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UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

ATOMIC SAFETY AND LICENSING BOARD

In the Matter of AMERGEN ENERGY COMPANY, LLC (License Renewal for the Oyster Creek Nuclear Generating Station)	Docket No. 50-0219-LR

CITIZENS' REBUTTAL REGARDING RELICENSING OF OYSTER CREEK NUCLEAR GENERATING STATION

REBUTTAL STATEMENT AND EXHIBITS

Richard Webster
Rutgers Environmental Law Clinic
123 Washington Street
Newark, NJ 07102-3094
Counsel for Citizens

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UNITED STATES OF AMERICA
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ATOMIC SAFETY AND LICENSING BOARD

Before Administrative Judges:
E. Roy Hawkens, Chair
Dr. Paul B. Abramson
Dr. Anthony J. Baratta

In the Matter of	)	
	)	Docket No. 50-219
AMERGEN ENERGY COMPANY, LLC	)	
OYSTER CREEK NUCLEAR	)	
GENERATING STATION	)	
	)	August 17, 2007
License Renewal for Oyster Creek Nuclear	)	
Generating Station	)	
	)	

CITIZENS' RESPONSE TO AMERGEN AND NRC STAFF INITIAL TESTIMONY

PRELIMINARY STATEMENT

In accordance with an Order from the Atomic Safety and Licensing Board (the "Board"), dated April 17, 2007, this response Brief to the Initial Statements of Position filed by American Energy Company LLC ("AmerGen") and NRC Staff is submitted on behalf of Nuclear Information and Resource Service, Jersey Shore Nuclear Watch, Inc., Grandmothers, Mothers and More for Energy Safety, New Jersey Public Interest Research Group, New Jersey Sierra Club, and New Jersey Environmental Federation (collectively "Citizens").

AmerGen has failed to show that there is reasonable assurance that the UT monitoring proposed for the drywell shell in the sandbed region will maintain the

required safety margins during any extended period of operation. Indeed, analyses by both AmerGen and Citizens show that the existing corrosion on the surface of the drywell shell probably already violates even the least stringent local area acceptance criterion. Citizens have also shown that the shell does not meet the other acceptance criteria with the required 95% confidence. Thus, based on the record before the Board, AmerGen's application to relicense the Oyster Creek Nuclear Generating Station should be denied.

ARGUMENT

I. Response To Board Question 11(a) Regarding The Term Reasonable Assurance

The definition of reasonable assurance has proved somewhat elusive because it is dependent on context. During operation, reasonable assurance of safety is not necessarily threatened by non-compliance with NRC's regulations. However, in the context of relicensing, the licensee is required to demonstrate with reasonable assurance that its aging management program will ensure ongoing compliance with the current licensing basis ('CLB"). 10 C.F.R. § 54.29. Thus, unless the applicant seeks a waiver it must provide reasonable assurance that it will comply with all the CLB requirements during any period of extended operation.

In the context of initial licensing, the United States Court of Appeals for the District of Columbia found no error when a licensing board equated "reasonable assurance" with a "clear preponderance of the evidence" and rejected claims that reasonable assurance means "beyond a reasonable doubt." *North Anna Env'tl Coalition v. NRC*, 533 F.2d 655, 667-68 (D.C. Cir. 1976). Thus, reasonable assurance in the relicensing context does not require absolute proof of compliance with the CLB, instead it requires there to be a clear preponderance of evidence in support such compliance.

Moving beyond legal terms to more quantifiable measures of certainty; the ACRS has asked whether a model that predicted results with 95% confidence would provide reasonable assurance and the NRC Staff confirmed that would:

> MR. CARUSO: Dr. Wallis, this is Ralph Caruso from the staff. . . . I think that your question is what does reasonable assurance mean, and I think that the ACRS has had this discussion with the Commission in the past about what reasonable assurance means, and I don't think there has ever been any definition that everyone has agreed to. This is an eternal question that we try to deal with, and it comes out of judgment to a large extent at this point. When we can quantify it, for example, and say setting safety limit MICPRs, we try to do that. We are trying to do our regulation in a more risk-informed manner, and that is another attempt to do it in a more quantifiable way. But right now these are the words that the law requires us to use to make a finding. So those are, unfortunately, the words that we use and they are not well defined.
> DR. WALLIS: But the law requires you to make a finding with 95 percent confidence.
> MR. CARUSO: No, the law requires us to make a reasonable assurance finding.
> DR. WALLIS: If your criterion is 95 percent confidence, then the fact that they have evaluated these uncertainties enables you to make that assessment.
> MR. CARUSO: We could say that a 95 percent confidence does define reasonable assurance, . . .[1]

In the more specific context of corrosion at Oyster Creek, both the reactor operator and NRC Staff have regarded 95% confidence as a good yardstick for reasonable assurance. NRC Staff stated in 1991 that the reactor operator "has repeatedly claimed" that the condition of the Oyster Creek drywell "is fully understood with a 95% confidence level. On the basis of this claim, the staff has requested GPUN [the former operator] to determine the extent of each corroded area." Review attached to Letter from Dromerick to Barton, dated November 19, 1991. Maintaining this approach, the reactor operator used a statistical method to demonstrate ongoing operability that involved

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[1] Transcript of ACRS Meeting on September 6, 2001 (*available at* http://www.nrc.gov/reading-rm/doc-collections/acrs/tr/fullcommittee/2001/ac010906.html).

calculating the lower 95% confidence limit and projecting it forward. NRC Testimony at 27. The exact method of doing this has varied, depending on whether statistically significant ongoing corrosion has been observed. *E.g.* Citizens' Ex. 10 at 2; AmerGen Ex. 20 at 49; AmerGen Ex. 23 at 11-20. Most recently, AmerGen has erroneously claimed it has actually calculated the minimum margins based on the lower 95% confidence limit. AmerGen Ex. 3 at 6-15 to 6-16; AmerGen Ex. 12 at 13-14.

In short, both the general considerations and the site-specific history of the corrosion issue show that NRC Staff and AmerGen adopted a standard that requires AmerGen to demonstrate compliance with the acceptance criteria with 95% confidence. This is not surprising. Using the mean of a number of measurements to demonstrate compliance with a deterministic parameter, like the required thickness of the shell, would only provide 50% confidence that the shell was actually thicker than the requirement. In the context of initial licensing, it would be unacceptable to put forward a design that would only assure compliance with the requirements the ASME code for half of the independent design parameters, which is what would be most likely to happen if the design called for the mean of each parameter to meet but not exceed ASME requirements. Indeed, it is customary to design with considerable margin above ASME code requirements to ensure compliance. Similarly, in the context of relicensing, it would not provide reasonable assurance to rely on the mean of a set of samples to demonstrate compliance with a particular parameter because that would mean compliance would not be assured in 50% of instances. Given the multitude of parameters that must be estimated and checked against acceptance criteria at each nuclear power plant, using such a standard would allow significant non-compliance and would virtually assure that

the CLB was not being met. In legal terms, using the mean of a set of samples would equate to a mere preponderance of the evidence, not a clear preponderance, as Courts have required to establish reasonable assurance.

II. Response To Board Question 12(e) Regarding The Current Licensing Basis

To date, the question of what exactly constitutes the CLB has remained murky. The CLB is defined in 10 C.F.R. §54.3 as:

> the set of NRC requirements applicable to a specific plant and a licensee's written commitments for ensuring compliance with and operation within applicable NRC requirements and the plant-specific design basis (including all modifications and additions to such commitments over the life of the license) that are docketed and in effect. The CLB includes the NRC regulations contained in 10 CFR Parts 2, 19, 20, 21, 26, 30, 40, 50, 51, 54, 55, 70, 72, 73, 100 and appendices thereto; orders; license conditions; exemptions; and technical specifications. It also includes the plant-specific design-basis information defined in 10 CFR 50.2 as documented in the most recent final safety analysis report (FSAR) as required by 10 CFR 50.71 and the licensee's commitments remaining in effect that were made in docketed licensing correspondence such as licensee responses to NRC bulletins, generic letters, and enforcement actions, as well as licensee commitments documented in NRC safety evaluations or licensee event reports.

Thus, the CLB incorporates requirements of the license and certain other documents such as the FSAR and formal commitments made in licensing correspondence. Amendments to the CLB may therefore be made through amendments to the license and through licensing correspondence. Through searching of the history Citizens have tentatively determined that no license amendment was made to change the requirements the drywell has to meet, but some additional conditions were incorporated into the CLB as a result of formal correspondence between NRC and the reactor operator.

Looking first at license amendment, amending the license is a formal process that requires an applicant to formally request a license amendment and NRC to accept. A

license amendment also triggers the National Environmental Policy Act ("NEPA"). Therefore an amendment cannot be granted by NRC unless it carries out an environmental review. *See e.g.* Letter from Dromerick to Barton, dated September 2, 1993 *available at* ML011210012. Citizens have been unable to locate a license amendment or an environmental review that relates to the issue of the acceptability of the drywell shell for operation. Thus, Citizens assert that the NRC did not grant a license amendment based on the GE modeling. The license therefore requires the licensee to show that the shell meets the ASME code requirements.

Turning to the correspondence between NRC and the reactor operater, it becomes clear that many claims and caveats stated during the NRC review of the safety of the drywell shell seem to have become lost in the mists of time. For example, the 1992 Safety Evaluation Report confirms that the licensee treated the corroded areas as "highly localized" in order to justify an increase in the allowable stress. Safety Evaluation Report attached to Memorandum from Stolz to Bagchi, dated April 9, 1992 ("1992 SER") at 3. The NRC Staff specifically stated that they rejected a proposal by the licensee to allow a 10% increase in the allowable stress throughout the drywell shell. *Id.* The 1992 SER also confirmed that the stresses modeled by GE exceeded the allowable stresses by 3% to 6%, but found that this was acceptable provided the areas corroded to 0.736 inches were "highly localized." *Id.* at 4-5. The NRC Staff also stated that "the extent of the reduction in thickness due to corrosion should be reasonably known." *Id.* at 3. Finally, the supporting analysis by Brookhaven National Laboratories ("BNL") attached to NRC's 1992 SER stated "if the actual thickness at 14R is close to the projected 0.736 inches

there may not be adequate margin left for further corrosion . . . ." Thus, at that time BNL did not believe that any further thinning of the drywell would be acceptable.

Thereafter, NRC made its acceptance of the GE uniform thickness analysis contingent upon subsequent inspections of the then-inaccessible areas. *See* Letter from Dromerick to Barton, dated April 24, 1992 (NRC required reactor operator to "confirm that the thickness of the corroded areas are as projected [using the interior data] and the corroded areas are localized"). The reactor operator responded by committing to take the external measurements after the sand had been removed from the sandbed region. Letter from DeVine to NRC, dated May 26, 1992. NRC agreed to this approach in June 1992, before the sand was actually removed. Letter from Dromerick to Barton, dated June 30, 1992. Thus, the correspondence to this point reflects a change in the CLB that allowed continued operation, provided the areas of the drywell that were 0.736 inches thick or less were "highly localized" and the thicknesses found in the external UT study confirmed that the interior grid measurements were representative of the state of the shell. This is confirmed to some extent by the SER, which refers to the GE analyses of January 1992 as "the current applicable analysis for the drywell." SER at 4-55.

However, some significant changes occurred after this point. The GE study accepted by NRC in April 1992 predicted a minimum safety margin above the buckling requirements of 14%. 1992 SER at 5. However, in 1993, the reactor operator revised the calculations to show that a uniform shell thickness of 0.736 inches yields no margin above the ASME requirement. AmerGen Ex. 17 at 42; Sandia Study at 77. GE confirmed the lack of margin at 0.736 inches by a letter from to GPU, which referred to

"0% margin in the base case calculation." Letter from Mehta toTumminelli, dated December 11, 1992. It is unclear whether NRC Staff reviewed and accepted the revised model at the time or whether NRC Staff would have imposed more stringent conditions in 1992 had they known that the model predicted no margin, as opposed to a 14% margin.

Furthermore, in order to investigate the effects of localized degradation beyond 0.736 inches, the reactor operator commissioned GE to predict the effect of a 9 feet by 4.5 feet cut out tray-shaped area in each Bay of a uniformly thick 0.736 inch shell. On December 11, 1992, GE showed that the effect of these areas was to reduce the buckling capacity by an amount that depended on the minimum thickness of the cut out area. Again, it is unclear whether NRC Staff reviewed and accepted these calculations as clarifying what "highly localized" meant.

Although AmerGen alleges that an acceptance criterion that loosely reflects the GE tray model forms part of the CLB, AmerGen Testimony part 2 at A.16, that claim is not supported by any evidence. Indeed, Citizens have found no evidence that the GE tray model or any specific local area acceptance criterion form part of the CLB. Furthermore, the SER supports the proposition that the GE tray model was not incorporated into the CLB. Specifically, Citizens have already provided evidence that the SER's favorable safety review was based upon a conservative interpretation of the tray model, which required contiguous severely corroded areas[2] to be less than 12 inches by 12 inches in size. SER at 4-56; AmerGen Ex. 13 at 6-7. In addition, the NRC accepted AmerGen's estimate that the extent of the severely corroded areas was 0.68 sq. ft., SER at 4-58, even though AmerGen has subsequently estimated that the extent of these areas is over 20

[2] This brief uses the term "severely corroded areas" to refer to areas that are thinner than 0.736 inches.

square feet. At this juncture, the "current applicable analysis" has now been undermined because: 1) the 14% margin that NRC believed the model showed was reduced to zero after NRC had accepted it,; 2) AmerGen has now shown that the severely corroded areas are not "highly localized" as required; and 3) the external results confirmed that the results from the interior grids were not representative of the conditions in each Bay. Thus, the conditions that NRC explicitly established in 1992 to accept that the GE model showed compliance with the license have been violated.

To meet the terms of the CLB during any period of extended operation, AmerGen would at minimum have to show that the areas of severe corrosion are "highly localized" and predict how those areas would change if thickness decreased to establish the available margin. As discussed in detail below, AmerGen cannot show that the areas of severe corrosion are "highly localized." In fact, AmerGen's own assessment shows that the areas of severe corrosion go well beyond the boundaries of the cut outs modeled by GE. Because the CLB rests on the assumption that these areas are "highly localized" AmerGen must now either accept that this plant cannot be relicensed or seek to amend the CLB to allow larger areas of severe corrosion.

Finally, a license condition imposed by the NRC Staff is that AmerGen must use a more sophisticated drywell model to analyze the current state of the drywell shell. SER at 1-18. If AmerGen sought to use such a new model to show that the areas of severe corrosion do not have to be "highly localized" or change any of the other acceptance criteria, that would constitute an amendment to the CLB, which would have to be approved by the NRC and would be significant new information upon which Citizens could base a new contention.

III. AmerGen Has Not Met Its Burden To Define The Existing Margins And Account For Uncertainty

Although AmerGen claims it has set acceptance criteria that involve evaluating at least five separate parameters (the mean thickness of the shell, the thinnest point on the shell, the thinnest 12 inch by 12 inch area on the shell, the thinnest three feet by three feet area on the shell, and the largest contiguous area that is thinner than 0.736 inches), it has only evaluated the average margin for the mean thickness of the shell. It has therefore failed to meet its burden of calculating any margin for four of the parameters. It has also failed to calculate the available margin at 95% confidence for the one margin it has estimated. In fact, analyses by Citizens and AmerGen show that it is likely that the drywell shell fails even the least stringent local area acceptance criterion and Citizens have shown that there is less than 95% confidence that the shell meets the other acceptance criteria.

Furthermore, for the external measurements, which must be used to provide any estimate of at least four of the five parameters required to judge acceptance, AmerGen has taken an inherently contradictory position. AmerGen argues that the external measurements are not accurate enough to allow margins to be determined, but AmerGen has also maintained that it can use those same measurements to determine whether the shell complies with the acceptance criteria. This position is unsustainable. To determine compliance with numerical criteria, AmerGen must be able to provide an estimate of the amount by which those criteria are exceeded.

Finally, even if the Board accepts AmerGen's argument that the mean margin is currently 0.064 inches, using AmerGen's own statistical methods, this translates into a margin of 0.036 inches at the lower 95% confidence limit if an allowance of 0.01 inches

for possible systematic error is made. *See* AmerGen Ex. 3 at 6-16 (minimum mean thickness is 0.800 inches, minimum required is 0.736 inches, and standard error of mean is 0.09 inches). Future corrosion rates after refueling outages are up to 0.01 inches per year from the interior and 0.039 inches per year from the exterior. The total corrosion rate could therefore be approximately 0.05 inches per year. This means that, at minimum, a UT monitoring frequency of greater than once per year is required.

A. The Scope Of AmerGen's Burden Regarding Margins

In its Order dated June 19, 2007, the Board stated that it expected parties to address whether the "extant pattern of corrosion" could result in susceptibility to buckling failure either now or in the future. *Id.* at 9 n. 11. More recently, the Board indicated that it expected AmerGen to show to a known confidence level that the drywell shell will not violate the minimum thickness requirements in the interval between UT inspections taking into account the variance of the data. Board Order dated July 11, 2007 at 4. As discussed above, 95% confidence is required to provide reasonable assurance. Thus, AmerGen bears the burden of evaluating the current margins using the estimated lower 95% confidence limits for the various required parameters, and then projecting conservatively how they could change over time.

B. AmerGen Has Failed To Show That There Is Any Margin Above The Mean Thickness Acceptance Criterion

Contrary to the requirements and the established statistical method, AmerGen has failed to state the margin above the mean thickness criterion to 95% confidence. Instead, AmerGen has compared the mean of the interior grids to the acceptance criterion. *Compare* AmerGen Testimony Part 3 at A.31 *with* AmerGen Ex. 20 at Appendix 10,

Sheet 4. In fact, the lower 95% confidence limit in grid 19A for the 2006 results was 0.788 inches. AmerGen Ex. 20 at Appendix 10, Sheet 4. Subtracting an allowance of 0.01 inches for systematic error, as proposed by AmerGen, Citizens' Ex. 10 at 2, yields an estimate of the lower 95% confidence limit taking into account both random and systematic error of 0.778 inches. Comparing this to the acceptance criterion of 0.736 inches shows that AmerGen's estimate of the existing margin above the mean acceptance criterion would be 0.042 inches if it applied the established statistical methods to the 2006 data from the internal grids. Thus, at minimum, the assured margins are less than AmerGen has alleged.

Furthermore, far from showing that the internal grid data are sufficiently representative to be used to generate the margin above the mean acceptance criterion, AmerGen's exhibits actually show the opposite. AmerGen has estimated that the margin for the average thickness in Bay 1 is 0.365 inches based on the internal data, AmerGen Ex. 3 Attachment 1 at Figure 1, while the former reactor operator estimated the same margin to be 0.064 inches using the external data. AmerGen Ex. 17 at 7, Appendix B. Further illustrating this point, Citizens' Exhibit 12 at Figure 4 uses the internal data taken in the trench in Bay 17 to confirm that the internal grid data overestimates the thickness of the drywell at the extreme upper and lower levels of the sandbed region, where the external data are more representative. Finally, a number of AmerGen evaluations of "representative thickness" admit plainly that the internal grid data in certain Bays is not representative of the true mean thickness of the Bay because of the pattern of corrosion. Citizens' Ex. 45 at 3; Citizens Ex. 46 at OCLR29744-5.

Thus, a reliable estimate of a representative mean thickness for each Bay cannot be obtained from the internal grid data alone. Citizens therefore alleged that AmerGen should also use the external data as an input to the established statistical method, but without any correction for potential systematic error, recognizing that the external data is slightly biased towards the thin side. AmerGen has resisted this approach saying that it is too conservative because external data actually represent the thinnest points on the drywell shell. AmerGen Testimony Part 3 at A.30. However, this assertion is directly contradicted by the available data and is undercut by visual observations of the surface of the shell. First, the results for 2006 show that at some points in Bays 7, 15, 17 and 19 AmerGen scanned a 0.25 inch area around the nominal location of the point. AmerGen Ex. 19 Attachment 4 at 8, 16, 18, 20. In most cases, AmerGen found a thinner point than the reported point. *Id.* Strikingly, in Bay 15, the reported results were all the maximum readings obtained, while the minimum readings were as much as 0.068 inches less than the recorded value. *Id.* at 16. Similarly, in Bay 19 the reported results were up to 0.07 inches more than the minimum recorded value. *Id.* at 20. Second, NRC Staff have noted that AmerGen could not locate exactly the locations measured in 1992. NRC Staff Testimony at A17. This indicates that they were not located at obvious low points in the surface of the shell. Third, Dr. Hausler has pointed out that the lack of any absolute reference points and the state of the surface mean that is it impossible to locate the thinnest points visually. Thus, the data and observations support Citizens' view that while the external data is biased slightly low, the reported 2006 data do not represent the thinnest points on the drywell shell.

AmerGen has also alleged that the external data do not provide sufficient information to allow comparison with the mean thickness criteria. AmerGen Testimony Part 3 A.29. If true, this would mean that AmerGen would have no systematic means of deriving a representative mean thickness for each Bay and so could not meet its burden to show compliance with the mean thickness criterion to 95% confidence. However, notwithstanding the lack of "sufficient information," AmerGen has alleged that comparing the mean of the external measurements in each Bay with 0.736 inches demonstrates compliance with the acceptance criterion. *Id.* at A.30. This is incorrect, because it only demonstrates compliance with the mean thickness requirement at the 50% confidence level, not the required 95% confidence level. In fact, as Citizens showed in their initial filing, the external data do not comply with the acceptance criteria at the 95% confidence level if the thinnest measurements obtained are used. Thus, AmerGen has failed to meet its burden of showing compliance with the acceptance criterion for mean thickness with 95% confidence.

C. AmerGen Has Failed To Show That There Is Any Margin Above The Acceptance Criteria For Severely Corroded Areas

Citizens Initial Statement shows that AmerGen was inconsistent in the way it stated the local area acceptance criterion, relates the various criteria used, provides evidence that the inconsistency resulted in part from AmerGen's concerns about the validity of past practice, and suggests that of the criteria used the most justifiable is to limit areas that are less than 0.736 inches thick to be both smaller than 12 inches by 12 inches and thicker than 0.636 inches on average. In addition, Citizens presented contour plots based on the external measurements in direct response to the Board's expectation that the parties would present evidence on whether the pattern of corrosion on the drywell

shell could make it susceptible to buckling at the start of any period of extended operation or thereafter.

AmerGen's latest approach to the task of showing that the corroded areas are localized is presented in Revision 2 of the 24 Calculation (AmerGen Exhibit 16). This calculation is inadequate on its face because it fails to show that the severely corroded areas are localized, fails to predict how the severely corroded areas would change if the shell got thinner, and fails to take account of uncertainties in the measurements and the methods used to estimate the severely corroded areas. AmerGen's testimony also failed to address these issues. Thus, AmerGen has not met its burden to show that the CLB will be maintained during any extended period of operation.

AmerGen's initial statement suggests that the acceptance criterion for local areas of corrosion is based on a 3 foot by 3 foot tray of corrosion modeled by GE which is 0.563 inches thick in the center 1 foot by 1 foot and then tapers back to 0.736 inches thick. AmerGen Testimony Part 2 at A.14. AmerGen further suggests that this criterion is "volumetric," but is unclear what this means. *Id.* at A.15. Dr. Hausler notes that GE actually modeled an area that was half the size that AmerGen has alleged. NRC Staff agreed with AmerGen on this criterion, but made no mention of the criterion being volumetric and noted that AmerGen has more recently used a value of 0.636 for the thinnest one square foot. NRC Staff Testimony at A.9. Therefore, AmerGen alleges that, provided the corrosion is within the spatial envelope of the modeled tray, the effect on buckling would be insignificant.

The dispute about the appropriate local area acceptance criterion may become academic because Citizens have shown that the severely corroded areas of the drywell

shell are probably not bounded by the spatial envelope that AmerGen has alleged defines acceptance. Therefore, the shell fails even AmerGen's statement of the least stringent acceptance criterion. Obviously, if the shell fails the least stringent acceptance criterion, it would fail more stringent acceptance criteria and would fail by even more if the lower 95% confidence limit was compared with the acceptance criterion, as is actually required to provide reasonable assurance.

AmerGen's own calculation shows the essential problem. In both Bays 1 and 19, AmerGen's assessment of the 2006 results shows a 3 foot by 3 foot area that is less than 0.736 inches in average thickness. AmerGen Ex. 16 at 34, 92-93. Unless the sides of these areas are vertical, which is highly unlikely, AmerGen's own assessment shows that the severely corroded areas in Bays 1 and 19 are larger than 3 feet by 3 feet. Thus, these Bays probably fail even the least stringent local area acceptance criterion. Furthermore, it appears that Bay 13 also contains a similar severely corroded area that is larger than 3 feet by 3 feet. AmerGen's assessment does not reach such a conclusion about Bay 13, because it makes use of a correction that Dr. Hausler believes is not justified. A 3 feet by 3 feet area is shown in Bay 13 on Figure 13. *Id.* at 64. By inspection, this area contains points 6, 7, 8, 11, 12, 15, and 16. Averaging these points yields an average thickness of 0.714 inches. Thus, the raw UT data indicate that Bay 13 also contains a severely corroded area that is larger than 3 feet by 3 feet. In short, because the severely corroded areas in Bays 1, 13, and 19 are probably not enveloped by the trays of corrosion modeled by GE, they cannot be accepted.

Furthermore, AmerGen and Citizens agree that the characterization of the severly corroded areas is highly uncertain. Thus, the 95% confidence intervals on the location of

the edge of these areas are very wide. This is illustrated qualitatively by the lack of points to define the edge of the areas marked for evaluation by AmerGen. AmerGen Ex. 16 at 29, 64, 95. AmerGen has therefore failed to provide reasonable assurance that the existing severely corroded areas on the drywell shell are within the bounds of the modeled tray shapes even if those shapes define the CLB requirement that those areas be "highly localized."

Moreover, the areas of severe corrosion shown in AmerGen's latest assessment were chosen by eye based on an unstated assumption that the severely corroded areas are no larger than 3 feet by 3 feet. This assumption is not valid. An objective contouring approach has shown that in Bays 1 and 19, there are areas of severe corrosion that do not fit within the 3 feet by 3 feet tray. Ex. 13 at Figures 1, 5. Because these areas go outside the envelope of the modeled tray, they cannot be accepted as being within the CLB.

In terms of the thickness profile AmerGen has shown that, at best, the margins are probably extremely narrow. E.g. AmerGen Ex. 16 at 32, 97. In fact, if the uncorrected measurements are used, the thickness profile would go outside the tray profile in Bay 1. *See* AmerGen Ex. 16 at 22, 32 (uncorrected UT result for location 1 is 0.710 inches, which would be below required profile). Furthermore, because the single point results show large uncertainty, AmerGen cannot show that the thickness profile is enveloped by the modeled trays at 95% confidence.

Finally, the methods AmerGen has used to evaluate the size of the severely corroded areas were not established in the SER, because NRC Staff have stated that they did not consider AmerGen Ex. 16 during their review of license renewal. NRC Staff Testimony at A.9. In fact, the NRC Staff approved the application based upon

AmerGen's unjustified assertion that that the total area of the drywell thinner than 0.736 inches was 0.68 square feet. SER at 4-58. Thus, the SER found reasonable assurance because NRC Staff erroneously thought that the severely corroded areas were actually "highly localized" as required by the CLB.

D. AmerGen Has Not Established Any Margin For The Thinnest Point In The Sandbed Region

There is no dispute that the thinnest point on the drywell must be thicker than 0.49 inches. AmerGen's testimony merely states that the thinnest local measurement is 0.602 inches and uses this to compare with the acceptance criterion. AmerGen Testimony Part 3 at A.5, A.32. This does not provide reasonable assurance that the criterion is being met because of the uncertainty in the measurement and the uncertainty that the thinnest spot on the drywell was actually measured. Citizens already showed in their initial statement that the lower 95% confidence limit for the thickness of certain parts of the drywell shell is below this criterion. In addition, Dr. Hausler shows that if 40 measurements had been taken in Bay 13, extreme value statistics show that it is likely that a point thinner than 0.49 inches, the acceptance criterion, would have been observed. Thus, AmerGen has not provided reasonable assurance that it can maintain this CLB requirement during any extended period of operation.

IV. AmerGen Has Shown That A Corrosive Environment Could Exist On The Exterior Of The Sandbed Region

AmerGen has acknowledged that circumstances exist which could cause water to be present on the exterior of the shell in the sandbed region. It has also acknowledged that the coating could deteriorate. In addition, AmerGen alleged that the entire drywell shell was coated, but Citizens have found evidence that certain areas of the shell were left

uncoated because they were inaccessible. Finally, AmerGen has presented no evidence on how fast future corrosion could occur and has assumed away the most problematic issues that must be resolved.

A. Water Could Access The Sandbed Region

AmerGen has acknowledged that there are two circumstances in which water could occur on the exterior of shell in the sandbed region. The plant could be forced into an outage that requires the fuel cavity to be flooded before there is any chance to apply measures to mitigate leaks in the cavity liner, AmerGen Testimony Part 1 at A.17, and water could condense on the exterior of the shell. AmerGen Testimony Part 3 at A.15. In addition, other circumstances could cause water to flow onto the exterior of the shell in the sandbed region, such as leakage from other sources or deterioration of the trough that catches that water that continues to leak from the reactor cavity during refueling, even after AmerGen has taken measures to reduce the leakage.

At various times in the past there has been leakage onto the exterior of the drywell shell because the drywell cavity liner leaks and the trough that was provided to catch general leakage is very shallow, has only one drain, and was damaged. Citizens' Ex. 15 at 134-35; Citizens' Ex. 24 at 222-23; AmerGen Testimony Part 1 at A.20; AmerGen Testimony Part 3 at A.5. More recently, during the 1994 and 1996 refueling outages, the committed mitigation measures were not used and water leaked into the exterior sandbed region. AmerGen Testimony Part 4 at A.8-9; AmerGen Testimony Part 5 at A.14. Therefore, water could flow onto the exterior of the drywell shell in the sandbed region if a forced outage occurred that required the reactor cavity to be flooded without having the mitigation measures applied.

In addition, AmerGen has acknowledged that it has been unable to devise a means of stemming the leakage from the reactor cavity during refueling. Citizens' Ex. 24 at 219-21. In the 2006 outage around one gallon per minute of leakage was observed even after the required tape and strippable coating were applied to the fuel cavity liner, but water was not observed in the sandbed region. AmerGen Testimony Part 4 at A.9. This does not prove that water could not penetrate into the sandbed region during future outages. In fact, there are a number of factors that could lead to further leakage. First, the trough is still subject to high temperatures that could cause the concrete to deteriorate and the condition of the trough was seen to be far from ideal in the most recent outage. Citizens' Exs. 48-49. Second, serious leaks have been observed in the past even after taping and strip coating. Citizens' Ex. 50. Third, the intended function of the trough is to act as a backup for other components. Citizens' Ex. 24 at 220. Thus, if the trough degraded further, the mitigation measures were less effective than in 2006, or leakage occurred from other components, water could enter the drywell again, even without a forced outage.

Finally, AmerGen acknowledges that use of the drywell chillers, which are used during refueling and other outages when access to the drywell is needed, could lead to condensation. AmerGen Testimony Part 4 at A.15. The potential for condensation is apparently confirmed by an analysis of water that had drained from the exterior of the sandbed region before March 2006, which showed no activity. Citizens' Ex. 23. This is consistent with the source being condensation.

B. The Exterior Of The Drywell Shell Could Be Unprotected By The Coating

Based on unpublished data, AmerGen has alleged that the epoxy coating could last for thirty years without serious deterioration. AmerGen Testimony Part 5 at A.9. However, at the ACRS AmerGen stated that its internal estimates of coating life had ranged from ten to twenty years and it had been in touch with the coating manufacturer, who could provide no guaranteed coating life. Citizens' Ex. 16 at 61. In its testimony, NRC Staff acknowledged that one element that led to it requiring UT monitoring during the extended period of operation was the "unknown duration of the effectiveness of the epoxy coating . . ." NRC Staff Testimony at A.23. Thus, based on the testimony to date, there is general agreement that the coating could fail during the period of extended operation, but it is uncertain exactly when it might fail. Given the potential presence of water, it is therefore reasonable to conclude that a corrosive environment could come into existence during the period of extended operation and further corrosion of the exterior of the drywell shell in the sandbed region could result.

Finally, AmerGen testified that the recent visual inspections did not identify any gaps or failures to coat any portion of the sandbed region. AmerGen Testimony Part 5 at A.23. This statement leaves open the possibility that portions of the shell in the sandbed region were not coated because they are inaccessible. Citizens' Ex. 40-41. Thus, at present, AmerGen has failed to establish that the epoxy coating was applied to all of the drywell shell in the sandbed region.

V. AmerGen Has Failed To Address Corrosion From The Interior Of The Sandbed Region

Apparently relying on a legal argument, AmerGen presented no testimony about corrosion of the interior drywell shell in the sandbed region. However, AmerGen tacitly acknowledged that corrosion from the interior of the shell would be just as important as corrosion from the exterior, stating that the sandbed region is "that portion of the drywell shell that is between 8'11" and 12'3" which was historically filled with sand on the exterior . . . .[W]e are referring to the thickness of the drywell shell in this region . . ." AmerGen Testimony Part 3 at A.6. In contrast, NRC Staff acknowledged that corrosion of the drywell shell in the sandbed region from the interior could occur, NRC Staff Testimony at A12(a), and estimated that the interior corrosion rate has been around 2 mils per year in the interior trenches located in Bays 5 and 17. *Id.* at A11. AmerGen's calculations yield similar results, but AmerGen attributes the thickness loss to exterior corrosion between 1986 and 1992, when the exterior coating was applied. AmerGen Ex. 19 at 5.

To date, Citizens have not seen any analysis of the uncertainty attached to this corrosion rate. Clearly, the time base for the corrosion is extremely uncertain. In addition, the estimate is based on the subtraction of the mean of the trench data in 1986 from the mean of the trench data in 2006. The difference in the means is 0.038 inches. NRC Staff Testimony at A11. The error in each mean is approximately plus or minus 0.005 at 95% confidence. Thus, the error in the subtraction is very roughly around plus or minus 0.01 inches, translating to an error in the estimated corrosion rate of plus or minus 25%.

The interpretation of these results is very difficult. AmerGen's explanation that the thinning is caused by exterior corrosion seems unlikely, because Bays 5 and 17 are the least corroded Bays and the estimated corrosion rate in Bay 17 was not significant or was very small. AmerGen Ex. 23. Indications are that corrosion on the interior could occur at outages or when water flows to the interior during operation. Thus, it is likely that the 2 mils per year average represents a situation where interior corrosion occurred in fits and starts over the years. Considerably higher short term corrosion rates have probably occurred. In the absence of any good information on this issue, it is prudent to allow for a corrosion rate of up to 10 mils per year after new water is introduced onto the interior floor by repairs to control rod drives, use of the containment spray, or other sources.

VI. Overall Corrosion Rate

The initial filings make it clear that neither AmerGen nor Citizens are able to provide a good estimate of the potential future corrosion rate. Citizens adopted the statement of AmerGen's that the exterior corrosion rate could be 0.039 inches per year, Citizens' Ex. 29 at ¶¶ 16, 17, while AmerGen adopted a historic corrosion rate previously quoted by Citizens, 0.017 inches. AmerGen Testimony Part 5 at A.15. In addition, AmerGen has pointed out that if water can only reach the exterior of the shell during outages, a critical parameter is the time for which the plant is offline and the rate at which the water on the exterior of the shell would evaporate.

AmerGen makes a number of critical errors in its approach to estimating exterior corrosion. Most obviously, Mr. Gordon fails to consider the situation where the plant is forced to fill the drywell cavity in a forced outage. *Id.* at A.13. Mr. Gordon also fails to

allow for other forced outages that could lead to condensation on the exterior of the drywell surface. In addition, Mr. Gordon has not used a reasonable approach to estimate the time in which any water on the exterior of the shell would evaporate, because he has used an equation which applies to pools or open ponds. *Id.* at A.19. Thus, the equation inherently assumes that the evaporation of the water does not affect the air into which it is evaporating. This assumption is invalid for the exterior of the sandbed region which has very limited air exchange. It is therefore likely that in the event of water leakage into the region, the air in the sandbed region would become fully saturated during the outage. This, it would have very limited capacity to absorb moisture as the temperature increased with plant start up.

After the air becomes saturated at the operating temperature, it would not absorb more moisture unless air is being exchanged with the outside. The ability of new air to reach the sand pocket has been reduced by the placement of tubes leading to polysterene bottles in the sandbed drains. Thus, it is likely that any moisture on the exterior of the shell would evaporate slowly. Citizens do not have access to sufficient information to provide a quantitative estimate of the rate of evaporation, but, purely for illustration, Citizens will assume that water could remain in the sandbed for up to a year.

VII. Minimum Monitoring Frequency Is More Than Once Per Year

The total corrosion rate has been conservatively estimated to be 0.039 inches per year from the exterior and 0.01 inches per year from the interior in the year after an outage in which the reactor cavity is flooded or the drywell chillers are used. Summing the interior and exterior corrosion rates provides a reasonable upped bound estimate of 0.049 inches per year for the corrosion rate. Thus, even if the Board ignores the external

thickness measurements and finds that the available margin at 95% confidence is 0.036 inches, UT monitoring is needed more than once per year.

CONCLUSION

AmerGen has failed to show that there is reasonable assurance that the UT monitoring proposed for the drywell shell in the sandbed region will maintain the required safety margins during any extended period of operation. Indeed, analyses by both AmerGen and Citizens show that the existing corrosion on the surface of the drywell shell probably already violates even the least stringent local area acceptance criterion and CLB. Citizens have also shown that the shell does not meet the other acceptance criteria with the required 95% confidence. Thus, based on the record before the Board and for the foregoing reasons, AmerGen's application to relicense the Oyster Creek Nuclear Generating Station should be denied.

Respectfully submitted

Richard Webster, Esq
RUTGERS ENVIRONMENTAL
LAW CLINIC
Attorneys for Petitioners

Dated: August 17, 2007

CITIZENS' EXHIBIT LIST

No.	Exhibit	Other Reference
1	GPU Nuclear, Drywell Steel Shell Plate Thickness Reduction (July 21, 1995).	Citizen's Exhibit NC 8
2	Partial Cross Section of Drywell and Torus.	Citizen's Exhibit NC 10
3	Memorandum from Peter Tamburro on the Unclear Documentation of Calculation C-1302-187-5320-024 (AR 00461639 Report) (Mar. 30, 2006).	Exhibit ANC 8
4*	Exelon Nuclear, Calculation C-1302-187-5320-024 Revision 1: O.C. Drywell Ext. UT Evaluation in Sandbed (Jan. 12, 1993).	AmerGen's Exhibit 3
5*	Exelon Nuclear, Calculation C-1302-187-E310-041 Revision 0: Statistical Analysis of Drywell Vessel Sandbed Thickness Data 1992, 1994, 1996, and 2006 (Dec. 12, 2006).	Exhibit SJA 1
6	Affidavit of Peter Tamburro, Mar. 26, 2007.	
7	AmerGen, NRC Information Request: Audit Question Numbers AMP-141, 210, 356 (Apr. 5, 2006).	Citizen's Exhibit NC 1
8*	AmerGen, Passport 00546049 07 (AR A2152754 E09): Water Found in Drywell Trench 5 - UT Data Evaluation (Nov. 7, 2006).	Exhibit SJA 2

* Citizens understand that these exhibits marked with a * will be provided by AmerGen, however, if AmerGen fails to submit these exhibits as anticipated they will be submitted by the Citizens at a later date.

9	Structural Integrity Associates, Inc., Statistical Analysis of Oyster Creek Drywell Thickness Data (Jan. 4, 2007).	AmerGen's Exhibit 4
10	AmerGen, NRC Information Request: Audit Question Numbers AMP-357, 356, 210 (Jan. 24, 2006 and Feb. 16, 2006).	Citizen's Exhibit NC 2
11	Email from Peter Tamburro to Ahmed Ouaou (June 6, 2006, 14:03 EST).	OCLR00013624-13625
12	Memorandum from Dr. Rudolf Hausler, Apr. 25, 2007 (Redacted).	
13	Memorandum from Dr. Rudolf Hausler, July 19, 2007.	
14	AmerGen, Reference Material to the ACRS: Photograph of the Sand Bed Region (1992).	Exhibit SJA 3
15	Transcript of Nuclear Regulatory Commission Proceedings, Advisory Committee on Reactor Safeguards Subcommittee on Plant License Renewal Oyster Creek Generating Station (Jan. 18, 2007) (Excerpted Pages: p.1-10, p.132-144, p.207-224, p. 353-358).	
16	Transcript of Nuclear Regulatory Commission Proceedings, Advisory Committee on Reactor Safeguards Meeting of Plant License Renewal Subcommittee (Oct. 3, 2006) (Excerpted Pages: p.1-8, p.59-63).	
17	Email from Steven Hutchins to John Hufnagel Jr., with Drywell White Papers attachment (Sept. 18, 2006, 16:51 EST).	OCLR00013714 - 13734
18	Affidavit of Jon R. Cavallo, Mar. 26, 2007.	

19	AmerGen, Action Request: Determine the Proper Sealant for Drywell Sandbed Floor Voids (Oct. 23, 2006).	Exhibit ANC 5
20	Letter from Richard J. Conte, Chief Engineering Branch 1, Nuclear Regulatory Commission, to Richard Webster, Esq., Rutgers Environmental Law Clinic (Nov. 9, 2006).	Exhibit ANC 6
21	Letter from J.C. Devine, Jr., Vice President of Technical Functions, GPU Nuclear, to the Nuclear Regulatory Commission (Dec. 5, 1990) (Attachment 3; GPUN Detailed Summary Addressing Water Intrusion and Leakage Effects Related to the Oyster Creek Drywell).	OCLR00029270-29283
22	GPU Nuclear, Clearing of the Oyster Creek Drywell Sand Bed Drains (Feb. 15, 1989).	OCLR00028912-28918
23	AmerGen, Disclosed Document Relating to Drywell Leakage.	OCLR00013354
24	Transcript of Nuclear Regulatory Commission Proceedings, Advisory Committee on Reactor Safeguards 539th Meeting (Feb. 1, 2007) (Excerpted Pages: p.1-3, p. 172-177, p. 217-224).	
25	Letter from the Nuclear Regulatory Commission to C. Crane (Jan. 17, 2007) ("Inspection Report").	ML070170396
26	Email from Steven Dunsmuir, FIN/Operations RO, Exelon Corp., to Howie Ray, et al. (Oct. 22, 2006, 04:52 EST).	OCLR00014454-14455
27	Email from Tom Quintenz to Kevin Muggleston, et al. (Feb. 1, 2006, 17:02 EST).	OCLR00013629
28	GPU Nuclear, Evaluation of February 1990 Drywell UT Examination Data (Mar. 8, 1990).	Citizen's Exhibit NC 9

29	Affidavit of Gordon, Mar. 26, 2007.	
30	Letter from Jill Lipoti, Director Division of Environmental Safety and Health, New Jersey Dept. of Environmental Protection, to Dr. Pao-Tsin Kuo, Director Division of License Renewal, U.S. Nuclear Regulatory Commission (Apr. 26, 2007).	
31*	AmerGen, Calculation Sheet C-1302-187-5300-01.	
32*	GPU Nuclear, Calculation Sheet C-1302-187-5320-024 Revision 0: Oyster Creek Drywell Exterior Evaluation in Sandbed (1993).	Citizen's Exhibit NC 3
33*	Exelon Nuclear, Calculation C-1302-187-5320-024 Revision 2: O.C. Drywell Ext. UT Evaluation in Sandbed (Mar. 18, 2007).	
34*	ACRS Information Packet (Dec. 2006).	Exhibit ANC 2
35	Letter from AmerGen to the NRC (2103-06-20426) (Dec. 3, 2006) (Excerpted Pages: Dec. 3, 2006 Letter, p.1-3, p. 9-15, p. 17-24).	Exhibit ANC 1
36	Email from Caroline Schlaseman, MPR Associates, Inc., to Howie Ray (Nov. 2, 2006, 12:09 EST).	OCLR00015433-15434
37	Background and Statement of Facts	Attachment 5 to Hausler Initial Testimony
38	Memorandum from Dr. Rudolf Hausler, Subject: Response To The Questions About Statistics (Aug. 16, 2007).	

39 Memorandum from Dr. Rudolf Hausler, Subject: Further Discussion of the Nature of the Corroded Surfaces and The Residual Wall Thickness of the Oyster Creek Dry Well (Aug. 16, 2007).

40. Email from William Russell to Frederick Polaski, et al., Subject: Challenge Board #1 additional comment (Nov. 30, 2006, 9:48 EST), attached to email from John Hufnagel Jr. to Ahmed Ouaou, et al. (Nov. 30, 2006 10:41 EST).

41. GPU Nuclear, Technical Functions Safety/Environmental Determination and 50.59 Review (Jan. 5, 1993).

42. Email from Peter Tamburro to Ahmed Ouaou, Cc Howie Ray, et al., Subject: Surface Are (sic) of the Drywell in the sand bed (Apr. 3, 2006 3:24 PM).

43. Email from John O'Rourke to Michael Gallagher, et al., Subject: External Inspections of DW in Sandbed Region (Oct. 10, 2006 8:08 AM), attached to email from John Hufnagel to John O'Rourke (Oct. 10, 2006 8:10 AM).

44. Memorandum, GPU Nuclear from K. L. Whitmore, Civil/Structural Mgr. to J. C. Flynn, Manager, Special Projects, Engineering Projects, Subject: Inspection of drywell sand bed region and access holes (Jan. 28, 1993).

45. AmerGen Technical Evaluation 330592-27-27 (Apr. 20, 2007).

46. Email from John O'Rourke to Marcos Herrera, Cc Michael Gallagher et al., Subject: Oyster Creek Drywell Thickness to be Used for Base Case Analysis, with OYSTER CREEK DRYWELL THICKNESSES, Rev2.doc attachment (Feb. 28, 2007 7:20 PM).

47. Issue # 00557180, Exelon Nuclear Issue - Statement of Confirmation, Originator: Kathy Barnes (Nov. 13, 2006).

48. Email from Tom Quintenz to John O'Rourke, Subject: Notes of video inspection results of trough area with Video Inspection of Concrete Trough Notes November 1996.pdf attachment (Oct. 10, 2006 2:26 PM).

49. GPU Nuclear, Material Nonconformance Report (Oct. 27, 1986).

50. Memorandum, GPU Nuclear from R. Miranda, Engineer, Technical Functions to Distribution, Subject: 14R Reactor Cavity Leak Detection Effort (Feb. 1, 1993).

51. Sketches showing ultrasonic and "Echo to Echo" techniques, and explanations of sketches.

Exhibit No. 38

CORRO-CONSULTA

8081 Diane Drive
Tel: 972 962 8287 (office)
Tel: 972 824 5871 (mobile)

Rudolf H. Hausler
rudyhau@msn.com

Kaufman, TX 75142
Fax: 972 932 3947

Memorandum
August 16, 2007

Response To The Questions About Statistics

I. Some Background on the Origin of Statistics

- Collecting data of all sorts is a basic human and/or societal occupation. The data one collects are very simply observations put into a quantitative form. For instance, the child may separate out the red from the green pebble at the beach and then count them

- Statistics is a tool to organize and describe some innate properties of data, i.e. properties of the observations one has made.

- The most prevalent observations are measurements, and the most important property of measurements, any measurement, is the fact that they are not absolutes, as we tend to assume, but in fact estimates. Hence, the data we collect are estimates and statistics is a tool to describe certain properties of these estimates.

- What are these properties? Take an example: We have a corroded surface, which is characterized by pits. (Pitting is a most prevalent form of corrosion). We would like to know how deep the pits are. We take a micrometer, for instance, or a microscope, and start measuring the depth of pits. We measure 87 pits and acquire 87 data points each describing the depth of a pit. We now need to describe what we have done in some way that is more concise and more understandable than a collection of 87 data points. We take recourse to some statistical tools.

- The first thing we do is to calculate the **average pit depth**, also called the mean. The next day the boss comes with another piece of corroded surface, from another structure, and wants to know whether the pits are the same, or maybe were caused by a different phenomenon. So, we start all over again measuring pit depth but only take 47 pit depth measurements. We quickly calculate the average of the 47 data points and because the new average is slightly different but we then have a statistical problem – **how much confidence can we have that the two averages (means) are indeed different or come from the same universe of pit depths.**

II. What Statistics can do and can't do

- One needs to recognize that statistics is a set of rigorous mathematical equations to answer certain very specific questions one may have about a collection of data. However, one also needs to recognize that as with all mathematical theories, they are based on assumptions, and one always needs to test whether the assumptions in a given mathematical procedure actually reflect the true nature of the phenomenon under scrutiny. Example: if the variation of the pit depths is truly normal, then Gaussian statistics will apply because they are based on the observation that measurements close to the mean are more frequent than the ones further removed. Since AmerGen and NRC have decided that Gaussian statistics are what applies to the sandbed corrosion problem, that is what we will discuss first. (An alternative will be discussed later on).

- The basic assumption underlying Gaussian statistics is the notion that the variations within the universe of data, which characterize a particular parameter, are distributed normally as defined above. The universe (also sometimes called the population) therefore can be represented by the well-known bell-curve. This simply means that the frequency of data close to the mean is higher than the frequency of data removed from the mean.

- The Gaussian or Normal Distribution curve shown in Figure 1 is rigorously described by a mathematical formula which simply says that the logarithm of the probability density p(y) (or how often a value occurs within its population) of a particular value is a quadratic function of the difference between the value and the mean of the population.

$$p(y) = const. \cdot 1/\sigma \cdot e^{-[(y-\eta)^2/2\cdot\sigma^2]}$$

where y = attribute (value to be measured)
σ = standard error
η = mean of the population

III. The Error Measurement

- Since one can never measure the entire population, but only samples of the population, the average of the sample (the sample mean) and the standard deviation of the sample (standard error)[1] become **estimates** of the true population mean and the true probability density distribution, i.e. the true standard deviation. This, however, is only true if the samples have been selected randomly. The difference between a value y and the mean of the population is often called the error. However, the error is a complex function of a lot of things, some can be controlled others cannot. Therefore we would prefer to call this difference ((y-η)

[1] The variance is the square of the standard deviation

the variability in the data. The variability is composed (in the simplest case) by the "innate" reproducibility of the instrument (the accuracy of the instrument [2)]) and by the natural variation of the measured parameter (pit depth as a function of location on the surface).

- This is demonstrated in Table 1. During the 2006 refueling outage the external UT measurements from 1992 were repeated. We had already shown [3)] that even though there was a slight bias between the 1992 and 2006 data (of about 20 mil) which might have been interpreted as ongoing corrosion, this bias was not statistically significant in view of the inherent variability of the data (individual UT measurements). In 2006, additionally, duplicate and triplicate measurements were made externally in some bays. From these repeat measurements it was possible to estimate the standard deviation associated with the error of the measurement only. The results are summarized in Table 1 below.[4] In the columns headed by 'std. dev. variability' we calculated the spread of the remaining wall thicknesses between pits as a standard deviation. It is easy to understand that the wall thickness measurements will vary from pit to pit because one could not expect corrosion to be uniform over the entire surface [5)]. Hence one finds the wall thicknesses vary within certain limits as expressed by the standard deviation [6)].

  Now, it must be also understood that the variability of the data arises from two sources: a) the actual variation of the pit depths (residual wall thickness) and the measuring error. If only wall thicknesses are measured, the two effects are hopelessly confounded. In the present case, in 2006 duplicate measurements were made in some cases as shown in Table 1. It was then possible to estimate the measuring error form these repeated measurements. As Table 1 shows the measuring error (Std. Dev. from 2006 Repeat Measurements) is smaller than the variability of the wall thickness measurements themselves. This is of course anticipated since the latter contain, as mentioned above, both the error as well as the variability of the wall thicknesses. It is interesting to note that the measurement error depends on the roughness of the surface. Indeed, if the error is plotted against the variability a straight line results which extrapolates roughly to 0.01 inches at 0.01 inch (see Figure 5), i.e. the instrument error one would expect, from the manufacturers specifications, if the surface had not been corroded and were still in a pristine state.

[2)] UT instruments are generally said to be accurate within +/- 1 to 2% of wall thickness, where newer instruments are more accurate than the older ones.

[3)] R. H. Hausler Memorandum to Richard Webster, Esq. April 25, 2007, Figure 7

[4] The standard deviations derived from repeat measurements shown in Table 1 differ slightly from those previously presented, because I have used a more rigorous calculation method than previously.

[5)] In acid for instance one could anticipate and observe that the thinning of the probe (wall) is uniform over the entire surface with no evidence of pitting. In neutral solution where the build-up of corrosion product layers can be anticipated corrosion will not be uniform over the surface and localized attack can be anticipated.

[6)] If the pit depths, or by implication the remaining wall thickness measurements, are normally distributed, characterizing the variability with a standard deviation makes sense. If the distribution is a different one (which we suspect) then the data spread should be characterized differently.

IV. Definition of Confidence Limits and Statistical Testing

Referring back to Figure 1, it turns out that about 66% of all data belonging to the universe of data estimated by the standard deviation are within the mean m +/- 1s and 95% of the data are roughly within m +/- 2s. The exact multiple of s to be used is derived from the Student's t-distribution, which takes account of our imprecise knowledge of the true population variance. The multiples of s that encompass a certain portion of the data decrease as the number of samples increase. At the limit, when the number of samples is large, the students-t distribution becomes equivalent to the classic Gaussian distribution

Now it may arise that one asks of a particular measurement whether it belongs to this universe. If the point is more than two s removed from the mean there is a certain probability that it does not belong and vice versa. One can specify that probability with the Student's t-test, which calculates the chance that a sample would deviate that much from the population mean. The student t-test may also compare the means of two sets of measurements to calculate the chance that the difference between the means is caused by random variation.

Similarly one may ask the question whether the variabilities of two sets of data are the same. The comparisons are made on the basis of the variances (s^2) rather than the means and the test is called the F-test. Imagine two machines turning out bolts. The mean length of the bolts is the same for both machines, but the variance, i.e. the spread of the length measurement is different. The F-test indicates the probability that the difference in the variance is real. It might tell us that one of the machines needs to be better adjusted. Similarly, one might ask the question whether the variance of the measured residual wall thicknesses for Bay 5 in 2006 is different from that of Bay 19. If the F-test returns a probability of between 95 and 99%, this might tell us something about the corrosion mechanism or the cause of corrosion in the two Bays.

Getting back to the simple comparison of two measurements, one may for instance posit the hypothesis that the mean m_1 does not belong to the same universe of data as m_2. Based on the Student t-test one may find that there is a 75% probability that the hypothesis is true. Customarily one would not accept this as sufficiently significant. If how ever there was a 95% probability for m_2 to belong to a different universe, one would very likely accept the hypothesis. Happily, these statistical probabilities have been calculated and are available in tables. Even better, nowadays, computer codes have made life very easy for the experimental statistician (see for instance Fig 2 to be discussed later).

The 95% confidence limits based on the 95% probability of a specific hypothesis being accepted as true is often used in science as an indicator that it is unlikely that the observed effect is caused by random variation. However, there is no set standard in the literature or in engineering that imposes such limits. There may be

certain recommended practices, which embrace this limit as practical but not as imperative. The reason for this is quite understandable. From a practical point of view 95% confidence may be too little if the consequences of drawing an erroneous conclusion are large. In such cases, the required confidence limit could as well be 99%, or in the case of GE, which advertised 5s as the a company wide standard, it is more like 99.9%. What is, however vitally important is risk assessment. To perhaps clarify the difference between probability (confidence) and risk contemplate the following situation: A blind man crossing a major thoroughfare has a one in a hundred chance of being hit by a car. The confidence level therefore is 99% that he will make it across. The risk he takes, however, is unacceptable, because he would cross thousands of roads in his lifetime and so a he would have a very high chance of being hit. Hence, assessing the confidence one may have in acquired data is only the first step, albeit an important one, in assessing risk. Generally, it is the process of risk assessment that imposes the confidence level to be used.

In the pipeline industry both internal and external corrosion damage is assessed by ILI (internal line inspection, also sometimes referred to as intelligent line inspection). Pigs equipped with sensors (either UT or magnetic flux leakage – and in earlier years mechanical calipers) are pushed through a pipeline, and the responses of the sensors recorded, to be downloaded and interpreted after the run. The API (American Petroleum Institute) has prepared a Standard for In-Line Inspection Systems Qualification [7)]. The 65 page documents standardizes the entire process. We are here only interested in the statistical handling of the data. As the title indicates it is the "system" that is being standardized. The basis question is: "how accurate is the instrumentation in the pigs"? This is being demonstrated by verification of the indicated corrosion (or other) anomalies where the buried line can be accessed. The anomalies are located by means of the distance measurements (made by the pig) and verified with an alternate method or instrument. The paradigm for verification is as follows: The pig is specified (by the manufacturer) to detect anomalies with an accuracy of +/-10% of wall thickness. Verification occurs with a certain additional error, say 5%. If the anomaly is verified within the pooled accuracies it is accepted, otherwise it is rejected. The aim of this verification is to be 95% confident that the measurements of the pig have identified at least 80% of the anomalies correctly and within the set specifications. The thinking is not applicable to the Oyster Creek drywell shell problem, because no effort has been made to independently verify the corrosion anomalies. At Oyster Creek it is assumed that the UT measurements are correct. The Pipeline example however shows that a 95% confidence limit is considered adequate, albeit not imperative.

There is power in Numbers

There is another side to using statistics. As indicated above, by repeating measurements one can determine the standard deviation (accuracy) of the

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[7)] API – 1163 Qualification of In-Line Inspection Systems, 2004

instrument and calculate a mean for the particular point that was measured. The more measurements that go into the mean the more accurate the mean becomes. Expressed in a formula:

$$s_m = \frac{s_x}{\sqrt{n}}$$

where s_m = standard deviation of the mean
s_x = standard deviation of a single measurement
n = number of measurements used for the mean [8)]

Applied to the problem at hand this would mean that the more wall thicknesses are determined, the greater the confidence we can have in the mean. However, this will not change the distribution (spread) of the wall thicknesses, it will only better define it and better define the average wall thickness. But structures do not fail by averages. Just likes storms do not destroy villages, but extreme storms do. Structures, like pipelines, for instance, fail where the deepest pit is located. So, how do we apply this thinking to the drywell?

V. Margins and Extremes

Sandia recently made a new study of the integrity of the drywell. The result was that the safety factor for the undegraded shell was 3.85 while for the degraded shell is was 2.15, or 7.5 % above the minimum safety factor specified by the ASME code. The input to the calculation for the degraded shell was all the external thickness data from 1992 some of which are shown in Table 1 below. The first question we may ask is whether the 100 odd data points truly represent the state of the corroded drywell. The answer is: not likely, but that is speculation, perhaps. However, we do know that the standard deviation of the error for the individual measurement is of the order of 0.029 inches in the more heavily corroded areas, the ones of interest. This means that the 95% confidence interval for individual wall thickness measurements is of the order of 0.058 or also about 7.5% of the remaining wall thickness. The model took no account of this uncertainty. Furthermore, the Sandia model has other non-conservative features and was designed to provide accurate absolute predctions. Specifically, the model did not attempt to model the actual shapes and placement of the observed corrosion features, and it did not use the 2006 data which all agree is more accurate and shows the drywell shell is on average approximately 0.02 inches thinner than measured in 1992 data. Therefore, the Sandia model does not establish any margin with a high degree of confidence.

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8) This formula essentially says that the means of samples are more narrowly distributed than the samples themselves. This is a direct consequence of the "Central Limit Theorem".

In addition, we question whether the buckling models should take explicit account of other uncertainties, including variation in nominal wall thickness [9], variations in tensile strength, variation in temper properties, inclusions in the steel sheet (of which the UT tests seem to have found a relatively large number), and perhaps many more. It may be that the safety factor of 2 is designed to take account of these, but it appears that designers err on the safe side to ensure that this requirement is met with a very high degree of certainty at the outset, when the variation in wall thickness is much less than it is after 40 years of corrosion.

There are two criteria of primary interest with respect to the integrity of the Oyster Creek Dry well. First is the buckling criterion discussed above and addressed by the Sandia study. Then there is a pressure criterion, which says that a corroded area thinner than 0.536 inches shall be greater than 0.49 inches and not larger than 2.5 inches in diameter. In this case only one relatively small area corroded fairly deep could in fact lead to non-compliance with the safety requirements. The trouble is one does not know where this spot could be. One therefore tries to extract from the available data whether such a spot could exist and with what probability.

In the first attempt to answer the question one would probably examine the available data for "normalcy" (i.e. normal, or random, distribution). Figure 2 shows a histogram generated in the SAS software called JMP. While the computer program churns out a result it is up to the operator to decide whether the result justified the underlying assumption. In this case one clearly recognizes, even without any further statistical tests, that the assumption of "normalcy" is not fulfilled. (In fact statistical tests, which are not shown in the printout do confirm this). The aspect of a histogram often depends on the "bin size" (i.e. the width of the intervals chosen for the density counts). Figure 3 shows that reducing the bin size to 25 from 50 in Fig. 2, leads to the same conclusion, namely that the data are not normally distributed. It would therefore not be prudent to use the statistical data from Figure 2 and calculate the 2.5% probability for the lowest wall thickness, 790 – 2*112 = 564 mils. Of course, one could have asked for the 1% probable thinnest thickness which would have been around 790 – 3*112 = 454 mils or thin enough to violate the safety requirement. In view of the high stakes in these considerations one may then want to explore other approaches.

VI. Extreme Value Statistics

An alternate approach is in the application of extreme value statistics, which does require the data to be normally distributed. Figure 4 shows the data from Bay 13 (external measurements made in 1992). The theory requires that when the ordered data are plotted against a double logarithmic function of the reduced or relative order of the data points (the reduced variate) in the series, a straight line is obtained. Figure 4 shows the result. The correlation would appear to be

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9) while the nominal thickness may well have been 1.154 inches the manufacturer's tolerances vary from 10 mils to as much as 2 to 3%.

considerably better than under the assumption of normalcy (Fig. 2). The regression function of the straight line can be used to extrapolate values, which would have been obtained if more points had been measured. Thus, if 37 points had been measured, one might have observed a point of the order of 490 mils residual wall thickness. Larger number of data points might well have included even lower wall thicknesses. This is a disturbing result because it indicates that there is a significant chance that the drywell shell would not contain the gases in an accident condition.

Extreme value statistics, as I understand it, was developed in order to predict damage from extreme weather conditions. For example the 100-year flood plain is based on such predictions. These predictions only say how high water may rise if the extreme amount of rain falls. They do not predict when this may happen. Similarly, extreme value statistics applied to corrosion only says that there may be a pit deeper than all the others with a certain probability based on the number of observations, but it does not say where this pit (or damage) may be unless it has actually been measured.

VII. Extreme Value Statistics in Industry and Risk Assessment

Extreme value statistics is beginning to be used in the pipeline industry. This writer has used the approach to calculate the corrosion rate (pitting rate) in pipelines based on successive scans and evaluation of the resulting data according to extreme value statistics. Pipelines are scanned by intelligent pigs, using either mechanical calipers (rarely used any more), UT, or Magnetic Flux Leakage (MFL) technology. This technology has been growing rapidly with advances in the respective areas. Successive MLF scans for instance rarely record the same corrosion feature twice. There are a number of reasons for this too numerous to go into here. However, because of this, extreme value statistics is the only means to compare successive scans and estimate an overall corrosion rate, It must be remembered, however, that it is individual pits that corrode, not the ensemble of pits, and one initially assumes that all the pits are subject to the postulated corrosion mechanism. If different conditions prevail along the pipeline, then the data may have to be partitioned appropriately and analyzed separately.

VIII. Some General Remarks

I hope that these very brief remarks make it clear that the application of statistics (any statistics) in the oilfield is a difficult problem. However, in view of the fact that some recent incidences have led to the criminalization of negligence with respect to corrosion prevention of structures in the public sector, and with DOT and EPA setting rules, companies have begun to realize that failures are becoming less and less acceptable. However, while diligence has been legislated, there are currently no standards with respect to the certainty required. This means it is left to the individual companies to assess risk based on the probability predictions extracted from the data collected.

This gets us right back to risk assessment, and the probability of the "extreme corrosion damage", and the corrosion rate based upon such estimates, are only a small part of the overall input into the Monte Carlo simulations that calculate the value of the risk the company is bearing and in the end dictate corporate behavior.

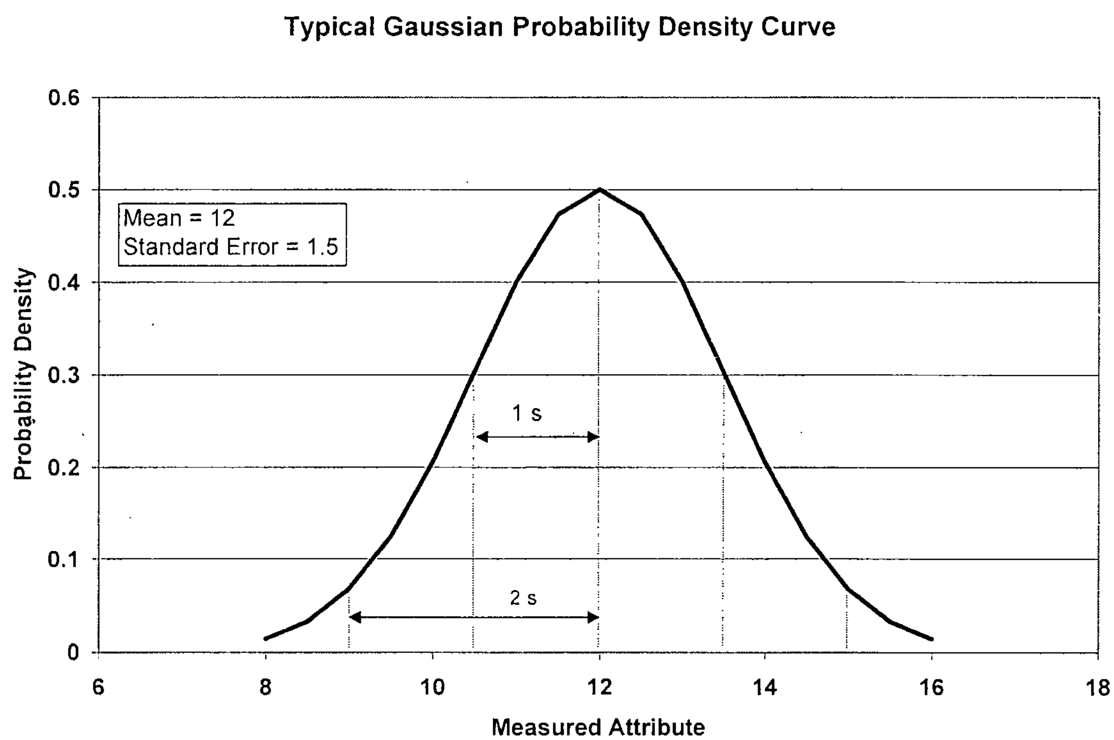
In conclusion, it appears to us, that similarly to corporate behavior, where the responsibility lies squarely on the shoulders of the engineer and responsible personnel, the nuclear industry, and in particular the NRC, should take a much more sophisticated look at uncertainty and risk. Here the NRC Staff initially required the drywell shell to meet the deterministic design criteria for both pressure and buckling with a very high degree of certainty. However, the Staff seem to have drifted from this stance to approving the safety of the proposed relicensing, when compliance with those same criteria can no longer be established with any certainty. Although NRC Staff at one point required AmerGen to show margin with a nominal 97.5% confidence and the Staff appear to espouse that standard in the SER and in their testimony, they failed to apply it in practice.

Finally, I would like to point out that this writer at least recognizes the large investment in the nuclear industry, recognizes the complexity of the installations, and appreciates the accident free (or near accident free) operations up to this point. I also am of the opinion that safe nuclear power generation, safe spent fuel handling, and safe spent fuel storage, and reprocessing are in the future of the country. However, just like it has evolved in the pipeline industry, in the refining industry, and in offshore oil and gas production, the personnel involved in the nuclear industry must be held to the highest standards of technical and ethical judgment, which must trump corporate imperatives (see for instance the BP Alaska debacle). Relying on past performance when predicting future behavior of 40-year-old installations is not enough. Aging management has to be a lot more sophisticated and must require the industry to demonstrate it can meet safety-related requirements on an on-going basis with a high degree of certainty.

Table 1

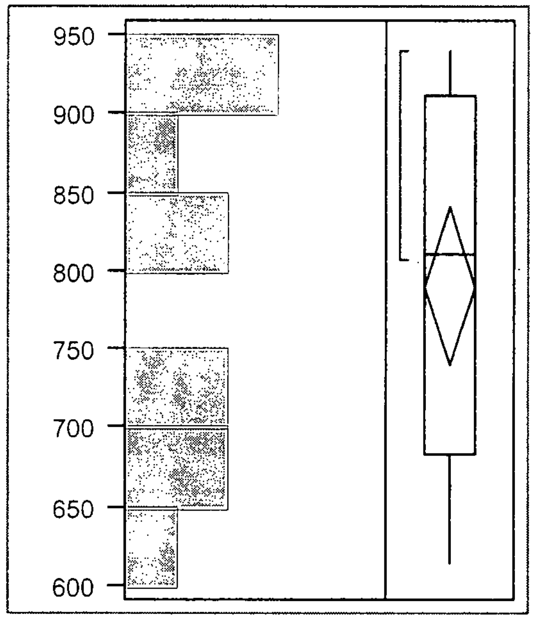
Comparison of the Data Spread in the External UT Measurements with the Standard Deviation of Duplicate or Triplicate Measurements at the same Spot							
Bay	1992 average			2006 Average			
	No of Data Points	Measure ments	Std. Dev. as Variability	No of Data Points	Measure ments	Std. Dev. as Variability	Std Dev. from 2006 Repeat Measurements
5	8	0.994	0.053	8	0.96	0.0386	0.017
7	7	1.004	0.043	7	1.007	0.027	0.017
15	11	0.816	0.054	11	0.81	0.053	0.023
19	10	0.889	0.08	10	0.848	0.083	0.029

Figure 1



<u>Figure 2</u>: histogram for external wall thickness measurements in Bay 13
(Generated in JMP)

1993 WT



Quantiles

maximum	100.0%	941.00
	99.5%	941.00
	97.5%	941.00
	90.0%	933.40
quartile	75.0%	912.50
median	50.0%	810.50
quartile	25.0%	684.50
	10.0%	629.10
	2.5%	615.00
	0.5%	615.00
minimum	0.0%	615.00

Moments

Mean	790.8636
Std Dev	112.1926
Std Error Mean	23.9195
Upper 95% Mean	840.6066
Lower 95% Mean	741.1206
N	22.0000
Sum Weights	22.0000

Figure 3

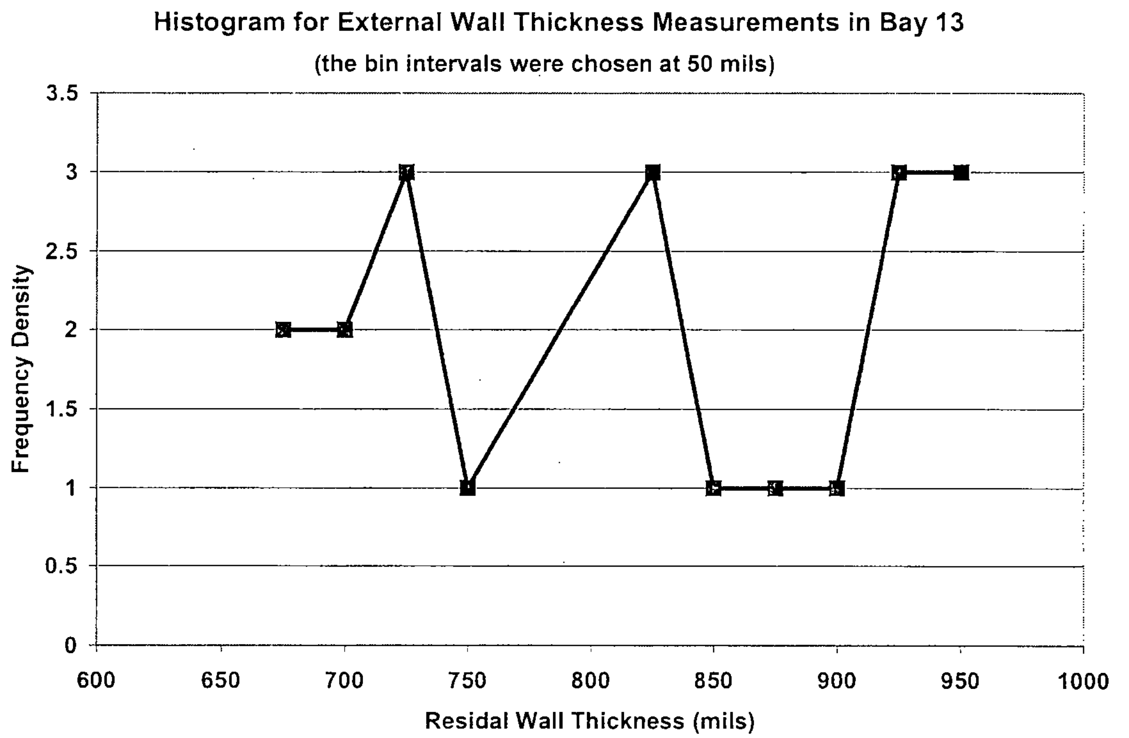


Figure 4

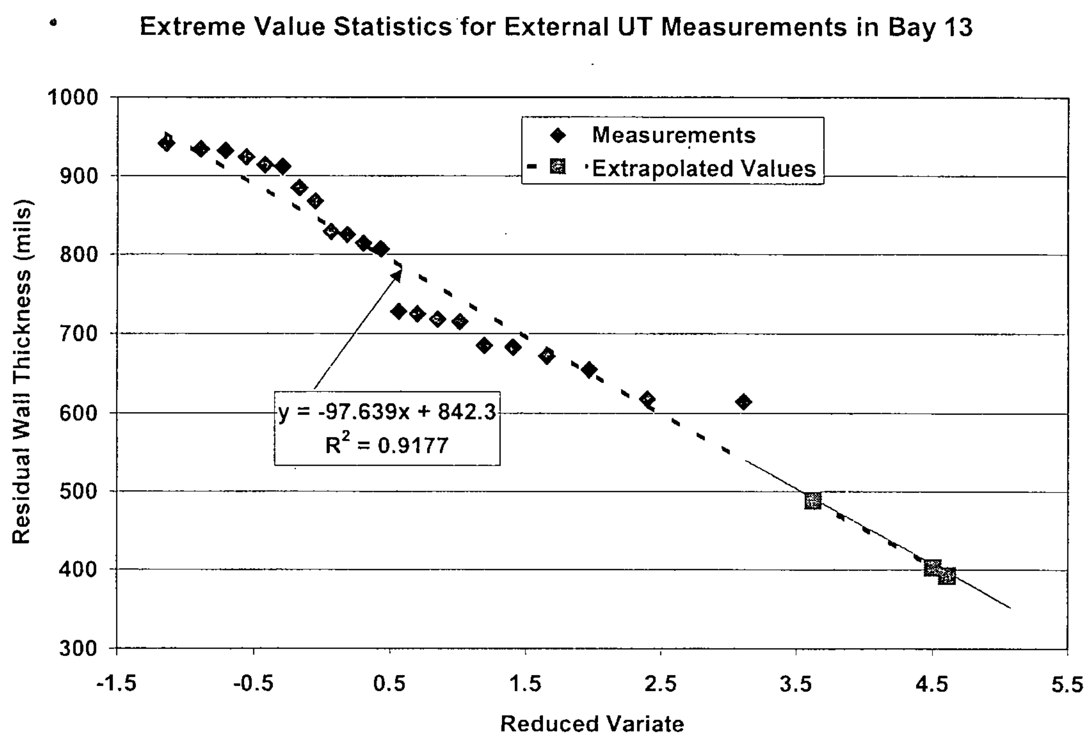


Figure 5

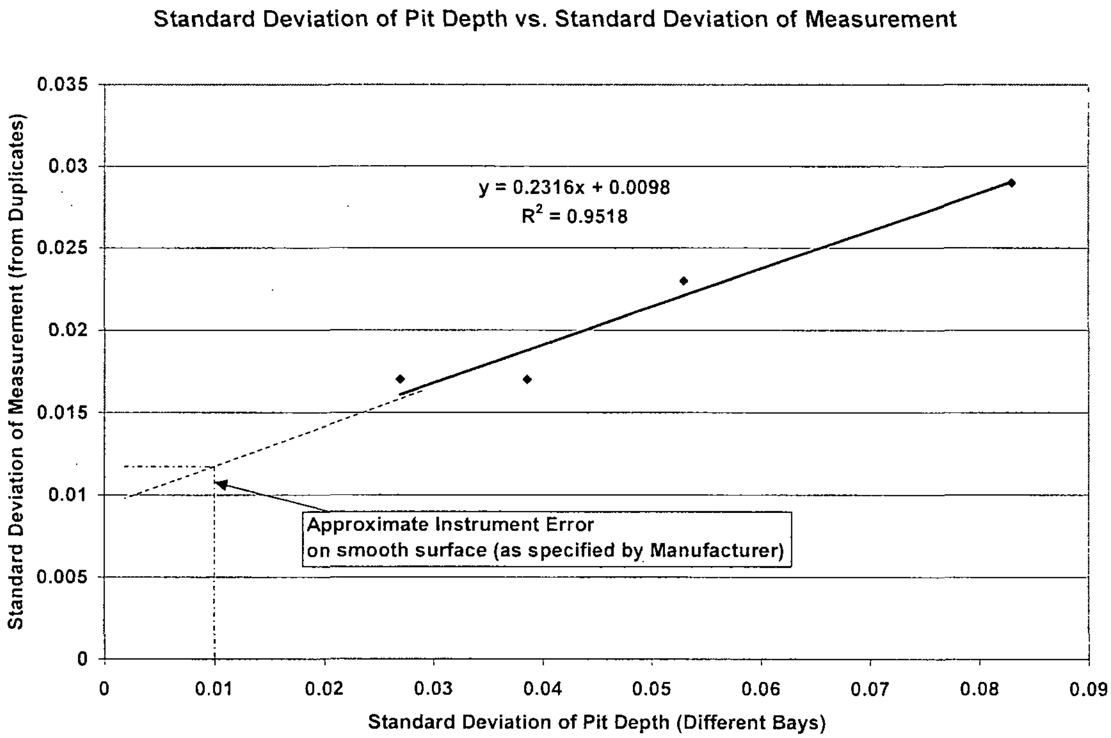

Standard Deviation of Pit Depth vs. Standard Deviation of Measurement
y = 0.2316x + 0.0098
R2 = 0.9518
Approximate Instrument Error
on smooth surface (as specified by Manufacturer)
Standard Deviation of Measurement (from Duplicates)
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0.09
Standard Deviation of Pit Depth (Different Bays)

Exhibit No. 39

CORRO-CONSULTA

8081 Diane Drive
Tel: 972 962 8287 (office)
Tel: 972 824 5871 (mobile)

Rudolf H. Hausler
rudyhau@msn.com

Kaufman, TX 75142
Fax: 972 932 3947

Memorandum

Richard Webster, Esq.
Rutgers Environmental Law Clinic
Rutgers University
Newark, New Jersey

August 16, 2007

Subject: **Further Discussion of the Nature of the Corroded Surfaces and The Residual Wall Thickness of the Oyster Creek Dry Well**

I. Introduction

It is understood from the NRC testimony that ..."the license renewal safety review process focuses on the 'potential detrimental effects of aging that are not routinely addressed by ongoing regulatory oversight programs'" [1]. This is an extremely important statement with respect to the efforts by 'citizens' to contribute constructively to the discussion of the integrity of the Oyster Creek drywell shell. The statement in essence urges "thinking out of the box" and focuses on future potential events that are difficult to predict. NRC and AmerGen both have stated that the aging processes in question are slow and can be monitored within relatively long intervals, without risking an undesirable event. It is, however, a well-established fact and acknowledge by those skilled in the art that "rate to failure", i.e. the rate of the aging process, be it corrosion, degradation of coatings, fatigue etc., is not constant with time (often also said to be non-linear). While almost imperceptibly slow in the beginning, the processes accelerate later in the life of the structure and my lead to failure

[1] NRC Staff Initial Statement of Position on the Drywell Contention, pg. 7, July 20, 2007

exponentially with time. **It is also a well established correlation that the logarithm of the cumulative failure rate of complex aging structures is linear with time, i.e. failures accumulate exponentially as time goes on** [2]. In discussing, therefore, the processes and the monitoring of aging one has to be acutely aware that the rates of these processes are not constant with time but can and often do, after a slow initiation period, accelerate exponentially. **Monitoring intervals therefore cannot be judged by past performance.**

We also try to guard against using terminologies, which tend to create in one's mind images with conflict with the real world. It has, for instance, been said all through these proceedings that "the thinnest spots in the drywell wall in the sandbed area were identified visually (and by micrometer readings). This is utterly impossible, because just by looking at the corroded surface one cannot guess at the remaining wall thickness because one has no reference point back to the original surface. Micrometer readings can establish pit depth, but only with reference to the remaining surface, not the original one. Similarly, 2-inch plugs had been removed from the drywell wall in order to verify the UT measurement at that location. One such plug was examined by a third party [3] corrosion expert and assessed as showing *uniform corrosion*. While the assessment may have been correct for the surface of the 2-inch plug, it certainly was not representative for the drywell surface in the sandbed area in general, because here corrosion was highly non-uniform, as one would expect from the corrosion mechanism. It has also been said that the corrosion damage was caused by *galvanic corrosion.* Galvanic corrosion is defined as occurring between dissimilar metals. There were no dissimilar metals present in the sandbed area. The prevailing corrosion phenomenon is generally identified as differential aeration cell occurring under a deposit. As such, for a number of reasons, the corrosion will be highly non-uniform and characterized by pitting and trough formation, as was indicted by the term golf ball like pimpled surface (which is not what is commonly understood by uniform corrosion).

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[2] This correlation was discussed by Professor Dr. Roger Staehli in a Plenary Lecture during the NACE Convention of 2004 in New Orleans with special reference to the Nuclear Industry
[3] AmerGen's Pre-filed direct testimony Part 6, Future Corrosion, Barry Gordon, pg 4.

Another terminology, which causes a great deal of confusion relates to the removal of air from the reactor cavity during normal operation. Inerting, presumably with nitrogen has been said to make "the likelihood of corrosion very low" [4)]. The fact, however, is that the oxygen content in the atmosphere is reduced only from 20% to 5% [5)]. Corrosion, therefore, will continue however, at a reduced rate [6)]. In fact, it appears that several instances of carbon steel corrosion have been identified in the RBCCW system inside the containment [7)].

These examples, which are only a few of many, demonstrate that it is important not to use words, expressions, sentences, which create imagery not consistent with reality. The containments do not contain *an inert atmosphere;* rather they contain a reduced oxygen atmosphere for the purpose of preventing the formation of an explosive one.

It has been said, and this is obviously not in dispute, that the outside steel surface of the drywell in the former sandbed area had been thoroughly coated with a primer and two epoxy paint coats. Additionally, the concrete floor of the former sandbed had been built up with epoxy, etc, etc. This of course creates the image of a well-protected structure where the protective coating would have to be destroyed or damaged before corrosion could take place. **However, what had not been highlighted until recently [8)] is the fact that there are concerns about areas that were not accessible to cleaning and/or coating.**

These comments, some of which will be discussed in more detail below, bear directly on the question of "how well do we really know the condition of the drywell", i.e. the uncertainties, which surround this entire project. AmerGen has repeatedly indicated both the UT measurements using the internal grids and particularly the external

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[4)] NRC Staff Initial Statement of Position on the Drywell Contention, July 20, 2007 pg. 15, A12(a)
[5)] e-mail from T. Quintenz to K. Muggleston, 2/1/2006.
[6)] See also expert opinion by Dr. R. M. Latanision, letter to Mr. Ron Zak, NJDEP-Bureau of Nuclear Engineering, March 26, 2007
[7)] e-mail from K. Muggleson to G. Beck 1/31/07 (RAI regarding corrosion of carbon steel mechanical components in containment atmosphere).
[8)] e-mail from W. T. Russell to F. Polaski, 11/30/06

measurements gave conservative results because they were obtained from areas that were most corroded. For the external measurements, the only evidence for this statement stems from visual observation of the corroded surfaces. Presenting the data AmerGen had generated in contour plots [9] seemed to suggest that corrosion could, at least in certain cases, be more severe outside the areas that had been examined by UT. At minimum, the contour plots showed that the most severely corroded areas in the sandbed region are very poorly defined spatially. There is therefore tremendous uncertainty about the extent and the thickness of these areas. Instead of merely making optimistic or pessimistic assumptions, statistics may be used to attempt to quantify that uncertainty and illustrate the limits of our current knowledge about the corrosion of the drywell shell. At this point there are two principles one must be acutely aware of. These are: a) the larger the variability of a particular measurement, the larger will be the confidence limits within which the real value might be found. (For example: the reproducibility (s) of wall external thickness measurements is of the order 0.03 inch. The 95% confidence limits within which the wall thickness at that particular spot might be found is therefore approximately +/- 0.06 inch.); b) if it becomes necessary to estimate the thicknesses within tighter confidence limits it will be necessary to perform a larger number of measurements, because the mean will have tighter confidence limits than individual measurements. Indeed, if the null hypothesis is well demonstrated, then successive data sets may be pooled to increase certainty. Thus, a requirement for increased certainty could initially drive a higher monitoring frequency than proposed. However, in areas where there are no measurements, one is reduced to conjecture, and the question in the end is whether AmerGen can show that the drywell meets safety requirements, despite the large uncertainty associated with the proposed monitoring program.

II. Background

The purpose of this discussion is to systematically establish the confidence levels associated with the various wall thickness measurements and the conclusions drawn from them. In reviewing the various documents dealing with these subjects it became

[9] R. H. Hausler Memorandum to R. Webster, Esq., July 18, 2007

apparent that the methodology of measurement and interpretation was not always consistently applied and hence it is necessary to get back to the basics of what can be validly concluded from the data we have. This discussion is therefore not intended to be a critique of the methodology of UT measurements, nor the evaluation procedures of the data, but rather a further attempt to extract additional information from the existing data, and establish a reasonable perspective for the conclusions.

III. A thought about Confidence limits

I believe everybody can agree that the *realistic assessment* of the extent of the corrosion damage on the external wall of the drywell in the former sandbed area is crucial for the establishment of the current fitness for service condition of this vessel. Additionally it will set realistic limits to the margins, which may still exist regarding further allowable corrosion.

Since fitness for service is determined on the basis of various model calculations (buckling calculation) and specific codes, such as the ASME pressure vessel code, the question boils down to the definition of "realistic" in "realistic assessment". Here is of course where experts begin to disagree because some may assess a given situation as less "severe" than others would.

For instance, NRC and AmerGen have at times practiced a statistical approach to the interpretation of measured data, and applied the 95% confidence limits to the reported results. I believe this to be prudent, since corrosion rates, for instance, determined from residual wall thicknesses as a function of time should be seen both in the as correlated form as well as in the extreme form based on the 95% confidence limits, since particularly the upper 95% confidence limit would result in more rapid deterioration or a faster elimination of still available margins [10)].

[10)] See for instance Calc. C-1302-187-5300-20 (various revisions)

The 95% confidence limits embrace 95% of all data belonging to a specific family of data, which have been experimentally determined. The limits are defined as the mean of the data +/- approximately two (2) standard deviations (s) (depending on the degrees of freedom). Hence if a data point lies outside any of the 2 s limits it is said not to belong to the same family and is often characterized as atypical [11)]. As an example, a location of corrosion damage in Bay 13 has been identified with a residual wall thickness of 0.602 inches. The standard deviation of this particular measurement has been identified from a series of duplicate measurements as being approximately 0.03 inches. Therefore, if the data are normally distributed, there is a 2.5% probability that the remaining wall thickness at this particular location could in fact be lower than 0.542 inches (the normal distribution is symmetric so the upper and lower tails beyond the 95% confidence limits each contain 2.5% of the data). If this result characterizes an area of 1 sq. ft. around it, the result should be compared to the acceptance criterion of either 0.636 inches or 0.536 inches for localized corrosion damage This comparison indicates that there could be 2.5% probability that the remaining margin is zero or less than 0.006 inches, depending on which acceptace criterion the Board decides is appropriate. It is of course within the purview of NRC or the ASLB to determine whether 2.5% probability for a certain event not to happen is or is not sufficiently conservative. (Parenthetically it may be interesting to note how over the years the statistical confidence limits have changed since in 1992 99% confidence was still considered appropriate for nuclear safety considerations and here the lower 99% confidence limit would have eliminated the remaining margin completely. [12)]. To avoid this result, AmerGen's Testimony has argued that statistics should not be applied to the external measurements. Nevertheless, this residual wall thickness has been reported by AmerGen. The duplicate measurements also have been reported by AmerGen and calculating the standard deviation for a single UT wall thickness measurements on the outside of the drywell from these duplicate measurements is a simple exercise in Statistics 101 [13)]. Are we therefore resigned to

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[11)] See for instance also Calc. 1302-187-5320-24 Rev. 0

[12)] Calc. No. C-1302-187-5300-19 at page 37 for instance

[13)] It should be remembered that there are actually two types of "standard deviations" in the set of measurements presented by AmerGen. The series of 49 measurements made by means of a grid on the

live with a 2.5% or 0.5% probability that in the event of a nuclear accident the drywell may not serve as a primary containment and may release radioactive emanations into the environment? Not necessarily: the well-known resolution of large uncertainties caused by large standard deviations of single measurements is to repeat the measurement a few times because the standard deviation of the mean of multiple measurements is reduced according to the well know *central value theorem*.

While the standard deviation for single measurements is quite large and tends to lead to the conclusion that at least in one area the limit for local wall thickness reduction has been reached, the spread of the measurements leads to the same conclusion as has been shown in Figure 6 of R. H. Hausler Memo of 4/25/07 [14]. In this latter case, however, additional measurements would not reduce the spread of the data since in heavily corroded areas the pit distribution is systemic and could not be made tighter by additional measurements, only the mean would get better defined.

Since very few external wall thickness measurements have been repeated, which holds in particular for those measurements resulting in low residual wall thicknesses, one is saddled with large uncertainties in the interpretation of the UT wall thickness measurements. This is neither a criticism of AmerGen's UT measurement methodology nor of their interpretation of the data, but simply a statement of fact, which AmerGen and NRC could have arrived at themselves if they had pushed their data analysis to the same insights.

IV. Residual Wall Thickness Measurements and the Buckling Criteria (Fitness for Service Criteria)

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inside of the vessel presents a certain spread of wall thicknesses which can be represented by a standard deviation if the distribution of the measurements is indeed Gaussian. (Similarly, the external measurements are somehow distributed). However, there is another standard deviation, which originated from repeated measurements at the same spot. This standard deviation represents the repeatability of the measurement proper. This standard deviation could actually be determined from duplicate wall thickness measurements made on the outside of the drywell in the sandbed area.

[14] R. H. Hausler Memorandum to R. Webster, Esq., April 15, 2007 at 17.

The analyses of the UT residual wall thickness measurements in combination with the various fitness for service criteria is intended to arrive at a reliable estimate of the remaining margin, if any. The remaining margin together with an estimate of the potential corrosion rate will determine the frequency of inspection. It has been said that the remaining margin is at least 64 mils (800 mils minus 736 mils) and that the estimated corrosion rate is at most 2 mils per year (mpy). It will be shown that these statements, even if not totally grabbed out of thin air, cannot stand up to detailed scrutiny.

The remaining margin of 64 mils is based on the lowest average for the 49 point 6 inch by 6 inch internal grid measurement in one Bay (Bay 19A). It should be remembered here that the NRC had wisely requested that "the grids shall be one square foot except unless justified otherwise" [15)]. Apparently the total area of the dry well in the former sand bed is 701.5 square feet. Of this only 115.6 square feet would be accessible for UT measurements from the inside. However, the total surface area that was and will be inspected by UT is only 3.9 square feet [16)] or about 0.5% of the total area of interest. If it had been established that corrosion was spread uniformly through the sandbed area one could let the grid measurements stand as being representative. However, quite the contrary is the case. Corrosion based on UT measurements varies from bay to bay from almost nothing to 30% (on average) of wall thickness in the horizontal direction at the elevation of the grid measurements. More importantly, corrosion also varies over the approximately 3 foot height of the sandbed area in the vertical direction. This had been conclusively shown in my Memo of April 25, 2007 [17)]. ***The UT wall thickness measurements by means of and at the locations of the internal grids therefore cannot be considered representative of what may be going on in the lower parts of the sand bed region.***

A large number of UT measurements were performed in the sandbed areas after removal of the sand. It has been said that these measurements were conservative

[15)] NRC Notice 71 FR 67923, Nov. 24, 2006
[16)] e-mail from P. Tamburro to A. Ouaou, Surface area of the Drywell in the sandbed, 4/3/06
[17)] R.H. Hausler Memorandum to Richard Webster, Esq., April 25, 2007

because they had been accomplished in areas, which were, by visual examination and micrometer measurements, identified as the thinnest areas. It should be obvious to all skilled in the art that neither visual examination of nor micrometer measurements on a corroded surface can identify or even estimate the thinnest remaining wall thickness. Visual examination will identify the corroded areas but the degree of wall thinning cannot be determined because of the absence of a reference point, i.e. the original surface was corroded away and one does not know a priori by how much. Indeed, the inspector who did the assessment of the extent of corrosion in the sandbed area stated that: "*I could not visually determine which of the thin spots are the thinnest*" [18)]. Furthermore, what this inspector (not a corrosion engineer) interpreted as "thin spots" were really the corroded areas, because that was all he could see. He also stated that: "*the thin spots comprise about 20% of the total area of the corroded portion of the shell. They are spread throughout the bay, but are closer together (about 1 ft apart) in the vicinity of the vent pipe and further apart toward the frame*". It is clear from the above that the visual inspection may have identified areas, which may have appeared more heavily corroded than others, however, the claim that these were the thinnest areas is untenable. **Moreover, the Whitmore document [(5)] makes it clear that the heavily corroded areas extended into the bays away from the vent pipes, areas, which were not examined by UT.** This was indeed suspected from the contour plots established from AmerGen's external UT measurements [19)]. There is therefore great uncertainty with respect to the extent as well as the severity of corrosion in the sandbed area, and we contend that recent efforts at AmerGen to in essence downplay this state of affairs in their attempts to obtain yet another structural analysis is ill advised [20)]. While previously the most corroded Bay, Bay 13, was said to have an average thickness of 0.8 +/- 0.04 (2s) inches and a margin of 0.064 inches was derived there from, this same bay is now said to have an average thickness of 0.907 inches.

[18)] Memorandum from K. L. Whitmore to J. C. Flynn, January 28, 1993, re. Inspection of Drywell sandbed region and access holes.
[19)] R. H. Hausler Memorandum to Richard Webster Esq., 7/18/07
[20)] AmerGen Tech Eval. 330592-27-27, 4/20/07

V. The Nature of the Corroded Surface

Much of the confusion as to which data set to use for comparison with the acceptance criteria stems from the manner in which the data have been acquired. The corroded metal surface in the sandbed region after removal of the sandbed is said to have the appearance of a "golf ball" in terms of a dimpled surface, except of course for the fact that the dimensions of the corrosion features are larger than the dimples on the surface of a golf ball. Since it was necessary to assess the remaining wall thickness in the external regions because there appeared to be corrosion more severe than reflected by the inside grid measurements, UT measurements were made only in those areas of the sand bed which were easily accessible.

It has been said time and again that these measurements were conservative and reflecting only the thinnest areas, which had been identified visually and by micrometer readings. Now, we submit that it is utterly impossible to assess the remaining wall thickness of a corroded area by looking at it or in fact by making micrometer measurements. The fundamental reason for this is a lack of knowledge regarding the extent of the total recess of the surface due to "general corrosion" rather than pitting. We have prepared a simple graph to illustrate the difficulty **(Figure 3)**. Clearly, even the highest dimple may not be at the height of the original surface. The micrometer only gives a measure of the pit depth relative to the remaining surrounding surface. Hence micrometer measurements cannot possibly reflect the remaining wall thickness at that location. As illustrated in Figure 3 the pit depth may be deceiving relative to the remaining wall thickness as a comparison between measurement 2 and measurement 3 indicates – clearly depending on the point of reference. It is of course even more difficult to identify the remaining wall thickness visually. In fact, reviewing the contour plots we have presented in Ref. 21 below [21] one can see that a majority of the measurements had been made in areas of moderate or no corrosion.

[21] R. H. Hausler Memorandum to Richard Webster July 18, 2007

We therefore submit that the statement that the areas of least remaining wall thickness were selected for external measurements and the results are therefore conservative is erroneous and misleading. The ramification of this conclusion affect the way data are treated down the line and finally the assessment or uncertainties of the remaining margins.

Because of the rough external corroded surface it was recognized that UT measurements might be difficult. For this reason in some cases the areas around the deeper pits are said to have been ground flat to accommodate the UT probe. Does this mean that the resulting measurements are overly conservative or invalid? We think not. These measurements represent to the best of everybody's knowledge the true state of the remaining wall thickness, and the fact that maybe more metal had been ground away than corresponded to the pit depth was never demonstrated and is really irrelevant because the UT measurement of the remaining wall thickness is what it is.

However, not all areas chosen for external remaining wall thickness measurements were ground down. It was therefore felt that the roughness of the surface was falsifying the measurements and that a correction for the roughness was indicated. In order to achieve this, epoxy imprints were made of two one square foot areas in Bay 13. Twenty micrometer-readings were made on each of these imprints in order to characterize the roughness of the corroded area.

These roughness data were subsequently used to "*correct*" some UT measurements[22]. In order to better understand the procedure, we have prepared the following graphs:

- **Figure 4** shows a schematic of the epoxy imprint of the remaining corroded surface. On that epoxy surface replica 20 micrometer measurements of the "pit depth" were made in order to characterize the roughness of the surface.

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[22] In fact we understand that only those measurements which indicated a remaining wall thickness of less than 0.736 inch were also assessed by micrometer and then subject to correction for roughness.

(Note that the replica was actually a negative of the surface. Therefore each depression on the replica related to a raised area on the surface. The twenty measurements were averaged and the standard deviation calculated. This was done for both replicas. It turns out that there is no statistical difference between the average micrometer readings from both replicas, hence a grand average and pooled variance could be calculated. The average "roughness" (dimple height) is 125 mils with a pooled standard deviation of 70 mils. This number reflects the average variation in height from valley to peak and in essence characterizes the roughness of the surface.

- It should be mentioned that that kind of roughness is also reflected in Fig. 2 of the April 25 Memorandum (6), derived from the UT grid measurement in the Trench of Bay 17.

- **Figure 5** shows how the average roughness correction is being used to correct the UT measurements. The UT measurements reflect the residual wall thickness (UT). Additionally micrometer measurements were made at each location where a UT measurement had been performed. Now the UT result and the micrometer result are added and the average roughness is subtracted from the sum in order to obtain the so called "*evaluation thickness*". It is observed that with this correction every UT measurement, except for one, which had been below 736 mil is moved to above 736 mils and therefore into the acceptable range.

- In discussing this procedure one has to remember that the correction was made because the UT measurement was said to be inaccurate because of the air gap between the probe and the metal surface caused by the inherent roughness. Now it was never established to what extent the accuracy of the UT measurement suffered because of this air gap. Did it over- or underestimate the remaining wall thickness? Similarly, the micrometer measurement is affected by the roughness of the remaining surface as well.

There is no guarantee, nor was this discussed at all, that the reference point for the UT measurement and the micrometer measurement are the same. As Figure 3 suggest, the reference can be high or low. Finally, adding the micrometer measurement to the UT measurement might have made some sense if the sum were to reflect the original wall thickness where upon the roughness could have been subtracted to indicate a possible correction. This was however not the case since in addition to pitting there was general reduction of wall thickness. (This is supported by the description of the "bathtub ring".

- This entire procedure is extremely fraught with uncertainties. There is the perceived uncertainty of the UT measurement, never established but postulated. There is the uncertainty of the micrometer measurements, and then there is the correction for which there does not seem to be a justification.

- That there really was no justification for this type of manipulation of the UT data became clear in 2006. Now the surface was coated and flat to accommodate the UT probe. The UT probe compensated for the thickness of the coating. Hence the UT measurements in 2006 should indeed reflect the true remaining wall thickness at the point of measurement. Comparing the uncorrected 1992 with the 2006 means for all measurements (200 d.f.) one finds an average small bias of 20 mils which, however, statistically is non significant (s_{mean} = 11 mils). Therefore it is highly unlikely that the surface roughness had any effect in biasing the UT measurements prior to coating the surface. There was therefore no need to calculate the so-called *evaluation thickness*. Furthermore, the evaluation thickness was also calculated for other bays which were less corroded and for which the surface roughness had not been determined (i.e. using the value obtained from the Bay 13 epoxy replicas).
- It was never made clear why in the calculation of the "*evaluation thickness*" the mean micrometer depths plus 1 standard deviation was used. In fact Mr.

Tamburro realized the arbitrariness of the algorithm when he indicated a lack of established procedure [23], and the absence of a justification of why it should be justified to compare the evaluation thickness to the design basis required minimum wall thickness of 0.736 inches. Yet, even though AmerGen was aware of the lack of clarity and justification, it continued the practice in Rev. 2 [24]

- Therefore, the evaluation thickness should be disregarded (as has been done at times) in favor of the actual measurements.

VI. Establishing the Available Margins

If for any reason corrosion in the sandbed area should continue, the question remains as to how much margin there is still available. The acceptance criteria, both for general wall thinning as well as localized corrosion have been discussed before, and their inconsistent and arbitrary application highlighted. AmerGen and NRC nonetheless have consistently maintained that there is sufficient margin remaining such that even under the worst possible circumstances a 4-year inspection cycle can assure the continued integrity of the drywell.

We shall in the following take a look at the data on the basis of which such decisions were made. We are readily prepared to stipulate that the grid UT measurements "on average" returned residual wall thickness values above 800 mils, and if representative would therefore reflect a remaining margin for general corrosion of 64 mils above the average thickness criterion (It should be noted that 800 mils is an average and no confidence limits have been reported for this number. Therefore, this could only be the margin at 50% confidence, even if the grids were representative). But we also know:

[23] AR Report 00461639, P. Tamburro to H. Ray, Calc C-1302-187-5320-024 is not clearly documented. 3/3/2006

[24] Calc. C-1302-187-5320-024-Rev.2, 3/21/07, P. Tamburro reviewed by J. Abramovici

- That because of the location of the internal grid measurements they are not representative of the overall corrosion damage (as discussed above). This is demonstrated by way of an example in Figures 1 and 2 for Bay 13.
- That for Bay 1, where only a strip grid was used for internal UT measurements (1 inch by 7 inch for only 7 UT locations), the results returned by the internal measurements in no way reflect the overall corrosion in that Bay [25)]
- That therefore the external UT measurements have to be used for the assessment of the severity of corrosion and the residual margins.

Calc. 24 [26)] is the first manifestation of how the external UT data were to be dealt with. Here Table 1 lists all the measurements that were below 736 mils and shows that when the "evaluation thickness" was computed, as shown above, all but two of these data points were above 736 mils, but all were judged "acceptable". It is interesting to note that all points with residual wall thickness less than 736 mils were found in an area dubbed the bathtub ring. This area was said to be 18 inches wide and 30 long for a total surface area of 3.5 square feet [24)]. Without the correction, i.e. without calculating the "evaluation thickness" this area would have been out of compliance [27)]. But the evaluation thickness did not make any sense, and in 2006 it was shown that the UT measurements across the epoxy coating were essentially the same as those made before the coating had been applied. This presented a serious problem, because it essentially obviated the correction, which led to the "evaluation thickness".

A number of different approaches were taken to in effect rescue the drywell from being condemned. NRC commissioned a new buckling analysis *using advanced techniques for modeling and analyzing the complex shell structure to determine the*

[25)] see Figure 3 R. H. Hausler Memorandum to R. Webster, Esq., July 18, 2007
[26)] Calc. No. C-1302-187-5320-024, Rev. 0 4/16/93
[27)] The GE compliance criterion stipulated that if an area was thinner than 736 mils it had to thicker than 536 mils and no larger than 1 square foot. (This formulation of the criterion for localized corrosion was subsequently modified several times in various ways).

controlling loads [28]. It turns out that the input data for this study were the degradation data contained in Cal. 24, Rev 0 (see 24). Sandia found a safety factor against buckling of 2.15 for the degraded shell, based on the Calc. 24 data. As discussed in my companion Memorandum on statistical procedures, the standard deviation of the UT measurements was of the order of 0.03 inch or 95% confidence limits of 0.06 inches, which corresponds to about 7.5% of residual wall thickness. This at least puts the remaining margin corresponding to 7.5 % of the safety factor in question. This, coupled with other deficiencies that I have discussed elsewhere, may well mean that there is no remaining margin left. In addition, there are equally alarming concerns, such as the fact that there may be areas, which have not been cleaned or in fact coated because of their inaccessibility.

VII. Discussion of Future Uncertainties

Future degradation of the drywell may occur because of a number of factors. These will be discussed below. In all of this it must be remembered that because something has not happened in the past does not mean it cannot happen in the future. And because something that happened in the past and was presumably corrected does not mean the correction will hold in the future. However, more seriously are those things, which could have (or should have) been anticipated but were not.

- Pinholes in the Coating: When the coating was qualified in extensive model tests and model applications, constant attention paid to the inclusion of dust and residual pinholes in the coating [29]. Test coatings prepared on a life-size Bay mock-up were routinely tested for dust inclusions and pinholes. Such were indeed detected on the test panels prepared in a clean environment. It is therefore all the more surprising that no such tests were ever done after the coatings had been applied to the steel surfaces of the drywell in the sandbed areas.

[28] NRC Staff initial statement of position on the drywell contention, July 20, 2007 page 15

[29] MPR Associates, Inc.: *Results of Painting Process Qualification Tests for Drywell Exterior In the Sandbed area at Oyster Creek*, 11/9/92, GPU Nuclear Document 133825.

Admittedly pinholes are rare where two coats of paint (epoxy coating) have been applied, however, tests with the wet sponge techniques as described earlier and as standardized by NACE are quite simple to carry out and it is unclear why these tests were not done.

- <u>The Nature of Epoxy Coatings and the Question of Aging:</u> Epoxy coatings are the reaction product of two ingredients: a) the epoxide itself, which is a phenol derivative containing two ethylene oxide groupings and b) a di-functional amine compound generally designated as the curing agent. When the two ingredients react with each other, the viscosity of the mixture increases until eventually a hard substrate is obtained. Once the coating (or cast) has hardened is it commonly assumed that the reactions have terminated. In fact, unreacted functionalities keep reacting for a long time, even when the product has become solid. Granted these solid state reactions are excruciatingly slow, but the contribute to the product's becoming brittle with time, contracting and cracking. These processes are slow and the results can be spontaneous. Visual inspection cannot discern internal stresses. Residual stresses, however, can lead to spontaneous cracking, particularly under conditions of constant vibration and fatigue and elevated temperature. Hence we think that the assurances, brought forth by Mr. John Cavallo [30], that the coating will last the life of the plant (even including the expanded operation of the plant), are overly optimistic. In view of the fact that failures of the coating can occur spontaneously and that the resulting corrosion could be as rapid as it was in the presence of the sand, we cannot rely on a coating inspection program that only reviews the coating once every four years.

- <u>Some Properties of Epoxy Coatings:</u> All coatings (organic substrates) exhibit a certain permeability to uncharged molecules. Oil field experience, for instance has shown that epoxy coatings are subject to spontaneous de-lamination as a consequence of abrupt pressure drops. The phenomenon

[30)] Affidavit John Cavallo, at 22: 3/26/2007

clearly demonstrates that CO_2 for instance, but other gases as well (CH_4) can defuse through the coating. More detailed investigation have shown that both water and H_2S can diffuse as well. Granted, these diffusion rates are slow, in fact approximately 3 orders of magnitude slower than diffusion of these same species in water. However, the slow diffusion of water and oxygen through the coating can cause formation of a thin oxide layer on the surface of the metal, which destroys the coating's adherence properties. Combined with the residual stresses in the coating de-lamination will cause cracking and of course will then provide access to water and the atmosphere. These processes are slow and will be accelerated by elevated temperature. None of this is predictable, however, one knows that it has happened, and therefore can infer that it could happen again. For these reasons we think the coating could fail in between the four year inspection cycles.

- Comments regarding Visual Observations: Essentially all epoxy coatings contain a filler. It has been said repeatedly that the coating used at Oyster Creek in the sandbed area is whiteish-grey indicating that the filler may be an oxide like possibly titanium oxide (this had never been specified). The filler functions as an agent to make the coating less brittle with aging, but it also opens up pathways for the diffusion of uncharged particles. Visual observation cannot detect what may go on underneath the coating until the coating fails. Similarly, corrosion at pinholes can proceed slowly until the pressure caused by the corrosion products leads to cracking of the coating. John Cavallo is wrong when he posits that the corrosion product occupies from 7 to 10 times the volume of iron from which it originates [30)]. A quick search in the Handbook of Chemistry and Physics teaches that iron has a density of 7.9 gm/cc (depending on the specific alloy) while iron oxide (Hematite) has a density of 5.24, and the hydrated iron oxide (rust) has a density of about 3.6. The iron oxide, which can form underneath the coatings, will therefore cause stresses, which will eventually lead to cracking. Similarly, corrosion occurring due to diffusion of water and oxygen through possible pinholes will eventually lead to cracking and blistering. While the results of

these processes can be seen by visual inspection the onset cannot. Once blistering has occurred it may be too late because the margins here are, at best, tiny.

- Water, Origin and Frequency: There is universal agreement that without water no corrosion damage will occur. However, water has in the past leaked into the sandbed area, and even after the sand had been removed, water leakage was observed at times. The sandbed floors are supposed to be shaped such that water accumulations are not supposed to occur. Even if water should reach the sandbed area it is supposed to drain away, however, the drains were observed to be plugged. Finally, it is being said that even if water should for some reason accumulate in the sanded area it would evaporate quickly without being able to do a lot of harm. Specifically, Mr. Barry Gordon [31)] tries to convince us that water accumulations in the space of the former sandbed would evaporate quickly. In order to support the argument Mr. Gordon uses an engineering equation applicable to the evaporation of water from a pond or pools, in which wind velocity controls the evaporation rate. The former sandbed area, however, is a totally stagnant space where water might evaporate until the atmosphere above it is saturated with water vapor. Hence the equation used by Mr. Gordon describes a steady state, while the rate of evaporation in the confined space of the sandbed area would have to be described by a transient equation.

Where does the water come from? There clearly are many possibilities all of which point to some sort of a leak. Leaks are not predictable (otherwise they would be prevented). When possible they are repaired in the hopes that they would not occur again. However, it is impossible to rule out further leakage. The situation, however, is reminiscent of earlier incidences. "The core samples validated the UT measurements and confirmed that the corrosion of the exterior of the drywell was due to the presence of oxygenated wet sand

[31)] Barry Gordon Affidavit 3/26/2007

and exacerbated by the presence of chloride and sulfate in the sandbed region [32]. The origin of the chloride and sulfate was to our knowledge never firmly established, but was attributed to impurities dissolved into the water along the leakage path.

- Summary: Clearly a number of factors must come together in order for continued damage to occur in the former sandbed area on the exterior or the interior. The most important one is the presence of aerated aggressive water. In addition, on the exterior, the coating has to have failed in some manner at the location where water is present. And finally the corrosion has to occur at a location where the drywell has already been damaged. It has already been shown that only a very small fraction of the entire sandbed area has been surveyed with respect to corrosion damage. There is no guarantee that other areas have not experienced similar or worse corrosion damage. It has also been argued that at this advanced stage in the aging process of the coating, failure is to be expected. And finally, the presence of stagnant water cannot be ruled out. Therefore, if AmerGen can establish that it has some margin, I believe it prudent to use UT techniques to monitor the thickness of the drywell frequently. At this time, because AmerGen has not shown that there is any margin, I am unable to set forth an exact frequency. The corrosion rate from the interior could be a multiple of 0.002 mils per year and the corrosion rate from the exterior could be as high as 0.039 inches per year. Thus, even if the mean margin were 0.064 inches as AmerGen has alleged, the proposed monitoring frequency of once every four years is insufficient.

[32] AmerGen Letter to NRC 12/3/2006, 92130-06-20426, Enclosure, page 12 of 74

Figure 1

Iso Wall Thickness Lines for the Internal UT Measurements
in Bay Location 13A

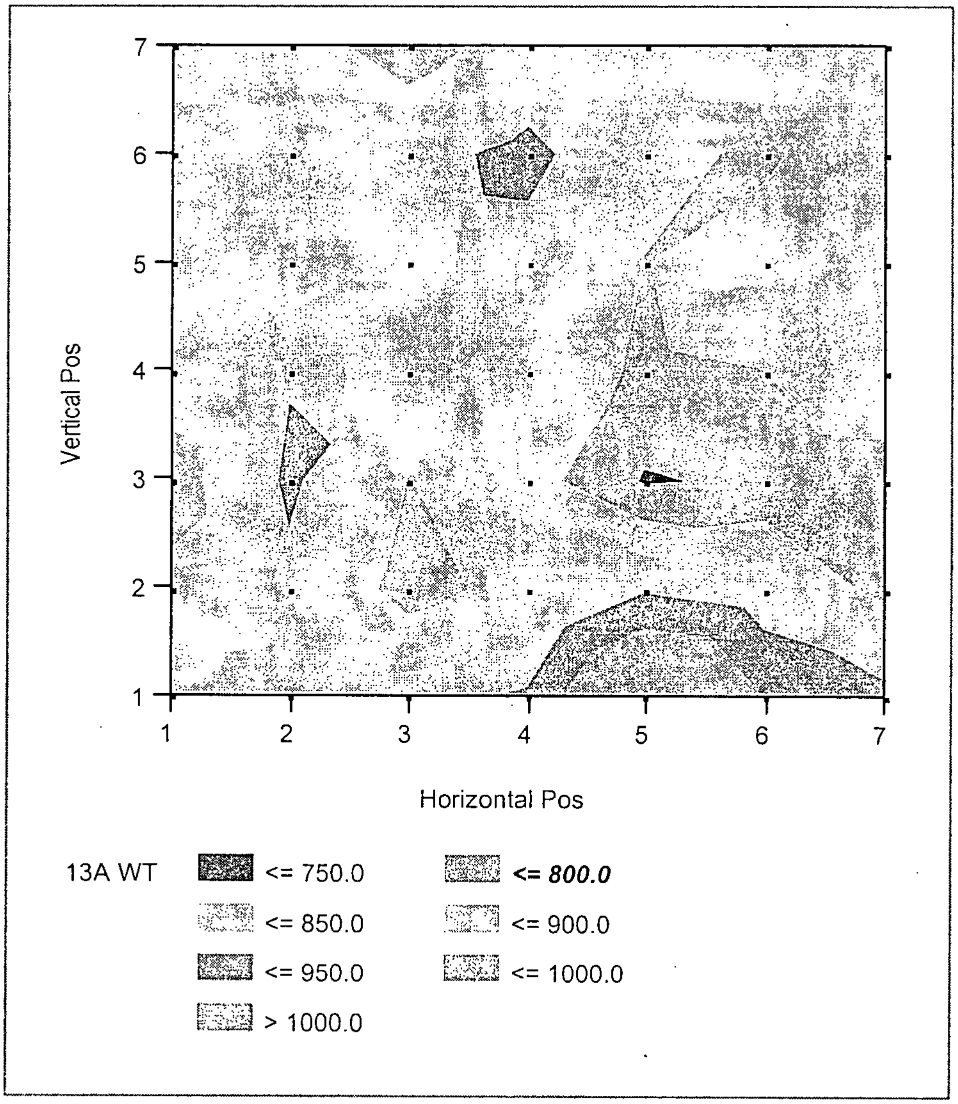


Figure 2

Contour Plot for External UT Measurements in Bay 13

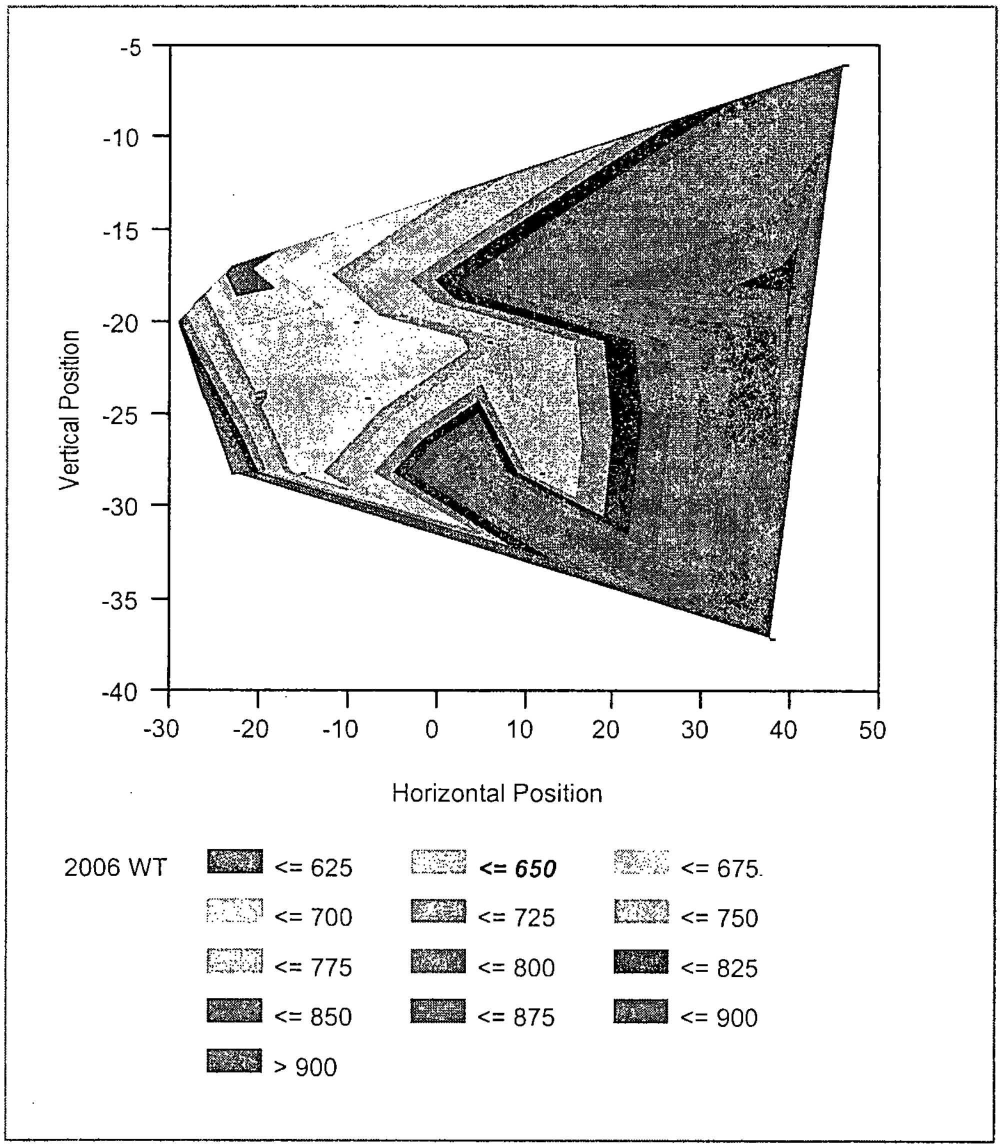
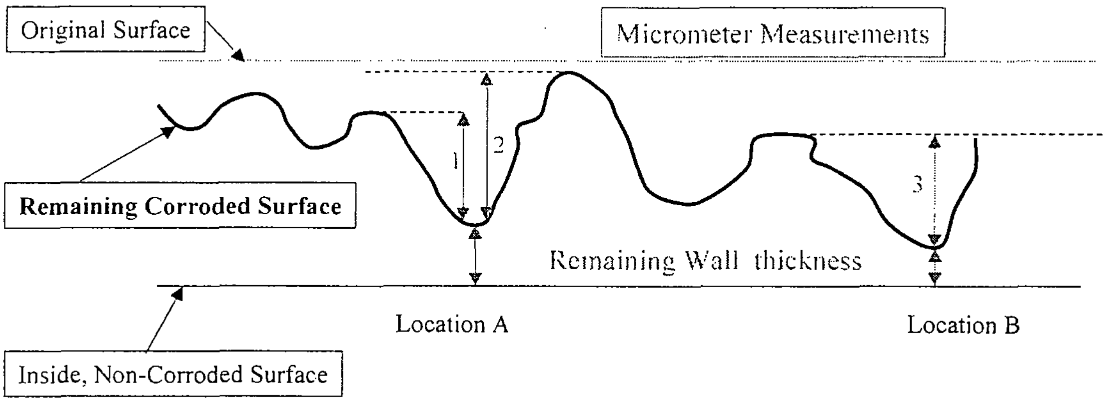


Figure 3

The Problem of Identifying the Thinnest Remaining Wall Thickness by ***Visual Observation*** or by ***Micrometer Measurements***.



Location A: Since the remaining, corroded surface is "dimpled", the *Micrometer Measurement* clearly depends on the point of reference. However, the point of reference is not, cannot be, the ***Original Surface,*** hence the *Micrometer Measurement* is in no relationship to the remaining wall thickness.

Location B: Here the "Pit Depth" obtained by micrometer measurement (3) is smaller than (2) in location A but the remaining wall thickness here is the least. Visual observation would identify Location B as less corroded because visually one has no reference point, in particular, one cannot refer back to the original surface area.

Figure 4

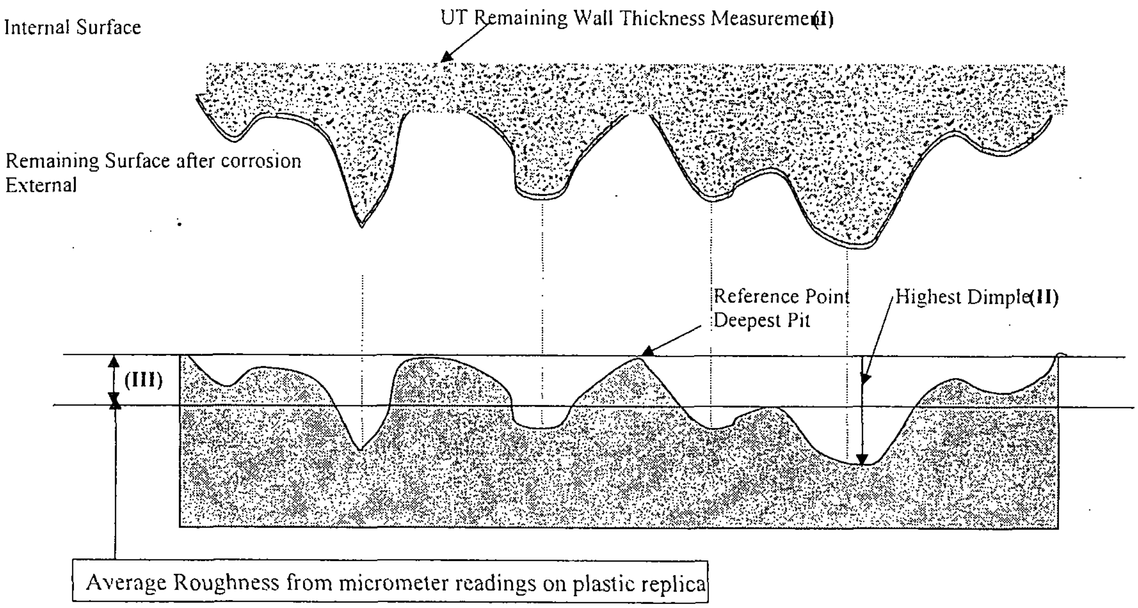
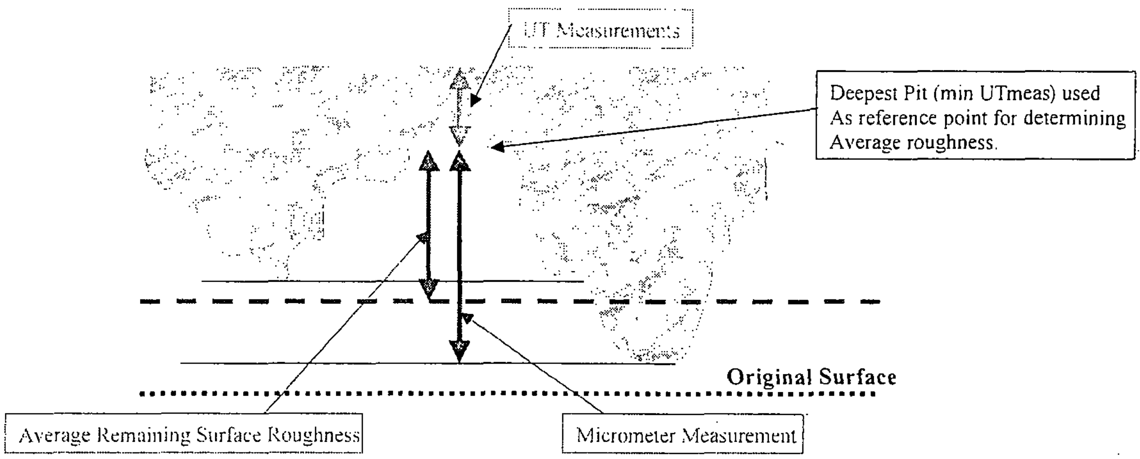


Figure 5

Schematic Presentation of Drywell External Surface – State of Corrosion



Evaluation Thickness = UT Measurement + Micrometer Measurement – Average Surface Roughness

Exhibit No. 40

From: Hufnagel Jr, John G
Sent: Thursday, November 30, 2006 10:41 AM
To: Ouaou, Ahmed; Warfel Sr, Donald B
Cc: Polaski, Frederick W
Subject: FW: Challenge Board #1 additional comment

See Russell's clarified points. I will include in the action item list.

- John.

-----Original Message-----
From: Robinson, Jill M.
Sent: Thursday, November 30, 2006 9:53 AM
To: Hufnagel Jr, John G
Subject: FW: Challenge Board #1 additional comment

fyi
-----Original Message-----
From: William T Russell [mailto:wtrussell@msn.com]
Sent: Thursday, November 30, 2006 9:48 AM
To: Polaski, Frederick W; Robinson, Jill M.
Cc: john.hufnagle@exeloncorp.com
Subject: Challenge Board #1 additional comment

I reviewed my notes this morning and I have an additional comments from yesterdays challenge board.

The Mini-Mod for Cleaning and Coating the Drywell Exterior in the Sand Bed Area has many caveats related to areas that may not be able to be cleaned or are inaccessible. We discussed this generally yesterday. For example:

- Section 6.10.1 discusses actions for areas at the edges of the sand bay that cannot be cleaned.
- Figure 3 discusses interference with the rebar and encasing pipes. Note that this rebar is not protected with concrete and may need a new AMR if the pipes were not filled with concrete or other protective materials.

Assuming there are areas that could not be accessed and/or protective coating applied, results in unprotected surfaces or gaps that would allow water ingress and creates the potential for new of AMR questions. Logical questions for AMR for unprotected or unsealed areas include:

- Are these areas within the UT sampling from the inside? If not why is this ok?
- Some discussion of why these areas were not sealed or protected should be developed to support a conclusion that it was not practicable.
- A possible preventive measure may be to use an injection sealant or penetrating sealant that displaces water to seal these areas.

Overall the issues with upper drywell OD, drywell ID at the floor joint and imbedded steel plate are reasonable and have significant margin.

The local effects of corrosion for 2.5 inch diameter areas appear to be controlled by leak tightness and LOCA pressure loading. This seems reasonable and is consistent with the code.

The buckling local effect used to date is a single area 12x12 (the grids for inspection are 6x6). The impact of

additional areas of corrosion that may be near these areas has not been addressed in any calculation. Given that the sand bed degradation has nearly the same height and it is worse in some bays that are adjacent, this cumulative effect needs to be addressed. If for example there was uniform thinning in an area 6" high and several feet long what would be the affect on margin? I recommend that GE update its analysis to address these potential affects. This is a logical question from review of the GE analysis and cause of degradation. If water caused the degradation, it is likely thin in height and wide due to water level within the sand layer. This may require additional UT from the inside to determine the radial extent of thinning due to corrosion.

I recommend John send out the action items from the challenge board to make sure the issues captured are clear and complete.

Bill

Exhibit No. 41

DRF 150 386
DRF 127 718 (ISR)

GPU Nuclear

Technical Functions
Safety/Environmental Determination and 50.59 Review
(EP-016)

UNIT Oyster Creek	PAGE 1 OF 22
DOCUMENT/ACTIVITY TITLE Clean and Coat Drywell Ext. in Sand Bed	SE Rev. No. 2
DOCUMENT NO. OC-MM-402950-010 (if applicable) DOC REV. NO. 0	SE No. - 402950-011

Type of Activity Modification
(Modification, procedure, test, experiment, or document)

1. Is this activity/document listed in Section I or II of the matrices in Corporate Procedure 1000-ADM-1291.01? ☒Yes ☐No

   If the answer to question 1 is "no" stop here. (Section IV activities/documents should be reviewed on a case-by-case basis to determine if this procedure is applicable.) This procedure is not applicable and no documentation is required. If the answer is "yes" proceed to question 2.

2. Is this a new activity/document or a substantive revision to an activity/document? (See Exhibit 3, paragraph 3, this procedure for examples of non-substantive changes) ☒Yes ☐No

   If the answer to question 2 is "no" stop here. This procedure is not applicable and no documentation is required. If the answer is "yes" proceed to answer all remaining questions. These answers become the Safety/Environmental Determination and 50.59 Review.

3. Does this activity/document have the potential to adversely affect nuclear safety or safe plant operations? ☒Yes ☐No

4. Does the activity/document require revision of the system/component description in the FSAR or otherwise require revision of the Technical Specifications or any other part of the SAR? ☐Yes ☒No

5. Does the activity/document require revision of any procedural or operating description in the FSAR or otherwise require revision of the Technical Specifications or any other part of the SAR? ☒Yes ☐No

6. Are tests or experiments conducted which are not described in the FSAR, the Technical Specifications or any other part of the SAR? ☐Yes ☒No

   No because No tests or experiments are conducted

   Documents checked:

   If any of the answers to questions 3, 4, 5 or 6 are yes, prepare a written safety evaluation on a Safety Evaluation form.

   If the answers to 3, 4, 5, and 6 are no, this precludes the occurrence of an Unreviewed Safety Question or Technical Specifications change. Provide a written statement in the space provided above (attach additional sheet if necessary) to support the determination, and list the documents you checked.

7. Does this document involve any potential Non-Nuclear environmental impact? ☐Yes ☒No

8. Are the design criteria as outlined in TMI-1 SDD-T1-000 Div. I or OC-SDD-000 Div. I Plant Level Criteria affected by, or do they affect the activity/document? ☐Yes ☒No

   If yes, indicate how resolved

   If the answer to question 7 is yes, either redesign or provide supporting documentation which will permit Environmental Licensing to determine if an adverse environmental impact exists and if regulatory approval is required (Ref. 1000-ADM-1216.03). If in doubt, consult the Radiological and Environmental Controls Division or Environmental Licensing for assistance in completing the evaluation.

Signatures	Date
Engineer/Originator Dawn Jacobs DAWN JACOBS MPR	12/31/92
Section Manager [signature] BRIAN LIPFORD MPR	12/31/92
Responsible Technical Reviewer S. D. Leshnoff S.D. LESHNOFF	1/5/93
Other Reviewer(s)	

N 5047 (02-88)

OCLR00022240

3.3.11 Containment Isolation

With sand removed from the sand bed area and the drywell exterior cleaned and coated, containment isolation is not affected.

During sand removal, cleaning and coating, containment isolation will not be affected. An impact analysis, Reference 3.1.5, identifies limits as to the weight of tools which may be carried or lifted above the torus, as well as the maximum heights at which they may be carried to avoid load drops that might damage the torus or its internal coating. In general, that analysis requires that tools be covered with padding while being moved across the top of the torus. These limits on tool weight, lift height, and padding thickness will be observed during cleaning and coating work. The limits are detailed in OC-MM-402950-009.

3.3.12 Materials Compatibility

The drywell exterior surface will be cleaned with a water-based cleaner and coated with epoxy primer and epoxy paint. An epoxy primer will be brushed/poured into the drywell-to-concrete gap at the base of the sand bed area. An epoxy caulk may be applied over any remaining drywell-to-concrete gap that the epoxy primer did not fill. The specific materials to be used are described in OC-MM- 402950-010. These materials have been reviewed for compatibility in this application and approved for use by GPUN's Material Engineering department. The application of these materials will not increase the corrosion rate of the drywell exterior.

3.4 Licensing Basis Documents/Margin of Safety

With the sand removed and the drywell exterior cleaned and coated, the margin of safety discussed in SE-000243-002 (Reference 3.1.3) is not reduced.

After the drywell exterior has been cleaned, the steel surface will be free of active corrosion cells so that corrosion will be reduced. Accordingly, it is acceptable to clean but not coat the surface during 14R if time constraints prevent coating application. After the drywell is coated, the steel surface will not be wet by any future water leaks into the sand bed, so that future corrosion will be further minimized. Whether or not the drywell surface is coated during 14R, this modification will make it more likely that the margin of safety will be maintained.

Cleaning and coating in portions of the sand bed area which are difficult to access will be performed on a best effort basis. Accordingly, some patches of the drywell exterior may be left uncleaned and/or uncoated. Possible

preferential corrosion of these uncleaned/uncoated patches was evaluated. Two conditions may exist in which patches of the drywell exterior are left uncleaned/uncoated: (1) the patches are uncleaned/uncoated while the bulk of the drywell exterior is coated or, (2) the patches are uncleaned/uncoated while the bulk of the drywell exterior is cleaned but not coated. In both cases, the bulk of the drywell will not be cathodic with respect to the uncleaned/uncoated patches, and therefore, galvanic cells (i.e., preferential corrosion) between the uncleaned/uncoated patches and the bulk of the drywell exterior is unlikely to exist. It is expected that the uncleaned/uncoated patches will continue to experience general corrosion, but at a reduced rate since the sand and moisture will no longer be present.

3.5 Nuclear Safety/Safe Plant Operation

This modification will have no adverse effect on nuclear safety or safe plant operations. As discussed in Section 3.3.1, the safety functions of the plant systems potentially effected by this modification will not be degraded during and after sand removal, cleaning, and coating.

Sand removal, rust removal and surface preparation tools will vibrate the drywell locally in the sand bed area. Cleaning and coating will not be performed during plant operation, so that there is no potential for this vibration to initiate an inadvertent plant shutdown. Also, based on previous experience with more aggressive tools and cutting activities this vibration will not be severe enough to effect plant equipment.

3.6 Probability of Occurrence or Consequence of an Accident

With sand removed and the drywell cleaned and coated in the sand bed area, the probability of occurrence of an accident is not increased.

Neither the probability of occurrence of an accident nor the consequences of an accident will be increased during sand removal, cleaning, and coating activities.

3.7 Probability of Occurrence or Consequence of Malfunction of Safety Equipment

For the reasons given in Section 3.3 above, removing sand from the sand bed area and cleaning and coating the drywell steel in the sand bed area will not increase the probability of occurrence or consequence of malfunction of safety equipment.

Exhibit No. 42

From: Tamburro, Peter
Sent: Monday, April 03, 2006 3:24 PM
To: Ouaou, Ahmed
Cc: Ray, Howie; Quintenz, Tom
Subject: Surface Are of the Drywell in the sand bed
Action Required: None
Recommendation: None

Ahmed

1) Total surface area of the Drywell Vessel that was (prior to 1992) in contact with sand in the sandbed.

701.5 square feet

2) Total surface area of the Drywell Vessel that was (prior to 1992) in contact with sand in the sand bed and is accessable by UT from inside the Drywell Vessel

115.6 Square feet

3) Total Surface area of the Drywell Vessel that will be inspected by UT

3.9 square feet

From: Tamburro, Peter <Peter.Tamburro@exeloncorp.com>
Sent: Wednesday, June 14, 2006 9:57 AM
To: Ouaou, Ahmed <u999ao2@ucm.com>
Cc: Ray, Howie <u001fhr@ucm.com>; Quintenz, Tom <u777teq@ucm.com>
Subject: average Thickness of thinnest Sanebed area in sandbed - 1996

Ahmed -

Calculation C-10302-187-5320-024 and the respective NDE Data sheets provide the following information related to the worst Drywell Vessel sandbed location for corrosion (located in Bay 13). The worst corrosion was located over a 15" by 43' inch area (15" axial and 43" circumferential). This area included 7 pits (very local - less than 2" in diameter) that were less than 0.736". The thinnest of these was 0.618". Calculation C-10302-187-5320-024 develops a thicknesses profile of this area (starts on page 25) and concludes that this area is on average 0.778" thick.

Exhibit No. 43

From: Hufnagel Jr, John G <john.hufnagel@exeloncorp.com>
Sent: Tuesday, October 10, 2006 8:10 AM
To: O'Rourke, John F. <t925jfo@ucm.com>
Subject: RE: External Inspections of DW in Sandbed Region

Thanks for the clear update, John.

-----Original Message-----
From: O'Rourke, John F.
Sent: Tuesday, October 10, 2006 8:08 AM
To: Gallagher, Michael P; Polaski, Frederick W; Warfel Sr, Donald B; Hufnagel Jr, John G; Ouaou, Ahmed
Subject: External Inspections of DW in Sandbed Region

In response to a question by Mike last night, I talked to Pete Tamburro this morning about the external UTs. Currently, Pete's spec has not been revised and is still specifying 16 locations to be examined. There are 19 locations that were less than 0.736 inch thickness; however, 3 were in bays that were not originally planned to be accessed and inspected. One of our recommendations could be to inspect these other 3.

Mike mentioned a figure of 125 inspections done externally in the sandbed region. Pete could not confirm the number without going to the data sheets and counting up the number of inspections. The 19 subset were the locations under 0.736. The remainder were above 0.736. All locations inspected are located on the data sheets; therefore, re-inspections in the locations above 0.736 can be done with reasonable assurance that the readings would be close to the areas originally inspected. Pete noted that not all the areas were prepared by grinding. If the surface was reasonably flat such that a good reading could be taken, prep's were not done. Locating such areas would be done by the horizontal and vertical measurements on the data sheets.

Pete said he sent Ahmed a copy of the calculation (the '24' calc) that has the data attached.

Any questions, let me know. John

Exhibit No. 44

GPU Nuclear

Memorandum

Subject: INSPECTION OF DRYWELL SAND BED REGION AND ACCESS HOLES

Date: January 28, 1993

From: K. L. Whitmore - Civil/Structural Mgr.

Location: Morris Corp. Center 5320-93-020

To: J. C. Flynn - Manager, Special Projects, Engineering Projects

As requested by you, I conducted two visual inspections of the drywell sand bed region and several of the access holes. On December 22, 1992, I entered Bays 3, 5 and 17. From inside these bays, I could see all or portions of 1, 3, 5, 7, 15, 17 and 19. On January 21, 1993, I entered Bays 13, 15 and 17. From inside these bays, I could see all or portions of Bays 11, 13, 15, 17 and 19. At the time of the first inspection, bays 1, 3, 5, 17 and 19 had been cleaned of sand and corrosion material. No concrete repair or drywell coating had begun. At the time of the second inspection, Bays 11, 13 and 15 had been cleaned of sand and corrosion material. Primer had been placed on the floor in preparation of epoxy placement. However, no concrete repairs or drywell coating had begun in those bays. Bays 17 and 19 had been completed. The epoxy floor had been installed and the drywell had been coated. Following is a summary of my observations during these two inspections:

1. Drywell Shell
   The drywell shell is sound metal with no loose material, rust or laminations. There are no apparent cracks or discontinuities. The shell is characterized by a rough surface full of dimples similar to the outside surface of a golf ball. The dimples are of varying sizes, but most are less than 1/2" in diameter. The shell appears to be relatively uniform in thickness except as noted below:

   (a) Above the elevation of the bottom of the holes through the concrete shield wall for the vent pipe (approximately 6" below the vent pipe reinforcement ring to drywell shell weld), corrosion is much less than below that elevation. Therefore, there is an obvious change in thickness at this elevation.

   (b) There are two strips around the vessel just below the vent pipe holes described in (a) above which are slightly thinner than the general area of the shell. These strips have been described as "bathtub rings."

KLW/WP/MEMO/2093-020/1

TVO

(c) In addition to the dimples, there are spots that appear to be thinner than the general area. The dimples in the surface occur in these thin spots to the same degree as in the rest of the corroded portion of the shell. The "thin" spots are typically a foot to 18" in diameter and probably comprise about 20% of the corroded area. In general, except in Bay 13, the thin spots are not readily apparent. Therefore, a more detailed characterization is difficult for the other Bays (see (d) below). I could not determine visually which of the thin spots are the thinnest. However, due to the small differences between the "thick" areas and the "thin" areas, and the amount of metal removed in preparation for the UT measurements, it is highly likely that the thickness readings reported in the UT measurements encompass the thinnest spots in the shell.

(d) Due to the results of the thickness measurements, a more detailed visual inspection was conducted of the drywell shell in Bay 13. The conditions observed during the inspection of Bay 13 are summarized below:

- The variation in thickness is greater in Bay 13 than in the other bays.
- The "thin" spots are about a foot to 18" in diameter and are at least 1 ft. apart (edge to edge, or 2 to 2-1/2 ft. center to center). Some spots are thinner than others. Again, I could not determine precisely which spots are the thinnest. However, due to the amount of metal removed to perform the UT measurements, the reported thicknesses in all likelihood envelop the smallest thicknesses in the shell.
- The thin spots comprise abut 20% of the total area of the corroded portion of the shell. They are spread throughout the bay but are closer together (about 1 ft. apart) in the vicinity of the vent pipe and further apart toward the frames.

All of the observations discussed above apply in general to all portions of the drywell shell in the sandbed area. However, Bay 13 has a greater variation between the "thick" and "thin" areas than any of the other observed bays. In addition, the abrupt change in thickness at the elevation described in (a) above is more pronounced in Bay 13 than in other bays which were inspected. In fact, in the other bays the thin spots are not apparent unless a concerted effort is made to locate them. Due to this, a more detailed characterization is not drawn for the other bays.

After cleaning and coating, the drywell shell is sound metal with no apparent cracks, laminations, scale or rust. The surface is dimpled, but does not have severe changes in thickness which would result in significant stress risers.

2. <u>Concrete Floor in the Sand Bed</u>
The floor of the sand bed was found to be uneven and unfinished. A number of small and some large voids were found in the floor of the sand bed. In many places, the reinforcing bars placed to form the drainage channel in the floor are exposed. The deepest void observed in the floor is about 20" deep and about 3'-4' long. This void is located adjacent to the drywell shell. A number of smaller voids were also observed. A more complete and accurate recording of voids and exposed reinforcing is contained in MNCRs 92-188 and 93-062. The exposed reinforcing is generally sound with very little evident corrosion. The concrete in the floor is sound and no cracks are apparent.

After repair, the floor is sound, smooth and resilient. The configuration will lead to rapid draining of the sand bed should water enter the area. In addition, the slope provided will prevent water from standing adjacent to the drywell shell.

3. <u>Concrete in Shield Wall, Frames and Access Holes</u>
A number of small fissures, cracks and voids were observed in the drywell sand bed access holes. In addition, a number of voids and areas of exposed reinforcement were observed in the shield wall in the sand bed region. The voids in the sand bed area and access holes are documented in MNCR 93-062. The voids observed in the concrete comprise an insignificant percentage of the area of the shield walls. All voids are localized and isolated, and do not appear to be associated with any concrete cracking or spalling. All exposed concrete is sound and free of signs of degradation. Exposed bars appear to be sound and generally free of corrosion. In the areas where reinforcing is exposed, the reinforcing appears to be consistent with the reinforced concrete design drawings. No areas were observed which caused any concern with regard to structural adequacy of the shield wall, concrete frames or the Reactor Building.

This completes the record of observations from my inspection of the drywell sand bed region. If you have any questions or need additional information, please let me know.

K. L. Whitmore
Extension 7546

/rw

cc: A. R. Baig - Engineer, Engineering Projects
J. J. Colitz - Director, Engineering Projects
J. H. Horton - Mechanical Analysis Manager
S. K. Saha - Engineer, Engineering & Design
D. G. Slear - Director, Engineering & Design
S. C. Tumminelli - Manager, Engineering Mechanics
M. Yekta - Engineer, Engineering & Design

Exhibit No. 45

Purpose:
The purpose of this Tech Eval is to document representative thickness of the Drywell Vessel based on inspection and associated calculations.

This information will be provided to Structural Integrity Associates as input in the development of a Finite Element Model of the Oyster Creek Drywell Vessel (Contract Number 1002562, Requisition Number 846565). As such, the intent per this Tech Eval is to define representative thicknesses based on the 2006 Refueling Outage ultrasonic thickness measurements to obtain a realistic picture of the margins that currently exist for the Oyster Creek drywell.

This Tech Eval has been performed in accordance with CC-AA-309-101 Revision 8.

This Tech Eval is classified as Safety Related "Q"

A HU-AA-1212 review has been performed of this technical product. Based on a Medium Consequence Factor (Possibility of a Regulatory Open Item) and three Process and Human Performance Risk Factors, the Risk Rank was determined to be "1". Therefore, Independent Review in accordance CC-AA-309-101, revision 8 is acceptable.

Assumptions

1 The purpose of this Tech Eval is to provide representative thicknesses for each region and elevation. Oyster Creek Engineering has developed several calculations that demonstrate that the inspection data meets acceptance criteria (References 1, 2, 3, and 5). However, in many cases the UT data is treated conservatively when compared to the acceptance criteria. This conservative treatment results in assumed vessel thicknesses that are thinner and more widespread (i.e., bigger surface area) than is actually in the field. This approach is proper and acceptable for the referenced documents since their purpose is to demonstrate all acceptance criterion is met.

   The purpose of this Tech Eval, however is to provide realistic representative thickness of a region. These representative thicknesses will be design input to calculations that will demonstrate that both existing margins and the margins that will exist at the end of the period of extended operation are acceptable.

   Therefore, the results based on these representative thickness values will be more accurate.

   The intent of this Tech Eval is to define representative thicknesses based on the actual ultrasonic measurements taken from inside the drywell. The UT measurements taken from outside the drywell are less representative since these measurements purposely concentrated on thin local areas (less than 2 ½" in diameter) and due to the surface preparations needed to obtain accurate external UT reading.

Methodology

1) For regions other than the sandbed, a representative value will be chosen based on the thinnest average grids values from the monitoring program and associated calculations and that have been provided to the regulator in various presentations and submittals and, therefore, is part of the public record. These values may be values documented for past inspections, rather than the most recent value for that region. Although this remains conservative (selecting the thinnest average value), the variability in the data is not as significant as in the sandbed region and the values used are consistent with those previously provided to regulatory organizations.

2) Since the existing margin in the sandbed region is smaller, more representative general thickness values will be determined based on the following:

   a) As noted in the assumptions, internal grid measurements will be used as the basis for the representative thickness. These measurements are considered to be the most accurate since the coating on the inside surface of the drywell was removed for the measurements and a protective grease coating is applied after measurements are taken (to eliminate the possibility of internal surface corrosion). The average internal grid measurements were used as the primary indicator of the representative general thickness of each bay. However, other data sources were used to verify or augment the applicable values for each of the bays. These other sources of data were the external data, pictures of the external surfaces of the sandbed, and the trench data in bays 15 and 17. Augmentation of the grid data is described in the sections 2b through 2h.

   b) The external individual UT readings were deliberate attempts to identify the thinnest local areas less than 2 ½" inches in diameter in each bay. Therefore, using these values (only) to define representative general thicknesses is not appropriate. However, the external data was used to define locally thin areas that are thinner than 0.736" (see item 3 below) and that will be included in the analysis model.

   c) The measurement data makes it evident that the wall loss experienced while the sand was present did not encompass the entire sandbed region from elevation 8' 11" to 12' 3" since the regions were either not completely filled with sand or not completely filled with water. Pictures taken in 1992 of the external shell surface (after sand removal) confirmed the presence of a "transition" line at approximate elevation 11'. Above this "transition" line the thickness of the vessel is close to nominal wall thickness and below the line are areas that exhibit wall loss due to the corrosion. Therefore, the general wall thickness of each sandbed bay has been divided into two areas; above and below elevation 11' 0". This will reduce the conservatism that would be introduced by assuming the entire bay thickness is equivalent to an average of the external readings or the average of the internal grids readings.

d) Where the internal grid measurements were clearly not representative of the corrosion on the shell in that bay, representative measurement from adjacent bays were utilized to provide a representative general thickness. Bay 1 is the prime example of the use of this methodology. Visual and photographic observations of Bay 1 and Bay 19 indicate these to be two of the most heavily corroded bays. External UT reading in Bay 1 confirms the presence of corrosion. Yet, the internal Grid UT examination in Bay 1 would indicate near nominal thickness. Since some of the external readings occur above elevation 11' 0", it was concluded that corrosion for the whole bay should be assumed. Therefore, the values from the adjacent corroded bay (Bay 19) were deemed to be more representative for Bay 1 than the internal grid value.

e) Where the trenches were cut out of the drywell floor (elevation 10' 3") allowing UT measurements from inside the Drywell in large areas, these measurements were used to determine the general thickness of these bays (Bays 5 and 17). The trench UT data consists of hundreds of individual UT readings over a large area, rather than only 49 readings or less over smaller regions. Therefore, the results of these inspections are concluded to be representative of the general thickness of these two bays.

f) Where the internal data indicates a "transition" line through the grid, the average of the lower reading were used to define that particular bay general thickness below elevation 11'.

g) In one case (bay 15) there were no internal grid or external individual data available below elevation 11'. Therefore, an average of the two adjacent bays was used. The basis for this approach is the assumption that there is a general wall thickness gradient between the two adjacent bays that would adequately represent the general thickness of the bay between them.

h) For bays 9, 15, and 17 (above elevation 11') there are multiple internal grids. Therefore in these bays, the weighted average of the multiple grids were calculated by summing the total number of valid thickness readings and dividing by the total number of valid readings.

3) In several bays of the sandbed region there are locally thin areas that are thinner than 0.736" and are confined to areas no larger than 36" by 36". These areas will be input to the model as defined locally thin circular areas. These areas were selected directly from calculation C-1302-187-5320-024 revision 2. To facilitate computer modeling of the locally thinned areas, larger circular areas were overlaid over the thin square areas identified in calculation C-1302-187-5320-024 revision 2. The circular areas completely capture the square areas. This introduces a small amount of conservatism since the area of the circles exceeds the area of the squares. Although conservative, this is not expected to significantly impact the overall results obtained from the analysis.

Detail Evaluation:

Regions other than the Sandbed

Region	Elevations	Value in mils	References
Cylindrical Region	**71' 6" to 93'**	**604**	1) Oyster Creek License Renewal ACRS 1/18/07 Presentations Slide 14 (reference 3) 2) 1994 average grid value for grid 9-20 Calculation C-1302-187-5320-037 Revision 3 appendix 7 page A7-20 of 29 (reference 4)
Knuckle Region	**65' 2 7/8" to 71' 6"**	**2530**	1) Oyster Creek License Renewal ACRS 1/18/07 Presentations Slide 14 (reference 3) 2) 2006 average grid value for bay 9 Calculation C-1302-187-5320-037 Revision 3 page 11 of 48 (reference 4)
Upper Spherical Region	**50' 11/18" to 65' 2 7/8"**	**676**	1) Oyster Creek License Renewal ACRS 1/18/07 Presentations Slide 14 (reference 3) 2) 1994 average grid value for grid 13 –32 - Calculation C-1302-187-5320-037 Revision 3 appendix 5 page A5-23 of 38 (reference 4)
Middle Spherical Region	**37' 3" to 50' 11/18"**	**678**	1) Oyster Creek License Renewal ACRS 1/18/07 Presentations Slide 14 (reference 3) 2) 2006 average grid value for grid 13–31 - Calculation C-1302-187-5320-037 Revision 3 appendix 3 page A3-24 of 36 (reference 4)
Lower Spherical Region	**To 23' 6 7/8" to 37' 3"**	**1160**	1) Oyster Creek License Renewal ACRS 1/18/07 Presentations Slide 14 (reference 3) 2) 2006 average grid value for bay 19- Calculation C-1302-187-5320-037 Revision 3 page 11 of 48 (reference 4)
Embedded Region (1154 Nominal Thickness)	**6' 7" below 8' 11"**	**1113**	1) Oyster Creek License Renewal ACRS 1/18/07 Presentations Slide 124 (reference 3) 2) Tech Eval 00546049-07, Attachment 7 page 1 of 2 "Water Found in Drywell Bay 5 – UT Data Evaluation
Embedded Region (676 Nominal Thickness)	**Below 6' 7"**	**636**	1) Tech Eval 00546049-07, page 8 of 10 "Water Found in Drywell Bay 5 – UT Data Evaluation

Sandbed Region

BAY	Above Elevation 11'-0" (mils)	Basis	Below Elevation 11'-0" (mils)	Basis
1	826	Same value as used for Bay 19 (adjacent bay)	826	Same value as used for Bay 19 (adjacent bay)
3	1180	Internal grid average (single grid) Ref. 2 page 7	950	Numerical average thickness between Bays 1 & 5
5	1185	Internal grid average (single grid) Ref. 2 page 7	1074	Average of internal trench data points (six 49 point grids). Refer to page 5 of 10 of A2152754 E09
7	1133	Internal grid average (single grid) Ref. 2 page 7	1034	Numerical average thickness between Bays 5 & 9
9	1074	Weighted average of two internal grids (49 point and 7 point) Ref. 2 page 6 and 7	993	Smaller of the two internal grid averages (49 point grid) Ref. 2 page 6
11	860	Average of two internal grids (both 49 point) Ref. 2 page 6	860	Average of two internal grids (both 49 point) Ref. 2 page 6
13	907	Average of two internal grids (both 49 point; 7 point grid data not used) Ref. 2 page 6 and 7	907	Average of three internal grids (both 49 point; 7 point grid data not used) Ref. 2 page 6 and 7
15	1062	Weighted average of two internal grids (49 point and 7 point) – Ref. 2 page 6 and 7	935	Numerical average thickness between Bays 13 & 17
17	863	Weighted average of the bottom of internal grid 17A (28 points) and internal grid 17D (49 points). – Ref. 2 page 6 Data for grid 17/19 not used.	963	Average of internal trench data points (six 49 point grids). Refer to page 6 of 10 on Tech Eval A2152754 E09
19	826	Average of three internal grids (all 49 points) – Ref. 2 page 6	826	Average of three internal grids (all 49 points) – Ref. 2 page 6

Locally Thin Areas
See Attachment 1

Conclusion:
The attached table provides representative thicknesses of the Drywell Vessel based on 2006 inspection and other past inspections. These values shall be used as general thickness values for the associated region.

OYSTER CREEK DRYWELL THICKNESSES FOR USE IN BASE CASE ANALYSIS		
LOCATION		THICKNESS (mils)
Cylindrical Region		604
Knuckle Region		2530
Upper Spherical Region		676
Middle Spherical Region		678
Lower Spherical Region (Note 1)		1160
Embedded Region (1154 Nominal Thickness)		1113
Embedded Region (676 Nominal Thickness)		636
SANDBED REGION		
BAY	Above Elevation 11'-0" (mils)	Below Elevation 11'-0" (mils)
1	826	826
3	1180	950
5	1185	1074
7	1133	1034
9	1074	993
11	860	860
13	907	907
15	1062	935
17	863	963
19	826	826

In addition since there are several locally thin areas in the sandbed. Specific thin area shall be modeled per Attachment 1.

Reference:

1) Calculation C-1302-187-5320-024 Revision 2
2) Calculation C-1302-187-5320-041 Revision 0
3) Calculation C-1302-187-5320-037 Revision 3
4) Oyster Creek License Renewal ACRS 1/18/07 Presentation
5) Tech Eval 00546049-07, "Water Found in Drywell Bay 5 – UT Data Evaluation

Attachments
Attachment 1 – Sketches showing locally thin area. (5 pages)

Prepared By – Peter Tamburro 4/20/07

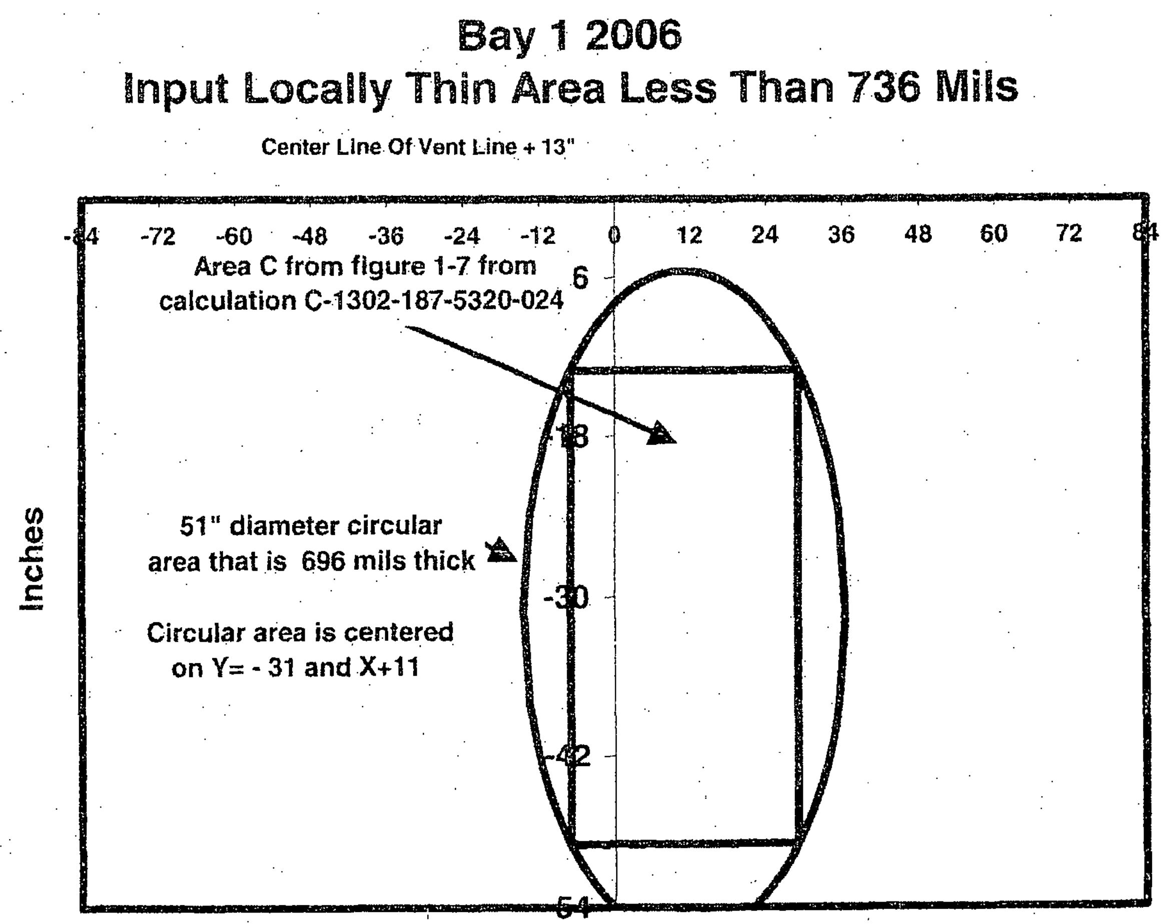
Independent Review:

The Independent Review has been completed in accordance with ER-AA-309-101. I have independently verified and agreed with the methodology, inputs, and results of this Technical Evaluation. All of my comments were answered and incorporated as appropriate.

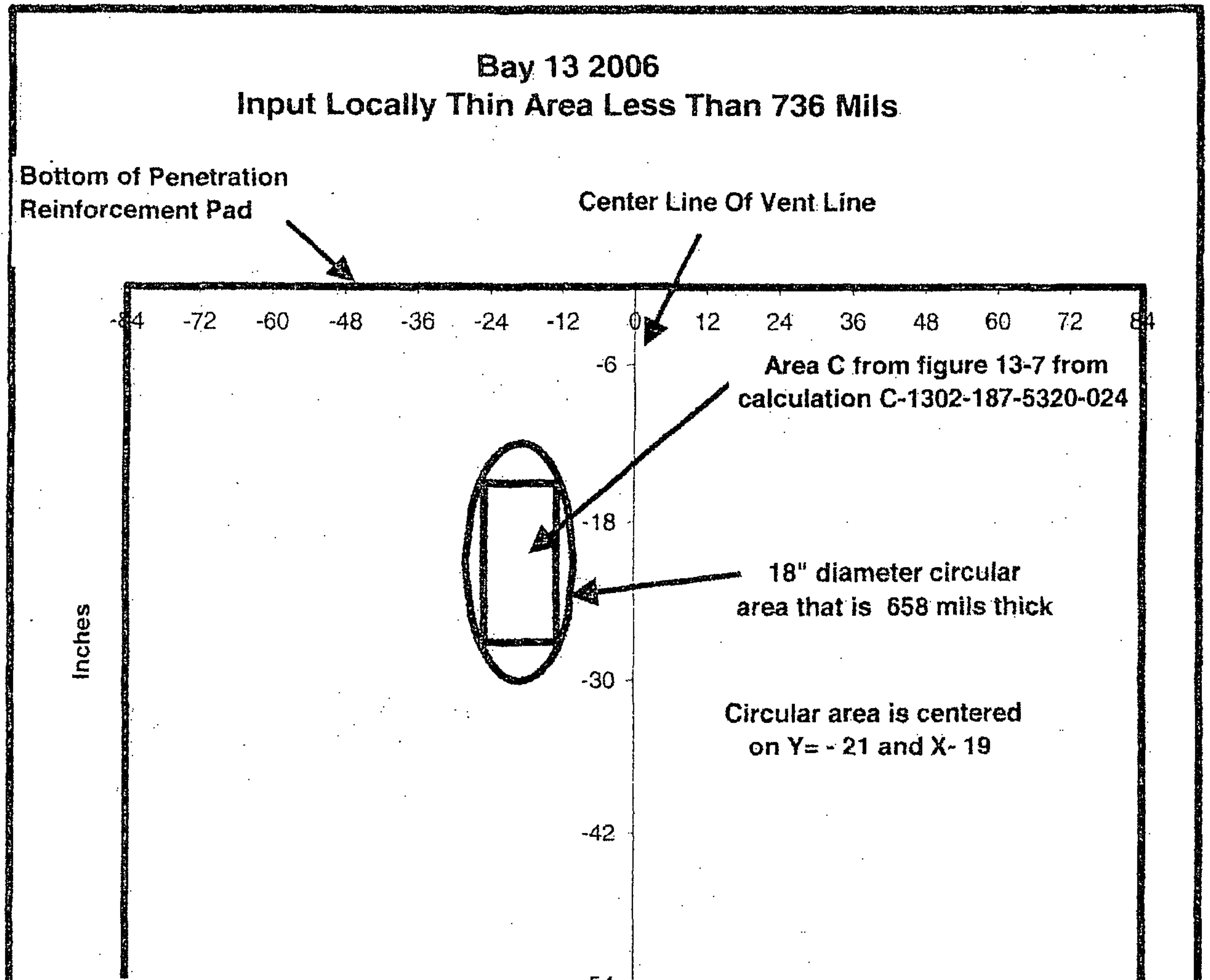
Independently Reviewed By: David P. Olszewski Date: 4/20/2007 4/20/07

Manager's Comments: The preparer and reviewer are qualified to perform this task. This data is being prepared, reviewed and approved to verify the inputs to be used to complete the drywell shell analysis project. Therefore, the HU-AA-1212 risk rank of 1 is appropriate and the existing process reviews are acceptable.

Manager Approval: F. H. Ray 4/20/2007. F. Harris Ray 4/20/07

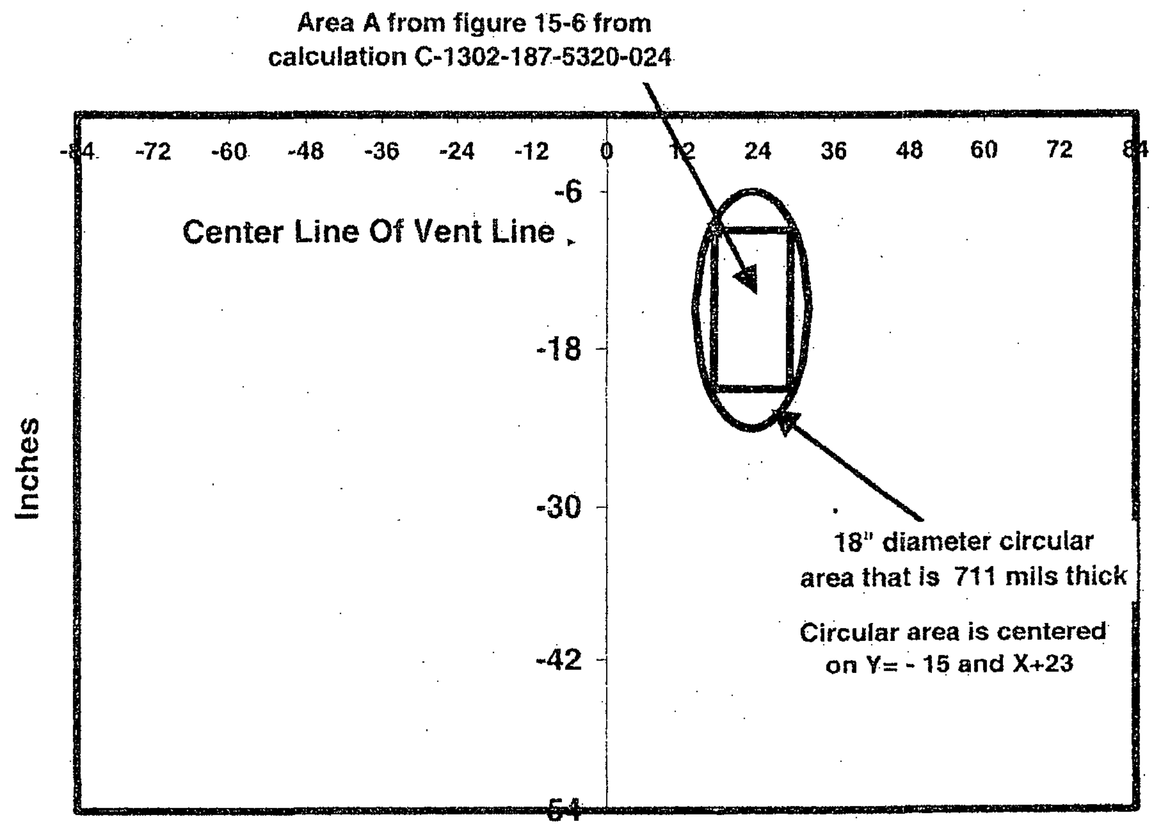


All X and Y dimensions are referenced from 13 inches to the right of centerline of the vent line (X direction) and the bottom of the Penetration Reinforcement Pad (Y dimension). Reference NDE Data sheets 92-072-12 page 1 of 2 and 1R21LR-022 page 2 of 2.



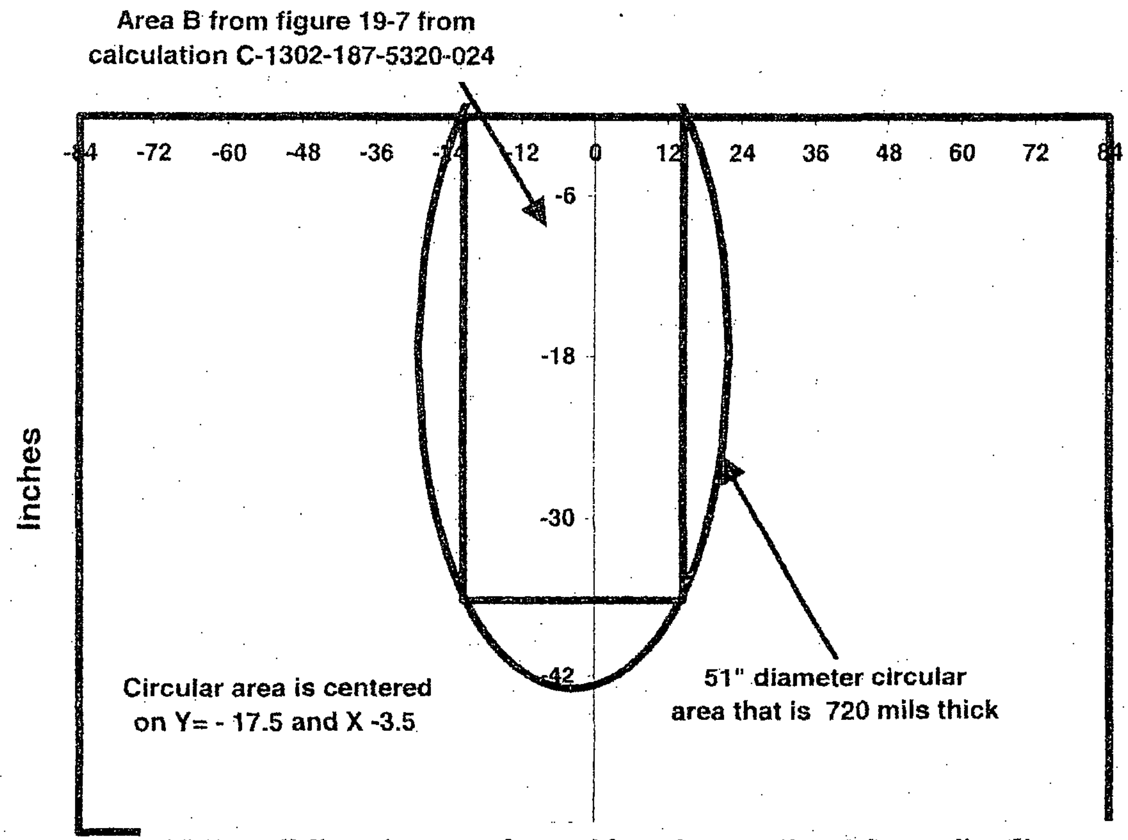
All X and Y dimensions are referenced from the centerline of the vent line (X direction) and the bottom of the Penetration Reinforcement Pad (Y dimension). Reference NDE Data sheet 92-072-24 page 1 of 2 and 1LR-010 page 2 of 2.

Bay 15 2006
Input Locally Thin Area Less Than 736 mils

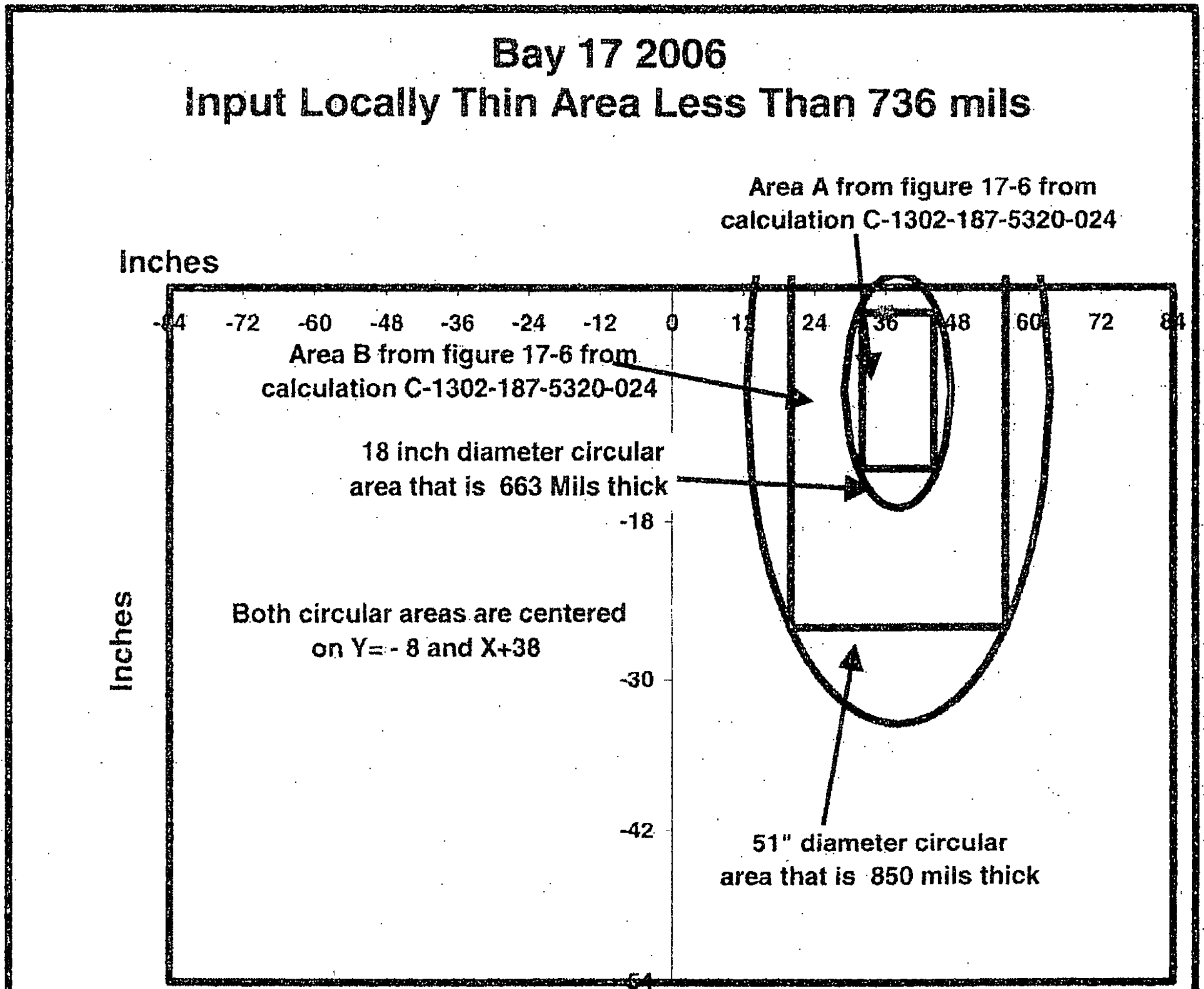


All X and Y dimensions are referenced from the centerline of the vent line (X direction) and the bottom of the Penetration Reinforcement Pad (Y dimension). Reference NDE Data sheet 92-072-21 page 1 of 1 and 1R21LR-015 page 2 of 2

Bay 19 2006
Input Locally Thin Area Less Than 736 Mils



All X and Y dimensions are referenced from the centerline of the vent line (X direction) and the bottom of the Penetration Reinforcement Pad (Y dimension). Reference NDE Data sheet 92-072-02 page 1 of 1 and 1R21LR-020 page 2 of 2.



All X and Y dimensions are referenced from the centerline of the vent line (X direction) and the bottom of the Penetration Reinforcement Pad (Y dimension). Reference NDE Data sheet 92-072-04 page 1 of 1 and 1R21LR-021 page 2 of 2.

Exhibit No. 46

From: O'Rourke, John F.
Sent: Wednesday, February 28, 2007 07:20 PM
To: Marcos Herrera (E-mail)
Cc: Gallagher, Michael P; Polaski, Frederick W
Subject: Oyster Creek Drywell Thicknesses to be Used for Base Case Analysis
Attachments: OYSTER CREEK DRYWELL THICKNESSES, Rev2.doc

Marcos: The attached document provides the thicknesses to be used. Please share this info within SI as appropriate. We can discuss any issues on our update call tomorrow.

John

OYSTER CREEK DRYWELL RE-ANALYSIS
DRYWELL THICKNESSES FOR BASE CASE

The base case analysis for the Oyster Creek Drywell Re-Analysis is defined as the 3 dimensional, finite element model using the thicknesses measured during the 2006 1R21 Refueling Outage. Various discussions have been held between the License Renewal Project and Oyster Creek Site Engineering to establish the correct thicknesses to use in the model, particularly in the sandbed region.

The purpose for performing the re-analysis is to identify how much margin exists in the drywell in its current configuration given a more realistic and accurate 3 dimensional modeling versus the more conservative one-tenth segment modeling performed in the early 1990s by General Electric. The GE analysis is the current analysis of record. This re-analysis is expected to demonstrate that higher margins exist regarding shell thicknesses and margins of safety than are contained in the current analysis. The re-analysis will also confirm the structural integrity of the drywell during all loading conditions and show compliance with design basis both now and through the period of extended operation.

The model is being 'built' using Oyster Creek specific input data. This includes the Oyster Creek operating and accident conditions, penetration information, response spectra, piping loads, materials, internal loads, jet loads, boundary conditions and shell thicknesses. Load combinations are as specified in the UFSAR and are unchanged from the current analysis.

THICKNESS INPUT

For all drywell shell areas except the sandbed region and the embedded shell, the shell thicknesses to be used in the model are the "Minimum Measured General Thicknesses" reported to the ACRS Full Committee on slide 18 of the AmerGen presentation. These thicknesses are as follows:

- Cylindrical Region: 604 mils
- Knuckle Region: 2530 mils
- Upper Spherical Region: 676 mils
- Middle Spherical Region: 678 mils
- Lower Spherical Region: 1160 mils (Note: This does not include the sandbed region)

These thicknesses are based on the grid readings taken during the 1R21 Outage.

For the 676 mil nominal embedded shell, there is no measurement data available. AmerGen concluded in its presentation to the ACRS that, if there is corrosion of this shell, it is no worse than 1 mil per year based on actual UT thickness measurements.

Therefore, since the shell has been embedded since original construction (the concrete that embedded the shell was poured in 1966), which, at the time of the 1R21 outage, was 40 years, the thickness value to be used in the re-analysis is 676 mils less 40 mils or 636 mils which is most likely conservative but not overly conservative. This portion of the drywell shell is also not expected to be the limiting portion of the shell.

For the portion of the 1154 mil nominal shell that is also embedded on both sides, additional concrete was removed from the trench in Bay 5 to obtain grid measurements of a portion of this shell segment. Since actual 2006 measurement data is available for this area, the average of the grid measurements will be used for the thickness of this shell segment. That average, as calculated by Site Engineering, is 1113 mils.

SANDBED REGION

For the sandbed region, the discussions between the LR Project and Site Engineering have attempted to define shell thicknesses for each bay that were realistic, defendable to outside agencies and not overly conservative. The thicknesses chosen are based on the internal grid measurements taken at elevation 11'-3" and in the trenches in Bays 5 and 17. The external point measurements present a very conservative representation of shell thickness in that they were chosen visually as the thinnest points in the bays and some metal (unquantified) was removed to prepare the surface for UT measurement and, as such, the thicknesses chosen were not based on external point measurements. Where the internal grid measurements in a particular bay present an unrealistic representation of the shell thickness for the entire sandbed region, engineering judgment was used to appropriately apply internal grid data from adjacent bays to represent the most realistic thicknesses for some of the bays. A bay-by-bay explanation of the rationale for what thicknesses are to be used is presented below. Also, a summary table is included that provides all the thickness measurements to be used for the various areas of the drywell for the base case analysis.

External point measurements were used in a limited way to confirm the basis for an engineering judgment, assuming a normally statistical distribution, regarding an appropriate thickness to use in the re-analysis. Another use for the external point measurements was to define areas of local thinning that encompassed a number of the external points. These areas utilize the average of the points contained within the locally thin areas (defined as either a 12 inch by 12 inch area, a 36 inch by 36 inch area or, in one case, a 2 ½ inch diameter circular area around one point). These are the only uses of the external point measurements.

The internal grid measurements demonstrate that, for several bays, the external corrosion began below the level of the elevation of the grid readings. Whether there was insufficient sand in the bay such that the shell was not in contact with wetted sand or the water level in those bays did not rise to the elevation of the grid readings is not known. The internal grid readings and visual information in the form of exterior shell pictures confirm that, in some bays, near nominal shell thicknesses exist at the upper portions of the sandbed region. To more realistically represent the thicknesses in the bays and to

ensure that the near nominal thicknesses are appropriately modeled in the re-analysis, the bays were divided into 2 segments, one above and one below the 11'-0" elevation with appropriate thickness values as described below in the bay-by-bay explanations.

SANDBED REGION SHELL THICKNESSES

The following is an explanation, by bay, of the shell thicknesses to be used in the re-analysis model and the rationale for using each of the values. The thickness information is summarized in a table following the bay-by-bay explanation.

Bay 1: This bay is appears to be exhibiting a different corrosion pattern than is exhibited in most of the other bays. It is also not exhibiting a normal distribution pattern based on the grid average with a 22 mil sigma. Since this bay is adjacent to Bay 19 and these two bays were judged to be the most corroded bays, the average grid value of 826 mils from Bay 19 will be used this entire bay. The external point test would support a value higher than 826 mils; therefore, to use 826 mils is conservative and acceptable.

Bay 3: This bay has nominal or above wall thickness above 11'-0"; however, using the grid average for the entire bay would not adequately represent the corrosion below 11'-0". Above 11'-0", the grid average of 1180 mils will be used. Below 11'-0", the average of the thicknesses below 11'-0" from Bays 1 (826 mils) and 5 (1074 mils) will be used for Bay 3 (950 mils).

Bay 5: This bay also has nominal or above wall thickness above 11'-0"; therefore, the grid average of 1185 mils will be used. Below 11'-0", the average of the trench readings above the sandbed floor, since the trench spans the entire length from the floor to close to elevation 11'-0", will appropriately represent the general thickness of the bay below 11'-0". This value is calculated as 1074 mils.

Bay 7: This bay has close to nominal wall thickness above 11'-0"; therefore, the grid average of 1133 mils will be used. Below 11'-0", similar to Bay 3, a representative thickness of the average between Bay 5 (1074 mils) and Bay 9 (993 mils) will be used for the shell thickness below elevation 11'-0" (1034 mils).

Bay 9: This bay exhibits corrosion both above and below elevation 11'-0". Above 11'-0", the thickness can be appropriately represented by the weighted (one is a 49 point grid and the other is a 7 point grid) average of the two internal grids (1074 mils). Below 11'-0", it is more appropriate to use the smaller of the two internal grid averages for the general shell thickness. This value is 993 mils.

Bay 11: This bay exhibits corrosion both above and below elevation 11'-0". Therefore, the average of the internal grid measurements will be used for the general shell thickness for the entire bay. This value is 860 mils (average of 822 and 898).

Bay 13: This bay exhibits corrosion both above and below elevation 11'-0". There are 3 internal grid measurements in this bay (two 49 point grids and one 7 point grid). The 7 point grid indicates good wall thickness and appears to be an anomaly in this bay given that the other two grids are indicating corrosion.. Therefore, the average of the two 49 point internal grids will be used for the general shell thickness for the entire bay. This value is 907 mils.

Bay 15: This bay is exhibiting higher thicknesses above elevation 11'-0". Therefore, this bay will be split as above and the weighted average of the two grids (one 49 point and one 7 point) will be used for the thickness of the shell above 11'-0". This value is 1062 mils. Below 11'-0", similar to Bays 3 & 7, a representative thickness of the average between Bay 13 (907 mils) and Bay 17 (954 mils) will be used for the shell thickness below elevation 11'-0" (931 mils).

Bay 17: This bay has two 49 point grids and a portion of a grid that is partially in Bay 17 and partially in Bay 19. Since this third grid is at the edge of the bay, it will not be used to determine any representative thickness of the bay. Of the remaining two grids, the majority of the area above elevation 11'-0" appears to be best represented by the weighted average of the bottom of the grid closest to Bay 15 (Grid 17A) and the entire middle grid (Grid 17D). This value is 864 mils. Below 11'-0", Bay 17 has a trench similar to Bay 5. The trench provides representative data for most of the sandbed region between elevations 8'-11" and 11'-0". Therefore, the average of the internal grid measurements in the trench area will be used for the shell thickness below 11'-0". This value is 954 mils.

Bay 19: This bay exhibits corrosion both above and below elevation 11'-0". Therefore, the average of the internal grid measurements (three 49 point grids) will be used for the shell thickness for the entire bay. This value is 826 mils.

Exhibit No. 47

Create another New Issue   Create another Issue from '00557180'   Print Close window

AS REQUIRED, PRINT ISSUE REPORT AND PROVIDE TO YOUR SUPERVISOR
Note: This is your only notice. You will not have an opportunity to print this confirmation later.

Exelon Nuclear Issue - Statement of Confirmation

Issue #: 00557180 **Originator:** KATHY BARNES **Submit Date:** November 13, 2006

Basic Information

Affected Facility:	Oyster Creek
Dscv Date:	11/07/2006 11:00
How Discovered Code:	H02
Event Date:	11/07/2006 11:00
Affected Unit:	NA
Affected Sys:	--
Subject:	COMMITMENTS MADE FOR GL 87-05 ARE NOT IN THE RA DATABASE

Required Information

Condition Description:

Commitments were made as a result of the GL 87-05 as well as other correspondence, meetings, etc. concerning our Drywell Corrosion Monitoring and Water Intrusion mitigation plans. The correspondence covers the time period of 1986 through present. A check of the Lotus Notes database presently used for commitment tracking did not indicate any commitments have been made. Based on limited research an SER was issued with subsequent correspondence, which committed us to a corrosion monitoring activities and leakage monitoring activities for the Drywell. The correspondence was used to formulate what is thought to be the present commitments for leakage monitoring. That information was utilized as an input to the outage leakage monitoring activities to determine the steps necessary to meet the present commitments and the License Renewal commitments for leakage monitoring. The documents were annotated with reference to the correspondence for the present commitments and to Passport commitment tracking numbers for the License Renewal commitments.

Subsequent research determined other correspondence exists which indicated we initiated "preventive maintenance to clear the sand bed drains periodically". There were no preventive maintenance activities prior to this outage to clear the sand bed drains. It is not known at this time whether this is a commitment by virtue of it being in our correspondence with the NRC. IR 547236 documents the existence of debris in the sand bed drains, when performing the first known formalized maintenance activity to inspect the drains. Although the debris did not affect the capability to monitor the leakage from the sand bed drains, there is a question of where did the debris came from and when should be the next time we inspect the drains, and on what frequency. An ACIT was issued to address these concerns. No

	been reviewed in searching for prior commitments. Commitments were not tracked in a database for all teh years of OC operation. Changes of ownership and changes in definition of what constitutes a commitment has resulted in inadequate understanding of what this older correspondence requires.
What are the consequences?	Without having a commitment tracking system or proper disposition of these historical commitments renders the site to potential repeat occurrences of missed commitments from a current license basis perspective.
Any procedural requirements impacted?	LS-AA-110 provides requirements for managing commitments in current regulatory correspondence. This issue report is related to historical commitments made by GPUN.
Identify any adverse physical conditions:	There was no PM established to periodically clear the sand bed drains of clogs.
List of Knowledgeable individuals:	T.Quintenz, H.Ray, P.Tamburro, J.Huffnagel, J.Kandasamy, D.Helker
Is this a repeat or similar condition?	Yes. There have been other recent examples of missed commitments from "old" correspondence that had not been captured in the OC commitment tracking database. IR 348545 (Tell-tale Drains - Poly bottles not having a PM to monitor DW leakage)
Routing	
Owed To Group:	ACAPALL
Routed to Group:	CR-OSC

From: Quintenz, Tom <Tom.Quintenz@exeloncorp.com>
Sent: Wednesday, September 20, 2006 2:02 PM
To: Ouaou, Ahmed <u999ao2@ucm.com>; Hufnagel Jr, John G <u000jgh@ucm.com>
Cc: Tamburro, Peter <u777p0t@ucm.com>; Warfel Sr, Donald B <u001dbw@ucm.com>; O'Rourke, John F. <t925jfo@ucm.com>
Subject: RE: Inspection of Sand Bed Drain Lines

I am responding to my action item from Dave Ryan that this is not a commitment, but must remain in scope for the outage.

-----Original Message-----
From: Ouaou, Ahmed
Sent: Wednesday, September 20, 2006 1:36 PM
To: Quintenz, Tom; Hufnagel Jr, John G
Cc: Tamburro, Peter; Warfel Sr, Donald B; O'Rourke, John F.
Subject: RE: Inspection of Sand Bed Drain Lines

I'll discuss with Don and John O' during turn over. I also think it is a good idea to look at the drains and sandbed floor for debris that could get into the drains when the coating in the bays with drains is inspected. It is not a commitment to check the drains; but we would not look good if we flood the sandbed because the drains are plugged

-----Original Message-----
From: Quintenz, Tom
Sent: Friday, September 15, 2006 5:36 PM
To: Hufnagel Jr, John G
Cc: Ouaou, Ahmed; Tamburro, Peter
Subject: RE: Inspection of Sand Bed Drain Lines

With regard to the suggested check of the configuration, suggest that we agree on the change and have the KS program engineer issue a revision to the appropriate recurring task(s) to implement the requirement.

-----Original Message-----
From: Hufnagel Jr, John G
Sent: Friday, September 15, 2006 5:03 PM
To: Quintenz, Tom
Cc: Ouaou, Ahmed; Tamburro, Peter
Subject: RE: Inspection of Sand Bed Drain Lines

I agree with your assessment. I also reviewed the June 20, 2006 letter which responded to NRC concerns outlined in the June 1 Public meeting, and as expected, found no commitment to inspect the sand bed drain lines for blockage.

As a separate but related point, do we have a recurring task to ensure that the tubing that goes from the sand bed drain to the poly bottles is intact? It seems we should verify the integrity of this configuration on some regular interval, even if it is not a commitment.

- John.

AR 00547236 Report

Aff Fac:	Oyster Creek	**AR Type:**	CR	**Status:**	APPROVED
Aff Unit:	NA	**Owed To:**	ACAPALL	**Due Date:**	11/20/2006
Aff System:	187			**Event Date:**	10/21/2006
CR Level/Class:	/			**Disc Date:**	10/21/2006
How Discovered:	H02			**Orig Date:**	10/21/2006
WR/PIMS AR:		**Component #:**			

Action Request Details

Subject: DEBRIS LOCATED IN BAYS 7 AND 11 SANDBED DRAIN LINES

Description:

Originator: PETER TAMBURRO Supv Contacted: Howie Ray

Condition Description:
Inspection of the Sandbed Drain Lines in accordance with Specification IS-328227-004 Rev. 13 showed that the drain line in bay 7 has debris, which could cause blockage of this line. The debris looks like loose concrete. This does not meet the acceptance criteria in the specification per section 3.2.5.2.

In addition the inspection of the drain line in bay 11 shows some loose debris in the bottom of the line directly downstream of the first elbow. However the line is not blocked and meets the acceptance criteria.

Operability

The purpose of the drain lines is to route water in the sandbed from the drywell vessel. At this time the remaining 4 lines are capable of performing this function. In addition since the line in bay 7 is not completely blocked it too would partially perform its function by draining the sandbed. So far in 1R21 no water has entered the sandbed.

Engineering has inspected the 5 bottles every day since the beginning of the outage (R2088495). To date no water has been found in any of the bottles or on the floor outside the sandbed bays.

Also Engineering and/or NDE have inspected all 10 Drywell Sandbed bays. To date no water or moisture has been observed in these bays and the coating is in good condition..

Engineering will continue to monitor (on a daily basis) the trough drain line for changes in flow rate and the five polyvinyl bottles for water.

Immediate actions taken:
Informed Howie Ray and the Engineering Control Center

Recommended Actions:

1) Continue to monitor the five poly bottles and trough drain line daily per our commitments

2) Recommend cleaning the drain lines in bays 7 and 11.

Operable Basis:

OCLR00013846

Exhibit No. 48

From:	Quintenz, Tom <Tom.Quintenz@exeloncorp.com>
Sent:	Tuesday, October 10, 2006 2:26 PM
To:	O'Rourke, John F. <t925jfo@ucm.com>
Cc:	Warfel Sr, Donald B <u001dbw@ucm.com>
Subject:	Notes of video inspection results of trough area
Attach:	Video Inspection of Concrete Trough Notes November 1996.pdf

I found these notes of review of video tapes of trough inspection

<<...>>

- Commitments Exchanged
- Journal Entry
- Thoughts & Ideas
- Agendas (telephone, meetings)
- Conversations

NOVEMBER 1996

DAILY RECORD OF EVENTS

5
TUESDAY
310th Day 56 Left
Week 45

Review of Rx Cavity Trough - Video Inspn

- Bay 1 is the highest + Bay 11 is the lowest point on concrete trough - Difference 2" in elevation
- Camera was snaked in thro' drainline @ El. 75' near Bay 11. First half inspn went counter clockwise i.e. Bay 11, 9, 8, 5 and stopped at Bay 3. Then second part of inspection was clockwise i.e. Bay 11, 13, 15 and upto 17.
- Chunks of concrete on Rx Cavity side of the berm is missing sporadically all over
- Fire Bar D all over trough
- D/W side berm is quite steep. Between Bay 3 and Bay 1 this berm & trough lip is broken. Will allow water drainage into D/W gap.
- At some locations plastic sheet (holding Firebar D to the shell) can be seen laying on the concrete lip.

Exhibit No. 49

GPU Nuclear **Material Nonconformance Report**

Unit: ☐TMI-1 ☐TMI-2 ☑Oyster Creek

Page 1 of 3

MNCR Number 86-870

RECNO
REV
DATE
RECTYPE 002-01
LOCATION
FORMNO A 0001975
RETENTION PERM

1. Identification

Originator: J. GIGLIOTTI / W. QUINLAN Dept/Date/Time: QC 10-21-86 1400
Material, Part, Component, etc.: CONCRETE RX. BLDG

Location: 95' EL REACTOR BLDG
Manufacturer (Name): N/A Code: N/A
P.R.# N/A Line # N/A Spec # N/A
BA # N/A Work Authorization # N/A
System: STRUCTURES System Tag No. 150
Dwg. No. BR-MD-4056 Heat Code No. N/A Other N/A
Nonconforming to (requirements): ~~ARW~~ DWG. REQUIREMENTS FOR SOLID CONCRETE

Description of Nonconformance: HAIR LINE CRACKS IN EXTERIOR CONCRETE OF DRYWELL. A RUST LIKE SUBSTANCE APPEARS TO HAVE EXUDED FROM CRACKS. SUBSTANCE UNKNOWN AT THIS TIME. AREA IDENTIFIED BY RAD. CON. SURVEYS SHOW ~~LITTLE~~ LITTLE OR NO CHANGE IN BACK GROUND READINGS

Located ≈15-20 Above Floor Level.

NON MOD. RELATED.

Hand carry to Quality Control Manager (normal working hours) or Unit/Group Shift Supervisor (backshift/weekend).

2. Evaluation & Validation

POTENTIALLY REPORTABLE:

	Important To Safety	10CFR50	10CFR21	10CFR71	10CFR73.71	L.E.R.
YES:	☒	☐	☐	☐	☐	☒
NO:	☐	☒	☒	☒	☒	☐

Evaluated By (Name): Paul S Dawson Date/Time: 10-21-86 1435
QC Mgr. Validation: Paul S Dawson Date/Time: 10-21-86 1435

If evaluated to be potentially reportable, notify U/GSS and send copy of MCNR to licensing.

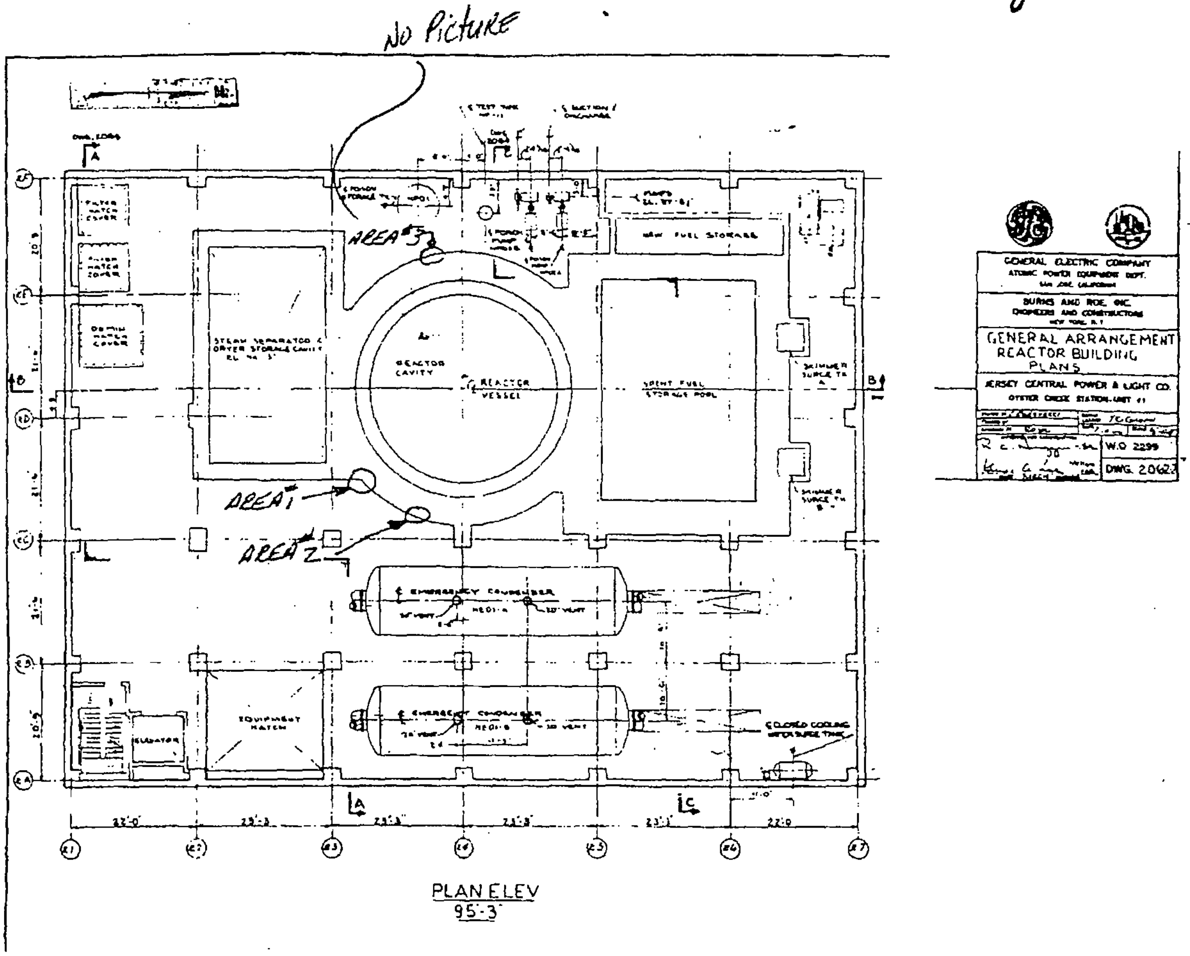
U/GSS Notified: ☒YES ☐NO Date/Time: 10-21-86 1435
Hold Tags Issued: ☐YES ☒NO No. of Tags: AREAS NOT EASILY ACCESSABLE
Tags Installed By (Name): — Date/Time: —
Material Segregation Required: ☐YES ☒NO
Segregation Verified By (Name): Date/Time: —
ACTION PARTY (Name): J. MALONEY Dept: PLANT MATERIEL

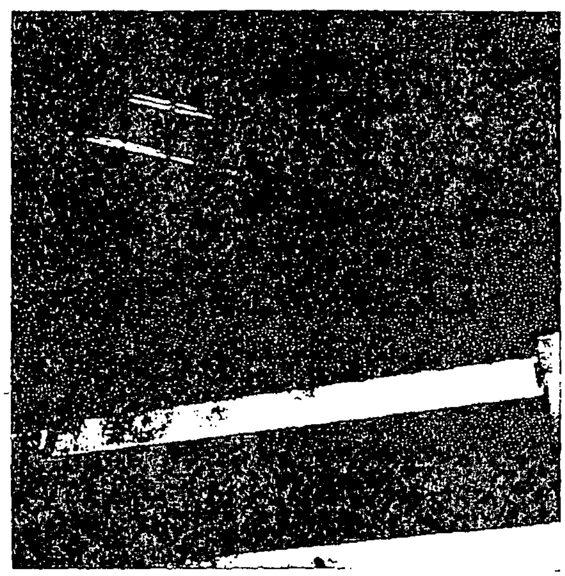
Forward to responsible individual/department (Action Party).

FORM 1000-ADM-7215.01-1 (9/85)

N61975 (06-86)

MNCR 86-870
Pg 3 of 3





AREA #1

AREA #2

OCLR00015024

GPU Nuclear — **Conditional Release Request**

A Conditional Release in accordance with Procedure 1000-ADM-7215.01 is requested for the following items:

A

Item Identification: DRYWELL CONCRETE CRACKS ABOVE EL.95'		
Unit: OYSTER CREEK	Vendor:	
System: REACTOR BUILDING DRYWELL CONCRETE	P.O.	Item No.
Spec/ECM/ECA	Serial # Drawing	

B Outstanding Nonconformances and/or Deficiencies:

MNCR #	RDN #	Other:
86-870		DEVIATION REPORT 86-493

C Reason for Conditional Release:

① THE HAIR LINE CRACKS HAD BEEN INVESTIGATED. THOSE WERE CAUSED BY HIGHER TEMPERATURE INSIDE THE DRYWELL. HOWEVER, THE STRUCTURAL INTEGRITY AT THIS POINT ARE STILL INSURED. TDR # 713 ADDRESSES THIS PROBLEM. ② WE DO NOT KNOW EXACTLY WHAT IS THE RUST LIKE SUBSTANCE EXUDED FROM THE CRACKS RIGHT NOW. IT DOES NOT APPEAR TO HAVE ANY IMMEDIATE SAFETY CONCERN. SOME KIND OF CHEMICAL ANALYSIS MUST BE PERFORMED BEFORE FURTHER ACTION TAKEN IF NECESSARY.

D Limitations:

Type 1) Release for installation, only:

Type 2) Release to test, energize, or pressure:

Type 3A/3B) Allowance to continue operations:
THE PLANT SHALL BE ALLOWED TO OPERATE BASED ON THE REASONS GIVEN IN SECTION 'C' OF THIS CONDITIONAL RELEASE.

E

Generic Release Requested:	Supervisor of Requesting Organization	Date:
☐ Yes ☒ No	[signature]	10-27-86

Approval/Concurrence: Type 1 ☐ Type 2 ☐ Type 3A ☐ Type 3B ☒

Type 1	QC Manager ____ Date: ____	
Type 2	Cognizant Eng. ____ Date: ____	Mgr. QA Mod/Ops/OCM ____ Date: ____
Type 3A	Operations ____ Date: ____	Mgr. QA Mod/Ops or Designee ____ Date: ____

Type 3B	Operations	PI. Eng.	Tech Functions/Site Eng.	Mgr. QA Mod/Ops/Designee
	Date:	Date:	Date:	Date:

Engineering Justification: (Required for Type 2, 3A, 3B & Generic Release)

THE CRACKS WERE CAUSED FROM HIGH TEMPERATURE INSIDE THE DRYWELL PER TDR #713. THE STRUCTURE INTEGRITY IS STILL O.K. A TASK WILL BE INITIATED TO DETERMINE WHAT IS THE SUBSTANCE FROM THE CRACKS. ACCORDINGLY, FURTHER ACTION WILL BE TAKEN IF NECESSARY.

T.H. CHANG / T.F. 10-27-86

FORM 1000-ADM-7215.01-2

OCLR00015025

Exhibit No. 50

DR 92-544

GPU Nuclear

Memorandum

Subject: 14R Reactor Cavity Leak Detection Effort

Date: February 1, 1993

From: R. Miranda - Engineer, Technical Functions

Location: Oyster Creek
5514-93-007

To: Distribution

The purpose of this memo is to provide a brief overview and current status of efforts to locate a leak which allowed reactor cavity water to wet the sandbed region of the Oyster Creek drywell.

Background:

On December 9, 1992, water was found leaking into the O.C. drywell sandbed at elevation (-) 19'-0" in and around Bay #11. The sandbed region was exposed to gain access to the lower portion of the drywell exterior in support of corrosion mitigation efforts planned for this outage. The first indication of water seeping into this area was coincident with reactor cavity floodup in preparation for reactor disassembly and fuel movements. Approximate water level in the cavity was at elevation 109'-0" at the time the leak was detected. The cavity at this level is about half full. It is believed, reactor cavity water leaked through a defect in the cavity, bypassed and/or seeped through a concrete trough designed to collect and channel water to equipment drain tanks. It is further believed, the water worked its way into an annulus between the drywell vessel and concrete containment wall, saturating insulation in this area before collecting in the sandbed region below. The identification of reactor cavity water was later confirmed by chemical analysis of water samples taken. The analysis revealed that tritium and gamma levels were consistent with that of reactor vessel and spent fuel pool water. Water continued to wet this region until after the cavity was drained.

Leak Detection Efforts:
° Pre Drain Down:

Prior to floodup, and as part of reactor disassembly/assembly and refueling efforts, the reactor cavity and equipment pool walls are covered with an impervious membrane to prevent water from seeping through numerous "thru-wall" cracks in the cavity liners. This membrane consists of placing stainless steel tape on large defects, and the spray application of a removable latex based coating. Initially it was believed, water seeped through application defects in the membrane and/or through cracks in exposed seal welds on penetrations penetrating the cavity. Early efforts to isolate the leak consisted of reviewing photographs, masking plans, daily log books, etc., to try and find a flaw in

the application of the membrane. High suspect areas were identified and three separate attempts were made to find the leak. They consisted of remotely injecting dye in and around the suspect areas, placing divers in the cavity to perform vacuum box and acoustic emission testing, and by remote acoustic emission testing in selected areas from the bridge crane. Areas thought to have the highest probability of leaking were sealed with an underwater epoxy coating. None of these efforts proved to have any affect on the quantity of water leaking into the sandbed region.

° Drain Down:

A series of flow curves plotting reactor cavity elevation and leak flow rate were developed to predict the elevation of the leak during drain down of the reactor cavity. By maintaining a constant drain down rate and measuring leakage flow it was anticipated the leak could be isolated to a specific elevation of the cavity. Leak retention time and other variables though, proved to impair the accuracy of this approach. Data collected was inconsistent with the plots developed which made a location difficult to predict. However, this attempt did identify a water level at which time the leak subsided in the sandbed. A later close visual examination of the cavity wall at this elevation revealed an application defect in the coating and S.S. tape. Vacuum box testing confirmed this area to be a "thru-wall leak".

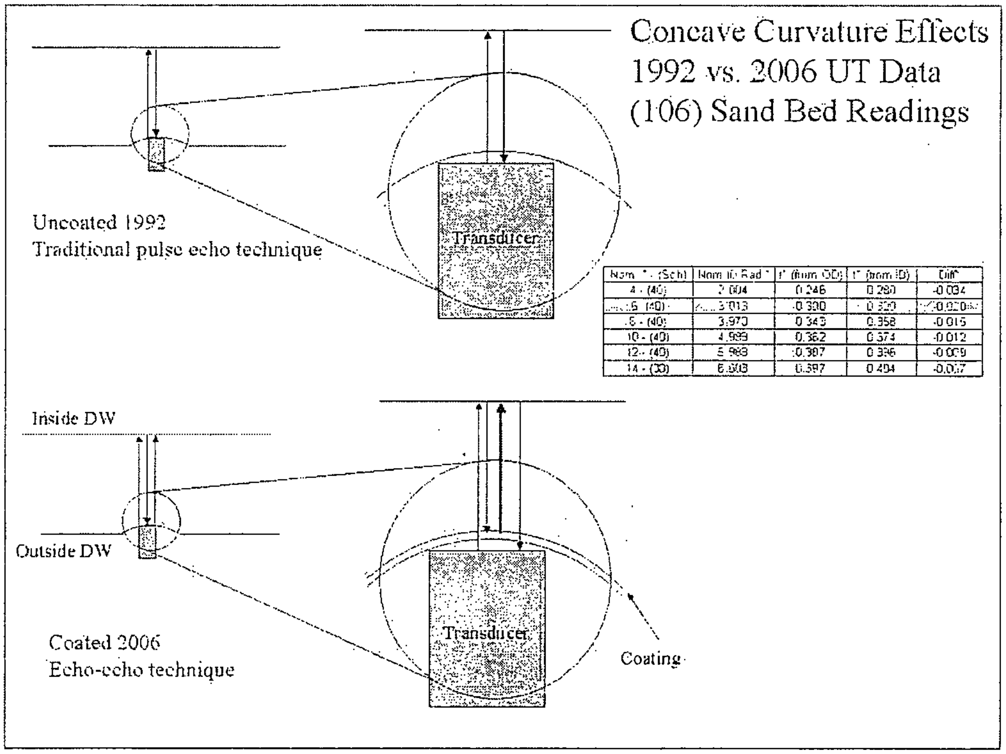
°Post Drain Down:

A series of inspections were also performed after the cavity was drained. Again, high suspect areas were targeted and remedial actions were performed where appropriate. The attached chart identifies the areas inspected and summarizes actions taken or planned.

Conclusion:

Several areas considered having the highest potential for being a leak were repaired or are scheduled for repair prior to the next cavity flood up. These areas are the 30" x 7" steel trough drain seal plate, the 8" diameter standard pipe well in the concrete trough, stainless steel patch #6/91 on the cavity west wall, the vent line penetration at elev. 109' and the 2" diameter concrete trough drain. Although these areas were identified as potential leak sources, we cannot positively conclude that all leak sources or locations have been identified. Considering that leak configurations differ under dry and wet conditions, assurance of a leak tight cavity will not be obtained until the cavity is reflooded, and inspections are performed.

Exhibit No. 51



Nom " - (Sch)	Nom ID Rad "	t" (from OD)	t" (from ID)	Diff
4 - (40)	2.004	0.246	0.280	-0.034
6 - (40)	3.013	0.300	0.320	-0.020
8 - (40)	3.970	0.343	0.358	-0.015
10 - (40)	4.989	0.362	0.374	-0.012
12 - (40)	5.983	0.387	0.396	-0.009
14 - (30)	6.563	0.397	0.404	-0.007

The upper sketch shows the ultrasonic technique used during 1992 and illustrates a typical (but exaggerated) dished area produced when surface prep was performed in 1992. The sound travel is shown with the arrows. The "air-gap" was assumed to be minimal.

The lower sketch shows the newer technology which allows us to now use a technique called "Echo to Echo". This technique was selected due to the surface being coated. The technique subtracts the coating thickness and displays only the actual thickness by using the multiple echoes generated (I.e. the 2nd round trip.) The echo-to-echo technique also subtracts the "air-gap" to display only the actual metal thickness. The bold(red) arrow shows the dimension that is being recorded.

The chart shows the mock-up results, comparing several various diameters and the resulting differences relating to concavity. The inspectors interview selected the 3" radius sample as the one to most represent a typical dish area.

UNITED STATES OF AMERICA
BEFORE THE NUCLEAR REGULATORY COMMISSION
OFFICE OF THE SECRETARY

In the Matter of	)	
	)	Docket No. 50-0219-LR
AMERGEN ENERGY COMPANY, LLC	)	
	)	ASLB No. 06-844-01-LR
(License Renewal for the Oyster Creek Nuclear Generating Station)	)	August 17, 2007

CERTIFICATE OF SERVICE

I, Richard Webster, of full age, certify as follows:

I hereby certify that on August 17, 2007, I caused Citizen's Rebuttal Statement, Exhibits and testimony in the above captioned matter to be served via email and U.S. Postal Service (as indicated) on the following:

Secretary of the Commission (Email and original and 2 copies via U.S Postal Service)
United States Nuclear Regulatory Commission
Washington, DC 20555-0001
Attention: Rulemaking and Adjudications Staff
E-mail: HEARINGDOCKET@NRC.GOV

Administrative Judge
E. Roy Hawkens, Chair (Email and U.S. Postal Service)
Atomic Safety and Licensing Board Panel
Mail Stop – T-3 F23
United States Nuclear Regulatory Commission
Washington, DC 20555-0001
E-mail: erh@nrc.gov

Administrative Judge
Dr. Paul B. Abramson (Email and U.S. Postal Service)
Atomic Safety and Licensing Board Panel
Mail Stop – T-3 F23
United States Nuclear Regulatory Commission
Washington, DC 20555-0001
E-mail: pba@nrc.gov

Administrative Judge
Dr. Anthony J. Baratta (Email and U.S. Postal Service)
Atomic Safety and Licensing Board Panel
Mail Stop – T-3 F23
United States Nuclear Regulatory Commission
Washington, DC 20555-0001
E-mail: ajb5@nrc.gov

Law Clerk
Debra Wolf (Email and U.S. Postal Service)
Atomic Safety & Licensing Board Panel
Mail Stop – T-3 F23
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001
E-mail: DAW1@nrc.gov

Office of General Counsel (Email and U.S. Postal Service)
United States Nuclear Regulatory Commission
Washington, DC 20555-0001
E-mail: OGCMAILCENTER@NRC.GOV

Mitzi Young (Email and U.S. Postal Service)
U.S. Nuclear Regulatory Commission
Office of the General Counsel
Mail Stop: O-15 D21
Washington, DC 20555-0001
E-mail: may@nrc.gov

Mary C. Batty (Email and U.S. Postal Service)
U.S. Nuclear Regulatory Commission
Office of the General Counsel
Mail Stop: O-15 D21
Washington, DC 20555-0001
E-mail: mcb1@nrc.gov

Alex S. Polonsky, Esq. (Email and U.S. Postal Service)
Morgan, Lewis, & Bockius LLP
1111 Pennsylvania Avenue, NW
Washington, DC 20004
E-mail: apolonsky@morganlewis.com

Kathryn M. Sutton, Esq. (Email and U.S. Postal Service)
Morgan, Lewis, & Bockius LLP
1111 Pennsylvania Avenue, NW
Washington, DC 20004
E-mail: ksutton@morganlewis.com

Donald Silverman, Esq. (Email and U.S. Postal Service)
Morgan, Lewis, & Bockius LLP
1111 Pennsylvania Avenue, NW
Washington, DC 20004
E-mail: dsilverman@morganlewis.com

J. Bradley Fewell (Email and U.S. Postal Service)
Exelon Corporation
200 Exelon Way, Suite 200
Kennett Square, PA 19348
E-mail: bradley.fewell@exceloncorp.com

John Covino, DAG (Email and U.S. Postal Service)
State of New Jersey
Department of Law and Public Safety
Office of the Attorney General
Hughes Justice Complex
25 West Market Street
P.O. Box 093
Trenton, NJ 08625
E-mail: john.corvino@dol.lps.state.nj.us

Valerie Gray (Email)
State of New Jersey
Department of Law and Public Safety
Office of the Attorney General
Hughes Justice Complex
25 West Market Street
P.O. Box 093
Trenton, NJ 08625
E-mail: valerie.gray@dol.lps.state.nj.us.

Paul Gunter (Email and U.S. Postal Service)
c/o Nuclear Information and Resource Service
6930 Carroll Ave., Suite 340
Takoma Park, MD 20912-4446
E-mail: paul@beyondnuclear.org

Edith Gbur (Email)
Jersey Shore Nuclear Watch, Inc.
364 Costa Mesa Drive. Toms River, New Jersey 08757
E-mail: gburl@comcast.net

Paula Gotsch (Email)
GRAMMIES
205 6th Avenue
Normandy Beach, New Jersey 08723
E-mail: paulagotsch@verizon.net

Jeff Tittel (Email)
New Jersey Sierra Club
139 West Hanover Street
Trenton New Jersey 08618
E-mail: Jeff.Tittel@sierraclub.org

Peggy Sturmfels (Email)
New Jersey Environmental Federation
1002 Ocean Avenue
Belmar, New Jersey 07319
E-mail: psturmfels@cleanwater.org

Michele Donato, Esq. (Email)
PO Box 145
Lavalette, NJ 08735
E-mail: mdonato@micheledonatoesq.com

Signed: ______________________
Richard Webster

Dated: August 17, 2007

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION
OFFICE OF THE SECRETARY

ATOMIC SAFETY AND LICENSING BOARD

Before Administrative Judges:
E. Roy Hawkens, Chair
Dr. Paul B. Abramson
Dr. Anthony J. Baratta

In the Matter of	)	
	)	
AMERGEN ENERGY COMPANY, LLC	)	
	)	Docket No. 50-0219-LR
(License Renewal for the Oyster Creek Nuclear Generating Station)	)	
	)	

AFFIDAVIT OF DR. RUDOLF H. HAUSLER REGARDING HIS PREFILED REBUTTAL TESTIMONY IN SUPPORT OF <u>CITIZENS' DRYWELL CONTENTION</u>

I, Dr. Rudolf H. Hausler of full age, do solemnly swear, as follows:

1. Through Corro-Consulta, Inc., I am employed as a consultant to the Citizens groups in this proceeding.

2. The attached pre-filed testimony represents my current opinion on the topics it covers.

3. I believe that the currently proposed UT monitoring frequency of every four years is inadequate for the reasons stated in my pre-filed testimony.

4. As stated in my pre-filed testimony I further believe that the UT data show that it is likely that the drywell shell in the sand bed region does not currently meet the applicable acceptance criteria. At minimum, I believe AmerGen cannot show to that the drywell shell in the sand bed region currently meets the applicable acceptance criteria with 95% certainty.

5. I declare under penalty of perjury that this affidavit and the attached pre-filed testimony and attachments thereto are factually accurate to the best of my knowledge, information and belief.

Rudolf H. Hausler

Dr. Rudolf H. Hausler

Sworn to me this 16th day of August, 2007

Debbie M Kerr

Notary Public

NOTARY PUBLIC STATE OF TEXAS
Debbie M Kerr
My Commission Expires
09/28/2010

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION
OFFICE OF THE SECRETARY

ATOMIC SAFETY AND LICENSING BOARD

Before Administrative Judges:
E. Roy Hawkens, Chair
Dr. Paul B. Abramson
Dr. Anthony J. Baratta

In the Matter of	)	
	)	
AMERGEN ENERGY COMPANY, LLC	)	
	)	Docket No. 50-0219-LR
(License Renewal for the Oyster Creek	)	
Nuclear Generating Station)	)	
	)	

PREFILED REBUTTAL WRITTEN TESTIMONY OF DR. RUDOLF H. HAUSLER REGARDING CITIZENS' DRYWELL CONTENTION

On behalf of Citizens, Dr. Rudolph H. Hausler hereby submits the following rebuttal testimony regarding Citizens' contention.

Q1. Have you reviewed the initial testimony of AmerGen and the NRC Staff in this case?

A1. Yes I have.

Q2. What is your overall reaction to the testimony?

A2. Overall, I do not think that either AmerGen or the NRC Staff thoroughly dealt with statistical uncertainties in the data, so that the conclusions reached about margins are far more optimistic than is merited by the data. AmerGen failed to analyze numerically the only data we have for the lower two thirds of the sandbed region. Furthermore, the NRC staff took false assurance from a study by Sandia National Laboratories (the "Sandia Study"), which actually indicates that the existing margins are, at best, perilously thin. Looking at the data, I believe that the areas of corrosion probably go beyond the current local area acceptance criteria and the corrosion shapes modeled by General Electric ("GE"). In addition, based on extreme values

statistics there is more than a 5% chance that the very local acceptance criterion of 0.49 inches is violated. Furthermore, AmerGen has effectively admitted that water can penetrate onto the exterior of the drywell shell during outages, and NRC Staff have admitted that corrosive conditions can occur on the interior of the drywell. I believe the corrosion rate estimated by AmerGen to be overly optimistic. Because overall corrosion rates could be approximately 0.049 inches per year and AmerGen is only claiming to have a margin of 0.064 inches, it is clear that the currently proposed UT monitoring frequency of once every four years is inadequate.

Q3. What additional materials have you reviewed in preparation for your rebuttal testimony?

A3. Among the materials I have reviewed are various AmerGen/Exelon and NRC documents and technical data, and GPU Nuclear safety evaluation data. A list of the most pertinent additional references to materials not already submitted to the Board is provided in Attachment 1 to this testimony.

Q4. Have you reviewed all of the documents listed in Attachment 1?

A4. Yes, I have used the documents in Attachment 1 to inform me of relevant facts and derive my conclusions.

Q5. Have you prepared a memorandum to answer the Board's questions contained in the Order, dated August 9, 2007?

A5. Yes. The memorandum contained in Citizens' Ex. 38 answers questions 1 to 6, question 9 in part, and question 10. I have not addressed questions 7, 8, and the rest of 9 because I believe they are best answered first by AmerGen. Question 11is a legal question, and I will answer question 12 to the best of my ability in this pre-filed testimony, even though I am not a structural engineer.

Q6. What is your answer to Board's question 12?

A6. The original GE model was based on a 36 degree pie slice of the sandbed region that was assumed to have a uniform thickness of 0.736 inches. This finite element model gave exactly the required safety factor of 2.0. To take some account of the lack of uniformity in reality, this was

augmented by subsequent modeling which showed how much the buckling capacity reduced when metal was cut out of the uniformly thick shell. In this modeling the elements in the sand bed region were 3 inch by 3 inch squares. Larger elements were used above the sand bed region to model the downcomers. The tray-shaped cut out was 1.5 feet by 3 feet (6 elements by 12 elements) in total with a centre area of 0.5 feet by 1 foot (2 elements by 4 elements) which was modeled as both 0.536 inches thick and 0.636 inches thick. The cut outs reduced the buckling capacity by 9.5% and 3.9% respectively. It appears that the idea of the model was to assume a worst case within which the measured results could be placed. To ensure that the actual areas of corrosion exert less effect on buckling than the modeled shapes, I believe that, at minimum, AmerGen should only accept an area thinner than 0.736 inches if it falls within the spatial envelope of the modeled cut outs. In addition, I believe AmerGen appropriately adopted a conservative criterion that was less than the size of the full cut-outs, because the mean thickness of some of the Bays is approaching 0.736 inches, so that a reduction of 3.9% in buckling capacity is potentially significant. The contour plots show that the shapes of the corroded areas cannot be enveloped within the modeled tray shapes because they are ill-defined and in at least Bays 1 and 19 are more like long grooves than squares. Thus, the areas depicted on the contour maps cannot be accepted based on the GE modeling. Furthermore, I continue to believe that in the SER AmerGen reasonably adopted, and NRC Staff approved, a local area acceptance criterion that requires the contiguous areas that are less than 0.736 inches thick to be less than one square foot in area. This criterion is exceeded in at least Bays 1 and 13. With respect to question 12(e), I believe that is primarily a legal question. However, I observe that from a technical standpoint, if the CLB requires the pattern of corrosion to be within that modeled by GE, the licensee appears to be outside the bounds of the CLB.

Q7. What is Citizens' Exhibit 39?

A7. Citizens' Exhibit 39 is my detailed response to the testimony presented by AmerGen and the NRC Staff.

Q8. To your knowledge, are Citizens' Exhibits 38 and 39, and this testimony, true and accurate?

A8. Yes, Citizens' Exhibits 38 and 39 and this testimony provide, to the best of my knowledge, true and accurate statements of my responses to AmerGen, the NRC Staff, and the Board's questions. I should point out that in Citizens' Exhibit 38 I have refined my calculation of the sample standard deviation. Because the calculations in Citizens' Exhibit 38 are the most accurate, these should be regarded as definitive.

Q9. Has AmerGen's and NRC Staff's initial testimony changed your opinions regarding the state of the drywell shell?

A9. No.

Q10. Has NRC Staff Required 95% confidence of the shell meeting the acceptance criteria in the past?

A10. Yes. NRC Staff testimony at A.22 shows that when significant corrosion was occurring, the lower 95% confidence limit of the current and anticipated future state of the shell was used to determine the monitoring interval. Even though the corrosion observed is no longer statistically significant, it continues to be reasonable to require that the drywell will meet safety requirements with at least 95% confidence at all times. In fact, the Sandia Study shows that on initial licensing the drywell shell met the ASME code with near certainty because the lowest safety factor was 2.77 and the fabricated plate thicknesses were reasonably well known. Sandia Study at 68. Thus, I believe that NRC should not issue a new license unless AmerGen can demonstrate with near certainty that it meets the ASME code. To do otherwise would significantly reduce the assurance of safety that we had when the plant opened.

Q11. Does the Sandia Study referenced by NRC Staff's Testimony at A.8 provide assurance that the drywell shell currently meets the safety requirements?

A11. No. First, Sandia specifically noted in its report that the study was not designed to provide absolute predictions of load factors. Sandia Study (available at ML070120395) at 12. This was in part because "the thicknesses assigned in each region were based on limited measurement data since a very small percentage of the shell has been examined." *Id.* at 84. Second, the Sandia Study predicted a 7% margin if the shell remained at the same thickness as in 1992 and the only areas thinner than 0.736 inches were two areas measuring 30 inches by 18

inches, one in Bay 1 and one in Bay 13, directly below the downcomers. *Id.* at 47-49. My analysis of the data has shown that this is far from bounding for two main reasons. First the 2006 measurements showed that the shell is now approximately 2 to 3% thinner overall than measured in 1992. Second, there are probably bigger areas thinner than 0.736 than assumed in Bays 1, 13, 15, and Bay 19, those areas are not directly below the downcomers, and Bays 1 and 13 contain more than one area thinner than 0.736 inches. Thus, the Sandia Study does not demonstrate that there is any current margin. Finally, the Sandia Study does not provide reasonable assurance because it did not take account of the uncertainty in the inputs.

Q12. AmerGen has claimed it cannot use the external results to estimate margins. Do you think this is correct?

A12. No. In their modeling study, Sandia National Laboratories used the external results to generate estimated thicknesses for the drywell shell in the sandbed region. Furthermore, even AmerGen personnel have stated in writing that the internal grid results in each Bay are often not representative of that Bay. Citizens' Ex. 45 at 3; Citizens' Ex. 46 at OCLR29744-45. This was confirmed by my analysis summarized in Citizens' Ex. 12 at Figure 4. Thus, it is essential to use the external data if the margins are to be calculated in a realistic manner. Finally, if AmerGen's were correct that the external data can only demonstrate compliance with the local area acceptance criteria, but cannot determine the margin above that criterion, AmerGen could not show that its proposed monitoring regime will maintain the required thicknesses during any period of extended operation because there would be no method of predicting when the unknown margin above the local area acceptance criterion could be violated.

Q13. Do AmerGen's analyses of the external data actually demonstrate compliance with the local area acceptance criteria?

A13. No, AmerGen's latest analysis actually demonstrates non-compliance with the local area acceptance criterion. Most obviously the assessment shows 3 feet by 3 feet areas that are thinner than 0.736 inches in Bays 1 and 19. AmerGen Ex. 16 at 34, 92-93. Because these areas are highly unlikely to have vertical sides, based on AmerGen's assessment, it is likely that the areas thinner than 0.736 inches are larger than 3 feet by 3 feet in each of these Bays. Furthermore, AmerGen's assessment is based on a correction technique that is not justified. Stripping out this

correction, the raw UT results show that the 3 feet by 3 feet area shown in Bay 13 is also thinner than 0.736 inches. *See Id.* at 56-57, 63-64. Finally, in Bay 1 the raw UT results go below the requirements in the transition zone between the thinnest areas and 0.736 inches.

Q.14. Do visual observations suggest that the external UT data actually represent the thinnest points?

A14. No. In fact, the best visual inspection we have shows that visually locating the thinnest parts of the shell was impossible. A memorandum dated January 28, 1993 describes a visual inspection of the shell when only Bays 17 and 19 had been fully coated. Citizens' Ex. 44. The inspection describes the surface as relatively uniform with small dimples most of which are that are approximately 0.5 inches in diameter. *Id.* at 1. In addition to the dimples, the inspection noted an area that is relatively uncorroded, below which were "two strips around the vessel" which were "slightly thinner than the general area." *Id.* In addition, the inspection noted less localized thin spots that were approximately a foot to 18 inches in diameter and covered around 20% of the corroded area. *Id.* at 2. Except for Bay 13, these thin spots were hard to detect because the variation in thickness is small. *Id.* In Bay 13, the thickness variations were more pronounced and the thin spots were at least 1 ft apart edge to edge near the downcomers and further apart toward the edges of the Bay. *Id.* The inspector noted that "I could not determine visually which of the thin spots are the thinnest." *Id.*

Q15. Is this conclusion confirmed by the UT data?

A15. Yes. The repeat exterior UT results and interior trench data taken in October 2006 prove definitively that the reported external UT measurements were not taken at the thinnest locations. First, the results for 2006 show that at some points in bays 7, 15, 17 and 19 AmerGen scanned a 0.25 inch area around the nominal location of the point. AmerGen Ex. 19 Attachment 4 at 8, 16, 18, 20. In most cases, AmerGen found a thinner point than the reported point. *Id.* Strikingly, in bay 15, the reported results were all the maximum readings obtained, while the minimum readings were as much as 0.068 inches less than the recorded value. *Id.* at 16. Similarly, in bay 19 the recorded results were up to 0.07 inches more than the minimum recorded value. *Id.* at 20. Second, as shown in Citizens' Ex. 12 Figure 4, the average of the external UT data taken at the top and bottom levels is higher than the average wall thicknesses measured in the trench in Bay

17 at the very bottom and the top. Taken together the visual inspection and the UT data show that while the external UT measurements may be somewhat biased towards the thin side, they are not taken at the thinnest points.

Q16. Do you agree with AmerGen's argument that the external results must be the thinnest results because some of the points were overground?

A16. No. As I testified to the previous question, the repeat measurements and trench data show that in general the points for which UT measurements were reported in 2006 are not the thinnest points on the shell. In addition, the idea of grinding is to create a flat area at the thickness of the thinnest point, not to make the area thinner. Furthermore, not all of the points were ground to facilitate measurement. Citizens' Ex. 43. Finally, NRC Staff have noted that AmerGen could not locate the locations measured in 1992 exactly. NRC Staff Testimony at A17. For example, in Bay 13 in 2006, AmerGen was unable to measure locations 1a, 2a, and 2, even though these points were all measured below 0.736 inches in 1992. *See* Citizens' Ex. 13 at Table 2. This indicates that they were not located at obvious low points in the surface of the shell. Moreover, AmerGen has inconsistently argued that the external UT measurements in 1992 were biased to the thick side by the curvature of the surface creating an air gap between the surface and the UT probe. Citizens' Ex. 51. Indeed, AmerGen's statistical analysis claims to show such bias. Citizens' Ex. 9 at 6-1. If this bias indeed exists, the only explanation offered assumes that the measured points were not overground. If the points were in fact overground, AmerGen has offered no plausible explanation for the observed differences in the thickness data between 1992 and 2006.

Q.17. What is the appropriate statistical approach to finding the thinnest point on the drywell shell?

A17. Because it is unlikely that the measured points are actually the thinnest points, a statistical approach must be taken to find the likely thinnest point on the shell. The 1992 external data for Bay 13 show quite definitively that they are not normally distributed. Thus, I believe the best approach is to use extreme value statistics to estimate the chance that a thinner point than the acceptance criterion (0.49 inches) would be found if more measurements were taken. Applying such an approach to Bay 13, it is likely that if 40 points had been measured, a much

thinner point than 0.49 inches would have been observed. Thus, I believe that there is a significant chance that the drywell shell Bay 13 currently fails the very local area acceptance criterion in.

Q18. To take account of the alleged bias in the external UT measurements, AmerGen has applied a correction technique to some of the measurements. Do you believe this correction technique is appropriate?

A19. No, it is inappropriate for a number of reasons. First, it was derived using only measurements in Bay 13. Because the visual inspection shows that Bay 13 is atypical, even if this technique were appropriate for Bay 13, it would not be appropriate for the other Bays. Second, the technique is not even appropriate for Bay 13, because it is not based on any viable physical or statistical theory. Instead, the operator appears to have selected a correction factor that is larger than the average surface roughness.

Q18. Since submitting your initial testimony have you refined your assumptions about the interior corrosion rate?

A18. Yes. NRC Staff have confirmed that UT data taken in the trenches have show that a corrosion rate of approximately 0.002 inches per year occurred between 1986 and 2006. The interpretation of these results is very difficult. AmerGen's explanation that the thinning is caused by exterior corrosion seems unlikely, because Bays 5 and 17 are the least corroded Bays and the estimated corrosion rate in Bay 17 was not significant or was very small (no corrosion rate was even estimated for Bay 5). AmerGen Ex. 23. Indications are that corrosion on the interior could occur at outages or when water flows to the interior during operation. Thus, it is likely that the 2 mils per year average represents a situation where interior corrosion occurred in fits and starts over the years. Considerably higher short term corrosion rates have probably occurred. In the absence of any good information on this issue, I believe it would be prudent to allow for an interior corrosion rate that is a multiple of 0.002 inches per year, if new water is introduced onto the interior floor by repairs to control rod drives, use of the containment spray, or other sources.

Q19. Has AmerGen or NRC Staff shown that water cannot be present in the exterior of the drywell shell?

A19. No. At various times in the past there has been leakage onto the exterior of the drywell shell because the drywell cavity liner leaks and the trough that was provided to catch general leakage is very shallow, has only one drain, and was damaged. Citizens' Ex. 15 at 134-35; Citizens' Ex. 24 at 222-23; AmerGen Testimony Part 1 at A.20; AmerGen Testimony Part 3 at A.5. More recently, during the 1994 and 1996 refueling outages, the committed mitigation measures were not used and water leaked into the exterior sandbed region. AmerGen Testimony Part 4 at A.8-9; AmerGen Testimony Part 5 at A.14. Therefore, water could flow onto the exterior of the drywell shell in the sandbed region if a forced outage occurred that required the reactor cavity to be flooded without having the leakage mitigation measures applied. In addition, AmerGen has acknowledged that it has been unable to devise a means of stemming the leakage from the reactor cavity during refueling. Citizens' Ex. 24 at 219-21. In the 2006 outage around one gallon per minute of leakage was observed even after the required tape and strippable coating were applied to the fuel cavity liner. AmerGen Testimony Part 4 at A.9. However, the trough is still subject to high temperatures that could cause the concrete to deteriorate and the condition of the trough was seen to be far from ideal in the most recent outage. Citizens' Exs. 48-49. In addition, quite serious leaks have been observed in the past even after taping and strip coating. Citizens' Ex. 50. Furthermore, the intended function of the trough is to act as a backup for other components. Citizens' Ex. 24 at 220. Thus, if the trough degraded further, mitigating measures were not as effective as in 2006, or leakage was observed in other components, water could enter the drywell again, even without a forced outage. Finally, AmerGen acknowledges that use of the drywell chillers, which are used during refueling and other outages when access to the drywell is needed, could lead to condensation. AmerGen Testimony Part 4 at A.15. The potential for condensation is apparently confirmed by an analysis of water that had drained from the exterior of the sandbed region before March 2006, which showed no activity. Citizens' Ex. 23. This is consistent with the source being condensation.

Q18. Is there a chance that some of the exterior of the drywell shell is not covered by a protective epoxy coat?

A18. Yes. Internal documents we have received from AmerGen indicate that areas of the shell in the sandbed region were not coated with epoxy because they are inaccessible. Citizens' Exs. 40-41.

Q19. Do you believe that AmerGen has used valid methods to evaluate the potential for external corrosion?

A19. No. AmerGen makes a number of critical errors in its approach to estimating exterior corrosion. Most obviously, Mr. Gordon fails to consider the situation where the plant is forced to fill the drywell cavity in a forced outage. AmerGen Testimony Part 5 at A.13. Mr. Gordon also fails to allow for other forced outages, which could lead to condensation on the exterior of the drywell surface. In addition, Mr. Gordon has not used a reasonable approach to estimate the time in which any water on the exterior of the shell would evaporate, because he has used an equation which applies to pools or open ponds. Id. at A.19. Thus, the equation inherently assumes that the evaporation of the water does not affect the air into which it is evaporating (steady state equation). This assumption is invalid for the exterior of the sandbed region which has very limited air exchange. It is therefore likely that in the event of water leakage into the region, the air in the sandbed region would become fully saturated during the outage (transient phenomenon). It would then have very limited capacity to absorb moisture as the temperature increased with plant start up. Then, after the air becomes saturated at the operating temperature, it would not absorb more moisture unless air is being exchanged with the outside. The ability of new air to reach the sand pocket has been reduced by the placement of tubes leading to polysterene bottles in the sandbed drains. Thus, it is likely that any moisture on the exterior of the shell would evaporate slowly. I do not have access to sufficient information to provide a quantitative estimate of the rate of evaporation.

Q20. In summary, are you convinced that the drywell will meet safety requirements during any extended period of operation?

A20. No. NRC Staff and AmerGen have created a miasma of uncertainty, which makes it difficult to show what the current situation is or how it could change in the future. However, I believe that the contour plots coupled with the visual observations show that it is likely that the corrosion goes beyond the envelope of the shapes modeled by GE. Furthermore, based on my

statistical analyses I believe there is a significant chance that the thinnest area of the drywell is thinner than the required amount (0.49 inches). In addition, the lower 95% confidence intervals of the external data are close to or below the criterion for mean thickness (0.736 inches). For example, based on raw UT data, I believe that Bay 15 could have a mean thickness of less than 0.736 inches at the lower 95% confidence limit and the lower 95% confidence limit of the mean thickness of Bay 13 in 1992 was 0.741 inches, a mere 0.006 inches above the requirement. There is also tremendous uncertainty in the potential corrosion rates for both interior and exterior corrosion. Thus, I believe the Board should not allow the proposed relicensing because AmerGen cannot demonstrate with any certainty that the drywell shell in the sandbed region can meet the ASME code at the start of any period of extended operation. If the Board decides to grant the license, it should ensure that AmerGen has provided an estimate of the thickness margin above each acceptance criterion that is reasonably certain. The UT monitoring frequency should be based on the smallest margin available. That frequency would be considerably less than once every four years because available margins are, at best, razor thin and such margins could be reduced to nothing in a matter of months.

Q21. Have you now completed your rebuttal testimony?

A21. Yes.

ATTACHMENT 1 – LIST OF MOST RELEVANT ADDITIONAL DOCUMENTS REVIEWED

No.	Document Identification	Other Reference
40.	Email from William Russell to Frederick Polaski, et al., Subject: Challenge Board #1 additional comment (Nov. 30, 2006, 9:48 EST), attached to email from John Hufnagel Jr. to Ahmed Ouaou, et al. (Nov. 30, 2006 10:41 EST).	
41.	GPU Nuclear, Technical Functions Safety/Environmental Determination and 50.59 Review (Jan. 5, 1993).	
42.	Email from Peter Tamburro to Ahmed Ouaou, Cc Howie Ray, et al., Subject: Surface Are (sic) of the Drywell in the sand bed (Apr. 3, 2006 3:24 PM).	
43.	Email from John O'Rourke to Michael Gallagher, et al., Subject: External Inspections of DW in Sandbed Region (Oct. 10, 2006 8:08 AM), attached to email from John Hufnagel to John O'Rourke (Oct. 10, 2006 8:10 AM).	
44.	Memorandum, GPU Nuclear from K. L. Whitmore, Civil/Structural Mgr. to J. C. Flynn, Manager, Special Projects, Engineering Projects, Subject: Inspection of drywell sand bed region and access holes (Jan. 28, 1993).	
45.	AmerGen Technical Evaluation 330592-27-27 (Apr. 20, 2007).	
46.	Email from John O'Rourke to Marcos Herrera, Cc Michael Gallagher et al., Subject: Oyster Creek Drywell Thickness to be Used for Base Case Analysis, with OYSTER CREEK DRYWELL THICKNESSES, Rev2.doc attachment (Feb. 28, 2007 7:20 PM).	

47. Issue # 00557180, Exelon Nuclear Issue - Statement of Confirmation, Originator: Kathy Barnes (Nov. 13, 2006).

48. Email from Tom Quintenz to John O'Rourke, Subject: Notes of video inspection results of trough area with Video Inspection of Concrete Trough Notes November 1996 (Oct. 10, 2006 2:26 PM).

49. GPU Nuclear, Material Nonconformance Report (Oct. 27, 1986).

50. Memorandum, GPU Nuclear from R. Miranda, Engineer, Technical Functions to Distribution, Subject: 14R Reactor Cavity Leak Detection Effort (Feb. 1, 1993).

51. Sketches showing ultrasonic and "Echo to Echo" techniques, and explanations of sketches.