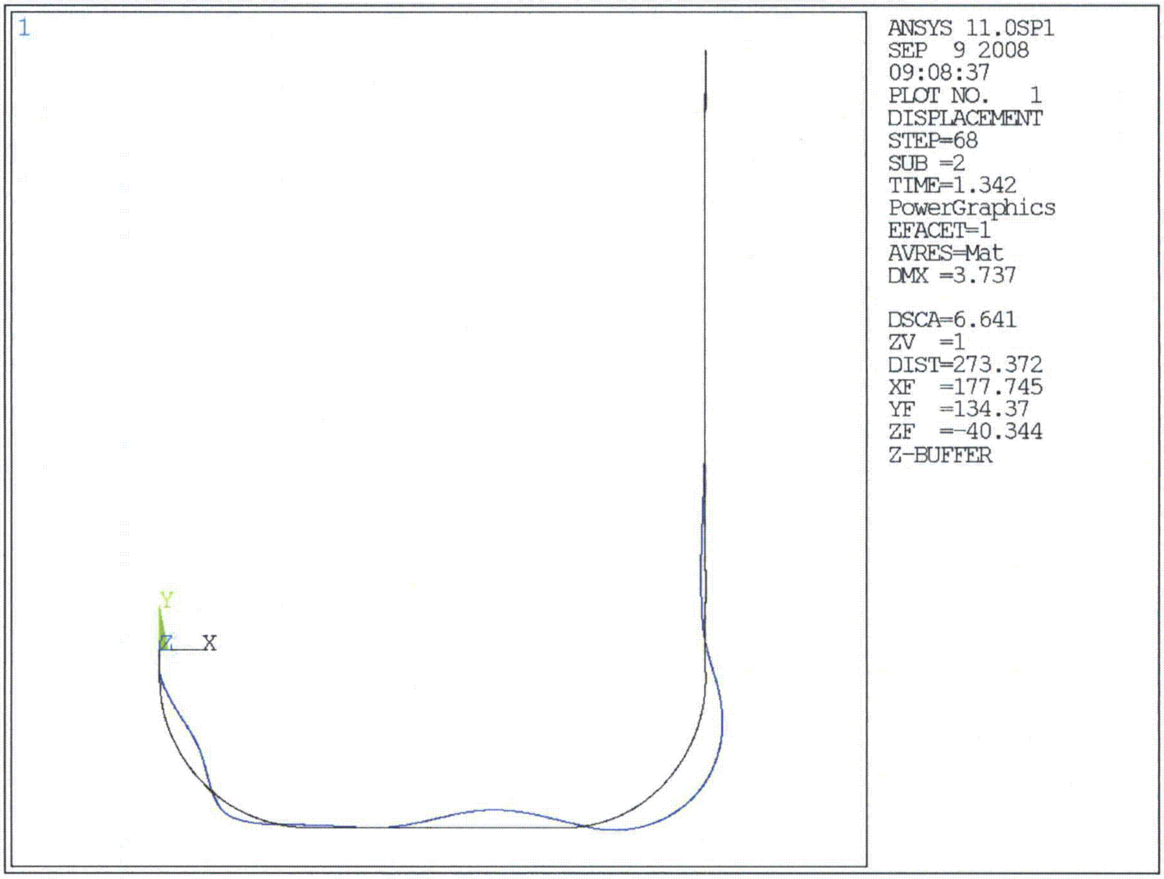

Figure 5-14: Displacement Plot of BMI Conduit at Time of Maximum Stress Intensity (Unit 1, Conduit 32)

6.0 Listing of Computer Codes Used and Runs Made in Calculation

Table 6-1: Summary of Computer Codes Used in Calculation

Code No.	Code Name	Code Ver.	Configuration Control Reference	Basis (or reference) that supports use of code in current calculation
1	ANSYS	11.0	[2] [16]	The ANSYS finite element code is a commercially available code intended to be used for a large variety of analysis types including: static elastic, dynamic elastic/plastic, and large deformation buckling analyses. When properly post-processed, the output is suitable to perform this report's evaluation.

Table 6-2
Electronically Attached File Listing

Run No.	Table 6-1 Code No.	Computer Run Description	Machine Name Run Date/Time	File Type	EDMS File Name or File Location
1	1	Creates the Point Beach BMI Unit 2 conduit number 32 model and spring-mass system, applies constraints and applies displacement time-history.	Concord July 16, 2008 16:43:50	input	pt_beach_bmi_dynamic_beam_NL.inp
				output	pt_beach_bmi_dynamic_beam_NL.out
2	1	Opens the database file constructed by computer run 1 and post-processes the computer run to determine the time, location, and magnitude of the maximum stress intensity for each node in the model.	Concord July 24, 2008 11:10:30	input	Point_Beach_BMI_Output.inp
				output	Point_Beach_BMI_Output.out
3	1	Creates Point Beach BMI conduit number 32 model, applies constraints, and performs a modal analysis.	Concord September 17, 2008 15:16:51	input	point_beach_modal.inp
				output	point_beach_modal.out
4	1	Creates the Point Beach BMI conduit number 32 model, applies constraints, and applies the 2-inch displacement.	Concord August 7, 2008 15:59:08	input	point_beach_bmi_static2.inp
				output	point_beach_bmi_static2.out
5	1	Creates the Point Beach BMI Unit 1 conduit number 32 model and spring-mass system, applies constraints and applies displacement time-history.	Concord August 29, 2008 9:45:00	input	pt_beach_bmi_dynamic_beam_NL_Unit1.inp
				output	pt_beach_bmi_dynamic_beam_NL_Unit1.out
6	1	Opens the database file constructed by computer run 5 and post-processes the computer run to determine the time, location, and magnitude of the maximum stress intensity for each node in the model.	Concord September 4, 2008 10:48:22	input	Point_Beach_BMI_Output_Unit1.inp
				output	Point_Beach_BMI_Output_Unit1.out
7	1	Creates Point Beach BMI conduit number 32 model and spring-mass system, applies constraints, and performs a modal analysis.	Concord September 17, 2008 14:05:41	input	point_beach_bmi_dynamic_modal_spring.inp
				output	point_beach_bmi_dynamic_modal_spring.out
8	1	Creates the Point Beach BMI Unit 1 conduit number 29 model and spring-mass system, applies constraints and applies displacement time-history.	Concord September 18, 2008 15:37:24	input	pt_beach_bmi_dynamic_Unit1_Long_BMI.inp
				output	pt_beach_bmi_dynamic_Unit1_Long_BMI.out

9	1	Opens the database file constructed by computer run 8 and post-processes the computer run to determine the time, location, and magnitude of the maximum stress intensity for each node in the model.	Concord September 19, 2008 13:13:00	input	Point_Beach_BMI_Output_Long_Unit1.inp
				output	Point_Beach_BMI_Output_Long_Unit1.out
10	1	Creates the Point Beach BMI Unit 2 conduit number 29 model and spring-mass system, applies constraints and applies displacement time-history.	Lightnin September 19, 2008 09:29:34	input	pt_beach_bmi_dynamic_Unit2_Long_BMI.inp
				output	pt_beach_bmi_dynamic_Unit2_Long_BMI.out
11	1	Opens the database file constructed by computer run 10 and post-processes the computer run to determine the time, location, and magnitude of the maximum stress intensity for each node in the model.	Lightnin September 20, 2008 12:52:33	input	Point_Beach_BMI_Output_Long_Unit2.inp
				output	Point_Beach_BMI_Output_Long_Unit2.out
12	1	Creates the Point Beach BMI Unit 1 conduit number 32 model and spring-mass system, applies constraints and applies displacement time-history. Large-deflection option included.	Suse105 November 13,2009 10:09:53	input	pt_beach1_bmi_short_32_nl.inp
				output	pt_beach1_bmi_short_32_nl.out
13	1	Opens the database file constructed by computer run 12 and post-processes the computer run to determine the time, location, and magnitude of the maximum membrane plus bending stress intensity for each node in the model.	Lightnin November 19, 2009 15:48:14	input	pb1_short_NL_m_plus_b_out.inp
				output	pb1_short_NL_m_plus_b_out.out
14	1	Opens the database file constructed by computer run 12 and post-processes the computer run to determine the time, location, and magnitude of the maximum membrane stress intensity for each node in the model.	Lightnin November 20, 2009 08:34:36	input	pb1_short_NL_m_out.inp
				output	pb1_short_NL_m_out.out
15	1	Creates the Point Beach BMI Unit 2 conduit number 32 model and spring-mass system, applies constraints and applies displacement time-history. Large-deflection option included.	Suse105 November 17, 2009 08:48:33	input	pt_beach2_bmi_short_32_nl.inp
				output	pt_beach2_bmi_short_32_nl.out
16	1	Opens the database file constructed by computer run 15 and post-processes the computer run to determine the time, location, and magnitude of the maximum membrane plus bending stress intensity for each node in the model.	Suse105 November 20, 2009 12:44:36	input	pb2_short_NL_m_plus_b_out.inp
				output	pb2_short_NL_m_plus_b_out.out
				input	
				output	
17	1	Opens the database file constructed by computer run 15 and post-processes the computer run to determine the time, location, and magnitude of the maximum membrane stress intensity for each node in the model.	Suse105 November 23, 2009 09:41:39	input	pb2_short_NL_m_out.inp
				output	pb2_short_NL_m_out.out
18	1	Creates the Point Beach BMI Unit 1 conduit number 29 model and spring-mass system,	Suse105 November 16,	input	pt_beach1_bmi_long_29_nl.inp
				output	pt_beach1_bmi_long_29_nl.out

		applies constraints and applies displacement time-history. Large-deflection option included.	2009 09:46:41		
19	1	Opens the database file constructed by computer run 18 and post-processes the computer run to determine the time, location, and magnitude of the maximum membrane plus bending stress intensity for each node in the model.	Lightnin November 20, 2009 12:52:04	input	pb1_long_NL_m_plus_b_out.inp
				output	pb1_long_NL_m_plus_b_out.out
20	1	Opens the database file constructed by computer run 18 and post-processes the computer run to determine the time, location, and magnitude of the maximum membrane stress intensity for each node in the model.	Lightnin November 20, 2009 15:15:42	input	pb1_long_NL_m_out.inp
				output	pb1_long_NL_m_out.out
21	1	Creates the Point Beach BMI Unit 2 conduit number 29 model and spring-mass system, applies constraints and applies displacement time-history. Large-deflection option included.	Suse105 November 17, 2009 12:41:57	input	pt_beach2_bmi_long_29_nl.inp
				output	pt_beach2_bmi_long_29_nl.out
22	1	Opens the database file constructed by computer run 21 and post-processes the computer run to determine the time, location, and magnitude of the maximum membrane plus bending stress intensity for each node in the model.	Suse105 November 20, 2009 14:55:28	input	pb2_long_NL_m_plus_b_out.inp
				output	pb2_long_NL_m_plus_b_out.out
23	1	Opens the database file constructed by computer run 21 and post-processes the computer run to determine the time, location, and magnitude of the maximum membrane stress intensity for each node in the model.	Suse105 November 23, 2009 08:30:53	input	pb2_long_NL_m_out.inp
				output	pb2_long_NL_m_out.out
24	1	Creates the Point Beach BMI Unit 1 conduit number 29 model and spring-mass system, applies constraints and applies displacement time-history. Floor contact included.	Suse105 November 17, 2009 16:08:12	input	pt_beach1_bmi_long_29_contact.inp
				output	pt_beach1_bmi_long_29_contact.out
				database	pt_beach_long_29.db
25	1	Opens the database file constructed by computer run 24 and post-processes the computer run to determine the time, location, and magnitude of the maximum membrane plus bending stress intensity for each node in the model.	Suse105 November 19, 2009 15:01:27	input	pb1_long_contact_m_plus_b_out.inp
				output	pb1_long_contact_m_plus_b_out.out
26	1	Opens the database file constructed by computer run 24 and post-processes the computer run to determine the time, location, and magnitude of the maximum membrane stress intensity for each node in the model.	Suse105 November 19, 2009 17:14:16	input	pb1_long_contact_m_out.inp
				output	pb1_long_contact_m_out.out
27	1	Creates the Point Beach BMI Unit 2 conduit number 29 model and spring-mass system, applies constraints and applies displacement	Suse105 November 23, 2009	input	pt_beach2_bmi_long_29_contact.inp
				output	pt_beach2_bmi_long_29_contact.out
				database	pt_beach_long_29.db

		time-history. Floor contact included.	13:28:53		
28	1	Opens the database file constructed by computer run 27 and post-processes the computer run to determine the time, location, and magnitude of the maximum membrane plus bending stress intensity for each node in the model.	Lightnin November 24, 2009 15:16:40	input output	pb2_long_contact_m_plus_b_out.inp pb2_long_contact_m_plus_b_out.out
29	1	Opens the database file constructed by computer run 27 and post-processes the computer run to determine the time, location, and magnitude of the maximum membrane stress intensity for each node in the model.	Suse105 November 25, 2009 08:23:31	input output	pb2_long_contact_m_out.inp pb2_long_contact_m_out.out
30	1	Creates the Point Beach BMI Unit 1 conduit number 29 model and spring-mass system, applies constraints and applies displacement time-history. Floor contact and large-deflection option included.	Suse105 November 18, 2009 16:34:46	input output database	pt_beach1_bmi_long_29_contact_NL.inp pt_beach1_bmi_long_29_contact_NL.out pt_beach_long_29.db
31	1	Opens the database file constructed by computer run 30 and post-processes the computer run to determine the time, location, and magnitude of the maximum membrane plus bending stress intensity for each node in the model.	Suse105 November 20, 2009 08:35:26	input output	pb1_long_contact_NL_m_plus_b_out.inp pb1_long_contact_NL_m_plus_b_out.out
32	1	Opens the database file constructed by computer run 30 and post-processes the computer run to determine the time, location, and magnitude of the maximum membrane stress intensity for each node in the model.	Suse105 November 20, 2009 10:58:59	input output	pb1_long_contact_NL_m_out.inp pb1_long_contact_NL_m_out.out
33	1	Creates the Point Beach BMI Unit 2 conduit number 29 model and spring-mass system, applies constraints and applies displacement time-history. Floor contact and large-deflection option included.	Suse105 November 24, 2009 11:21:05	input output	pt_beach2_bmi_long_29_contact_NL.inp pt_beach2_bmi_long_29_contact_NL.out
34	1	Opens the database file constructed by computer run 33 and post-processes the computer run to determine the time, location, and magnitude of the maximum membrane plus bending stress intensity for each node in the model.	Suse105 November 24, 2009 15:00:58	input output	pb2_long_contact_NL_m_plus_b_out.inp pb2_long_contact_NL_m_plus_b_out.out
35	1	Opens the database file constructed by computer run 33 and post-processes the computer run to determine the time, location, and magnitude of the maximum membrane stress intensity for each node in the model.	Suse105 November 24, 2009 16:19:57	input output	pb2_long_contact_NL_m_out.inp pb2_long_contact_NL_m_out.out

Appendix A: Additional Analyses

A.1 BACKGROUND AND PURPOSE

At the request of FPL Energy, LLC, additional analyses were performed to further assess the impact of the postulated head drop events from [7] on the acceptability of the BMI conduits of Point Beach Units 1 and 2. These additional analyses were used to study the effect of the large-deflection option within ANSYS and the effect of explicitly modeling BMI-to-floor contact. Neither the large-deflection option, nor floor contact were included in the results presented in Section 2.0 of this calculation note.

The large-deflection option is activated in ANSYS with the "NLGEOM, ON" command. If geometric nonlinearities are expected in the response of a structure, stiffness changes in the elements should be considered. By activating the large-deflection effects in ANSYS with the "NLGEOM, ON" command, the stiffness matrix of the elements will be updated as the shape and orientation changes. This will result in more accurate results of the response when large deflections are present.

As discussed in assumption 5 of Section 4.4, contact between the floor and the BMI conduit was not modeled because it was assumed that allowing the BMI conduit to deflect freely would cause the highest stresses. To assess the validity of this assumption, additional analyses were preformed to include BMI contact with the floor. The floor contact analyses apply only to the model of BMI conduit number 29 for Point Beach Units 1 and 2 because BMI conduit number 32 will not deflect enough to contact the floor. See Figure 4-1.

A.2 METHOD DISCUSSION

To study the impact of the large-deflection option and floor contact, three cases were considered for the BMI conduits of Point Beach Units 1 and 2. The first case applies to all conduit models; however, the second and third cases consider floor contact and, therefore, apply only to the BMI conduit number 29 model. The full 3 second displacement time-histories of Point Beach Units 1 and 2 were not applied to the models. Rather, the displacement time-histories were reduced to the first 1.5 seconds. It was determined that the full 3 second displacement time-histories were not necessary to capture the maximum stress intensities of the models. This assumption is based on the times of maximum stress intensities reported in Section 2.0 of this calculation note and the gradual damping of the displacement time-histories.

A.2.1 Case 1 – Large-Deflection Option

The first case uses the same models, methodologies, and assumptions discussed in the body of this calculation note, with the exception that the large-deflection option is included in the analyses. The results of this case can be compared to the results reported in Section 2.0 to determine the impact of including the large-deflection option.

A.2.2 Case 2 – Floor Contact

The second case uses the same models, methodologies, and assumptions discussed in the body of this calculation note, with the exception that the floor of the containment building is explicitly modeled and contact between BMI conduit number 29 and the floor is included in the analyses. The large-deflection option is not used in the analysis. The floor is modeled as a rigid surface positioned 1.25 inches below the BMI conduit, which is the minimum amount of clearance between a BMI conduit and the floor, as measured during the plant walk-down in [3, Attachment B]. Node-to-surface contact is used to establish contact between the floor and the BMI conduit. TARGE170 elements are used to mesh the rigid floor as the "target" surface, and CONTA175 elements are used to mesh the lower portion of the BMI conduit as the "contact" nodes. Contact is established when the nodes of the BMI conduit penetrate the rigid target surface representing the floor. Figure A-1 displays the model of the BMI conduit number 29 and the rigid floor. The contact nodes on the BMI conduit are highlighted in blue. The results of this case can be compared to the results reported in Section 2.0 to determine the impact of modeling floor contact.

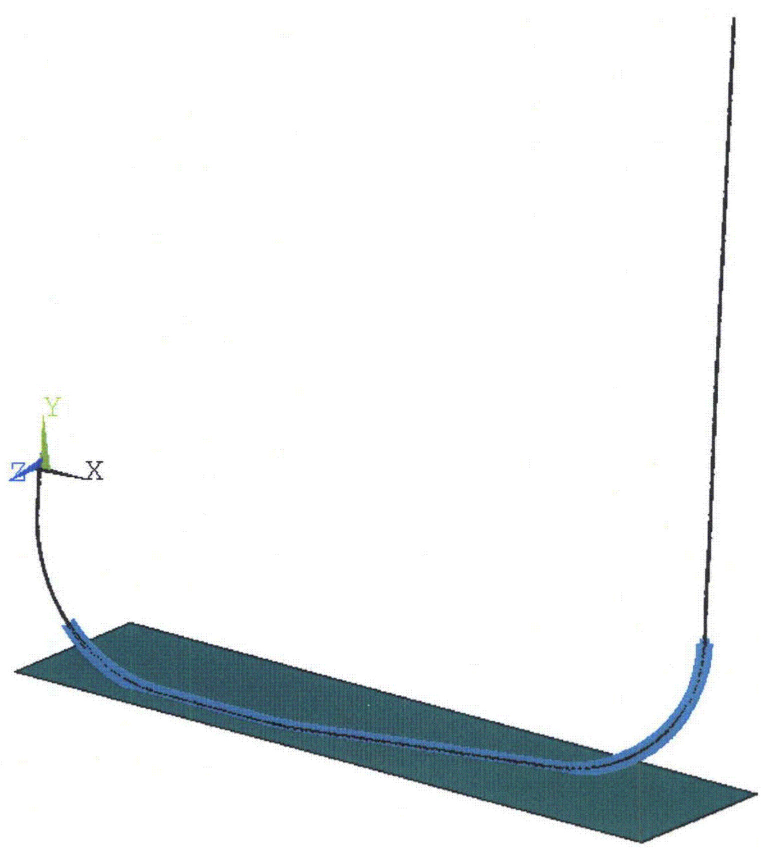

Figure A-1: Floor Contact Model

A.2.3 Case 3 – Large-Deflection Option and Floor contact

The third case uses the same models, methodologies, and assumptions discussed in the body of this calculation note. Case three is a combination of the previous two cases. Both floor contact and the large-deflection option are included in the analysis. The results of this case will be used to determine the impact of modeling floor contact and using the large-deflection option.

A.3 RESULTS DISCUSSION

For all three cases discussed in the previous section, the responses of the finite element models to the applied displacement time-histories were compared to the acceptance criteria discussed in Section 4.5. Post-processing macros, similar to the macro discussed in Section 5.2.1, were used to determine the maximum membrane and membrane plus bending stress intensities, over time, for each node. The largest stress intensity values were then compared to the acceptance criteria. The stress intensity results for all three cases are summarized in Table A-1 through Table A-3. These tables also list the unit, conduit number, specific location of maximum stress intensity, and time of maximum stress intensity.

Case 1 produced the largest membrane plus bending stress intensity values of the three cases. The results were also larger than those reported in Table 2-1; however, they remain within the acceptable limits defined in Section 4.5. Case 2 produced results that were about the same as those reported in Table 2-1, despite the inclusion of floor contact; however, the time of maximum membrane plus bending stress intensity occurs earlier for Case 2. This is caused by a change in dynamic response of the BMI conduit due to contact with the floor. Case 3 produced the lowest membrane plus bending stress intensity values. In this case, the use of the large-deflection option caused lower stresses than those seen in Case 2, where large-deflection effects were not included. Membrane stress intensity values had no significant change when floor contact was included and only changed slightly with the use of the large-deflection option. Membrane stress intensities remain well below the allowable limits for all cases.

Table A-1: Stress Intensity Results of Case 1

Case 1 – Large-Deflection Option							
Unit	**BMI Conduit Number**	**Stress Category**	**Location**	**Time (seconds)**	**Stress Intensity (psi)**	**Allowable Stress (psi)**	**Margin(1) (%)**
Unit 1	**32**	Membrane Stress	BMI Nozzle to BMI Conduit Interface(2)	1.2846	10,190	52,500	80.59
		Membrane plus Bending Stress	BMI Nozzle to BMI Conduit Interface(2)	1.3381	64,894	67,500	3.86
Unit 2	**32**	Membrane Stress	BMI Nozzle to BMI Conduit Interface(2)	1.2846	9,742	52,500	81.44
		Membrane plus Bending Stress	BMI Nozzle to BMI Conduit Interface(2)	1.3371	64,794	67,500	4.01
Unit 1	**29**	Membrane Stress	BMI Nozzle to BMI Conduit Interface(2)	1.2846	11,249	52,500	78.57
		Membrane plus Bending Stress	BMI Nozzle to BMI Conduit Interface(2)	1.3451	64,657	67,500	4.21
Unit 2	**29**	Membrane Stress	BMI Nozzle to BMI Conduit Interface(2)	1.2846	10,741	52,500	79.54
		Membrane plus Bending Stress	BMI Nozzle to BMI Conduit Interface(2)	1.3446	64,342	67,500	4.68

Notes:

1) Percent Margin = (1 – Actual Stress / Allowable Stress)·100%
2) This interface is represented in the finite element models as node 1. See Figures 4-5 and 5-1.

Table A-2: Stress Intensity Results of Case 2

Case 2 – Floor Contact							
Unit	**BMI Conduit Number**	**Stress Category**	**Location**	**Time (seconds)**	**Stress Intensity (psi)**	**Allowable Stress (psi)**	**Margin[1] (%)**
Unit 1	**29**	Membrane Stress	BMI Nozzle to BMI Conduit Interface[2]	1.2846	11,436	52,500	78.22
		Membrane plus Bending Stress	BMI Nozzle to BMI Conduit Interface[2]	1.3001	62,142	67,500	7.94
Unit 2	**29**	Membrane Stress	BMI Nozzle to BMI Conduit Interface[2]	1.2846	10,915	52,500	79.21
		Membrane plus Bending Stress	BMI Nozzle to BMI Conduit Interface[2]	1.3	61,430	67,500	8.99

Notes:

1) Percent Margin = (1 – Actual Stress / Allowable Stress)·100%
2) This interface is represented in the finite element models as node 1. See Figures 4-5 and 5-1.

Table A-3: Stress Intensity Results of Case 3

Case 3 – Large-Deflection Option and Floor Contact							
Unit	**BMI Conduit Number**	**Stress Category**	**Location**	**Time (seconds)**	**Stress Intensity (psi)**	**Allowable Stress (psi)**	**Margin[1] (%)**
Unit 1	**29**	Membrane Stress	BMI Nozzle to BMI Conduit Interface[2]	1.2846	11,249	52,500	78.57
		Membrane plus Bending Stress	BMI Nozzle to BMI Conduit Interface[2]	1.3000	60,367	67,500	10.57
Unit 2	**29**	Membrane Stress	BMI Nozzle to BMI Conduit Interface[2]	1.2846	10,741	52,500	79.54
		Membrane plus Bending Stress	BMI Nozzle to BMI Conduit Interface[2]	1.2998	59,652	67,500	11.63

Notes:

1) Percent Margin = (1 – Actual Stress / Allowable Stress)·100%
2) This interface is represented in the finite element models as node 1. See Figures 4-5 and 5-1.

A.4 CONCLUSION

Comparison of the membrane and membrane plus bending stress intensity results in Tables A-1 through A-3 to the results in Table 2-1 demonstrates the impact of the large-deflection option and floor contact on the acceptability of the BMI conduits of Point Beach Units 1 and 2. Allowing the BMI conduits to deflect freely, with no floor contact, including large-deflection effects produced the largest stresses. Although these stresses are larger than those reported in Table 2-1, the stress intensity values remain below the allowable limits. Therefore, the response of the BMI conduits at Point Beach Unit 1 and Point Beach Unit 2 to the postulated closure head drop events defined in [7] results in stresses within the acceptable limits stated in [1].

Checklist A: Proprietary Class Statement Checklist

Westinghouse Proprietary Class 1

☐ If the document contains highly sensitive information such as commercial documents, pricing information, legal privilege, strategic documents, including business strategic and financial plans and certain documents of the utmost strategic importance, it is Proprietary Class 1. Check the box to the left and see Appendix B of Procedure 1.0 in WCAP-7211, Revision 5, for guidance on the use of Form 36 and the distribution of this document. This document can be found at

http://worldwide.westinghouse.com/pdf/e3_wcap-7211.pdf.

Westinghouse Proprietary Class 2 – Non-Releasable

Review the questions below for applicability to this calculation, checking the box to the left of each question that is applicable. If one or more boxes are checked, the calculation is considered a Westinghouse Proprietary Class 2 – Non-Releasable document. See Appendix B of Procedure 1.0 in WCAP-7211, Revision 5, for guidance on the use of Form 36 and the distribution of this document.

☐ Does the document contain one or more of the following: detailed manufacturing information or technology, computer source codes, design manuals, priced procurement documents or design reviews?

☐ Does the document contain sufficient detail of explanation of computer codes to allow their recreation?

☐ Does the document contain special methodology or calculation techniques developed by or for Westinghouse using a knowledge base that is not available in the open literature?

☐ Does the document contain any cost information or commercially or legally sensitive data?

☐ Does the document contain negotiating strategy or commercial position justification?

☐ Does the document contain Westinghouse management business direction or commercial strategic directions?

☐ Does the document contain third party proprietary information?

☐ Does the document contain information that supports Westinghouse patented technologies, including specialized test data?

☐ Does the document contain patentable ideas for which patent protection may be desirable?

Westinghouse Proprietary Class 2 – Releasable

☐ If the calculation note is determined to be neither Westinghouse Proprietary Class 1 nor Westinghouse Proprietary Class 2 – Non-Releasable, it is considered Westinghouse Proprietary Class 2 – Releasable. Check the box to the left and refer to Appendix B of Procedure 1.0 in WCAP-7211, Revision 5, for guidance on use of Form 36 and the distribution of the document.

Westinghouse Non-Proprietary Class 3 – Releasable

☒ If the calculation note is determined to be neither Westinghouse Proprietary Class 1 nor Westinghouse Proprietary Class 2 – Non-Releasable or Releasable, it is considered Westinghouse Non-Proprietary Class 3 – Releasable. Check the box to the left and refer to Appendix B of Procedure 1.0 in WCAP-7211, Revision 5, for guidance on use of Form 36 and the distribution of the document.

Checklist B: Calculation Note Methodology Checklist

(Completed By Author)

No.	Self Review Topic	Yes	No	N/A
1	Was the latest version of the calculation note template used?	✓		
2	Is all information in the cover page header block provided appropriately?	✓		
3	Are all the pages sequentially numbered, and are the calculation note number, revision number, and appropriate proprietary classification listed on each page? Are the page numbers in the Table of Contents provided and correct?	✓		
4	Does this calculation note fulfill the customer requirements?	✓		
5	Is the Summary of Results and Conclusions provided in Section 2.0 consistent with the purpose stated in Section 1.0 and calculations contained in Section 5.0?	✓		
6	Is sufficient information provided for all References in Section 3.0 to facilitate their retrieval (e.g., from EDMS, SAP, CAPs, NRC's ADAMS system, open literature, etc.), or has a copy been provided in Appendix A?	✓		
7	Are Section 4.2 and the open items box on the calculation note cover sheet consistent?	✓		
8	Are all computer outputs documented in Table 6-2 and consistent with Table 6-1?	✓		
9	Are all computer codes used under Configuration Control and released for use?	✓		
10	Are the computer codes used applicable for modeling the physical and/or computational problem contained in this calculation note?	✓		
11	Have the latest and/or most appropriate versions of all computer codes been used?	✓		
12	Have all open computer code errors identified in Software Error Reports been addressed?	✓		
13	Are the units of measure clearly identified?	✓		
14	Are approved design control practices (e.g., Level 3 procedures, guidebooks, etc.) followed without exception? If Level 3 procedures are used, please list those used, either in the body of the calculation note or here: ES 4.2 (Rev. 0), PSDR-QP-4.5 (Rev. 1), ES 5.1 (Rev. 0), PSDR-QP-4.6 (Rev.1)	✓		
15	Are all hand-annotated changes to the calculation note initialed and dated by author and verifier? Has a single line been drawn through any changes with the original information remaining legible?			✓
16	Was a Pre-Job Brief held prior to beginning the analysis?	✓		
17	Was a Self Check performed prior to submitting the analysis for Peer Checks and/or final verification?	✓		
18	Was a Peer Check performed to review inputs documented in Section 4.6 prior to performing analyses?	✓		
19	Was a Peer Check performed to review results before documenting them in Section 5.0?	✓		
20	If required, have computer files been transferred to archive storage? Provide page number for list of files if not included in Table 6-2. Page	✓		
21	If applicable, have the results of any previous assessments on the analysis of record been incorporated in this calculation note?			✓
22	If this calculation note requires a change to a safety analysis database (e.g., SAIK), has the change been submitted such that the database will be updated?			✓

If 'NO' to any of the above, provide page number of justification or provide additional explanation here or on subsequent pages.

Checklist C: Verification Method Checklist

[Completed By Verifier(s)]

Verification Method (One or more must be completed by each verifier)			Initial If Performed
1	Independent review of document. (Briefly explain method of review below or attach.)		DPM
2	Verification performed by alternative calculations as indicated below.(1)		
	a.	Comparison to a sufficient number of simplified calculations which give persuasive support to the original analysis.	
	b.	Comparison to an analysis by an alternate verified method.	
	c.	Comparison to a similar verified design or calculation.	
	d.	Comparison to test results.	
	e.	Comparison to measured and documented plant data for a comparable design.	
	f.	Comparison to published data and correlations confirmed by experience in the industry.	
3	Completed Group-Specific Verification Checklist. (Optional, attach if used.)		
4	Other (Describe)		

(1) For independent verification accomplished by comparisons with results of one or more alternate calculations or processes, the comparison should be referenced, shown below, or attached to the checklist.

Verification: The verifier's signature (or Electronic Approval) on the cover sheet indicates that all comments or necessary corrections identified during the review of this document have been incorporated as required and that this document has been verified using the method(s) described above. For multiple verifiers, appropriate methods are indicated by initials. If necessary, technical comments and responses (if required) have been made on the "Additional Verifier's Comments" page.

Additional Details of Verifier's Review

The review of Revision 1 to this calculation note was conducted using the three-pass verification method. Consistent with item number 23 of Checklist B: Calculation Note Methodology Checklist of the new calculation note template, version 6.1, the guidelines of WCAP-16904-P were used for this finite element analysis.

The component structural analysis process was used in this work.

Checklist D: 3-Pass Verification Methodology Checklist

[Completed by Verifier(s)]

No.	3-Pass Verification Review Topic	Yes	No	N/A
	First Pass			
1	Were the general theme, scope of document, and scope of review clear?	✓		
	Second Pass			
2	Do the references appear to be documented correctly? Is there enough information present to ensure the referenced document is retrievable?	✓		
3	Do the acceptance criteria seem appropriate?	✓		
4	Does the technical content of the calculation note make sense from a qualitative standpoint and are appropriate methods used?	✓		
	Third Pass			
5	Do the results and conclusions meet the acceptance criteria? Do the results and conclusions make sense and support the purpose of the calculation note?	✓		
6	Has the technical content of the document been verified in adequate detail? Examples of technical content include inputs, models, techniques, output, hand calculations, results, tables, plots, units of measure, etc.	✓		
7	Does the calculation note provide sufficient detail in a concise manner? Note that sufficient detail is enough information such that a qualified person could understand the analysis and replicate the results without consultation with the author.	✓		
8	Is the calculation note acceptable with respect to spelling, punctuation, and grammar?	✓		
9	Are the references accurate? Do the references to other documents point to the latest revision? If not, are the reasons documented? Are the references retrievable?	✓		
10	Are computer code names spelled correctly? If applicable, are numerals included in the official code name as appropriate?	✓		
11	Has the calculation note been read word-for-word, cover-to-cover?	✓		

If 'NO' to any of the above, provide page number of justification or provide additional explanation here or on subsequent pages.

Additional Verifier's Comments

The signatures of the Author(s) and Verifier(s) on the cover page (or Electronic Approval) indicate acceptance of the comments and responses.

No.	Verifier's Comments	Author's Response (If Required)
	None	None Required