Becht Nuclear Services • 5224 Woodside Executive Court, Aiken, SC 29803
Tel. 803-648-7461 • Cell 803-979-1340 • www.bechtns.com

April 6, 2009

Mr. Ron Zak
New Jersey Department of Environmental Protection
Bureau of Nuclear Engineering
33 Artic Parkway
PO Box 415
Trenton, NJ 08625

Subject:

17693-L-001	Transmittal of Oyster Creek Drywell Review Report, Rev. 0	4/6/09	GLH

Dear Mr. Zak:

BNS is pleased to provide the subject item, our review of the Oyster Creek Drywell analysis, as fulfillment of our Scope of Work defined in our Proposal dated February 19, 2009.

Greg L. Hollinger

C: C. Becht, IV, Ph. D., P.E.
G. A. Antaki, P.E.

NJDEP Oyster Creek Drywell Review

Document No. 17693-R-001

Revision No. 0 (4/6/2009)

Prepared by: G. L. Hollinger, P.E.
Reviewed by: C. Becht IV, PhD., P.E.
Approved by: G. A. Antaki, P.E.

Record of Revisions

Revision	Description of Changes
0	4/6/2009: Initial Issue

Table of Contents

Executive Summary

BNS conducted a review of the documents listed as References 1 through 9a herein. A detailed review of the two Structural Integrity Associates Reports [1] and [2] was performed. A detailed review of the Sandia Report [3] was also performed. That review is a supplement to the overall evaluation and comparison with the SIA evaluations contained in their reports. The detailed review of the Sandia Report is not documented herein.

BNS believes that the SIA analysis reported in the 403 SIA Report [1] presents a modern, up-to-date deterministic evaluation of the Oyster Creek Drywell in accordance with ASME Section III, Subsection NE [10]. The Code requirements are satisfied for the drywell in its current (2006-2008) state of degradation with assumed thin regions based on limited thickness measurements and as modeled based on those measurements. As with any such deterministic engineering evaluation, there are conditions and assumptions with both positive and negative effects on the accuracy and conservatism of the evaluations. These assumptions are typically acceptable, since the design margins included in the Code allowable stresses and other criteria are set to account for such typical unknown conditions.

The analysis of two sensitivity cases reported in the 404 SIA Report [2] indicate that a modest reduction in thickness from the base case reported in the 403 Report [1] results in a slight increase in Code stress levels and a minimal effect on buckling safety factors. BNS believes that the two sensitivity cases presented in the SIA 404 Report do not represent an estimate of Code stresses and buckling factors at the end-of-extended-life, whereas the Sandia report does estimate an end-of-extended life condition. In both cases, however, Code limits are shown to be met. BNS concurs with those assessments based on the scope of review conducted and as reported herein.

BNS identified several items affecting the overall level of conservatism in SIA's evaluation of the drywell. The most significant is the possible level of negative conservatism associated with the hoop tension enhanced capacity reduction factors used for the refueling configuration evaluation. First, BNS shows that the required code buckling factor of safety (FS) is acceptable without use of Miller's modified capacity reduction factor. In addition, it is likely that with a less conservative treatment of the locally high theoretical buckling stress, paired with a more conservative treatment of the enhanced capacity reduction factors for each location of high compressive stress, the resulting buckling safety factors will continue to meet Code limits and will exhibit additional margin.

BNS believes that the uncertainty associated with the wall thinning measurements has been treated adequately for the measurements provided to-date, and as evaluated in two sensitivity cases in SIA's 404 Report [2]. BNS believes that the SIA 404 report does not address end-of-extended life conditions, per se. However, rather than performing more analysis now, whether deterministically-, statistically- or probabilistically-based, BNS recommends that continued measurement of drywell thickness and evaluation be an ongoing process, and that the interval of inspections and measurements be done and evaluated as frequently as practicable in the early years of extended operation.

1. Introduction

References in this report are denoted by [nn], where nn is a reference number listed in the References Section of this report. The agreed upon Scope of Work for which this report is prepared is provided in Appendix A. The following items summarize the Scope of Work.

- Perform a technical review of the three-dimensional structural analysis report of the Oyster Creek drywell. The structural analysis is presented in two documents, which this review considers "the two principal documents":
  - Structural Integrity Associates Report 0006004.403 R0, "Structural Evaluation of the Oyster Creek Drywell Summary Report" [1]. NOTE: This is termed the "403 Report" herein.
  - Structural Integrity Associates Report 0006004.404 R0, "Oyster Creek Drywell Sandbed Region Wall Thinning Sensitivity Analyses Summary Report" [2]. NOTE: This is termed the "404 Report" herein.

- The review is to include an independent technical review covering these and other identified attributes:
  - basis of acceptability of design inputs and assumptions
  - methodology
  - analytical modeling
  - applied loadings
  - sensitivity analysis
  - other items as necessary
  - specifically detail the validity of the capacity reduction factors used in the analysis

- The review is to be documented in a report to NJDEP-BNE including:
  - Details and scope of the review performed
  - Executive Summary
  - Comprehensive discussion of findings of;
    - Evaluations
    - Opinions
    - Deficiencies
    - Safety Issues
    - Other Items

The review considers the following documents as "supporting information" for the review.

- Sandia Report, SAND2007-0055, "Structural Integrity Analysis of the Degraded Drywell Containment at the Oyster Creek Nuclear Generating Station, " NOTE: This is termed "The Sandia Report" herein.
- Sandia e-mail to NRC, February 9,2007 [4].
- NRC Memo to ACRS, March 8 [5].
- ASLB Memorandum, October 29, 2008:ASLB (Hawkens, Abramson and Baratta) [6].
- NJDEP-BNE Letter to NRC, September 16, 2008 [7].
- NJDEP-BNE Letter to NRC, January 30, 2009 [8].
- Results of Three-Dimensional Structural Analysis of the Oyster Creek Drywell Shell, Associated with AmerGen's License Renewal Application (TAC No. MC7624) [9].

The process used for the review is outlined as follows.

1. Review the provided documents [1] through [9] on a first-pass basis to gain an overall view of the material. The issues identified in that first-pass review include:

   a. The capacity reduction factor tensile hoop stress for the refueling configuration evaluation.
   b. Modeling of thin areas with the shell radius equal to the un-thinned shell radius.
   c. The number of assumptions identified in lists and in the text of the reports.
   d. The relationship between the 1962 Section VIII requirements versus Section VIII Div. 2 and Section III, Subsection NE and use of a design-construction code (ASME Section III, Subsection NE) and minimum lower bound material properties for a fitness for service, life extension evaluation.
   e. A horizontal earthquake load of 2,150 k and its relationship to the response spectrum loading.
   f. Use of maximum attached piping support spans rather than spans as they exist in the plant.
   g. Potential for material property degradation from aging or exposure to radiation.
   h. Exemption from fatigue analysis with the irregularly shaped and potentially rough thin regions.
   i. No projection of thinning to end-of-life.
   j. Use of a solid model and linearization of stresses.

2. Perform a page-by-page review of both SIA reports 403 Report [1] and 404 Report [2], identifying questions and issues, recording them in a “notes table,” recording the document (403 or 404 report), page number, location on the page, the topic of the issue, the reviewer comment, and an experience-based judgment of the level of conservatism, negative conservatism and any uncertainty associated with the comment. Each of the comments is associated with one or more of the attributes listed in the Scope of Work (listed above).

3. Conduct teleconferences with NJDEP, EXELON and SIA to resolve questions, and decide if the resolution closed the comment or continued to keep it as a comment.

4. Categorize and report the review comments as one of the following:

   a. comments that illustrate positive (+) conservatism in the analysis.
   b. comments that illustrate negative (-) conservatism in the analysis.
   c. comments that illustrate neutral levels of conservatism in the analysis.
   d. comments that illustrate items of uncertainty.
   d. technical-associated editorial comments (for information only).

5. Using the information in process step 4 above, determine an overall judgment of the level of conservatism that this analysis represents with respect to meeting the requirements of The American Society of Mechanical Engineers Boiler and Pressure Vessel Code, Section III, Subsection NE for Class MC Components [10] supplemented by Nuclear Code Case N-284-1 [11] and two documents written by C. D. Miller, listed as references 23 and 26 of the 403 SIA Report [1]. WRC Bulletins 406 [12] and 462 [13] are used to supplement the review of the Miller references.

NOTE: The abbreviation “CRF” is used for “capacity reduction factor” throughout the report.

2. Summary of Results

Table 2.1 provides an overview of the review results in the form of general comments for the documents provided to Becht Nuclear Services by NJDEP (references 1 through 9a).

Table 2.1
Overview of Review Results of Documents Provided by NJDEP

NJDEP Ref No.		Content	Status
[1]	Structural Integrity Associates Report 0006004.403 R0, "Structural Evaluation of the Oyster Creek Drywell Summary Report"	Base Analysis Results, i.e., as-measured LTAs, but without sensitivity study.	Page-by-page initial/dated review complete. Issues marked on pages and recorded in a Table and categorized as an observation (ob, ob+ or ob-) indicating positive, negative or no impact on conservatism or with a level of uncertainty from -2 to 0.
[2]	Structural Integrity Associates Report 0006004.404 R0, "Oyster Creek Drywell Sandbed Region Wall Thinning Sensitivity Analyses Summary Report."	Sensitivity Study of Wall Thinning in the Sandbed region of the containment structure	Page-by-page initial/dated review complete. Issues marked on pages and recorded in a Table and categorized as an observation (ob, ob+ or ob-) indicating positive, negative or no impact on conservatism or with a level of uncertainty from -2 to 0.
[3]	Sandia Report, SAND2007-0055, "Structural Integrity Analysis of the Degraded Drywell Containment at the Oyster Creek Nuclear Generating Station"	Sandia's Independent Analysis of the Drywell	Page-by-page initial/dated review complete on marked pages. Used as source material and as a general comparison with SIA's analysis.
[4]	Sandia e-mail to NRC, February 9,2007	Comments about hoop tension based modified capacity reduction factors and Sandia's opinion that they should not be used for the refueling load combination because there is no internal pressure applied for that case.	Information, with BNS comments.
[5]	NRC Memo to ACRS, March 8, 2007	Explanation of misunderstanding created by a presentation slide regarding the hoop stress tension issue, particularly as it relates to hoop tension being included in the bifurcation analysis and then in the capacity reduction factor.	Information, with BNS comments.
[6]	ASLB Memorandum, October 29, 2008	Discussions of issues regarding sensitivity analyses, assignment of measured thicknesses, visual estimates of thicknesses, extrapolation between bays, Monte Carlo simulation, use of an outside expert to	Information, with BNS comments.

Table 2.1
Overview of Review Results of Documents Provided by NJDEP

		evaluate the adequacy of EXELON's analysis and its response to intervener's concerns expressed in meetings in the Fall of 2008, and how the 3D analyses bound expectation of Jude Baratta's directive, and the issue associated with use of the modified capacity reduction factor for hoop stress tension.	
[7]	NJDEP-BNE Letter to NRC, September 16, 2008	expectations of AmerGen's 3D FEA evaluation of the drywell: based on measurements from Oct 2008 outage; determine if all ASME Code allowables are met; submitted to NRC and NJDEP entirely; detailed version for independent review; NRC to review the documentation; NRC to discuss uncertainties; NRC to summarize its findings	Information
[8]	NJDEP-BNE Letter to NRC, January 30, 2009	Letter indicates the need for NRC and Sandia to review EXELON's analysis.	Information
[9]	Results of Three-Dimensional Structural Analysis of the Oyster Creek Drywell Shell, Associated with AmerGen's License Renewal Application (TAC No. MC7624)	Transmits The Structural Integrity Reports (403 and 404) as enclosures 1 and 2.	Information
[9a]	EELC Letter (Webster) to Sammuel J. Collins March 24, 2009	Request for Public Meeting and to Temporarily Cease Power Production at Oyster Creek Nuclear Generating Station on April 9, 2009.	Additional document from Scope of Work, for information and BNS comments.

Table 2.2 lists the positive conservatism items identified by BNS's review of the two SIA Reports [1] and [2].
NOTE: The term "ob+" signifies an observation exhibiting positive conservatism.

Table 2.2
Observations That Illustrating Positive (+) Levels of Conservatism in the Analysis

Source Report Page Reference	Item Description	Comment	Type of Comment
403, ASME B&PV Code Section III, Subsection NE, 1998	Rules for Design and Construction	Use of a design code such as Section III, Subsection NE to perform fitness for service evaluations is likely significantly conservative, including use of minimum (design code based) properties rather than as-built properties.	ob+
403 pg 2-6; CBI Drawings and Revisions	Material Properties of as-built shell material.	The reviewer acknowledges that use of the ASME Section III Subsection NE code allowable stresses and physical properties is conservative for this evaluation. Actual properties are likely higher, although they cannot be used to satisfy ASME Section III, Subsection NE requirements. This is considered a significant source of conservatism with respect to actual response of the drywell structure to loadings.	ob+
403 pg. 3-3	Using circular thinned areas to encompass square measurement areas.	Acceptable based on current industry practice, including ASME.	ob+
403 pg 4-3 item 2.	Gusset plates for guiding pins not included in the model.	The reviewer agrees that the gusset plates for the guiding pins need not be included, and the model is likely slightly conservative.	ob+
403 pg 4-4, item 13.	Modeling flange bolts as beam elements and without preload.	Reasonable modeling technique for local thin areas and buckling evaluations. Exclusion of preload here is likely slightly conservative for evaluations of interest in this analysis.	ob+
403 pg 4-5, item 21.	Concrete trenches in Bays 5 and 17 extended to sandbed region bottom elevation 8 ft 11.25 in.	Stated to be conservative, and appropriately so, since exclusion of support tends to be conservative for this analysis.	ob+
403 pg 5-15, 5-18	2% damping OBE and 4% for SSE	A conservative selection.	ob+
403 Page 6-2	Boundary Conditions.	Conservative boundary conditions used, ignoring any support from the 3-inch air gap between the drywell and the concrete containment, which is filled with "compressible material". Use of only circumferential restraint from the male star-truss lugs is a conservative condition. Telecon 3/26/09; SIA and EXELON explained that the only internal floor is at the bottom (10' 3" elevation). The reviewer agrees and the question on the comment is CLOSED.	ob+

Table 2.2 Observations That Illustrating Positive (+) Levels of Conservatism in the Analysis			
403 pg 6-3, 3rd para.	Structural boundary conditions for portion of bottom head encased in concrete and supported by embedded support skirt.	Reasonable modeling technique for this evaluation. The use of only radial constraint in the bottom head is likely insignificantly conservative, considering that the support skirt juncture with the drywell shell is restrained horizontally and vertically.	ob+
403 pg 6-4, 1st para.	Drywell shell structural boundary conditions above embedded bottom head.	The “free” boundary conditions – allowing translation and rotation is all three directions – is potentially conservative considering the restraint from the compressible material in the air space between the drywell shell and concrete building wall. Nonetheless, the reviewer agrees that the free boundary conditions are appropriate for this analysis. Telecon 3/26/09; SIA stated that the "no displacement" boundary condition means "free." The review agrees and the question on the comment is CLOSED.	ob+
403 pg 6-7 top 3 para.	Piping Spans for Connected Piping Deadweight	Actual data not used; lack of as-built information; a conservative uncertainty.	ob+
403; pg 6-7; item (b)	The span of the unsupported piping attached to penetrations to be “distance of maximum span from the penetration.”	Reasonable assumption, albeit an uncertainty, and likely conservative.	ob+
403; pg 6-7; item (c)	The weight from half of the maximum span of piping reacted at the penetration.	Reasonable assumption, albeit an insignificant uncertainty, and likely conservative.	ob+
403; pg 6-7; item (d)	Content of piping is water.	Reasonable condition and conservative since not all piping will be full of water.	ob+
403; pg 6-8; 1st para, 1st line.	List of assumptions on page 6-7 are an upper bound of the gravity loads from attached piping system.	Likely a reasonable conservative assumption.	ob+
403; pg 6-8; entire page after 1st line.	Discussion about gravity loads supporting list on pg 6-7 and list of items (a) through (d)	Reasonable and likely conservative.	ob+
403, pg 6-13, 2nd para.	OBE and SSE damping at 2% and 4% respectively per RG 1.61 and use of 2% for OBE, conservative.	Appropriate.	ob+

Table 2.2 Observations That Illustrating Positive (+) Levels of Conservatism in the Analysis			
403, pg 7-2, section 7.3, 3rd para.	Considering the post-accident case as a level C event.	An acknowledged conservative approach.	ob+

Table 2.3 lists Observations illustrating (-) levels of conservatism in the analysis.
NOTE: The term "ob-" signifies an observation exhibiting negative conservatism.

Table 2.3
Observations Illustrating Negative (-) Levels of Conservatism in the Analysis

Source Report Page Reference	Item Description	Comment	Type of Comment
403, 2006 and 2008 UT Inspections	Thickness inspections of upper cylinder, sphere, sandbed region	UT determination of existing thickness of drywell shell in local areas; presumes the thinnest area is found. This is the information gained from the 2006 and 2008 outages which sets the "base" SIA evaluation. It is likely that there may be other areas, and it is possible that there are thinner areas. However, what is used is a reasonable judgment of current degraded conditions without performing statistical analyses which would require definition of a probability of failure criteria. The item is therefore identified as a negative conservatism observation.	ob-
403 pg 3-3 para. g	Average of two adjacent bays assuming that there is a general wall thickness gradient between adjacent bays	Assigning wall-thinning to an area that may or may not exhibit it. The reviewer considers it a stated condition with possible negative conservatism and uncertainty.	ob-
403 pg 4-3	mid-thickness modeling, presumed to keep the unthinned shell centerline through all thinned areas.	Modeling the mid-thickness of the un-thinned shell for regions whose outside is corroded, misses some eccentricity and associated local moment when transitioning from thick shell to local thin area. See Fig. 3.1. Telecon 3/26/09; SIA explained that the use of the abrupt change in thickness generates fictitiously high stresses which are assumed to account for the missed eccentricity effect. Initially the reviewer agreed. Subsequent to the telecon, additional discussion within BNS has lead to a different opinion regarding the compensation of this missed effect by the step-change of thicknesses. BNS accepts that this could be a "second-order effect" and thereby identifies it as a potentially negative conservatism assumption. NOTE: BNS is not in agreement that the thickness step change is a compensating effect for the missed eccentricity with the use of shell elements. However, we do not believe that additional local bending stresses caused by this condition are a significant concern.	ob-
403 pg 4-4, item 16.	Modeling of the sandbend regions does not extend into the region where insert plates exist at the vent lines.	Presumes, reasonably, that the insert plates are not thinner than the local thin regions of the non-insert plate locations in the sandbed region.	ob-

Table 2.3 Observations Illustrating Negative (-) Levels of Conservatism in the Analysis			
403 pg 4-5, item 18 and page 4-2, next-to-last para.	Modeling of penetrations with reinforcing plates and fillet welds per Fig. 4-14. The plates are presumed to be modeled by the total thickness (shell plus plate) and without mid-surface offset.	Reasonable modeling technique for local thin areas and buckling evaluations, except the eccentric bending at these locations due to offset mid-planes of the shell is missed, causing negative conservatism.	ob-
403 pg 5-16, 1st para.	Mat rocking enveloped points out to the radius of the containment shell.	The statement implies an inaccuracy. Telecon 3/26/09; SIA will confirm adequacy of the rocking information. 3/27/09 Written response: Q2: Report No. 0006004.403, Rev. 1 [1], Section 5.7.1.2, 1st paragraph states that "The difference is due to the change in the locations on the base mat (elevation 10'-3") where the spectra are computed. Both analyses include the effect of rocking of the mat. The original analysis included the envelope of the spectra for locations on the mat that extended to the edge of the reactor building walls. The revised analysis included this same rocking effect but only enveloped the points out to the radius of the containment shell." Please elaborate on this statement. Response: The above statement is consistent with the description documented in the 4th paragraph of Section 4.2 in Reference 3. This methodology is adopted in the generation of the response spectra for the post-accident flooding condition. The approach taken by the revised analysis for spectra generation is acceptable.	ob-
403 pg 6-1 Section 6.2 (c).	Circumferential gap assumed to be closed.	The assumption is conservative for the local stresses in the cylindrical shell as stated, but response to other parts of the drywell under various load combinations is not likely conservative, since stresses will be developed during closure of the gap. Telecon 3/26/09; SIA stated that the gap is 0.01 in. and that any stress caused by closure of the gap is negligible. The reviewer agrees, and the question on the comment is CLOSED. A slight level of negative conservatism is identified.	ob-
403; pg 6-7; item (a)	The penetration is assumed as an anchor point or a support location.	Reasonable assumption, albeit an insignificant uncertainty and potentially an insignificant negative conservatism.	ob-
403, pg 6-15/6-16, section 6.5.8	Description and discussion of the modal frequency analysis.	The phrase "reasonable number" is taken as a perceived uncertainty.	ob-
403, pg 8-3, section 8.3.	Capacity Reduction Factors and Miller's Modified factor for tensile hoop stress [23].	See Section 3.2	ob-

The combined effect of the identified conservatisms is judged to illustrate that the analysis is appropriately conservative. None of the observation-identified negative conservatisms are singly or in-combination significant enough to consider further action. They are judged to be the types of negative conservatisms that are covered by design margins included in ASME Codes and Standards.

Table 2.4 lists the review items illustrating some level of uncertainty in the analysis.

Table 2.4
Review Items Illustrating Some Level of Uncertainty

Source Report Page Reference	Item Description	Comment	Uncertainty
			(-2 to 0)
403, 2006 and 2008 UT Inspections	Thickness inspections of upper cylinder, sphere, sandbed region	See Table 2.3 comment.	-2
403 pg 3-3 para. g	Average of two adjacent bays assuming that there is a general wall thickness gradient between adjacent bays	See Table 2.3 comment.	-1
403 pg 4-4, item 16.	Modeling of the sandbend regions does not extend into the region where insert plates exist at the vent lines.	Presumes, reasonably, that the insert plates are not thinner than the local thin regions of the non-insert plate locations in the sandbed region. This is considered an insignificant uncertainty and likely not significant with respect to levels of conservatism.	0-
403 pg 5-14, Section 5.5.	Small number of penetrations provided with piping loads.	Use of the word "provided" implies that there might be more that were not provided.	0-
403 pg 5-15, Section 5.7.1.1, 4th line.	Use of the response spectrum at 82 ft – 9 in.	Stating that it is available, and is therefore the reason it is used, implies uncertainty, and is likely not significant with respect to levels of conservatism.	0-
403 pg 6-7.	Piping Spans for Connected Piping Deadweight	Actual data not used; lack of as-built information; an insignificant, uncertainty and likely not significant with respect to levels of conservatism.	0-
403; pg 6-7; item (a)	The penetration is assumed as an anchor point or a support location.	Reasonable assumption, albeit an insignificant uncertainty and likely not significant with respect to levels of conservatism.	0-
403; pg 6-7; item (b)	The span of the unsupported piping attached to penetrations to be "distance of maximum span from the penetration."	Reasonable assumption, albeit an uncertainty, and likely a positive conservatism.	0-
403; pg 6-7; item (c)	The weight from half of the maximum span of piping reacted at the penetration.	Reasonable assumption, and an insignificant uncertainty, and likely insignificantly conservative.	0-
403, pg 6-15/6-16,	Description and discussion of the modal	The phrase "reasonable number" is a perceived uncertainty, but likely not significant with respect to	0- (perceived)

Table 2.4 Review Items Illustrating Some Level of Uncertainty			
section 6.5.8	frequency analysis.	levels of conservatism.	
403, pg 6-16, 2nd para.	Identification of the first significant mode for the refueling configuration case.	The reasons for stating that the first significant mode is the 5th mode are missing. This is a perceived uncertainty, but likely not significant with respect to levels of conservatism.	0- (perceived)
404, pg viii, pg. 1-1, 1-2, 1-3.	The purpose of the 404 report.	The purpose of the 404 report is to address "potential questions regarding uncertainties." The purpose, therefore is not to provide a definitive estimate of any extended end-of-life condition for thinning, such as an extrapolation of continued degradation as is done in the Sandia Report [3]. The "postulated additional thinning" in the 404 report is limited to 1) additional local thinning in Bay 1 from 696 mils to 596 mils, a 14% decrease in thickness; 2) general thinning of Bay 19 from 826 mils to 776 mils, a 6% decrease in thickness.	-1

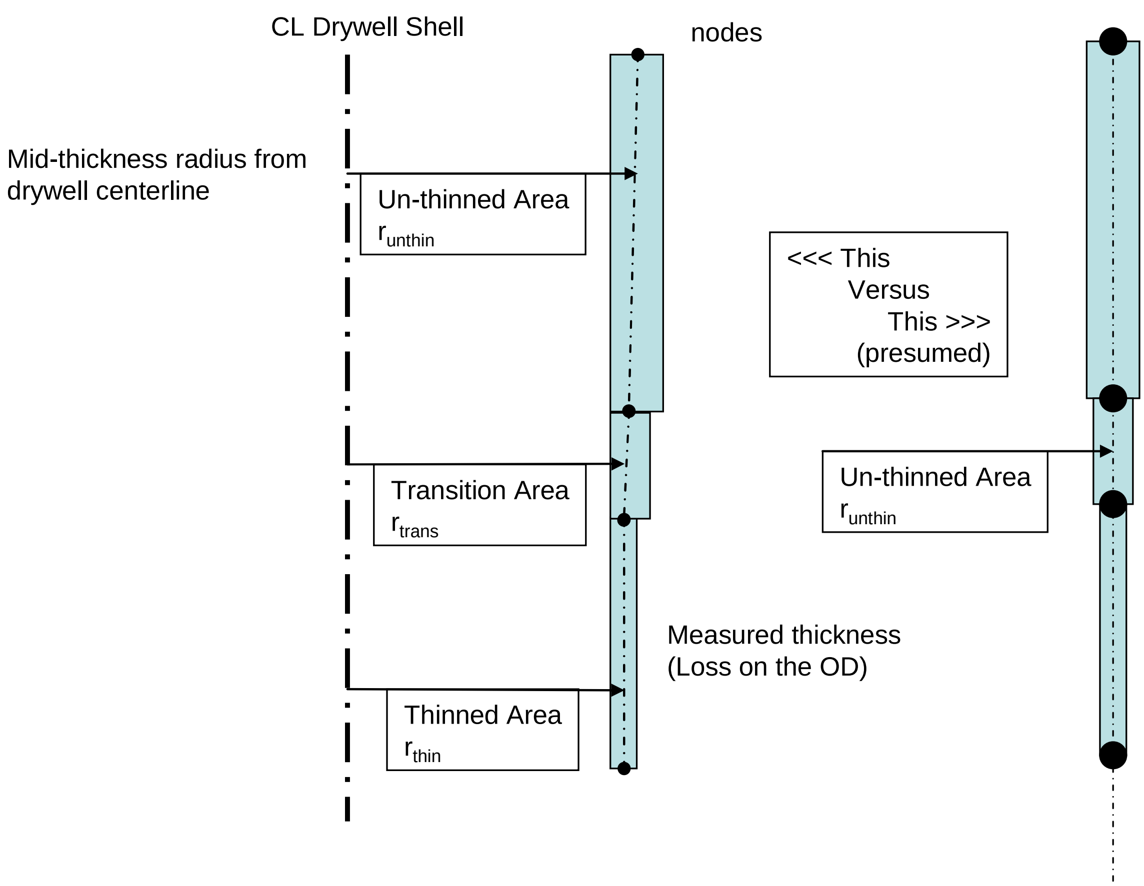
Table 2.5, which is placed in Appendix B, lists “technically-associated” editorial comments. These comments are associated with a technical aspect of the report, such as a reference number or equation. These are provided for information only, and they have no bearing on the technical evaluation. The reviewer states that these editorial comments are typical and should not be considered as an adverse reflection on the technical quality of the Reports [1] and [2].

3.0 Discussion and Conclusions

3.1 The Thinned Region Modeling Eccentricity Comment.

Regarding the comment in Table 2.3, for the 403 Report, pg 4-3, Figure 3.1 is provided as a supplemental description.

Figure 3.1
Thinned Region Eccentric Modeling Comment



3.2 **Modified Capacity Reduction Factor Comment.** Figures 3.2 and 3.3 are provided as a supplement to the comment on Section 8.3 of the 403 Report [1] from Table 2.3.

Figure 3.2 shows a case where the maximum compressive and maximum tensile stresses are approximately at the same location. Both the compressive stress and hoop tensile stresses are high (absolute values) in a local region – the blue circular region and the red circular region in Fig. 3.2. BNS believes that such a condition is not one that clearly justifies the use of the hoop tensile stress modified CRF, as SIA has done. Nonetheless, it may be possible to define an appropriate local characteristic length to mitigate the effects of taking the locally highest value of compressive stress. A portion of that line may be used over which to average compressive buckling stress. Similarly, it may be possible to define an appropriate hoop-direction local characteristic length to assure that an adequate region of hoop tension exists to provide the purported benefits of hoop tension on the CFR.

Figure 3.3 shows a case where the maximum compressive and maximum tensile stresses are not at the same location, which BNS believes would not qualify for using the modified Miller equation [23].

Figure 3.2
Modified Capacity Reduction Factor for Tensile Hoop Stress (Fig. 8-7a of SIA's 403 Report [1])

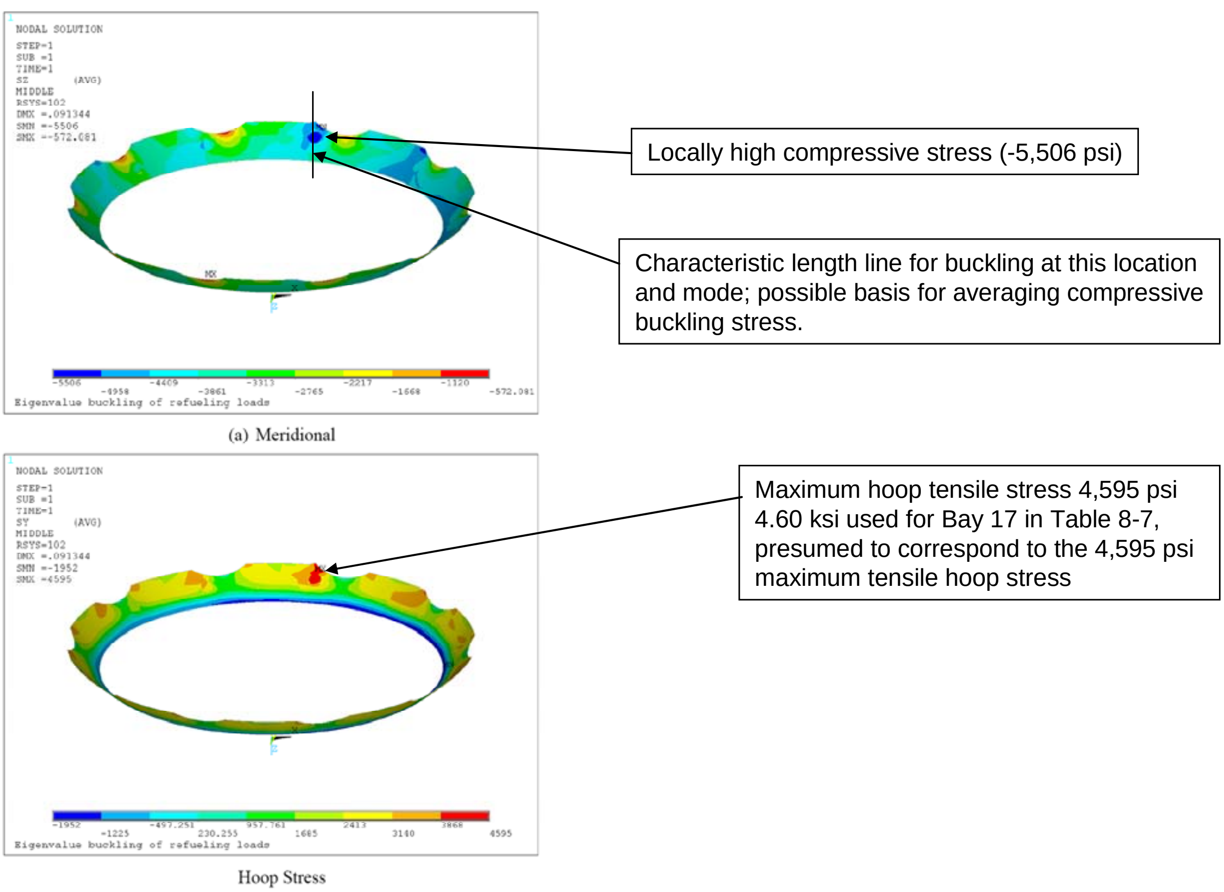


Figure 8-7: Refueling Buckling Stress, Sandbed Region

Figure 3.3
Modified Capacity Reduction Factor for Tensile Hoop Stress (Fig. 8-9a of SIA's 403 Report [1])

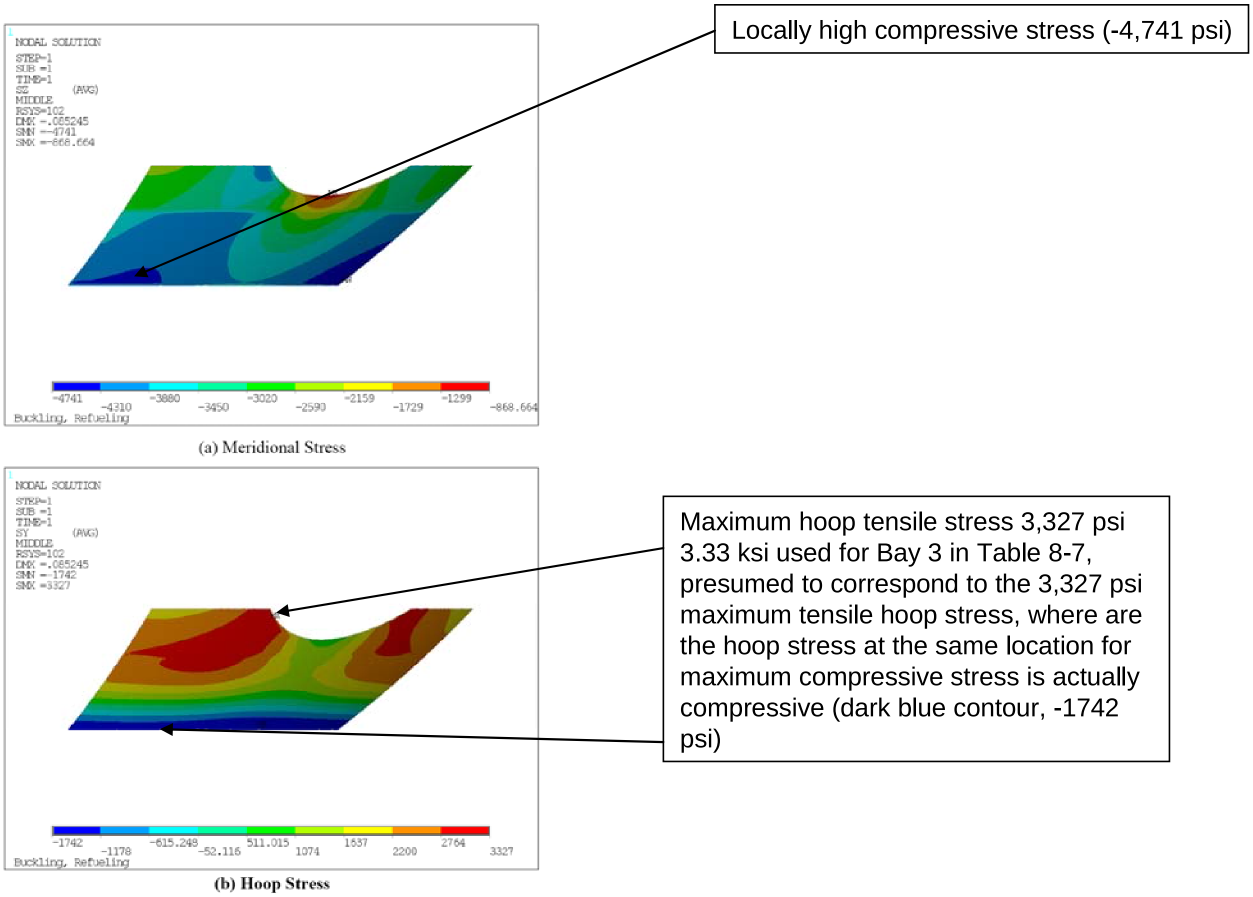


Figure 8-9: Refueling Buckling Stress, Bay 3 Sandbed Region

3.3 Review of the SIA Reports [1] and [2]. These reports represent a modern analysis of the Oyster Creek Drywell. The reports show that the drywell currently meets, and will likely continue to meet, the requirements of the ASME Boiler and Pressure Vessel Code, Section III, Subsection NE. These reports provide a conservative means of justifying continued operation in that the ASME Code being used is one written for Design and Construction of Equipment that has not yet been built or operated. The reviewer acknowledges that such is the regulatory requirement. Nonetheless, the reviewer considers this approach to be more conservative than using modern fitness for service evaluation techniques, which if used on the drywell, would likely show more margin than the current analyses reported in the two SIA Reports [1] and [2].

The use of Miller's modified capacity reduction factor [23] for the refueling case is not appropriate for all locations as explained in Section 3.2. However, when the modified factors are not used (more conservative), the resulting buckling safety factors meet N-284-1 [24].

3.4 Review of the Sandia Report [3]. The Sandia Report also represents a modern analysis of the Oyster Creek Drywell using an industry-typical 3D finite element analysis. The results differ somewhat from the SIA analysis, and those differences, on a bottom-line basis are discussed in a following section. The principal -- and most significant -- difference is Sandia's treatment of the tensile hoop-stress based capacity reduction factor for the refueling configuration evaluation. Sandia's treatment is acknowledged to be more conservative than SIA's treatment. The reviewer's opinion is that a more accurate representation of the tensile hoop stress capacity reduction factors lies somewhere between Sandia's approach and SIA's approach, as noted in Section 3.2. The reviewer believes that there are conservatisms in both Sandia's approach, and in SIA's approach regarding use of the highest axial compressive stress, "at a point" when it is more likely that buckling response is more of a global phenomenon, and that use of an averaging scheme as a function of the buckling mode would be more representative of buckling behavior – also as noted in Section 3.2.

3.5 Comparison of Results of the SIA Reports and the Sandia Report. Tables 3.1a and 3.1b show the controlling case differences in the base versus degraded stress evaluations for SIA and Sandia, respectively. The reviewer's interest in this comparison is that the SIA 404 report states (Section 6) that there is insignificant increase of stress from the base case to the two degraded (sensitivity) cases. By contrast, The Sandia Report (Section 4.3) states that there is a significant increase in stress from their base case to their degraded case.

Table 3.1a
Comparison of Controlling Results from SIA; $[(\sigma_{sensitivity} - \sigma_{base})/\sigma_{base}]^{\%}$

^{1} = Sensitivity Case 1; ^{2} = Sensitivity Case 2

Case	^1P_L	^2P_L	$^1P_L+P_b$ Top	$^2P_L+P_b$ Bot	$^1P_L+P_b$ Top	$^1P_L+P_b$ Bot	^1P+Q Top	^1P+Q Bot	^2P+Q Top	^2P+Q Bot
Bay 1, LC5 (Refueling)	3.7%	0.0%	0.5%	0.1%	0.2%	0.1%	0.2%	-1.8%	0.1%	0.2%
Bay 1, LC6 (Refueling)	5.6%	2.1%	2.1%	0.8%	2.9%	2.4%	0.7%	-2.5%	2.3%	0.2%
Bay 1, LC9 (Post-Accident)	-2.1%	0.2%	-0.3%	5.0%	0.1%	0.4%				
Bay 1, LC10 (Post-Accident)	-0.3%	0.0%	4.6%	6.7%	1.4%	0.8%				
Bay 19, LC5 (Refueling)	0.1%	3.7%	1.8%	0.9%	0.7%	2.2%	0.8%	0.2%	-0.3%	-0.7%
Bay 19, LC6 (Refueling)	0.0%	2.8%	0.2%	0.1%	1.5%	3.5%	0.1%	0.1%	0.3%	-1.3%
Bay 19, LC9 (Post-Accident)	0.1%	3.4%	0.1%	0.1%	3.3%	3.5%				
Bay 1, LC10 (Post-Accident)	0.2%	3.0%	0.2%	0.1%	1.1%	3.6%				
Max	5.6%	3.7%	4.6%	6.7%	3.3%	3.6%	0.8%	0.2%	2.3%	0.2%
Max(Max)		5.6%		6.7%		3.6%		0.8%		2.3%

Table 3.1b
Comparison of Controlling Code Stress Results from Sandia; [($_{degraded}$ – $_{base}$)/ $_{base}$]%

Sandia Tables 3-1 and 3-2				M axial	M hoop	M+B Ax	M+B Hoop
Cylinder	Refueling			9.2%	8.3%	8.2%	7.2%
Knuckle	Refueling			1.7%	1.0%	2.1%	1.2%
Upper Sphere	Refueling			8.8%	14.8%	10.7%	12.1%
Middle Sphere	Refueling			23.8%	24.0%	22.4%	23.1%
Thickened Middle Sphere	Refueling			26.9%	32.2%	21.1%	48.5%
Lower Sphere	Refueling			16.2%	28.3%	14.5%	24.7%
Local Region 1	Refueling			NA	NA	NA	NA
Local Region 13	Refueling			NA	NA	NA	NA
		MIN/MAX	MAX	26.9%	32.2%	22.4%	48.5%
			MIN	1.7%	1.0%	2.1%	1.2%
Sandia Tables 3-1 and 3-2				M axial	M hoop	M+B Ax	M+B Hoop
Cylinder	Post-Accident			7.1%	2.3%	5.6%	-0.3%
Knuckle	Post-Accident			-7.0%	-7.8%	-4.0%	-200.0%
Upper Sphere	Post-Accident			2.1%	10.2%	10.1%	8.5%
Middle Sphere	Post-Accident			16.0%	15.2%	19.3%	14.8%
Thickened Middle Sphere	Post-Accident			10.9%	28.4%	27.7%	21.7%
Lower Sphere	Post-Accident			30.8%	31.1%	14.4%	38.2%
Local Region 1	Post-Accident			NA	NA	NA	NA
Local Region 13	Post-Accident			NA	NA	NA	NA
		MIN/MAX	MAX	30.8%	31.1%	27.7%	38.2%
			MIN	-7.0%	-7.8%	-4.0%	-200.0%
Sandia Tables 3-3 and 3-5				M axial	M hoop	M+B Ax	M+B Hoop
Cylinder	Accident			9.7%	9.6%	11.9%	9.3%
Knuckle	Accident			1.1%	1.2%	1.4%	1.2%
Upper Sphere	Accident			6.9%	7.5%	6.6%	7.2%
Middle Sphere	Accident			15.0%	18.7%	23.1%	14.2%
Thickened Middle Sphere	Accident			11.5%	10.6%	17.5%	11.1%
Lower Sphere	Accident			40.3%	34.5%	88.0%	41.6%
Local Region 1	Accident			NA	NA	NA	NA
Local Region 13	Accident			NA	NA	NA	NA
		MIN/MAX	MAX	40.3%	34.5%	88.0%	41.6%
			MIN	1.1%	1.2%	1.4%	1.2%

Table 3.1a shows a maximum increase from base-to-degraded cases for SIA's evaluation as 6.7%.

Table 3.1s shows a maximum increase from base-to-degraded cases for Sandia's evaluation as 88.0%.

The reviewer concludes that this difference is explained by the significantly different thicknesses used in the base and degraded cases by SIA and Sandia. Table 3.2 provides a base and degraded modeled thickness comparison. Sandia' base case is for the as-built, un-degraded condition, i.e., the condition at beginning of life. This appears to be the principal difference that leads to the two apparently different conclusions about the amount of increase in stress from base-to-degraded conditions.

NOTE: In this comparison, the reviewer notices differences in material properties and allowable stresses. However, none of the differences are significant to the review reported herein.

Table 3.2 provides a comparison of the Base and Degraded thicknesses used by SIA and Sandia.

1. Main cylinder: no additional degraded thickness for SIA, and a 55 mil degraded thickness for Sandia.
2. Upper Sphere: no additional degraded thickness for SIA, and a 46 mil degraded thickness for Sandia.
3. Middle Sphere: no additional degraded thickness for SIA, and a 100 mil degraded thickness for Sandia.
4. Bottom Sphere: no additional degraded thickness for SIA, and no degraded thickness for Sandia.
5. Local Region 1: 230 mils degraded thickness for SIA thin region; 449 mils for Sandia general.
6. Local Region 13/19: 50 mil general and 106 mils local for SIA; 546 mils for Sandia general.

SIA's "base" is already degraded to account for the 2006 inspection measurements. Sandia's "base" is per original construction drawings. Hence, the larger difference in the base-degraded conditions for Sandia than for SIA.

Table 3.2
Comparison of SIA and Sandia Base and Degraded Thicknesses

Degraded Thicknesses (mils)	SIA Base	SIA Base Thin Regions	SIA-1 General	SIA-1 Thin Regions	SIA-2 General	SIA-2 Thin Regions	Sandia Base	Sandia Degraded
Cylinder (Main)	604	604	604	604	604	604	640	585
Upper Sphere	676	676	676	676	676	676	722	676
Middle Sphere	678	678	678	678	678	678	770	670
Bottom Sphere	636	636	636	636	636	636	676	676
Local Region 1 or Bay 1	826	696	826	596	826	596	1,154	705
Local Region 13 or Bay 19	826	720	826	720	776	720	1,154	618

3.6 Review of Other References [4], [5], [6], [9a] Regarding Key Issues Identified Therein.

3.6.1 Reference [4] is an email communication from Sandia on the modified capacity reduction factor. This two-page email summarizes Sandia's concerns related to the use of the modified reduction factor on the drywell refueling configuration evaluation. One concern is the "double-counting" effect of including hoop tension in the finite element model and then using the hoop tension capacity reduction factor modification. BNS believes that there is no double-counting as Sandia describes. However, BNS believes that application of the modified capacity reduction factor for locations that exhibit high localized compressive stresses in the presence of tensile stress somewhere else, or even at the same location is not justifiable. Another item of concern is the use of the modified CRF for shells that have undergone years of operation with environmentally induced degradation. BNS acknowledges that this is an arguable point, as Sandia states. However, if that position were adopted, then it would be inappropriate to use even for the flooded condition when there is internal pressure.

3.6.2 Reference [5] is a Memorandum to ACRS from NRC regarding explanation of Sandia's presentation on February 1, 2007. The main issue is the apparent misunderstanding of what did and did not constitute taking account of hoop tension.

3.6.3 Reference [6] is a Hearing Summary of October 29, 2008 describing the status of the process of review of SIA's analysis. The summary includes discussion of thin area measurements, inspections and suggested evaluation sensitivity studies, including use of 75 mils of thinning instead of 50 mils for Bay 19. A Monte Carlo uncertainty analysis was suggested by the "Citizens." BNS notes that if such a probabilistic-based approach were to be taken, the entire analysis would then need to be done using agreed-upon probabilistic methods, with probabilities of failure and consequences of failure identified to be meaningful.

3.6.4 Reference [9a] is a letter from EELC March 24, 2009 to NRC requesting that Oyster Creek cease power production on April 9, 2009 because of several issues, including that the SIA analysis does not fulfill commitments, that the SIA analysis does not use the 75 mil thinning for two adjacent bays, and that if the modified capacity reduction factor had not been used, the margin for the refueling case could be significantly reduced (60%).

3.7 Conclusions and Recommendations.

BNS believes that the SIA analysis reported in the 403 SIA Report [1] presents a modern, up-to-date deterministic evaluation of the Oyster Creek Drywell in accordance with ASME Section III, Subsection NE [10]. The Code requirements are satisfied for the drywell in its current (2006-2008) state of degradation with assumed thin regions based on limited thickness measurements and as modeled based on those measurements. As with any such deterministic engineering evaluation, there are conditions and assumptions with both positive and negative effects on the accuracy and conservatism of the evaluations. These assumptions are typically acceptable, since the design margins included in the Code allowable stresses and other criteria are set to account for such typical unknown conditions.

The analysis of two sensitivity cases reported in the 404 SIA Report [2] indicate that a modest reduction in thickness from the base case reported in the 403 Report [1] results in a slight increase in Code stress levels and a minimal effect on buckling safety factors. BNS believes that the two sensitivity cases presented in the SIA 404 Report do not represent an estimate of Code stresses and buckling factors at the end-of-extended-life, whereas the Sandia report does estimate an end-of-extended life condition. In both cases, however, Code limits are shown to be met. BNS concurs with those assessments based on the scope of review conducted and as reported herein.

BNS identified several items affecting the overall level of conservatism in SIA's evaluation of the drywell. The most significant is the possible level of negative conservatism associated with the hoop tension enhanced capacity reduction factors used for the refueling configuration evaluation. First, BNS shows that the required code buckling factor of safety (FS) is acceptable without use of Miller's modified capacity reduction factor. In addition, it is likely that with a less conservative treatment of the locally high theoretical buckling stress, paired with a more conservative treatment of the enhanced capacity reduction factors for each location of high compressive stress, the resulting buckling safety factors will continue to meet Code limits and will exhibit additional margin.

BNS believes that the uncertainty associated with the wall thinning measurements has been treated adequately for the measurements provided to-date, and as evaluated in two sensitivity cases in SIA's 404 Report [2]. BNS believes that the SIA 404 report does not address end-of-extended life conditions, per se. However, rather than performing more analysis now, whether deterministically-, statistically- or probabilistically-based, BNS recommends that continued measurement of drywell thickness and evaluation be an ongoing process, and that the interval of inspections and measurements be done and evaluated as frequently as practicable in the early years of extended operation.

4.0 References

The principal references – those subject to review or provided to BNS by NJDEP are listed in Table 4.1, termed “Principal References.” References identified by BNS’s review are included in Table 4.2 as “Additional References.”

Table 4.1
Principal References

NJDEP Ref No.		Author	Date	Pages	Filename
[1]	Structural Integrity Associates Report 0006004.403 R0, “Structural Evaluation of the Oyster Creek Drywell Summary Report"	Kok, Soo Bee (SIA)	1/9/2009	270 pp	OC Drywell 3-D Analysis 1 of 2.pdf
[2]	Structural Integrity Associates Report 0006004.404 R0, "Oyster Creek Drywell Sandbed Region Wall Thinning Sensitivity Analyses Summary Report.”	Kok, Soo Bee (SIA)	1/9/2009	129 pp	OC Drywell 3-D Analysis 2 of 2.pdf
[3]	Sandia Report, SAND2007-0055, "Structural Integrity Analysis of the Degraded Drywell Containment at the Oyster Creek Nuclear Generating Station"	Petti, Jason P. (Sandia)	January 2007	102 pp	Ref 3 Sandia Report.pdf
[4]	Sandia e-mail to NRC, February 9,2007	Hessheimer, Michael (Sandia)	2/9/2007	5 pp	Ref 4 Sandia e-mail to NRC.pdf
[5]	NRC Memo to ACRS, March 8, 2007	Kuo, P. T (NRC)	3/8/2007	7 pp	Ref 5 NRC Position to Sandia e-mail.pdf
[6]	ASLB Memorandum, October 29, 2008	ASLB (Hawkens, Abramson and Baratta)	10/29/2008	26 pp	Ref 6 ASLB October 29 2008.pdf
[7]	NJDEP-BNE Letter to NRC, September 16, 2008	Lipoti, Jil	9/16/2008	2 pp	Ref 7 BNE 9-26-08 Ltr 3D Analysis.pdf
[8]	NJDEP-BNE Letter to NRC, January 30, 2009	Lipoti, Jil	1/30/2009	2 pp	Ref 8 BNE 1-30-09 Ltr 3D Analysis.pdf
[9]	Results of Three-Dimensional Structural Analysis of the Oyster Creek Drywell Shell, Associated with AmerGen's License Renewal Application (TAC No. MC7624)	Gallagher, Michael P.	1/22/2009	3 pp	Transmittal for Ref. 1 and 2.

Table 4.2
Additional References

[10] The American Society of Mechanical Engineers, Boiler and Pressure Vessel Code, Section III, Subsection NE for Class MC Components, 1989 Edition with Winter 1991 Addenda.

[11] The American Society of Mechanical Engineers, Boiler and Pressure Vessel Code , Nuclear Code Case N-284-1, 1995.

[12] WRC Bulletin 462, "Commentary on the Alternative Rules for Determining Allowable Compressive Stresses for Cylinders, Codes, Spheres and Formed Heads for Section VIII, Divisions 1 and 2," The Welding Research Council, Inc., New York, NY, 2001.

[13] WRC Bulletin 406, "Proposed Rules for Determining Allowable Compressive Stresses for Cylinders, Cones, Spheres and Formed Heads," The Welding Research Council, Inc., New York, NY, 1995.

Appendix A
Scope of Work

SCOPE OF WORK

Item (1) – Technical Review of Report

Provide a fixed price to perform a technical review of the three-dimensional structural analysis report of the Oyster Creek drywell submitted to the NRC by Exelon Nuclear on January 22, 2009. The review need not be a number-by number verification of the calculation but rather an independent technical review which shall cover, but not be limited to, the basis and acceptability of design inputs and assumptions, methodology, analytical modeling, applied loadings, sensitivity analysis and ASME Code compliance. The review shall specifically address in detail the validity of the capacity reduction factors used in the analysis.

Should the technical review of the analysis require information not included in the submitted report and not otherwise publicly available, such information would be made available by Exelon Nuclear at the Oyster Creek Generating Station, in Lacey Township, NJ, or at Exelon Nuclear offices, in Kennett Square, PA, or via conference calls (any and all meetings or calls to be arranged by NJDEP-BNE), under provisions of a proprietary agreement restricting the dissemination of such information.

Results of the technical review shall be documented in a report to NJDEP-BNE and shall include, but not be limited to, details and scope of the review performed, comprehensive discussion of any findings, evaluations, opinions, deficiencies and/or safety issues. An Executive Summary shall be part of this report. This report shall be completed and provided to NJDEP-BNE on or before April 6, 2009 unless otherwise agreed to by NJDEP-BNE.

Consultation with NJDEP-BNE relating to this technical review (including briefings, findings and comment resolution related to the final report) should be included as part of this line item.

This technical review shall be performed by an expert (PhD) in the field.

In addition, please advise us of any possible conflicts of interest with Exelon Nuclear (owner/operator Oyster Creek Nuclear Generating Station) or their predecessor AmerGen, LLC, and/or Structural Integrity Associates, Inc., San Jose, CA (consultant to Exelon who prepared report that is to be reviewed).

Note: NJDEP-BNE has been working closely with the NRC on this issue. Therefore, any work you may have done with the NRC would not be considered a conflict of interest.

Item (2) – Possible Follow-up Consultation

Consultation and/or other supporting services provided to NJDEP-BNE subsequent to acceptance of the final report shall be billed on an hourly-rate (provide hourly-rate).

Appendix B

Review Observations with No Significance for Levels of Conservatism or Uncertainty

Table 2.5 Review Observations with No Significance for Levels of Conservatism or Uncertainty		
Source Report Page Reference	Item Description	Comment
403, CBI and GE Drawings	Nominal Shell Dimensions Used	Acceptable, and other than modeling the measurement-based local thin regions, the modeling does not include "imperfections" that are covered by the capacity reduction factors in the buckling evaluation.
403, CBI and GE Reports	Loads and Load Combinations	Acceptable, based on consideration of original analyses.
403 Report	Evaluation of ASME Section III Subsection NE Buckling Requirements	Appropriate, using the bifurcation methods and Code Case N-284-1 (or -2).
403 Page 4-1	Shell Element Finite Element Model with 208 penetrations	Industry practice; very extensive model with significant geometric detail beyond needs of the analysis.
403 pg 4-3 item 3.	Transition thicknesses.	Reasonable modeling technique for local thin areas and buckling evaluations using shell elements.
403 pg 4-3, item 4.	Penetrations with reinforcing plates; welds same materials as pipe; shell thickness of weld is equal to throat thickness of weld; radius to mid-thickness of reinforcing plate.	Reasonable modeling technique.
403 pg 4-3, item 5.	Penetrations with insert plates; transition zones are assigned the same materials as the insert plates.	Reasonable modeling technique.
403 pg 4-3, item 6.	Vertical location of the lower flange bolting ring and outer water seal at mid-point thicknesses.	Reasonable modeling technique using shell elements.
403 pg 4-3, item 7.	Star truss assembly modeled with male lug and base plate and the inside truss assembly.	Reasonable modeling technique for this evaluation.
403 pg 4-4, item 9.	Lifting lugs not modeled.	Reasonable modeling technique for this evaluation.
403 pg 4-4, item 10.	Fillet radii and corner radii of insert plates not included	Reasonable modeling technique for this evaluation since cyclic loading is not of interest, and is exempt in accordance with Section III, Subsection NE fatigue analysis exemption rules.

Table 2.5 Review Observations with No Significance for Levels of Conservatism or Uncertainty		
403 pg 4-4, item 11.	Knuckle region weld plates using fillet weld dimension for mid-surface node location.	Reasonable modeling technique using shell elements.
403 pg 4-4, item 12.	Modeling the head/shell flange as a rigid joint.	Reasonable modeling technique for this evaluation. NOTE: The reason given (use of shell elements) is not really a reason. The reviewer believes that the reason is that the evaluation of the drywell shell for local thin areas and buckling does not require detailed modeling of the joint. It is likely that any local sliding effects that are not captured with the modeling used do not interact significantly with the areas of concern in this analysis.
403 pg 4-4, item 14.	Penetrations smaller than 3 inches are not modeled.	Reasonable modeling technique for this evaluation.
403 pg 4-4, item 15.	Penetration pipe truncated 3 inches from the drywell shell.	Reasonable modeling technique for this evaluation. Interaction effects of longer truncation lengths are likely insignificant.
403 pg 4-4, item 17.	Two general thicknesses in the sandbed region at 11 ft and one below that.	Appears just to be a statement describing Fig. 4-13, which lacks informative labels.
403 pg 4-4, item 8.	Manhole details, insert plates in top head and access openings in star truss insert plates not included.	Reasonable modeling technique for this evaluation
403 pg 4-5, item 19 and page 4-2, next-to-last para..	Modeling of penetrations with insert plates; model insert plate transition as average of insert plate and shell plate thicknesses per Fig. 4-15.	Appropriate. Fig. 4-15 needs some informative labels consistent with the description.
403 pg 4-5, item 20.	Modeling of equipment/personnel hatch simplified.	Reasonable modeling technique for this evaluation
403 pg 4-5, item 22.	Bay 5 trench portion modeled with 10.5 inch constant width.	Not clear to the reviewer, but appears to be an acceptable modeling feature. Telecon 3/26/09; SIA explained that this is the sand bed area access trench. The reviewer understands, and the question on the comment is CLOSED.
403 pg 4-6, 2nd para.	Modeling the vent header/downcomer with just support stiffness.	Reasonable modeling technique for this evaluation
403 pg 4-6, 3rd para.	ANSYS Modeling versus analysis revision.	Use of an earlier ANSYS version to generate the model and then use of a later version to perform the analysis is presumed to be covered under the scope of SIA's Software V&V process. Complete V&V for version 8, Oyster Creek version. Telecon 3/26/09; SIA explained that their V&V has addressed this. The comment is CLOSED.

Table 2.5
Review Observations with No Significance for Levels of Conservatism or Uncertainty

403 pg 4-6, item 23.	Modeling the perforated deflector plates as equivalent property-based solid plates per Fig. 4-17.	Reasonable modeling technique for this evaluation
403 pg 4-9, Table 4-2.	Mesh sizes.	Reasonable modeling technique for local thin areas and buckling evaluations. Reference to any mesh sensitivity study would be useful regarding the ability to capture required local buckling modes. Telecon 3/26/09. SIA stated that the mesh study is now documented. The question on the comment is CLOSED.
403 pg 5-9	FSAR modified load conditions and combinations	Reduced internal pressure from 62 psi to 44 psi. Any ASME code stamp design pressure marking issues are presumed to have been addressed in FSAR.
403 pg 5-10, 2nd para.	Normal operating internal pressure atmospheric at 150F and external 2 psig at 205F.	Stated condition from reference document.
403 pg 5-10, last line.	Gravity loads and live loads are treated as quasi-static load in the analysis.	The reviewer presumes this means that added weight or mass has been added to the mass density of the shell elements. Telecon 3/26/09; SIA confirmed that and the question on the comment is CLOSED.
403 pg 5-11, 1st para.	Temporary load from fluid concrete not evaluated.	A construction load, no longer of concern.
403 pg 5-11, 3rd para.	P6 load is not included.	Load transmitted from the reactor to the concrete containment building without bearing on the drywell shell.
403 pg 5-11, 4th para.	Loads not distinguished as SSE or OBE.	The purpose of the statement is not clear, and could imply inaccuracy or conservatism issues. Telecon 3/26/09; Although not explicitly covered in the telecon, other discussions provided explanation sufficient enough to consider the question on the comment to be CLOSED.
403 pg 5-11, last para.	P1 and P2 loads referenced to Figure 5-5.	Reviewer does not find P1 and P2 loads on Fig. 5-5 . See 5-3. Telecon 3/26/09; SIA noted that the P1 and P2 forces are shown on Figure 5-3, but not 5-5 as stated. SIA may revise the reference from Fig. 5-5 to 5-3. The reviewer agrees, and the question on the comment is CLOSED.
403 pg 5-11, next-to-last para.	2.150 million lb horizontal earthquake load not included in Table 5-2.	No explanation given, but it may be related to the statement in the middle of page 5-6, i.e., that the seismic loads are evaluated by use of response spectrum analysis. Telecon 3/26/09; SIA confirmed the reviewer's expectation, and the question on the comment is CLOSED.
403 pg 5-12, 1st para.	Dry weight of compressible material between the drywell and concrete containment at 8 lb/cuft is used, and reference is made to 29 lb/cuft at the	Without further explanation use of 8 pcf versus 29 pcf for the unit weight of the compressible material appears to be un-conservative; wet when applied. Telecon 3/26/09; SIA explained that the 29 pcf value is the

Table 2.5
Review Observations with No Significance for Levels of Conservatism or Uncertainty

	spray nozzle.	wet material as it is deposited. It is for historical information and has no effect on the evaluation. The reviewer agrees and the question on the comment is CLOSED.
403 pg 5-12, 3rd para.	Weight of the air.	It is presumed not to be included in this evaluation, since it is identified as an original design test. Telecon 3/26/09; SIA explained it is mentioned because it was used in the original calculations, and that it has no effect on the current evaluation. The reviewer agrees and the question on the comment is CLOSED.
403 pg 5-12, 4th para.	1000 lb live load on weld pads.	No basis explicitly provided; presumed to be from original design.
403 pg 5-12, last para.	Vent thrust loads/end-cap effect; 2 psi external pressure; hydrostatic pressure due to water not explicitly defined	Load (explicit value) needs to be defined.
403 pg 5-13 and 5-14, Section 5.4	Excluding model details for small nozzles (3.12 in). No Code reinforcement is required implying that local stresses would be low. Therefore it is not necessary to model the small nozzle openings.	Reasonable modeling technique for this evaluation
403 pg 5-13,	Use of AD-510 from VIII-Div 2 for determining reinforcement requirements for small nozzles.	Section VIII, Div. 2 is a design-by-analysis code for Section VIII vessels, and Section III, Subsection NE is the code being used for evaluation. It is not clear why VIII-2 is chosen, except for its relationship with the 1962 Section VIII Code, which predates any VIII Div. 2 Code. Section VIII Div. 1 would be more appropriate for that relationship regarding required reinforcement. III-NE-3330 would be more appropriate for the relationship to the code being used for acceptance criteria for the thinned drywell evaluation. Telecon 3/26/09; SIA confirms the response. The reviewer accepts the explanation, and that it has no affect on the evaluation. The question on the comment is CLOSED.
403 pg 5-13, 5.3.7	Vent thrust load "interpretation"	The purpose of this statement is unclear, and is repeated from one page earlier. Telecon 3/26/09; SIA indicated it is to confirm that the load is essentially a boundary condition -- the reviewer agrees, and the question on the comment is CLOSED.
403 pg 5-14, Section 5.5.	Small number of penetrations provided with piping loads.	Use of the word "provided" implies that there might be more that were not provided.

Table 2.5 Review Observations with No Significance for Levels of Conservatism or Uncertainty		
403 pg 5-14 and pg 5-4 Section 5.3.1.3	Jet Forces and Table 5-1.	There is no mention of Jet Forces and no reference to Table 5-1 in Section 5.3.3. It is presumed that there should be. Otherwise, the implication is that they have not been considered in the analysis/evaluation. Telecon 3/26/09; SIA indicated that they have been considered, except for impingement evaluation. The reviewer agrees and the question on the comment is CLOSED.
403 pg 6-2 Section 6.2 (e) and (f).	Reactor building concrete wall is rigid compared to the drywell shell.	The reviewer agrees that the assumptions are reasonable for the evaluations being performed. The concrete walls and floors are thicker, but concrete is not as stiff as steel. Nonetheless, the stiffness of the concrete walls and floors is likely much greater than the drywell shell, although there are no calculations to illustrate this.
403 pg 6-2 Section 6.2 (g)	Not using shell manufacturing tolerances because measured thickness is used.	Reasonable modeling technique for this evaluation.
403 pg 6-3, 2nd para.	Drywell shell above 11 ft at 150F; concrete below 8 ft 11.25 in. at 70F (assumed); steady-state heat transfer analysis with no conduction to air or concrete.	Reasonable modeling technique for this evaluation
403 pg 6-4, Section 6.3.2.	Star Truss, circumferential closed gap boundary conditions	See Ref. No. 9.
403 pg 6-5 1st line.	“no displacement” boundary condition.	This statement is not clear. It can be understood to mean exactly opposite boundary conditions; 1) fixity of displacements by the phrase “no displacement, i.e. displacement = 0” or 2) no displacement boundary conditions are applied, i.e. displacements are non-specified "free" solution displacements. Telecon 3/26/09; SIA confirmed the reviewer's presumption that no displacement boundary condition was applied, and the question on the comment is CLOSED.
403 pg 6-5 Section 6.3.3.	Vent header boundary conditions – vertical restraint and lateral freedom.	The reviewer agrees that this boundary condition is appropriate, and insignificantly conservative, considering the restraint applied on the bottom head concrete encasement and support skirt.
403; pg 6-7; item (e)	Pipe insulation weight not included.	Assumed to be so negligible that it does not affect the statement that upper bound loads are considered.
403, pg 6-9; 6.4.3; 2nd para.	External piping loads applied to pilot node at the center of penetrations and weld pad loads applied as distributed force over the weld pad, etc.	Reasonable modeling technique for this evaluation

Table 2.5
Review Observations with No Significance for Levels of Conservatism or Uncertainty

403, pg 6-9; 6.4.3; 3rd para.	The moment at the bottom of the pedestal is assumed to transmit through the concrete floor, etc.	Reasonable modeling technique for this evaluation.
403, pg 6-9; 6.4.3; last para.	The horizontal earthquake load of 2,150K.	How does this relate to Section 6.4.8 which states that a response spectrum analysis is done? Telecon 3/26/09 SIA confirms that the static load is used in the buckling evaluation (Section 8) and the response spectra are used in the stress analysis (Section 7). The reviewer agrees and the question on the comment is CLOSED.
403, pg 6-10, Section 6.4.4, 2nd para.	Excluding the top head and bolts from the model for the refueling case.	Reasonable modeling technique for this evaluation.
403, pg 6-10, Section 6.4.4, 3rd line.	Refueling loads and Figure 5-5.	The reviewer does not find loads mentioned on Fig. 5-5. The loads are shown on Fig. 6-14.
403, pg 6-10, Section 6.4.5, both para.	Flood load as internal pressure as a function of water depth and inclusion of top head and bolts in the model.	Reasonable modeling technique for this evaluation.
403, pg 6-10, Section 6.4.6, both para.	Jet load at three locations and as Level D Conditions.	Reasonable modeling technique for this evaluation.
403, pg 6-10, Section 6.4.7, 2nd para.	Assuming the reactor vessel and drywell move together.	Appropriate, i.e., the reactor vessel and the drywell are effectively connected together for considering this type of motion (rotation about the vertical centerline of the reactor/drywell unit)
403, pg 6-11, section 6.4.8, 1st para, last sentence.	Calculating mode frequencies without the downcomers.	Reasonable modeling technique for this evaluation.
403, pg 6-12, 1st para (continued from previous page). And 2nd and 3rd paras.	Mass from inside water volume added to shell model density.	Reasonable modeling technique for this evaluation. The word "estimated" in the 2nd para. would be better stated as "calculated" to avoid the implication of inaccuracy.
403, pg 6-12, 4th and 5th para.	Flooded volume 80% of the drywell volume and not used for normal operating and refueling conditions.	Reasonable modeling technique for this evaluation. The word "estimate" in the 3rd para. would be better stated as "calculation" to avoid the implication of inaccuracy.
403, pg 6-12, last para.	E-W and N-S spectrum analysis and Rosenbluth Correlation Coefficient for closely spaced modes per NRC RG 1.92.	Appropriate.
403, pg 6-12, next-to-last para.	Single-point spectrum analysis performed.	Reasonable modeling technique for this evaluation.

Table 2.5
Review Observations with No Significance for Levels of Conservatism or Uncertainty

403, pg 6-13, first para.	SRSS stresses.	Appropriate.
403, pg 6-13, section 6.5.1.1, 1st para.	Overall membrane as "highly localized" and shown in Fig. 6-15.	The reviewer understands what is meant, but notes that it cannot be associated with the "general primary membrane stress" as defined in ASME Section III Codes. The highly localized area is not evident in Fig. 6-15, and is presumed to be 17,080 psi, the maximum stress intensity shown in the stress color spectrum in Fig. 6-15. It would be helpful to show the location in a focused plot.
403, pp 6-13, section 6.5.1.	Description and discussion of results for pressure loading in Figures 6-15 and 6-16.	(a) " ... thinned bay regions have high stress." The reviewer understands what is meant, but notes that it would be clearer to state that "the thinned regions show the highest stress intensity (43,146 psi)." (b) The high stress intensity locations are not evident in Figs. 6-15(b) and (c), and a focused plot would be useful to show the described location. [17080; 45146; 43024 psi] internal and [806; 1915; 1906 psi] external
403, pg 6-14, section 6.5.2.	Description and discussion of results for steady state thermal loading in Figures 6-17 through 6-19.	Similar comment regarding showing the high stress intensity locations in Fig. 6-18 and 6-19. The statement about disregarding the stresses in the vent header is appropriate since they have no bearing on the analysis of the drywell shell, i.e., the vent header assemblies are modeled only for boundary conditions for the drywell. [24192; 45463; 48757 psi].
403, pg 6-14, section 6.5.3	Description and discussion of results for gravity loading in Figure 6-20.	Similar comment regarding showing the high stress intensity locations in Fig. 6-20. [8340; 20138; 15949 psi].
403, pg 6-14, section 6.5.4	Description and discussion of application of mechanical and live loading in Figures 6-21 and 6-22.	An explanation of where the loads are applied for Fig. 6-21 would be useful to support descriptions in Section 5 for P1 through P9 (Table 5-2). Similar comment regarding showing the high stress intensity locations in Fig. 6-22. [26147; 27093; 25226 psi]
403, pg 6-15, section 6.5.5	Description and discussion of results for refueling loading in Figure 6-23.	Similar comment regarding showing the high stress intensity locations in Fig. 6-23. [18924; 21546; 19817 psi]
403, pg 6-15, section 6.5.6	Description and discussion of flooding water pressure load and results in Figures 6-24 and 6-25.	Similar comment regarding showing the high stress intensity locations in Fig. 6-25. [30021; 41033; 37932 psi]
403, pg 6-15, section 6.5.7	Description and discussion of OBE Seismic Anchor Movements results in Figure 6-26.	Similar comment regarding showing the high stress intensity locations in Fig. 6-26. [5172; 5492; 4952 psi]. The use of the words "maximum stress" and "high stress" that identify two locations could be more accurately stated as "the highest stresses occur in the star truss component where the anchor movement was applied and at the bottom of the drywell." The reviewer recommends eliminating "the cantilever effect" as a

Table 2.5
Review Observations with No Significance for Levels of Conservatism or Uncertainty

		potentially confusing way of explaining where maximum stresses occur where they do in this case.
403, pg 6-17, section 6.5.8.2.1.	Refueling configuration. Response Spectrum Analysis results; stresses.	Figures 6-27, 6-28, 6-29 and 6-30 show the "middle" stress intensities which are therefore membrane stress intensities. Therefore the "stress intensity" wording in that paragraph is presumed to mean "membrane stress intensity." Similarly; section 6.5.8.2.2 for Figures 6-31, 6-32, 6-33 and 6-34. [1195; 830; 1226; 1523 psi] and [40057; 52895; 10036; 68350 psi]
403, pg 6-18, section 6.5.10	Stress Intensity results for external piping SSE loads.	Figure 6-36 shows the "middle" stress intensities which are therefore membrane stress intensities. Therefore the "stress intensity" wording in that paragraph is presumed to mean "membrane stress intensity." [50507 psi]
403, pg 6-18, section 6.5.11	Stress Intensity results for external piping thermal loads.	Figure 6-37 shows the "middle" stress intensities which are therefore membrane stress intensities. Therefore the "stress intensity" wording in that paragraph is presumed to be "membrane stress intensity." [8022 psi]
403, pg 6-18, section 6.5.12	Stress Intensity results for flooding SSE seismic anchor movement loads.	Figure 6-38 shows the "middle" stress intensities which are therefore membrane stress intensities. Therefore the "stress" wording in that paragraph should be "membrane stress intensity." [9815 psi]
403, pg 6-18, section 6.5.9	Stress Intensity results for external piping OBE loads.	Figure 6-35 shows the "middle" stress intensities which are therefore membrane stress intensities. Therefore the "stress intensity" wording in that paragraph is presumed to mean "membrane stress intensity." [25247 psi]
403, pg 6-20, Table 6-2	Suggested Pipe Support Spacing.	The word "suggested" is presumed to mean "enveloping" since the piping attachment loads are conservatively calculated rather than taken from as-built/installed equipment data.
403, pg 6-22, Table 6-4	Penetration Valve Weights	The word "considered" in note (2) is presumed to mean "applicable" The word "considered" implies something was not included that should have been.
403, pg 7-2, section 7.3, 1st para.	Algebraic sum of individual load cases.	It is presumed that the unsigned SRSS seismic stresses from the response spectra analyses are appropriately handled regarding combination with "signed" stresses.

Table 2.5
Review Observations with No Significance for Levels of Conservatism or Uncertainty

403, pg 7-2, section 7.3, 2nd para.	Refueling and post-accident flooding conditions load combinations are "considered" to be governing cases.	The basis for considering these cases as the governing cases is from the old analyses -- original Parsons Report the FSAR, Update 7 and GE. This seems reasonable. The Sandia analysis considers one other case -- the accident case, which exhibits higher overall stresses but lower compressive stresses, and is therefore not evaluated for buckling. That is the reviewer's presumption.
403, pg 7-3, 1st para.	Effect of jet loads (LOCA) and that jet loads are not evaluated in this report.	The statement that jet loads are not evaluated in this report appears to contradict the information on loads in Section 6, particularly Case 9 of Table 6-1 and in supporting wording in Section 6.4.6. Telecon 3/26/09; SIA indicated that the jet loads are included in non-controlling load cases, and that impingement is not evaluated. The reviewer agrees and the question on the comment is CLOSED.
403, pg 7-3, next-to-last para.	Penetrations in the suppression chamber .. Are not included …	The reviewer acknowledges that they are not included because they are not in the scope of the evaluation.
403, pg 7-4, 1st line.	Bolts and pins not being included in the evaluation because they are not modeled, and bolt preloads are not considered.	Not modeling bolts and pins is not the reason for not evaluating them. It would be better to state that they are not in the scope of the evaluation.
403, pg 7-5, section 7.5	Fatigue evaluation exemption.	The reviewer concurs that the NE-3221.5(d) conditions are met. However, the thinned corroded areas are likely areas of stress concentration, in addition to being areas of lower general strength. Therefore, the reviewer presumes that SIA just did not consider it necessary to discuss this aspect perhaps because NE's fatigue exemption is silent on the level of total stress.
403, pg 7-6, 1st para.	The discussion on the results of the fatigue exemption listed in Table 7-11.	The 855 pressure cycles being more than sufficient is based on the assumed 200 cycles. That is all that needs to be stated. The reviewer understands the last statement regarding 135 ksi and the $3S_{m1}$ limit, but the way it is worded can appear unconservative, at least at first reading.
403, pg 7-7	Reconciliation of codes; 1962 Edition of Section VIII and case/interpretations 1270N, 1271N 1272N-5 and others.	The mention of the use of Section VIII Div. 2 in Section 5.4 (page 5-13) should be added.
403, pg 7-1, Section 7.1 2nd para.	Use of ASME Section III, Subsection NE, 1989 with 1991 Winter Addenda	This code edition and addenda are noted to be the "code of record" for Oyster Creek. Since this evaluation is for life extension, it may be more appropriate to use a later edition, at least as currently permitted by NRC. However, the reviewer believes there is not likely any significant differences with later

Table 2.5 Review Observations with No Significance for Levels of Conservatism or Uncertainty		
		editions of Subsection NE.
403, pg 7-1, Section 7.2 1st para.	Stress Intensity Allowables.	The reviewer presumes that there is an unstated assumption that the potential for decreased strength (yield, ultimate, etc.) of the drywell shell material as from irradiation, if any, is negligible.
403, pg 7-14	Copies of Stress Classification Guidance Tables from NE.	These tables from the 1989/W91 version of Subsection NE compare closely and appropriately to the 2007 edition of NE
403, pg 7-15, Table 7-6	Table 7-6 Load Combinations and relationship to the load cases listed in Table 6-1.	The Thrm1 load case listed in Table 6-1 is not included in any of the load combinations listed in Table 7-6. Telecon 3/26/09; SIA stated that Thrm1 is likely considered in a load case that did not control. SIA will confirm. 3/27/09 written response: Q1: The Load Combinations in Report No. 0006004.403, Rev. 1 [1], Table 7-6 includes the term Thrm2 but does not include Thrm1. Please explain why there is no Thrm1 in the load combinations. Response: Per Table 6-1 of the report [1], Thrm1 refers to the accident condition temperature. Per FSAR Section 3.8.2.3 (c) (5) [2], the load combination for the accident condition includes the accident condition temperature, Thmr1. The Accident Condition load combination was determined to not be one of the limiting load combinations and therefore was not evaluated in detail. The question on the comment is CLOSED.
403, pg 7-20, Table 7-11	Evaluation of Fatigue Analysis exemption for Subsection NE for various materials.	Table 7-11 does not show SA-516 Gr 70 and Gr 60, which is the material applicable to the evaluations in Section 7. It is presumed that since A-212 is no longer a listed material in ASME Section II Part D, that SA-516 and its 70 and 60 ksi grades are the equivalents. SIA uses 29 mpsi for E and Sandia uses 29.5 mpsi -- an insignificant difference for this evaluation.
403 pg 8-3, section 8.3.1, 1st para.	Use of Miller's modified capacity reduction factor ("CRF")	Reduction of Conservatism of the capacity reduction factors for the "presence of tensile hoop stress is not addressed in N-284-1, but its use is permitted as long as it is justified in the Design Report. The reviewer considers the inclusion of the 403 Report references [23] and [26] as valid justification.
403, pg 8-7, section 8.6, 1st para.	Use of g loads from the response spectrum at the significant mode.	Acknowledged as appropriate.

Table 2.5 Review Observations with No Significance for Levels of Conservatism or Uncertainty		
403, pg 8-7, section 8.6, 2nd para.	Boundary conditions are "similar" to the structural displacement used in the stress analysis.	Acknowledged as appropriate without the report describing what is "similar" instead of "the same."
403, pg 8-8, 2nd para.	The "average" CRF of the thin areas.	The average CRF of the thin areas is for information, and not for comparison to allowable buckling criteria.
403, pg 8-10, section 8.8.1, 1st and 2nd paras.	Use of N-284-1 and Miller Modified Capacity Reduction Factor (CRF)	Reduction of Conservatism of the capacity reduction factors for the "presence of tensile hoop stress is not addressed in N-284-1, but its use is permitted as long as it is justified in the Design Report. The reviewer considers the inclusion of the 403 Report references [23] and [26] as valid justification.
403, pg 8-11, 3rd and 4th paras.	The use of the spherical shell based CRF for the cylindrical portion of the drywell.	The cited reference indicates that the spherical shell-based equations are applicable to the cylindrical shell of the drywell.
404, pg 4-2, 2nd and 3rd para.	The use of a solid element submodel and linearization of stresses to obtain $P_L + P_b$ stresses.	This technique is appropriate.

Appendix C

Editorial Comments Associated with Technical Content
(non-technical editorials are not provided)

403 Report pg 5-13, last line and following onto pg 5-14.	Table 5-5 is not mentioned in the text.
403 Report pg 5-15, Section 5.7.1.1, 4th line.	Editorial: 82’-9’ should be 82’-9” (9 inches, not 9 feet).
403 Report pg 5-18, Section 5.7.2.2, 1st line.	Reference 18 is 20.
403; pg 6-8.	Editorials; (a) 3rd para, 2nd line "on" should be "in" or "for." (b) The reference to Table 6-5 in para. 2, line 2 should be Table 6-3.
403, pg 6-10, Section 6.4.4, 3rd line.	Loads are not shown on Fig. 5-5; they are shown on Fig. 5-3.
403, pg 6-15/6-16, section 6.5.8	Editorials; (a) last para, 1st sentence: "mode frequency" should be "modal frequency." -- occurs other places, as well. (b) pg 6-16, "excluded in" should be "excluded from."
403, pg 6-17, section 6.5.8.2.1.	Editorial: middle of each para of sections 6.5.8.2.2, the word "due" is apparently missing before "to"
403, pg 7-4, item (c)	Editorial: "Bending stress"
403, pg 7-6, 1st para.	Editorial: 1st line, "materials existed" should be "materials that existed".
403, pg 7-14	Editorial: Page 7-14, the top line in the table is missing.
403, pg 7-15, Table 7-6	Editorial: SAM(SSE) listed in Tab le 7-6 is designated as "SSESAM" in Table 6-1.
403, pg 8-2, Eqn 8-2	Editorial: alpha, α
403 pg 8-4, section 8.3.2, 1st para.	Editorial: "capacitor" should be "capacity".
403, pg 8-10, Section 8.8.1, 1st para.	Editorial: Reference 6 should be 24.
404, pg 4-2, 2nd and 3rd para.	Editorial: "P_l" should be "P_L" here and in other places in the 404 report.