From: <john.hufnagel@exeloncorp.com>
To: <dja1@nrc.gov>
Date: 06/20/2006 6:19:31 PM
Subject: Acrobat "Distilled" version of letter

Donnie,

The attached version of the June 20 supplemental letter is of better quality (and is smaller for e-mailing). If this makes life easier, use this one. The cover letter is scanned in, but the other pages should be clean.

- John.

<<Distilled Version 6-20-06 letter.pdf>>

CC: <dsilverman@morganlewis.com>

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Subject:	Acrobat "Distilled" version of letter
Creation Date	Tue, Jun 20, 2006 6:18 PM
From:	<john.hufnagel@exeloncorp.com>
Created By:	john.hufnagel@exeloncorp.com

Recipients
nrc.gov
DJA1 (D. Ashley)

morganlewis.com
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AmerGen

An Exelon Company

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10 CFR 50
10 CFR 51
10 CFR 54

2130-06-20353
June 20, 2006

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

Oyster Creek Generating Station
Facility Operating License No. DPR-16
NRC Docket No. 50-219

Subject: Supplemental Information Related to the Aging Management Program for the Oyster Creek Drywell Shell, Associated with AmerGen's License Renewal Application (TAC No. MC7624)

References:

1. NRC's "Request for Additional Information for the Review of the Oyster Creek Nuclear Generating Station, License Renewal Application (TAC 7624)", dated March 10, 2006

2. AmerGen's "Response to NRC Request for Additional Information, dated March 10, 2006, Related to Oyster Creek Generating Station License Renewal Application (TAC No. 7624)," dated April 7, 2006

3. NRC's "Summary of Meeting Held on June 1, 2006, Between the U.S. Nuclear Regulatory Commission Staff and AmerGen Energy Company, LLC Representatives to Discuss the Staff's Questions Regarding the Drywell Shell and the Oyster Creek Nuclear Generating Station License Renewal Application," dated June 9, 2006 (ADAMS # ML061600368)

In Reference 1, as part of its review of the AmerGen Energy Company (AmerGen) application for license renewal for Oyster Creek Generating Station (Oyster Creek), the NRC Staff requested additional information regarding the aging management program and activities associated with the Oyster Creek drywell containment shell. Reference 2 provided AmerGen's response to these RAIs.

On June 1, 2006, the NRC Staff held a public meeting with representatives from AmerGen to further discuss the drywell aging management program. At that meeting, the Staff posed several specific clarifying questions to AmerGen, as documented in Reference 3. Enclosure 1 of this letter provides AmerGen's responses to these questions. For clarity, the questions as provided in Reference 3 are repeated along with AmerGen's responses.

Given this submittal, AmerGen concluded that it was not necessary to have an additional meeting to review this material. Therefore, at AmerGen's request, the Staff cancelled the meeting that had tentatively been scheduled for June 22, 2006.

Enclosure 2 contains a summary of the regulatory commitments being made in this letter. Table A.5 from Appendix A of the License Renewal Application will be updated to reflect these new commitments and submitted on a schedule to support the Staff's processing of the Safety Evaluation Report.

If you have any questions, please contact Fred Polaski, Manager License Renewal, at 610-765-5935.

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

Respectfully,

Executed on 06-20-2006

Michael P. Gallagher
Vice President, License Renewal
AmerGen Energy Company, LLC

Enclosures: 1. Supplemental Information Related to Drywell Shell
2. Summary of Commitments

cc: Regional Administrator, USNRC Region I, w/o Enclosures
USNRC Project Manager, NRR - License Renewal, Safety, w/Enclosures
USNRC Project Manager, NRR - License Renewal, Environmental, w/o Enclosures
USNRC Project Manager, NRR - Project Manager, OCGS, w/o Enclosures
USNRC Senior Resident Inspector, OCGS, w/o Enclosures
Bureau of Nuclear Engineering, NJDEP, w/Enclosures
File No. 05040

Enclosure 1

Supplemental Information Related to Oyster Creek Drywell Shell

June 20, 2006

AmerGen Letter 2130-06-20353

A. Uncertainties in Ultrasonic Test (UT) Results:
Attachment 1A of the GPU Nuclear Corporation' s letter dated November 26, 1990, contains a statistical evaluation of the UT measurement data taken up to 1990. On the cover page of the report, GPU Nuclear Corporation made a disclaimer that;

> The work is conducted by an individual(s) for use by GPU. Neither GPU nor the authors of the report warrant that the report is complete or accurate.

The NRC requested the applicant to clarify the disclaimer or explain how the UT measurement data were evaluated, and used in the drywell analysis.

Response :
The disclaimer noted by the NRC staff is on the cover page of Technical Data Report (TDR) No. 948 Rev. 1, "Statistical Analysis of the Drywell Thickness Data". The disclaimer statement is a standard clause that was placed on TDRs developed in accordance with the applicable GPUN procedure at the time. AmerGen points out that TDR No. 1027, which is also a part of Attachment 1A includes the same disclaimer. The disclaimer was intended to reinforce that TDRs are not design basis documents and were not design verified in accordance with the GPUN QA Program.

In this case TDR 948 was developed to summarize the initiative that surveyed the drywell and that assessed initial corrosion rates based on data collected from 1986 through December 1988. However this TDR did not serve as the design basis document, which demonstrated the drywell shell met design basis requirements. The TDR in Section 1 (Introduction/Background) explains that the TDR documents the assumptions, methods and results of the statistical analysis used to evaluate the corrosion rates. The section then states that the complete analysis is documented in calculation C-1302-187-5300- 005.

Calculation C-1302-187-5300- 005, "Statistical Analysis of Drywell Thickness Data Thru 12-31-88" did serve as the design basis document, which demonstrated the drywell shell met design basis requirements. This calculation was developed and design verified in accordance with the GPUN QA Program and is approximately 200 pages long.

A review of the information contained in the TDR Section 4.6 (Summary of Conclusion) shows that it is consistent with the information in Section 2 (Summary of Results) in calculation C-1302-0187-5300-005. Thus, the information in the TDR No. 948 represents design quality information.

In response to the NRC's question on how the UT measurement data were evaluated and used in the drywell analysis, AmerGen provided a description of how the 49-point array statistical analysis was performed in response to NRC Q&A #AMP-356, item (4). In that response, AmerGen stated that the methodology and acceptance criteria that are applied to each grid of point thickness readings, including both global (entire array) evaluation and local (subregion of array) are described in engineering specification IS-328227 -004 and in calculation No. C-1302-187-5300-011, "Statistical Analysis of Drywell Thickness Data Thru 4-24-90". This calculation is the more recent version of calculation C-1302-187-5300 and has been submitted by AmerGen to the NRC. These two documents were submitted to the NRC in a letter dated November 26, 1990 and provided to the Staff during the AMP/AMR audit. A brief summary of the methodology and acceptance criteria is described below.

The initial locations identified in 1986 and 1987 where corrosion loss was most severe were selected for repeat inspection over time to measure corrosion rates. For locations where the initial investigations found significant wall thinning, UT inspection consisted of 49 individual UT data points equally spaced over a 6"x 6" area. Each new set of 49 values was then tested for normal distribution. If the data was normally distributed, then the mean value of the 49 points was calculated and used to represent the general drywell shell thickness in the tested area. If the

49 points were not normally distributed, then the grid was subdivided into datasets (usually 2, top and bottom) that were normally distributed. The mean value for each dataset was then calculated. The minimum mean value was compared to the minimum required thickness as described below.

The mean values of each grid were then compared to the required minimum uniform thickness criteria of 0.736 inches. In addition each individual reading was compared to the local minimum required criteria of 0.490 inches. The basis for the required minimum uniform thickness criteria and the local minimum required criteria is provided in response to NRC Question #AMP-210.

A decrease in the mean value over time is representative of corrosion. If corrosion does not exist, the mean value will not vary with time, although random variations in the UT measurements as a result of such factors as variables in the inspection process and in environmental conditions may occur.

If corrosion is continuing, the mean thickness will decrease linearly with time. Therefore the curve fit of the data is tested to determine if linear regression is appropriate, in which case the corrosion rate is equal to the slope of the line. If a slope exists, then upper and lower 95% confidence intervals of the curve fit are calculated. The lower 95% confidence interval is then projected into the future and compared to the required minimum uniform thickness criteria of 0.736 inches.

A process similar to that described above is applied to the thinnest individual reading in each grid. The lowest reading taken is also verified against the local minimum thickness requirement. Then the curve fit of the data is tested to determine if linear regression is appropriate. If a slope exists, then the lower 95% confidence interval is then projected into the future and compared to the required minimum local thickness criteria of 0.490 inches.

B. Use of ASME Sec. III, Subsection NE-3213.10 for Localized Corroded Areas:
The applicant used the provisions in ASME Code Section III, Subsection NE-3213.10, for areas of localized thinning. This provision, though not directly applicable to the randomly thin areas caused by corrosion, can be used with care and adequate conservatism. The NRC requested the applicant to clarify how NE-3213.10 was applied to the areas of localized thinning.

Response:
Clarification of how ASME Section III, Subsection NE-3213.10 was applied to the areas of localized thinning was provided in response to NRC RAIs issued in 1991, as a result of the Staff's review of the GE analysis (Ref. 7, and 8). AmerGen is not aware of any new practical engineering analysis methods that can be used as alternatives to ASME Section III, Subsection NE-3213.10 to more accurately reflect the corroded drywell shell. NRC Staff stated during the June 1, 2006 meeting that they are not aware of any such alternatives either.

More recently, AmerGen contracted GE to review the 1991 analysis of the drywell shell performed by GE (Ref. 1, & Ref. 2) for the purpose of identifying conservatism. GE's review is documented in a report prepared by the original author of the analysis (Ref. 9). The GE findings and position are summarized below.

Although the ASME Section III and Section VIII analysis procedures were not developed for randomly thin areas caused by corrosion, GE has concluded that the same analysis procedures are applicable to in-service components as long as the section thickness values used are adjusted to account for the reduction due to corrosion. Table 2-1 of Reference 1 lists the nominal thickness values and the 95% confidence level thickness values in the locally corroded areas. Even though the corroded thickness is present only in a very local area of a region, the reduced value was used for that drywell region in the Section VIII stress analysis.

ASME Section III, Subsection NE-3213.10 states that membrane stress produced by pressure or other mechanical loading and associated with a primary or discontinuity effect produces excessive distortion in the transfer of load to other portions of the structure. Conservatism requires that such stress be classified as a local primary membrane stress even though it has some characteristics of a secondary stress. A stressed region may be considered local if the distance over which the membrane exceeds $1.1S_{mc}$ does not extend in the meridional direction more than $1.0\sqrt{(Rt)}$ where S_{mc} is as defined in Subsection NE-3112.4, R is the minimum mid surface radius of curvature and t is the minimum thickness in the region considered. Regions of local primary stress intensity involving axisymmetric membrane distributions which exceed $1.1S_{mc}$ shall not be closer in the meridional direction than $2.5\sqrt{(Rt)}$ where R is defined as $(R_1 + R_2)/2$ and t is defined as $(t_1 + t_2)/2$, where t_1 and t_2 are the minimum thicknesses at each of the regions considered and R_1 and R_2 are the minimum midsurface radii of curvature at these regions where the membrane stress intensity exceeds $1.1S_{mc}$.

The requirements of ASME Section III, Subsection NE-3213.10 were satisfied by determining the maximum meridional extent of the areas where the local primary membrane stress exceeds 1.1 Smc, but is below the allowable value of 1.5 Smc [Reference 1]. The maximum extent was determined to be 11 inches (using the large displacement solution) and was found to be acceptable [i.e., less than the allowable value of $1.0\sqrt{(Rt)}$ or 17.6 inches]. Given that a uniform minimum corroded thickness for a drywell region is used in the evaluation, the preceding analysis is expected to be bounding for the actual corroded condition.

The preceding primary local stress condition was for the case of postulated accident or LOCA condition (load combination number V in Table 2-4 of Reference 1). A peak internal pressure of 62 psi was used in this calculation. This peak pressure was based on the measured peak pressure of 52 psi in Bodega Bay tests with an added pressure of 10 psi. An Oyster Creek-specific calculation with an adder of 15% showed the peak pressure during a postulated LOCA as 44 psi. This value was approved in 1993 by the NRC per Reference 5. The difference between 62 psi and 44 psi represents conservatism in the calculated value of the local primary membrane stresses in areas of the drywell above the sand bed region.

For the sand bed region, the minimum required general shell thickness of 0.736" is controlled by buckling due to the refueling load condition (Ref. 2). This load condition was considered a service level B and a safety factor of 2.0 was applied against buckling. This factor of safety is associated with plant operation. Since the plant is shutdown during refueling, which only occurs every 2 years, the safety factor of 2 introduces conservatism in the analysis.

Table-1 below presents drywell shell thicknesses (nominal, minimum measured at monitored locations, minimum required to satisfy ASME stress requirements) and the available thickness margin based on the revised drywell design pressure of 44 psi.

Table 1- Drywell Shell Thickness and the Minimum Available Thickness Margin

Drywell Region	Nominal Design Thickness, inches	Minimum Measured Thickness, inches	Minimum Required Thickness, inches	Minimum Available Thickness Margin, inches
Cylindrical	0.640	0.604	0.452	0.152
Knuckle	2.625	2.54	2.29	0.25
Upper Sphere	0.722	0.676	0.518	0.158
Middle Sphere	0.770	0.682	0.541	0.141
Lower Sphere	1.154	0.800 [1]	0.629	0.171
Sand Bed	1.154	0.800	0.736 [2]	0.064

1. The general thickness in the lower sphere is conservativel y assumed to be the same as the sand bed region
2. The minimum required general thickness in the sand bed region is controlled by buckling analysis, governed by load combinations that do not include the 44 psi pressure.

Based on the data presented in Reference 3, corrosion can reduce uniform elongation that could affect metal response to large plastic strains. However, Reference 3 also stated that to ensure a conservative design (presumably to resolve this concern), it is necessary to keep stresses and strains in corrosion areas from exceeding ASME code allowable limits [last paragraph, Section 6.5]. The stress analysis presented in Referenc e 1 assured that the code allowable limits are met in the corroded regions.

There is also an inherent conservatism in the primary stress limits specified in the NE-3200 rules for the design of Class MC cont ainment vessels versus the NC-3200 rules for the design of Class 2 vessels. The rules of NE-3300 for the design of Class MC vessels are essentially identical to the NC-3300 rules for the design of Class 2 vess els. However, higher allowable stresses are permitted for the NC-3200 vessels but not for primar y stresses in NE-3200 vessels. For example, the allowable basic stress intensity (Sm) for the Oyster Creek drywell material is 23,300 psi if it were used in a NC-3200 vessel versus 19,300 psi for the NE-3200 Class MC containment. The 19,300 psi value is based on a Code minimum ultimate strength of 70 ksi. Although CMTRs for the Oyster Creek drywell were not reviewed, it is reasonable to assume that the actual CMTR values of ultimate strength will be higher than the Code minimum value. This difference would also represent conservatism in the allowable stress values.

Although provisions in ASME Code Section III, Subs ection NE-3213.10 are not directly applicable to the randomly thin areas caused by corrosi on, AmerGen believes that the provisions are applicable to the analysis of Oyster Creek drywell shell based on the following:

- The stress analysis of Oyster Creek drywell presented in Reference 1 satisfies the local primary stress requirements of NE-3213.10. Conservatism in the allowable primary stress intensity value, the assumed peak pressure during the LOCA condition and the assumption of local corroded thickness in the entire region of the drywell provide additional structural margin.

- The Code primary stress limits are satisfied in the corroded condition and the number of fatigue cycles is small, the surface discontinuities from corrosion do not represent a significant structural integrity concern.
- As indicated in Table-1, UT measurements of the drywell shell above the sand bed region show that the measured general thickness contains significant margin. Considering the ongoing corrosion in that region is insignificant, the margin can be applied to offset uncertainties related to surface roughness.
- UT measurements of the drywell shell in the sand bed region show that the measured general thickness is greater than the 0.736" thickness assumed in the buckling analysis by significant margin except in 2 bays, bay 17 and bay 19. (Refer to response to RAI 4.7.2-1(d), Table-2). The margin in the general thickness of the two bays is 0.074" and 0.064" respectively. Considering that significant additional corrosion is not expected in the sand bed region, the margin can be applied to offset uncertainties related to the surface roughness.

C. UT Results Indicating Increased Drywell Shell Thickness:
Information provided by the applicant indicates that the UT measurements taken from inside the drywell after 1992 show a general increase in metal thickness. In at least one case, the increase is as much as 50 mils in a two-year period. The NRC requested the applicant to clarify what steps will be taken to verify the accuracy of UT measurements.

Response:

AmerGen is providing below a discussion of sensitivities involved with the UT measurement process and how they will be minimized in the future.

a. UT Instrumentation Uncertainties. The UT instrumentation, which includes the transducer, cable and ultrasonic unit, will be calibrated to within approximately +/-0.010 inches. Exelon Procedure (ER-AA-335-004) step 4.1.3 requires that the UT instruments must be checked within 2% of the calibration standard (block) prior to use. For the sand bed region, which is nominally 1" thick, a 1-inch thick calibration standard block is used. This results in checking the UT instrument to within 0.020" inches or +/- 0.010". UT instrumentation accuracy is verified under controlled conditions where UT thickness readings are performed on calibration blocks. The calibration blocks have been precisely machined to prescribed thicknesses, which are then verified by micrometer readings.

b. Actual Drywell Surface Roughness and UT Probe Location Repeatability
Due to the corrosion, the outside surface of the Drywell Vessel is not smooth and uniform. The surface condition is indicative of general corrosion, which is rough with high and low points spaced very closely together. This profile was verified when the sand was removed in 1992. The UT Instrumentation probes are 7/16" in diameter and are dual element transducers (i.e. half transmits sound and the other half receives). The probes emit a focused beam that measures an area significantly smaller than 7/16" diameter and will record the thinnest reading within that area.

   Because the surface roughness of the drywell within this 7/16" diameter can vary, the probe must be placed at precisely the same location to precisely repeat a thickness reading. A slight shift of the probe will result in a reading which is correct, but different from a previous reading.

   The variability associated with this factor is reduced by the use of the stainless steel template. The template has been manufactured with holes in a 7 by 7 pattern on 1 inch centers. Each of the 49 holes has been machined with a diameter so that the UT probe fits within each hole snugly. The templates are machined with 1/16" wide slits on each edge of the template at 0, 90, 180, and 270 degrees. During inspections the slits in the template are lined up with permanent marks that were placed on the drywell shell when the location was originally inspected. The UT readings are then taken by placing the probe inside each hole in the template.

Inspection procedures require that NDE personnel performing the inspection place the template precisely on the permanent markings.

c Actual Drywell Surface Roughness and UT Probe Rotation. The UT probe sends the signal from one side of the probe and receives the signal on the other side. The probe must be oriented in the same plane in order to measure exactly the same point. Test data taken on a mock up with similar roughness showed that a variance up to 0.016" was noted when rotating the probe 360 degrees over the same spot. Theref ore, a slight rotation of the probe will result in a reading, which is correct, but different from a previous reading.

Inspection procedures require that NDE personn el performing the inspection place the probe in the same orientation.

d Temperature Effects. Significant temperatur e differences between inspections may result in a shift in the material thickness. Therefore, the inspection specification will require that NDE personnel performing the inspection record the surface temperature of the area that is inspected.

e Batteries. Inspection specifications require the installation of new batteries prior to each series of inspections.

f NDE Technician. Inspection specificat ions require that personnel conducting UT examinations be qualified in accordance with Exelon Procedure ER-AA-335-004.

g Calibration Block. Exelon Procedure ER-AA-335 -004 requires that calibration blocks used during the inspection be inspected to verify that the ultrasonic response equals the physical measurement.

h Internal Surface Cleanliness. The inspecti on areas are covered with a qualified grease to protect the examination surface from rusting between inspection periods. The grease must be removed prior to the inspection and reapplied after the inspection. Tests performed in April and May of 2006 show that the presence of the grease will increase the readings as much as 12 mils. In 1996, the governing specification did not clearly specify the requirement to remove the grease prior to the inspection. Therefore it is possible that the requirement to remove the grease was not communicated to the contractor, and that the contractor who performed the 1996 inspection may have not removed the grease.

The inspection procedur es will clearly require that pers onnel conducting UT examinations remove the grease prior to performing the examination.

i UT Unit Settings. It is possible that the ultrasonic unit can be set in a "high gain" setting which may bias the machine into including the external coating as part of the thickness. Future inspections will use modern "state of the art" UT units that do not have gain settings.

j Identification of the Physical Inspection Location. There is a potential that inspection locations may be mislabeled on the data sheets.

The inspection procedures uniquely and clearly identify each inspection location and provide the specific instruction as to the area's location.

k Data Analysis. The above potential variables will be considered in the analysis of the data. The analysis not only determines a mean for each grid or sub-grid, but also the variance of the means. These variances will be compared to past inspection s to ensure consistency. The mean and the variance are compared to the acceptance criteria.

In addition, the mean UT thickness values for a current inspection will be computed and compared to the previous inspection prior to restarting from an outage. If data anomalies similar to 1996 are identified corrective actions will be taken, including new UT measurements, as necessary, to ensure accuracy of measurements.

D. Use of ASME Code Case 284:
The applicant used the methods and assumptions contained in ASME Code Case-284-1 in the buckling analysis of the Drywell shell in the sand-pocket area. The staff has not yet endorsed ASME Code Case 284. The staff does not take exception to the use of average compressive stress across the metal thickness for buckling analys is of the as-built shell. However, if corrosion has reduced the strength of the remaining metal through the cross section, this assumption may not be valid. The NRC requested the applicant to clarify its use of ASME Code Case 284.

Response:
Although Revision 1 of Code Case 284 had not yet been issued when the Reference 2 report was written, the authors had the benefit of consultation with Dr. Clarence Miller who was the primary author of the revision. Thus, the plasticity correc tion factors used in the evaluation (in Figure 2-4 of Reference 2) are the same as those in Figure 1610-1 of Code Case 284 Revision 1.

Paragraph 1500 in both revisions allows higher values of capacity reduction factors due to internal pressure by stating, "The influence of internal pressure on a shell structure may reduce the initial imperfections and therefore higher values of capacity reduction factors, α_i may be acceptable. Justification for higher values of α_i must be given in the design report." The technical approach documented and used in the Reference 2 analysis was reviewed and accepted by Dr. Miller in a report (Reference 4) that is also cited as one of the references in the NUREG/CR-6706 report (Ref. 3).

Thus, the technical approach used in the stability evaluation of Refere nce 2 is entirely consistent with the guidelines in Revision 1 of Code Case N-284.

In the Reference 6 report, Dr. Miller discussed the applicability of the N-284-1 methods to corroded shells. He indicated that the imperfection limit indicated by a parameter e/t (where 'e' is the eccentricity and 't' is the shell thickness) was assumed as 1.0 in Code Case N-284-1. The imperfections could be from the fabrication process in the case of a new shell or could be from a combination of fabrication and corrosion in the shel ls already in service. The contribution to e/t parameter from corrosion was defined as follows:

$$(e/t)_{corrosion} = (t_n - t_c)/(2t_c)$$

For the sand bed region, if we assume the minimum general corroded thickness of 0.736 inch and the nominal thickness of 1.154 inches, the $(e/t)_{corrosion}$ works out to be (1.154-0.736)/(2 x0.736) or 0.28. However, this does not mean the preceding value of $(e/t)_{corrosion}$ need always be added to the (e/t) value from fabrication. In fact it needs to be subtracted where the fabrication related eccentricity is in the outward radial direction. Since the fabrication relat ed eccentricitie s are likely randomly distributed and thus are equally like in ei ther direction, the overall net effect of the corrosion-induce d eccentricities would be insignific ant. Thus, it is concluded that the corrosion on the outside surface of the shell will not introduce eccentricities that would significantly impact the e/t value of 1.0 assumed in Code Case N-284.

The conclusions from the preceding discussion are summarized as follows:

- The stress analysis of Oyster Creek drywell presented in Reference 1 satisfies the local primary stress requirements of NE-3213.10. Conservatism in the allowable primary stress intensity value, the assumed peak pressure during the LOCA condition and the assumption of local corroded thickness in the entire region of the drywell provide additional structural margin.

- Since the Code primary stress limits are satisfied in the corroded condition and the number of fatigue cycles is small, the surface discontinuities from corrosion do not represent a significant structural integrity concern.
- The technical approach used in the stability evaluation of the Oyster Creek drywell is consistent with the requirements specified in Code Case N-284, Revision 1. Additional eccentricity produced by shell corrosion in service is expected to be accommodated within the allowable limit for imperfections.
- As indicated in Table-1, UT measurements of the drywell shell above the sand bed region show that the measured general thickness contains significant margin. Considering the ongoing corrosion in that region is insignificant , the margin can be applied to offset uncertainties related to surface roughness.
- UT measurements of the drywell shell in the sand bed region show that the measured general thickness is greater than the 0.736" thickness assumed in the buckling analysis by significant margin except in 2 bays, bay 17 and bay 19. (Refer to response to RAI 4.7.2-1(d), Table-2). The margin in the general thickness of the two bays is 0.074" and 0.064" respectively. Considering that significant additional corrosion is not expected in the sand bed region, the margin can be applied to offset uncertainties related to the surface roughness.

E. Junctions Between Plates of Different Thicknesses:
The UT measurements taken in the spherical portion of the drywell shell adequately represent the upper spherical area. However, there are no measurements taken in the lower portion of the spherical area above the sand-pocket area. To ensure that the spherical portion of the drywell shell is properly represented in the database, additional UT measurements taken approximately at or above the junction of the 0.722 inch and 1.154 inch thick plates would be desirable. Likewise, additional UT measurements taken on the cylindrical portion of the drywell shell at about 71 feet 6 inches (i.e. at the junction of the 0.640 inch plate and the thickened plate in the knuckle area) may be desirable. The NRC requested the applicant to clarify its UT sampling plan in context of the entire drywell shell assessment.

Response:

A review of the drywell fabrication and installation details show that the welds that attach the 0.770" (the correct thickness is 0.770 inches, not 0.722 inch as indicated in the meeting notes) nominal plates to the 1.154" nominal plates at elevation 23' 6 7/8" are double bevel full penetration welds. The external edge of the 1.154" plates is tapered to 3 to 12 minimum as required by ASME Section VIII, Subsection UW-35, while the internal edge of the 1.154" plates are flush with the 0.770" plates. Thus there are no ledges that could retain water leakage and result in more severe corrosion than in areas included in the inspection program. Also, this joint is located below the equatorial center of the sphere. Therefore, in the event that water may run down the gap between the drywell shell and the concrete wall it would not collect on this joint.

In 1991, Oyster Creek performed random inspections of the drywell shell. Ultrasonic testing inspections were conducted at 19 locations on either the 1.154" thick plates or on the 0.770" thick plates. The UT measurements were taken on a 6" x 6" grid (49 UTs) at each location. The UT measurement results show that thinning of the plates at these locations is less severe than the areas that are included in the corrosion-monito ring program. For this reason, the transition area was not added to the corrosion-monito ring program.

Based on the above, AmerGen concludes that areas monitored under the drywell corrosion-monitoring program bound the transition (from 1.154" to 0.770" thick plates) area of the drywell shell. Nevertheless, UT measurements will be taken on the 0.770" thick plate, just above the weld, prior to entering the period of extended operation. The measurements will be conducted at one location using the 6" x 6" grid. A second set of UT measurements will be taken two refueling outages later at the same location. The results of the measurements will be analyzed and evaluated to confirm that the rate of corrosion in the transition is bounded by the rate of corrosion of the monitored areas in the upper region of the drywell. If corrosion in the transition area is found to be greater than areas monitored in the upper region of the drywell, UT inspections in the transition area will be performed on the same frequency as those performed on the upper region of the drywell (every other refueling outage).

Similarly a review of fabrication and installation details of the containment drywell shell shows that the weld that connects the 2.625" knuckle plates to the 0.640"cylinder plates at elevation 71' 6" is a double bevel full penetration weld. The edges of the 2.625" plates were fabricated with a 3 to 12 taper to provide a smooth transition from the thicker to the thinner plate as required by ASME Section VIII, Subsection UE-35. Thus there are no ledges that could retain water leakage and result in more severe corrosion than the areas included in the inspection program.

In 1991, Oyster Creek performed random inspections of the drywell shell. Ultrasonic testing (UT) inspections were conducted at 18 locations on the 2.625" thick knuckle plate and at four (4) locations on the 0.640" thick cylinder plate. The UT measurements were taken on a 6" x 6" grid (49 UTs) at each location. The UT measurement results showed that thinning of the plates at these locations was less severe than the areas that are included in the corrosion-monitoring program. For this reason the knuckle area was not added to the corrosion-monitoring program.

Based on the above, AmerGen concludes that areas monitored under the drywell corrosion-monitoring program bound the knuckle area of the drywell shell. However, UT measurements will be taken above the 2.625" knuckle plate in the 0.640" thick plate prior to entering the period of extended operation. The measurements will be taken at one location using the 6" x 6" grid. A second set of UT measurements will be taken two refueling outages later at the same location. The results of the measurements will be analyzed and evaluated to confirm that the rate of corrosion in the transition is bounded by the rate of corrosion of the monitored areas in the upper region of the drywell. If corrosion in the transition area is found to be greater than areas monitored in the upper region of the drywell, UT inspections in the transition area will be performed on the same frequency as those performed on the upper region of the drywell (every other refueling outage).

F. Inspection of Inaccessible Regions:
It is not clear to the NRC whether the junction between the 1.154 inch plate and the 0.676 inch plate at the elevation 6 foot 10¼ inches is represented in the UT sampling plan. This area is below the bottom of the sand-pocket area, and is in contact with the concrete alkaline environment. However in the past, before sealing of the junction between the steel and the concrete, this area would have been subjected to the same type of contaminated water as the drywell shell in the sand-pocket area. The NRC considers this junction to be an area for possible corrosion. The NRC requested the applicant to incorporate this area in the sampling plan or justify why it should not be part of the sampling plan.

Response :
A review of the drywell construction and fabrication details shows that the drywell skirt is welded to the 1.154 inch thick plate below the sand bed floor before the 1.154" thick plate. This thick plate is welded to the 0.676" plate at elevation 6 foot 101/4 inches. The purpose of the skirt, which is also now embedded in concrete, was to support the drywell during construction. The presence of the skirt prevents moisture intrusion into the 0.676" plate.

Both the 1.154" thick plate and the 0.676" thick plate are embedded in concrete and are inaccessible for inspection as recognized by ASME Section XI, Subsection IWE-1232 and NRC Guidance (NUREG-1801 Rev. 1) for license renewal. These documents credit pressure testing performed in accordance with 10 CFR Part 50 Appendix J, Type A test, for managing aging effects of inaccessible portions of the drywell shell. NUREG-1801 and industry document, EPRI 1002950), indicate that corrosion of embedded steel is not significant if the following conditions are satisfied:

1. Concrete meeting the specifications of ACI 318 or 349 and the guidance of 201.2R was used for the containment shell or liner.
2. The concrete is monitored to ensure that it is free of cracks that provide a path for water seepage to the surface of the containment shell or liner.
3. The moisture barrier, at the junction where the shell or liner becomes embedded, is subject to aging management activities in accordance with ASME Section XI, Subsection IWE requirements.
4. Water ponding on the containment concrete floor are not common and when detected are cleaned up in a timely manner.

As noted in response to NRC Question #AMR-164, these conditions are satisfied for Oyster Creek. It is recognized the conditions were meant to apply to the drywell shell internal surface below the concrete floor inside the drywell of Mark I containments and liners of other containments. However the conditions are also applicable to the sand bed region of the Oyster Creek containment since the sand was removed in 1992. The concrete floor and the external moisture barrier (seal) are now accessible for visual inspection. Visual inspection of the sand bed floor and moisture barrier is conducted on a frequency of every other refueling outage.

Additionally, AmerGen contracted with Structural Integrity Associates, Inc. (SI) to provide an assessment of corrosion of the embedded drywell shell in the sand bed region. It asked SI to address corrosion of the drywell shell prior to 1992, when the shell was potentially exposed to moisture retained by the sand, and post 1992 after the sand was removed and other mitigative actions were taken to prevent water intrusion into the embedded shell. SI assessment results are summarized below.

<u>Corrosion of the Embedded Drywell Shell prior to 1992.</u>

The corrosion of the drywell shell in the sand bed region was caused by the moisture trapped in the sand bed due to water leakage into the region. The source of leakage was determined to be the reactor cavity, which is filled with deminer alized water during refueling outages. The water passed over the Firebar-D coating that was applied to the drywell shell to allow for formation of the required seismic gap between the drywell shell and the encircling concrete shield wall. The Firebar-D material is a magnesium oxychloride compound. The drywell was erected onsite and exposed to salt air environment during construction , which could also introduce contaminants to the sand bed environment. Chemistry test results on wet sand conducted in 1986 indicated that the leachate from the moist sand had a pH of 8.46 and contained only 45 ppb chlorides and <17 ppb sulfates.

As noted in EPRI 1002950, this water is not aggressi ve to concrete since the pH is greater than 5.5, the chlorides are less than 500 ppm and sulfates are less than1500 ppm. This means that the wetted concrete environment will provide a high pH environment that will protect the embedded shell from corrosion. Additionally, the corrosion rates calculated for the carbon steel plugs removed from the drywell shell in the sand bed region were comparable to carbon steel exposed to typical waters over a similar temperat ure range. While an increase in the salinity and impurity of the water will increase the kinetics of the corrosion reaction by increasing the electrolyte conductivity and can alter the form of corrosion experienced by steel (e.g., from general corrosion to pitting corrosion), impurities such as chloride and sulfate are not fundamentally involved in the corrosion anodic and cathodic reactions. In fact, increasing the salinity of the water decreases the dissolved oxygen content of the water and, thus, reduces the concentration of cathodic reactant present for the corrosion reaction.

It is reasonable to assume that the corrosion rate of the embedded shell is significantly less than the shell in contact with the sand bed for two primary reasons:

1. The carbon steel in the embedded region is in contact with high pH concrete that allows the creation of a passive film on the steel surface. That is, the presence of abundant amounts of calcium hydroxide and relatively small amounts of alkali elements, such as sodium and potassium, gives concrete a very high alkalinity (e.g., pH of 12 to 13). In fact, thermodynamic calculations reveal no corrosion of iron (steel) above pH 10 at room temperature.

2. Uniform corrosion will tend to occur when some surface regions become anodic for a short period, but their location and that of the cathodic regions constantly change. For example, general corrosion/rusting of mild steel will occur when there is a uniform supply of oxygen available across the surface of the steel and there is a uniform distribution of defects in the oxide film as is usually the case in the non-protective films formed on unalloyed steel. In the absence of areas of high internal stress (e.g., cold-worked regions) or segregated zones (e.g., non-uniform distributions of sulfide inclusions), a number of anodic regions will develop across the surface. Some areas will become less active while new anodic regions become available. Therefore, overall attack takes place at a number of anodic sites whose positions may change, leading to general rusting across the surface.

   If the supply of oxygen is not uniform across a surface, then any regions that are depleted in oxygen will become anodic as the case of moist sand in contact with the drywell steel. The remainder of the drywell surface including the embedded steel has oxygen available to it and therefore acts as a large cathodic area. When the cathodic area is larger, local attack will occur in the smaller anodic region. This phenomenon is referred to as differential aeration.

   Therefore, due to the creation of a differential aeration cell, the adjacent carbon steel in contact with the moist sand bed acts as an anode that sacrifices itself to the benefit of the steel in the embedded region. That is, the corrosion of the sand cushion steel preferentially corrodes as galvanically coupled to the embedded steel.

<u>Corrosion of the Embedded Drywell Shell after 1992.</u>

In response to RAI 4.7.2-1(c) AmerGen described several corrective actions taken to mitigate corrosion of the drywell shell. These mitigative actions are designed to minimize water intrusion into the sand bed region, provide for an effective drainage of the region in the event of water leakage and monitor the drains to detect leakage. If water leakage is observed coming from the sand bed region drains, numerous investigative and corrective actions will be taken (see item H below). In addition, a silicone seal is applied at the junction of drywell shell and the sand bed concrete floor to prevent intrusion of moisture into the embedded drywell shell. These actions mitigate subsequent long term significant corrosion of the embedded shell for the following two reasons:

1. The general lack of two of the four necessary fundamental parameters necessary for any form of corrosion to occur, an electrolyte, (i.e., moisture) and the cathodic reactant (i.e., oxygen), while only the lack of one fundamental parameter is sufficient to prevent corrosion. Sealing off the embedded steel will prevent any refreshment of moisture in the embedded region and any residual moisture will not support any subsequent corrosion

once all the dissolved oxygen is consumed in the cathodic corrosion reaction. The cessation of the corrosion reaction will occur regardless of the presence of contaminants that may be dissolved in the water (e.g., chloride, sulfate, etc.) since although these impurities can affect the kinetics of the corrosion reaction, they do not participate in the cathodic reduction reaction. Once the cathodic reaction is stopped, corrosion is stopped. Intermittent wetting and aeration of the embedded steel would produce only minimal additional corrosion.

2. The presence of concrete in contact with the embedded steel will mitigate corrosion even if sufficient moisture and oxygen are available due to the spontaneous formation of a thin protective oxide passive film on the embedded steel surface in the highly alkaline solution of the concrete. As long as this film is not disturbed, it will keep the steel passive and protected from corrosion.

In summary, AmerGen has extensively investigated drywell corrosion, including the embedded shell. A review of plant operating and industry experience indicates that corrosion of embedded steel in concrete is not significant because it is protected by the high alkalinity in concrete. Corrosion could only become significant if the concrete environment is aggressive. Historical data shows that the environment in the sand bed region is not aggressive, and thus any water in contact with the embedded shell is not aggressive. The data also shows that corrosion of the drywell shell in the sand bed region is due to galvanic corrosion and impurities such as chlorides and sulfates are not fundamentally involved in the corrosion anodic and cathodic reactions. Thus, only limited corrosion would be anticipated for the drywell embedded shell.

AmerGen has also committed to a comprehensive drywell corrosion-monitoring program for the period of extended operation. The program includes mitigative measures to prevent water intrusion into the sand bed region. The sand bed region concrete floor is sealed with epoxy coating. The junction between the sand bed region concrete floor and the drywell shell was sealed in 1992 to prevent moisture from impacting the embedded shell. Thus, additional significant corrosion of the embedded shell is not expected because of lack of moisture and depleted oxygen. AmerGen will also take specific actions, described in item H below, if water leakage is detected in the sand bed region drains.

For all of the above reasons, the corrosion rate for the embedded drywell shell is less than the corrosion rate of the sand bed region of the drywell shell. Also, direct monitoring of the drywell shell in the sand bed region adequately bounds any corrosion in the drywell embedded shell.

AmerGen thus concludes that corrosion monitoring of the sand bed region of the drywell shell is bounding with respect to corrosion that may have occurred on the drywell embedded shell prior to 1992. After 1992 and through the period of extended operation, corrosion of the embedded shell is insignificant because of the mitigative measures implemented and the robust drywell corrosion aging management program.

G. Sand Bed Region Inspection Increments:
In a letter dated April 4, 2006, AmerGen committed to perform UT measurements of the sand bed region every 10 years. In view of the uncertainty regarding the long-term effectiveness of the coating and water leakage, the NRC requested the applicant to clarify the commitment for UT measurement frequency in the sand bed region.

Response:
AmerGen is confident that the aging management program it committed itself to in the April 4, 2006 letter is adequate to ensure that significant drywell corrosion will be detected and addressed prior to impacting the intended function of the containment. The program requires visual inspection of the coating in the sand bed region on a frequency of every other refueling outage.

The program also requires performing UT inspecti ons in the upper regions of the drywell shell on a frequency of every other refueling outage. The measurements in the upper region of the drywell bound the sand bed region since the env ironment is the same and the sand bed region is protected with epoxy coating while the upper region is coated only with a Zinc primer.

In addition, AmerGen is committed to performing UT examinations of the sand bed region every 10 years. The 10-year frequency for the UT measurements is based on ASME Section XI requirements and is intended to confirm that the coating continues to mitigate corrosion. The initial UT measurements will be taken prior to entering the period of extended operation. The UT measurements are only a part of the overall program designed to provide reasonable assurance that significant corrosion is detected before containment intended function is adversely impacted.

Nevertheless, AmerGen will take a second set of UT measurements in the sand bed region two refueling outages after the measurements taken prior to entering the period of extended operation. The results of the measurements will be evaluated to determine the appropriate measurement frequency required to provide continued reasonable assurance that corrosion is being effectively monitored and managed during the period of extended operation. The frequency will be established as appropriat e, but not to exceed every 10 years.

H. In addition to items listed in the June 9, 2006 NRC meeting summary, AmerGen provides additional information on the actions that will be taken if water is detected in the sand bed region drains.

<u>Corrective Actions to be taken if Water is Detected in the Sand Bed Drains</u>

AmerGen will monitor the sand bed region drains on a daily basis during refueling outages and take the following actions if water is detected. The actions will be completed prior to exiting the outage.

a. The source of water will be investigated and diverted, if possible, from entering the gap between the drywell shell and the drywell shield wall.
b. The water will be chemically analyzed to aid in determining the source of leakage.
c. A remote inspection will be performed in the trough drain area to determine if the trough drains are operating properly
d. The condition of the coating and the moisture barrier (seal) in the affected bays will be inspected.
e. If the coating is degraded and visual inspection indicates corrosion is taking place, then UT thickness measurements will be tak en in the affected areas of the sand bed region. The measurements will be taken from either inside or outside the drywell to ensure that the shell thickness in areas affected by water leakage is measured. UT thickness measurements and evaluation will be consistent with the existing program.
f. The degraded coating and/or the seal will be repaired in accordance with station procedures.
g. UT measurements will be taken in the upper region of the drywell consistent with the existing program.

AmerGen will also monitor the sand bed region drains quarterly during the operating cycle. If water is detected, actions listed below will be tak en. Actions that require an outage to accomplish (d, e, f, and g), will be completed prior to exiting the next scheduled refueling outage.

a. The leakage rate will be quantified to determi ne a representative flow rate. The leakage rate will be trended.
b. The source of water will be investigated and diverted, if possible, from entering the gap between the drywell shell and the drywell shield wall.
c. The water will be chemically analyzed to aid in determining the source of leakage.

d. The condition of the coating and the moisture barrier (seal) in the affected bays will be inspected during the next refueling outage or an outage of opportunity.
e. If the coating is degraded and visual inspection indicates corrosion is taking place, then UT thickness measurements will be taken in the affected areas of the sand bed region. The measurements will be taken from either inside or outside the drywell to ensure that the shell thickness in areas affected by water leakage is measured. UT thickness measurements and evaluation of the results will be consistent with the existing program.
f. UT measurements will be taken in the upper region of the drywell consistent with the existing program.
g. The degraded coating and/or the seal will be repaired in accordance with station procedures.

References

1. "An ASME Section VIII Evaluation of Oyster Creek Drywell for Without San Case, Part I – Stress Analysis," GE Report, Index No. 9-3, Revision 0, DRF # 00664.
2. "An ASME Section VIII Evaluation of Oyster Creek Drywell for Without San Case, Part II – Stability Analysis," GE Report, Index No. 9-4, Revision 0, DRF # 00664.
3. "Capacity of Steel and Concrete Containment Vessels With Corrosion Damage," NUREG/CR-6706, February 2001.
4. Miller, C.D., 1991, "Evaluation of Stability Analysis Methods Used for the Oyster Creek Drywell," Docket No. 50-219, September 12, 1991, CBI Technical Services Company, Report prepared for GPU Nuclear Corporation.
5. Letter from Alexander W. Dromerick of the NRC to John J. Barton of GPU Nuclear Corporation, dated September 13, 1993, subject: Issuance of Amendment No. 165 (TAC No. M81093).
6. Miller, C.D., "Applicability of ASME Code Case N-284-1 to Buckling Analysis of Drywell Shell," June 15, 2006.
7. Letter from Alexander W. Dromerick to John J. Barton (GPU), "Request for Additional Information on Oyster Creek Corroded Drywell Analysis (TAC No. 79166)", dated May 23, 1991. ADAMS Accession #9106030240.
8. Letter from J. C. Devine, Jr. (GPU) to U. S. Nuclear Regulatory Commission, "Oyster Creek Drywell Containment", dated June 20, 1991. ADAMS Accession #9106240280.
9. GE Report, "NRC Question Response Input to AmerGen on Oyster Creek Drywell Structural Evaluations", by Dr. H. S. Mehta, June 2006.

Enclosure 2

Summary of Commitments

June 20, 2006

AmerGen Letter 2130-06-20353

Enclosure 2

Summary of Commitments

The following table identifies the commitments made in this document. Any other actions discussed in this submittal represent intended or planned actions. They are described to the NRC for the NRC's information and are not regulatory commitments.

Commitment	Committed Date or Outage	One-Time Action (Yes/No)	Programmatic (Yes/No)
1. In addition to AmerGen's previous commitment to perform drywell sand bed region Ultrasonic Testing (UT) prior to the period of extended operation (see AmerGen letter 2130-06-20284, dated April 4, 2006), AmerGen will perform additional UT inspection of this area two refueling outages after the initial inspection. Subsequent inspection frequency will then be established as appropriate, not to exceed 10-year intervals.	Two refueling outages subsequent to the next Drywell sand bed UT inspections	No	Yes
2. AmerGen will conduct UT thickness measurements on the 0.770 inch thick plate at the junction between the 0.770 inch thick and 1.154 inch thick plates, in the lower portion of the spherical region of the drywell shell. These measurements will be taken at one location using the 6"x6" grid. These measurements will be performed prior to the period of extended operation and repeated at the second refueling outage after the initial inspection, at the same location. If corrosion in this transition area is greater than areas monitored in the upper drywell, UT inspections in the transition area will be performed on the same frequency as those in the upper drywell (every other refueling outage).	Prior to the period of extended operation and two refueling outages later	No	Yes

Commitment	Committed Date or Outage	One-Time Action (Yes/No)	Programmatic (Yes/No)
3. AmerGen will conduct UT thickness measurements in the drywell shell "knuckle" area, on the 0.640 inch thick plate above the weld to the 2.625 inch thick plate. These measurements will be taken at one location using the 6"x6" grid. These measurements will be performed prior to the period of extended operation and repeated at the second refueling outage after the initial inspection, at the same location. If corrosion in this transition area is greater than areas monitored in the upper drywell, UT inspections in the transition area will be performed on the same frequency as those in the upper drywell (every other refueling outage).	Prior to the period of extended operation and two refueling outages later	No	Yes
4. The sand bed region drains will be monitored daily during refueling outages. If leakage is detected, procedures will be in place to determine the source of leakage and investigate and address the impact of leakage on the drywell shell, including verification of the condition of the drywell shell coating and moisture barrier (seal) in the sand bed region and performance of UT examinations of the shell in the upper regions. UTs will also be performed on any areas in the sand bed region where visual inspection indicates the coating is damaged and corrosion has occurred. UT results will be evaluated per the existing program. Any degraded coating or moisture barrier will be repaired. These actions will be completed prior to exiting the associated outage.	Daily during refueling outages	No	Yes

Commitment	Committed Date or Outage	One-Time Action (Yes/No)	Programmatic (Yes/No)
5. The sand bed region drains will be monitored quarterly during the plant operating cycle. If leakage is identified, the source of water will be investigated, corrective actions taken or planned as appropriate. In addition, if leakage is detected, the following items will be performed during the next refueling outage: • Inspection of the drywell shell coating and moisture barrier (seal) in the affected bays in the sand bed region • UTs of the upper drywell region consistent with the existing program • UTs will be performed on any areas in the sand bed region where visual inspection indicates the coating is damaged and corrosion has occurred • UT results will be evaluated per the existing program • Any degraded coating or moisture barrier will be repaired	Quarterly during non-outage periods	No	Yes